DIALOGUES ON INSTINCT;

WITH

ANALYTICAL VIEW OF THE RESEARCHES

ON

FOSSIL OSTEOLOGY.

BY

HENRY, LORD BROUGHAM, F.R.S.,

And Member of the National Institute of France.

LONDON:

CHARLES KNIGHT AND CO., LUDGATE STREET.

1844.

12280

NOTICE FROM THE EDITOR OF THE WEEKLY VOLUME.

Lord Brougham has kindly consented to the republication, in this cheap and compact form, of his "Dialogues on Instinct" and his "View of the Researches on Fossil Osteology," which formed a considerable part of his "Dissertations on subjects of Science connected with Natural Theology," in the two supplementary volumes of the edition of Paley's "Natural Theology," in 5 vols., by Lord Brougham and the late Sir Charles Bell. Lord Brougham has translated the Latin quotations for this edition.

CONTENTS.

OF INSTINCT.

Place—Brougham, in Westmoreland.

Time—Sept. 1837.

Persons—*A.* Lord Spencer (Althorp).

B. Lord Brougham.

OF INSTINCT.

BOOK, OR DIALOGUE I.

INSTINCT—Introduction; (Facts).

When the General Election of 1837 was near its close, and every day brought the accounts of those mighty boasts of our expected successes under the new reign, so idly made, being overthrown by the activity and resources of our adversaries and the listlessness of the people on our behalf, Lord A. came to me on his way to the North, where he was minded to diversify with field-sports his habitual life of farming. Those pursuits had never interfered with the duty he owed his country as long as he deemed that the sacrifice of all his domestic comforts could prove serviceable to his public principles; nor had they ever at any time prevented him from cultivating a sound philosophy, in the study of which much of his leisure is always consumed. When I passed a few days with him at Wiseton, the summer before, we had discussed together some of the more interesting topics which form the subject of these speculations, connected with Natural Theology, though of a substantive interest independent of the relation in which they stand to that sublime inquiry; and, while I remained at Harrington, we had corresponded constantly on the subject of Instinct, one of the most curious in its minute details and of the most interesting in its bearings upon the philosophy of mind, independent of its immediate connexion with theological speculations, but, it must at the same time be admitted, one of the most difficult, and upon which the labours of philosophers have cast a very imperfect light. It was natural then that we should renew these discussions when we afterwards met in Westmoreland. The weather being fine, we ranged somewhat among the lake scenery, and by the rivers and through the woods which variegate our northern country. There was not much to tempt us in the aspect of public affairs, which, if not gloomy for the country at large, was yet not very flattering for the liberal party, among whom the single object seemed now to be the retention of office, and who might say with the Roman patriot in the decline of liberty,—"Nostris enim vitiis, non casû aliquo, rempublicam verbo retinemus, reapse vero jampridem amisimus."* Nor, indeed, on these matters was there a perfect agreement between us two; for while we augured as little favourably the one as the other of our prospects, we ascribed to different causes the condition of affairs which gave rise to these forebodings: he, tracing it to the great natural weight and influence of the Tories throughout the country, both in church and state; I, relying more on the energies of an improved and active people, provided the government

* "By our own misconduct, not by any calamity, though we may still have the name of a free government, we yet have lost the reality."—Cic. Frag. de Rep. lib. v.

had acted so as to merit their support; but lamenting that no pains had been taken by them to show any superiority of popular principles, or make the country feel itself better off under their rule than they would have been under the adverse faction, while I perceived sufficiently plain indications that the accession of the Court favour in this new reign would have the effect of lessening rather than promoting any popular tendencies which might still exist. Altogether, therefore, the state of the commonwealth was a subject less suited to engage our conversation; and we naturally dwelt little upon passing and unpleasing topics, as unsatisfactory, transitory, and fleeting—"ista quæ nec percunctari nec audire sine molestiâ possumus."* But upon those matters of permanent interest and universal importance, and which the follies or faults of men could not despoil of their dignity or deprive of their relish, we loved to expatiate; and coming to the island in the neighbouring river, found a convenient seat where the discussion might be carried on under the cool shade which the wood afforded against an autumnal sun: "Here," said I, "we may resume our Wiseton conversation."—"Ventum in insulam est. Hâc vero nihil est amœnius; utenim hoc quasi rostro finditur Fibrenus, et divisus equaliter in duas partes latera hæc alluit, rapideque dilapsus cito in unum confluit, et tantum complectitur quod satis sit modicæ palæstræ loci; quo effecto tanquam id habuerit operis ac muneris ut hanc nobis efficeret sedem ad disputandum, statim præcipitat in Lirem."†—"Here," said I, "we may

* "Things which we can neither inquire about nor hear without vexation."—Cic. Acad. Quæst. lib. ii.

† "We came to the island. But than this spot nothing

resume our Wiseton conversation;" "si videtur considamus hic in umbrâ, atque ad eam partem sermonis ex quâ egressi sumus revertamur."*

A. Have you reconsidered my opinion, or rather the inclination of opinion, which I had last year, that it will be advisable, if not necessary, to begin with defining Instinct, in order that we may the more clearly understand what we are discussing?

B. I have indeed; and I remain of my own, as often happens through obstinacy and unwillingness to give up a preconceived notion; but here it is, I believe, from much reflection upon the subject, that I still regard the definition as rather the end of our inquiry than its commencement. Indeed, this may generally be observed of metaphysical, or rather psychological inquiries: they are not like those of the mathematician, who must begin by defining; but that is because his definition is, in fact, a statement of part of the hypothesis in each proposition. Thus, whoever enunciates any proposition respecting a property of the circle predicates that property of a figure whose radii are all equal; and it is as if he began by saying, "Let there be a curve line, such that all the straight lines drawn from its points to another point within

can be more agreeable; for here the Fibrenus is split as by the prow of a vessel, and being divided into two equal branches, washes the sides; then, after rapidly separating, it quickly unites in one stream, embracing space enough of ground for a moderate-sized place of exercise: after which, as if it only had the work and office of providing us with a seat for our discussion, it straightway falls into the Liris."—Cic. de Leg. lib. ii.

* "If you please we may here sit down under this shade, and revert to that part of our conversation from which we had departed."—Cic. de Leg. lib. ii.

it are equal, then I say that the rectangles are equal, which, &c." The general definition only saves the trouble of repeating this assumption, as part of the hypothesis in each proposition. But the nature of instinct, or of any other thing of which we discourse in psychology, is not the hypothesis we start from; it is the goal or conclusion we are seeking to arrive at. Indeed, so it is in physical science also; we do not begin, but end, by defining the qualities of bodies, or their action on one another.

A. I grant this. But if there be more things than one which men call by the same name, for example, of Instinct, must we not begin by ascertaining what we mean by the word, in order to avoid confusion? And this seems to bring on the necessity at least of some definition.

B. I agree that there must in this case be a definition; but it is only a definition of terms, and does not imply our stating the nature of the thing defined: it only implies that we must understand what the thing is to which the given word applies, and, if two things go under the same name, that we should be agreed in the outset which of the two things we mean when we use the word; perhaps, that we invest some second name, or give some qualifying addition to the given one, to express one of the two things, and keep the different meanings distinct.

A. The best way will be that we should come to particulars—give an example or two: perhaps it may suffice to mention the different kinds of Instinct, if, which I take for granted you do not doubt, there be more things than one going under that name.

B. Certainly; and there can here be no difficulty at all in our way; and, to show you how little alarmed I am at defining, when it is clear that I am only called upon to define a word, and thereby make a distinct reference to a thing known or unknown in its own nature—not to pretend giving an account of that nature—I will at once begin by both inventing names and defining their meaning. There are some Instincts which may be called *physical*, and others *mental*, in the animal system; by physical I mean those actions or motions or states of body which are involuntary; as the action of the heart, and the peristaltic motion of the bowels, over which, generally speaking, we have no direct control by the operation of the will—for I put out of view such rare instances, almost monstrous, as Darwin has recorded of a person who could suspend the pulsations of his heart at pleasure, and another, still more rare, of one who could, at will, move his bowels by accelerating the peristaltic action.* Even if all men could acquire such control over those motions, they would still be involuntary; because they could still be carried on wholly without our will interfering, and without our minds necessarily having any knowledge whatever of them. So the secretions are all performed involuntarily, and may go on wholly without our knowledge; we can affect them as we can the involuntary motions of the heart and fluids, indirectly, because the passions and feelings of the mind have always an effect upon them; but still they exist and proceed, the parts perform their functions, and those functions serve the ends of their appointment, wholly independent

* Zoonomia.

of our will, or of any effort whatever on our part. We can affect them also immediately through the influence of physical agents, voluntarily applied as stimulants or sedatives, or the operation of voluntary motion, as well as mediately by the power which the mind derives from its union with the body; but they can go on of themselves, and, in all cases of healthy condition, go on better without any the least interruption on our part than with it.

A. This is certain: my only doubt is whether these can be justly or correctly termed instinctive operations at all. When I speak of Instinct, I mean something very different; namely, those voluntary movements, or that voluntary action of the mental faculties which is contradistinguished from reason. However, there is no harm, but much convenience, in beginning by defining and classifying, so as to leave on one side the physical and involuntary instincts—those things which may properly enough be called incidents of animal life, because there seems great difficulty in drawing a line between such motions and actions and those which subsist in vegetables.

B. There does certainly appear to be this difficulty. I hardly see how any line can be drawn between the motions of the lowest species of animal, the mollusca for instance, and those found in plants. There is in both organized form, a system of vessels, growth by extension not by apposition, a circulation of fluids and secretion of solids from those fluids, or of one fluid from another. There is also production of seed, and from the seed continuation of the species. But it is not only convenient that we should define in order to leave on one side what we are not to discuss, that it may not confound our inquiry; the definition and classification may also carry us on, some little way, in our argument with respect to the other class of Instincts, Instinct properly so called, the Mental Instincts; at least, it seems to furnish us at the very outset with an analogy.

A. I have a dread, at least a suspicion, of all analogies, and never more than when on the slippery heights of an obscure subject; when we are as it were *inter apices* of a metaphysical argument, and feeling, perhaps groping, our way in the dark or among the clouds. I then regard analogy as a dangerous light, a treacherous *ignis fatuus*.

B. It is even so, if we follow it beyond where we can see quite clear and find a firm footing. But all light is good, and the best way is not to despair, still less put out any glimmering we have, but rather to increase it by adding others, or make it available by using apt instruments. However, we are getting too metaphorical: only it is my comfort that you began, and that I am led astray by one who (as you said in your inimitable letter to your Lancashire antagonist) is not one of "the eloquent people." But to return from where your poetical imagery led us—analogy may sometimes illustrate, and it may often lead to useful and strict inquiry, by suggesting matters for comparison and investigation.

A. Then what comparison do you make between the two kinds of Instinct? or rather, as the question is of analogy, how do you state a relation of the mental Instinct, which we shall call Instinct simply if you please, similar to or identical with some relation of physical Instinct?

B. As thus—the physical Instincts are independent of will, or mind altogether, though they never are found except where animal life and consequently mind exists; but yet mind may influence them. Just so the mental Instincts are independent of reason altogether, though they are found in union with it and reason may influence them. It is a question if they are ever found without reason; for that depends on our solution of the *vexata quæstio*, "Whether the lower animals have reason at all or no?" Therefore, I will not say that here the analogy is complete, and will not affirm that, as physical Instinct is never found without animal life, so mental Instinct is never found without reason; but we may safely say that in this other respect the analogy is perfect, namely, that where mental Instinct is found with reason it can act without reason, though reason may also interfere with it; and in this respect, at least, reason seems to bear the same relation to mental Instinct which animal life bears to physical Instinct. We may go further, and add, that as in plants, where the motions are without animal life, those motions are more perfect and more undisturbed, so if there be any animal wholly without reason, the operations of mental Instinct are the more regular and perfect; and, in any animal whatever, they are so in proportion as reason is dormant or inactive.

A. It may be as you say; but this will not carry us, as you seem to be aware, far on our road. However, it is well enough to remark it; for we thus gain perhaps a clearer and more steady view of the relation between Reason and Instinct, always supposing that there is any warrant for treating the two as different: because you are aware that some have considered them as identical: I mean not merely by denying that there is any specific difference, any difference in kind, between our faculties and those of brutes—though this denial is of course involved in their doctrine—but by going a step further, and holding that what we call our Reason, and are so proud of, is merely a bundle of Instincts, as some have termed it—a more acute and perfect degree of Instinct. Smellie, in his entertaining work on the Philosophy of Natural History, holds this opinion.—That is a book, by the way, much less esteemed than it deserves, even as a collection of facts and anecdotes; but I also think the honest printer (for such he was) had a good deal of the philosopher in him. I suppose, as the well-educated printers in the foreign university towns, and some of our own Oxford men, used to be critics and scholars, from the atmosphere of the place, so your Edinburgh printer, when well bred, is a metaphysician.

B. You are right as to Smellie at least, and I agree with you as to his book, though it is too long, and in parts loosely reasoned, as well as not over-accurate in his facts, according to what I have heard from naturalists. But he was a man of considerable merit; and lived a good deal in the literary and scientific circles of Edinburgh. I knew him, but slightly. He would have done much more had his habits been less convivial. But I rather fancy the somewhat pretending title of his book tended to make men disallow the merit which it unquestionably has.

A. But what do you hold of the dogma in question, and of which he is perhaps the most round asserter?

B. I entirely deny it; nor do I conceive that any part of the subject is more free from all doubt than this, unless indeed we come to the question of liberty and necessity, and resolve the whole into a mere dispute about terms.

A. Liberty and necessity! preserve us!—I am taken by surprise. Why I had no idea that we could ever have got among those heights and clouds already—" apart set on a hill retired," and reasoning on " free-will," like the gentry more acute than amiable, who held their metaphysical disputations there.

B. Don't be alarmed—but the subjects in one single point do certainly touch. What I mean is this: if you say that, when a man reasons, one idea suggests another, and that he must follow the train, and can no more avoid drawing his conclusion, when he compares two ideas, than a bird can avoid building its nest in a particular fashion, or a bee can help making hexagonal cells, then you seem doubtless to liken Reason with Instinct. But this is true only on the supposition that a man's mind is mechanical, and that his faculties are placed beyond his control. Now, suppose it to be admitted that I cannot avoid drawing a certain conclusion from premises in mathematical matters—as that the three angles of a figure are equal to two right angles, if that figure have those three angles only—I am under no such necessity in any question of moral or probable evidence; and on a question like that different minds will differ, or the same mind at different times. Again, I am under no necessity—even if I admit that I have no choice on moral evidence—I am under *no necessity* of exercising my volition in one given way, unless indeed you deny that I have ever any free-will at all. If so, and if you contend that, the same motives being presented to my volition in the same circumstances, I must needs choose the same course, you may also contend that, the same circumstances being presented to my judgment in the same frame of the feelings, I must needs draw the same conclusion; and this may seem to make out an identity of Reason with Instinct: but this is the dispute of liberty and necessity which every man's consciousness and hourly experience decides in favour of liberty, except in so far as it is a mere dispute about terms. But I really do think that, allowing the question to be disposed of either way, there is a specific difference between Reason and Instinct: for, even upon the principle of necessity, suppose the man and the bee to be equally under the entire control of the premises in reasoning, and the circumstances or motives in willing, whatever it is that each does, be it the necessary consequence of the circumstances or not, is different in the two cases. Suppose that if the bee reasoned she would be under the necessity of drawing the same conclusion, and that if she exercised an election, she could not avoid choosing one course, and that it is the same with the man—it still is not only not proved that the bee does reason or choose, while we know that the man does, but the contrary seems proved.

A. How so? Were I to maintain the contrary I should deny that we have any such proof. How do you prove the negative proposition, that the bee does not reason and will?

B. Observe, I do not say we have the proof of the negative as clearly as we have of the affirmative. But, beginning with laying aside those actions of animals which are either ambiguous or are referable properly to reason, and which, almost all philosophers allow, show a glimmering of reason; and confining ourselves to what are purely instinctive, as the bee forming a hexagon without knowing what it is, or why she forms it; my proof of this not being reason, but something else, and something not only differing from reason in degree but in kind, is from a comparison of the facts—an examination of the phenomena in each case—in a word, from induction. I perceive a certain thing done by this insect, without any instruction, which we could not do without much instruction. I see her working most accurately without any experience, in that which we could only be able to do by the expertness gathered from much experience. I see her doing certain things which are manifestly to produce an effect she can know nothing about, for example, making a cell and furnishing it with carpets and with liquid, fit to hold and to cherish safely a tender grub, she never having seen any grub, and knowing nothing of course about grubs, or that any grub is ever to come, or that any such use, perhaps any use at all, is ever to be made of the work she is about. Indeed, I see another insect, the solitary wasp, bring a given number of small grubs and deposit them in a hole which she has made, over her egg, just grubs enough to maintain the worm that egg will produce when hatched —and yet this wasp never saw an egg produce a worm—nor ever saw a worm—nay, is to be dead long before the worm can be in existence—and moreover she never has in any way tasted or used these grubs, or used the hole she made, except for the prospective benefit of the unknown worm she is never to see. In all these cases, then, the animal works positively without knowledge, and in the dark. She also works without designing anything, and yet she works to a certain defined and important purpose. Lastly, she works to a perfection in her way, and yet she works without any teaching or experience. Now, in all this she differs entirely from man, who only works well, perhaps at all, after being taught—who works with knowledge of what he is about—and who works, intending and meaning, and, in a word, designing to do what he accomplishes. To all which may be added, though it is rather perhaps the consequence of this difference than a separate and substantive head of diversity, the animal works always uniformly and alike, and all his kind work alike—whereas no two men work alike, nor any man always, nay any two times alike. Of all this I cannot indeed be quite certain as I am of what passes within my own mind, because it is barely possible that the insect may have some plan or notion in her head implanted as the intelligent faculties are: all I know is the extreme improbability of it being so; and that I see facts, as her necessary ignorance of the existence and nature of her worm, and her working without experience, and I know that if I did the same things I should be acting without having learnt mathematics, and should be planning in ignorance of unborn issue; and I therefore draw my inference accordingly as to her proceedings.

A. Come, come, Master B., I begin to surround you and drive you from your original position, maintained both now and last summer, about the impossibility of defining. Have you not as nearly as possible been furnishing a definition? At least, are not the materials of definition brought together which you deprecated, and would have us reserve to the last?

B. Patience, good man—patience! What is this to what you have gone through? Fancy yourself once more in the House of Commons, on the Treasury bench, listening to ——— ———

A. God forbid!

B. Or suppose yourself again in Downing Street, with Drummond announcing a succession of seven deputations or of seventeen suitors.

A. The bare possibility of it drives me wild. Why, to convert you to the most absurd doctrine I could fancy—to make you swallow all the Zoonomia whole, and believe that men derive their love of waving lines and admiration of finely-moulded forms from the habit of the infant in handling his mother's bosom, or even to drive you into a belief that the world was made by chance—would be an easy task compared to the persuading any one suitor at any one of the offices that you had any difficulty in giving him all he asks, or convincing any one of those seven deputations that there exists in the world another body but itself.

B. Or to convince any one man, who ever asked any one job to be done for him, that he had any one motive in his mind but the public good, to which he was sacrificing his private interest. I remember M. [Melbourne] once drolly observing, when I said no man could tell how base men are till he came into office, "On the contrary, I never before had such an opinion of human virtue; for I now find that no man ever drops the least hint of any motive but disinterestedness and self-denial—and all idea of gain, or advantage, is the only thing that none seem ever to dream of." But now compose yourself to patience and discussion—take an extra pinch of snuff—walk about for five minutes, a distance of five yards and back, with your hands in your breeches' pockets, and then return to the question with the same calmness with which you would have listened to a man abusing you by the hour in Parliament, or with which you looked an hour ago, in the Castle farm, at the beast you had bred, and which by your complacent aspect I saw you had sold pretty well.

A. But, indeed, I sometimes can't help fancying that it may be as well to take our observations upon Instinct from the operations and habits of such large animals as him you speak of—at least, not from insects; because it is possible that if we could see as accurately all the detail of the latter as we do of the former, much of the marvellous might disappear, and we might be as well able to account for their proceedings, which now seem to us so unintelligible, as we are to account for those of the greater animals, which are clumsy and cumbrous enough, and rather appear to proceed from an obscure glimmering of reason than from an inexplicable power guiding them unconsciously to work with the perfection which we ascribe to the bee. In a word, might not the cells be found to have as many imperfections, as great deviations from the true form, as any of the ox's operations have from perfect exactness, if either the bee were as large as the ox, or our senses as acute as the bee's? Has she not as great aberrations from the exact pattern in proportion to her own size and to the instruments, her feet and feelers, which she works with? I throw this out as a matter very fit to be settled in the outset, in order that our own reasoning may not proceed upon gratuitous assumption.

B. For the sake of ascertaining how far the working is as perfect as it appears, I admit the importance of your observation; but for nothing more. I deny that it affects the body of the argument at all; because that depends in no degree upon the perfection of the work. Thus the proceedings of the solitary wasp are just as good for my purpose as those of the bee. Nay, the instinctive operations of the greater animals furnish exactly the same materials for reasoning, though they may not be so striking. However, to the point of your comparison—you must keep in mind that we have applied the powers of the microscope to the operations of the bee. Now, without going to an instrument of the power of Torre's, which magnified the linear dimensions between 2000 and 3000 times, and consequently the surface above 6,000,000 of times, take the much more ordinary power of 400, which magnifies the surface 160,000-fold—nay, if you take a microscope of only a 90-times magnifying power, you will see the work of the bee in a straight line, exactly as you do that of a man with the naked eye. But, I need hardly add that, if you only saw it a quarter as well, or with a glass that magnified 20 times, it would be enough: for then you would examine it as you do the beaver's with your naked eye. But, further, all the difficulty you suggest proceeds upon a fallacy. The lines may not be exactly even which the bee forms; the surfaces may have inequalities to the bee's eye though to our sight they seem plane; and the angles, instead of being pointed, may be blunt or roundish: but the proportions are the same; the equality of the sides is maintained, and the angles are of the same size; that is, the inclination of the planes is just—in other words, all the inequalities don't affect the proportions of the parts; for they are common to each thing compared with another; the axis running through the inequalities (to speak more rigorously) is in the true direction, and the junction of the two axes forms the angle of 60° as accurately as if there were no inequalities. Now, then, the bee places a plane in such a position, whatever be the roughness of its surface, that its inclination to another plane is the true one required.

