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NATURAL THEOLOGY

Or, Evidences of the Existence and Attributes of the Deity, Collected from the Appearances of Nature

William Paley

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Natural Theology

William Paley (1743-1805), a British Christian apologist, argues for the existence of God as the intelligent creator of the world in this, his last book, published in 1802. He builds on early modern natural theology including the works of John Ray, William Derham, and Bernard Nieuwentyt, and chooses to ignore Hume, who had argued against design. Paley uses analogy and metaphors, including a particularly well-written version of the 'watchmaker analogy', to prove that the world is designed and sustained by God. Most of his examples are taken from medicine and natural history. This sixth edition also contains a detailed bibliography, appendices on Paley's courses, and background notes on key figures. It was an influential best-seller throughout the nineteenth century, read by theologians and scientists alike, and reprinted in cheap editions. It inaugurated a tradition of natural theological works, amongst them the Bridgewater Treatises (which also appear in this series), and is a landmark of Western thought.

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BY WILLIAM PALEY, D.D.

ARCHDEACON OF CARLISLE.

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TO

THE 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

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

which I was capable, and difpofed me without hefitation to obey the call in the beft manner that I could. In the choice of a fubject I had no place left for doubt: in faying which, I do not fo much refer, either to the fupreme importance of the fubject, or to any fcepticifm concerning it with which the prefent times are charged, as I do, to its connection with the fubjects treated of in my former publications. The following difcuffion alone was wanted to make up my works into a fyftem: in which works, fuch 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 refult from both. It is of fmall importance, that they have been written in an order, the very reverfe of that in which they ought to be read. I commend therefore the prefent volume to your Lordfhip's protection, not only as, in all probability, my laft labor, but as the completion of a confiftent and comprehenfive defign.

Hitherto, My Lord, I have been fpeaking of myfelf, and not of my Patron. Your Lordfhip wants not the teftimony of a dedication; nor any teftimony from me: I confult therefore the impulfe of my own mind alone when I declare, that in no refpect has my intercourfe with your Lordfhip been more gratifying to me, than in the opportunities, which it has afforded me, of obferving your earneft, active, and unwearied folicitude, for the advancement of fubftantial Chriftianity; a folicitude, neverthelefs, accompanied with that candor of mind, which fuffers no fubordinate differences of opinion, when there is a coincidence in the main intention and object, to produce any alienation of efteem, or diminution of favor. It is fortunate for a country, and honorable to its government, when qualities and difpofitions 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.

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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 endeavour to relax itſelf, turns round the box. We next obſerve a flexible chain (artificially wrought for the ſake of flexure) communicating the action of the ſpring from the box to the fuſee.

We then find a ſeries of wheels, the teeth of which catch in, and apply to, each other, conducting the motion from the fuſee to the balance, and from the balance to the pointer; and at the ſame time, by the ſize and ſhape of thoſe wheels, ſo regulating that motion, as to terminate in cauſing an index, by an equable and meaſured progreſſion, to paſs over a given ſpace in a given time. We take notice that the wheels are made of braſs, in order to keep them from ruſt; the ſprings of ſteel, no other metal being ſo elaſtic; that over the face of the watch there is placed a glaſs, a material employed in no other part of the work, but, in the room of which, if there had been any other than a tranſparent ſubſtance, the hour could not be ſeen without opening the caſe. This mechaniſm being obſerved (it requires indeed an examination of the inſtrument, and perhaps ſome previous knowledge of the ſubject, to perceive and underſtand it; but being once, as we have ſaid, obſerved and underſtood), the inference, we think, is inevitable; that the watch muſt have had a maker; that there muſt have exiſted, at ſome time and at ſome place or other, an artificer or artificers who formed it for the purpoſe which we find it actually to anſwer; who comprehended its conſtruction, and deſigned its uſe.

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

II. Neither, ſecondly, would it invalidate

our

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

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.

CHAP-

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 poſ-ſeſſed 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 ad-juſtment of laths, files, and other tools, evi-dently and ſeparately calculated for this pur-poſe; 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 con-viction of the conſummate ſkill of the con-triver. Whether he regarded the object of the contrivance, the diſtinct apparatus, the intricate, yet in many parts intelligible, me-chaniſm by which it was carried on, he would perceive, in this new obſervation, nothing but

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,

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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

from defign remains as it was. Marks of defign and contrivance are no more accounted for now, than they were before. In the fame thing, we may afk for the caufe of different properties. We may afk for the caufe of the colour of a body, of its hardnefs, of its heat; and thefe caufes may be all different. We are now afking for the caufe of that fubferviency to an ufe, that relation to an end, which we have remarked in the watch before us. No anfwer is given to this queftion by telling us that a preceding watch produced it. There cannot be defign without a defigner; contrivance without a contriver; order without hocice; arrangement, without any thing capable of arranging; fubferviency and relation to a purpofe, without that which could intend a purpofe; means fuitable to an end, and executing their office in accomplifhing that end, without the end ever having been contemplated, or the means accommodated to it. Arrangement, difpofition of parts, fubferviency of means to an end, relation of inftruments to an ufe, imply the prefence of intelligence and mind. No one, therefore, can rationally believe, that the infenfible, inanimate watch, from which the watch before us iffued, was the proper caufe of the mechanifm we fo much admire in it; could be truly faid to have conftructed the inftrument, difpofed its parts, affigned their office, determined their order, action, and mutual dependency, combined their feveral motions into one refult, and that alfo a refult connected with the utilities of other beings. All thefe 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 fuppofing the watch before us to have been produced from another watch, that from a former, and fo on indefinitely. Our going back ever fo far brings us no nearer to the leaft degree of fatisfaction upon the fubject. Contrivance is ftill unaccounted for. We ftill want a contriver. A defigning mind is neither fupplied by this fuppofition, nor difpenfed with. If the difficulty were diminifhed the further we went back, by going back indefinitely we might exhauft it. And this is the only cafe to which this fort of reafoning applies. Where there is a tendency, or, as we increafe the number of terms, a continual approach towards a limit, *there*, by fuppofing the number of terms to be what

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 im-

mediately

mediately 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 unorganized, unmechanized, ſubſtance, without mark or indication of contrivance. It might be 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 unorganized bodies to ſpring from one another), or by individual perpetuity. But that is not the queſtion now. To ſuppoſe it to be ſo, is to ſuppoſe that it made no difference whether 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,

ceeded, 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.

CHAP-

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 preciſely the

the ſame proof that the eye was made for viſion, as there is that the teleſcope was made for aſſiſting it. They are made upon the ſame principles; both being adjuſted to the laws by which the tranſmiſſion and refraction of rays of light are regulated. I ſpeak not of the origin of the laws themſelves; but ſuch laws being fixed, the conſtruction, in both caſes, is adapted to them. For inſtance; theſe laws require, in order to produce the ſame effect, that the rays of light, in paſſing from water into the eye, ſhould be refracted by a more convex ſurface, than when it paſſes out of air into the eye. Accordingly we find, that the eye of a fiſh, in that part of it called the cryſtalline lenſe, is much rounder than the eye of terreſtrial animals. What plainer manifeſtation of deſign can there be than this difference? What could a mathematical inſtrument-maker have done more, to ſhew his knowledge of his principle, his application of that knowledge, his ſuiting of his means to his end; I will not ſay to diſplay the compaſs or excellency of his ſkill and art, for in theſe all compariſon is indecorous, but to teſtify counſel, choice, conſideration, purpoſe?

To ſome it may appear a difference ſufficient to deſtroy all ſimilitude between the eye and the

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 elſe beſide the known laws of mechaniſm taking place; whereas, in the automaton, for the comparatively few motions of which it is capable, we trace the mechaniſm throughout. But, up to the limit, the reaſoning is as clear and certain in the one caſe as the other. In the example before us, it is a matter of certainty, becauſe it is a matter which experience and obſervation demonſtrate, that the formation of an image at the bottom of the eye is neceſſary to perfect viſion. The image itſelf can be ſhewn. Whatever affects the diſtinctneſs of the image, affects the diſtinctneſs of the viſion. The formation then of ſuch an image being neceſſary (no matter how), to the ſenſe of ſight, and to the exerciſe of that ſenſe, the apparatus by which it is formed is conſtructed and put together, not only with infinitely more art, but upon the ſelf-ſame principles of art, as in the teleſcope or the camera obſcura. The perception ariſing from the image may be laid out of the queſtion; for the production of the image, theſe are inſtruments of the ſame kind. The end is the ſame; the means are the ſame. The purpoſe in both is alike; the contrivance for accompliſhing that purpoſe is in both alike. The lenſes of the teleſcope,

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and the humours of the eye bear a complete resemblance to one another, in their figure, their position, and in their power over the rays of light, viz. in bringing each pencil to a point at the right diſtance from the 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 telefcope. His obfervation taught him, that, in the eye, the evil was cured by combining together lenfes compofed of different fubftances, i. e. of fubftances which poffeffed different refracting powers. Our artift borrowed from thence his hint; and produced a correction of the defect by imitating, in glaffes made from different materials, the effects of the different humours through which the rays of light pafs before they reach the bottom of the eye. Could this be in the eye without purpofe, which fuggefted to the optician the only effectual means of attaining that purpofe?

But further; there are other points, not fo much perhaps of ftrict refemblance between the two, as of fuperiority of the eye over the telefcope; yet, of a fuperiority, which, being founded in the laws that regulate both, may furnifh topics of fair and juft comparifon. Two things were wanted to the eye, which were not wanted, at leaft in the fame degree, to the telefcope; and thefe were, the adaptation of the organ, firft, to different degrees of light; and, fecondly, to the vaft diverfity of diftance at which objects are viewed by the naked eye, viz. from a few inches to as many miles.

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

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, other things remaining the ſame, this point, by the immutable properties of light, is carried further back, when the rays proceed from a near object, than when they are ſent from one that is remote. A perſon who was uſing an optical inſtrument, would manage this matter by changing, as the occaſion required, his 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.

jecture. The change, though sufficient for the purpose, is so minute as to elude ordinary observation. Some very late discoveries, deduced from a laborious and most accurate inspection of the structure and operation of the organ, seem at length to have ascertained the mechanical alteration which the parts of the eye undergo. It is found, that by the action of certain muscles, called the straight muscles, and which action is the most advantageous that could be imagined for the purpose,—it is found, I say, that, whenever the eye is directed to a near object, three changes are produced in it at the same time, all severally contributing to the adjustment required. The cornea, or outermost coat of the eye, is rendered more round and prominent; the crystalline lense underneath is pushed forward; and the axis of vision, as the depth of the eye is called, is elongated. These changes in the eye vary its power over the rays of light in such a manner and degree as to produce exactly the effect which is wanted, viz. the formation of an image *upon the retina*, whether the rays come to the eye in a state of divergency, which is the case when the object is near to the eye, or come parallel to one another, which

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 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

rious 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 a great diſtance; a power of which, in birds of rapine, ſurpriſing examples are given. The fact accordingly is, that two peculiarities are found in the eyes of birds, both tending to *facilitate* the change upon which

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

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

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

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

There is one property, however, common, I believe, to all eyes, at leaſt to all which have been examined *, namely, that the optic nerve

* The eye of the ſeal or ſea-calf, I underſtand, is an exception. Mem. Acad. Paris, 1701, p. 123.

enters the bottom of the eye, not in the centre or middle, but a little on one ſide; not in the point where the axis of the eye meets the retina, but between that point and the noſe.—The difference which this makes is, that no part of an object is unperceived by both eyes at the ſame time.

In conſidering viſion as achieved by the means of an image formed at the bottom of the eye, we can never reflect without wonder upon the ſmallneſs, yet correctneſs, of the picture, the 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 ſixpence, 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

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, an anxiety for its preſervation, due, if we may ſo ſpeak, to its value and its tenderneſs. It is lodged in a ſtrong, deep, bony ſocket, compoſed by the junction of ſeven different bones*, hollowed out at their edges. In ſome few ſpecies, as that of the coatimondi†, the orbit is not bony throughout; but whenever this is the caſe, the upper, which is the deficient part, is ſupplied by a cartilaginous ligament; a ſubſtitution which ſhews the ſame care. Within this ſocket it is imbedded

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

in fat, of all animal fubftances the beft adapted both to its repofe and motion. It is fheltered by the eyebrows, an arch of hair, which, like a thatched penthoufe, prevents the fweat and moifture of the forehead from running down into it.

But it is ftill better protected by its *lid.* Of the fuperficial parts of the animal frame, I know none which, in its office and ftructure, is more deferving of attention than the eyelid. It defends the eye; it wipes it; it clofes it in fleep. Are there, in any work of art whatever, purpofes more evident than thofe which this organ fulfils; or an apparatus for executing thofe purpofes more intelligible, more appropriate, or more mechanical? If it be overlooked by the obferver of nature, it can only be becaufe it is obvious and familiar. This is a tendency to be guarded againft. We pafs by the plaineft inftances, whilft we are exploring thofe which are rare and curious; by which conduct of the underftanding, we fometimes neglect the ftrongeft obfervations, being taken up with others, which, though more recondite and fcientific, are, as folid arguments, entitled to much lefs confideration.

In order to keep the eye moift and clean,

which

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

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

It were, however, injuſtice to diſmiſs the eye as a piece of mechaniſm, without noticing that moſt exquiſite of all contrivances, the *nictitating membrane*, which is found in the eyes of birds and of many quardrupeds. Its uſe is to ſweep the eye, which it does in an inſtant; to ſpread over it the lacrymal humor; to defend it alſo

 from

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 out by force like a piece of elaſtic gum, and by its own elaſticity returning, when the force is removed, to its former poſition. Such being its nature, in order to fit it up for its office it is connected by a tendon or thread with a muſcle in the back part of the 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 advan-

tage,

tage, 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 †."

* 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.

In the configuration of the mufcle, which, though placed behind the eye, draws the nictitating membrane over the eye, there is, what the authors, juft now quoted, defervedly call a marvellous mechanifm. I fuppofe this ftructure to be found in other animals; but, in the Memoirs from which this account is taken, it is anatomically demonftrated only in the caffowary. The mufcle is *paffed through a loop formed by another mufcle*; and is there inflected; as if it were round a pulley. This is a peculiarity; and obferve the advantage of it. A fingle mufcle with a ftraight tendon, which is the common mufcular form, would have been fufficient, if it had had power to draw far enough. But the contraction, neceffary to draw the membrane over the whole eye, required a longer mufcle than could lie ftraight at the bottom of the eye. Therefore, in order to have a greater length in a lefs compafs, the cord of the main mufcle makes an angle. This, fo far, anfwers the end; but, ftill further, it makes an angle, not round a fixed pivot, but round a loop formed by another mufcle; which fecond mufcle, whenever it contracts, of courfe twitches the firft mufcle 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 through 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,

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is the refuge of imperfection. To have recourse to expedients, implies difficulty, impediment, restraint, defect of power. This question belongs to the other senses, as well as to sight; to the general functions of animal life, as nutrition, secretion, respiration; to the œconomy of vegetables; and indeed to almost all the operations of nature. The question therefore is of very wide extent; and, amongst other answers which may be given to it, beside reasons of which probably we are ignorant, one answer is this. It is only by the display of contrivance, that the existence, the agency, the wisdom of the Deity, *could* be testified to his rational creatures. This is the scale by which we ascend to all the knowledge of our Creator which we possess, so far as it depends upon the phænomena, or the works of nature. Take away this, and you take away from us every subject of observation, and ground of reasoning; I mean as our rational faculties are formed at present. Whatever is done, God could have done, without the intervention of instruments or means: but it is in the construction of instruments, in the choice and adaptation of means, that a creative intelligence is seen. It is this which constitutes the order

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and beauty of the univerſe. God, therefore, has been pleaſed to preſcribe limits to his own power, and to work his ends within thoſe limits. The general laws of matter have perhaps the nature of theſe limits; its inertia, its reaction; the laws which govern the communication of motion, the refraction and reflection of light, the conſtitution of fluids non-elaſtic and elaſtic, the tranſmiſſion of ſound through the latter; the laws of magnetiſm, of electricity; and probably others yet undiſcovered. Theſe are general laws; and when a particular purpoſe is to be effected, it is not by making a new law, nor by the ſuſpenſion of the old ones, nor by making them wind and bend and yield to the occaſion (for nature with great ſteadineſs adheres to, and ſupports them), but it is, as we have ſeen in the eye, by the interpoſition of an apparatus correſponding with theſe laws, and ſuited to the exigency which reſults from them, that the purpoſe is at length attained. As we have ſaid, therefore, God preſcribes limits to his power, that he may let in the exerciſe, and thereby exhibit demonſtrations of his wiſdom. For then, i. e. ſuch laws and limitations being laid down, it is as though one Being ſhould have fixed certain rules;

and, if we may ſo ſpeak, provided certain materials; and, afterwards, have committed to another Being, out of theſe materials, and in ſubordination to theſe rules, the taſk of drawing forth a creation: a ſuppoſition which evidently leaves room, and induces indeed a neceſſity, for contrivance. Nay, there may be many ſuch agents, and many ranks of theſe. We do not advance this as a doctrine either of philoſophy or of religion; but we ſay that the ſubject may ſafely be repreſented under this view, becauſe the Deity, acting himſelf by general laws, will have the ſame conſequences upon our reaſoning, as if he had preſcribed theſe laws to another. It has been ſaid, that the problem of creation was, "attraction and matter being given, to make a world out of them:" and, as above explained, this ſtatement perhaps does not convey a falſe idea.

We have made choice of the eye as an inſtance upon which to reſt the argument of this chapter. Some ſingle example was to be propoſed; and the eye offered itſelf under the advantage of admitting of a ſtrict compariſon with optical inſtruments. The ear, it is probable,

bable, 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 fufficient to fhew that it is an inftrument adapted to the reception of *found*; that is to fay, already knowing that found confifts in pulfes of the air, we perceive, in the ftructure of the ear, a fuitablenefs to receive impreffions from this fpecies of action, and to propagate thefe impreffions to the brain. For of what does this ftructure confift? An external ear (the concha), calculated, like an ear-trumpet, to catch and collect the pulfes of which we have fpoken; in large quadrupeds, turning to the found, and poffeffing 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 finufes thereof tending and conducting the air towards it: of a thin membrane, like the pelt of a drum, ftretched acrofs this paffage upon a bony rim: of a chain of moveable, and infinitely curious, bones, forming a communication, and the only communication

cation 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 of 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,

membrane, the drum of the ear, vibrate, all the four 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

ternatural 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

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with confined air, becaufe the expanfion of that air by heat, or its contraction by cold, would have diftended or relaxed the covering membrane, in a degree inconfiftent with the purpofe which it was affigned to execute. The only remaining expedient, and that for which the euftachian tube ferves, is to open to this cavity a communication with the external air. In one word; it exactly anfwers the purpofe of the hole in a drum.

The membrana tympani itfelf, likewife, deferves all the examination which can be made of it. It is not found in the ears of fifh; which furnifhes 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 elaftic medium. It bears an obvious refemblance to the pelt or head of a drum, from which it takes its name. It refembles alfo a drum head in this principal property, that its ufe depends upon its tenfion. *Tenfion* is the ftate effential to it. Now we know that, in a drum, the pelt is carried over a hoop, and braced, as occafion requires, by the means of ftrings attached to its circumference. In the membrane of the ear, the fame purpofe is provided for, more fimply, but not lefs mechanically, nor lefs fuccefsfully, by a different expedient, viz. by the end of a bone (the handle of the malleus) preffing upon its centre. It is only in very large animals that the texture of this membrane can be difcerned. In the Philofophical Tranfactions for the year 1800, (vol. i.) Mr. Everard Home has given fome curious obfervations upon the ear, and the drum of the ear, of an *elephant*. He difcovered in it, what he calls a radiated mufcle, that is, ftraight mufcular fibres, paffing along the membrane from the circumference to the centre; from the bony rim which furrounds it, towards the handle of the malleus, to which the central part is attached. This mufcle he fuppofes to be defigned to bring the membrane into unifon with different founds: but then he alfo difcovered, that this mufcle itfelf cannot act, unlefs the membrane be drawn to a ftretch, and kept in a due ftate of tightnefs, by what may be called a foreign force, viz. the action of the mufcles of the malleus. Suppofing his explanation of the ufe of the parts to be juft, our author is well founded in the reflection which he makes upon it: "that this mode of adapting the ear to different founds, is one of the moft beautiful applica-

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tions of mufcles in the body; *the mechanifm is fo fimple, and the variety of effects fo great.*"

In another volume of the Tranfactions above referred to, and of the fame year, two moft curious cafes are related, of perfons who retained the fenfe of hearing, not in a perfect, but in a very confiderable degree, notwithftanding the almoft total lofs of the membrane we have been defcribing. In one of thefe cafes, the ufe here affigned to that membrane, of modifying the impreffions of found by change of tenfion, was attempted to be fupplied by ftraining the mufcles of the outward ear. "The external ear," we are told, "had acquired a diftinct motion upward and backward, which was obfervable whenever the patient liftened to any thing which he did not diftinctly hear: when he was addreffed in a whifper, the ear was feen immediately to move; when the tone of voice was louder, it then remained altogether motionlefs."

It appears probable, from both thefe cafes, that a collateral, if not principal, ufe of the membrane, is to cover and protect the barrel of the ear which lies behind it. Both the patients fuffered from cold: one, "a great

 increafe

increafe of deafnefs from catching cold;" the other, "very confiderable pain from expofure to a ftream of cold air." Bad effects therefore followed from this cavity being left open to the external air; yet, had the author of nature fhut it up by any other cover, than what was capable, by its texture, of receiving vibrations from found, and, by its connection with the interior parts, of tranfmitting thofe vibrations to the brain, the ufe of the organ, fo far as we can judge, muft have been entirely obftructed.