A. I suppose it is so; but, at any rate, the solitary wasp carrying the grubs in proper number and placing them in the hole over the egg, or the bee placing her egg in the liquor at the bottom of the cell, and making that cell of the length to which the worm when hatched will grow—she having never seen either the worm or the chrysalis—is sufficient for our purpose.

B. Not to mention the operations of the worm itself in spinning the cocoon, and making it precisely the size required to line or carpet the cell when expanded and applied to it—nay, the motions of the chick in the egg, which always begins at the same place, and moves itself on in the same direction, chipping away till it effects its own liberation—all of which must be prior to experience, and without the possibility of teaching.

A. You desired me last summer to examine, with a view to the same point, the ducklings hatched under a hen, and then taking the water, without the possibility of her teaching. They have the form, web-feet, &c., which enables them to swim, and which a chicken has not. Their manner of getting into the water I cannot say I well ascertained; but it is certain enough that the hen's proper brood would not have got in, and probably she would have succeeded in preventing them, though she might not be able to keep the ducklings out.

B. However, a more decisive case occurred to me afterwards: that of chickens hatched in the Egyptian ovens. I have lately seen an intelligent Bey and his aide-de-camp, who gave me the whole process; and, as was to be expected, there is not the slightest difference between the conduct and motions, and habits generally, of these chickens, and of such as are hatched and brought up by hens. This fact, as well as the working of the chrysalis in spinning the cocoon, and of the chick in chipping with its bill-scale, renders it quite unnecessary to inquire whether or not the honey-bee or social wasp work by instruction from other bees or wasps. That, however, appears to be impossible, when we consider that as many as 30,000 young insects come from one nest, to teach whom there are not old ones anything like enough; and to teach whom in a few hours, or even days, to work as exactly as themselves seems wholly impossible. The observation of cases where such teaching is impossible, as in the chrysalis and unhatched chicken, at once removes all doubt, and precludes the possibility of supposing that the wasp's and the bee's architecture can be traditional, or handed down by teaching, from the first insects of the species that were created. Henceforward, therefore, we must assume as part of the fact that the cells of the bee are made without any instruction or any experience, and are as perfect at first as they ever are; which, by the way, explains another peculiarity of instinct—that it never improves in the progress of time. The bee, 6000 years ago, made its cells as accurately, and the wasp its paper as perfectly, as they now do.

A. Let us advert to one thing more, and, having settled it, the way may at least be said to be cleared for the argument, perhaps somewhat of progress even to be made in the inquiry. You have been speaking of Instincts in the plural; of course you do not mean to be taken literally, as admitting more kinds of mental Instinct than one.

B. Certainly not; any more than when speaking of the mental faculties I admit of more minds than one, or more parts than one of a single mind. This last form of speech has been so used, or rather abused, especially by the philosophers of the Scottish school, accurate and strict as they for the most part are, that they seem to treat the mind as divided into compartments, and to represent its faculties as so many members, like the parts of the body. But it is one thing or being perceiving, comparing, recollecting—not a being of parts, whereof perception is one, reasoning another, and recollection a third; so Instinct is one and indivisible, whatever we may hold it to be in its nature, or from whatever origin we may derive it. This thing, or being, is variously applied, and operates variously. There are not different Instincts, as of building, of collecting food for future worms, of emigrating to better climates—but one Instinct, which is variously employed or directed. I agree with you, however, that we have now done something more than merely clearing away the ground. We have taken a first step, or, if you will, laid a foundation. We have ascertained the peculiar or distinctive quality of Instinct, and that which distinguishes it from Reason. It acts without teaching, either from others, that is, instruction, or from the animal itself, that is, experience. This is generally given as the definition or description of Instinct. But we have added another peculiarity, which seems also a necessary part of the description—it acts without knowledge of consequences—it acts blindly, and accomplishes a purpose of which the animal is ignorant.

A. I pause here and doubt of this addition. I perfectly admit the fact that it produces an effect, manifestly the object of its operation, and yet without knowing it, consequently without intending it or designing it. But there seems reason to think that it always intends to produce some one effect, and does produce it—that it has some one purpose, and accomplishes it, and so designs something which it does. Thus animals are impelled by hunger to eat; their eating produces chyle, blood, and all that is secreted from the blood; yet they had no design to promote their own growth and preserve their own life. At least they ate long before they had any such design or any knowledge that such would be the consequence of gratifying hunger. So of continuing their species. May not the solitary wasp, for instance, have its organs and its senses so constructed as to receive an immediate gratification from collecting and burying grubs? If so, her knowledge extended to one, the first, event, and she had the design in view of producing this event; though wholly ignorant of any subsequent event. The desire of the first event, the fact of that event being a gratification to the insect, was the means taken by the Creator of the insect for making her do that which was to produce the important consequence, forming the real object in view, though concealed from the animal. Thus we may conceive that the insect is endowed with an appetite for carrying grubs, and that this is so adjusted in point of intensity as to be satiated when just so many grubs are transported as will feed the next season's worm, which is endowed with the desire to eat these grubs, rejected as food by the parent insect. So the wasp's senses may make the flavour, or the smell (for that seems all she enjoys), of a living caterpillar more grateful than of a dead one; and hence she takes those that will keep sweet till her own grub is hatched.

B. I do not deny the possibility of all this; although there seems something gratuitous in it, and we possibly never can know the truth by any observations or experiments. I shall presently show why I do not think it would entitle us to erase this ignorance of what you would call the second event, or the object of the secondary design, from our list of the characteristics of Instinct. But in the meantime I will mention what occurs to me on your objection in point of fact. The instant that a solitary wasp is hatched, or a bee can fly, away they go to the spot where the caterpillars or the wax-yielding substances are to be found. What guides them through the air to things they cannot descry or do not know the use of?

A. It costs me no more to suppose that there is some smell or other sensation to guide them—some odour, for example, which penetrates the air, and being grateful to them makes them desire to approach the odoriferous body. Thus the bee smells the nectary of flowers; she flies to them, she sips, and the wax is secreted in her stomach. I grant you that I have more difficulty with her operation in using it.

B. You clearly have; for what should be the special gratification of that? We are admitting that she has no kind of knowledge that the cell is to be used in hatching and rearing the brood, any more than that an hexagonal figure, with a certain inclination of its rhomboidal bottom, is to enable her and her associates to employ the space and the wax in the way of all others most economical of room and work and materials; and so as just to accommodate the size of the unknown and unseen worm, chrysalis, or young bee, and no more—and also to suit its form.

A. I think I could suppose also in this case that her desire of action—her love of motion—is gratified by the operation, and is satiated by continuing that motion to a certain extent, where she stops.

B. But allowing your right to make all these suppositions equally gratuitous, one after another, and to extend them as the argument proceeds, and to relieve the pressure as the fact pinches—see what it is that you must assume. The comb is constructed thus. Wax-making bees bring a small mass of this material and place it vertically to the plane from which the comb is to hang down. Then other bees begin to excavate, one on one side, another on the other, and they work with such perfect nicety, as never to penetrate through the thin layer of wax; also so equally that the plate is of equal thickness all throughout, its surfaces being parallel. You must, therefore, suppose some repugnance at once to a plate ever so little thicker, and to one ever so little thinner than the plate's given thickness. Indeed, this supposition, which some naturalists have made, is wholly unsatisfactory, and shows no accurate regard to the facts any more than their notion (a most crude one) that the hexagon cells arise from so many cylinders pressing on each other. The supposed instinct not to perforate wax, but to draw back when they come to a given thickness, is inconsistent with the fact; for the original plate they work on is uneven and of different thicknesses on both sides, and there is no bee in the world that ever made cylindrical cells. Huber has distinctly shown, from having observed them at their work, that they make them in quite another way; nor indeed, if they did, could any pressure ever produce hexagons, and far less rhomboidal plates. The wax-worker's bringing plates of a given thickness is also wholly incapable of accounting for the angles, that is, the inclination of the plates—for supposing the bee to make a groove (as she does), and suppose she has some means of bisecting its arc by two chords, this only, with the thickness of the cake, would determine the depth of the rhomboid, and that can be easily shown not to be the rhomboid actually made. She therefore makes angles wholly independent of the thickness, not to mention that were we to admit that the cake's thickness governs the whole, we do not solve the problem; the difficulty is only removed a step; for then how is that exact thickness obtained? But this will not do even to that extent; a great deal more is done by the bee, and a great deal more must be supposed to make it conceivable that she has any immediate or primary intention. She works so that the rhomboidal plate may have one particular diameter and no other, and always the same length, and that its four angles may be always the same, the opposite ones equal to each other, but each two of different quantity from the other two; and then she inclines the plates at given angles to one another. Why is there such a gratification to the bee in a straight line—in a straight line at right angles to a plane—in rhomboids—in rhomboids with certain angles—any more than in lines or planes inclining at other angles to one another? Why is the bee, after working for half a quarter of a line in one direction, to go on, and not take delight in a change of direction? If she goes on, why is she to be pleased with stopping at one particular point? Nay, why is each bee to take delight in its own little part of the combined operation? Why is each to derive pleasure from doing exactly as much as is wanted, and in the direction wanted, in order that when added to what others have before done, and increased by what others are afterwards to do, a given effect, wholly unknown to her and to all the rest, her coadjutors, may be produced?

A. It certainly is difficult to say. I can barely imagine the different bees so formed that some inexplicable gratification may be the consequence of moving in one line, and making one angle, and that any other line or angle whatever may be disagreeable to them. The concert in the operation of animals seems to increase this difficulty much, always supposing there is real concert without any arrangement, communication, or knowledge. No man ever acted so as to make his operations chime in with another's, unless he either had previous concert with that other, or both acted under a common superior, and obeyed his direction; and then the joint operation was that of this superior. But suppose a man were compelled by some feeling he could not account for, and did not at all understand, to go at a given time, to a certain place, and with such speed as to arrive there at a given moment, and were to find another just arrived there, who came to meet him without the former previously knowing of this,—we should have a case similar to that of animals acting in concert, supposing them to do so. There is, however, some doubt of this as to the bees; for Huber has said that they all act in succession rather than co-operate contemporaneously.

B. I really can see no difference that this makes in the argument as to concert. One bee brings wax and does not sculpture; another sculptures and does not bring wax: but the wax-worker brings just as much as the sculpturing bee wants, and at the very time she wants it; also, one works on the face, and another on the back of the same rhomboidal plate; and all so work as never to interfere with or jostle one another, which is the perfection of concert, and can only among men be effected by discipline, which refers the whole of the different purposes to one superintendent, and makes his unity of design the guiding rule and impulse, because concert among the different agents is otherwise unattainable. But I own I can see no greater difficulty thrown in our way by concert than by blind agency—supposing it blind as to both the events, and not merely blind as to the secondary consequence—and your supposition of a first event known and designed, the secondary being hidden from the animal, would, I think, account for a case of concert, as much as for any other operation; for your hypothesis of sensations and impulses would apply to concert. You might say that each bee was induced by the gratification of doing a certain thing, to take a certain line at such a time; that what it did should answer to what some other bee was by the like means induced to do at the same time. I see no difference in the two applications of this hypothesis.

A. I rather think the time makes some difference; at least in rendering an addition to the hypothesis necessary. For though the gratification of bringing the caterpillars to its nest will account for the solitary wasp doing what is also to serve the purpose of feeding its young next season, something more is required than this motive to make one bee act in concert with another; it is necessary that there should be a gratification, not only in doing the thing required, but in doing it at the very moment required; so that both bees must be supposed to feel at the very same instant of time the desire of the gratification in question, and yet without any concert or communication. I hardly see how my supposition of sensations and pleasures or pains will explain this.

B. I all along have seen the greatest difficulty in your explanation; but does this consideration of time increase it materially?—or rather, is it not in all cases part of the riddle which instinctive operations present to us? Thus the solitary wasp acts, that is, according to your hypothesis, feels the given sensation or derives the supposed gratification at such precise time that her acting upon it will suit the time required for the birth and growth of the worm. The bird breeds,—but before laying her eggs, and without any knowledge when she is to lay them, makes her nest, and it is ready at the very time required. Therefore she feels the desire of nest-making at the proper moment. I will admit, however, that there is something still more extraordinary in two separate and independent insects feeling the same impulse at the same moment; and the difficulty is incalculably augmented, if twenty or thirty insects all have the impulse separately, but all at once, so as to act together. Indeed, I cannot help regarding your solution as not only a gratuitous hypothesis, for that it must needs be from the nature of the thing, but one hardly conceivable, and in truth as difficult to suppose possible as any other thing which we can fancy in order to explain the phenomenon—for instance, some invisible power or influence acting upon the animal, or upon the different animals at once. This is not at all more gratuitous, and it more easily explains the phenomenon.

A. Consider if there is really any such essential difference between the case of instinct which we have been considering, and any of the best known operations of men, as well as animals, where we are not wont to speak of instinct at all. Thus men eat from hunger, which they intend to satisfy; but the consequential effect, not intended, is chylification, sanguification, secretion, and growth or sustentation of the body, as well as the effect intended, and immediately produced, of satisfying hunger. The mother eats things which satisfy her appetite, and that is all she cares for; but those things also produce milk, which nourishes her infant, and that she never thought of. The time is also suited by the feeling. The hunger gives the supply when the system wants it; the eating produces the milk when the infant requires it. How does this differ from the other case?

B. Much every way. The difference is wide and marked. In the cases you put, the mental instinct is confined to produce the effect intended; and having produced it, the mind stops there and does nothing more. The powers of matter, its physical qualities, set in motion, do the rest, of course beyond our direct control, and unaided by us as unknown to us. But in the case of Instinct the mind performs both parts—both the things which it knows and intends, and the thing which it neither knows nor intends. The mother eats—nature produces the milk without the least action of hers. But the bee not only gratifies herself (if that is the cause of her architecture) by the structure of the cell, but by her art, by her work, she does the other thing also, that of providing a lodging for her young. It is as if the mother in your supposed case were both to eat intentionally for satisfying her hunger, and at the same time, without knowing or intending it, were to make milk by some process of internal churning. It is as if in eating we at once chewed and swallowed, and also with our tongue or teeth or fingers made chyme, and then chyle, and then blood. It is as if the animal in pairing both gratified his sexual passion and voluntarily made the young by some process of manipulation, though without knowing what he was about, or intending to do it.

A. You must here distinguish a little, or rather you must take into your account a point of resemblance which you are passing over. How can any one even acting with design affect matter in fashioning it or moulding it, except by availing himself of the powers, mechanical or chemical, belonging to matter? If I distil, it is by availing myself of the process of fermentation and of evaporation, and of condensation. If I sow and reap, it is by availing myself of the prolific powers of heat and moisture in the process of vegetation. So even in processes where I seem to do more and nature to do less; if I build, or carve, or weave, it is by availing myself of the qualities of cohesion and gravitation, and of the powers of the wedge in hewing, or of friction in polishing. Do not the animals who eat, the mothers who give suck after eating and thereby secreting milk, in like manner do part themselves, and as to the rest avail themselves of the powers of nature in chylification, sanguification, and secretion? You perceive how much more nearly akin the cases are than you have stated.

B. I am well aware of it; indeed, we are now coming nearly into the controversy about productive labour, which you and I have often amused ourselves with as political economists; when I have always held that it was a far less easy thing than those who discussed the metaphysical parts of that science supposed, to draw the line between productive and unproductive labour, either by including manufactures or only commerce in the latter—and agriculture alone or with manufactures in the former, the productive class. Be it so: I am content, if there be as marked a distinction here as between the labour which produces or moulds matter into a new substance, and that which only exchanges one thing for another; or defends the community, or administers justice among its members. But, in truth, we have, in our present argument, a specific difference, admitting all that you have urged, as to the affections and properties of matter being used by the animal in both processes. The great and broad difference is this. In the one case, as in the wasp carrying the caterpillar to its nest, which she does and means to do, or, if you will, gratifying her senses with the carrying, whatever instruments she works with, she does the thing knowingly and intentionally; she does it by means of gravitation and cohesion, but still it is she, her action, her will, her mind that does it. In the other case, that of leaving the caterpillar in the nest for months, she has done; she quits the work; nothing she does is at all conducive to the operation then performed by nature; but what she did was all that could be done excepting by nature. So the mother eats the galactigenous matter, and then has done; nature does all the rest. But there is this material difference in what the bee or the wasp does,—that she finishes the whole operation voluntarily; it is as if the mother were not only to become gravid, but to prepare the child's clothes and habitation herself, and yet to do this without knowing what she was about, and while she intended to do, and thought she was only doing, some perfectly different thing. If, indeed, you put the case of a person ploughing and sowing for the purpose of strengthening his limbs or amusing himself, and not meaning anything to grow, and also ignorant that anything will grow, and yet choosing the seed which will grow, and sowing it at the right time to make it grow—then you merely put the case of Instinct in other words; and the one thing will be as difficult to explain as the other. And if one man should, by mere blind chance, do this the first time, and some other man, equally ignorant of what the use of thrashed wheat was, should reap and thrash it, and garner it away—and if all men were to do so in two bodies, equally ignorant of what they were about, and yet both chiming in with each other in their operations, and both agreeing with the nature of things, then we should say this is the self-same case with Instinct—but we should add that this could not happen without some overruling power not only giving those men the desire to stretch their limbs, but guiding them immediately how to do it—for there, as here, two designs and only one designer appears, and therefore some non-apparent contriver must exist and work. We may again put it thus—When a man brews or tills, he does something himself, and leaves the rest to the powers of nature. So when a mother eats or drinks to gratify hunger or thirst, she has done; nature does the rest, namely, supports her body and secretes the milk for her young. But the bee or the wasp does the whole. They use the powers of matter, indeed, as the farmer and brewer do, and as the mother does, in the operation itself performed by them, namely, breaking the ground, throwing the seed, steeping the grain, eating the victuals—but the insects finish the operation, and leave nothing to be done. The solitary wasp has completed a cell and provided food; the young have only to eat it. The bee has completed a cell with food likewise. Neither mind nor matter on the part of either insect has anything more to do; the thing they intended and knew all about is done, and in doing that thing they did something else neither known to nor intended by them. They only used the powers of matter in doing the thing they intended. They did not leave any natural powers to do the other thing not intended by them; but they did it also, though unintentionally. Man does what he intended, but he does nothing more—nature does the rest, both where he intended it, as in ploughing or brewing, and where he did not, as after eating to satisfy his hunger. In the bee it is like a whole manufacture completed by the animal, though unintentionally; as if a man were to make a skein of fine lace while he only meant to amuse himself with twirling the bobbins, or playing with his fingers among the flax or the threads.

A. I certainly think we do get to something like a specific difference. But compare the work of the insect with certain chemical processes. If you mix, or if any natural process mixes, certain salts, and the liquor is left to evaporate, there are formed crystals, say hexagons, as accurately as the bee forms her cells. Also certain bodies move in lines which have properties similar to the angles in the comb, as a heavy body falling through the shortest of all lines. There is no doubt a difference here, and a marked one; yet it is as well to consider it.

B. Doubtless there is a difference, and the greatest possible. These forms are assumed, and these motions performed: for instance, a stone falling to the ground in the shortest line, or the planets, all arranged respecting their masses, the direction of their motions, and the inclinations of the planes they move in, so as, according to Laplace's beautiful theorem, to preserve the system of the universe steady, by affixing limits, maxima and minima, between which the irregularities oscillate; all these things are the direct and uninterrupted agency of the property which the Deity has impressed on matter at its creation; perhaps, of the laws which His power perpetually maintains. But they are wholly unconnected with any animal workmanship of any kind; they have no subordinate mind to guide them; nor can any act of ours, or of any animal, affect them. On the contrary, in all our operations we must conform to them.

A. Unquestionably it is so; and this is the distinction, and the broad one. But then it follows from the preceding deductions, that we must consider in the works of Instinct the animal acting as an agent, though ignorantly and unintentionally,—a tool or instrument blindly used to do a certain thing without its own knowledge or design; and the tool being a living thing, the mind is the instrument. In the case of matter, the matter is the instrument blindly serving the purpose by obeying the physical law. In our case the mind is the instrument, and obeys the mental law as perfectly and as blindly.

B. There is one thing, however, always to be considered. We have hitherto been viewing Instinct alone, and arguing as if animals always acted by it, and never otherwise. Now this is quite impossible, at least in the sense in which we have taken the word Instinct. There may be some doubt if we are right in so limiting the term, though I have a very clear opinion that we are. Paley and all or almost all others define Instinct to be a disposition or acting prior to experience, and independent of instruction. But among other objections, there is this one to the definition, that it amounts to saying "an acting without knowledge," and yet does not say it. There may be no experience, and yet no Instinct, *e. g.*, we may act on the information of others—but then what shall be said of the information given by reasoning; that is, by our inferences from our own thoughts? This is plainly not instruction. Is it experience? If so, the definition seems only to say, that Instinct is anything that is not reason, in other words, that Instinct is Instinct. But I apprehend, when we speak of instinctive operations we always have an eye to some end which is blindly served by the act—some act done by the animal, in which he does what he does not mean, and in doing which he is a blind instrument.

A. How is it when we speak of instinctive desires?

B. I should say we then mean something different from merely animal or natural desires, for that would make every thing instinctive. We mean desires which are subservient to some purpose towards which they move: some end beyond the doing the act seems always involved in our notion of Instinct. We do not call mere moving, yawning, stretching, instinctive; and when we speak of sucking or eating, and the desire or power to suck or eat, as instinctive, it is surely with a regard to the subserviency of those operations to support life that we so term them. If they did nothing for our frame, we might call them natural, hardly instinctive.

A. But be this as it may, no one can doubt that animals, if we allow them to have these Instincts, and to act for ends unknown to themselves, have other actions of a kind resembling our own, and quite distinguishable from what we have been calling Instincts; therefore it signifies little whether or not we are right in giving the name to actions accomplishing undesigned and unknown purposes, provided we keep that definition in view. These animals also have other actions, where they both know and intend and accomplish their definite object.

B. Undoubtedly, they have many such in which their operations of mind and body cannot be distinguished from our own. Now whether these are under the guidance of faculties like ours; whether they have reason; whether they have faculties differing from our own in kind, or only in degree —we need not at present stop to inquire. It is quite enough for us that they have two kinds of operations, one which we agree to call Instinctive, distinguished by the ignorance of the object and want of intention; the other both knowingly and intentionally done: so man, acting almost always rationally, also acts in some rare cases unintentionally—chiefly in early infancy.

A. There may be instinctive acts with knowledge, and there may be acts not instinctive without knowledge. Does not this break in upon the definition which excludes knowledge as well as design? Many parts of human conduct seem to be guided by Instinct, and yet with knowledge.