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 connection, their operation, and the uſeful reſult of that operation. I do inſiſt moſt ſtrenuouſly upon the correctneſs of this compariſon; that it holds as to every mode of ſpecific propagation; and that whatever was true of the watch, under the hypotheſis above mentioned, is true of plants and animals.

I. To begin with the fructification of plants. Can it be doubted but that the feed contains a particular organization? Whether a latent plantule with the means of temporary nutrition, or whatever elfe it be, it inclofes an organization fuited to the germination of a new plant. Has the plant which produced the feed any thing more to do with that organization, than the watch would have had to do with the ftructure of the watch which was produced in the courfe 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 inferted within it a mechanifm fuited 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 defign manifefted in it, to his intention: the art, to him as the artift: the collocation of each part, to his placing: the action, effect, and ufe, to his counfel, intelligence, and workmanfhip. In producing it by the intervention of a former watch, he was only working by one fet of tools inftead of another. So it is with the plant, and the feed produced by it. Can any diftinction be affigned between the two cafes;

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

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 higheſt; from irrational to rational life, from brutes to the human ſpecies; without perceiving, as we proceed, any alteration whatever in the terms of the compariſon. The rational animal does not produce its offspring with more certainty or ſucceſs than the irrational animal: a man than a quadruped, a quadruped than a bird; nor (for we may follow the gradation through its whole ſcale) a bird than a plant: nor a plant than a watch, a piece of dead mechaniſm, would do, upon the ſuppoſition which has already ſo often been repeated. Rationality therefore has nothing to do in the buſineſs. If an account muſt be given of the contrivance which we obſerve; if it be demanded, whence aroſe either the contrivance by which the young animal is produced, or the contrivance manifeſted

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 subser-

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viency 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 dexterity with which the work is executed, then indeed, in order to defend thefe qualities from accufation, we muft be able, either to expofe fome intractablenefs and imperfection in the materials, or point out fome invincible difficulty in the execution, into which imperfection and difficulty the matter of complaint may be refolved; or, if we cannot do this, we muft adduce fuch fpecimens of confummate art and contrivance proceeding from the fame hand, as may convince the enquirer, of the exiftence, in the cafe before him, of impediments like thofe which we have mentioned, although, what from the nature of the cafe is very likely to happen, they be unknown and unperceived by him. This we muft do in order to vindicate the artift's fkill, or, at leaft, the perfection of it; as we muft alfo judge of his intention, and of the provifions employed in fulfilling that intention, not from an inftance in which they fail, but from the great plurality of inftances in which they fucceed. But, after all, thefe are different queftions from the queftion of the artift's exiftence; or, which is the fame, whether the thing before us be a work of art or not: and the queftions ought always to be kept feparate in the mind. So likewife it is in the works of nature.

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;

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.

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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

parts which are ufeful, and of which we know the ufe. The indication of contrivance, with refpect to them, remains as it was before.

III. One atheiftic way of replying to our obfervations 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 fee muft neceffarily have had fome form, and that it might as well be its prefent form as any other. Let us now apply this anfwer to the eye, as we did before to the watch. Something or other muft have occupied that place in the animal's head; muft have filled up, we will fay, that focket: we will fay alfo, that it muft have been of that fort of fubftance which we call animal fubftance, as flefh, bone, membrane, cartilage, &c. But that it fhould have been an *eye*, knowing as we do what an eye comprehends, viz. that it fhould have confifted, firft, of a feries of tranfparent lenfes (very different, by the bye, even in their fubftance, from the opaque materials of which the reft of the body is, in general at leaft, compofed; and with which the whole of its furface, this fingle portion of it excepted, is covered): fecondly, of a black cloth or canvafs (the only membrane of the body which is

 black)

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

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 to 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

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human body, for inftance, chance, i. e. the operation of caufes without defign, may produce a wen, a wart, a mole, a pimple, but never an eye. Amongft inanimate fubftances, a clod, a pebble, a liquid drop might be; but never was a watch, a telefcope, an organized body of any kind, anfwering a valuable purpofe by a complicated mechanifm, the effect of chance. In no affignable inftance hath fuch a thing exifted without intention fomewhere.

IV. There is another anfwer which has the fame effect as the refolving of things into chance; which anfwer would perfuade us to believe, that the eye, the animal to which it belongs, every other animal, every plant, indeed every organized body which we fee, are only fo many out of the poffible varieties and combinations of being, which the lapfe of infinite ages has brought into exiftence; that the prefent world is the relict of that variety; millions of other bodily forms and other fpecies having perifhed, being by the defect of their conftitution incapable of prefervation, or of continuance by generation. Now there is no foundation whatever for this conjecture in any thing which we obferve in the works of nature:

ture: no ſuch experiments are going on at preſent; no ſuch energy operates as that which is here ſuppoſed, and which ſhould be conſtantly puſhing into exiſtence new varieties of beings. Nor are there any appearances to ſupport an opinion, that every poſſible combination of vegetable or animal ſtructure has formerly been tried. Multitudes of conformations, both of vegetables and animals, may be conceived capable of exiſtence and ſucceſſion, which yet do not exiſt. Perhaps almoſt as many forms of plants might have been found in the fields, as figures of plants can be delineated upon paper. A countleſs variety of animals might have exiſted which do not exiſt. Upon the ſuppoſition here ſtated, we ſhould ſee unicorns and mermaids, ſylphs and centaurs; the fancies of painters and the fables of poets realized by examples. Or, if it be 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,

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,

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 diſtinguiſh the hypotheſis as applied to the works of nature, from this ſolution, which no one would accept, as applied to a collection of machines.

V. To the marks of contrivance diſcoverable in animal bodies, and to the argument deduced from them, in proof of deſign, and of a deſigning Creator, this turn is ſometimes attempted to be given, viz. that the parts were not intended for the uſe, but that the uſe aroſe out of the parts. This diſtinction is intelligible. A cabinet-maker rubs his mahogany with fiſh-ſkin; yet it would be too much to aſſert that the ſkin of the dog fiſh was made rough and granulated on purpoſe for the poliſhing of wood, and the uſe of cabinet-makers. Therefore the diſtinction 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 ſometimes been, it amounts to ſuch another ſtretch of aſſertion, as it would be to ſay, that all the implements of the cabinet-maker's workſhop, as well as his fiſh-ſkin, were ſubſtances accidentally configurated, which he had picked up, and converted to his uſe;

uſe; that his adzes, ſaws, planes, and gimlets, were not made as we ſuppoſe, to hew, cut, ſmooth, ſhape out, or bore wood with; but that, theſe things being made, no matter with what deſign, or whether with any, the cabinet-maker perceived that they were applicable to his purpoſe, and turned them to account.

But, again; ſo far as this ſolution is attempted to be applied to thoſe parts of animals the action of which does not depend upon the will of the animal, it is fraught with ſtill more evident abſurdity. Is it poſſible to believe that the eye was formed without any regard to viſion; that it was the animal itſelf which found out, that, though formed with no ſuch intention, it would ſerve to ſee with; and that the uſe of the eye, as an organ of ſight, reſulted from this diſcovery, and the animal's application of it? The ſame 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

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,

geſtion, 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 ſurrounded. They would, otherwiſe, be capacities without objects; powers without employment. The web foot determines, you ſay, the duck to ſwim: but what would that avail, if there were no water to ſwim in? The ſtrong, hooked bill, and ſharp talons, of one ſpecies of bird, determine it to prey upon animals: the ſoft ſtraight bill, and weak claws, of another ſpecies, determine it to pick up ſeeds: but neither determination could take effect in providing for the ſuſtenance of the birds, if animal bodies and vegetable ſeeds did not lie within their reach. The peculiar conformation of the bill, and tongue, and claws of the woodpecker, determines that bird to ſearch for his food amongſt the inſects 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 inſects lodged under their bark, or in their trunk? The pro-

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boſcis with which the bee is furniſhed, determines him to ſeek for honey; but what would that ſignify, if flowers ſupplied none? Faculties thrown down upon animals at random, and without reference to the objects amidſt which they are placed, would not produce to them the ſervices and benefits which we ſee: and if there be that reference, then there is intention.

Laſtly, the ſolution fails entirely when applied to plants. The parts of plants anſwer their uſes, without any concurrence from the will or choice of the plant.

VI. Others have choſen 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 ſuch explanation, it ſhould ſeem to be a mere ſubſtitution of words for reaſons, names for cauſes. Order itſelf 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,

VII. Laftly, the confidence which we place in our obfervations upon the works of nature, in the marks which we difcover of contrivance, choice, and defign ; and in our reafoning upon the proofs afforded us; ought not to be fhaken, as it is fometimes attempted to be done, by bringing forward to our view our own ignorance, or rather the general imperfection of our knowledge of nature. Nor, in many cafes, ought this confideration to affect us, even when it refpects fome parts of the fubject immediately under our notice. True fortitude of underftanding confifts in not fuffering what we know to be difturbed by what we do not know. If we perceive an ufeful end, and means adapted to that end, we perceive enough for our conclufion. If thefe things be clear, no matter what is obfcure. The argument is finifhed. For inftance ; if the utility of vifion 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 fo), ought it to prejudice the inference which we draw from thefe premifes, that we cannot explain the ufe of the fpleen? Nay more ; if there be parts of the eye, viz. the cornea, the cryftalline, the retina, in their

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

ceſſarily 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.

CHAP.

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,

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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 all the reſt. So it is with the evidences of a divine agency. The proof is not a concluſion, which lies at the end of a chain of reaſoning, of which chain each inſtance of contrivance is only a link, and of which, if one link fail, the whole falls; but it is an argument ſeparately ſupplied by every ſeparate example. An error in ſtating an example 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

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

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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

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caufe of nervous agency, or even of the fubftance and ftructure of the nerves themfelves, a ground of queftion or fufpicion as to the reafoning which we inftitute concerning the mechanical part of our frame. That an animal is a machine, is a propofition neither correctly true, nor wholly falfe. The diftinction which we have been difcuffing will ferve to fhew how far the comparifon, which this expreffion implies, holds; and wherein it fails. And, whether the diftinction be thought of importance or not, it is certainly of importance to remember, that there is neither truth nor juftice in endeavouring to bring a cloud over our underftandings, or a diftruft into our reafonings upon this fubject, by fuggefting that we know nothing of voluntary motion, of irritability, or the principle of life, of fenfation, of animal heat, upon all which the animal functions depend; for our ignorance of thefe parts of the animal frame concerns not at all our knowledge of the mechanical parts of the fame frame. I contend, therefore, that there is mechanifm in animals; that this mechanifm is as properly fuch, as it is in machines made by art; that this mechanifm is intelligible and certain; that it is not the lefs fo,

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becaufe it often begins or terminates with fomething which is not mechanical; that whenever it is intelligible and certain, it demonftrates intention and contrivance, as well in the works of nature as in thofe of art; and that it is the beft demonftration which either can afford.

But whilft I contend for thefe propofitions, I do not exclude myfelf from afferting that there may be, and that there are, other cafes, in which, although we cannot exhibit mechanifm, or prove indeed that mechanifm is employed, we want not fufficient evidence to conduct us to the fame conclufion.

There is what may be called the *chymical* part of our frame; of which, by reafon of the imperfection of our chymiftry, we can attain to no diftinct knowledge; I mean, not to a knowledge, either in degree or kind, fimilar to that which we poffefs of the mechanical part of our frame. It does not therefore afford the fame fpecies of argument as that which mechanifm affords; and yet it may afford an argument in a high degree fatiffactory. The *gaftric juice*, or the liquor which digefts the food in the ftomachs of animals, is of this clafs. Of all menftrua it is the moft active, the moft univerfal. In the human ftomach 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,

received, that of "the chymical wonder of animal nature."

Still we are ignorant of the compofition 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 chymiftry; for, fhould the time ever arrive, which is not perhaps to be defpaired of, when we can compound ingredients, fo as to form a fclvent which will act in the manner in which the gaftric juice acts, we may be able to afcertain the chymical principles upon which its efficacy depends, as well as from what part, and by what concoction, in the human body, thefe principles are generated and derived.

In the mean time, ought that, which is in truth the defect of our chymiftry, to hinder us from acquiefcing in the inference, which a production of nature, by its place, its properties, its action, its furprifing efficacy, its invaluable ufe, authorizes us to draw in refpect of a creative defign?

Another moft fubtle and curious function of animal bodies is *fecretion.* This function is femi-chymical and femi-mechanical;

cal; 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

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

of branches; their extremities every where communicating with little round bodies, in the ſubſtance of which bodies the ſecret of the machinery ſeems to reſide, for there the change is made. We can diſcern pipes laid from theſe round bodies towards the pelvis, which is a 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 ſee an organized apparatus, be its conſtruction or action what it will, which we call that gland. We ſee the blood, or part of the blood, after it has paſſed

through

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 see also at the same time a new and specific fluid issuing from the same gland by its excretory duct, i. e. by a third pipe or conduit; which new fluid is in some cases discharged out of the body, in more cases retained within it, and there executing some important and intelligent office. Now supposing, or admitting, that we know nothing of the proper internal constitution of a gland, or of the mode of its acting upon the blood; then our situation is precisely like that of an unmechanical looker-on, who stands by a stocking-loom, a corn-mill, a carding-machine, or a threshing-machine, at work, the fabric and mechanism of which, as well as all that passes within, is hidden from his sight by the outside case; or, if seen, would be too complicated for his uninformed, uninstructed understanding to comprehend. And what is that situation? This spectator, ignorant as he is, sees at one end a material enter the machine, as unground grain the mill, raw cotton the carding-machine, sheaves of unthreshed corn the threshing-machine; and,

when

when he caſts his eye to the other end of the apparatus, he ſees the material iſſuing from it in a new ſtate; and, what is more, in a ſtate manifeſtly adapted to future uſes; the grain in meal fit for the making of bread, the wool in rovings ready for ſpinning into threads, the ſheaf in corn dreſſed for the mill. Is it neceſſary that this man, in order to be convinced, that deſign, that intention, that contrivance has been employed about the machine, ſhould be allowed to pull it in pieces; ſhould be enabled to examine the parts ſeparately; explore their action upon one another, or their operation, whether ſimultaneous or ſucceſſive, upon the material which is preſented to them? He may long to do this to gratify his curioſity; he may deſire to do it to improve his theoretic knowledge; or he may have a more ſubſtantial reaſon for requeſting it, if he happen, inſtead of a common viſitor, to be a mill-wright 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

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 reſorting to appointment. Why, for inſtance, is the ſaliva, which is diffuſed over the ſeat of taſte, inſipid, whilſt ſo many others of the ſecretions, the urine, the tears, and the ſweat, are ſalt? Why does the gland within the ear ſeparate a viſcid ſubſtance, which defends that paſſage; the gland in the upper angle of the eye, a thin brine, which waſhes the ball? Why is the ſynovia of the joints mucilaginous; the bile bitter, ſtimulating, and ſoapy? Why does the juice, which flows into the ſtomach, contain powers, which make that bowel, the great laboratory, as it is by its ſituation the recipient, of the materials of future nutrition? Theſe are all fair queſtions; and no anſwer can be given to them, but what calls in intelligence and intention.

My object in the preſent chapter has been to teach three things: firſt, that it is a miſtake to ſuppoſe, that, in reaſoning from the appearances of nature, the imperfection of our knowledge proportionably affects the certainty of our concluſion; for in many caſes it does not affect it at all: ſecondly, that the different parts of the animal frame may be claſſed and diſtributed, according to the degree of exactneſs with which we can compare them with works of art: thirdly, that the *mechanical* parts of our frame, or, thoſe in which this compariſon is moſt complete, although conſtituting, probably, the coarſeſt portions of nature's workmanſhip, are the propereſt to be alledged as proofs and ſpecimens 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 anatomiſts call a proceſs, viz. a projection, ſomewhat ſimilar, in ſize and ſhape, to a tooth; which tooth, entering a correſponding hole or ſocket in the bone above it, forms a pivot or axle, upon

which

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

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

II. Another mechanical contrivance, not unlike the laſt in its object, but different and original in its means, is ſeen in what anatomiſts call the *fore-arm*; that is, in the arm between the elbow and the wriſt. Here, for the perfect uſe of the limb, two motions are wanted; a motion at the elbow backward and forward, which is called a reciprocal motion; and a rotatory motion, by which the palm of the hand, as occaſion requires, may be turned upward. How is this managed? The fore-arm, it is well known, conſiſts of two bones, lying along ſide each other, but touching only towards the ends. One, and only one, of theſe bones, is joined to the cubit, or upper part of the arm, at the elbow; the other alone, to the hand at the wriſt. The firſt, by means, at the elbow, of a hinge joint (which allows only of motion in the ſame plane), ſwings backward and forward, carrying along

 with

with it the other bone, and the whole fore-arm. In the mean time, as often as there is occasion to turn the palm upward, that other bone to which the hand is attached, rolls upon the first, by the help of a groove or hollow near each end of one bone, to which is fitted a corresponding prominence in the other. If both bones had been joined to the cubit or upper arm at the elbow, or both to the hand at the wrist, the thing could not have been done. The first was to be at liberty at one end, and the second at the other: by which means the two actions may be performed together. The great bone which carries the fore-arm, may be swinging upon its hinge at the elbow, at the very time, that the lesser bone, which carries the hand, may be turning round it in the grooves. The management also of these grooves, or rather of the tubercles and grooves, is very observable. The two bones are called the radius and the ulna. Above, i. e. towards the elbow, a tubercle of the radius plays into a socket of the ulna; whilst below, i. e. towards the wrist, the radius finds the socket, and the ulna the tubercle. A single bone in the fore-arm, with a ball and socket joint at the elbow, which admits of motion in all directions, might, in some degree, have answered the purpose, of both moving the arm and turning the hand. But how much better it is accomplished by the present mechanism, any person may 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

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

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,

ner, 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

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

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,

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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

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 that 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

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 expense of safety. The backbone of a serpent, for coherence and flexibility, is one of the most curious pieces of

* Der. Phys. Theol. p. 396.

animal mechanifm, with which we are acquainted. The chain of a watch, (I mean the chain which paffes between the fpring-barrel and the fufee) which aims at the fame properties, is but a bungling piece of workmanfhip in comparifon with that of which we fpeak.

IV. The reciprocal enlargement and contraction of the *cheft* to allow for the play of the lungs, depends upon a fimple yet beautiful mechanical contrivance, referable to the ftructure of the bones which inclofe it. The ribs are articulated to the back-bone, or rather to its fide projections, *obliquely*; that is, in their natural pofition they bend or flope from the place of articulation downwards. But the bafis upon which they reft at this end being fixed, the confequence of the obliquity, or the inclination downwards, is, that, when they come to move, whatever pulls the ribs upwards, neceffarily, at the fame time, draws them out; and that, whilft the ribs are brought to a right angle with the fpine behind, the fternum, or part of the cheft to which they are attached in front, is thruft forward. The fimple action, therefore, of the elevating mufcles does the bufinefs; whereas, if the ribs had been articulated with the bodies of the vertebræ

tebræ 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 covered with a

* Anat. p. 229.

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

VI. The *ſhoulder-blade* is, in ſome material reſpects, a very ſingular bone: 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 connection, 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

no ufe that we know of, in being able to turn the calves of the legs before; and there would have been great confinement by reftraining the motion of the thighs to one plane. The difadvantage would not have been lefs, if the joints at the hip and the knee had been both of the fame fort; both balls and fockets, or both hinges: yet why, independently of utility, and of a Creator who confulted that utility, fhould the fame bone (the thigh-bone) be rounded at one end, and channelled at the other?

The *hinge joint* is not formed by a bolt paffing through the two parts of the hinge, and thus keeping them in their places; but by a different expedient. A ftrong, tough, parchment-like membrane, rifing from the receiving bones, and inferted all round the received bones a little below their heads, inclofes the joint on every fide. This membrane ties, confines, and holds the ends of the bones together; keeping the correfponding parts of the joint, i. e. the relative convexities and concavities, in clofe application to each other.

For the *ball and focket joint*, befide the membrane already defcribed, there is in fome important joints, as an additional fecurity, a

 fhort,

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 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 mechaniſm more unequivocal, or more free from objection, than this ligament. Nothing can be more mechanical; nothing, however ſubſervient to the ſafety, leſs capable of being generated

by

by the action of the joint. I would particularly solicit the reader's attention to this provision, as it is found in the head of the *thigh-bone*; to its strength, its structure, and its use. It is an instance upon which I lay my hand. One single fact, weighed by a mind in earnest, leaves oftentimes the deepest impression. For the purpose of addressing different understandings and different apprehensions, for the purpose of sentiment, for the purpose of exciting admiration of the Creator's works, we diversify our views, we multiply examples; but, for the purpose of strict argument, one clear instance is sufficient: and not only sufficient, but capable perhaps of generating a firmer assurance than what can arise from a divided attention.

The *ginglymus*, or hinge joint, does not, it is manifest, admit of a ligament of the same kind with that of the ball and socket joint, but it is always fortified by the species of ligament of which it does admit. The strong, firm, investing membrane above described, accompanies it in every part: and, in particular joints, this membrane, which is properly a ligament, is considerably stronger on the sides than either before or behind, in

order

order that the convexities may play true in their concavities, and not be ſubject to ſlip ſideways, which is the chief danger; for the muſcular tendons generally reſtrain the parts from going further than they ought to go in the plane of their motion. In the *knee*, which is a joint of this form, and of great importance, there are ſuperadded to the common proviſions for the ſtability of the joint, two ſtrong ligaments which croſs each other; and croſs each other in ſuch a manner, as to ſecure the joint from being diſplaced in any aſſignable direction. "I think," ſays Cheſelden, "that the knee cannot be completely diſlocated without breaking the *croſs* ligaments*." We can hardly help comparing this with the binding up of a fracture, where the fillet is almoſt always ſtrapped acroſs, for the ſake of giving firmneſs and ſtrength to the bandage.

Another no leſs important joint, and that alſo of the ginglymus ſort, is the *ankle*; yet, though important, (in order, perhaps, to preſerve the ſymmetry and lightneſs of the limb,) *ſmall*, and, on that account, more liable to injury. Now this joint is ſtrengthened, i. e.

* Cheſ. Anat. ed. 7th, p. 45.

is defended from dislocation, by two remarkable processes or prolongations of the bones of the leg, which processes form the protuberances that we call the inner and outer ankle. It is part of each bone going down lower than the other part, and thereby overlapping the joint: so that, if the joint be in danger of slipping outward, it is curbed by the inner projection, i. e. that of the tibia; if inward, by the outer production, i. e. that of the fibula. Between both, it is locked in its position. I know no account that can be given of this structure except its utility. Why should the tibia terminate, at its lower extremity, with a double end, and the fibula the same, but to barricade the joint on both sides by a continuation of part of the thickness of the bone over it?

The joint at the *shoulder* compared with the joint at the *hip*, though both ball and socket joints, discovers a difference in their form and proportions, well suited to the different offices which the limbs have to execute. The cup or socket at the shoulder is much shallower and flatter than it is at the hip, and is also in part formed of cartilage set round the rim of the cup. The socket, into which the

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

The suppleness and pliability of the joints we every moment experience; and the *firmness* of animal articulation, the property we have hitherto been considering, may be judged of 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

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

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

smooth

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 complete and rigid oſſification being prevented from taking place by the continual motion and rubbing of the ſurfaces. Which being ſo, what we repreſent as a deſigned 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 ſo, it anſwers the argument. To me, the ſurmounting of the ends of the bones with griſtle, looks more like a plating with a different metal, than like the ſame metal kept in a different ſtate by the action to which it is expoſed. At all events we have a great particular benefit, though ariſing from a general conſtitution: but this laſt not being quite what my argument requires, leſt I ſhould ſeem by applying the inſtance to overrate its value, I have thought it it fair to ſtate the queſtion which attends it.

IV. In ſome joints, very particularly in the knees, there are looſe cartilages or griſtles between the bones, and within the joint, ſo that the ends of the bones, inſtead of working upon one another, work upon the intermediate cartilages. Cheſelden has obſerved *, that the contrivance of a looſe ring is practiſed 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 ſcrew of large vices. The cartilages of which we ſpeak have very much of the form of theſe rings. The compariſon moreover ſhews the reaſon why we find them in the knees rather than in other joints. It is an expedient, we have ſeen, which a mechanic reſorts to, only when ſome ſtrong and heavy work is to be done. So here the thigh-bone has to achieve its motion at the knee, with the whole weight of the body preſſing upon it, and often, as in riſing from our ſeat, with the whole weight of the body

* Ib. p. 13.

to

to lift. It ſhould ſeem alſo from Cheſelden's account, that the ſlipping and ſliding of the looſe cartilages, though it be probably a ſmall and obſcure change, humoured the motion of the end of the thigh-bone, under the particular configuration which was neceſſary to be given to it for the commodious action of the tendons; and which configuration requires what he calls a variable ſocket, that is, a concavity, the lines of which aſſume a different curvature in different inclinations of the bones.

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

In considering the joints, there is nothing, perhaps, which ought to move our gratitude more than the reflection, *how well they wear*. A limb shall swing upon its hinge, or play in its socket, many hundred times in an hour, for sixty years together, without diminution of its agility: which is a long time for 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

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

joints were capable of a freer motion, there are no mufcles to produce it. Whereas at the fhoulder and the hip, where the ball and focket joint allows by its conftruction of a rotatory or fweeping motion, tendons are placed in fuch a pofition, and pull in fuch a direction, as to produce the motion of which the joint admits. For inftance, the fartorius or taylor's mufcle, rifing from the fpine, running diagonally acrofs the thigh, and taking hold of the infide 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 fame time, to the ball and focket joint at the hip, and the hinge joint at the knee. There is, as we have feen, a fpecific mechanifm in the bones for the rotatory motions of the head and hands: there is, alfo, in the oblique direction of the mufcles belonging to them, a fpecific provifion for the putting of this mechanifm of the bones into action. And mark the confent of ufes. The oblique mufcles would have been inefficient without the articulation: the articulation would have been loft, without the oblique mufcles. It may be proper however to obferve with refpect 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

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,

ency, by two muſcles drawing againſt, and balancing, each other. In a hemiplegia, when the muſcle on one ſide is weakened, the muſcle on the other ſide draws the mouth awry.

III. Another property of the muſcles, which could only be the reſult of care, is their being almoſt univerſally ſo diſpoſed, as not to obſtruct or interfere with one another's action. I know but one inſtance in which this impediment is perceived. We cannot eaſily ſwallow whilſt we gape. This, I underſtand, is owing to the muſcles employed in the act of deglutition being ſo implicated with the muſcles of the lower jaw, that, whilſt theſe laſt are contracted, the former cannot act with freedom. The obſtruction is, in this inſtance, attended with little 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

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

bedded 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 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

blance 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

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 diſpoſition 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 entangle-

ment

ment of its fibres, in any wife impede its motion, or render the determination or fuccefs of its efforts uncertain.

I here intreat the reader's permiffion to ftep a little out of my way to confider *the parts of the mouth* in fome of their other properties. It has been faid, and that by an eminent phyfiologift, that, whenever nature attempts to work two or more purpofes by one inftrument, fhe does both or all imperfectly. Is this true of the tongue regarded as an inftrument of fpeech, and of tafte; or regarded as an inftrument of fpeech, of tafte, and of deglutition? So much otherwife, that many perfons, that is to fay, nine hundred and ninety-nine perfons out of a thoufand, by the inftrumentality of this one organ, talk, and tafte, and fwallow, very well. In fact, the conftant warmth and moifture of the tongue, the thinnefs of the fkin, the papillæ upon its furface, qualify this organ for its office of tafting, as much as its inextricable multiplicity of fibres do for the rapid movements which are neceffary to fpeech. Animals which feed upon grafs, have their tongues covered with a perforated

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 weight of the food itſelf, it in truth is not ſo, even in the upright poſture of the human neck; and moſt evidently is not the caſe with quadrupeds,

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

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

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

Or let a perſon only obſerve his own hand whilſt he is *writing*; the number of muſcles, which are brought to bear upon the pen; how the joint and adjuſted operation of ſeveral tendons is concerned in every ſtroke, yet that five hundred ſuch ſtrokes 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 ſpace 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 handwriting 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 mufcles, *fphincter* or circular mufcles appear to me admirable pieces of mechanifm. It is the mufcular power moft happily applied; the fame quality of the mufcular fubftance, but under a new modification. The circular difpofition of the fibres is ftrictly mechanical; but, though the moft mechanical, is not the only thing in fphincters which deferves our notice. The regulated degree of contractile force with which they are endowed, fufficient for retention, yet vincible when requifite; together with their ordinary ftate of actual contraction, by means of which their dependance upon the will is not conftant but occafional, gives to them a conftitution of which the conveniency is ineftimable. This their femi-

voluntary

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 cooperating muſcles is very great. Dr. Nieuentyt, in the Leipſic Tranſactions, reckons up a hundred muſcles that are employed every time we breathe: yet we take in, or let out, our breath, without reflecting what a work is thereby performed; what an apparatus is laid in of inſtruments for the ſervice, and how many ſuch contribute their aſſiſtance to the effect. Breathing with eaſe is a bleſſing of every moment: yet, of all others, it is that which we poſſeſs with the leaſt conſciouſneſs. A man in an aſthma is the only man who knows how to eſtimate it.

IV. Mr. Home has obſerved *, that the

* Phil. Tranſ. part i. 1800, p. 8.

moſt important and the moſt delicate actions are performed in the body by the ſmalleſt muſcles: and he mentions, as his examples, the muſcles which have been diſcovered in the iris of the eye and the drum of the ear. The tenuity of theſe muſcles is aſtoniſhing. They are microſcopic hairs; muſt be magnified to be viſible; yet are they real effective muſcles; and not only ſuch, but the grandeſt and moſt precious of our faculties, ſight and hearing, depend upon their health and action.

V. The muſcles act in the limbs with what is called a mechanical diſadvantage. The muſcle at the ſhoulder, by which the arm is raiſed, is fixed nearly in the ſame manner, as the load is fixed upon a ſteelyard, within a few decimals, we will ſay, of an inch, from the centre upon which the ſteelyard turns. In this ſituation, we find that a very heavy draught is no more than ſufficient to countervail the force of a ſmall lead plummet, placed upon the long arm of the ſteelyard, at the diſtance of perhaps fifteen or twenty inches from the centre, and on the other ſide of it. And this is the diſadvantage which is meant. And an abſolute diſadvantage, no doubt, it would

would be, if the object were to ſpare the force of muſcular contraction. But obſerve how conducive is this conſtitution to animal conveniency. Mechaniſm has always in view one or other of theſe two purpoſes; either to move a great weight ſlowly, and through a ſmall ſpace, or to move a light weight rapidly, through a conſiderable ſweep. For the former of theſe purpoſes, a different ſpecies of lever, and a different collocation of the muſcles, might be better than the preſent: but for the ſecond, the preſent ſtructure is the true one. Now ſo it happens, that the ſecond, and not the firſt, is that 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 or minute. In like manner, a huſbandman or a gardener will do more execution, by being able to carry his

 ſcythe,

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,

ner, 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 manifeſt 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

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*.

* Chef. Anat. p. 119.

III. The

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 precifely contradicts the opinion, that the parts of animals may have been all formed by what is called *appetency*, i. e. endeavour, perpetuated, and imperceptibly working its effect, through an incalculable feries of generations. We have here no endeavour, but the reverfe of it; a conftant renitency and reluctance. The endeavour is all the other way. The preffure of the ligament conftrains the tendons; the tendons react upon the preffure of the ligament. It is impoffible that the ligament fhould ever have been generated by the exercife of the tendon, or in the courfe of that exercife, forafmuch as the force of the tendon perpendicularly refifts the fibre which confines it, and is conftantly endeavouring, not to form, but to rupture and difplace, the threads of which the ligament is compofed.

Keill has reckoned up, in the human body, four hundred and forty-fix mufcles, diffectible and defcribable; and hath affigned an ufe to every one of the number. This cannot be all imagination.

Bifhop Wilkins hath obferved from Galen, that there are, at leaft, ten feveral qualifications

tions to be attended to in each particular muſcle, viz. its proger figure, its juſt magnitude, its fulcrum, its point of action ſuppoſing the figure to be fixed, its collocation with reſpect to its two ends the upper and the lower, the place, the poſition of the whole muſcle, the introduction into it of nerves, arteries, veins. How are things, including ſo many adjuſtments, to be made; or, when made, how are they to be put together, without intelligence?

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

Mechanifm may be difplayed in the one kind of fubftance, as well as in the other.

Although the few inftances we have felected, even as they ftand in our defcription, are nothing fhort perhaps of logical proofs of defign, yet it muft not be forgotten, that, in every part of anatomy, defcription is a poor fubftitute for infpection. It was well faid by an able anatomift*, and faid in reference to the very part of the fubject which we have been treating of, " Imperfecta hæc mufculorum defcriptio, non minùs arida eft legentibus, quàm infpectantibus fuerit jucunda eorundem præparatio. Elegantiffima enim mechanicês artificia, creberrimè in illis obvia, verbis nonnifi obfcurè exprimuntur; carnium autem ductu, tendinum colore, infertionum proportione, et trochlearium diftributione, oculis expofita, omnem fuperant admirationem."

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

CHAP-

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 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 fingers' ends. A more difficult mechanical problem could hardly I think be propoſed, than to diſcover a method of conſtantly

ſtantly 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, ſe-

condly

condly 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.

thread. For which reafon this fyftem lies deep under the integuments; whereas the veins, in which the mifchief that enfues from injuring the coats is much lefs, lie in general above the arteries; come nearer to the furface; are more expofed.

It may be further obferved concerning the two fyftems taken together, that, though the arterial, with its trunk and branches and fmall twigs, may be imagined to iffue or proceed, in other words to *grow* from the heart, like a plant from its root, or the fibres of a leaf from its footftalk (which however, were it fo, would be only to refolve one mechanifm into another), yet the venal, the returning fyftem, can never be formed in this manner. The arteries might go on fhooting out from their extremities, i. e. lengthening and fubdividing indefinitely; but an inverted fyftem, continually uniting its ftreams, inftead of dividing, and thus carrying back what the other fyftem carried out, could not be referred to the fame procefs.

II. The next thing to be confidered is the engine which works this machinery, viz. the *heart*. For our purpofe, it is unneceffary to afcertain the principle upon which the heart

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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 muscular cavities are necessarily squeezed together, so as to force out from them any fluid which they may at that time contain: by the relaxation of the same fibres, the cavities are in their turn dilated; and, of course, prepared to admit every fluid which may be poured into them. Into these cavities are inserted 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 simplest idea of its action is, that, by each contraction, a portion of blood

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is forced as by a ſyringe into the arteries; and, at each dilatation, an equal portion is received from the veins. This produces, at each pulſe, a motion and change in the maſs of blood, to the amount of what the cavity contains, which in a full grown human heart, I underſtand, is about an ounce, or two table-ſpoons full. How quickly theſe changes ſucceed one another, and by this ſucceſſion how ſufficient they are to ſupport a ſtream or circulation throughout the ſyſtem, may be underſtood by the following computation, abridged from Keill's Anatomy, p. 117, ed. 3d. "Each ventricle will at leaſt contain one ounce of blood. The heart contracts four thouſand times in one hour; from which it follows, that there paſſes through the heart, every hour, four thouſand ounces, or three hundred and fifty pounds of blood. Now the whole maſs of blood is ſaid to be about twenty-five pounds, ſo that a quantity of blood equal to the whole maſs of blood paſſes through the heart fourteen times in one hour; which is about once every four minutes." Conſider 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

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Bridge; and the water roaring in its paſſage through that pipe, is inferior, in impetus and velocity, to the blood guſhing from the whale's heart. Hear Dr. Hunter's account of the diſſection of a whale. "The aorta meaſured a foot diameter. Ten or fifteen gallons of blood is thrown out of the heart at a ſtroke with an immenſe velocity, through a tube of a foot diameter. The whole idea fills the mind with wonder*."

The account which we have here ſtated, of the injection of blood into the arteries by the contraction, and of the correſponding reception of it from the veins by the dilatation, of the cavities of the heart, and of the circulation being thereby maintained through the blood-veſſels of the body, is true, but imperfect. The heart performs this office, but it is in conjunction with another of equal curioſity and importance. It was neceſſary that the blood ſhould be ſucceſſively brought into contact, or contiguity, or proximity with the *air*. I do not know that the chymical reaſon, upon which this neceſſity is founded, has

* Dr. Hunter's account of the diſſection of a whale. Phil. Tranſ.

been

been yet ſufficiently explored. It ſeems to be made appear, that the atmoſphere which we breathe is a mixture of two kinds of air; one pure and vital, the other, for the purpoſes 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 ſame 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 leaſt; by comparing the air which is breathed from the lungs, with the air which enters the lungs, it is found to have loſt ſome of its pure part, and to have brought away with it an addition of its impure part. Whether theſe experiments ſatisfy the queſtion, as to the need which the blood ſtands in, of being viſited by continual acceſſes of air, is not for us to enquire into; nor material 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 theſe veſſels, upon which the application of the air to the blood depends, would, if collected and expanded, be, in a man, equal to a ſuperficies of fifteen feet ſquare. Now in order to give the blood in its courſe the benefit of this organization (and this is the part of the ſubject with which we are chiefly concerned), the following operation takes place. As ſoon as the blood is received by the heart from the 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

* Keill's Anat. p. 121.

ſyſtem.

fyftem. This affigns to the heart a double office. The pulmonary circulation is a fyftem within a fyftem; and one action of the heart is the origin of both.

For this complicated function, four cavities become neceffary; and four are accordingly provided: two, called ventricles, which *fend out* the blood, viz. one into the lungs, in the firft inftance; the other into the mafs, after it has returned from the lungs: two others alfo, called auricles, which *receive* the blood from the veins; viz. one, as it comes immediately from the body; the other, as the fame blood comes a fecond time after its circulation through the lungs. So that there are two receiving cavities, and two forcing cavities. The ftructure of the heart has reference to the lungs, for without the lungs one of each would have been fufficient. The tranflation of the blood in the heart itfelf is after this manner. The receiving cavities refpectively 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 fame blood into the mouths of the arteries.

The account here given will not convey to a reader

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 glorioully 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 warineſs.

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

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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 endeavouring 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,

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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. Upon 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 pro-

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per 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; fitting loofely and eafily about it; guarding its fubftance, without confining its motion; and containing likewife a fpoonful or two of water, juft fufficient to keep the furface of the heart in a ftate of fupplenefs and moifture. How fhould fuch a loofe covering be generated by the action of the heart? Does not the inclofing of it in a fac, anfwering no other purpofe but that inclofure, fhew the care that has been taken of its prefervation?

ONE USE of the circulation of the blood (probably amongft other ufes) is to diftribute nourifhment to the different parts of the body. How minute and multiplied the ramifications of the blood-veffels, for that purpofe, are; and how thickly fpread, over at leaft the fuperficies of the body, is proved by the fingle obfervation, that we cannot prick the point of a pin into the flefh, without drawing blood, i. e. without finding a blood-veffel. Nor, internally, is their diffufion lefs univerfal. Blood-veffels run along the furface of membranes, pervade the fubftance of mufcles, penetrate the bones. Even into every tooth, we trace, through a fmall hole in the root, an artery to feed the bone, as well as a vein to bring back

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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 one 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.

II. 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 a wide paſſage 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 chemiſtry, and I am endeavouring 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

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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 of ſize enough to hold about two table ſpoon-

 fulls;

fulls; and from this veſſel a duct or main pipe proceeds, climbing up the back part of the cheſt, and afterwards creeping along the gullet till it reach 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 earth-worm 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 diſcernible even by the beſt microſcope. Fourthly, The main pipe which carries the chyle from the reſervoir to the blood, viz. the thoracic duct, being fixed in an almoſt upright poſition, and wanting that advantage of propulſion which the arteries poſſeſs, is furniſhed with a ſucceſſion of valves to check the aſcending fluid, when once it has paſſed them, from falling back. Theſe valves look upward, 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

ing 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?

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

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 the digeſting fluid 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 chemical 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

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. Entire 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 chemiſtry. 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;

tion; 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

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

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

bag,

bag, and ſend into the duodenum, an extraordinary quantity of bile, to meet the extraordinary demand which the repletion of the ſtomach by food is about to occaſion*. Cheſelden deſcribes † the gall bladder as ſeated againſt the duodenum, and thereby liable to have its fluid preſſed out, by the paſſage of the aliment through that cavity; which likewiſe will have the effect of cauſing it to be received into the inteſtine, at a right time, and in a due proportion.

There may be other purpoſes anſwered by this 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

* Keill's Anat. p. 64. † Anat. p. 164.
‡ Keill from Malpighius, p. 63.

find

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 in the bladder. Theſe enter the bladder near its neck, running obliquely for the ſpace of an inch between its coats†. It is, in both caſes, ſufficiently evident, that this ſtructure has a neceſſary mechanical tendency to reſiſt regurgitation; for whatever force acts in ſuch a direction as to urge the fluid back into the orifices of the tubes, muſt, at the ſame time, ſtretch the coats of the veſſels, and, thereby, compreſs that part of the tube, which is included between them.

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

* Keill's Anat. p. 62. † Cheſ. Anat. p. 260.

it

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

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. Such is its ſtructure. And we may here remark the almoſt complete ſucceſs of the expedient, viz. how ſeldom it fails of its purpoſe, compared with the number of inſtances in which it fulfils it. Reflect, how frequently we ſwallow, how conſtantly we breathe. In a city feaſt, for example, what deglutition, what anhelation! yet does this little cartilage, the epiglottis, ſo effectually interpoſe its office, ſo ſecurely guard the entrance of the windpipe, that, whilſt morſel after morſel, draught after draught, are courſing one another over it, an accident of a crumb or a drop ſlipping into this paſſage, (which nevertheleſs muſt be opened for the breath every ſecond of time,) excites, in the whole company, not only alarm by its danger, but ſurpriſe by its novelty. Not two gueſts are choked in a century.

There is no room for pretending, that the action of the parts may have gradually formed the epiglottis: I do not mean in the ſame individual, but in a ſucceſſion of generations. Not only the action of the parts has no ſuch tendency,

tendency, but the animal could not live, nor confequently the parts act, either without it, or with it in a half formed ftate. The fpecies was not to wait for the gradual formation or expanfion of a part, which was, from the firft, neceffary to the life of the individual.

Not only is the larynx curious, but the whole windpipe poffeffes a ftructure, adapted to its peculiar office. It is made up (as any one may perceive by putting his fingers to his throat) of ftout cartilaginous ringlets, placed at fmall and equal diftances from one another. Now this is not the cafe with any other of the numerous conduits of the body. The ufe of thefe cartilages is to keep the paffage for the air *conftantly* open; which they do mechanically. A pipe with foft membranous coats, liable to collapfe and clofe when empty, would not have anfwered here; although this be the general vafcular ftructure, and a ftructure which ferves very well for thofe tubes, which are kept in a ftate of perpetual diftenfion by the fluid they inclofe, or which afford a paffage to folid and protruding fubftances.

Neverthelefs, (which is another particularity well worthy of notice,) thefe 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;

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

4 another,

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 likewiſe, all that is neceſſary, and all that contributes, to the growth, nouriſhment, and ſuſtentation of the limb, the repair of its waſte, the preſervation of its health: ſuch as the circulation of the blood through every part of it; its lymphatics, exhalants, abſorbents; its excretions and integuments. All theſe ſhare in the reſult; join in the effect: and how all theſe, or any of them, come together without a deſigning, diſpoſing intelligence, it is impoſſible to conceive.