B. This would no doubt overturn the definition, provided it be clear that "*knowledge*," and the "*presence of knowledge*," are here used in the same sense as in that definition. But we must make a distinction. There is a knowledge of some *end* or *object* in view, and a knowledge of the *means* whereby that end or object is to be attained;

in other words, of the *mode* of *operating*—of the *process*. There is also a distinction to be taken between instinctive *desires* and instinctive *operations*. The objection you have now made refers to the former—to desires; the latter, the operations, are chiefly referable to the great question respecting the controlling mind, or actual interposition of the Deity, to which we are approaching; but it also refers, in some measure, to the objection which you raise. Knowledge of consequence comes within the description of object or end; and if there be no intention to attain an end actually pursued, there can be no knowledge of it; and conversely, if there be no knowledge of it, there can be no intention to attain it. Take any instance of what you call human instinct, as hunger, or the sexual passion—these are desires, and their gratification may be pursued without any knowledge of, and consequently without any view to, the consequences of making chyle and blood to support the individual, or offspring to continue the race. As far as the mere gratification of the desire or supplying of the want goes, we may be said both to know what we are doing and to intend or mean to do it. We are attracted by our senses, that is, by the effect of our senses on our minds, to do certain things; and this is called instinctive acting,—I apprehend incorrectly. It is *natural* desire, but why instinctive? When we say Instinct, do we not mean something beyond this? Desires may be subservient to Instincts; but are they all we mean by Instinct? They may lead to the attainment of a certain end; they may be the way in which Instincts operate: but are they themselves Instincts? If two foods are presented to an animal, a man for example, who knows nothing of either; and he is impelled, without knowing why, to take the one and reject the other, and the one is wholesome and the other a poison; we at once call this the operation of instinct, which some define to be knowledge without instruction or experience, but which I have wished rather to call mental action without knowledge, or at least independent of knowledge. So in Galen's beautiful experiment on the kid just born, having been taken out of the mother, and which of course had never sucked, when, upon many shallow pans with different liquids being placed near it, the animal preferred at once the pan containing goat's milk. If the reason for the preference is some greater gratification of the senses, or that the one food is pleasing, for instance, in smell fragrant, and the other offensive, this may be the mode taken by nature to make Instinct operate according to your former hypothesis, which we have been discussing at large; and we certainly cannot tell that such may not, in all cases, be the mode taken by nature for working to the same end. It seems, however, eminently unlikely that the whole operations of bees, for example, should be owing to the pleasure their senses receive from one particular form and proportion alone, and a repugnance to all others, because of their being disagreeable to those senses. But do we not, in all cases, mean, by using the word Instinct, to point out the unknown connexion between the thing done and something else of which the animal—the agent—is not aware? I grant you that we speak of Instinct of hunger and Instinct of sex; but is not this only a way of saying, and do we not mean, merely desire of food or sex, the gratification of which is a natural propensity, and known and felt by us to be such? Thus it is an Instinct which makes animals propagate their kind while they merely mean to gratify their passions, and which enables them to prepare a nest, and have it quite ready at the very time they are to want it for laying their eggs in. We always seem to have the *motive*, the *end*, and the *blind instrumentality* in our view when we speak correctly of Instinct. I may intend to do a thing, and know both the object in view and that portion of the operation or process which depends on me—*e. g.*, to eat for the purpose of making chyle. My ignorance of that process, with which I have nothing to do, would not make the operation of mine be called an Instinct. Indeed, even if I eat to satisfy hunger, without any design of supporting the system, this act is not instinctive, except in so far as doing and meaning one thing, I am doing another thing ignorantly and unintentionally.

A. I think we have got as far as we can in these preliminary discussions and observations of Facts, and may now proceed to Theorize and infer.

B. However, we are come, or coming, to a part of the subject where we should be among our books; for we shall now have to look at them in proceeding further. At least, it is as well we should observe what has been held on this matter by philosophers. So we had better adjourn for the present; and resume our conversation in the library, if indeed you, who are accustomed to Althorp and Spencer House, can condescend to call anything in this part of the world by that name. We commonly, from feeling this modesty, name it the Book-room.

A. And I dare swear, also from your love of the Saxon idiom.

B. Possibly; though I would that our good old English never suffered more havoc than by calling Book-rooms Libraries. I expect to outlive it, as Serjeant Maynard said he had nearly done the law, with the lawyers.

BOOK OR DIALOGUE II.

INSTINCT.—(Theory.)

Having thus far carried on our discussion in the open air, we removed, towards the afternoon, to the library—"cum satis ambulatum videretur, tum in bibliothecâ assedimus"*—and there conveniently pursued the subject, which greatly interested us both.

B. The manifest difference between Instinct and Reason which we have been observing, and its regular and constant action, always the same, and never improved, but never different, indeed apparently incapable of improvement, was probably the consideration which induced Descartes to consider animals as machines.

A. I am aware that this is commonly said of him. But I know not how that great man could really have held so untenable a position. Did he really consider them as mechanical contrivances—as mere physical substances, without anything answering to what we call Mind?

B. He is always so represented; but when you examine his own statement closely, you really find that this is an exaggeration, and that his doctrine

* "When we thought we had walked long enough, we took our seats in the library."—Cic. de Div. ii.

differs not very much from that commonly received. As has oftentimes happened to others, his sentiments are rather taken from the statement of them by those who were controverting them, than from his own words.

A. Where are they to be found?

B. Look here—you have them in the short treatise on Method, the introduction to his work on Dioptrics and Meteors. He dwells on brutes having no gift of speech, which yet requires very little reason, he says; and therefore he concludes not that they are less rational than man, "sed plane esse rationis expertia." * Thus far no doubt can exist; he only gives a very common opinion on the subject, though an opinion controverted by some, as I shall hereafter ask you to discuss: but it forms a head distinct from our present inquiry. But a little way further on he proceeds to illustrate his position in a manner which has given rise to the notion in question. "They do many things even better than ourselves," he says, "but this does not prove them to be endowed with reason, for this would prove them to have more reason than we have, and that they should excel us in all other things also—but it rather proves them to be void of reason, and that nature acts in them according to the disposition of their members, as we see a clock, which is only composed of wheels and

* De Methodo, 36.—"Istud autem non tantum indicat bruta minore vi pollere quam homines, sed illa plane esse rationis expertia. Videmus enim exiguâ admodum opus esse ad loquendum."

(Of Method, 36.—"But that not only indicates that brutes have less power than men; it also proves them to be void of reason. For we see that very little reason is required to enable men to speak.")

weights, can measure time better than we can with all our skill." He goes on to show that the interests of virtue are greatly injured by the belief, not that brutes have souls, but that they have souls like our own—"brutorum animam ejusdem esse cum nostrâ naturæ,"—and that therefore we have nothing more to hope or fear in a future state than flies or ants; whereas he had shown our souls to be by their nature independent of the body, and therefore not mortal like and with it. All this you perceive is anything rather than the doctrine that brutes are mere machines.

A. But where do you find the adversary's representation of it which you mentioned?

B. Here, in this other and very curious volume, containing his Correspondence with many learned persons, and some less learned, as Christina, Queen of Sweden, and our Princess Elizabeth, the Electress Palatine and stock of our present Royal family, to whom he writes, among other letters, one on her brother Charles the First's execution—which, to console her, he praises as more glorious than an ordinary death—"pulchrior, felicior, et dulcior."*

A. Does the Princess enter on the question of animals?

B. No; she seems to have been ailing with fever, and having been light-headed, she applies to the philosopher to explain to her how in the night she felt an irresistible desire to make verses: this he courteously explains (after saying it reminded him of a similar anecdote related by Plato, of Socrates), that it is owing to the agitation of the animal spirits, which in weak brains produces

* "Finer, happier, sweeter."—Epist. Pars I., Ep. xxvii.

madness, but in strong ones only a genial warmth, leading to poesy, and thereupon he holds her Serene Highness's case to be "ingenii solidioris et sublimioris indicium."*

A. Upon my word, I shall begin to think a person who could thus theorize as well as flatter about animal spirits and Serene Highnesses, was capable of shutting his eyes to the most ordinary facts, and believing brutes to be machines.

B. Do not undervalue this great man: he is the true author of all the modern discoveries in mathematics. He made the greatest step that ever man made since the discovery of algebra, which is lost in the obscurity of remote ages: I mean his application of algebra to geometry, the source of all that is most valuable and sublime in the stricter sciences and in natural philosophy. But assuredly his physical and psychological speculations are much less happy; although it was no mean fame to be the author of a treatise, the answer to which was the first work ever composed by man—Newton's Principia. But I was coming to the controversy on Instinct. An ingenious clergyman of Cambridge, Henry More, objected to the doctrine of the great philosopher, as laid down in that treatise to which we have been referring, on Method; and he began by describing the doctrine as denying sense and life to brutes. He speaks of Descartes's genius, "chalybis instar rigidum et crudele, quod uno quasi ictû omnium ferme animantium genus vitâ ausit sensûque spoliare in marmora atque machinas vertendo."† This he repeats in various

* "The proof of a more solid and more lofty understanding."

† "Rigid and heartless like steel, which, as by a single

ways, and argues against, as the doctrine of Descartes.

A. Nothing in what we have read out of Descartes' own writings justifies this. Is there any other passage to which More can allude?

B. He refers expressly to the passage in the "Tractatus de Methodo," and discusses the argument there given from the want of speech. But there remains a letter of Descartes to a certain great personage (ad Magnatem quendam), in which he repeats the doctrine of the treatise at somewhat greater length, but using the same comparison of a clock, and using it as a comparison. His whole contention is, that they, the brutes, have not reason like us, which he terms sometimes "intellect," or thought—"intellectum vel cogitationem." But that he means reason, and does not mean to assert that brutes are machines, seems plain from this, that in the same passage he allows them natural cunning, or craft, as well as strength—"imo et puto nonnullos (animantes) esse posse quæ naturalibus astutiis instructæ sunt quibus homines etiam astutissimos decipiant."* This is anything rather than describing them as mere machines.†

stroke, can deprive almost all animals of life and sensation, turning them into marbles and machines."—Epist. Pars I., Ep. lxvi.

* "Nay, I also think there may exist some brutes endowed with natural cunning to deceive the most cunning of men."—Epist. Pars I., p. 107.

† He afterwards, in the same letter, says, that although brutes do nothing to show they can think, yet it may by some be supposed that as they have limbs like our own, so thought (cogitatio) may be joined with those limbs, as we know it is with our own, although in them the thinking principle (cogitatio) may be less perfect than in us. "Ad quod," says he, "nihil est quod respondeam nisi quod si illa

A. But what does Descartes reply to his correspondent's letter, in which he represents that to be his doctrine? Does he object to Mr. More's statement?

B. Why, singularly enough, he does not in distinct terms repudiate it, though this may be owing to his supposing that, as he had used the comparison of the clock, Mr. More is also speaking in the same terms, especially as Mr. More had professedly used figurative language, and spoken of Descartes' cutting off all animals as with a sword. But he speaks certainly in this answer* more strongly than elsewhere. "I have diligently inquired," says he, "whether all the motions of animals came from two principles, or only from one; and as I find it clear that they arise from that principle alone which is corporeal and mechanical, I can by no means allow them to have a thinking soul. Nor am I at all hindered in this conclusion by the cunning and sagacity of foxes and dogs, nor by those actions done by animals from lust, hunger, or fear; for I profess to be able easily to explain all these things by the sole conformation of their limbs." He adds, that though he sees no proof of the affirmative proposition (of their having a thinking principle), yet he also admits there is no proof of the negative; and he then comes back to his favourite topic of its "being less likely that worms should have immortal souls, than that they should

cogitant ut nos, animam etiam ut et nos immortalem habent, quod non est verisimile;" ("To which I can only answer, that if they think as we do, they must also have, like us, an immortal soul, which is not probable;") and he proceeds to say, that oysters, sponges, and other imperfect animals, can hardly be supposed immortal.

* Pars I. Ep. lxvii.

move like machines;" and again refers to the want of speech.

A. How any man who ever saw dogs in a field pointing, or greyhounds chasing a hare, or still more, dogs sleeping and manifestly dreaming without any external object to excite their senses or motions, or who had observed birds taught tunes, could ever suppose them mere corporeal or material mechanism, things made of dead matter and without life, I cannot comprehend.

B. The best of it is that he positively affirms they have life. The letter I have just been reading from, and in which his doctrine, if anywhere, is stated the most explicitly, concludes by warning Mr. More not to suppose he denies them life; and it is remarkable that he uses the very words *vita* and *sensus*, which Mr. More had represented him as refusing to brutes—"Velim tamen notari me loqui de cogitatione, non de vitâ vel sensû. Vitam enim nullo animali denego."*

A. Then what does he mean by life and sense?

B. He goes on to tell you, "utpote quam in solo cordis calore consistere statuo;" mistaking the indication or effect of life for life itself. He adds, "nec denego etiam sensum, quâtenus ab organo corporis pendet."† Now, can it be that Descartes really supposed he had taken a tenable distinction here between mind in man and in brutes? Or that there could be any perceptible difference between a machine endowed with life and sensation, and

* "I would have it borne in mind, however, that I am speaking of thought, not of life or sensation, for life I deny to no animal."

† "Nor do I deny them sensation, in so far as that depends upon the organs of the body."

capable of imitation, of learning, and of much cunning—and a body animated by a mind? To speak of sensation as depending upon the corporeal organs is either unintelligible or it is a begging of the question, and the very same definition might be given of our own sensation—nay, is given of it by the materialists, who hold our mind to be the mere result of a physical organization. Yet with these Descartes differs more indeed than with all others.

A. I cannot help thinking, on the whole, that it is very possible this great man may have only meant to deny the brutes a reason, or mind like ours, a power of ratiocination, and not to consider them as mere machines. But I am clear of one thing, that if he did mean the latter, a more untenable doctrine never was broached upon this, or indeed upon any other subject.

B. We may therefore, I conceive, pass over this theory altogether. But another and a greater man has been so pressed with the difficulties of the subject, that he has recourse to a very different supposition, and instead of holding the Deity to have created brutes as machines without any mind at all, he considers their whole actions as the constant, direct, and immediate operation of the Deity himself. Such is the doctrine of Sir Isaac Newton, which is saying enough to prevent any one from hastily rejecting it, or rashly forming his opinion against it.

A. Does he not mean merely to derive the actions of brutes from a perpetually superintending and sustaining power of the Deity, as we ascribe the motions of the heavenly bodies to the same constantly existing influence? He probably only means that the brute mind, having been created, is as much under the Divine governance as the material powers, qualities, and motions are: in other words, that mind was created, and matter was created; and that still the actions and passions of both are constantly under the guidance of the Creator. So that Sir Isaac Newton would no more deny the separate existence of the minds of brutes, than he would the separate existence of their bodies, or of the heavenly bodies.

B. Here are his own words. The passage occurs in the famous 31st Query, or General Scholium to the Optics;* and you see that, after recounting the structure of animal bodies as proofs of design, he adds, "And the instinct of brutes and insects can be the effect of nothing else than the wisdom and skill of a powerful, ever-living agent, who, being in all places, is more able by his will to move the bodies within his boundless uniform sensorium, and thereby to form and reform the parts of the universe, than we are by our will to move the parts of our bodies." He proceeds to guard the reader against a supposition of the Deity being the soul of the world, or of brutes, or of His being composed of members or parts, stating that He only "governs and guides all matter by his prevailing power and will." So that you see he draws the distinction between the

* There is nothing more admirable for extent and generalisation of view than this 31st Query. The happy conjecture respecting the nature of the diamond in the 2nd Book (Part II., Prop. 10), does not surpass the wonderful sentence in the query, where Sir Isaac Newton classes together, as similar operations, respiration, oxydation, and combustion. These have since been discovered to be the same process. In Sir Isaac Newton's time, their diversity seemed as great as that between the diamond and charcoal.

mind or will of men, which influences the motions of their bodies, and the influence which moves brutes; plainly enough referring the latter to the Deity himself, as the *primum mobile*, or actuating principle; for he allows that the kind of ubiquity or universal action to which you refer applies to our bodies, and I presume to our minds also, which were created and are sustained by Him. Of that no doubt can exist, because elsewhere he has laid down as clear this ubiquity, called, as you know, *essential* ubiquity, to contra-distinguish it from *potential* or *virtual*. You find this plainly stated in the Principia—here is the celebrated General Scholium: "Omnipresens est non per virtutem solam, sed etiam per substantiam"—"In ipso continentur et moventur universa, sed sine mutuâ passione."* Therefore it is quite manifest that, in here treating of Instinct, that is, of the operations of animals, he considers the Deity's action as different from that general direction which he ascribes to Him over matter and mind by His essential ubiquity. In other cases He acts on matter and mind, and in the case of mind, He acts on matter mediately or through the agency of mind, which mind He moves. But here He acts, according to Sir Isaac Newton, directly on matter, and is the moving and acting principle of animals; and such has generally been the construction put upon his words as you have them here in the 31st Query. It has been so stated by so popular a poet as Pope, and also, though with less precision, by

* "He is omnipresent, not virtually alone, but substantially"—"In him all things are contained and moved, but without mutually affecting each other."—Principia, lib. iii., Sch. Gen.

Addison. The former takes the distinction, in his Essay on Man, between brutes as only having volition, which in them acts for both willing and reasoning: while men have the double faculty. He expresses himself with his wonted felicity:—

> " See then the acting and comparing powers,
> One in *their* nature, which are two in ours;
> And Reason raise o'er Instinct as you can,
> In this 't is God that acts, in that 't is Man."
>
> *Essay, Ep.* iii.

Addison, in his 120th Spectator, after giving many instances in which he jumbles together Instinctive and Intelligent operations, concludes with the remark, that "they can no more be explained than gravitation can; and come not from any law of mechanism, but are an immediate impression from the first mover, and the Divine energy acting in the creature."

A. This dogma of Newton is certainly great authority—the greatest human authority. For it is the opinion—and, regard being had to the awful nature of the subject as well as the contemplative and religious nature of the man, it is probably the well-considered opinion—of the greatest inquirer into nature that ever existed, and whose conjectures have been almost as happy, and are certainly quite as marvellous, as his complete discoveries.

B. Observe, too, that it is the opinion of his maturer years. The Scholium to the Principia was added in the later editions—when written does not clearly appear, but the second edition was published in 1713, and the third as late as 1726. The 31st Query to the Optics was added at a time which can be fixed better. The first edition of the Optics, published in 1704, had not the queries. The second, published in 1717, had them; and the third edition was corrected by the author's own hand a short time before his death; from which corrected copy the one I am now citing was printed in the year 1730, after his decease. But as he first published this passage in 1717, and was born in 1642, he was then in his 75th year, and had long before made all his discoveries.

A. I quite agree that as far as mere authority goes, no opinion ever had so great a weight—nevertheless we have the same illustrious man's authority, and example too, to teach us that it is by our own reason alone that we ought to be guided in philosophizing, and we must bring to the test of that canon even HIS best considered opinions.

B. This I of course freely admit. Let us, then, examine a little this doctrine of immediate interposition—which regards the work of the bee, for instance, as the direct and immediate operation of Divine wisdom and power.

A. I need hardly warn you against being seduced by another bias, as powerful as Sir Isaac Newton's authority—the disposition we must have, if possible, to believe in a doctrine which, by exhibiting the finger of God as perpetually moving and working before our eyes, seems to bring us constantly into His presence, as if we saw a perpetual miracle wrought, and almost enables us to commune with the Deity, as the Patriarchs did of old. The gratification to us, as men, of reaching this position, should not make us, as philosophers, open our ears the more readily to any unsound or inconsistent reasonings, assume facts on slight grounds, or, passing over flaws in the argument, receive easily erroneous conclusions from what we see.

B. Again I entirely agree with you. Far from making greater haste to reach a position so delightful, I should take the greater care of my steps, that I might not slip and fall by the way : for that the road is slippery, the light glimmering, and the route over high ground, leading through precipitous passes, must, I think, be admitted freely. But let us step on cautiously as we have hitherto done.

A. We left off with the deduction that brutes act from a principle, a thinking principle, a mental principle, something different from their bodies and from surrounding objects, but that they act towards an end of which they are ignorant, and accomplish that end without design, though very possibly they may also in so acting accomplish some intermediate end of which they are aware, and which they intend to attain.

B. We may add another thing to the proposition. The end which they accomplish blindly and instinctively is far the more important of the two, admitting that there is another and intermediate one. For, suppose your theory to be correct, that the solitary wasp gratifies some sense in carrying caterpillars and the bee, in making hexagons and rhomboids, it is plain that this is a very trifling matter; it neither feeds, nor clothes, nor lodges her, nor her brood; whereas, the purposes to which those works are subservient are the continuation of the species of the insects respectively—the greatest and most favourite end in nature.

A. True; and you may add another thing, which I allow, even if my theory be ever so certainly correct—that the only possible use of the intermediate end is the accomplishment of the other end—for if you grant me that the wasp carries caterpillars, and the bee makes geometrical figures, to please themselves, or gratify some sense, it is of no importance that either should receive that gratification: its only use is the unknown and unintended consequence of providing for the unborn issue.

B. We are now then arrived at a very important height, from whence we may survey the subject correctly and advantageously.

A. Let us be quite sure that we have left no obstructions, or rather that we have passed over nothing material—that we have left no objections in our rear, which may rise up and mock any inference we now draw. For instance, are all our facts clear? As to the bee's architecture, some have questioned the theory. I have heard it said that what seems so perfect a structure, and so judicious a dividing out of the space, so as to save room and work and material, is only the necessary consequence of placing a number of cylindrical or globular bodies together; that if you blow many soap-bubbles in a basin they will, by their weight and pressure, settle into hexagons.

B. There never was anything more absurd than what some, calling themselves philosophers, have said without a moment's reflection on this subject. No less a name than Buffon may be cited for such nonsense. There are two decisive answers:—*First*, the soap-bubbles will not make hexagons, although your eye may see straight lines formed by their intersections, but not one hexagon the least like the bee's will you find in all the foam; and *next*, there is not a single globe, or cylinder, or any figure like it ever made by any bee. Huber has seen them, or rather had them carefully observed, when at work;

they first make a groove, and then form its walls into planes, and all the rest is a making of planes and angles one after the other without any circular figures at all. So some one finding the eye of the bee to be a net-work, when greatly magnified, and each mesh a hexagon, thought he had found out why the bee works in that figure. To which the answer was obvious, that men and other animals having circular pupils should, by parity of reason, work in circles. But another answer was just as decisive; that the light entering by a hexagon almost infinitely small no more helps the bee to that figure than if it entered by a circle or a square. Its paws and feelers are to work. Nay, suppose even it had a small pattern hexagon ready made, would its working a large one on that model be at all less wonderful? Not to mention that the hexagon is not the greatest wonder; the rhomboidal bottom of the cell, and the angles which its three plates form with each other, and with the walls, are the wonder, and no one pretends to account for that. I pass over the form of the limbs; nothing can possibly be deduced from them in the smallest degree fitted to aid the bee in her marvellous work.

A. Have not some sceptical inquirers thrown other doubts upon the mathematical part of this great wonder? I think I have heard something of the kind, as if Maclaurin, or whoever was the discoverer, had rather been fanciful, or over-refining, and that the bee had turned out to be not so good a geometrician as they had supposed.

B. Here is a sample of those doubts—though they are not indeed, like Newton's sound conjectures, stated with the modesty of doubts—but somewhat dogmatically. It was the celebrated Maraldi who first measured the angles, and found them to be 109° 28′ and 70° 32′ respectively. Réaumur afterwards set a young mathematician, pupil of Bernoulli, called Kœnig, to find what were the angles that made the greatest saving of wax, and the result was by his analysis 109° 26′ and 70° 34′, being within two minutes of his own measurement, which measurement he had not communicated to Kœnig. But it turns out that the bee was right and the analyst wrong: for by solving the problem in another way I find that he erred by two minutes; and other mathematicians, with whom I have communicated, distinctly find the same thing, and we have also found how the error crept in.*

A. These angles must have been very nicely measured; for the difference of two minutes, or the 2000th part of the lesser angle, is very small indeed. How were the angles first ascertained?

B. Maraldi was a most accurate observer, and he gives the angles, as I have stated, 109° 28′ and 70° 32′; and he gives them to differ with the result of Kœnig's calculus, which was made after Maraldi had measured—so he could not have fancied the amount. But I have reduced it from measuring an angle to the easier operation of measuring a small line. If those are the angles, then it follows that the breadth of the rhomboid is exactly equal

* See this fully explained in the experiments and demonstrations relating to the comb in this volume. There is some contradiction in Maraldi's statement, 'Mém. Acad. des Sciences,' 1712, pp. 310–312; but the above measure has always been considered to be that which he intended to state as his result.

to the side of the hexagon, and you find it appears to be so. Also, if those are the angles, the rhomboidal plates are inclined to one another at the angle of 120°, that of the hexagon; and you find they do not differ when you place them together, one within the other. However, I admit that this is not a very close admeasurement of such small differences; and I presume Maraldi must have employed a micrometer. I have used one to compare the breadth of the plates and sides, and I certainly can find no inequality. At all events, the bee seems entitled to the benefit of Maraldi's previous measurement, which had been thought to put her in the wrong, now that the analyst and not she has been found in error. This, however, is nothing to what follows. A Berlin academician, thinking, I suppose, to do a kindness by Frederic II., objected to the bee, that though, if the dimensions of the cell be given, the saving is as I have stated, yet there is such a great waste of wax arising from those dimensions as proves the saving of wax to be no object. He sets himself the problem of what he calls a *minimum minimorum;* namely, to find the proportion between the length and breadth of the cell which saves most wax; and he finds it something quite wide of the actual proportions. Now, I went over this analysis, and again found the bee right, and the philosopher at fault; for he had wholly left out the hexagonal covering of the cell's mouth, which, whether for brood or honey, there always is; and I found the actual or bee's proportions to save more than the academician's, when this was taken into the calculation. I moreover found the sides to be so much thinner than the bottom, that a shallow and wide cell would have cost more, even independent of the covering at the mouth. Again, he admits the form chosen to suit the bee's shape, which the form he calls a true minimum never could; but I show that it saves wax as well. Lastly, I have solved another problem of a like kind, namely, to find the angles that save most of the fine or difficult work, which is the angular or corner-working evidently, and that also is the thickest part of the work necessarily. I find the solution gives the very same angles which the bee uses, and which also save wax in the other view. So that she has hit upon the very form which in every respect is the most advantageous, and turns out to be on all grounds right—as indeed we might well suppose when we recollect who is her Teacher.*

A. All this is most satisfactory, and it was worth stopping to state it. However, as we have made a pause before our next advance, it may be just as well to stop for a moment longer in order to consider what the bee's operation really is. How we should go to work had we to build cells is plain enough. Suppose we had discovered, which we should do by mathematical investigation, the proper form, the due proportion of the width to the length, and the proper angles of the bottom or roof—then we should have drawings and plans; and by these we should either cut our planks, if the

* Lord Brougham has given in the original work (*Dissertations on Paley's Natural Theology*, vol. i.) all the mathematical demonstrations by which the positions in the text are shown to be undeniably true. He has also given a variety of curious observations and experiments on the architecture of bees, which appear to have escaped former philosophers. This part of the work, as too abstruse, is unavoidably omitted in the present publication.—Ed.

structure were of wood; or if it were of stone, which more resembles the bee's materials, and is, be it observed, much more difficult and complicated to work with, we should, by those plans and by models or frames, run our courses. It would be a nice and difficult work to make this masonry, and would require the builder, both in hewing the stones and in putting them up, to follow the details of the plan in its parts, and without any regard to the general figure or result. He would be wholly unable to succeed if he looked to that; all his building would be awry and out of the required figure; his only chance is to make his plan exact, and his model-frames suit it; and then he has instruments and tools, plumb-lines, squares and plumbs together, in order to raise his perpendiculars. By these he proceeds, for he cannot trust his eye or his hand a moment beyond the mere adjusting his work to his instrument and his plan. Now the bee confessedly has neither plan, except what is in her head; nor any model at all whereby to guide her hand; nor any instrument to adjust her work to the plan in her head; nor any tool to work with except her paw and her feeler, which is as her eye in doing the work. Then how does she work?

B. Certainly, this is a most important consideration. We cannot trust our eye or our hand an instant. We have no exact perception of the line, and no steadiness in pursuing it. We have recourse to plans and instruments because we cannot form our lines by volition, that is, by having a form in our mind and by making our hands follow that form. We therefore must first lay it down sensibly, and then guide our hands by material means. Thus we have no power of forming a dome, an arch, or a circle, or a perpendicular, or a level, or even a straight line at all, or any one line or form which we conceive in our mind. Far from being able to follow these lines in great works, as roofs and walls and excavations, we cannot even represent such forms on a sheet of paper by our handywork. If we could do this we should work like the insect, who acts immediately, and not through the instrumentality of means. Unable to execute any purpose of our minds, as she does, we have recourse to instruments. We endeavour, as far as we can, to reduce every thing to a physical or material process—to exclude mental operation or agency altogether—to make the whole a material, or as we call it, accurately enough, a mechanical operation. Reason no doubt has taught us to do so; but it has taught us a general rule; and there is little or no reason, little or no operation of the mind, in its application to the particular cases. On the contrary, the use of the rule or method is that it precludes the operation of the mind as much as possible, and makes the whole physical, or nearly so. To take an instance—we reduce, by engraving or printing, the whole operation of drawing a picture, or writing a page, to turning a lever, which does the work for us. So in building, though there is less mechanical facility, we guide our hand by the instruments employed and the lines drawn, making the operation as mechanical, as little mental, as possible. The bee's operation is all mind together. She has no plans, no instruments, no tools. It is as if by waving our hands among plastic materials we formed walls, and domes, and columns, and never deviated a hair's breadth from the perfectly accurate plan. I am very decidedly of opinion that this essential difference between the works of Reason and Instinct is of the greatest importance to our inquiry: for nothing can more show the peculiarity of the instinctive operation; or more prove that the mind of the agent is as it were the machine, and the instrument, to perform the work, and to perform it with an unerring certainty and with absolute perfection.

A. Does this, which appears to me, as it does to you, a most important consideration, bring us at all back towards the ground of Descartes, which we had passed over as forming a position wholly untenable: I mean, that the insect is a mere machine, fashioned by a perfectly skilful mechanic, and wound up to perform the functions which he designed?

B. Certainly not. The proposition which we have just been deducing from the facts is rather of a kind the very reverse: it affirms that the insect's mind performs the whole operation; it makes the insect's mind the machine, if I may so speak. But let us see to what it also leads or seems to lead us. We perceive there is mind at work, action exerted, effect produced; but we see that the mind is quite unconscious of the effect, and that the action works to a purpose which the mind never contemplated. There is a thing done, an important and rational thing done, but done by an agent who neither intends nor knows anything about it. Here there is design, but there is no designer—an action and an object no doubt; but that action performing, besides what the agent intended, knew, and did, something else (and that something the only important thing), which the agent neither knew nor intended, and cannot possibly be said to have done at all. This by no means leads us back to Descartes' position, but does it not lead us to Sir Isaac Newton's? The design is manifest; the action is perfectly and surely adapted to it; the purpose is with singular regularity effected; must there not be a designer, and who can that be but the Deity? There is none other that can be suggested even. Must it not be He?

A. Doubtless in one sense it must, as he is the designer of all we see. But how is he more the designer here than he is of the motions of the heavenly bodies, or the growth and germination of plants?

B. As thus. In those cases there is nothing but matter affected, or acting; whatever laws were originally imposed on matter are followed; whatever qualities first communicated to it are displayed: all is material. There was design in the original formation of it, in the prescribing those laws, and impressing those qualities. That design these bodies fulfil; they conform to the primæval and original intention of their being. But there is no renewed design, no repeated intention, no special and particular disposition in each case of action. The Deity made a stone, and made the earth, so that the stone falls to the ground by virtue of the general rule of their formation. He is not to be referred to; he needs not interfere each time the support is withdrawn from the stone, in order to direct the path it shall take. If on that support being withdrawn some interposition were required to decide how it should go—for instance, whether it should stand still or not—although it be admitted, that if it move it can but move in the straight line downwards, the case would more resemble Instinct, though even here it would be different; for it is as if each hair's breadth of the stone's motion required a new action to carry it on in its course.

A. The Deity created matter so as to obey in each case certain general laws: so he created mind in like manner to obey certain laws in each case. Wherein do the two facts differ, the fact of material and the fact of mental action?

B. As thus. The moving power is wanting in the one case. The law is that matter shall act in a certain way, and mind in a certain way; but is it the mind of the insect that acts when the whole mental process is wanting, namely, the knowledge, thought, and will? Its mind acts, subject not only to a general law, but to a particular impulse each time. Who gives the impulse? Besides, your doctrine of the Deity creating the insect's mind such as to act so in given circumstances, applies quite as much to our Reason as to its Instinct. Let me, however, put a case: suppose we saw a man born blind, to our own knowledge, without any teaching, and without ever having tried it before, move his fingers in the design of giving them exercise, as to keep them warm, &c., but holding a pencil in them, and by the same act producing, unknown to himself, a beautiful and finished portrait, of perfect resemblance to the original: or suppose we saw a man who had been born and lived in a foreign country, and was utterly ignorant of our language, of which he had never heard a word, write a letter in correct English, or a beautiful copy of verses, while only meaning to try whether a pen was well cut, or the ink rightly made—these acts are quite analogous to the Instinct of bees. Nay, we may take a nearer case, and suppose a man who never had learnt mathematics, and did not know a line from an angle, to solve on a slate a problem of great difficulty with perfect and unerring accuracy, and this while he was only trying the pen and the slate; and suppose he then applied this solution to the combinations of a perfect time-keeper, while he thought he was only cutting off the superfluous pieces of two lumps of brass and steel of which he intended to make weights, he being wholly ignorant of what a time-keeper meant. There is nothing more strange in this than the bee's architecture. It is indeed exactly, and in all its parts, a parallel instance. In all such cases (the extra thing done, and not known or intended, being far more difficult and more important than the thing intended and known to be done), we should at once pronounce that there was a miracle, because of the thing done being without the possibility of the apparent agent doing it unassisted, according to the ordinary laws of nature. In other words, want of power in the immediate agent compels us to believe in the interposition of another agent having the power. There is *dignus vindice nodus*, and we call in the *vindex*. This is the foundation of all belief that there must be supernatural agency where the laws of nature are suspended. But in the cases put there is not only want of power, but of design. If want of power in the apparent agent drives us to suppose or infer the action of another unseen agent, want of intention or design should drive us to infer the intending of another designer, and want of both power and intention should make us infer the thinking of a planner who intends, and the action of an agent able to perform the work; in other words, to infer the interference of one who has both the will and the power, each of which is wanting in the immediate or apparent agent.

A. In the case you put of a miracle, there is a single instance, and because it is solitary, we say the laws of nature are suspended, and we call in supernatural aid. In the case of Instinct, it is the constant course; it would be a suspension of the law, and a miracle, were it ever otherwise. It is as much part of the law of nature that the animal should do the thing in question without intending it, or knowing how he does it, nay, that he does it at all, as that man should do it knowingly and intentionally, or that the animal should knowingly and intentionally do those other things in which he acts rationally, and not instinctively. Therefore this case does not resemble a miracle.

B. The case of a miracle I did not put in this way or with this view at all. I do not say that the instinctive act of the animal, or of man when he acts merely from Instinct, as he does, though most rarely, are to be compared with miracles as being suspensions of natural law; but only that the same reason which makes us, when arguing from such suspension of natural laws, conclude that some power has interposed different from the powers acting under those laws, requires us, when arguing from the acts done by the animal without either design or power, to conclude that some agent has interposed of power sufficient, and some intending and designing being of will fitted, to do the acts in question. Suppose, to put again my first case with a variation, we saw a blind man draw a likeness as often as he stretched his fingers with a pencil in them, and every foreigner of a certain class write good English verses as often as he tried a pen, and every man of a particular description make excellent time-keepers as often as he cut away the parings of the metal balls he was forming into weights—we should in every such instance of these general laws (as they could now be) have a right to draw an inference of one and the same kind. What would that be? Manifestly that here the same thing was done without knowledge or intention, which in the other class of cases (those where reason and experience operated) was done by means of knowledge, and with intention. For the gist of the question and the whole difficulty is this—that we have two classes of cases—the same act done in the one class knowingly and intentionally, and in the other, without knowledge or intention—and as in the vast majority of all acts taken together of all kinds of agents, we can see no such thing—indeed, cannot form the idea of such a thing—as an act without power and will to do it, or a thing resulting to all appearance from intention, because in itself such a thing as we should do if we intended a given thing, and yet without any Being to intend, so we are compelled to infer the power, that is, the knowledge of the intender.

A. Indeed, it must be observed, that when we speak of a miracle we mean, and commonly do mean, two things, not only the fact seen of the laws of nature being suspended, but the inference drawn of some power interposing capable of suspending them, and therefore above them, and having sway over them; and this inference arises from the necessity under which we feel of accounting for the phenomenon observed by supposing an adequate cause; in short, from our being unable to conceive anything done without a cause. The ordinary powers with which we are acquainted fail to account for this event, and we therefore infer another power to be in operation.

B. Certainly it is so; but then this is precisely the case with Instinct, as compared with the other phenomena, namely, those things done with both knowledge and design on the part of the agent, that is, things in doing which the agent is known to us, and intends, and knows what he does. Suppose, according to the case so well put by Paley, in the beginning of his book,—suppose you find on a common a watch going and producing manifestly an effect according to its construction; this would show a design in its maker; but only a former, or bygone, a spent and executed design. Nothing would be seen designing or intending, as it were, before your eyes. Suppose, then, you saw the watch, or other machine, making a second and third machine, but not by mechanical contrivance —for that, too, like the case put by Paley, would still only be evidence of a former, or bygone, or executed design,—you must suppose a new watch to be made before your eyes without any material agency, or, which is the same thing, made by a machine wholly incapable of performing the operation itself. Then you would necessarily infer from these the existence of some being, some thinking and designing and skilful being, capable of doing what you saw, that is, of making the machine; and you would suppose this just as much if you saw an incapable body performing the operation, as if you saw the operation performed without any visible or sensible material agent at all. Now, this is precisely the case of the bee: it is the incapable body or being.

A. May it not all be said to be only another inference of original and general design, as we deduce that conclusion from the structure of the limbs of animals, and the functions suited to that structure which those limbs perform?

B. Even if it were so, there is the broad distinction between mere mental and mere physical agency; and the difference between the inferences to which those agencies respectively lead. But I apprehend the difference is greater still than this. The two cases are not at all the same or alike, hardly even analogous. We never know of matter, or any combination of material parts, acting or affected but in one way. We have not matter with, and matter without, gravity, cohesion, impenetrability. But if the phenomana of instinct are to be regarded as only one class of mental phenomena, we have here two kinds of mind, endowed with wholly different qualities, and acting in wholly different ways; one kind such that the being possessed of it neither knows nor intends what he is doing, and yet all the while does exactly as if he both knew and intended. Nay, in one case, the agent possessing this mind is manifestly able to act; in the other, he is as clearly incompetent in any way that we can conceive. If no being is here concerned except the apparent, and unconscious, and impotent agent, it is like matter gravitating to a centre which does not exist: and then, to make the thing still more incomprehensible, and the difference between matter as subject to general laws and this case the more extreme, both these kinds of mind are found in the same individual; for he sometimes uses, as it were, the one, sometimes the other; he sometimes acts knowingly and intentionally; sometimes blindly, as an instrument to do he knows not what, nor cares—as if we had a piece of matter, a lump of metal, for instance, which at one time was heavy, and at another flew about in the air.

A. There is certainly a material difference; and I should not much wonder if we were, sooner or later, driven by the extraordinary nature of the case to some new conclusion. These things have really not been sifted as they deserved. Men have rested satisfied with general and vague statements, and I suppose their attention has been too much engaged by the great curiosity of the facts connected with the subject to let them closely reason upon the theory. However, I must again recur to my supposition, and refuse to quit this position where we now stand until we have examined it more accurately. There are two kinds of mind, I will say. Then the Deity created two kinds originally. As he created two kinds of substance or existence, mind and matter, and as he endowed these with different qualities, so did he endow the two kinds of mind with different qualities. As he made matter solid and heavy, and made mind imperceptible to the senses, but endowed it with consciousness, so he gave the two kinds of mind different qualities—both of course must have consciousness, which I take to be the essence of all mind, at least we cannot conceive mind to exist without it—but one he made such that it could act rationally, knowing and intending all it did—the other such that it acted without knowing or intending. This hypothesis, you perceive, gets rid of the necessity of supposing a constant interposition of the Deity, unless in the sense in which He is said to interfere for the purpose of maintaining and executing the general laws which he originally framed for the whole universe.

B. I perceive no such thing. I do not think your supposition at all meets the fact, or removes the difficulty, or dispenses with the other inference. In one sense I may grant your assumption, namely, if you only meant that the Deity originally willed the animal should act in a certain way for a purpose which He fore-ordained, and which He yet concealed from the animal itself, though fore-known to Him, the Creator. But in the same way all rational acts and intentions may be said to have been fore-known and fore-ordained by the Creator, which indeed seems, at least in the case of an intelligent agent, only to mean that with the Deity there is no such thing as present and future, but all things are seen as present. But then this resolves itself into saying that the Deity originally designed and ordered the animal's acts; and that this is the same thing as if He actually superintended and did each act of the animal at the moment of action—which is the same thing with saying that the Deity constantly acts and not the animal, and that is the theory in question. But, in any other sense, to what does your objection, or the hypothesis put by you in order to escape the conclusion, amount? Only to this, that the Deity created the instinctive mind such that it acts without knowledge or intention, exactly as the rational mind acts with both the one and the other. Now the theory of course never meant to deny that the instinctive mind was created by the Deity, and endowed with certain qualities. Sir Isaac Newton expressly excludes the supposition of the Deity being the *anima mundi*, or the soul of any part of nature, and clearly never intended to represent Him, as Himself the soul of animals, but only as constantly guiding that soul. But the theory holds that the mind being endowed with certain qualities originally and at its creation, those qualities are summed up in this one, namely, to act, and to act *quasi* mind, but without knowledge or design, and yet to produce all the effects of both, and, moreover, that this constitutes the whole of the qualities of instinctive mind. This mind therefore was created such that it must always be the blind instrument in the Creator's hands; its knowledge and design, by the hypothesis, reside as it were out of itself and in some other intelligent being, that is, in the Deity, who is to supply at each instant, the knowledge and design wanting in the animal mind, or to know and intend for it—and whether the Deity performs this operation, exercises knowledge and intention, beforehand and once for all, or constantly and continually at all times, seems an immaterial distinction referable to the former head of the alternative. The question always recurs—Was a mind created of such a species that it could act *quasi* mind without knowing and intending? Is not that contrary to the nature and essence of mind? Nay, is it not a contradiction in terms? And is not your whole hypothesis of two kinds of mind grounded on a false position, which supposes a substratum to be endowed with various qualities, and then, in order to make two kinds of that substratum, confounds the qualities with the essence? For what is mind but that which thinks, knows, wills? If there be no knowledge, will, intention, at all, mind is not concerned in the operation, and we come to the Cartesian hypothesis, that the animal is a machine. Therefore knowledge and design there must be; and it must either exist in the animal mind or in some other mind which uses or employs the animal as an instrument. Can this higher mind do so beforehand, or otherwise than by constant operation, that is, constant exertion of itself?

A. Then are we not getting either to the Deity being the soul of the animal, or to the mind of the animal having none of the qualities constituting mind?

B. We may suppose the mind to be the mere power of giving voluntary motion to the limbs, and to consist of no other quality, unless it thinks and intends. Then the Deity may have suffered it to have these powers, and to use them in some things, and there His own intelligence does not interfere; but not to use such powers in other things, and there His intelligence does interfere.

A. There *is* knowledge and intention in the animal. The bee, for instance, knows it is carrying wax to a given place, and placing it in a given direction. So far as the thing is done, the agent knows, and wills, and intends what it is doing, and this in every possible case of instinctive action.

B. But the whole question arises, not upon what the bee knows and intends, *e. g.*, putting particles of wax in a place, but upon what she cannot possibly know anything about—the giving her work a peculiar form, most difficult to discover at first, most advantageous for a certain end, and still more difficult to follow and work by even when discovered. The question always is, who designs and knows these things unknown to the bee? And we cannot conceive the Deity acting thus originally through a future and non-existing animal; although we can easily enough imagine Him acting through an existing animal at the time. This is supposable on the theory of essential ubiquity, or indeed upon any theory of ubiquity, even virtual. It merely requires ubiquity—whether of essence, or of power—some ubiquity—which no one denies who believes in a Deity at all.