CHAP-

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 inſtruments are brought together, and often within how ſmall a compaſs. It is a cluſter of contrivances. In a canary bird, for inſtance, and in the ſingle ounce of matter which compoſes his body (but which ſeems to be all employed), we have inſtruments, for eating, for digeſting, for nouriſhment, for breathing, for generation, for running, for flying, for ſeeing, for hearing, for ſmelling; each appropriate; each entirely different from all the reſt.

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

I. The firſt is, the exact correſpondency of the two ſides of the ſame animal; the right hand anſwering to the left, leg to leg, eye to eye, one ſide of the countenance to the other; and with a preciſion, to imitate which in any tolerable degree forms one of the difficulties of ſtatuary, and requires, on the part of the artiſt, a conſtant attention to this property of his work, diſtinct from every other.

It is the moſt difficult thing that can be to get a wig made even; yet how ſeldom is the *face* awry? And what care is taken that it ſhould not be ſo, the anatomy of its bones demonſtrates. The upper part of the face is compoſed of thirteen bones, ſix on each ſide, anſwering each to each, and the thirteenth, without a fellow, in the middle: the lower part of the face is in like manner compoſed of ſix bones, three on each ſide, reſpectively correſponding, and the lower jaw in the centre. In building an arch could more be done in order to make the curve *true*, i. e. the parts equi-diſtant from the middle, alike in figure and poſition?

The exact reſemblance of the *eyes*, conſidering how compounded this organ is in its ſtructure, how various and how delicate are the ſhades of colour with which its iris is tinged,

tinged, how differently, as to effect upon appearance, the eye may be mounted in its socket, and how differently in different heads eyes actually are set, is a property of animal bodies much to be admired. Of ten thousand eyes, I don't know that it would be possible to match one, except with its own fellow; or to distribute them into suitable pairs by any other selection than that which obtains.

This regularity of the animal structure is rendered more remarkable by the three following considerations. First, the limbs, *separately* taken, have not this correlation of parts; but the contrary of it. A knife drawn down the chine cuts the human body into two parts, externally equal and alike; you cannot draw a straight line which will divide a hand, a foot, the leg, the thigh, the cheek, the eye, the ear, into two parts equal and alike. Those parts which are placed upon the middle or partition line of the body, or which traverse that line, as the nose, the tongue, the lips, may be so divided, or, more properly speaking, are double organs; but other parts cannot. This shews that the correspondency which we have been describing does not arise by any necessity in the nature

of

of the ſubject; for, if neceſſary, it would be univerſal, whereas it is obſerved only in the ſyſtem or aſſemblage: it is not true of the ſeparate parts: that is to ſay, it is found where it conduces to beauty or utility; it is not found, where it would ſubſiſt at the expence of both. The two wings of a bird always correſpond; the two ſides of a feather frequently do not. In centipedes, millepedes, and that whole tribe of inſects, no two legs on the ſame ſide are alike; yet there is the moſt exact parity between the legs oppoſite to one another.

2. The next circumſtance to be remarked, is, that, whilſt the cavities of the body are ſo configurated, as, *externally*, to exhibit the moſt exact correſpondency of the oppoſite ſides, the contents of theſe cavities have no ſuch correſpondency. A line drawn down the middle of the breaſt divides the thorax into two ſides exactly ſimilar; yet theſe two ſides incloſe very different contents. The heart lies on the left ſide; a lobe of the lungs on the right; balancing each other, neither in ſize nor ſhape. The ſame thing holds of the abdomen. The liver lies on the right ſide, without any ſimilar viſcus oppoſed to it on the left. The ſpleen

ſpleen indeed is ſituated over againſt the liver; but agreeing with the liver, neither in bulk nor form. There is no equipollency between theſe. The ſtomach is a veſſel, both irregular in its ſhape, and oblique in its poſition. The foldings and doublings of the inteſtines do not preſent a parity of ſides. Yet that ſymmetry which depends upon the correlation of the ſides, is externally preſerved throughout the whole trunk: and is the more remarkable in the lower parts of it, as the integuments are ſoft; and the ſhape, conſequently, is not, as the thorax is by its ribs, reduced by natural ſtays. It is evident, therefore, that the external proportion does not ariſe from any equality in the ſhape or preſſure of the internal contents. What is it indeed but a correction of inequalities? an adjuſtment, by mutual compenſation, of anomalous forms into a regular congeries? the effect, in a word, of artful, and, if we might be permitted ſo to ſpeak, of ſtudied collocation?

3. Similar alſo to this, is the third obſervation: that an internal inequality in the feeding veſſels is ſo managed, as to produce no inequality in parts which were intended to correſpond. The right arm anſwers accurately

rately to the left, both in ſize and ſhape; but the arterial branches, which ſupply the two arms, do not go off from their trunk, in a pair, in the ſame manner, at the ſame place, or at the ſame angle. Under which want of ſimilitude, it is very difficult to conceive how the ſame quantity of blood ſhould be puſhed through each artery: yet the reſult is right; the two limbs, which are nouriſhed by them, perceive no difference of ſupply, no effects of exceſs or deficiency.

Concerning the difference of manner, in which the ſubclavian and carotid arteries, upon the different ſides of the body, ſeparate themſelves from the aorta, Cheſelden ſeems to have thought, that the advantage which the left gain by going off at a much acuter angle than the right, is made up to the right by their going off together in one branch*. It is very poſſible that this may be the compenſating contrivance; and if it be ſo, how curious, how hydroſtatical!

II. Another perfection of the animal maſs is the *package*. I know nothing which is ſo ſurpriſing. Examine the contents of the

* Cheſ. Anat. p. 184. ed. 7th.

trunk

trunk of any large animal. Take notice how ſoft, how tender, how intricate they are; how conſtantly in action, how neceſſary to life. Reflect upon the danger of any injury to their ſubſtance, any derangement of their poſition, any obſtruction to their office. Obſerve the heart pumping at the centre, at the rate of eighty ſtrokes in a minute: one ſet of pipes carrying the ſtream away from it, another ſet, bringing, in its courſe, the fluid back to it again: the lungs performing their elaborate office, viz. diſtending and contracting their many thouſand veſicles, by a reciprocation which cannot ceaſe for a minute: the ſtomach exerciſing its powerful chymiſtry: the bowels ſilently propelling the changed aliment; collecting from it, as it proceeds, and tranſmitting to the blood an inceſſant ſupply of prepared and aſſimilated nouriſhment: that blood purſuing its courſe; the liver, the kidneys, the pancreas, the parotid, with many other known and diſtinguiſhable glands, drawing off from it, all the while, their proper ſecretions. Theſe ſeveral operations, together with others more ſubtile but leſs capable of being inveſtigated, are going on within us, at

one

one and the ſame time. Think of this; and then obſerve how the body itſelf, the caſe which holds this machinery, is rolled, and jolted, and toſſed about, the mechaniſm remaining unhurt, and with very little moleſtation even of its niceſt motions. Obſerve a rope-dancer, a tumbler, or a monkey; the ſudden inverſions and contortions which the internal parts ſuſtain by the poſtures into which their bodies are thrown; or rather obſerve the ſhocks, which theſe parts, even in ordinary ſubjects, ſometimes receive from falls and bruiſes, or by abrupt jerks and twiſts, without ſenſible, or with ſoon recovered damage. Obſerve this, and then reflect how firmly every part muſt be ſecured, how carefully ſurrounded, how well tied down and packed together.

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

1. The *heart* (ſuch care is taken of the centre of life) is placed between two ſoft lobes of the lungs; is *tied* to the mediaſtinum and to the pericardium, which pericardium is not only itſelf an exceedingly ſtrong membrane, but *adheres* firmly to the duplicature of the mediaſtinum, and, by its point, to the middle tendon of the diaphragm. The heart is alſo *ſuſtained* in its place by the great blood-veſſels which iſſue from it*.

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

3. The *liver* is faſtened in the body by two ligaments: the firſt, which is large and ſtrong, comes from the covering of the diaphragm, and penetrates the ſubſtance of the liver;

* Keill's Anat. p. 107. ed. 3d. † Ib. 119.

the

the ſecond is the umbilical vein, which, after birth, degenerates into a ligament. The firſt, which is the principal, fixes the liver in its ſituation, whilſt the body holds an erect poſture; the ſecond prevents it from preſſing upon the diaphragm when we lie down; and both together *ſling* or ſuſpend the liver when we lie upon our backs, ſo that it may not compreſs or obſtruct the aſcending vena cava*, to which belongs the important office of returning the blood from the body to the heart.

4. The *bladder* is tied to the navel by the urachus transformed into a ligament: thus, what was a paſſage for urine to the fœtus becomes, after birth, a ſupport or ſtay to the bladder. The peritonæum alſo keeps the viſcera from confounding themſelves with, or preſſing irregularly upon, the bladder: for the kidneys and bladder are contained in a diſtinct duplicature of that membrane, being thereby partitioned off from the other contents of the abdomen.

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

6. The *pancreas* or ſweetbread is ſtrongly tied to the peritonæum, which is the great

* Cheſ. Anat. p. 162.

wrapping

wrapping ſheet, that incloſes all the bowels contained in the lower belly *.

7. The *ſpleen* alſo is confined to its place by an adheſion to the peritonæum and diaphragm, and by a connection with the omentum †. It is poſſible, in my opinion, that the ſpleen may be merely a *ſtuffing*, a ſoft cuſhion to fill up a vacancy or hollow, which, unleſs occupied, would leave the package looſe and unſteady: for ſuppoſing that it anſwers no other purpoſe than this, it muſt be vaſcular, and admit of a circulation through it, in order to be kept alive, or be a part of a living body.

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

9. The ſepta of the brain, probably, prevent one part of that organ from preſſing with

* Keill's Anat. p. 57.
† Cheſ. Anat. p. 167. ‡ Ib. p. 149.

too great a weight upon another part. The proceſſes of the dura mater divide the cavity of the ſkull, like ſo many inner partition walls; and, thereby, confine each hemiſphere and lobe of the brain to the chamber which is aſſigned to it, without its being liable to reſt upon, or intermix with, the neighbouring parts. The great art and caution of packing, is to prevent one thing hurting another. This, in the head, the cheſt, and the abdomen, of an animal body, is, amongſt other methods, provided for, by membranous partitions and wrappings, which keep the parts ſeparate.

THE ABOVE may ſerve as a ſhort account of the manner, in which the principal viſcera are ſuſtained in their places. But, of the proviſions for this purpoſe, by far, in my opinion, the moſt curious, and where alſo ſuch a proviſion was moſt wanted, is in the *guts*. It is pretty evident, that a long narrow tube (in man about five times the length of the body) laid from ſide to ſide in folds upon one another, winding in oblique and circuitous directions, compoſed alſo of a ſoft and yielding ſubſtance, muſt, without ſome extraordinary precaution for its ſafety, be continually diſplaced by the various, ſudden, and abrupt motions

motions of the body which contains it. I ſhould expect that, if not bruiſed or wounded by every fall, or leap, or twiſt, it would be entangled, or be involved with itſelf; or, at the leaſt, ſlipped and ſhaken out of the order in which it is diſpoſed, and which order is neceſſary to be preſerved for the carrying on of the important functions, which it has to execute in the animal œconomy. Let us ſee therefore how a danger ſo ſerious, and yet ſo natural to the length, narrowneſs, and tubular form of the part, is provided againſt. The expedient is admirable; and it is this. The inteſtinal canal, throughout its whole proceſs, is knit to the edge of a broad fat membrane, called the meſentery. It forms the margin of this meſentery, being ſtitched and faſtened to it like the edging of a ruffle: being four times as long as the meſentery itſelf, it is, what a ſempſtreſs would call, " puckered or gathered on" to it. This is the nature of the connection of the gut with the meſentery; and, being thus joined to, or rather made a part of the meſentery, it is folded and wrapped up together with it. Now the meſentery, having a conſiderable dimenſion in breadth, being in its ſubſtance, withal, both thick and ſuety, is capable of a cloſe and ſafe folding, in comparison of what the inteſtinal tube would admit of, if it had remained looſe. The meſentery likewiſe not only keeps the inteſtinal canal in its proper place and poſition under all the turns and windings of its courſe, but ſuſtains the numberleſs ſmall veſſels, the arteries, the veins, the lymphedučts, and, above all, the lacteals, which lead from or to almoſt every point of its coats and cavity. This membrane, which appears to be the great ſupport and ſecurity of the alimentary apparatus, is itſelf ſtrongly tied to the firſt three vertebræ of the loins *.

III. A third general property of animal forms is *beauty*. I do not mean relative beauty, or that of one individual above another of the ſame ſpecies, or of one ſpecies compared with another ſpecies; but I mean, generally, the proviſion which is made, in the body of almoſt every animal, to adapt its appearance to the perception of the animals with which it converſes. In our own ſpecies, for example, only conſider what the parts and materials are, of which the faireſt body is compoſed; and no further obſervation will be

* Keill's Anat. p. 45.

neceſſary to ſhew, how well theſe things are wrapped up, ſo as to form a maſs, which ſhall be capable of ſymmetry in its proportion, and of beauty in its aſpect; how the bones are covered, the bowels concealed, the roughneſſes of the muſcles ſmoothed and ſoftened; and how over the whole is drawn an integument, which converts the diſguſting materials of a diſſecting-room into an object of attraction to the ſight, or one, upon which it reſts, at leaſt with eaſe and ſatisfaction. Much of this effect is to be attributed to the intervention of the cellular or adipoſe membrane, which lies immediately under the ſkin; is a kind of lining to it; is moiſt, ſoft, ſlippery, and compreſſible; every where filling up the interſtices of the muſcles, and forming thereby their roundneſs and flowing line, as well as the evenneſs and poliſh of the whole ſurface.

All which ſeems to be a ſtrong indication of deſign, and of a deſign ſtudiouſly directed to this purpoſe. And it being once allowed, that ſuch a purpoſe exiſted with reſpect to *any* of the productions of nature, we may refer, with a conſiderable degree of probability, other particulars to the ſame intention; ſuch as the teints of flowers, the plumage of birds, the furs of beafts, the bright fcales of fifhes, the painted wings of butterflies and beetles, the rich colours and fpotted luftre of many tribes of infects.

There are parts alfo of animals ornamental, and the properties by which they are fo, not fubfervient, that we know of, to any other purpofe. The *irides* of moft animals are very beautiful, without conducing at all, by their beauty, to the perfection of vifion; and nature could in no part have employed her pencil to fo much advantage, becaufe no part prefents itfelf fo confpicuoufly to the obferver, or communicates fo great an effect to the whole afpect.

In plants, efpecially in the flowers of plants, the principle of beauty holds a ftill more confiderable place in their compofition; is ftill more confeffed than in animals. Why, for one inftance out of a thoufand, does the corolla of the tulip, when advanced to its fize and maturity, change its colour? The purpofes, fo far as we can fee, of vegetable nutrition, might have been carried on as well by its continuing green. Or, if this could not be, confiftently with the progrefs of vegetable life, why break into fuch a variety of colours? This is no proper

proper effect of age, or of declension in the ascent of the sap; for that, like the autumnal teints, would have produced one colour in one leaf, with marks of fading and withering. It seems a lame account to call it, as it has been called, a disease of the plant. Is it not more probable, that this property, which is independent, as it should seem, of the wants and utilities of the plant, was calculated for beauty, intended for display?

A ground, I know, of objection, has been taken against this whole topic of argument, namely, that there is no such thing as beauty at all: in other words, that whatever is useful and familiar comes of course to be thought beautiful; and that things appear to be so, only by their alliance with these qualities. Our idea of beauty is capable of being in so great a degree modified by habit, by fashion, by the experience of advantage or pleasure, and by associations arising out of that experience, that a question has been made, whether it be not altogether generated by these causes, or would have any proper existence without them. It seems, however, a carrying of the conclusion too far, to deny the existence of the principle, viz. a native capacity of perceiving beauty, on account of an influence, or of varieties proceeding from that influence, to which it is ſubject, ſeeing that principles the moſt acknowledged, are liable to be affected in the ſame manner. I ſhould rather argue thus: The queſtion reſpects objects of ſight. Now every other ſenſe hath its diſtinction of agreeable and diſagreeable. Some taſtes offend the palate, others gratify it. In brutes and inſects, this diſtinction is ſtronger, and more regular, than in man. Every horſe, ox, ſheep, ſwine, when at liberty to chooſe, and when in a natural ſtate, that is, when not vitiated by habits forced upon it, eats and rejects the ſame plants. Many inſects which feed upon particular plants, will rather die than change their appropriate leaf. All this looks like a determination in the ſenſe itſelf to particular taſtes. In like manner, ſmells affect the noſe with ſenſations pleaſurable or diſguſting. Some ſounds, or compoſitions of ſound, delight the ear, others torture it. Habit can do much in all theſe caſes, (and it is well for us that it can; for it is this power which reconciles us to many neceſſities;) but has the diſtinction, in the mean time, of agreeable and diſagreeable, no foundation in the ſenſe itſelf? What is true of of the other ſenſes is moſt probably true of the eye, (the analogy is irreſiſtible,) viz. that there belongs to it an original conſtitution, fitted to perceive pleaſure from ſome impreſſions, and pain from others.

I do not however know, that the argument which alledges beauty as a final cauſe, reſts upon this conceſſion. We poſſeſs a ſenſe of beauty, however we come by it. It in fact exiſts. Things are not indifferent to this ſenſe: all objects do not ſuit it: many, which we ſee, are agreeable to it; many others diſagreeable. It is certainly not the effect of habit upon the particular object, becauſe the moſt agreeable objects are often the moſt rare; many, which are very common, continue to be offenſive. If they be made ſupportable by habit, it is all which habit can do; they never become agreeable. If this ſenſe, therefore, be acquired, it is a reſult; the produce of numerous and complicated actions of external objects upon the ſenſes, and of the mind upon its ſenſations. With this *reſult* there muſt be a certain congruity to enable any particular object to pleaſe: and that congruity, we contend, is conſulted in the *aſpect* which is given to animal and vegetable bodies.

IV. The

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

V. Of animal bodies, conſidered as maſſes, there is another property, more curious than it is generally thought to be; which is the faculty of *ſtanding:* and it is more remarkable in two-legged animals than in quadrupeds, and, moſt of all, as being the talleſt, and reſt-

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ing upon the ſmalleſt baſe, in man. There is more, I think, in the matter than we are aware of. The ſtatue of a man, placed looſe upon its pedeſtal, would not be ſecure of ſtanding half an hour. You are obliged to fix its feet to the block by bolts and ſolder, or the firſt ſhake, the firſt guſt of wind, is ſure to throw it down. Yet this ſtatue ſhall expreſs all the mechanical proportions of a living model. It is not therefore the mere figure, or merely placing the centre of gravity within the baſe, that is ſufficient. Either the law of gravitation is ſuſpended in favor of living ſubſtances, or ſomething more is done for them, in order to enable them to uphold their poſture. There is no reaſon whatever to doubt, but that their parts deſcend by gravitation in the ſame manner as thoſe of dead matter. The gift therefore appears to me to conſiſt in a faculty of perpetually ſhifting the centre of gravity, by a ſet, of obſcure indeed, but of quick balancing actions, ſo as to keep the line of direction, which is a line drawn from that centre to the ground, within its preſcribed limits. Of theſe actions it may be obſerved, firſt, that they in part conſtitute what we call ſtrength. The dead body drops down. The mere adjuſtment

ment therefore of weight and preſſure, which may be the ſame the moment after death as the moment before, does not ſupport the column. In caſes alſo of extreme weakneſs the patient cannot ſtand upright. Secondly, that theſe actions are only in a ſmall degree voluntary. A man is ſeldom conſcious of his voluntary powers in keeping himſelf upon his legs. A child learning to walk is the greateſt poſture-maſter in the world; but art, if it may be ſo called, ſinks into habit; and he is ſoon able to poiſe himſelf in a great variety of attitudes, without being ſenſible either of caution or effort. But ſtill there muſt be an aptitude of parts upon which habit can thus attach; a previous capacity of motions which the animal is thus taught to exerciſe: and the facility, with which this exerciſe is acquired, forms one object of our admiration. What parts are principally employed, or in what manner each contributes its office, is, as hath already been confeſſed, difficult to explain. Perhaps the obſcure motion of the bones of the feet may have their ſhare in this effect. They are put in action by every ſlip or vacillation of the body, and ſeem to aſſiſt in reſtoring its balance. Certain it is, that this circumſtance in the ſtructure of the foot, viz. its being compoſed of many ſmall bones, applied to, and articulating with, one another, by diverſely ſhaped ſurfaces, inſtead of being made of one piece, like the laſt of a ſhoe, is very remarkable. I ſuppoſe alſo that it would be difficult to ſtand firm upon ſtilts or wooden legs, though their baſe exactly imitated the figure and dimenſions of the ſole of the foot. The alternation of the joints, the knee joint bending backward, the hip joint forward; the flexibility, in every direction, of the ſpine, eſpecially in the loins and neck, appear to be of great moment in preſerving the equilibrium of the body. With reſpect to this laſt circumſtance it is obſervable, that the vertebræ are ſo confined by ligaments as to allow no more ſlipping upon their baſes, than what is juſt ſufficient to break the ſhock which any violent motion may occaſion to the body. A certain degree alſo of tenſion of the ſinews appears to be eſſential to an erect poſture; for it is by the loſs of this, that the dead or paralytic body drops down. The whole is a wonderful reſult of combined powers, and of very complicated operations. Indeed that *ſtanding* is not ſo ſimple a buſineſs as we imagine it to be, be, is evident from the ſtrange geſticulations of a drunken man, who has loſt the government of the centre of gravity.

We have ſaid that this property is the moſt worthy of obſervation in the *human* body; but a *bird*, reſting upon its perch, or hopping upon a ſpray, affords no mean ſpecimen of the ſame faculty. A chicken runs off as ſoon as it is hatched from the egg; yet a chicken, conſidered geometrically, and with relation to its centre of gravity, its line of direction, and its equilibrium, is a very irregular ſolid. Is this gift, therefore, or inſtruction? May it not be ſaid to be with great attention, that nature hath balanced the body upon its pivots?