A. A child shall place together different lines and angles, or other parts of figures, so as to form certain diagrams. The figures he thus unwittingly makes have certain properties quite unknown to him. All he intends or knows is to put the parts together; the rest is consequential, arising from the necessary relations of number and figure: so in cases of physical or contingent truth: he may do, and mean to do, and know that he is doing, what will form a certain combination; but the laws of nature acting on that combination, produce, unknown to him, effects which he never intended, and knew nothing of; as if he mixed sulphuric acid and oil of turpentine, and there was an explosion; or an acid and an alkali, and there was a neutral salt and a crystallization.

B. This, when examined, we shall find either to be a case wholly different from the one in question, or to be only *idem per idem*, as lawyers say when they have a case put which is like enough to the one in hand, but just as difficult to resolve; so, in either way, the argument will remain unaffected. If the child plays with the things at random, and they happen to fall into a certain shape once, or it may be twice, that is certainly not the case of the bee, which regularly, and without ever failing, always makes the figure required; and, upon being obstructed in her operations, varies her means till she can again attain the particular form. If, on the other hand, the child places the things always accurately in the same way, then the case not only resembles the one in question, but becomes identical with it; all the arguments and all the difficulties apply; it is exactly *idem per idem.* So again, if the child does a certain thing with knowledge and design to do that and no more, leaving the rest to be done by some law of matter unknown to it— this is not the case of Instinct; for the bee does all that is done by the operation of mental agency; the wall, the hexagon, the rhomboid, are all made by the bee's living power; she does not place wax and leave it to fall into hexagonal forms, as we mix salts and leave them to crystallize into cubes or hexagonal prisms; she forms the figures herself, and when she has done her work nothing remains to be done further by any law of nature. But if the child makes a combination constantly and correctly, say some useful substance not to be made by accident or random working, then the case becomes the same, and the argument is not affected by it in any way.

A. You often complain of my obstinacy; which I call sometimes caution, and sometimes slowness, according as I may be in a self-complacent or a modest humour.

B. Then, as I do not remember ever to have seen you in the former state of mind, I am sure you must always call it slowness, which no one else ever called it; but I will call it caution, and ask what more it leads to?

A. To this—that I would again hanker after my doctrine of general laws, primarily impressed on matter and mind both. You argue, and argue justly, that the operations of matter and of mind are to be kept apart; you allow that the material operation is explicable by and referable to general laws; you allow, too, that whatever is wrought by the operation of mind, acting as such, is explicable by and referable to general laws of mind, originally imposed, *e. g.*, to desire what is agreeable to it by its general constitution; to reject what is by the same constitution disagreeable. But you say that we see, in the case of instinctive actions, operations for which desires and aversions will not account, and operations carried on as if by the most refined and correct reason, and yet without any material or physical interposition; that is, without any instrumentality whatever, as if a cast were made without a mould, or a print without a plate. From hence you say it is difficult to understand how there should not be here an intelligent being, as well as mere desires connected with the senses—a cause connected with the understanding. Now, hankering as before, I still ask—though perhaps, after our long argumentation, with somewhat diminished confidence—may not this be accounted for by supposing a general law adapting and adjusting all the proportions beforehand? May not the Deity have originally appointed the taste or desire of carrying caterpillars in the solitary wasp, for instance, exactly to the very number required to feed the worm after born, when, by the laws of matter, the egg shall have been hatched and the grub produced? So may not the bee form her hexagons and her rhomboids, in consequence of a gratification felt by a fore-ordained law of her nature, in following those lines and angles, and no other?

B. That this is barely conceivable I may perhaps admit. But it is wholly unlike any other operation of the senses and desires of which we have any knowledge. It means this, that each desire is so nicely adjusted as to produce in the animal the effects of reason and intention in man, or of reason and intention in the same animal when acting with design and knowledge, and not instinctively. The bird is to have a pleasure in bringing sticks or moss to a certain place, just at a given time, and putting them in one position—the solitary wasp, in bringing, and only in bringing, for it never tastes, a certain number of caterpillars, and to have no gratification in bringing one more, but the strongest desire, because a sensible pleasure, in bringing the eleventh as much as the first—also no kind of gratification in carrying the eleventh to any other place than the same where all the other ten were put—also a like pleasure in forming the hole for them, without the least regard to the use she is to make of it, nay, ignorant beforehand of its being to have any use; and yet all the pleasure of carrying caterpillars is to consist in carrying them to that particular hole, and there is no gratification to be derived from carrying them to a place one hair's breadth on the right or the left. Still more—it means that the bee is to have such a gratification as proves irresistible, and occupies her whole life, in tracing certain lines and angles; and yet this strong desire is so far under control, even of reason, that on obstacles being interposed, other lines and angles are to be made, reason suspending the desire for the moment. So that the law originally imposed, and the quality impressed on the mind, was not one and inflexible, to do a certain act in all circumstances, viz., to follow the impulse of the desires implanted, and which form the animal's nature; but it was a law or order coupled with a condition, and, as it were, giving a discretionary power provisionally, or a power to be used in certain circumstances; it was as thus—a law or order to do a certain thing, to obey the impulse of the desire, unless certain events shall happen; and then and in that case to cease following the impulse of the desire, and to follow another guide, or rather to use a faculty, namely, reason, and act according as it should direct, allow, or recommend in the circumstances. Now, in the mere union of desires with reason, while the desires act blindly by impulse and the reason with discrimination, there is nothing at all inconsistent or incomprehensible; it is the ordinary case of all mental operations. But the peculiarity of the case now supposed is that the desires act exactly like reason, producing the very same effects unknown to the agent which reason does with his knowledge. Are we not then calling different things by the same name, when we say that it is the influence of desires and appetites which makes the bee form her cell and the spider her web? Might not the same kind of argument be applied to the operations admitted on all hands to be those of reason, for example, the investigations of Newton or Lagrange? Might it not be said that they were influenced by an irresistible propensity, from deriving some gratification in drawing one line and using one divisor rather than another? But we know this not to be the fact. Why and how? Only from their statements and our own consciousness. But for this, the same argument might be used, and no one could refute it. So in the case of the animal we argue thus, because we cannot ask her and learn how she works. The impulse (it must all along be borne in mind) of which the argument speaks is a physical one, *i. e.*, the effect of some external object, or, which is the same thing, some operation of the animal's body, on her senses; it is a gratification of this specific kind which the explanation assumes—if not, it explains nothing. Then how little resemblance does any such gratification which we can form any idea of (leading the bee to her lines or angles, and the solitary wasp to her carriages and deposits) bear to what we know and feel to be the ordinary nature of physical gratification, and the desires connected with it?

A. This consideration has much weight—I mean the way you put the question as to the mathematicians. It seems to show that we have just the same right, in the case of the animal's instinct, to conclude in favour of design and reason, and an intelligent agent, and to conclude against its being animal impulse or the direct operation of the physical senses, as we should have, did we see the mathematicians at work, observe their process, and mark the result congruous with that process, before we spoke to them on the subject of how their working was conducted. Indeed it is remarkable that we are in point of fact just as much without the evidence which the thus inquiring of them would afford, as we are in the case of the animal; for who ever asked the question of either Newton or Lagrange, and yet who doubts that both worked their problems from knowledge with intelligence? The reason why we do not ask them is, that we have no kind of doubt in our minds; the view of the operation is enough for us. This is because we say to ourselves, "If I did so and so, I know it would be from knowing and meaning to do so and so, and not from any physical gratification." This inference we transfer to others, by saying, "Therefore I believe they act in like manner."

B. Certainly; and this, observe well, is the foundation of all our reasoning as to design. The only argument we ever have or can have in favour of any intelligent cause, from seeing the adaptation of means to ends, on surveying the works of nature, is, that, if we had done so and so, we should have had the design. All we see is the fact of an adaptation; the inference of a cause, or of a designing being, rests on the kind of reasoning you have just stated. So that in reality we have reached this important position, that our argument for the existence of a designing cause at all in the universe rests on no better, indeed no other foundation than our argument that instinctive action proves an interposition of the Deity at each moment.

A. I must further observe, however, that beside the great weight of this consideration as last presented, I feel the difficulty of the hypothesis of an original law generally imposed to be much aggravated by the consideration you adverted to at the same time, of a provisional and conditional law—a law to operate or not, according to circumstances, as if two implements had been given to the animal, Instinct and Reason; for I feel the very gratuitous nature of this assumption; and I know that there is not a greater proof of our reasoning being merely hypothetical on any question than when we find ourselves obliged to mould, refit, and modify our hypothesis, in order that we may adapt it to the new observations of fact.

B. But there remains a difficulty still more insuperable in your way, which you do not yet advert to. The supposition of a law, and a provisional or conditional law, is all along founded on the assumption of a person to obey it, to act instinctively, unless a certain thing happens, and then to use Reason till a certain other thing happens, and then to fall back upon Instinct again. What can be more gratuitous, not to say absurd? The supposition that the Instinct is to cease and the Reason to begin in a certain event, implies that the animal acting by Instinct all the while was reasonable and intelligent, else how could he know when to lay down his Instinct and take up his Reason? If I send a man to go straight on till he meets a messenger, or sees a finger-post, he is just as much a rational agent all the while he does not deviate from the way, as he is when, meeting the messenger or seeing the guide-post, he does deviate. So that the theory involves here this absurdity, that the instinctive action is all the while an intelligent and rational operation, contrary to the supposition. I can really imagine nothing more decisive or demonstrative than this—and I purposely kept it to the last.

A. Perhaps the end is not yet come; you have said nothing of the known errors or mistakes of instinct—and thus I reserve also my strongest argument to the last. I own that it was this consideration which, always meeting me, drove me to deny the Newtonian doctrine, and to find any or every other escape from it; for surely if the Deity is always acting, there can be no mistake—every thing must be perfectly successful and quite certain. Yet how many cases of mistaken instinct do we see? Mules begotten; flies deceived by the smell of the stapelia to lay their eggs where they cannot breed the maggots, supposing the vegetable an animal substance putrefying; and many others. Now, if this was only the result of similar desires originally implanted, there is no difficulty; for the law would be to follow that smell, and this law is obeyed.

B. Now, I really think you have just yourself answered your strongest argument; for you admit there was that general law. Had it no design? Doubtless, and but one, to lead the animal towards its food, and the nest for its young—the two great objects of all nature, preserving the individual, and continuing the species. Yet here they fail in particular instances, and do neither. Then is not this a defect or imperfection in the general law, detracting, *pro tanto*, from its adaptation to work its undoubted purpose? The same Being gave the general law whom the Newtonian theory supposes to be the particular agent. Then is it not just as inconsistent with His perfections to believe He has made a faulty statute, as to suppose that He makes a mistake in particular cases? Can there be any difference at all here?

A. How do we get out of this in the general case?

B. You mean, how do we answer sceptical, or rather atheistical arguments, drawn from these supposed errors or imperfections? Only by saying, that as in the great majority of cases the design is perfect, and the wisdom complete, it is probable that further knowledge would remove all apparent anomalies, and reduce everything to order, and to a consistency with perfect wisdom and skill. In truth, we always assume design, even where we cannot trace it. The physiologist never supposes any part which he sees produced, as the spleen, to have no use; but rests satisfied that there is a purpose, though he has failed to discover it; and he hopes that it will hereafter be revealed to his inquiring eye. So when he finds apparent imperfection, he has a right—nay, it is sound logical reasoning—to suppose, that further knowledge would prove it to be perfect, as in the vast bulk of cases he has found perfection. The instances of erroneous or defective instinct are as mere nothing compared to those of true or perfect instinct.

A. We also approach here the argument on the Origin of Evil. There is something to be said, though perhaps not much, as to the irreverent nature of the supposition that the Deity acts, considering the meanness or impurity of some instinctive operations, and the trifling nature of others.

B. You may well say, not much in this; there is absolutely nothing at all. Our present argument only refers to physical, and not to moral considerations. Moral feelings or actions are of course not instinctive at all. There is no blame where there is no choice—no knowledge—no intention—no reason. Then, as to indifferent acts; there is nothing small, or mean, or impure in the Deity's eye. There is nothing in this more than is sometimes, without due consideration, urged against the doctrine of Essential Ubiquity. It all proceeds upon a forgetfulness that the Deity cares as much for one creature as another; all are alike proofs of his wisdom; all alike objects of his favour. So as to matter; there is nothing impure or disgusting, except in relation to our weak and imperfect senses, which are, for wise purposes, so formed as to delight in some things and to repudiate others. This is all relative, and relative to ourselves and our imperfect nature. To the Deity it can have no application. The structure and functions of the maggot, bred in the most filthy corruption that can disgust our senses, exhibits, even to the eye of the philosopher, how cumbered soever with the mortal coil, as marvellous a spectacle of Divine skill and benevolence as the sanguiferous or the nervous system of the human body, or the form of the most lovely and fragrant flower that blows.

A. I think the instinct of hunger has begun to operate upon my structure; whether stimulated by the operation of the gastric juice upon the coats of the stomach, or how otherwise, I do not stop to inquire. Nor do I apprehend that our good hostess's instinctive love of order and method would approve of our keeping dinner waiting.

B. Your own excellent mother was the pattern of that regularity, as of so many other admirable qualities; and the intercourse of society was in this, as in far more important particulars, greatly reformed by her example. Therefore let us adjourn our further discussion, of which not much remains, at least not much that is difficult, till to-morrow.

BOOK OR DIALOGUE III.

ANIMAL INTELLIGENCE.—(Facts.)

A. It must be confessed, that for a subject so extremely amusing as well as interesting in a higher view, Instinct has been giving us but little matter of entertainment. I question if any persons ever talked upon it for so many hours without almost a single anecdote, or illustration of any kind from the facts, which are inexhaustible in variety, and every hour present new matter of wonder. Indeed, those ordinarily known are full of interest; and we have been going on with, I think, two, the bee and the solitary wasp, never even casting a look over the rest of this boundless and variegated field.

B. Why truly so; and the reason is plain enough. We had a problem to solve, and we set ourselves to try our hand at it. We assumed that the whole facts resembled those few to which we applied our arguments, or from which we drew our inferences; and our choosing two was quite right and safe—indeed, one rather than two, for we have dwelt more on the solitary wasp than even the bee, because no question could ever be made in her case of training or traditionary instruction. I do not at all repent of having pursued this course; it has prevented digressions and distractions, which would have ensued, had we gone upon the facts at large. We should have been perplexed, sometimes by questions of evidence, sometimes by minute differences of no importance to the argument, sometimes by analogies only calculated to mislead. Our way has been to pitch upon a good example or two, which in some sort embody the subject, as far as matter of fact is concerned—an abstraction of Instinct, as it were, without immaterial particulars—and to confine our reasonings and our illustrations to that. However, there can be no sort of reason why we should not now reward ourselves with a little of the entertainment which, as you say, so amply belongs to this great subject.

A. The Instincts which we have been considering as our choice examples, especially that of the bee, are certainly the most wonderful of all the animal phenomena. But the cases where sagacity is shown, and which seem really quite inconsistent with the doctrine that denies brutes all rational faculties, are most frequently cited to raise men's wonder; and, as I take it, for this reason, that we set out with supposing the common animals to be wholly devoid of intelligence, and are astonished to find them sometimes acting as if they had it—while the operations of Instinct being in many brutes above what any degree of intellect can account for, we refer these to a totally different origin.

B. I quite agree with you. Perhaps one need not go much more now into examples of Instinct. None can exceed that of the bee, which has from the beginning of the creation been working, and all over the world working, in the same manner, upon the successful solution of a problem in the higher mathematics, which only the discovery of the differential calculus a century and a half ago could enable any one to solve without great difficulty at all; and which a celebrated mathematician, who was devoted to the ancient geometry, though an adept also in modern analysis, when he solved, conceived that he had gained no small victory for that favourite science by showing that it could solve this question of maxima and minima.

A. Nevertheless, there are other wonders of a like kind, those which show Instinct to be as great in manufactures as the honeycomb proves it to excel in architecture. The paper-making of the wasp is of this class. She makes a paper as excellent as any manufacturer at Maidstone; she has been for sixty centuries acquainted with what was only discovered by men between five and six centuries ago—for I think the question raised by Meerman confined the discovery to the years between 1270 and 1302, though afterwards a specimen was produced as early as 1243. Moreover, when some of the more recent improvements, as the lengthening and equalizing the fibres, are considered, it is found that the wasp was all along acquainted with these useful devices also.

B. I have observed, too, in examining her structures, that she makes two kinds of paper, white and brown, the former being fine cambric paper, and the two glued together by an excellent smooth and durable kind of cement. The white paper, I find, takes the ink as well as if it were sized.

A. When stories are told to excite wonder under the head of Instinct, they generally relate not to

Instinct, but to the Reason or Intelligence which animals show. However, there are other wonders of Instinct beside those we have been adverting to. The uniformity of the operations of animals of the same species everywhere and at all times is remarkable; and the expertness they show from the first clearly proves that instruction and experience has nothing at all to do with the matter. Bring up a crow under a hen or under any other bird, it makes as exact a crow's nest as if it were born and bred in a rookery.

B. So Maraldi found that a bee an hour old flew off to the proper flowers, and returned in a little time with two pellets of farina, then supposed to be the material for making wax, now known to be used only in making bees breed, since the capital discovery of our John Hunter showed wax to be, like honey, a secretion of the animal. Nay, before birth too the animal works to an end, and with the same exact uniformity. The inimitable observations of the great Réaumur show that the chick, in order to break the egg-shell, moves round, chipping with its bill-scale till it has cut off a segment from the shell. It always moves from right to left; and it always cuts off the segment from the big end. There is no such thing as a party of what Gulliver calls "little-endians" in nature. All these singular Instincts, however, regular and uniform though they be, are, when circumstances require it, interfered with by the rational process of adapting the means to the end, and varying those means where the end cannot otherwise be attained. But Instinct is regular and steady in all ordinary circumstances.

A. The vast extent of the works performed by animals, especially by insects, is no less wonderful than their instinctive skill. This arises from their immense numbers, and the singular Instinct whereby they always work in concert when gregarious. What can be more astonishing than the work of the termites, or white ants, which in a night will undermine and eat out into hollow galleries a solid bed or table, leaving only the outside shell or rind, and soon will make that too disappear!

B. Or the ant-hills in tropical countries, twelve and fifteen feet high, as if men were to make a building the height of the Andes or Himalaya Mountains, when they are vain of having made the little pyramids? But let us go to instances of the other class—of Intelligence.

A. Had we better begin this new discussion by ascertaining whether or not the doctrine of a specific difference between man and the lower animals is well founded; or had we better begin with the facts?

B. I am upon the whole for beginning with the facts; and I should come at once, as we have just been speaking of concerted operations of Instinct, to the case of the beaver, which is, under the head of Intelligence, almost as wonderful as the proceedings of the bee and the ant are under that of Instinct.

A. But before quitting the bee, and the ant, and the wasp, let us just observe their rational acts. They are nearly as notable as their instinctive ones. The bee, upon being interrupted by Huber in her operations, shortened the length of her cells; diminished their diameter; gradually made them pass through a transition from one state to another, as if she was making the instinctive process subservient to the rational; and, in fine, adapted her building to the novel circumstances imposed upon her; making it, in relation to these, what it would have been in relation to the original circumstance if they had continued unaltered. It is found, too, that the ant, beside the wonderful works which she instinctively performs, has the cunning to keep aphides, which she nourishes for the sake of obtaining from them the honey-dew forming her favourite food, as men keep cows for their milk, or bees for their honey.

B. On this discovery of Huber some doubt has lately been thrown; and do not let us trouble ourselves with anything at all apocryphal when the great body of the text is so ample and so pure. But the expeditions of a predatory nature are by all admitted. They resemble some of the worst crimes of the human race; the ants undertake expeditions for the purpose of seizing and carrying off slaves, whom they afterwards hold in subjection to do their work—so that the least significant and the most important of all animals agree together in committing the greatest of crimes—slave-trading.

A. With this material difference, that the ant does not pharisaically pretend to religion and virtue, while we bring upon religion the shame of our crimes by our disgusting hypocrisy. But the wasp, too, shows no little sagacity as well as strength. Dr. Darwin relates an incident, to which he was an eye-witness, of a wasp having caught a fly almost of her own size; she cut off its head and tail, and tried to fly away with the body, but finding that, owing to a breeze then blowing, the fly's wings were an impediment to her own flight, and turned her round in the air, she came to the ground and cut off the fly's wings one after the other with her mouth. She then flew away with the body unmolested by the wind.*

B. I have myself observed many instances of similar fertility of resource in bees. But perhaps the old anecdote of the Jackdaw is as good as any—who, when he found his beak could not reach the water he wanted to drink, threw into the pitcher pebble after pebble till he raised the surface of the liquid to the level of his beak. Lord Bacon tells it of a Raven filling up the hollows in a tree where water had settled.

A. Or the Crows of whom Darwin speaks in the north of Ireland, who rise in the air with limpets and muscles, to let them fall on the rocks and break them, that they may come at the fish. It is said that animals never use tools, and Franklin has defined man a tool-making animal; but this is as nearly using tools as may be—at least, it shows the same fertility of resources, the using means towards an end.

B. It does a little more. It shows the highest reach of ingenuity, the using the simplest means to gain your end—the very peculiarity for which Franklin's own genius was so remarkable. He could make an experiment with less apparatus, and conduct his experimental inquiry to a discovery with more ordinary materials, than any other philosopher we ever saw. With an old key, a silk thread, some sealing-wax, and a sheet of paper, he discovered the identity of lightning and electricity. Here we are instituting a harmless comparison between the bird and the sage: but the crow's genius is said once to have come in collision with the head

* Zoonomia, Sec. xvi. 16.

of a philosopher in a less agreeable manner, when, mistaking the bald skull of Anaxagoras for a rock, she let fall the oyster from such a height that it killed him.

A. But there certainly must be allowed to be even nearer approaches to tool-making, or, at least, to the use of tools, among animals. There are many insects which use hollow places, and some which use hollow reeds or stalks for their habitations.

B. Indeed they do; and perhaps the most remarkable of all proofs of animal intelligence is to be found in the nymphæ of Water-Moths, which get into straws, and adjust the weight of their case so that it can always float—at least, Mr. Smellie says that when too heavy they add a piece of straw or wood, and when too light a bit of gravel.* If this be true, it is impossible to deny great intelligence to this insect.

A. Why should we doubt it? The crow in rising and letting the muscle fall shows as great knowledge of gravitation as the moth in this case.