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

attitude which the legs and thighs take by the bird ſitting down, and to which the mere weight of the body gives the force that is neceſſary.

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

1. All the bones of the body are covered with a *perioſteum*, except the teeth; where it ceaſes, and an enamel of ivory, which ſaws and files will hardly touch, comes into its place. No one can doubt of the uſe and propriety of this difference; of the "analogy" being thus "interrupted;" of the rule, which belongs to the conformation of the bones, ſtopping where it does ſtop: for, had ſo exquiſitely ſenſible a membrane as the perioſteum, inveſted the teeth, as it inveſts every other bone of the body, *their* action, neceſſary expoſure, and irritation, would have ſubjected the animal to continual pain. General as it is,

it was not the ſort of integument which ſuited the teeth. What they ſtood in need of, was a ſtrong, hard, inſenſible, defenſive coat: and exactly ſuch a covering is given to them, in the ivory enamel which adheres to their ſurface.

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

nails

nails upon other parts of the body. They would be ſcattered over the ſurface, like warts or pimples.

3. All the great cavities of the body are incloſed by membranes except the *ſkull.* Why ſhould not the brain be content with the ſame covering as that which ſerves for the other principal organs of the body? The heart, the lungs, the liver, the ſtomach, the bowels, have all ſoft integuments, and nothing elſe. The muſcular coats are all ſoft and membranous. I can ſee a reaſon for this diſtinction in the final cauſe, but in no other. The importance of the brain to life, (which experience proves to be immediate,) and the extreme tenderneſs of its ſubſtance, make a ſolid caſe more neceſſary for it, than for any other part: and ſuch a caſe the hardneſs of the ſkull ſupplies. When the ſmalleſt portion of this natural caſquet is loſt, how carefully, yet how imperfectly, is it replaced by a plate of metal! If an anatomiſt ſhould ſay, that this bony protection is not confined to the brain, but is extended along the courſe of the ſpine, I anſwer, that he adds ſtrength to the argument. If he remark, that the cheſt alſo is fortified by bones, I reply that I ſhould have alledged this in-

ſtance myſelf, if the ribs had not appeared ſubſervient to the purpoſe of motion, as well as of defence. What diſtinguiſhes the ſkull from every other cavity is, that the bony covering completely ſurrounds its contents, and is calculated, not for motion, but ſolely for defence. Thoſe hollows, likewiſe, and inequalities, which we obſerve in the inſide of the ſkull, and which exactly fit the folds of the brain, anſwer the important deſign of keeping the ſubſtance of the brain ſteady, and of guarding it againſt concuſſions.

CHAPTER XII.

COMPARATIVE ANATOMY.

Whenever we find a general plan purſued, yet with ſuch variations in it, as are, in each caſe, required by the particular exigency of the ſubject to which it is applied, we poſſeſs, in ſuch plan and ſuch adaptation, the ſtrongeſt evidence, that can be afforded, of intelligence and deſign; and evidence, which the moſt completely excludes every other hypotheſis. If the general plan proceeded from any fixed neceſſity in the nature of things, how could it accommodate itſelf to the various wants and uſes which it had to ſerve, under different circumſtances, and on different occaſions? *Arkwright's* mill was invented for the ſpinning of cotton. We ſee it employed for the ſpinning of wool, flax, and hemp, with ſuch modifications of the original principle, ſuch variety in the ſame plan, as the texture of thoſe different materials rendered neceſſary. Of the machine's being put together with deſign,

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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,

therefore, whatever that cauſe was, has been concerned in the orgin; 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 re-ferred,

ferred, what naturalifts 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 thickeft upon the belly; as are the feathers in water fowl. We know the final caufe of all this; and we know no other.

The *covering of birds* cannot efcape the moft vulgar obfervation. Its lightnefs, its fmoothnefs, its warmth; the difpofition of the feathers all inclined backward, the down about their ftem, the overlapping of their tips, their different configuration in different parts, not to mention the variety of their colours, conftitute a veftment for the body, fo beautiful, and fo appropriate to the life which the animal is to lead, as that, I think, we fhould have had no conception of any thing equally perfect, if we had never feen it, or can now imagine any thing more fo. Let us fuppofe (what is poffible only in fuppofition) a perfon who had never feen a bird, to be prefented with a plucked pheafant, and bid to fet his wits to work, how to contrive for it a covering which fhall unite the qualities of warmth, levity, and leaft refiftance to the air, and the higheft degree of each; giving it alfo 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 feathers, is, amongſt animal ſubſtances, ſui generis; neither bone, fleſh, membrane, nor tendon*.

But the artificial part of a feather is the *beard*, or, as it is ſometimes, I believe, called, the vane. By the beards are meant, what

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

are

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 ocaſions 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

taking notice, that the threads or laminæ of which we have been ſpeaking, in their natural ſtate *unite*; that their union is ſomething more than the mere appoſition of looſe ſurfaces; that they are not parted aſunder without ſome degree of force; that nevertheleſs there is no glutinous coheſion between them; that, therefore, by ſome mechanical means or other, they catch or claſp among themſelves, thereby giving to the beard or vane its cloſeneſs and compactneſs of texture. Nor is this all: when two laminæ, which have been ſeparated by accident or force, are brought together again, they immediately *reclaſp*: the connection, whatever it was, is perfectly recovered, and the beard of the feather becomes as ſmooth and firm as if nothing had happened to it. Draw your finger down the feather, which is againſt the grain, and you break, probably, the junction of ſome of the contiguous threads; draw your 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 by means of a vaſt number of fibres or teeth, which the laminæ ſhoot forth *on each ſide*, and which hook and grapple together. A friend of mine counted fifty of theſe fibres in one twentieth of an inch. Theſe fibres are crooked; but curved after a different manner; for thoſe, which proceed from the thread on the ſide towards the extremity of the feather are longer, more flexible, and bent 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

thread or lamina has been feparated from another by fome external violence, it might be reclafped with fufficient facility and expedition*.

In the *oftrich*, this apparatus of crotchets and fibres, of hooks and teeth, is wanting; and we fee the confequence of the want. The filaments hang loofe and feparate from one another, forming only a kind of down; which conftitution of the feathers, however it may fit them for the flowing honours of a lady's head-drefs, may be reckoned an imperfection in the bird, inafmuch as wings, compofed of thefe feathers, although they may greatly affift it in running, do not ferve for flight.

But under the prefent divifion of our fubject, our bufinefs with feathers is, as they are the *covering* of the bird. And herein a fingular circumftance occurs. In the fmall order of birds which winter with us, from a fnipe downwards, let the external colour of the feathers be what it will, their Creator has univerfally given them a bed of *black* down next their bodies. Black, we know, is the warmeft colour: and the purpofe here is, to *keep in* the

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

heat,

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 similar, the surface of all the wrens would exceed the surface of the turkey, in the proportion of the length, breadth, (or, of any homologous line,) of a turkey to that of a wren; which would be, perhaps, a proportion of ten to one. It was necessary therefore that small birds should be warmer clad than large ones; and this seems to be the expedient, by which that exigency is provided for.

II. In comparing different animals, I know no part of their structure which exhibits greater variety, or, in that variety, a nicer accommodation to their respective conveniency, than that which is seen in the different formations of their *mouths*. Whether the purpose be the reception of aliment merely, or the catching of prey, the picking up of seeds, the cropping of herbage, the extraction of juices, the suction of liquids, the breaking and grinding of food, the tafte of that food, together with the refpiration of air, and, in conjunction with it, 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 mouthfulls 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 fnout, like a prong or ploughfhare, has made its way to the roots upon which it feeds. A conformation

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

ables the goofe to graze, to collect its food from the bottom of pools, or to feek it amidft the foft or liquid fubftances with which it is mixed. The *long* tapering bill of the fnipe and woodcock, penetrates ftill deeper into moift earth, which is the bed in which the food of that fpecies is lodged. This is exactly the inftrument which the animal wanted. It did not want ftrength in its bill, which was inconfiftent with the flender form of the animal's neck, as well as unneceffary for the kind of aliment upon which it fubfifts; but it wanted length to reach its object.

But the fpecies 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,

curacy, the puddle, the brake, every mixture which is likely to contain her food. The operation is thus carried on. The liquid or ſemiliquid ſubſtances, in which the animal has plunged her bill, ſhe draws, by the action of her lungs, through the narrow interſtices which lie between theſe teeth; catching, as the ſtream paſſes acroſs her beak, whatever it may happen to bring along with it, that proves agreeable to her choice, and eaſily diſmiſſing all the reſt. Now ſuppoſe the purpoſe to have been, out of a maſs of confuſed and heterogeneous ſubſtances, to ſeparate for the uſe of the animal, or rather to enable the animal to ſeparate for its own, thoſe few particles which ſuited its taſte and digeſtion, what more artificial, or more commodious, inſtrument of ſelection, could have been given to it, than this natural filter? It has been obſerved alſo, what muſt enable the bird to chooſe and diſtinguiſh with greater acuteneſs, as well, probably, as what greatly increaſes its luxury, that the bills of this ſpecies are furniſhed with large nerves, that they are covered with a ſkin, and that the nerves run down to the very extremity. In the curlew, woodcock, and ſnipe, there are *three pairs* of nerves, equal almoſt 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 obfervations. The fimilitude between the bills of birds and the mouths of quadrupeds, is exactly fuch, as, for the fake of the argument, might be wifhed for. It is near enough to fhew the continuation of the fame plan: it is remote enough to exclude the fuppofition of the difference being produced by action or ufe. A more prominent contour, or a wider gape, might be refolved into the effect of continued efforts, on the part of the fpecies, to thruft out the mouth, or open it to the ftretch. But by what courfe of action, or exercife, or endeavour, fhall we get rid of the lips, the gums, the teeth; and acquire, in the place of them, pincers of horn? By what habit fhall we fo completely change, not only the fhape of the part, but the fubftance of which it is compofed? The truth is, if we had feen no other than the mouths of quadrupeds, we fhould have thought no other could have been formed: little could we have fuppofed, that all the purpofes of a mouth, furnifhed 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 whimble, 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 exerciſe of their force, but in their collocation, which is a determinate circumſtance, and muſt have been original.

IV. The

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 plates 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 yields its chyle with more difficulty, there the paſſage is circuitous and dilatory, that 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 un-

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

neceſſary,

neceſſary, 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 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, than 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

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 eges 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 anmial 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

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 another. The ſkylark 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,

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

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 poſi-

tion,

tion, 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 pairs 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

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 muſcles, 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 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

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

to

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 amongſt 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,

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

proach of their enemy from behind, whence he may ſteal upon them unſeen. This is a critical diſtinction; and is mechanical: but it may be ſuggeſted, and, I think, not without probability, that it is the effect of 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

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

kinds included in theſe claſſes of animals; and then, ſuch particularities as are confined to one or two ſpecies.

I. Along each ſide of the neck of large *quadrupeds*, runs a ſtiff robuſt cartilage, which butchers call the pàx-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 not 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

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 each 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, ſkates, which are without the air bladder, ſeldom riſe in the water, and that with effort. The manner in which the purpoſe is attained, and the ſuitableneſs of the means to the end, are not difficult to be apprehended. The riſing and ſinking of a fiſh in water, ſo far as it is independent of the ſtroke of the fins and tail, can only be regulated by the ſpecific gravity of the body. When the bladder, contained in the body of 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 it is 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 the 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

When the fang is raifed, the clofing of the jaw preffes its root againft the bag underneath; and the force of this compreffion fends out the fluid with a confiderable impetus, through the tube in the middle of the tooth. What more unequivocal or effectual apparatus could be devifed, for the double purpofe of at once inflicting the wound and injecting the poifon? Yet, though lodged in the mouth, it is fo conftituted, as, in its inoffenfive and quiefcent ftate, not to interfere with the animal's ordinary office of receiving its food. It has been obferved alfo, that none of the harmlefs ferpents, the black fnake, the blind worm, &c. have thefe fangs, but teeth of an equal fize; not movable, as this is, but fixed into the jaw.

II. In being the property of feveral different fpecies, the preceding example is refembled by that which I fhall next mention, which is the *bag of the opoffum.* This is a mechanical contrivance, moft properly fo called. The fimplicity of the expedient renders the contrivance more obvious than many others; and, by no means, lefs certain. A falfe fkin under the belly of the animal, forms a pouch into which the young litter are received

ceived at their birth; where they have an eaſy and conſtant acceſs to the teats; in which they are tranſported by the dam from place to place; where they are at liberty to run in and out, and where they find a refuge from ſurpriſe and danger. It is their cradle, their aſylum, and the machine for their conveyance. Can the uſe of this ſtructure be doubted of? Nor is it a mere doubling of the ſkin, but 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

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

more

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

tain it unchanged for a confiderable length of time. This property qualifies it for living in the defart. Let us fee therefore what is the internal organization, upon which a faculty, fo rare and fo beneficial, depends. A number of diftinct facs or bags (in a dromedary thirty of thefe have been counted) are obferved to lie between the membranes of the fecond ftomach, and to open into the ftomach near the top by fmall fquare apertures. Through thefe orifices, after the ftomach is full, the annexed bags are filled from it. And the water, fo depofited, is, in the firft place, not liable to pafs into the inteftines; in the fecond place, is kept feparate from the folid aliment; and, in the third place, is out of the reach of the digeftive action of the ftomach, or of mixture with the gaftric juice. It appears probable, or rather certain, that the animal, by the conformation of its mufcles, poffeffes the power of fqueezing back this water from the adjacent bags into the ftomach, whenever thirft excites it to put this power in action.

II. The *tongue of the woodpecker*, is one of thofe fingularities, which nature prefents

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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.

mouth. If this be not mechaniſm, what is? Should it be ſaid, that, by continual endeavours to ſhoot out the tongue to the ſtretch, the woodpecker ſpecies may by degrees have lengthened the organ itſelf, beyond that of other birds, what account can be given of its form; of its tip? How, in particular, did it get its barbs, its dentation? Theſe barbs, in my opinion, wherever they occur, are deciſive proofs of mechanical contrivance.

III. I ſhall add one more example for the ſake of its novelty. It is always an agreeable diſcovery, when, having remarked in an animal an extraordinary ſtructure, we come at length to find out an unexpected uſe for it. The following narrative furniſhes an inſtance of this kind. The babyroueſſa, or Indian hog, a ſpecies of wild boar found in the Eaſt Indies, has two *bent* teeth, more than half a yard long, growing upwards, and (which is the ſingularity) from the upper jaw. Theſe inſtruments are not wanted for defence, that ſervice being provided for by two tuſks iſſuing from the under jaw, and reſembling thoſe of the common boar. Nor does the animal uſe them

them for defence. They might ſeem therefore to be both a ſuperfluity and an incumbrance. But obſerve the event. The animal ſleeps ſtanding; and, in order to ſupport its head, hooks its upper tuſks upon the branches of trees.

CHAPTER XIV.

PROSPECTIVE CONTRIVANCES.

I CAN hardly imagine to myſelf a more 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 a lamb does not bud, or at leaſt does not ſprout to any conſiderable length, until the animal be capable of browſing upon its paſture; becauſe ſuch a ſubſtance upon the forehead of the young animal, would very much incommode the teat of the dam in the office of giving ſuck.

But in the caſe of the *teeth*, of the human teeth at leaſt, the proſpective contrivance looks ſtill 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

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 chemiſtry having been able to make milk out of graſs: we have, ſecondly, the organ for its reception and retention: we have, thirdly, the excretory duct, annexed to that organ: and we have, laſtly, the determination of the milk to the breaſt, at the particular juncture when it is about to be wanted. We have all theſe properties in the ſubject before us; and they are all indications of deſign. The laſt circumſtance is the ſtrongeſt of any. If I had been to gueſs beforehand, I ſhould have conjectured, that, at the time when there was an extraordinary demand for nouriſhment in one part of the ſyſtem, there would be the leaſt likelihood of a redundancy to ſupply another part. The advanced pregnancy of the female has no intelligible tendency to fill the breaſts with milk. The lacteal ſyſtem is a conſtant wonder: and it adds to other cauſes of our admiration, that the number of the teats or paps in each ſpecies is found to bear a proportion to the number of the young. In the ſow, the bitch, the rabbit, the cat, the rat, which have numerous litters, the paps are numerous and are diſpoſed along the whole length of the belly:

in the cow and mare they are few. The moſt ſimple account of this, is to refer it to a deſigning Creator.

But, in the argument before us, we are entitled to conſider not only animal bodies when framed, but the 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 conſe-

consequence of a great and sudden alteration, which the animal is to undergo at its birth. Is it to be believed that the eye was formed, or, which is the same thing, that the series of causes was fixed by which the eye is formed, without a view to this change; without a prospect of that condition, in which its fabric, of no use at present, is about to be of the greatest; without a consideration of the qualities of that element, hitherto entirely excluded, but with which it was hereafter to hold so intimate a relation? A young man makes a pair of spectacles for himself against he grows old: for which spectacles he has no want or use whatever at the time he makes them. Could this be done without knowing and considering the defect of vision to which advanced age is subject? Would not the precise suitableness of the instrument to its purpose, of the remedy to the defect, of the convex 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,

ſtate, affords a proof no leſs clear of deſtination to a future purpoſe; and a proof proportionably ſtronger, as the machinery is more complicated, and the adaptation more exact.

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

As part and parcel of the ſame plan, ought to be mentioned, in ſpeaking of the lungs, the proviſionary contrivances of the foramen ovale and ductus arterioſus. In the fœtus, pipes are laid for the paſſage of the blood through the lungs; but, until the lungs be inflated by the inſpiration of air, that paſſage is impervious, or in a great degree obſtructed. What then is to be done? What would an artiſt, what would a maſter, do upon the occaſion? He would 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,

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.

CHAP-

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 an 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 to the effect finally produced. Thus, referring the ſpring to the wheels, our obſerver 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 connection 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 reſt of the works, he ſaw, when he came to underſtand its action, that which rendered their motions equable. Laſtly, in looking upon the index and face of the watch, he ſaw the uſe and concluſion of the mechaniſm, viz. marking the ſucceſſion of minutes and hours; but all depending upon the motions within, all

upon

upon the ſyſtem of intermediate actions between the ſpring and the pointer. What thus ſtruck his attention in the ſeveral parts of the watch he might probably deſignate by one general name of "relation:" and obſerving with reſpect to all caſes whatever, in which the origin and formation of a thing could be aſcertained by evidence, that theſe relations were found in things produced by art and deſign, and in no other things, he would rightly deem of them as characteriſtic of ſuch productions. To apply the reaſoning here deſcribed to the works of nature.

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

I. There are firſt, what, in one form or other, belong to all animals, the parts and powers which ſucceſſively act upon their *food.* Compare this action with the proceſs of a manufactory. In man and quadrupeds, the aliment is, firſt, broken and bruiſed by mechanical inſtruments of maſtication, viz. ſharp ſpikes or hard knobs, preſſing againſt, or rubbing upon, one another: thus ground and comminuted, it is carried by a pipe into the ſtomach, where it waits to undergo a great chemical action, which we call digeſtion: when

when digested, it is delivered through an orifice, which opens and shuts as there is occasion, into the first intestine: there, after being mixed with certain proper ingredients, poured through a hole in the side of the vessel, it is further dissolved : in this state, 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 ; with 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 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 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

* Diſſ. I. ſec. liv.

birds,

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 theſea nimals is fitted for the purſuit of living prey. Accordingly it has been found by experiments, tried not many years ago with perforated balls, that the gaſtric juice of ruminating animals, ſuch as the ſheep and the ox, ſpeedily diſſolves vegetables, but makes no impreſſion upon animal bodies. This accordancy is ſtill more particular. The gaſtric juice even of granivorous birds, will not act upon the grain, whilſt whole and entire. In performing the experiment of 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, in this caſe, is the relation between the offices aſſigned to the digeſtive organ;

gan between the mechanical operation, and the chemical procefs.

II. The relation of the kidneys to the bladder, and of the ureters to both, i. e. of the fecreting organ to the veffel receiving the fecreted liquor, and the pipe laid from one to the other for the purpofe of conveying it from one to the other, is as manifeft as it is amongft the different veffels employed in a diftillery, or in the communications between them. The animal ftructure, in this cafe, being fimple, and the parts eafily feparated, it forms an inftance of correlation which may be prefented by diffection to every eye, or which, indeed, without diffection is capable of being apprehended by every underftanding. This correlation of inftruments to one another fixes intention fomewhere.

Efpecially when every other folution is negatived by the conformation. If the bladder had been merely an expanfion 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, iffuing from different fides of the body, yet from both conveying the fame 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

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

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 connection 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

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 eyebrows, not only cloſes up the apertures which lead to the eyes, but preſents a cuſhion, as it were, to any ſharp or protruding ſubſtance, which might puſh againſt them. This aperture even in its ordinary ſtate is like a pin hole in a piece of velvet, ſcarcely pervious to looſe particles of earth.

Obſerve then, in this ſtructure, that which we call relation. There is no natural connection between a ſmall ſunk eye and a ſhovel palmated foot. Palmated feet might have been joined with goggle eyes; or ſmall eyes might have been joined with feet of any other form. What was it therefore which brought them together in the mole? That which brought together the barrel, the chain, and the fuſee, in a watch: deſign; and deſign, in both caſes, inferred, from the relation which the parts bear to one another in the proſecution of a common purpoſe. As hath already been obſerved, there are different ways of ſtating the relation, according as we 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

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.

CHAP-

CHAPTER XVI.

COMPENSATION.

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

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

If

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;

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

analogy obſerved in winged animals. A ſingular defect required a ſingular ſubſtitute.

III. The *crane* kind are to live and ſeek their food amongſt the waters; yet, having no web 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

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.

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

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 theſe reticulations have been counted in the two eyes of a drone bee.

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

VII. The

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

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, corkſcrew, 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

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 became 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,

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; h. e. is calculated

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 these qualities when it comes under the subjection of man, the loss is compensated by his protection. Perhaps there is no species of quadruped whatever, which suffers 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 from 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 it then goes on to diſſolve them; not ſparing even the tougheſt 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, deer, 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 granivorous 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 coffee-mill would do. It has been proved by the moſt correct experiments, that the gaſtric juice of theſe birds will not operate

* Spal. Diſſ. III. ſec. cxl.

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 a hooked, notched, beak; ſhort, muſcular legs; 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 conſi-

 derable

derable 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

was, mufcular action, i. e. reciprocal contraction and relaxation being given, to defcribe how fuch an animal might be conftructed, capable of voluntarily changing place. Something, perhaps, like the organization of reptiles, might have been hit upon by the ingenuity of an artift; or might have been exhibited in an automaton, by the combination of fprings, fpiral wires, and ringlets; but to the folution of the problem would not be denied, furely, the praife of invention and of fuccefsful thought; leaft of all could it ever be queftioned, whether intelligence had been employed about it, or not.

CHAP-

CHAPTER XVII.

THE RELATION OF ANIMATED BODIES TO INANIMATE NATURE.

WE have already confidered *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 fame animal, or of another individual of the fame fpecies.

But the bodies of animals hold, in their conftitution and properties, a clofe and important relation to natures altogether external to their own; to inanimate fubftances, and to the fpecific qualities of thefe, e. g. *they hold a ftrict relation to the* ELEMENTS *by which they are furrounded.*

I. Can it be doubted, whether the *wings of birds* bear a relation to air, and the *fins of fifh* to water? They are inftruments of motion, feverally fuited 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 inftruments were differently conftituted?

II. The

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 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

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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 and 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 connection 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 likewiſe, 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 perſons of men, who much exceed the ordinary ſtature, betray this tendency.

VI. Again; and which includes a vaſt variety of particulars, and thoſe of the greateſt importance,

importance, how close is the *suitableness* of the earth and sea to their several inhabitants; and of these inhabitants to the places of their appointed residence!

Take the *earth* as it is; and consider the correspondency of the powers of its inhabitants with the properties and condition of the soil which they tread. Take the inhabitants as they are; and consider the substances which the earth yields for their use. They can scratch its surface, and its surface supplies all which they want. This is the length of their faculties; and such is the constitution of the globe, and their own, that this is sufficient for all their occasions.

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

VII. The last relation of this kind which I shall mention is that of *sleep* to *night*. And it appears to me to be a relation which was expressly

expreſsly intended. Two points are manifeſt: firſt, that the animal frame requires ſleep; ſecondly, that night brings with it a ſilence, and a ceſſation of activity, which allows of ſleep being taken without interruption, and without loſs. Animal exiſtence is made up of action and ſlumber: nature has provided a ſeaſon for each. An animal, which ſtood not in need of reſt, would always live in daylight. 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 expenſe 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.

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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 obvious and 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.

VIII. 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 constitu-
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tion of animals fufceptible of torpor, bears a relation to winter, fimilar to that which fleep bears to night. Againft not only the cold, but the want of food, which the approach of winter induces, the preferver of the world has provided, in many animals by migration, in many others by torpor. As one example out of a thoufand, the bat, if it did not fleep through the winter, muft have ftarved, as the moths and flying infects, upon which it feeds, difappear. But the tranfition from fummer to winter carries us into the very midft of phyfical aftronomy, that is to fay, into the midft of thofe laws which govern the folar fyftem at leaft, 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,

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;

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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

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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

hatching of a chicken both would be, and ought to be, to a philofopher.

But admit the fparrow by fome means to know, that within that egg was concealed the principle of a future bird, from what chemift was fhe to learn, that *warmth* was neceffary to bring it to maturity, or that the degree of warmth, imparted by the temperature of her own body, was the degree required?

To fuppofe, therefore, that the female bird acts in this procefs from a fagacity and reafon of her own, is to fuppofe her to arrive at conclufions, which there are no premifes to juftify. If our fparrow, fitting upon her eggs, expect young fparrows to come out of them, fhe forms, I will venture to fay, a wild and extravagant expectation, in oppofition to prefent appearances, and to probability. She muft have penetrated into the order of nature, further than any faculties of ours will carry us: and it hath been well obferved, that this deep fagacity, if it be fagacity, fubfifts in conjunction with great ftupidity, even in relation to the fame fubject. "A chemical operation," fays Addifon, "could not be followed with greater art or diligence, than is feen in hatching a chicken: yet is the procefs carried on without

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

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 ſees a brood of callow birds in their neſt, can believe that they are taking a plan of their habitation?) but leaves unaccounted for, one principal part of the difficulty, "the preparation of the neſt before the laying of the egg." This ſhe could not gain from obſervation in her infancy.

It is remarkable alſo, that the hen ſits upon eggs, which ſhe has laid without any communication with the male; and which are therefore neceſſarily unfruitful. That ſecret ſhe is not let into. Yet, if incubation had been a ſubject of inſtruction or of tradition, it ſhould ſeem that this diſtinction would have formed part of the leſſon: whereas the inſtinct of nature

ture is calculated for a ſtate of nature; the exception, here alluded to, taking place, chiefly, if not ſolely, amongſt domeſticated fowls, in which nature is forced out of her courſe.

There is another caſe of oviparous œconomy, which is ſtill leſs likely to be the effect of education, than it is even in birds, namely, that of *moths* and *butterflies*, which depoſit their eggs in the preciſe ſubſtance, that of a cabbage for example, from which, not the butterfly herſelf, but the caterpillar which is to iſſue from her egg, draws its appropriate food. The butterfly cannot taſte the cabbage. Cabbage is no food for her: yet in the cabbage, not by chance, but ſtudiouſly and electively, ſhe lays her egg. There are amongſt many other kinds, the willow caterpillar, and the cabbage caterpillar; but we never find upon a willow, the caterpillar which eats the cabbage; nor the converſe. This choice, as appears to me, cannot in the butterfly proceed from inſtruction. She had no teacher in her caterpillar ſtate. She never knew her parent. I do not ſee, therefore, how knowledge acquired by experience, if it ever were ſuch, could be tranſmitted from one generation to another. There is no opportunity either for

inſtruction

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 στοργη, the parental affection, which I contend

tend 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 of 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 as careful in making

provision

provifion for them, as any other bird. She does not leave her egg in every hole.

The falmon fuffers no furmountable obftacle to oppofe her progrefs up the ftream of frefh rivers. And what does fhe do there? She fheds a fpawn, which fhe immediately quits, in order to return to the fea; and this iffue of her body fhe never afterwards recognizes in any fhape whatever. Where fhall we find a motive for her efforts, and her perfeverance? Shall we feek it in argumentation, or in inftinct? The violet crab of Jamaica performs a fatiguing march, of fome months continuance, from the mountains to the fea-fide. When fhe reaches the coaft, fhe cafts her fpawn into the open fea; and fets out upon her return home.

Moths and butterflies, as hath already been obferved, feek out for their eggs, thofe precife fituations and fubftances, in which the offspring caterpillar will find its appropriate food. That dear caterpillar the parent butterfly muft never fee. There are no experiments to prove that fhe would retain any knowledge of it, if fhe did. How fhall we account for her conduct? I do not mean for her art and judgment in felecting and fecuring a maintenance

nance 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

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of the young animal to maintain itself: never anticipates it. In the sparrow tribe, when it is perceived that the young brood can fly, and shift for themselves, then the parents forsake them for ever; and, though they continue to live together, pay them no more attention than they do to other birds in the same flock *. I believe the same thing is true of all gregarious quadrupeds.

In this part of the case the variety of resources, expedients, and materials, which animals of the same species are said to have recourse to, under different circumstances, and when differently supplied, makes nothing against the doctrine of instincts. The thing which we want to account for is the propensity. The propensity being there, it is probable enough that it may put the animal upon different actions according to different exigences. 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,

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

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 the 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

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 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 milk ſo agreeable to the lamb that it ſhould follow it up with its noſe, or ſeek with its mouth the place from which it proceeded? No obſervation, no experience, no argument could teach the new dropped animal, that the ſubſtance, from which the ſcent iſſued, was the material of its food. It had never taſted milk before its birth. None of the animals, which are not deſigned for that nouriſhment, ever offer to ſuck, or to ſeek out any ſuch food. What is the concluſion, but that the ſugeſcent parts of animals are fitted for their uſe, and the knowledge of that uſe put into them?

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

relief, which, in the heated ſtate of her abdomen, ſhe experiences from the preſſure of round ſmooth ſurfaces, or from the application of a temperate warmth. How comes this extraordinary heat or itching, or call it what you will, which you ſuppoſe to be the cauſe of the bird's inclination, to be felt, juſt at the time when the inclination itſelf is wanted; when it tallies ſo exactly with the internal conſtitution of the egg, and with the help which that conſtitution requires in order to bring it to maturity? In my opinion, this ſolution, if it be accepted as to the fact, ought to increaſe, rather than otherwiſe, 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?

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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 recogniſe 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 winged race, the young bird is ſupplied by an importation

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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,

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 ascertained, because it admits not of a clear, or very probable, comparison, with any organs which we possess ourselves, or with the organs of animals which resemble ourselves in their functions and faculties, or with which we are better acquainted than we are with insects. We want a ground of analogy. This difficulty stands in our way as to some particulars in the insect constitution which we might wish to be acquainted with. Nevertheless, there are many contrivances in the bodies of insects, neither dubious in their use, nor obscure in their structure, and most properly mechanical. These form parts of *our* argument.

I. The *elytra*, or scaly wings of the genus of scarabæus or beetle, furnish an example of this kind. The true wing of the animal is a light transparent membrane, finer than the finest gauze, and not unlike it. It is also when expanded, in proportion to the size of the

the animal, very large. In order to protect this delicate ſtructure, and, perhaps, alſo to preſerve it in a due ſtate of ſuppleneſs and humidity, a ſtrong, hard, caſe is given to it, in the ſhape of the horny wing which we call the elytron. When the animal is at reſt, the gauze wings lie folded up under this impenetrable ſhield. When the beetle prepares for flying, he raiſes the integument, and ſpreads out his thin membrane to the air. And it cannot be obſerved without admiration, what a tiſſue of cordage, i. e. of muſcular tendons, muſt run, in various and complicated, but determinate directions, along this fine ſurface, in order to enable the animal, either to gather it up into a certain preciſe form, whenever it deſires to place its wings under the ſhelter which nature hath given to them; or to expand again their folds, when wanted for action.

In ſome inſects, the elytra cover the whole body; in others, half; in others, only a ſmall 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

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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, affifted, in fome cafes, by a periftaltic motion, paffes to its deftined lodgment. In the œftrum or gadfly, the wimble *draws out* like the pieces of a fpy-glafs; the laft piece is armed with three hooks, and is able to bore through the hide of an ox. Can any thing more be neceffary to difplay the mechanifm, than to relate the fact?

III. The *ftings* of infects, though for a different purpofe, are, in their ftructure, not unlike the piercer. The fharpnefs to which the point in all of them is wrought; the temper and firmnefs of the fubftance of which it is compofed; the ftrength of the mufcles by which it is darted out, compared with the fmallnefs and weaknefs of the infect, and with the foft or friable texture of the reft of the body; are properties of the fting to be noticed, and not a little to be admired. The fting of a *bee* will pierce through a goatfkin glove. It penetrates the human fkin more readily than the fineft point of a needle. The *action* of the fting affords an example of the union of chemiftry and mechanifm, fuch as, if it be not a proof of contrivance, nothing is. Firft, as to the

the chemiſtry; 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 point of 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 chemiſtry 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 chemical 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

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. It is observable also, that the plant is not the worse for what the bee does to it. The harmless plunderer rifles the sweets, but leaves the flower uninjured. 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.

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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 commu-

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 wings. 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,

pillars, 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 ſilkworm, 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

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 this 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 *ſilkworm* or *ſpider*, whereby theſe inſects form their *thread*, is as inconteſtably mechanical as a wire-drawer's mill. In the body of the ſilkworm are two bags, remarkable for their form, poſition, and uſe. They wind round the inteſtine; when drawn out they are ten inches in length; though the animal itſelf be only two. Within theſe bags, is collected a glue; and communicating with the bags, are two paps or outlets, perforated, like a greater, by a number of ſmall holes. The glue or gum, being paſſed through theſe minute apertures, forms hairs of almoſt imperceptible finenefs; and thefe hairs, when joined, compofe the filk which we wind off from the cone, in which the filkworm has wrapped itfelf up: in the fpider the web is formed from this thread. In both cafes, the extremity of the thread, by means of its adhefive quality, is firft attached by the animal to fome external hold; and the end being now faftened to a point, the infect, by turning round its body, or by receding from that point, draws out the thread through the holes above defcribed, by an operation, as hath been obferved, exactly fimilar to the drawing of wire. The thread, like the wire, is formed by the hole through which it paffes. In one refpect there is a difference. The wire is the metal unaltered, except in figure. In the animal procefs, the nature of the fubftance is fomewhat changed, as well as the form: for, as it exifts within the infect, it is a foft, clammy, gum or glue. The thread acquires, it is probable, its firmnefs and tenacity from the action of the air upon its furface, in the moment of expofure; and a thread fo fine is almoft all furface. This property, however, of the pafte, is part of the contrivance.

The mechanifm itfelf confifts of the bags, or refervoirs, 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 lefs 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 afk, what could the bee do with the honey, if it had not the wax? how, at leaft, could it ftore it up for winter? The wax, therefore, anfwers a purpofe with refpect to the honey; and the honey conftitutes that purpofe with refpect to the wax. This is the relation between them. But the two fubftances, though, together, of the greateft ufe, 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 pafte, made out of a dry powder, not fimply by kneading it with a liquid, but by a digeftive procefs in the body of the bee. What account can be rendered of facts fo circumftanced, 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 lefs neceffary faculty of conftructing repofitories 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 pincers more mechanical, than this provision, in their structure? or is any structure more clear and certain in its design?

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IV. St. Pierre tells us *, that in a fly with fix feet (I do not remember that he defcribes the fpecies) the pair next the head, and the pair next the tail, have brufhes at their extremities, with which the fly dreffes, as there may be occafion, the anterior or the pofterior part of its body; but that the middle pair have no fuch brufhes, the fituation of thefe legs not admitting of the brufhes, if they were there, being converted to the fame ufe. This is a very exact mechanical diftinction.

V. If the reader, looking to our diftributions of fcience, wifh to contemplate the chemiftry, as well as the mechanifm of nature, the infect creation will afford him an example. I refer to the light in the tail of a *glow-worm*. Two points feem to be agreed upon by naturalifts concerning it: firft, that it is phofphoric; fecondly, that its ufe is to attract the male infect. The only thing to be enquired after, is the fingularity, if any fuch there be, in the natural hiftory of this animal, which fhould render a provifion of this kind more neceffary for *it*, than for other infects. That fingularity feems to be the difference, which fubfifts between the male and the female; which differ-

* Vol. i. p. 342.

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ence 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 habits, 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 chemiſtry 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 ſtream 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 ſpectacle, 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

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

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 ſhell 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

cious fiſh. The other remark is, upon the property, in the animal excretion, not only of congealing, but of congealing or, as a builder would call it, *ſetting* in water, and into a cretaceous ſubſtance, firm and hard. This property is much more extraordinary, and, chemically ſpeaking, more ſpecific, than that of hardening in the air; which may be reckoned a kind of exſiccation, like the drying of clay into bricks.

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

IV. The ſhell of a lobſter's tail, in its articulations and overlappings, repreſents the jointed part of a coat of mail; or rather, which I believe to be the truth, a coat of mail is an imitation of a lobſter's ſhell. The ſame end is to be anſwered by both: the ſame properties, therefore, are required in both, namely, hardneſs and flexibility, a covering which may guard the part without obſtructing its motion. For this double purpoſe, the art of man, expreſsly exerciſed upon the ſubject, has not been able to deviſe

vise any thing better than what nature presents to his observation. Is not this therefore mechanism, which the mechanic, having a similar purpose in view, adopts? Is the structure of a coat of mail to be referred to art? Is the same structure of the lobster, conducing to the same use, to be referred to any thing less than art?

Some, who may acknowledge the imitation, and assent to the inference which we draw from it, in the instance before us, may be disposed, possibly, to ask, why such imitations are not more frequent than they are, if it be true, as we alledge, that the same principle of intelligence, design, and mechanical contrivance, was exerted in the formation of natural bodies, as we employ in the making of the various instruments by which our purposes are served. The answers to this question are, first, that it seldom happens, that precisely the same purpose, and no other, is pursued in any work which we compare of nature and of art; secondly, that it still 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 fubftitute for an arm or a hand. In the example which we have felected, I mean of a lobfter's fhell compared with a coat of mail, thefe difficulties ftand lefs in the way, than in almoft any other that can be affigned; and the confequence is, as we have feen, that art gladly borrows from nature her contrivance, and imitates it clofely.

But to return to infects. I think it is in this clafs of animals, above all others, efpecially when we take in the multitude of fpecies which the microfcope difcovers, that we are ftruck with what Cicero has called "the *infatiable* variety of nature." There are faid to be fix thoufand fpecies of flies; feven hundred and fixty butterflies; each different from all the reft. (St. Pierre.) The fame writer tells us from his own obfervation, that thirty-feven fpecies of winged infects, with diftinctions well expreffed, vifited a fingle ftrawberry plant in the courfe of three weeks*. Ray obferved, within the compafs of a mile or two of his own houfe, two hundred kinds of butterflies, nocturnal and diurnal. He likewife

* Vol. i. p. 3.

afferts,

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 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, beſides 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 *tuſt*, when expanded upon the ſurface, the inſect both ſupports itſelf

* Wiſd. of God, p. 23. † Derham, p. 7.

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 cauſe of this we have not far to ſeek. Did all animals covet the ſame element, retreat, or food, it is evident how much fewer could be ſupplied and accommodated, than what at preſent live conveniently together, and find a plentiful ſubſiſtence. What one nature rejects, another delights in. Food, which is nauſeous to one tribe of animals, becomes, by that very property which makes it nauſeous, an alluring dainty to another tribe. Carrion is a treat to dogs, ravens, vultures, fiſh. The exhalations of corrupted ſubſtances attract flies by crowds. Maggots revel in putrefaction.

CHAPTER XX.

OF PLANTS.

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

The one great intention of nature in the ſtructure of plants ſeems to be the perfecting of the *ſeed*; and, what is part of the ſame intention, the preſerving of it until it be *perfected.* This intention ſhews itſelf, in the firſt place, by the care which appears to be taken to protect and ripen, by every advantage which can be given to them of ſituation in the plant, thoſe parts which moſt immediately contribute to fructification, viz. the antheræ, the ſtamina, and the ſtigmata. Theſe parts

parts are usually lodged in the centre, the recesses, or the labyrinths of the flower; during their tender and immature state, are shut up in the stalk, 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.

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 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 impene-

* Phil. Tranſ. part ii. 1796, p. 502.

trable

trable 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,

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 ſubtile 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,

len, 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 ſurpriſing comparative ſize; aſſuming in different plants an incalculable variety of forms, but all evidently conducing

to

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

* 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 plum, 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

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 membranous, 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

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.

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

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

have

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; 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

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 conceive 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 of 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 touch-

ed

ed without being broken. Yet, in beans, peas, grafs feeds, grain, fruits, it is fo fenced on all fides, fo fhut up and protected, that, whilft the feed itfelf is rudely handled, toffed into facks, fhovelled into heaps, the facred particle, the miniature plant, remains unhurt. It is wonderful alfo, how long many kinds of feed, by the help of their integuments, and perhaps of their oils, ftand out againft decay. A grain of muftard feed has been known to lie in the earth for a hundred years; and, as foon as it had acquired a favourable fituation, to fhoot as vigoroufly as if juft gathered from the plant. Then, as to the fecond point, the temporary fupport of the future plant, the matter ftands thus. In grain, and pulfe, and kernels, and pippins, the germ compofes a very fmall part of the feed. The reft confifts of a nutritious fubftance, from which the fprout draws its aliment for fome confiderable time after it is put forth; viz. until the fibres, fhot out from the other end of the feed, are able to imbibe juices from the earth, in a fufficient quantity for its demand. It is owing to this conftitution, that we fee feeds fprout, and the fprouts make a confiderable progrefs, 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

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 objects?" Who gave such a quality to these connate parts, as to be susceptible of *different* "stimulation;" as to be "excited" each only by its own element, and precisely by that, which the success of the vegetation requires? I say, "which the success of the vegetation requires," for the toil of the husbandman would have been in vain; 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

* Darwin's Phytologia, p. 144.

of

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 without aſſiſtance, *furniſhed with theſe tendrils.*" Make only ſo ſimple a comparifon as that between a pea and a bean. Why does the pea put forth tendrils, the bean not; but becaufe the ftalk of the pea cannot fupport itfelf, the ftalk of the bean can? We may add alfo, as a circumftance not to be overlooked, that in the pea tribe, thefe clafps do not make their appearance, till they are wanted; till the plant has grown to a height to ftand in need of fupport.

This word "fupport," fuggefts to us a reflection upon a property of graffes, of corn, and canes. The hollow ftems of thefe claffes of plants, are fet, at certain intervals, with joints. Thefe joints are not found in the trunks of trees, or in the folid ftalks of plants. There may be other ufes of thefe joints; but the fact is, and it appears to be, at leaft, one purpofe defigned by them, that they *corroborate* the ftem; which, by its length and hollownefs, would, otherwife, be too liable to break or bend.