B. But an old Monkey at Exeter Change, having lost its teeth, used, when nuts were given him, to take a stone in his paw and break them with it. This was a thing seen forty years ago by all who frequented Exeter Change, and Darwin relates it in his Zoonomia. But I must say that he would have shown himself to be more of a philosopher had he asked the showman how the monkey learned this expedient. It is very possible he may have been taught it, as apes have oftentimes been taught human habits. Buffon, the great adversary of brute intelligence, allows that he had known an Ape who dressed himself in clothes to which he

* Transactions of Royal Society of Edinburgh, vol. i., p. 42.

had become habituated, and slept in a bed, pulling up the sheets and blankets to cover him before going to sleep; and he mentions another which sat at table, drank wine out of a glass, used a knife and fork, and wiped them on a table-napkin. All these things, of course, were the consequence of training, and showed no more sagacity than the feats of dancing-dogs and bears, or of the learned pig—unless it were proved that the ape on being taught these manipulations became sensible of their convenience, and voluntarily, and by preference, practised them—a position which no experiments appear to support. Smellie, however, mentions a Cat which, being confined in a room, in order to get out and meet its mate of the other sex, learnt of itself to open the latch of a door; and I knew a Pony in the stable here, that used both to open the latch of the stable, and raise the lid of the corn-chest—things which must have been learnt by himself, from his own observation, for no one is likely to have taught them to him. Nay, it was only the other day that I observed one of the Horses taken in here to grass, in a field through which the avenue runs, open one of the wickets by pressing down the upright bar of the latch, and open it exactly as you or I do.

A. I have known, as most people living in the country have, similar instances, and especially in dogs.

B. But there is one instance of animals catching their prey in a way still more like the tool-making animal. I do not allude merely to the Spider's web, or to the Pelican's use of his large open pouch in fishing; but to an American bird, of which you find a curious account in the *Philadelphia Trans-*

*actions.** It is called the *neun-tödter* by the Germans, as we should say the *nine-killer*, and is found to catch grasshoppers and spear them when dead upon twigs where the small birds come on which it feeds; for the grasshoppers themselves it never touches. These are left, generally about nine in number (from whence its name), the whole winter, and they attract the birds of which the animal in question makes its prey. This is really using one creature as a bait, in order thereby to decoy and catch another.

A. It is certainly a singular and curious instance, whether of Instinct or Intelligence. Are there not stories told of apes using a cat or some other animal—I should suppose rather anything than a cat—to get chesnuts out of the fire?—or what else is the origin of the phrase *cat's paw?*

B. Fable, I presume. Many fables have a real origin in fact: this, I suspect, has not. Monkeys, on the contrary, have been used by men to obtain fruit or cocoa-nuts, by pelting them, and their defending themselves with a fire of nuts.

A. That, however, is a plain instance of sagacity and imitation. They used missiles, as missiles were used against them. Some of our own belligerent measures of retaliation have not always been nearly so judiciously contrived.

B. No: we once, by way of retaliating on Napoleon, helped him; as if the monkeys had pelted themselves, instead of throwing at us. However, an unexceptionable authority, Captain Cook, or at least Captain King, in Cook's last voyage, has a singular instance of sagacity in the use of means, and almost weapons, in Bears. Here you have his

* Vol. iv.

account of their mode of hunting: "The wild deer (*barein*) are far too swift for those lumbering sportsmen; so the bear perceives them at a distance by the scent; and, as they herd in low grounds, when he approaches them, he gets upon the adjoining eminence, from whence he rolls down pieces of rock; nor does he quit his ambush, and pursue, until he finds that some have been maimed."*

A. Certainly, such a well-attested fact as this is very important, and worth a thousand stories of lions and jackals. But you spoke of coming at once to the Beaver, as the parallel to the Bee.

B. Certainly it is, and may be called, in respect of its works, the Bee of quadrupeds, or if you will, of Intelligent animals, holding among them as high a place as does the Bee among Instinctive creatures. Nevertheless, there may be some doubt raised how far Instinct has a share in his operations. They are of great uniformity: all packs or companies of beavers, and at all times, build the same shaped structure, and resemble one another closely in matters which are arbitrary, and therefore cannot be considered as the result of experience or reflection—cannot be dictated by circumstances. This, however, opens a question of some difficulty, which, according to the plan we are pursuing, may be left to the end of our discussion, after we shall have gone through the facts. In considering the beaver, I think we shall do well to follow Buffon, as we did upon the ape, because he purposely rejected everything marvellous or doubtful in the accounts he had received from travellers, and these must have been numerous, for Canada was then a French colony. Those singular animals assemble

* Cook's Third Voyage, vol. iii., p. 306.

in bodies of from two to four hundred, and choose a convenient station in the lake or the river, having regard to the slope of its banks and their woodiness, but also, no doubt, to the frequency of floods in the water. If it is a lake, or a river that varies little in its level, they build their huts without any further structure, but if the level changes much, they construct a dam or dyke, what we call a breakwater, extending eighty or a hundred feet across, and ten or twelve broad: they thus keep the water nearly of the same height, at least they thus always obtain a sufficient depth of water. They then work in concert on the wood, gnawing the trees and branches to suit their operations. A tree the thickness of a man's body they will soon bring down by gnawing round its base, but on one side merely, and they know so exactly the operation of gravity on it, that they make it fall always across the stream, so as to require no land-carriage. It must be observed, in passing, that if they do this the first time they have built, and without any previous experience of falling bodies, the operation must be taken as purely instinctive. They form their cabins so as to contain from fifteen to twenty-five or thirty animals; each cabin has two doors, one to the land, and one to the water, in order that they may either go ashore, or bathe or swim, and sit in the water, which is part of their pleasure, or rather of their amphibious existence. They have in each cabin also a storehouse for placing the parts of the shoots on which they feed (for that they make provision against winter is quite certain), and room enough for accommodating their young when brought forth. The cabins are built on piles, so as to be out of the water;

they are neatly plastered with cement, the animal's flat and scaly tail being used as a trowel in this operation. They are of sufficient strength to resist not only the stream and floods to which occasionally they may be exposed, but also severe storms of wind. The beavers choose to work with a kind of earth not soluble in water, and which they mix with clay. Such is the account of those very rational and intelligent proceedings which Buffon, sceptical beyond all men of stories respecting animal reason, sifted out of all he had heard, after rejecting everything that bore the appearance of exaggeration or fancy. He adds, that a single beaver which he had, showed, in its solitary and domestic state, no signs of sagacity or resources; but rather appeared to be a stupid animal. According to his strange theory, that animals are degenerating in mind, and losing their faculties as man improves (a notion derived from confounding their loss of dominion, power, and numbers, in a wild state, with their loss of intellect),* he considers the beaver as the "only subsisting monument of the ancient intelligence of brutes."

A. They say doubts have of late been cast upon the former accounts of the beaver. I am told, Hearne, one of the best North American travellers, is cited for this.

B. Here is what that excellent observer says upon the subject: you shall judge if he has in the least altered the case. The beavers select, he says, either in small lakes or in rivers, spots where the water is of such depths as not to freeze to the bottom, preferring, however, running water, because this helps them to convey the timber they

* Vol. iv., p. 73, and v., p. 21.

require. They begin by forming a dyke across with fascines, stones, and mud, but without piles buried in the ground; this dyke, whose only use is to give them a convenient level of water, is convex on the upper side fronting the stream; and it becomes solid and strong by repeated repairs, so that the branches sprout, and birds build in the hedge which it forms. Each hut contains commonly one or two, but sometimes four families; and sometimes each is separated from the others by a partition. The hut has a door opening on the water, and no connexion with the land. He then goes on to show how they cut down and build, wherein he differs from the common accounts only in saying that no piles are used in the construction. They work, he says, only by night, and each season they cover the buildings with a new coat of mud-plaster, as soon as the frost sets in. In summer they make excursions in the woods, choosing the trees they mean to make use of, and marking the position of new settlements, when their increase of numbers requires them to plant colonies. Their wood-cutting begins at the end of summer, and the building is carried on in autumn. They have also subterraneous retreats along the banks of the river or lake, to serve as a place of refuge when they may be attacked by the glutton. You perceive, then, that there is very little discrepancy between this account and Buffon's; indeed, there is one remarkable addition to the latter, if it can be relied upon, the precaution taken in summer to choose and to mark out the convenient stations where the new settlements are afterwards to be made.

A. There seems reason to suppose that other animals still preserve their sagacity and act in concert. No one can have observed a flock of pigeons without perceiving that they have sentinels posted to give the alarm. Indeed, wilder birds act in like manner. Fieldfares, when they are occupying a tree which you approach, remain steady and fearless until one at the extremity rises on her wings and gives a loud and very peculiar note of alarm, when they all get up and fly, except one who continues till you get near, as if she remained to see that there really was occasion for the movement, and to call them back if the alarm proved a false one. She too at length flies off repeating the alarm-note.

B. In the forests of Tartary and of South America, where the Wild Horse is gregarious, there are herds of five hundred or six hundred, which, being ill prepared for fighting, or indeed for any resistance, and knowing that their safety is in flight, when they sleep, appoint one in rotation who acts as sentinel, while the rest are asleep. If a man approaches, the sentinel walks towards him as if to reconnoitre or see whether he may be deterred from coming near—if the man continues, he neighs aloud and in a peculiar tone, which rouses the herd and all gallop away, the sentinel bringing up the rear. Nothing can be more judicious or rational than this arrangement, simple as it is. So a horse, belonging to a smuggler at Dover, used to be laden with run spirits and sent on the road unattended to reach the rendezvous. When he descried a soldier he would jump off the highway and hide himself in a ditch, and when discovered would fight for his load. The cunning of Foxes is proverbial; but I know not if it was ever more remarkably displayed than in the Duke of Beaufort's country; where Reynard, being hard pressed, disappeared suddenly, and was, after strict search, found immersed in a water-pool up to the very snout, by which he held a willow-bough hanging over the pond. The cunning of a Dog, which Serjeant Wilde tells me of, as known to him, is at least equal. He used to be tied up as a precaution against hunting sheep. At night he slipped his head out of the collar, and returning before dawn, put on the collar again, in order to conceal his nocturnal excursion. Nobody has more familiarity with various animals (beside his great knowledge of his own species) than my excellent, learned, and ingenious friend, the Serjeant; and he possesses many curious ones himself. His anecdote of a drover's dog is striking, as he gave it me, when we happened, near this place, to meet a drove. The man had brought seventeen out of twenty oxen from a field, leaving the remaining three there mixed with another herd. He then said to the dog "Go, fetch them;" and he went and singled out those very three. The Serjeant's brother, however, a highly respectable man, lately Sheriff of London, has a dog that distinguishes Saturday night, from the practice of tying him up for the Sunday, which he dislikes. He will escape on Saturday night and return on Monday morning. The Serjeant himself had a gander which was at a distance from the goose, and hearing her make an extraordinary noise, ran back and put his head into the cage—then brought back all the goslings one by one and put them into it with the mother, whose separation from her brood had occasioned her clamour. He then returned to the place whence her cries had called him. I must however add, that I often have conversed with Scotch shepherds coming up from the

Border country to our great fairs, and have found them deny many of the stories of the miraculous feats of sheep-dogs. Alfred Montgomery and I, the other day, cross-questioned a Roxburghshire shepherd with this result.

A. Many of the feats which we are now ascribing to intellectual faculties may be instinctive operations. How shall we distinguish?

B. The rule seems simple. Where the act is done in ordinary and natural circumstances, it may be called instinctive or not, according as it is what our reason could, in the like circumstances, enable us to perform or not, and according as the animal is in a situation which enables him to act knowingly or not. Thus a bee's cell is made by a creature untaught; a solitary wasp provides food for an offspring it never can see, and knows nothing of. We set these things down to Instinct. If horses, fearing danger, appoint a sentinel, it may be Instinct certainly, but there is here nothing to exclude Intelligence, for they do a thing which they may well do by design, and so differ from the bee; they are aware of the object in view, and mean to attain it, and so differ from the wasp. But these remarks apply to acts done in ordinary circumstances, and which I admit may or may not be instinctive. Another class is clearly rather to be called rational. I mean where the means are varied, adapted, and adjusted to a varying object, or where the animal acts in artificial circumstances in any way. For example, the horse opening a stable-door, the cat a room-door, the daw filling a pitcher with stones. So there is a singular story told by Dupont de Nemours in Autun's *Animaux Célèbres*, and which he says he witnessed himself. A Swallow had slipped its foot into the noose of a cord attached to a spout in the Collége des Quatre Nations at Paris, and by endeavouring to escape had drawn the knot tight. Its strength being exhausted in vain attempts to fly, it uttered piteous cries, which assembled a vast flock of other swallows from the large basin between the Tuilleries and Pont Neuf. They seemed to crowd and consult together for a little while, and then one of them darted at the string and struck at it with his beak as he flew past; and others following in quick succession did the same, striking at the same part, till after continuing this combined operation for half an hour, they succeeded in severing the cord and freeing their companion. They all continued flocking and hovering till night; only, instead of the tumult and agitation in which they had been at their first assembling, they were chattering as if without any anxiety at all, but conscious of having succeeded.

A. The means taken to escape from danger, and to provide for security, are certainly often of this description, the danger being often of a kind purely accidental and solitary, and the operation of the animal varying in different and new circumstances. Some birds wholly change their mode of building to avoid snakes, hanging their nests to the end of branches, and making the exit in the bottom, in places where those reptiles abound.

B. So too the Ants in Siam make no nests on the ground, as with us, but on trees, that country being much subject to inundations. But you find this change of habits in animals, upon circumstances changing, pretty general. The Dogs which the Spaniards left in the island of Juan Fernandez were found to have lost the habit of barking, when

Juan and D'Ulloa visited that famous spot in the course of their journey in South America. Possibly they found that barking warned their prey, and enabled it to escape. But Dogs in Guinea howl and do not bark, and when European dogs are taken there they lose their bark in three or four generations. This fact, then, is somewhat equivocal.

A. The docility of some animals may, however, as it seems to me, be strictly ranged within the class of facts we are speaking of. Although children, as well as animals, learn through fear and kindness, both operating (and fear alone would suffice), yet it is an act of Intelligence to follow the dictates of both feelings: it implies this process of reasoning,—"If I do so and so, I shall have such a punishment or such a reward." Now the degree to which animals are teachable is wonderful. All Singing-Birds probably learn their whole notes.

B. Yes; Daines Barrington has demonstrated this by numerous experiments* on various birds; the young untaught birds, being placed in the nests of different species of birds, always had the song of those it nestled with; and we all know how a Piping Bullfinch can be taught almost any tune. They seem to have no notion of harmony or melody. I recollect a Green Linnet, which I had when a boy, or rather a mongrel between that and a goldfinch, being placed in a kitchen, and leaving its own fine and sweet notes, to take to an imitation, and a very good and exceedingly discordant one, of a jack which, being ill-constructed, generally squeaked as if it wanted oiling.

* Phil. Trans., 1776.

A. Dogs show the greatest talents in learning. The feats of pointers, but still more of shepherds' dogs, after making all the deductions you have mentioned, are astonishing. It almost seems as if the shepherd could communicate, by sign or by speech, his meaning, when he desires to have a particular thing done. But assuredly the dog takes his precautions exactly as he ought, to prevent the sheep from scattering, and to bring back runaways. Indeed, Greyhounds and other dogs of chace, as well as Pointers backing one another, show the adaptation of, and variation in, the means used towards an end.

B. Retrievers exceed all other dogs in this respect. There was one died here a year or two ago that could be left to watch game, till the keeper went to a given place, and she would then join him after he had ranged the field; nay, could be sent to a spot where game had been left, and where she had not been before. Indeed, she did many other things which I have hardly courage to relate.

A. How were her pups? I have always found such extraordinary faculties hereditary.

B. My worthy, intelligent, and lamented friend, T. A. Knight (so long President of the Horticultural Society), has proved very clearly that the faculties of animals are hereditary to such a point as this. He shows that even their acquired faculties—the expertness they gain by teaching—descends in the race. His paper is exceedingly curious. But I think we need hardly go so far as to his minute details for proof of the fact. It is found that where man has not been, no animals are wild and run away from his approach. When Bougainville went to the Falkland Islands (or, as the French call them, the Malouines), he found himself and his men immediately surrounded by all kinds of beasts and birds, the latter settling on their shoulders. No navigators had ever been there before. Lord Monboddo says that the same thing had been related to him by navigators.* It seems clear, then, that the running away from man, which seems natural to all wild animals in or bordering upon inhabited countries, is an acquired propensity, transmitted to the descendants of those whose experience first taught it them as necessary for their safety.

A. Have you Knight's paper here? I know the accuracy of his observation to equal his great ingenuity.

B. To that I too can bear my testimony. Here is his principal paper, read lately before the Royal Society. It is given as the result of his observations and experiments, made for a period of sixty years; it is therefore most justly entitled to great respect. He chiefly dwells on the case of Springing Spaniels, and among other instances gives this, which is indeed very remarkable. He found the young and untaught ones as skilful as the old ones, not only in finding and raising the woodcocks, but in knowing the exact degree of frost which will drive those birds to springs and rills of unfrozen water. He gives the instance, too, of a young retriever, bred from a clever and thoroughly-taught parent, which, being taken out at ten months old, with hardly any instruction at all, behaved as well and knowingly as the best-taught spaniel, in rushing into the water for game that was shot, when pointed out to it, however small, bringing it, and

* Origin of Language, b. ii., ch. 2.

depositing it, and then going again, and when none remained, seeking the sportsman and keeping by him. He imported some Norwegian ponies, mares, and had a breed from them. It was found that the produce "had no mouth," as the trainers say; and it was impossible to give it them; but they were otherwise perfectly docile. Now in Norway, draught horses, as I know, having travelled there and driven them, are all trained to go by the voice, and have no mouth.—Again, he observed that they could not be kept between hedges, but walked deliberately through them—there being, he supposes, none in the country from which their dams came.

A. Does he speak of any other animal?

B. Yes, he mentions his observation on Woodcocks, which he could remember having been far less wild half a century ago; for on its first arrival in autumn, it was tame, and chuckled about if disturbed, making but a very short flight, whereas now, and for many years past, it is very wild, running in silence and flying far. He gives an instance of sagacity in a Dog, unconnected with hereditary intelligence. He one day had gone out with his gun and a servant, but no dog. Seeing a cock, he sent the servant, who brought this spaniel. A month afterwards he again sent for the same dog from the same place. The servant was bringing him, when at twenty yards from the house the spaniel left him, and ran away to the spot, though it was above a mile distant. This he often repeated, and always with the same result; as if the animal knew what he was wanted for. Leonard Edmunds tells me of a dog (a Newfoundland spaniel) of Mr. Morritt's, at Rokeby, which has been known to take the shorter road to where he knew he was wanted, and leave the servant or keeper to go round about. You yourself told me of a dog that met you sporting by a short cut unknown to you.

A. The manner in which animals can find their way is very extraordinary. But though, in many cases, it may be through close observation, and observation the clearer and better remembered because, like the Indian woodsmen, they have so few ideas; yet, in other cases, it seems an Instinct very difficult to conceive in its workings. In truth, if the stories told be true, I question if any instance we have yet examined of Instinct be so truly unaccountable on any principles of intelligence. I have known of dogs sent to a distance, and coming home immediately, though taken in the dark.

B. That might be from smell or track, but stories are also told of dogs and cats taken in hampers, and finding their way back speedily. L. Edmunds had one that was carried from Ambleside to three miles on the other side of Burton, a distance of twenty-seven miles, in a close hamper, by a coach; and it found its way back next morning. Dr. Beattie's account of a dog which was carried in a basket thirty miles' distance, through a country he never had seen, and returned home in a week, is less singular than this, even if it were as well authenticated. Dr. Hancock, in his excellent work on Instinct, which, however, contains fully as much upon the peculiar tenets of the Society of Friends as upon our subject, relates the story of a dog being conveyed from Scotland to London by sea, and finding his way back; of a Sheep returning from Yorkshire to Annandale, a distance of at least eighty miles; and of another Sheep returning from Perthshire to the neighbourhood of Edinburgh. Kirby and Spence, too, in their *Introduction to Entomology*, state, on the authority of a captain in the Navy, a strange anecdote of an Ass taken from Gibraltar to Cape de Gat on board of ship, and finding its way immediately back through Spain to the garrison, a distance of two hundred miles of very difficult country. The ass had swam on shore when the ship was stranded. This fact seems to be well authenticated, for all the names are given, and the dates.

A. There is no end of such facts, and many of them seem sufficiently vouched. The *Letters on Instinct* mention a cat which had been taken to the West Indies, and on the ship returning to the Port of London she found her way through the city to Brompton, whence she had been brought.

B. That is a work I have often wished to see, and never been able to get. Dr. Hancock quotes it for one of the most remarkable proofs of sagacity and resource in the Goat, and this operation has been, it seems, observed more than once. When two Goats meet on a ledge bordering upon a precipice, and find there is no room either to pass each other, or to return, after a pause, as if for reflection, one crouches down and the other walks gently over his back, when each continues his perilous journey along the narrow path.

A. In Rees's Cyclopædia a story is given as well vouched, of a cat that had been brought up in amity with a bird, and being one day observed to seize suddenly hold of the latter, which happened to be perched out of its cage, on examining, it was found that a stray cat had got into the room, and that this alarming step was a manœuvre to save the bird till the intruder should depart. But what do you make of carrier-pigeons? The facts are perhaps not well ascertained; there being a good deal of mystery and other quackery about the training of them.

B. I desired one of the trainers (they are Spitalfields weavers generally) to come, that I might examine him about his art, but he has never been with me. I have read and considered a report made to me on the subject. It is said the bird begins his flight by making circles, which increase more and more in diameter as he rises; and that he thus pilots himself towards his ground. But still this indicates an extraordinary power of observation; for they come from Brussels to London and return. Nay, they have been known to fly from the Rhine to Paris. Serjeant Wilde took pigeons of the Rock kind to Hounslow, and they flew back to Guildford-street in an hour. They were taken in a bag, and could see or smell nothing by the way. On being let loose, they made two or three wide circles, and then flew straight to their dovecot. The Serjeant also knew of a cat which a shopkeeper's apprentice in Fore-street had been desired to hang, and found he could not. He then took it in a bag to Blackfriars Bridge and threw it into the river—the cat was at home in Fore-street as soon as the apprentice. He might have made a circuit, but certainly the cat returned in an hour or two. The grocer's name was Gardner—the distance is certainly above a mile, and through the most crowded part of London. The case of bees is referable to Instinct clearly. Honey-finders in America trace their nests by catching two bees, carrying them to a distance, and letting them fly.

Each takes the straight line towards the nest or hive, and by noting these two lines, and finding where they intersect each other, the hive is found. Now the bee is known to have a very confined sphere of vision, from the extremely convex form of her eye. She is supposed only to see a yard or so before her.