Graffes are Nature's care. With thefe fhe clothes the earth: with thefe fhe fuftains its inhabitants. Cattle feed upon their leaves; birds upon their fmaller feeds; men upon the larger; for few readers need be told that the plants, which produce our bread corn, belong to to this clafs. In thofe tribes, which are more generally confidered as graffes, their extraordinary means and powers of prefervation and increafe, their hardinefs, their almoft unconquerable difpofition to fpread, their faculties of revivifcence, coincide with the intention of nature concerning them. They thrive under a treatment by which other plants are deftroyed. The more their leaves are confumed, the more their roots increafe. The more they are trampled upon, the thicker they grow. Many of the feemingly dry and dead leaves of graffes revive, and renew their verdure, in the fpring. In lofty mountains, where the fummer heats are not fufficient to ripen the feeds, graffes abound, which are viviparous, and confequently able to propagate themfelves without feed. It is an obfervation, likewife, which has often been made, that herbivorous animals attach themfelves to the leaves of graffes; and, if at liberty in their paftures to range and choofe, leave untouched the ftraws which fupport the flowers *.

THE GENERAL properties of vegetable nature, or properties common to large portions

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

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

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 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.

ſtitution. 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 theſe 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 calyx, 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 cloſely into the ſtructure of this plant, we find that, inſtead of its being neg-

* Ib. p. 203.

lected,

lected, 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 in all caſes 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, and is probably ſoon over. The maturation of the impregnated ſeed, which in other plants pro-

* Ib. p. 360.

ceeds

ceeds 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 froſt." But then a new difficulty preſents itſelf. Seeds, though perfected, are known not to vegetate at this depth in the earth. Our ſeeds therefore, though 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 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

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 antient 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.

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

CHAP-

CHAPTER XXI.

THE ELEMENTS.

WHEN we come to the elements, we take leave of our mechanics; becaufe we come to thofe things, of the organization of which, if they be organized, we are confeffedly ignorant. This ignorance is implied by their name. To fay the truth, our inveftigations are ftopped long before we arrive at this point. But then it is for our comfort to find, that a knowledge of the conftitution of the elements is not neceffary for us. For inftance, as Addifon has well obferved, "we know *water* fufficiently, when we know how to boil, how to freeze, how to evaporate, how to make it frefh, how to make it run or fpout out, in what quantity and direction we pleafe, without knowing what water is." The obfervation of this excellent writer has more propriety in it now, than it had at the time it was made: for the conftitution, and the conftituent parts, of water, appear in fome meafure to have been lately difcovered;

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. Ἐξ ὕδατος τα παντα: *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; 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 atmofphere raifes the water, and leaves the falt. Pure and frefh as drops of rain defcend, they are collected from brine. If evaporation be folution, (which feems to be probable,) then the air diffolves the water and not the falt. Upon whatever it be founded, the diftinction is critical; fo much fo, that, when we attempt to imitate the procefs by art, we muft regulate our diftillation with great care and nicety, or, together with the water, we get the bitternefs, or, at leaft the diftaftefulnefs, of the marine fubftance: and, after all, it is owing to this original elective power in the air, that we can effect the feparation which we wifh, by any art or means whatever.

By evaporation water is carried up into the air; by the converfe 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 defcending, like a fheet; not in rufhing down in columns from a fpout; but in moderate drops, as from a cullender. Our watering-pots are made to imitate fhowers of rain. Yet, à priori, I fhould have thought either of the two former methods more likely to have taken place than the laft.

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

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 conſequences, to know, that they tend powerfully to reſtore to the air that purity, which ſo many cauſes are conſtantly impairing.

II. In WATER, what ought not a little to be admired, are thoſe negative qualities which conſtitute its *purity*. Had it been vinous, or oleaginous, or acid; had the ſea been filled, or the rivers flowed, with wine or milk; fiſh, conſtituted as they are, muſt have died; plants, conſtituted as they are, would have withered; the lives of animals, which feed upon plants, muſt have periſhed. Its very *inſipidity*, which is one of thoſe negative qualities, renders it the beſt of all menſtrua. Having no taſte of its own, it becomes the ſincere vehicle of every other. Had there been a taſte in water, be it what it might, it would have infected every thing we ate or drank, with an importunate repetition of the ſame flavor.

Another thing in this element, not leſs to be admired, is the conſtant *round* which it travels; and by which, without ſuffering either adulteration or waſte, it is continually offering itſelf to the wants of the habitable globe. From the ſea are exhaled thoſe vapours which form the clouds. Theſe clouds deſcend in ſhowers, which, penetrating into the crevices of the hills, ſupply ſprings. Which ſprings flow in little ſtreams into the valleys; and, there uniting, become rivers. Which rivers, in return, feed the ocean. So there is an inceſſant circulation of the ſame fluid; and not one drop probably more or leſs now, than there was at the creation. A particle of water takes its departure from the ſurface of the ſea, in order to fulfil certain important offices to the earth; and, having executed the ſervice which was aſſigned to it, returns to the boſom which it left.

Some have thought that we have too much water upon the globe; the ſea occupying above three quarters of its whole ſurface. But the expanſe of ocean, immenſe as it is, may be no more than ſufficient to fertilize 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.

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, chemical 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,)

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 travels from the ſun at the rate of twelve millions of miles in a minute. 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

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.

CHAP-

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 affords; 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

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

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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 domeſtie 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;

longs; 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 "myſtic dance," and 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,

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 favour; 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

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thofe which move fhould be cold: for, in fact, comets are bodies on fire, or at leaft capable of the moft intenfe heat, yet revolve round a centre: nor does this order obtain between the primary planets and their fecondaries, which are all opaque. When we confider, therefore, that the fun is one; that the planets going round it are, at leaft, feven; that it is indifferent to their nature which are luminous and which are opaque; and alfo, in what order with refpect to each other, thefe two kinds of bodies are difpofed; we may judge of the improbability of the prefent arrangement taking place by chance.

If, by way of accounting for the ftate in which we find the folar fyftem, it be alledged (and this is one amongft the gueffes of thofe who reject an intelligent Creator) that the planets themfelves are only cooled or cooling maffes, and were once, like the fun, many thoufand times hotter than red hot iron; then it follows, that the fun alfo himfelf muft be in his progrefs towards growing cold; which puts an end to the poffibility of his having exifted, as he is, from eternity. This confequence arifes out of the hypothefis with ftill more certainty, if we make a part of it, what the philofophers who maintain it, have ufually taught,

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

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 endeavour to explain. The earth, it is well known, is not an exact globe, but an oblate ſpheroid, ſomething like an orange. Now the axes 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 axes 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. The ſhorteſt diameter is that upon which in fact the earth turns; and it is, as the reader

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 axes, 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,

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 antient 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:

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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 e ſome cauſe for change: by virtue, I ſay, 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 thought it to be, 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.

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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 for believing 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 ſeems to imply a contrariety of properties, to ſuppoſe an æthereal fluid to *act* but not to *reſiſt*; powerful enough to carry down bodies with great force towards a centre, yet, inconſiſtently with the nature of inert matter, powerleſs and perfectly yielding with reſpect to the motions which reſult from the projectile impulſe. By calculations drawn from antient notices of eclipſes of the moon, we can prove, that, if ſuch a fluid exiſt at all, its reſiſtance has had no ſenſible effect upon the moon's motion for two thouſand five hundred years. The truth is, that, except this one circumſtance of the variation of the attracting force at different diſtances agreeing with the variation of the ſpiſſitude, there is no reaſon whatever to ſupport the hypotheſis of an emanation; and, as it ſeems to me, almoſt inſuperable reaſons againſt it.

II. (*) Our ſecond propoſition is, that, whilſt the poſſible laws of variation were infinite, the

admiſſible

admissible laws, or the laws compatible with the preservation of the system, lie within narrow limits. If the attracting force had varied according to any *direct* law of the distance, let it have been what it would, great destruction and confusion would have taken place. The direct simple proportion of the distance would, it is true, have produced an ellipse; but the perturbing forces would have acted with so much advantage, as to be continually changing the dimensions of the ellipse, in a manner inconsistent with our terrestrial creation. For instance; if the planet Saturn, so large and so remote, had attracted the earth, both in proportion to the quantity of matter contained in it, which it does; and also in any proportion to its distance, i. e. if it had pulled the harder for being the further off, (instead of the reverse of it,) it would have dragged the globe which we inhabit out of its course, and have perplexed its motions, to a degree incompatible with our security, our enjoyments, and probably our existence. 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

tractive 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

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

varying directly as the diſtance; the inconveniency of which law in other reſpects we have already noticed.

We may follow this regulation ſomewhat further, and ſtill more ſtrikingly perceive that it proceeded from a deſigning mind. A law both admiſſible and convenient was requiſite. In what way is the law of the attracting globes obtained? Aſtronomical obſervations and terreſtrial experiments ſhew that the attraction of the globes of the ſyſtem is made up of the attraction of their parts: the attraction of each globe being compounded of the attractions of its parts. Now the admiſſible and convenient law which exiſts, could not be obtained in a ſyſtem of bodies gravitating by the united gravitation of their parts, unleſs each particle of matter were attracted by a force varying by one particular law, viz. varying inverſely as the ſquare of the diſtance: For, if the action of the particles be according to any other law whatever, the admiſſible and convenient law which is adopted, could not be obtained. Here then are clearly ſhewn regulation and deſign. A law both admiſſible and convenient was to be obtained. The mode choſen for obtaining that law was by making *each* particle of of matter act. After this choice was made, then further attention was to be given to each particle of matter, and one, and one only particular law of action to be aſſigned to it. No other law would have anſwered the purpoſe intended.

(*) 2. 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 or vibratory 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 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;

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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 rond in orbits nearly circular, the

change

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, whic hwould 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. Nor will this difficulty be got rid of, by ſuppoſing that the ſame violent blow which ſhattered the ſun's ſurface, and ſeparated large fragments from it, puſhed the ſun himſelf out of his place; for the conſequence of this would be, that the ſun and ſyſtem of ſhattered fragments, would have a progreſſive motion, which, indeed, may poſſibly be the caſe with our ſyſtem; but then each fragment would in every revolution return to the ſurface of the ſun again. The hypotheſis is alſo contradicted by the vaſt difference

ference 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*.

To conclude: In aſtronomy, the great thing

* "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 quality 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 Philoſ.* p. 407. ed. 3.

is to raiſe the imagination to the ſubject, and that oftentimes in oppoſition to the impreſſion made upon the ſenſes. An illuſion, 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,

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 controlled 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*.

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

CHAP-

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

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

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 corporeal 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

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at the moſt, touch and taſte. Ought ſuch an animal to conclude againſt the exiſtence of odours, ſounds, and colours? To another ſpecies is given the ſenſe of 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 preſumptuous 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

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 univerfal in its operation, is no object of fenfe to us; if upon any other kind of fubftance or action, upon a fubftance and action from which *we* receive no diftinguifhable impreffions. Is it then to be wondered at, that it fhould, in fome meafure, be the fame with the divine nature?

Of this however we are certain, that, whatever the Deity be, neither the *univerfe*, nor any part of it which we fee, can be he. The univerfe itfelf is merely a collective name: its parts are all which are real; or which are *things*. Now inert matter is out of the queftion; and organized fubftances include marks of contrivance. But whatever includes marks of contrivance, whatever, in its conftitution, teftifies defign, neceffarily carries us to fomething beyond itfelf, to fome other being, to a defigner prior to, and out of, itfelf. No animal, for inftance, can have contrived its own limbs and fenfes; can have been the author to itfelf of the defign with which they were conftructed. That fuppofition involves all the abfurdity of felf-creation, i. e. of acting without exifting. Nothing can be God, which is ordered by a wifdom and a will, which itfelf is void of; which is indebted for any of its properties

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 Deity, 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

neſſes 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 favour 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 antient 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

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 produce at all. Of every argument, which would raise a question as to 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

* Ch. I. s. vii.

must

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 things, that exiſts. This is what we are ſecretly apt to do when we ſpeak of organized bodies (plants, for inſtance, or animals) owing their production, their form, their growth, their qualities, their beauty, their uſe, to any law or laws of nature: and when we are contented to ſit down with that anſwer to our enquiries 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

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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 fulfill 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,

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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 areſtill 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 chemiſtry, for inſtance, would be mechaniſm) if our ſenſes were acute enough to deſcry it. Neither mechaniſm, therefore, in the works of nature, nor the intervention of what are called ſecond cauſes, (for I think that they are the ſame thing,) excuſes the neceſſity of an agent diſtinct from both.

If, in tracing theſe cauſes, it be ſaid, that we find certain general properties of matter, which

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 fecretory 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

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order, ſo as to become collectively plants or animals, i. e. organized bodies, with parts bearing ſtrict and evident relation to one another, and to the utility of the whole: and it ſhould ſeem that theſe particles could not move in any other way than as they do; for they teſtify not the ſmalleſt ſign of choice, or liberty, or diſcretion. There may be 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, reſides merely in the *name*; which name, after all, compriſes, perhaps, under it a diverſified, multifarious, or progreſſive operation, diſtinguiſhable into parts. The power in organized bodies, of producing bodies like themſelves, is one of theſe principles. Give a philoſopher this, and he can get on. But he does not reflect, what this principle, (if ſuch he

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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 calicoes, 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.

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The opinion, which would confider "generation" as a *principle* in nature; and which would affign this principle as the caufe, or endeavour to fatisfy our minds with fuch a caufe, of the exiftence of organized bodies, is confuted, in my judgment, not only by every mark of contrivance difcoverable in thofe bodies, for which it gives us no contriver, offers no account, whatever; but alfo by the further confideration, that things generated, poffefs 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 fame body, as the mouth of an animal to the throat, the throat to the ftomach, the ftomach to the inteftines, thofe to the recruiting of the blood, and, by means of the blood, to the nourifhment of the whole frame: or if it were only one generated body bearing a relation to another generated body, as the fexes of the fame fpecies to each other, animals of prey to their prey, herbivorous and granivorous animals to the plants or feeds upon which they feed, it might be contended, that the whole of this correfpondency was attributable to generation, the common origin from which thefe fubftances proceeded. But what fhall we fay 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,

dity, 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

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

The "suppositions" here alluded to all agree in one character. They all endeavour 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

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

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 antient 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

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 accompanies 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,

* I truſt I may be excuſed, for not citing, as another fact which is to confirm the hypotheſis, a grave aſſertion of

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,

of this writer, that the branches of trees upon which the ſtag feeds, break out again in his horns. Such *facts* merit no diſcuſſion.

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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.

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 led 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,

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(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 in 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,

ever, 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

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, s offered of a ſingle change being known to have taken place. Nor is the order of generation obedient to the principle upon which this theory is built. The mammæ* of the male have not vaniſhed by inuſitation; *nec curtorum, per multa ſæcula, Judæorum propagini deeſt præputium.* It is eaſy to ſay, and it has been ſaid, that the alterative proceſs is too ſlow to be perceived; that it has been carried on through tracts of immeaſurable time; and that the preſent order of things is the reſult of a 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,

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

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is ſaid to be no other than the effect of carrying burthens; a ſervice in which the ſpecies has been employed from the moſt antient 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 wetneſs, 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 conformation, is nothing more, fay our phi-

* Goldfmith, vol. vi. p. 52.

lofophers,

losophers, than the reſult of habit; not of the habit or effort of a ſingle pelican, or of a ſingle race of pelicans, but of a habit perpetuated through a long ſeries of generations. The pelican ſoon found the conveniency, of reſerving in its mouth, when its appetite was glutted, the remainder of its prey, which is fiſh. The fullneſs produced by this attempt, of courſe ſtretched the ſkin which lies between the under chaps, as being the moſt yielding part of the mouth. Every diſtenſion increaſed the cavity. The original bird, and many generations which ſucceeded him, might find difficulty enough in making the pouch anſwer this purpoſe: but future pelicans, entering upon life with a pouch derived from their progenitors, of conſiderable capacity, would more readily accelerate its advance to perfection, by frequently preſſing down the ſac 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

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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 fed upon fish. How comes it to pass, that the pelican alone was the inventress, and her descendents 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,

tures, 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 endeavour 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 ſchemes and 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.

CHAP-

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 power 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 antient, and almoſt univerſal, propenſity to idolatrous ſubſtitutions. They are the reſources of a labouring 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 condeſcenſion to the ſtate of our faculties, of which, they, who have moſt reflected upon the ſubject, will be the firſt to acknowledge the want and the value.

Nevertheleſs,

Neverthelefs, if we be careful to imitate the documents of our religion, by confining our explanations to what concerns ourfelves, and do not affect more precifion in our ideas than the fubject allows of, the feveral terms, which are employed to denote the attributes of the Deity, may be made, even in natural religion, to bear a fenfe, confiftent with truth and reafon, and not furpaffing our comprehenfion.

Thefe terms are, omnipotence, omnifcience, omniprefence, eternity, felf-exiftence, neceffary exiftence, fpirituality.

"Omnipotence," "omnifcience," "infinite" power, "infinite" knowledge, are *fuperlatives*; expreffing our conception of thefe attributes in the ftrongeft, and moft elevated, terms, which language fupplies. We afcribe power to the Deity under the name of "omnipotence," the ftrict and correct conclufion being, that a power, which could create fuch a world as this is, muft be, beyond all comparifon, greater than any which we experience in ourfelves, than any which we obferve in other vifible agents; greater, alfo, than any which we can want, for our individual protection and prefervation, in the Being upon whom we depend. It is a power likewife, to which we are not

not authorized 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

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 we not meet with gravity, magnetiſm, electricity; together with the proper-

ties

ties 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

alſo what metaphyſicians denominate an eſſential ubiquity: and which idea the language of ſcripture ſeems to favour: 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 contraverted 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 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.

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

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 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

atmoſpheres as we have. In all the planets the axes 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

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.

other. 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 aquatic 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.

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 circum-

ſtance,

ſtance, 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

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,

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 gratification. What elſe ſhould fix them ſo cloſe to the 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

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

ference 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 eaſe 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

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 that 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 conſcience, and looks forward, with humble confidence in the mercy of God, and with devout aſpirations towards his eternal and ever increaſing favor."

What is ſeen in different ſtages of the ſame life, is ſtill more exemplified in the lives of

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

different animals. Animal enjoyments are infinitely *diverſified.* The modes of life, to which the organization of different animals reſpectively determines them, are not only of various, but of oppoſite kinds. Yet each is happy in its own. For inſtance; animals of prey, live much alone; animals of a milder conſtitution, in ſociety. Yet the herring, which lives in ſhoals, and the ſheep, which lives in flocks, are not more happy in a crowd, or more contented amongſt their companions, than is the pike, or the lion, with the deep ſolitudes of the pool, or the foreſt.

But it will be ſaid, that the inſtances which we have here brought forward, whether of vivacity or repoſe, or of apparent enjoyment derived from either, are picked and favorable inſtances. We anſwer that they are inſtances, nevertheleſs, which compriſe large provinces of ſenſitive exiſtence; that every caſe which we have deſcribed, is the caſe 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, accompliſhing their wiſhes, purſuing their pleaſures, taking their paſtimes! In each individual how many things muſt go right

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 queftionable than in any other, the prepollency of good over evil, of health for example, and eafe, over pain and diftrefs, is evinced by the very notice which calamities excite. What enquiries does the ficknefs of our friends produce! What converfation their misfortunes! This fhews that the common courfe of things is in favor of happinefs; that happinefs is the rule, mifery the exception. Were the order reverfed, our attention would be called to examples of health and competency, inftead of difeafe and want.

One great caufe of our infenfibility to the goodnefs of the Creator is the very *extenfivenefs* of his bounty. We prize but little what we fhare only in common with the reft, or with the generality, of our fpecies. 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 judgement perverted by our ſelfiſhneſs. A bleſſing ought in truth to be the *more* ſatisfactory, the bounty at leaſt of the donor 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

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 judgement 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 perceptions as to have continually offended us, inſtead of miniſtring to our refreſhment and delight. He might have made, for example, every thing we taſted bitter; every thing we ſaw loathſome; every thing we touched a ſting; every ſmell a ſtench; and every ſound a diſcord.

" If he had been indifferent about our happineſs 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 produce it.

" But either of theſe, and ſtill more both of them, being too much to be attributed to accident, nothing remains but the firſt ſuppoſition, that God, when he created the human ſpecies, wiſhed their happineſs; and made for them

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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 is 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 ſoles of the feet. Here pain and miſery 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 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

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 favourable 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

cafe of bites, which produce death in large animals, (of ftings I think there are none,) to be very few. The experiments of the Abbé Fontana, which were numerous, go ftrongly to the proof of this point. He found that it required the action of five exafperated vipers to kill a dog of a moderate fize; but that, to the killing of a moufe or a frog, a fingle bite was fufficient; which agrees with the ufe which we affign to the faculty. The Abbé feemed to be of opinion, that the bite even of the rattlefnake would not ufually be mortal; allowing, however, that in certain particularly unfortunate cafes, as when the puncture had touched fome very tender part, pricked a principle nerve for inftance, or, as it is faid, fome more confiderable lymphatic veffel, death might fpeedily enfue.

3. It has been, I think, very juftly remarked concerning ferpents, that, whilft only a few fpecies poffefs the venomous property, that property guards the whole tribe. The moft innocuous fnake is avoided with as much care as a viper. Now the terror, with which large animals regard this clafs 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.

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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 fertile 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

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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 be, whilſt it remains finite and limited, it may always be aſked, why it is 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

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

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,

3. But, to do juftice to the queftion, the fyftem of animal *deftruction* ought always to be confidered in ftrict connection with another property of animal nature, viz *fuperfecundity*. They are countervailing qualities. One fubfifts by the correction of the other. In treating, therefore, of the fubject under this view, (which is, I believe, the true one,) our bufinefs will be, firft, to point out the advantages which are gained by the powers in nature of a fuperabundant multiplication; and, then, to fhew, that thefe advantages are fo many reafons for appointing that fyftem of animal hoftilities, which we are endeavouring to account for.