A. I fancy we must pass over the subject of migration for a like reason. It seems still involved in much obscurity and doubt, though I take for granted that no one now yields to Daines Barrington's theory, which denies it altogether.

B. Clearly no one; the facts are quite indisputable as far as negativing that goes; and indeed his reasonings are so full of prejudice, or preconceived opinion, and his suppositions for disposing of the facts so strained, that his argument never could have had much weight. One fact seems also not to be disputed, and is referable to Instinct alone. I mean the agitation which, without any cause, comes on upon a bird of any of the migratory classes at the appointed season of migration. It is, in all probability, connected with the sexual impulses.

A. The communication with each other, which animals have by sounds or signs, can, I think, hardly be doubted.

B. The observations of Huber clearly show that ants have a kind of language by means of their feelers or antennæ; and every day's experience seems to show this in other animals.

A. Some believe that they have a notion of what men are saying, and no doubt very strange and lucky guesses have sometimes been made, one of which I wrote you an account of. I had it from a most accurate and literal person, and it tends to prove that his shooting dogs had found out his intention of going into Nottinghamshire the day after. However, it is perfectly clear that these things are referable to minute and exact observation of things which escape us in the greater multitude of our ideas and concerns. All this, however, only illustrates the more how well animals can profit by experience, and draw correct inferences from things observed by them.

B. Among other instances referable plainly to intelligence must be ranked the devices which one animal is known to fall upon for benefiting by another's operations. The ant enslaving workers is the most curious instance certainly. But the cuckoo laying in other birds' nests, and leaving her progeny to be brought up by them, is another. Nor can this be set down wholly to the score of Instinct; for there are abundant proofs of her also building when she cannot find a nest, and then she lays in her own, and hatches and rears her brood. This curious and important fact, long disbelieved by vulgar prejudice, was known to that great observer Aristotle, who says she sometimes builds among rocks, and on heights.* Darwin confirms this by the observations of two intelligent friends whom he cites.† The man-of-war bird is a still more singular instance of contrivance, for though its food is fish, it has not such a form as to be fit for catching any, and therefore it lives piratically on the prey made by other fishing birds; hence the name we have given it.

A. Only think of our never having all this while said a word, or more than a word, of either the

* Lib. vi., c. 1. † Zoonomia, vol. xvi., p. 13.

Fox or the Elephant, proverbially the two wisest of animals. Of the former's cunning every day shows instances; but that the elephant should be left to take care of a child unable to walk, and should let it crawl as far as his own chain, and then gently lift it with his trunk and replace it in safety, seems really an extraordinary effect of both intelligence and care, and shows that fine animal's gentle nature, of which so many anecdotes are told by travellers in the East.

B. The amiable qualities of brutes are not quite within the scope of our discussion, unless indeed in so far as whatever things are lovely may also be said to betoken wisdom, or at least reflection. The natural love of their offspring I should hardly cite in proof of this, because it seems rather an instinctive feeling. But the attachments formed between animals of different classes, a cat and a horse, a dog and a man, and often between two elderly birds, may be cited as interesting. One of these friends has been known to be unable to survive the other. I have heard this of two old parrots, upon the best authority.

A. We have said nothing of fishes, or of any marine animals.

B. Why, of these our knowledge is necessarily very limited. That they have remarkable Instincts, some of them resembling those of land animals, is certain. The Sepia, or cuttle-fish, ejecting a black or dark-brown fluid to facilitate his escape, resembles the stratagem of some beasts emitting an intolerable effluvia in the face of their pursuers. The Whale, when attacked by the Sword-fish, diving to such a depth that his enemy cannot sustain the pressure of the water, is another well-known example of defensive action. I used to observe with interest the wary cunning of the old Carp in the ponds here: there was no decoying them with bait, which the younger and less experienced fish took at once. So little have men formerly undervalued the faculties of fishes, that Plutarch wrote an ingenious treatise in the form of a dialogue, on the question whether land or water animals have the most understanding.

A. How does he treat this odd question?

B. Here is his book; and certainly as far as the first portion of the subject goes, where the merits of land animals are concerned, he sails before the wind. To his first remark I willingly subscribe, that those hold the most stupid doctrine upon the subject (*οἱ αβελτερως λεγοντες*) who say that animals do not really fear, rejoice, remember, rage, &c., but only do something like fearing, rejoicing, &c. (*ὡσανεῖ φοβεισθαι*, &c.); and he asks what such reasoners would think were it also contended that animals do not see, but make as if they saw; nor hear, but make as if they heard; nor roar, but make as if they roared; and, finally, do not live, but only did something like living. He then relates a great variety of facts respecting the sagacity of animals, some of them evidently fabulous (as the love of a dragon for a young woman), and some, as the account of the ant laying in grain, now proved to be erroneous; but he gives others worthy of attending to. Thus, the contrivance of African crows, who, when the water was scarce, threw pebbles into deep cracks of the earth, so as to bring the fluid up towards the surface, and within their reach—the similar cunning of a dog on board of a vessel—the like device fallen upon by elephants to rescue one that had fallen into a pit—the astuteness of the fox, used by the Thracians as a kind of guide in crossing a river frozen over, to find out whether the ice is thick enough, which the animal does by stopping and listening to hear if the water is running near the surface—the judicious mode of flight in which cranes and other birds of passage marshal themselves, forming a wedge-like body, with the strongest birds at the front angle or point. But when he comes to the other side of the question, and is to state the case for the fishes, we find a great falling off both in his facts and in his evidence. Beside telling very absurd stories about crocodiles in Egypt obeying the call of the priests and submitting to their influence, he dwells upon the Sepia, whose escape in a black cloud of his own making he compares to the tactics of Homer's gods; upon the cunning shown by fishes in gnawing lines to escape with the hook; nay, upon a story he tells of their helping one another to escape when caught, which is plainly groundless; upon the Torpedo, or electrical eel, giving shocks, which is clearly a mere physical quality, and no more indicates reason than the shark using his teeth; upon shoals of fishes, like flocks of birds, forming themselves into wedges when they move from one sea to another, which is certainly true; upon the dolphin loving music, which is purely fabulous, as well as the feats of wisdom and philanthropy that he ascribes to this fish (*μονος γαρ ἀνθρωπον ασπαζεται καθο ἀνθρωπος εστι*); finally, upon all the fables to be found in the poets respecting this fish. After reciting one of these, by way of proving his case in favour of marine animals, he innocently enough says that although he had promised to relate no fables, he now finds himself, he knows not how, in the company of Cæranus and Ulysses, and so he brings his notable argument to a close.

A. How does he ultimately decide the question propounded?

B. With a verse of Sophocles, intimating that both sides have gained some advantage towards a common purpose; but the victory is given to neither, the umpire pronouncing that both the arguments combined overthrow the doctrine of those who deny Reason and Intelligence to animals generally.

A. There are no modern books which fully discuss this subject systematically, either as regards Instinct or Intelligence. One is exceedingly disappointed in consulting our best writers, whether metaphysicians or naturalists, with this view; and the omission is the less to be excused because there are great opportunities of observing and comparing: this branch of knowledge is eminently suited to inductive reasoning; we live as it were among the facts, and have not only constant facilities for making our experiments, but are in some sort under a constant necessity of doing so.

B. Truly it is as you say. I have often felt this disappointment and this disapprobation. The works of metaphysical writers contain a few scattered suggestions, or dogmas, and with these they leave the subject. Naturalists, who could throw so much light upon it, confine themselves chiefly to the structure and functions of the organs, and leave the mental part of the subject out of view. Yet a physiologist, who also applied himself to this latter branch of the inquiry, would be the person best qualified to grapple with its difficulties and to throw light upon it. Therefore I learnt with extreme satisfaction that an able and learned professor of Natural History had given a course of lectures upon it at Paris, and was still more gratified to find that he soon afterwards published them. I speak of M. Virey's work; those two thick volumes lying there contain above a thousand pages on the Habits and Instinct of Animals; and to raise my expectation still higher, it professes by its title to deal in facts—for it is called *Histoire des Mœurs et de l'Instinct des Animaux.*

A. Well; I suppose you rushed upon it to slake your thirst?

B. As a traveller upon a delicious and copious spring, and found it a picture; or upon a luscious-looking large peach, and found my mouth filled with chalk. I have had these volumes here these two years, and I can barely now say I have been able to get through them. They are throughout not only written in the very worst style of French sentimental declamation, but they avoid all precision, all details, all facts, as something grovelling, common-place, and unimportant. The constant object is not to find out or illustrate some truth, to describe or arrange some phenomenon, but to say something pretty, far-fetched, and figurative. And all this with an arrangement of the classes of animals so methodical, that on looking at the contents, and finding they proceed regularly from the structure of the globe and the general qualities of its different products, to mammalia, then to birds, reptiles, fishes, and so downwards through the invertebrated animals, ending with zoophytes and mollusca, you naturally expect under each head to have what the title promises, a History of the

Habits and Instincts; and find nothing of the kind from beginning to end, but only trope after trope, one piece of finery after another, nothing but vague declamation long drawn out, an endless succession of the most frivolous sentimentality. Truly such a work, from so learned a naturalist, one who could so well have instructed and entertained us, had he but chosen to be plain and didactic, instead of being brilliant and rhetorical, where all eloquence and ornament are absolutely misplaced, is no small offence in the literary world.

A. I'll assure you our French neighbours are not the only sinners in this particular. I have been somewhat mortified of late years at perceiving a tendency to fine writing and declamation among our own men of science, and I ascribe it, in some degree, to the more general diffusion of scientific knowledge, which naturally introduces the more popular style of composition. Our Society of Useful Knowledge has no sins of this sort on its conscience, because we correct with unsparing severity all we publish; but you may perceive the tendency of popular explication to run in this bad direction, from the kind of matter that is often submitted to us for revision. I am sure I sometimes draw my pen through half a page of fine writing at a time.

B. I will engage for it you do inexorably whenever you find such outrages. My experience is precisely the same; and I am just as severe on those parts, evidently the prime favourites of the learned and very able writers. But we originally set out with firmly resolving to be most rigorous in matters of taste, being aware, as you say, of the tendencies of popular writers. In truth, however, that vile florid style darkens instead of illustrating;

and while we never can write too clearly to the people, we never can write too simply, if our design be to write plainly and intelligibly. But though our Society is free from having any of this blame, I cannot quite acquit of all blame the meetings, however useful and praiseworthy in other respects, of an association which brings crowds of hundreds and thousands together, to hear mathematicians and chemists making declamatory speeches. I must say that those assemblages offer some violence to Science, at least they somewhat lower her by showing her cultivators trying a trade they no more can, or even ought to excel in, than poets in solving questions of fluxions. It is since these meetings, otherwise useful and excellent, rose into eloquence, that I have seen a mathematical discussion, by a very able and learned man, in two consecutive pages of which I reckoned up above twenty metaphors—all tending to darken the subject—to say nothing of poetical quotations without any mercy. Formerly declamations were reckoned so little an accomplishment of scientific men, that when Bishop Horsley filled our Royal Society with a factious controversy, the ministerial side, Sir Joseph Banks's party, had to send for assistance—and where think you they went for an orator?

A. I suppose to some Nisi Prius advocate.

B. Guess again.—No!—So humble were their views of oratory that they went to the other side of the hall, as the lawyers say, and got for their champion, Mr. Anguish, who was Accountant-General, a Chancery man, and had perhaps made as few speeches as any one in that Court. But in the work which I have referred to, and even in those scientific meetings, there is at least much that is highly valuable, much good grain, and the trash may be rejected as chaff—whereas, in this piece of French declamation all is chaff, and hardly a grain can be gleaned out of the light and worthless matter.

A. Can you find nothing by sifting and bolting it? I generally find something even in the worst books.

B. I will not say that these heavy volumes of light matter contain absolutely nothing; but wondrous little assuredly they have to reward the pains of searching. What can be more hateful than a man of science unable to speak of granivorous animals without terming them Pythagoreans and Gymnosophists; calling the crying baboon of South America a wild Demosthenes, the lion a generous prince, the jackal a courtier; describing the nightingale as appealing to Heaven against the robber of her nest, and the crocodiles as the "sad orphans of nature," because hatched in the sand; nay, carrying his ridiculous fancies into actual practice, seriously explaining the mild temper of one animal by the sweetness of its humours, and the ferocity of another by the acrid juices of its system—all a pure fiction in fact, as well as a gross absurdity in theory! Then mark the consistency of a philosopher—a consistency worthy of the veriest mob. He denounces, as the most atrocious of men, the experimenter on a living dog or rabbit, Fontana, or Majendie, I suppose, and afterwards speaks with the utmost composure of dividing a bee in two, in order to examine her honey-bag. Of the bee, indeed, he seems very moderately informed. He speaks of Aristarchus having devoted his life to the study of this insect, instead of Aristomachus; assumes to be true the notion long exploded of honey being collected from flowers, instead of a secretion in the stomach; will not believe that wax, too, is a secretion, though he refers unconsciously to Huber's experiment of obtaining it from bees feeding upon sugar and water; and, to set off his modern natural history with a little false classical lore, must needs call the cells "their citadel, or the palladium of their republic."

A. Bad enough in all conscience. But now give us the grain or two of wheat in all this bushel of chaff.

B. First, and this makes it more provoking, the anthor writes clearly and admirably when he chooses to leave off declaiming. There is a long note upon vertebrated and invertebrated animals, showing with much clearness and precision that in the former, which have a cerebral and nervous system, Intelligence prevails; in the latter, Instinct. He maintains the specific difference of Instinct and Reason or Intelligence with great force and clearness; indeed, there seems nothing to find fault with in his statements here, except that he places the seat of Intelligence in the cerebral nervous system, and of Instinct in the ganglionic, and thus is forced to deny Intelligence altogether to insects, whereas we have seen that Huber's observations plainly show the bee to have the capacity of varying its means in accomplishing the end in view when the circumstances vary; and this surely cannot be distinguished from Intelligence. Also he discusses, with perfect strictness of reasoning, the hypothesis of a very celebrated naturalist, no less than M. Lamarck, and, I must say, refutes very satisfactorily the theory of my most learned and worthy colleague, for whom we all must feel the most profound respect. He had been induced to suppose that Instinct results from the habits originally acquired by animals adapted to the circumstances in which they found themselves placed at the beginning of the creation, and that these habits occasioned an adaptation of their structure to particular operations, as well as a constant capacity and desire to perform them. Now, my only objection to M. Virey's refutation of this theory, which is merely the exploded doctrine of appetencies in a new form, is, that it requires no such elaborate answer to overthrow it. For what do we see in all nature which in the least entitles us to suppose any animal at any period to have had the power of altering his bodily structure, creating one part and altering another according to his wants? Besides, if animals, at their first creation, had so much power and so much intelligence as this theory supposes, why should this all cease and leave them only possessed of blind Instincts now? The reasoning, however, of M. Virey is sound, and does much credit to his acuteness.

A. But have you found, in his volumes, no facts; nothing to place among the phenomena which we are collecting previous to resuming our discussion respecting the faculties of brutes?

B. Very little; and that so wrapped up in declamation, and so disfigured with figures (if I may thus speak), that there is no small difficulty in seizing hold of it. What he says of the architecture of squirrels, marmots, rats, and some other rodents, is new to me. I had only been aware of the beaver, among this tribe, as remarkable for ingenuity. But it seems these others excel all animals in digging subterranean dwellings; they make compartments or chambers, which they line with clay, and cover with a roof from the weather; in some of these chambers they stow vegetables, which they previously dry in the sun; others they use for the reception of their young; in others they sleep. He brings together some curious instances of swift and long-sustained flights of birds. Thus the smallest bird, he says, can fly several leagues in an hour; the hawk goes commonly at the rate of a league in four minutes, or above forty miles an hour. A falcon of Henry II. was flown from Fontainebleau, and found, by its ring, at Malta next day. One, sent from the Canaries to Andalusia, returned to Teneriffe in sixteen hours, a distance of nearly seven hundred miles, which it must have gone at the average rate of twenty-four miles an hour. Gulls go seven hundred miles out to sea and return daily; and Frigate-birds have been found at twelve hundred miles from any land. Upon their migration he states, as a known fact, that Cranes go and return at the same date, without the least regard to the state of the weather, which shows, no doubt, if true, a most peculiar instinct; but these, and, indeed, all facts which we find stated by a writer so addicted to painting and colouring, must be received with a degree of suspicion, for which no one but M. Virey is to be blamed. The accounts, however, of the swiftness of birds, I can well credit, from an experiment which I made when travelling on a railway. While going at the rate of thirty miles an hour, I let fly a bee; it made its circles as usual, and surrounded us easily. Now, if there was no current of air or draught to bear it along, this indicated a rate of ninety miles an hour; and even allowing for a current, the swiftness must have been great. I should, however, wish to repeat this experiment before being quite sure of so great a swiftness in so small an insect.

A. Have you given all your gleanings from this work?

B. I should, perhaps, add these two. We find in it a curious passage from an old Spanish author of the seventeenth century, giving a quaint and lively account of the sagacity of the beggars' dogs at Rome; and we also find the titles of some German works on the faculties of brutes, which are truly curious, and show how great a degree of attention that laborious people have paid to the subject, but, at the same time, betray not a little of the characteristic boldness and enthusiasm of their speculations.

A. I conclude you have never seen more than these titles in this book?

B. Never; and I really should wish to see the works themselves. One is *Mayer de peccatis et pœnis Brutorum*, 1686, in quarto. Another, in 1725, *Hermanson de peccatis Brutorum;* this, however, is printed at Upsal. A third is *Schrœder de Simulacris virtutum in Brutis Animantibus*, 1691; and a fourth, *Schrœder de Brutorum Religione*, 1702. Then, it appears that one Drechsler wrote, in 1672, a *Dissertation on the Speech of Animals*, and Meyer and Martin, not to be outdone, followed this up a few years after, the one with a *Treatise on the Logic of Animals*, and another with one *De Animalium Syllogismo.*

A. Does the Spaniard give any curious particulars of dogs?

B. Not perhaps any that surpass what we have been stating from facts known among ourselves.

But his account is diverting enough. "The blind-man's dog," says he, "will take him to the places where he may best hope to get his alms, and bring him thither through the crowd by the shortest way and the safest; nay, he will take him out of the city some miles to the great church of St. Paul, as you go to Ostia. When in the town he cometh to a place where several ways meet, and with the sharpness of ear that the blind have, guided by some sound of a fountain, he gives the string a jerk by either hand, straightway will the poor dog turn and guide him to the very church where he knows his master would beg. In the street, too, knoweth he the charitably-disposed houses that be therein, and will lead thither the beggar-man, who, stopping at one, saith his pater-noster; then down lieth the dog till he hear the last word of the beadsman, when straight he riseth and away to another house. I have seen myself, to my great joy, mingled with admiration, when a piece of money was thrown down from some window, the dog would run and pick it up and fetch it to the master's hat; nor, when bread is flung down, will he touch it be he ever so hungry, but bring it to his master, and wait till he may have his share given him. A friend of mine was wont to come to my dwelling with a great mastiff, which he left by the door on entering; but he, seeing that his master had entered after drawing the string of the bell, would needs do likewise, and so made those within open the door, as though some one should have rung thereat."

A. Upon my word, you have been amusing yourself with making the old Castilian speak in old English.—But now, I think, we may be said to have gone at sufficient length into the facts, and to have gathered together a collection large enough for our purposes of speculation—nor have we perhaps much more to do with this in that way. For can any one rationally doubt that they evince in these brutes some faculties at least approaching in kind to our own—nay, and to such of our own as we are wont to prize the most, and to be the proudest of? No blind impulse of a mechanical kind, no mere instinct, or feeling, or operative principle, apart from knowledge, experience, learning, even intention,—can surely account for the things we have just been considering as done by animals—and one example, and an ordinary one, is as good as a thousand. The cat opening a door from observing men do so before it; or the bird, from its own observation of the effect produced by solid bodies, sunk in water, raising the water by throwing in pebbles; or letting muscles fall to break the shells—these things surely argue a thinking and a reasoning process.

B. There seems little doubt of this; however, we may perhaps adjourn the further discussion, as we no longer require to be among our books, but may take our walk out in the sun, which is far from disagreeably hot to-day.

A. I have no kind of objection, and will meet you on the Terrace as soon as I have written my letters.

BOOK OR DIALOGUE IV.

ANIMAL INTELLIGENCE.—(Theory.)

We accordingly finished our letters, and prepared to go out and walk about in the sunny exposure, which a north-west wind made agreeable, as in the north it often does, even at this season—" calceis et vestimentis sumptis, placitum est ut in aprico maxime patente loco conveniremus :*"—where, as we walked about, he began in continuation of his last remark.

A. I know not why so much unwillingness should be shown by some excellent philosophers to allow intelligent faculties, and a share of reason, to the lower animals, as if our own superiority was not quite sufficiently established, to leave all question of jealousy out of view, by the immeasurably higher place which we occupy in the scale of being, even should we admit the difference to be in degree rather than in kind ; because when the difference of degree becomes so vast, there is hardly any more chance of encroachment or confusion, hardly any more likeness or comparison, than if the difference were radical and in kind. Some writers, as D. Stewart, really seem to treat the question as one of an exciting nature, and almost to regard the purity

* " Having taken our boots and greatcoats, we chose to meet in an open and sunny exposure."—Cic. De Repub. lib. i. cap. 12.

of religious belief as involved in the controversy. How is this, and why should it be?

B. It is possible that the origin of the feelings shown by those good and able men, resembles that of Descartes' absurd theory, of brutes being like machines, which, as far as he holds it, he avows to have proceeded from the notion that unless they are so, their souls would be immortal. But another reason may be assigned. The sceptical, or free-thinking, philosophers always lowered human nature as much as possible. They regarded it as something gained to their arguments against religious belief, if they could show the difference to be slighter than is supposed between men and brutes; and that there is a chain of being from the plant, nay almost from inorganic matter, up to man. They seem to have had a confused idea that this helped them even to account for the constitution of the universe, "without the hypothesis of a Deity," as Laplace is said to have termed it when Napoleon questioned him on the remarkable omission in the 'Mécanique Céleste.' Thus much is certain in point of fact, that those philosophers, and especially the French school, were fond of lowering the human intellect by raising that of animals; and while the priests were lavish of their admission that our moral nature is utterly corrupt but claimed for our intellectual capacity to be only a little lower than the angels, the society of the Encyclopédie, and the coterie of Baron d'Holbach were fond of levelling the intellectual distinction between immortal and confessedly mortal beings, though they denied the moral depravity of their race with perhaps no very strict regard either to the evidence of their consciousness or of their observation. It thus appears that this theory of a difference in kind is found in company with that of scepticism, just as some other theories are usually coupled with it also; for example, the selfish system,—philosophical necessity,—expediency,—materialism,—all of which are held by Hume, Voltaire, Helvetius, Diderot, and other free-thinkers; yet all of which are also held by some as determined believers as any that are to be found in any church. Priestley, for instance, held all these doctrines, and Paley all but the last. Hume's opinion on the reason of brutes cannot be doubted from some accidental remarks interspersed in his writings. Helvetius, a materialist and sceptic both, has explicitly stated that if the arm of man had chanced to terminate in the foot of a horse, he would still have been found wandering about as the tenant of the woods.* The company in which the opinion has been found has thus greatly disinclined pious men towards it. Professor Robinson, in his attacks on the French school, is nowhere more severe upon them than where he impeaches them of endeavouring to lower the dignity of human nature,† and undoubtedly such attempts may be made in a manner to hurt the interests both of religion and of morals.