In almoft all cafes nature produces her fupplies with profufion. A fingle cod fifh fpawns, in one feafon, a greater number of eggs, than all the inhabitants of England amount to. A thoufand other inftances of prolific generation might be ftated, which, though not equal to this, would carry on the increafe of the fpecies with a rapidity which outruns calculation, and to an immeafurable extent. The advantages of fuch a conftitution are two: firft, that it tends to keep the world always full; whilft, fecondly, it allows the proportion between the

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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 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

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 ſudden multiplication, 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

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;

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. Defencelefsnefs and devaftation are repaired by fecundity.

We have dwelt the longer upon thefe confiderations, becaufe the fubject to which they apply, namely, that of animals *devouring* one another, forms the chief, if not the only inftance, in the works of the Deity, of an œconomy, ftamped by marks of defign, in which the character of utility can be called in queftion. The cafe of *venomous* animals is of much inferior confequence to the cafe of prey, and, in fome degree, is alfo included under it. To both cafes it is probable that many more reafons belong, than thofe of which we are in poffeffion.

OUR FIRST PROPOSITION, and that which we have hitherto been defending, was, "that in a vaft plurality of inftances, in which *contrivance* is perceived, the defign of the contrivance is beneficial."

OUR SECOND PROPOSITION is, "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."

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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 ex-

 iſtence;

istence; and that is, of capacities for pleasure, in cases, wherein, so far as the conservation 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 ministring 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 be also 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 ap-

* 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.

propriate

propriate ſenſe for the perception of the 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 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 paſtureand 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

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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, was made to ſuit the object: the ſecond; that the object, by its original conſtitution, was made to ſuit 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

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us, not only choice and ſelection, out of a boundleſs variety of poſſible qualities with which theſe objects might have been endued, but a *proportioning alſo of degree*, becauſe an exceſs or defect of intenſity ſpoils the perception, as much almoſt as an error in the kind and nature of the quality. Likewiſe the degree of 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.

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Some infects confine themfelves to two or three kinds of plants or animals. Some again fhew fo ftrong a preference, is to afford reafon to believe that, though they may be driven by hunger to others, they are led by the pleafure of tafte to a few particular plants alone; and all this, as it fhould feem, independently of habit or imitation.

But fhould we accept the third hypothefis, and even carry it fo far, as to afcribe every thing which concerns the queftion to habit, (as in certain fpecies, the human fpecies moft particularly, there is reafon to attribute fomething,) we have then before us an animal capacity, not lefs perhaps to be admired, than the native congruities which the other fcheme adopts. It cannot be fhewn to refult from any fixed neceffity in nature, that what is frequently applied to the fenfes fhould of courfe become agreeable to them. It is, fo far as it fubfifts, a power of accommodation confidered and provided by the author of their ftructure, and forms a part of their perfection.

In whichever way we regard the fenfes, they appear to be fpecific gifts, miniftring, not only to prefervation, but to pleafure. But what we 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.

ciple. I have been a great follower of fiſhing myſelf, and in its cheerful ſolitude have paſſed ſome of the happieſt hours of a ſufficiently 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 mere 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 ſome meaſure, not only ſuper-added,

added, but unmixed gratifications, having no pains to balance them*.

I do not know whether our attachment to *property* be not ſomething more than the mere dictate of reaſon, or even than the mere effect of aſſociation. Property communicates a charm to whatever is the object of it. It is the firſt of our abſtract ideas; it cleaves to us the cloſeſt and the longeſt. It endears to the child its plaything, to the peaſant his cottage, to the landholder his eſtate. It ſupplies the place of proſpect and ſcenery. Inſtead of coveting the beauty of diſtant ſituations, it teaches every man to find it in his own. It gives boldneſs and grandeur to plains and fens, tinge and colouring to clays and fallows.

All theſe conſiderations come in aid of our *ſecond* propoſition. The reader will now bear in mind what our *two* propoſitions were. They were, firſtly, that, in a vaſt plurality of inſtances, in which contrivance is perceived, the deſign of the contrivance is beneficial: ſecondly; that the Deity has added pleaſure to animal ſenſations beyond what was neceſſary for any other purpoſe; or when the purpoſe,

* Balguy on the Divine Benevolence.

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ſo far as it was neceſſary, might have been effected by the operation of pain.

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

Of the ORIGIN OF EVIL no univerſal ſolution has been diſcovered: I mean no ſolution which reaches to all caſes of complaint. The moſt comprehenſive is that which ariſes from the conſideration of *general rules*. We may, I think, without much difficulty, be brought to admit the four following points: firſt, that important advantages may accrue to the univerſe from the order of nature proceeding according to general laws: ſecondly; that general laws, however well ſet and conſtituted, often thwart and croſs one another: thirdly; that from theſe thwartings and croſſings frequent particular inconveniences will ariſe: and fourthly; that it agrees with our obſervation to ſuppoſe, that ſome degree of theſe inconveniences takes place in the works of nature. Theſe points

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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 cafes, of apparent evil, for which *we* can fuggeft no particular reafon, are governed by reafons, which are more general, which lie deeper in the order of fecond caufes, and which on that account are removed to a greater diftance from us.

The doctrine of *imperfections*, or, as it is called, of evils of imperfection, furnifhes an account, founded like the former, in views of univerfal nature. The doctrine is briefly this. It is probable that creation may be better replenifhed, by fenfitive beings of different forts, than by fenfitive beings all of one fort. It is likewife probable, that it may be better replenifhed, by different orders of beings rifing one above another in gradation, than by beings poffeffed of equal degrees of perfection. Now a gradation of fuch beings implies a gradation of imperfections. No clafs can juftly complain of the imperfections which belong to its place in the fcale, unlefs it were allowable for it to complain, that a fcale of being was appointed in nature: for which appointment there appear to be reafons of wifdom and goodnefs.

In like manner, *finitenefs*, or what is refolvable into finitenefs, in inanimate fubjects, can never be a juft fubject of complaint, be-

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caufe, if it were ever fo, it would be always fo: we mean, that we can never reafonably demand that things fhould be larger or more, when the fame demand might be made, whatever the quantity or number was.

And to me it feems, that the fenfe of mankind has fo far acquiefced in thefe reafons, as that we feldom complain of evils of this clafs, when we clearly perceive them to be fuch. What I have to add therefore is, that we ought not to complain of fome other evils, which ftand upon the fame foot of vindication as evils of confeffed imperfection. We never complain that the globe of our earth is too fmall: nor fhould we complain, if it were even much fmaller. But where is the difference to us, between a lefs globe, and part of the prefent being uninhabitable? The inhabitants of an ifland, may be apt enough to murmur at the fterility of fome parts of it, againft its rocks, or fands, or fwamps; but no one thinks himfelf authorifed to murmur, fimply becaufe the ifland is not larger than it is. Yet thefe are the fame griefs.

The above are the two metaphyfical anfwers which have been given to this great queftion. They are not the worfe for being metaphyfical, provided

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.

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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, or even its subsidency, 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 connection 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

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

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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 may have mixed itſelf with them. This they do, in eruptive fevers, by a kind of deſpumation, as Sydenham calls it, analogous in ſome meaſure to the inteſtine action by which fermenting liquors work the yeſt to the ſurface. The ſolids, on their part, when their action is obſtructed, not only reſume that action, as ſoon as the obſtruction is removed, but they ſtruggle with the impediment; they take an action as near to the true one, as the difficulty and the diſorganization, with which they have to contend, will allow of.

Of *mortal* diſeaſes the great uſe is to reconcile us to death. The horror of death proves the value of life. But it is in the power of diſeaſe to abate, or even extinguiſh, this horror; which it does in a wonderful manner, and, oftentimes, by a mild and imperceptible gradation. Every man who has been placed in a ſituation to obſerve it, is ſurpriſed with the change which has been wrought in himſelf, when he compares the view which he entertains of death upon a ſick bed, 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 purchafe this immunity at the expenfe of thofe mental powers which enable him to look forward to the future?

Death implies *feparation:* and the lofs of thofe whom we love muft neceffarily, fo far as we can conceive, be accompanied with pain. To the brute creation, nature feems to have ftepped in with fome fecret provifion for their relief, under the rupture of their attachments. In their inftincts towards their offspring, and of their offspring to them, I have often been furprifed to obferve how ardently they love, and how foon they forget. The pertinacity of human forrow (upon which time alfo, at length, lays its foftening hand) is probably, therefore, in fome manner connected with the qualities of our rational or moral nature. One thing however is clear, viz. that it is better that we fhould poffefs affections, the fources of fo many virtues and fo many joys, although they be expofed to the incidents of life, as well as the interruptions of mortality, than, by the want of them, be reduced to a ftate of felfifhnefs, apathy, and quietifm.

Of other external (evils ftill confining ourfelves to what are called phyfical or natural evils) a confiderable part come within the

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ſcope of the following obſervation. The great principle of human ſatisfaction is *engagement.* It is a moſt juſt diſtinction, which late the 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 voluptuouſneſs, conſiſts. Now for rational occupation, which is, in other words, for the very material of contented exiſtence, there would be no place left, if either the things with which we had to do were abſolutely impracticable to our endeavours, or if they were too obedient to our uſes. A world furniſhed with advantages on one ſide, and beſet with difficulties, wants, and inconveniences on the other, is the proper abode of free, rational, and active natures, being the fitteſt to ſtimulate and exerciſe their faculties. The very *refractorineſs* of the objects they

have

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 ſcale, ſo as to admit of a greater or leſs number of inhabitants, according as the quantity of proviſion, 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

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

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 endeavours for 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,

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

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, or 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 labour with liberty. It is, moreover, the ſtimulant of enterpriſe in all projects and undertakings, as well as of diligence in the moſt

beneficial

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 tranquillity 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

5 conſiſts.

confifts. It is not, as hath been rightly obferved, by what the *Lord Mayor* feels in his coach, but by what the *apprentice* feels who gazes at him, that the public is ferved.

As we approach the fummits of human greatnefs, the comparifon of good and evil, with refpect to perfonal comfort, becomes ftill more problematical; even allowing to ambition all its pleafures. The poet afks, "What is grandeur, what is power?" The philofopher anfwers, "Conftraint and plague; et in maximâ quâque fortunâ minimum licere." One very common error mifleads the opinion of mankind upon this head, viz. that, univerfally, authority is pleafant, fubmiffion painful. In the general courfe of human affairs, the very reverfe of this is nearer to the truth. Command is anxiety, obedience eafe.

Artificial diftinctions fometimes promote real quality. Whether they be hereditary, or be the homage paid to office, or the refpect attached by public opinion to particular profeffions, they ferve to *confront* that grand and unavoidable diftinction which arifes from property, and which is moft overbearing where there is no other. It is of the nature of property, not only to be irregularly diftributed, but to run into large maſſes. Public laws ſhould be ſo conſtructed as to favour its diffuſion as much as they can. But all that can be done by laws, conſiſtently with that degree of government of 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 priviléges 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

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 it ſhews this, 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 tranquillity? 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 places.

NATURAL

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 lefs neceffity in it for its being by chance. Again, the meeting might be moft unfortunate, though the errands, upon which each party fet out upon his journey, were the moft innocent or the moft laudable. The bye effect may be unfavorable, without impeachment of the proper purpofe, for the fake of which, the train, from the operation of which thefe confequences enfued, was put in motion. Although no caufe act without a good purpofe, accidental confequences, like thefe, may be either good or bad.

II. The *appearance of chance* will always bear a proportion to the ignorance of the obferver. The caft of a die, as regularly follows the laws of motion, as the going of a watch; yet, becaufe we can trace the operation of thofe laws through the works and movements of the watch, and cannot trace them in the fhaking and throwing of the die, (though the laws be the fame, and prevail equally in both cafes,) we call the turning up of the number of the die chance, the pointing of the index of the watch, machinery, order, or by fome name which excludes chance. It is the fame in thofe events which depend upon the will of a free and rational agent. The verdict of a jury, the fentence of a judge, the refolution of an affembly, 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

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

The *seasons* are a mixture of regularity and chance. They are regular enough to authorize expectation, whilst their being, in a considerable degree, irregular, induces, on the part of the cultivators of the soil, a necessity for personal attendance, for activity, vigilance, precaution. It is this necessity which creates farmers; which divides the profit of the soil between the owner and the occupier; which, by requiring expedients, by increasing employment, and by rewarding expenditure, promotes agricultural arts and agricultural life, of all modes of life the best, being the most conducive to health, to virtue, to enjoyment. I believe it to be found in fact, that where the soil is the most fruitful and the seasons the most constant, there the condition of the cultivators of the earth is the most depressed. Uncertainty, therefore, has its use even to those who sometimes complain of it the most. Seasons of scarcity themselves are not without their advantages. They call forth new exertions; they set contrivance and ingenuity at work; they

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 whom 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

dition 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

wants of mankind in a ſtate of civilization, and ſtill more in a ſtate of refinement, require to be done.

It appears to be alſo true, that the exigencies of ſocial life call not only for an original diverſity of *external* circumſtances, but for a mixture of different faculties, taſtes, and tempers. Activity and contemplation, reſtleſſneſs and quiet, courage and timidity, ambition and contentedneſs, not to ſay even indolence and 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,

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,

kind, 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 is it 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,

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 diſturbed by it. Or if it be ſtill aſked, Of what uſe at all then is the doctrine, if it neither alter our meaſures nor regulate our conduct? I anſwer again, that it is of the greateſt uſe, but that, it is a doctrine of ſentiment and piety, not (immediately at leaſt) of action or conduct; that it applies to the conſolation of men's minds, to their

devotions,

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 connection, 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 brought about by wise expedients, of concerted trains of causes terminating in the happiest results; so much, in a word, of counsel, intention, and benevolence: a mind, I say, drawn into the habit of thought which these observations excite, can hardly turn its view to the condition of our own species, without 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

or become their own. If it be ſaid, that this is to enter upon a religious rather than a philoſophical conſideration, I anſwer that the name of religion ought to form no objection, if it ſhall turn out to be the caſe, that the more religious our views are, the more probability they contain. The degree of beneficence, of benevolent intention, and of power, exerciſed in the conſtruction of ſenſitive beings, goes ſtrongly in favor, not only of a creative, but of a continuing care, that is, of a ruling Providence. The degree of chance which appears to prevail in the world requires to be reconciled with this hypotheſis. Now it is one thing to maintain the doctrine of Providence along with that of a future ſtate, and another thing without it. In my opinion, the two doctrines muſt ſtand or fall together. For although more of this apparent chance, may perhaps, upon other principles, be accounted for, than is generally ſuppoſed, yet a future ſtate alone rectifies all diſorders; and if it can be 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 Indian ſlave, who, amidſt his wrongs, retains his benevolence, I, for my part, look upon, as amongſt the foremoſt of human candidates for the rewards of virtue. The kind maſter of ſuch a ſlave, that is, he, who, in the exerciſe of an inordinate authority, poſtpones,

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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 condition into which we are caſt, but upon our behaviour in it; then is it a much more fit ſubject of *chance* than we

* 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.

uſually

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 purpofes, may happen to fet them out; but the event is governed by that which depends upon themfelves, the application of what they have received. In dividing the talents, no rule was obferved; none was neceffary; in rewarding the ufe of them, that of the moft correct juftice. The chief difference at laft appears to be, that the right ufe of more talents, i. e. of a greater truft, will be more highly rewarded, than the right ufe of fewer talents, i. e. of a lefs truft. And fince, for other purpofes, 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 apprehenfions of diftributive juftice, than this is?

We have faid, that the appearance of *cafualty*, which attends the occurrences and events of life, not only does not interfere with its ufes, as a ftate of probation, but that it promotes thefe ufes.

Paffive virtues, of all others the fevereft and the moft fublime; of all others, perhaps, the moft acceptable to the Deity; would, it is evident, be excluded from a conftitution, in which happinefs and mifery regularly followed virtue

and

and vice. Patience and compofure under diftrefs, affliction, and pain; a fteadfaft keeping up of our confidence in God, and of our reliance upon his final goodnefs, at the time when every thing prefent is adverfe and difcouraging; and (what is no lefs difficult to retain) a cordial defire for the happinefs of others, even when we are deprived of our own: thefe difpofitions, which conftitute, perhaps, the perfection of our moral nature, would not have found their proper office and object in a ftate of avowed retribution; and in which, confequently, endurance of evil would be only fubmiffion to punifhment.

Again; one man's fufferings may be another man's trial. The family of a fick parent is a fchool of filial piety. The charities of domeftic life, and not only thefe, but all the focial virtues, are called out by diftrefs. But then, mifery, to be the proper object of mitigation, or of that benevolence which endeavours to relieve, muft be really or apparently cafual. It is upon fuch fufferings alone that benevolence can operate. For were there no evils in the world, but what were punifhments, properly and intelligibly fuch, benevolence would only ftand in the way of juftice. Such evils, con-

fiftently

fiſtently 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,

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.

CHAP-

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

the ſocket of the hip joint, the pulley or trochlear muſcle of the eye, the epiglottis, the bandages which tie down the tendons of the wriſt and inſtep, the ſlit or perforated muſcles at the hands and feet, the knitting of the inteſtines to the meſentery, the courſe of the chyle into the blood, and the conſtitution of the ſexes as extended throughout the whole of the animal creation. To theſe inſtances, the reader's memory will go back, as they are ſeverally ſet forth in their places: there is not one of the number which I do not think deciſive; not one which is not ſtrictly mechanical: nor have I read or heard of any ſolution of theſe appearances, which, in the ſmalleſt degree, ſhakes the concluſion that we build upon them.

But, of the greateſt part of thoſe, who, either in this book or any other, read arguments to prove the exiſtence 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 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 understandings 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

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 glides and 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, poſfeſſed 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, will or can 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

bending a hooked tooth, concerting and providing an appropriate mechanifm, for the clafping and reclafping of the filaments of the feather of a humming bird. We have proof, not only of both thefe works proceeding from an intelligent agent, but of their proceeding from the fame agent: for, in the firft place, we can trace an identity of plan, a connection of fyftem, from Saturn to our own globe; and when arrived upon our globe, we can, in the fecond place, purfue the connection through all the organized, efpecially the animated, bodies which it fupports. We can obferve marks of a common relation, as well to one another, as to the elements of which their habitation is compofed. Therefore one mind hath planned, or at leaft hath prefcribed a general plan for, all thefe productions. One Being has been concerned in all.

Under this ftupendous Being we live. Our happinefs, our exiftence, is in his hands. All we expect muft come from him. Nor ought we to feel our fituation infecure. In every nature and in every portion of nature, which we can defcry, we find attention beftowed upon even the minuteft parts. The hinges in the wings of an *earwig*, and the joints of its

antennæ,

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 ſerioufneſs, not only to all that can be diſcovered concerning him by reſearches into nature, but to all that is taught by a revelation, which gives reaſonable proof of having proceeded from him.

But, above every other article of revealed religion, does the anterior belief of a Deity, bear with the ſtrongeſt force, upon that grand point, which gives indeed intereſt and importance to all the reſt—the reſurrection of the human dead. The thing might appear hopeleſs, did we not ſee a power at work adequate to the effect, a power under the guidance of an intelligent will, and a power penetrating the inmoſt receſſes of all ſubſtance. I am far from juſtifying the opinion of thoſe, who "thought it a thing incredible that God ſhould raiſe

raiſe the dead;" but I admit that it is firſt neceſſary to be perſuaded, that there *is* a God to do ſo. This being thoroughly ſettled in our minds, there ſeems to be nothing in this proceſs (concealed as we confeſs it to be) which need to ſhock our belief. They who have taken up the opinion, that the acts of the human mind depend upon *organization*, that the mind itſelf indeed conſiſts in organization, are ſuppoſed to find a greater difficulty than others do, in admitting a tranſition by death to a new ſtate of ſentient exiſtence, becauſe the old organization is apparently diſſolved. But I do not ſee that any impracticability need be apprehended even by theſe; or that the change, even upon their hypotheſis, is far removed from the analogy of ſome other operations, which we know with certainty that the Deity is carrying on. In the ordinary derivation of plants and animals from one another, a particle, in many caſes, minuter than all aſſignable, all conceivable dimenſion; an aura, an effluvium, an infiniteſimal; determines the organization of a future body: does no leſs than fix, whether that which is about to be produced, ſhall be a vegetable, a merely ſentient, or a rational being; an an oak, a frog, or a philoſopher; makes all theſe differences; gives to the future body its qualities, and nature, and ſpecies. And this particle, from which ſprings, and by which is determined a whole future nature, itſelf proceeds from, and owes its conſtitution to, a prior body: nevertheleſs, which is ſeen in plants moſt deciſively, the incepted organization, though formed within, and through, and by a 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 becaufe confcioufnefs carries identity and individuality along with it through all changes of form or of vifible qualities. In the moft general cafe, that, as we have faid, of the derivation of plants and animals from one another, the latent organization is either itfelf fimilar to the old organization, or has the power of communicating to new matter the old organic form. But it is not reftricted to this rule. There are other cafes, efpecially in the progrefs of infect life, in which the dormant organization does not much refemble that which inclofes it, and ftill lefs fuits with the fituation in which the inclofing body is placed, but fuits with a different fituation to which it is deftined. In the larva of the libellula, which lives conftantly, and has ftill long to live, under water, are defcried the wings of a fly, which two years afterwards is to mount into the air. Is there nothing in this analogy? It ferves at leaft to fhew, that, even in the obfervable courfe of nature, organizations are formed one beneath another; and, amongft a thoufand other inftances, it fhews completely, that the Deity can mold and fafhion the parts of material nature, fo as to fulfil any purpofe whatever which he is pleafed to appoint.

They

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

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

* See Search's Light of Nature, passim.

formed, for the moral and accountable part of his terreſtrial creation. That great office reſts with him: be it ours to hope and to prepare: under a firm and ſettled perſuaſion, that, living and dying, we are his; that life is paſſed in his conſtant preſence, that death reſigns us to his merciful diſpoſal.

FINIS.