A. Has not Lord Monboddo given great offence of the same kind, and in the same quarters?

B. Possibly he has; although from his station as a judge, and a man of most loyal political opinions, and also from his being an orthodox believer, at least as far as professions go, he has been less blamed than the rest. He was an admirable Grecian, such as in modern times Scotland has very rarely pro-

* De l'Esprit. † Proofs of a Conspiracy.

duced; and there is an infinite deal of ingenuity and subtlety as well as learning in his writings, with a constant display of most correct taste in judging of the ancient controversies. But his theory has subjected him to great ridicule, not so much from his holding that there is a gradation in the whole scale of beings, and that the mental faculties of man are found in the minds of brutes, as from his denying any specific difference even in body; and holding that originally men were fashioned like monkeys, and lived like them wild and savage.

A. I could much more readily understand this doctrine giving offence and scandal as heterodox, than the other; for it seems not very easily reconcilable either to our religion or indeed to almost any other received among civilized nations.

B. I consider it a thing just as little supported by the facts, as it is repugnant to all known systems of theology. But my objection to it is really not founded upon its tendency to lower human nature. On the contrary, I doubt if it does not rather exalt our faculties beyond all the ordinary doctrines, and draw a broader line of distinction between us and the lower animals than that which it was intended to efface. For surely if we have not only by our intelligence made the great progress from a rude to a refined state—from the New Zealander to Laplace, and Newton, and Lagrange—but have also, by the help of the same faculties, made the progress from the state of monkeys and baboons, while all other animals are the same from one generation to another, and have made not a single step for sixty centuries, and never have attempted in a single instance to store up for after-times the experience of a former age, our faculties must needs be immeasurably superior to theirs. In short, the only question is as to the nature of the difference.

A. I can well suppose a difference merely in degree sufficient to explain any diversity of condition or result. We have only to compare individual men together to perceive this. It is admitted that reason, nay, that the power of forming abstract ideas, as well as drawing inferences from premises, is possessed by persons whom yet you shall in vain attempt to teach the simplest mathematical demonstration. Then their faculties only differ in degree from those by which Pascal learnt geometry without a master or a book, and Newton discovered Fluxions, and Lagrange and Euler the Calculus of Variations. It may truly be said, that there is no difference in kind which could make a greater diversity in the result.

B. It may indeed be truly so said; but it may also be added, that there is not a greater difference, call it in kind or in degree, between the person whose obtuseness you have supposed, and a sagacious retriever, or a clever ape, than between the great mathematicians you have named, and that same person. Locke, whose calmness of understanding was equal to his sagacity, and never allowed his judgment to be warped by prejudice, or carried away by fancy and feelings, seems to have held this opinion, and indeed to have allowed some reason to animals. "There are some brutes," he observes, "that seem to have as much knowledge and reason as some that are called men;" and he goes on to say that there is such a connexion between the animal and the vegetable kingdom, as makes the difference scarcely perceptible between the lowest of the one and the highest of the other.

A. You quoted Addison's paper upon Instinct yesterday, in proof of his taking the Newtonian view of the subject. What does he say as to the Reason, and generally the Intelligent faculties, of animals?

B. He is, as you are aware, no very great reasoner; insomuch, indeed, that I have known persons made converts to Deism, or rather from Christianity, by reading his most feeble treatise on the Evidences. One man of great virtue, learning, and ability confessed as much to me. Accordingly, he is very wavering and inconsistent on this subject also, and encounters it with prejudice. At one place he says, reason cannot be the cause of brutes acting as they do; and then, after seeming to deny it, he only adds a kind of admission that they have reason: "for," says he, "were animals endued with it to as great a degree as man," &c. And again, in the same paper, he seems to deny it altogether. "One would wonder to hear," he says, "sceptical men disputing for the reason of animals, and telling us it is only our pride and prejudices that will not allow them the use of that faculty." This is exactly the notion to which I was a little while ago imputing the unwillingness of so many reasoners to allow brutes their fair share of intelligence. You see Addison considers it the natural course of a sceptic; yet surely Locke was as firm a believer as himself, and certainly a far more reflecting and intelligent one.

A. Perhaps we had as well consider, before going into the question, by what kind of logic the argument is to be conducted, by what sort of evidence we are to try the cause.

B. I presume there can be no doubt here. We must examine it according to the rules of inductive science. The facts are before us. Some we gather from observation—those relating to animals; some, as those respecting the nature of the human mind, we ascertain by our own consciousness, or at least chiefly by that, though in some sort also by observing other men's conduct, and communicating with them; but having no means of communicating with animals, we are reduced to our observation merely; and then we naturally draw the inference that, because the same things done by ourselves would be known by us to be done from certain mental powers, therefore we ascribe those powers to the animals. This conclusion as to ourselves is certain, because we know and feel it to be so by our own consciousness. With respect to animals it is not nearly so certain, because we cannot either enter into their minds, as we do into our own, or communicate with them, as we do with our fellow-men. Nevertheless, by varying our observations on them, by making experiments on their faculties, by placing them in new and arbitrary combinations of circumstances, we can reduce the chances of error to a very small amount, and render our inferences as highly probable as most of the propositions of contingent truth are.

A. It is not, however, necessary that we should now go into an investigation of the nature of the human faculties. Our researches are in their nature comparative only.

B. Certainly; and therefore, agreeing with you, I would begin by laying down this position, that all we have to do is to grant or to deny the existence of certain mental faculties, and to ascertain the meaning of the terms which we employ in expressing these. Whatever those faculties may be in us, all we are now to consider is, whether or not the brutes have the same, or in any degree.

A. I think it quite right and really for our safety, in conducting the inquiry, to lay down a second preliminary principle or caution, namely, that we have no right to argue from the mere effects produced by certain endowments, or by any given combination or modification of these. Thus, when we see what has been achieved by man, and contemplate the extraordinary monuments raised by his industry, his activity, and his intelligence, and the power which he has acquired over the operations of nature, and of all other animals, profiting so largely by both, and when we compare this with the feeble state of those animals, their having no accumulation of either knowledge or possessions, and gained nothing upon man or by man, we are drawing a contrast which really proves nothing; because it is just as easily accounted for by supposing the two classes extremely different in degree, as by assuming that they differ in the kind of their faculties. Thus to take a common instance, and one which Adam Smith himself gives as marking a great difference between us and the brutes, they have no appearance of barter; but if barter arises from comparing ideas together, and forming a conclusion from the premises, and if, from other facts, animals appear to possess that power, there being no positive barter only shows that their judgment or reasoning faculties are weaker than ours, or that for some other reason, it is immaterial to the argument what, they have not acquired that particular result of the reasoning faculty.

B. I entirely agree in this general position, holding that the neglect of it has been one main cause of the errors into which philosophers have fallen on this question; I must, however, doubt the correctness of the position, that the brutes are wholly ignorant of barter. No one, as Smith says, ever saw one dog barter a bone with another. But many of the operations of both dogs and horses in dividing their labour, and of insects, as ants, in helping each other, seem referable to a principle not to be easily distinguished from barter. The division of labour is clearly to be observed among them. Of course I do not mean that comminute division by which bees work together, and in which they incalculably excel ourselves; for that we have classed as instinctive and unintentional, and therefore it cannot enter into our present argument. But horses plainly help one another in drawing, and take different parts of the work; so do dogs in the chace. However, to leave no doubt about it, and allowing beavers to act instinctively, the wild horses sleeping and watching by turns is a clear and unequivocal instance of the division of labour. But I admit your position—that if anything which is the result of a faculty, proved already to be one of the animal mind, is not possessed by them, this is no argument against their having that faculty. It may lead us to be the more cautious in examining the proofs by which their possession of the faculty is established: but that is all. Indeed, such distinctions are taken upon no more philosophical ground than he would have for his classification who should make two divisions of metals or of water, one the solid, and another the fluid, accordingly as they had different temperatures.

A. I hold it to be a part of the same preliminary position, that if brutes are shown to possess any given simple faculties, their not having the power of doing things only to be accomplished by combinations of these simple powers, does not impeach the proposition, already established, of their having those simple powers. For it would only show that they have not the combination, though they may have the separate powers. Does any other proposition occur to you as convenient to be laid down in the outset?

B. I should say this, which is perhaps rather a corollary from the last, that we must carefully distinguish between simple and composite faculties, as they are called. Indeed, I deny the accuracy of this form of speech, and I believe it tends much to error in metaphysical speculations. No system of psychology, ancient or modern, sanctions it; neither those of Hartley, Priestley, Berkeley, nor that of Reid and Stewart and Brown, although I think it has been much encouraged by the speculations of these last, and their separate treatment of our mental powers under distinct heads, how necessary soever this was for the elucidation of the subject. The mind being one, and entire, and invariable, without parts or composition, acts always as one being. It recollects, praises, judges, abstracts, imagines; and when you say that it exercises a compound, or complex, or composite faculty, as for example, the imagination, you only mean that it first exerts one faculty, then another, and then a third. We never should call the process by which chemists bleach vegetable substances a composite operation, because they first make oxymuriatic gas, then mix lime with water, then, by agitation of the water exposed to the gas, cause lime to combine, and then expose the vegetable fibre to this compound liquor; we say that these are so many successive operations performed, and not one complex operation. And so imagination is not one compound faculty, nor is imagining one complex operation of the mind. But that mind in succession remembers, abstracts, judges or compares ideas, and reasons or compares judgments—and the whole four successive operations form imagination; to which you may add the further operation of taste, which, rejecting one and selecting other results of imagination, produces the fruits of refined or purified fancy; if indeed this taste itself be anything but a sound exercise of judgment—a judgment refined by experience, that is, by constant attention to what is pleasing, and what disagreeable. The rapidity with which all these separate operations are performed by the mind, neither prevents them from being in succession and separately performed, nor at all shows the mind to have composition or parts. Giving names to certain combinations, or rather successions of operations, and not to others, may be correct; but it must be admitted is somewhat capricious. We talk of imagination as if it were one operation, though it is many; and yet we give no separate name to several other successions as rapid of our mental operations. So as to our moral feelings. We speak of conscience as one; yet it is, as Smith describes it, a succession (he says a compound) of several, among which pity for the party injured, and fear of the consequences to ourselves, are the chief. Yet we give no name to the reflection on past enjoyments, which is as quick a succession of several emotions,—namely, recollection, comparison of the present, and sorrowing for the contrast. However, as regards our present purpose, the simplest part of the proposition is, that any given simple faculty or single operation of the mind being found to be possessed by animals, the circumstance of their not possessing the compound exclusively, or several combined, or a successive operation of different faculties, is no proof against their having the simple ones. Thus, if they have no fancy, it is no proof that they have no memory or judgment; because they may have these without having abstraction, which is one of the faculties that go to make the imaginative process. But it is also no proof of their being without abstraction, and all the other simple or single faculties; for it only proves that they have not the power of using these faculties together, or rather in quick succession, and for the same joint purpose. And should they have the simple or single, without having the compound faculties or processes, this would again argue no specific difference, but rather a diversity of degree.

A. I think these preliminary positions not only have cleared the ground for us, but helped us a good way on our journey. There appears hardly much more to reason about now. The subject has been a good deal enveloped in mist and smoke, from confusion of ideas, and from prejudice and high feeling. These being blown away, it seems pretty clear what the structure is that we are to examine.

B. Before going to the brute faculties, let us just cast a glance over the faculties which have been enumerated as belonging to ourselves, and see if they should not be a little simplified—Sensation, Perception, Consciousness, Memory, Abstraction, Imagination, Judgment, Reasoning, to which have been added Taste and the Moral Sense; and Mr. Stewart thinks these not enough, adding among others, the power of connecting general or abstract signs with the things signified. Now suppose we admit the correctness of calling a state of mind in which it is purely passive an active power or faculty, as Sensation, which is merely the effect produced upon the mind by the operation of the senses, and involves nothing like an exertion of the mind itself, any more than receiving a hurt or a gratification passively is any exertion of the body, although the operation whereby that reaches the mind may be termed bodily exertion; then it will follow, and not otherwise, that Sensation is a faculty. But Perception is no doubt an active exertion of the mind. *Memory* differs from Recollection as Sensation does from Perception. The state of mind in which one idea calls up another, or a present state of mind influenced by a past state, is Memory. The exertion by which the mind voluntarily induces the present state from the past, is Recollection. The one is the *sensation*, the other the *perception* of the past, as sensation and perception are of the present.

A. Is not Perception an inference from Sensation? I have the sensation of solidity or of smell, and I perceive either the solid, resisting body, and the odorous body, or I perceive the solid or odorous quality, that is, I infer a being from the sensation, or I infer a quality; the former seems a simple inference, the latter an inference coupled with an abstraction.

B. I do not incline altogether to this opinion; but at any rate it will not apply to Memory and Recollection; for Recollection is not an inference from Memory; it is an effort by which the mind throws itself into the state into which it might have been brought by the former ideas recurring of themselves. In Perception we do not voluntarily throw the mind into the state of Sensation; we draw an inference from that sensation according to your theory. But I think it pretty clear that there is something between the sensation and the inference —the simple apprehension and the conclusion drawn. The latter is clearly an inference that an external being exists which created the sensation and the perception. But I think there is also a perception upon the sensation, and which cannot certainly exist without it. However, be this as it may, to our present purpose it makes no difference, except as far as there can be no doubt of the mind being in a much more passive state in the two conditions of feeling and remembering than in the other two of recollecting and perceiving.

A. Then of Imagination we have already disposed. It consists of the successive, though rapidly succeeding operations of other faculties whereby we create or combine new ideas that had no previous existence, abstracting the qualities of one object to clothe another with them. But Abstraction we may allow to be a simple operation and one of the most important. What do you make of two that I do not remember you to have named, Attention and Conception?

B. I omitted them purposely. I can see really nothing in Attention but the degree in which certain other faculties operate. It is only the intensity with which I perceive. Possibly there may be some good from considering it as the difference between Perception and Sensation: in the latter case the mind passively receives the impression of the senses; in the former it fixes itself steadily upon those impressions, so as to feel them by a voluntary effort more acutely. As for Conception, which used formerly to be called Simple Apprehension, it is only the forming ideas of objects neither presented by the senses nor by the imagination; and I am unable to separate it from Memory and from Abstraction—from memory as far as it deals with former ideas, from abstraction as far as it deals with quality apart from the objects remembered or imagined.

A. Then Judgment being the comparison of ideas, and Reasoning the comparison of judgments, that is, of the ideas arising from the former comparison, may be set down as one faculty—that of Comparing—and I conclude you make quick work with Taste and the Moral Sense, of which the one gives us preferences among objects of mental gratification, and the other among objects of moral approbation?

B. They are both evidently exercises of the judging and reasoning powers,—say the comparing powers, according to two standards,—the one the sense of beauty or fitness, of what is pleasing or agreeable; the other, the sense of what is just and right. But whether this last sense is natural or acquired, and how acquired, is a question that has long divided philosophers, and which will very certainly never be determined. Nor is it more easy to determine the other, which is quite a kindred one, how it is that our taste is formed, and whether it be natural or acquired. All that we can say on this subject is, to remark the little practical importance which belongs to either question, and to state that, as far as our present discussion is concerned, the only faculty involved in either the one or the other is that by which we compare different ideas.

A. Our enumeration then of mental faculties seems to resolve into Perception, active or passive; Memory, active or passive; Consciousness, Abstraction, and Comparison; then how do we place animals as to the first?

B. Clearly no animal, nothing having life, can be conceived to exist, without Passive Perception at all events, and hardly any without Active Perception also. Consciousness too seems a necessary quality of every mind; it is the knowing one's own existence; so Memory of the passive kind must exist in every mind; without Consciousness and Memory no animal could know its own personal identity; and no acts could be done by it upon the supposition of that identity. With respect to Active Memory and Conception, if this is to be held a separate faculty, it is implied in Comparison, or in judgment and reasoning; so that our inquiries come to be confined within sufficiently narrow limits. Do the lower animals possess Abstraction and Comparison? I will at once begin with Abstraction, because it is the power most generally denied to brutes; and this arises, as I conceive, from an ill-grounded notion of its nature, and from a supposition that it is a faculty of a far more refined nature, subservient to operations of a much more difficult kind, than the truth will warrant us in affirming. The truth appears to be, that there are, if not two kinds of Abstraction, an active and a passive, yet certainly some degrees of Abstraction so easy and even unavoidable, that we can hardly conceive almost any mind incapable of forming them. But on the other hand, the very highest and most difficultly attained reach of human thought is connected with Abstraction. Observing this, philosophers have passed all under one name, and because the brutes could not conduct algebraical investigations or metaphysical reasonings, have denied them all power whatever of forming abstract ideas.

A. To a certain degree this is no doubt true. The abstraction by which we reason upon m and n or x as only numbers; deal with x the unknown quantity, multiplying it and speaking of m times x, or dividing it and speaking of one n^{th} part of x, is no doubt a high and refined reach of thought; but so is the forming to ourselves an idea of abstract qualities; indeed I know not if, when we reason about m and x, we do more than mechanically deal with the letters; whereas in reasoning of colour or smell as abstracted from the rose with which we always have seen them conjoined, and forming to ourselves the idea of something in the abstract which we have only ever seen in the concrete,—of some ideal existence of which in actual existence we have never known anything, nor can know,—we really appear to go a step further. Now do you maintain that Abstraction is ever otherwise than a difficult and painful operation?

B. First of all be pleased to observe that many philosophers altogether deny, even to man, the power of forming abstract ideas. The dispute of the *Nominalists* and *Realists*, so well ridiculed by Swift, or rather by Arbuthnot in Scriblerus, is as old as metaphysical inquiries, under one name or another. They consider it impossible for us really to form these abstractions, and hold that we only are using words and not dealing with ideas, just as you seem to think we do in algebraical language. Mr. Stewart is among those who conceive that we think in language. My opinion, if against such venerable authority I may venture to hold one, is different. I think we have ideas independent of language, and I do not see how otherwise a person born deaf and dumb and blind can have ideas at all; which I know they have, because I carefully examined the one of whom Mr. Stewart has given so interesting an account. Indeed he has recorded the experiment of the musical snuff-box which I then made upon this unhappy but singular boy. But next I am to show you that abstraction independent of algebra, or metaphysical reasoning altogether, is neither difficult nor painful. Without Abstraction we cannot classify in any way, or make any approach to classification. Now I venture to say that no human being, be he ever so stupid, is without some power of classification, nay, that he is constantly exercising it with great care, and almost unavoidably, and acting upon the inferences to which it leads. He can tell a man from a horse. How? By attending to those things in which they differ. But he can also tell a stone from both, and he knows that the stone is different from both. How? By attending to those things in which the two animals agree, and to those things in which they differ from the stone. So every person having accurate eyes and the use of speech can call a sheet of paper and a patch of snow both white; a piece of hot iron and of hot brick both hot. He has therefore the idea in his mind of colour and of heat in these several cases, independent of other qualities, that is, abstracted from other qualities; he classifies the white bodies together, independent of their differences; the hot bodies, independent of theirs; and he contrasts the white metal with the white snow, because they differ in temperature, without regarding their agreeing together in colour. All this is Abstraction, and all this is quite level to the meanest capacity of men. But is it not also level to brute intellect? Unquestionably all animals know their mates and their own kind. A dog knows his master, knows that he is not a dog, and that he differs from other men. In these very ordinary operations we see the animal mind at one time passing over certain resemblances and fixing on differences; at another time disregarding differences and fixing only on resemblances. Nay, go lower in the scale. A bull is enraged by a red colour, be the form of the body what you please. A fish is caught by means of a light, be it of any size or any form.

A. These things which you last mention are mere sensations. The red light or the flame impresses the retina and affects the animal's sensorium, his brain—irritating the quadruped, and attracting the fish.

B. What then? Other sensations pass to his mind through his senses at the same time. He has the sensation of form as well as colour; yet he passes this entirely over, and only considers the colour. However, take those cases in which animals are attracted to certain places. They are hungry and go to a certain field to eat, without the least regard to its position or its shape; because it agrees with other fields in bearing the food which the beast is in quest of. Flies approach the light because they believe it to be the open air where they wish to go. So the bird never throws stones into a river or puddle to raise the water; but it does throw them into the ewer. It abstracts water from the thing containing it; and could not reason upon the effects of the operation without a process of Abstraction. Indeed, upon the footing on which you would put it, I know not that all our own abstract ideas may not in the end be resolved into sensations and their immediate consequences. I know of no evidence that you have of our abstract ideas being formed in any other way, except on our consciousness, and our continual communication of ideas and experience through speech. In the case of the brute we have all the same phenomena, and, excluding the operation of blind Instinct, we are forced to the like conclusions.

A. I think we may go a step further; have not animals some kind of language? At all events they understand ours. A horse knows the encouraging or chiding sound of voice and whip, and moves or stops accordingly. Whoever uses the sound, and in whatever key or loudness, the horse acts alike. But they seem also to have some knowledge of conventional signs. If I am to teach a dog or a pig to do certain things on a given signal, the process I take to be this. I connect his obedience with reward, his disobedience with punishment. But this only gives him the motive to obey, the fear of disobeying. It in no way can give him the means of connecting the act with the sign. Now connecting the two together, whatever be the manner in which the sign is made, is Abstraction; but it is more, it is the very kind of Abstraction in which all language has its origin—the connecting the sign with the thing signified; for the sign is purely arbitrary in this case as much as in human language.

B. May we not add that they have some conventional signs among themselves? How else are we to explain their calls? The cock grouse calls the hen; the male the female of many animals. The pigeon and the fieldfare and the crow make signals; and the wild horse is a clear case of signals. All this implies not only Abstraction, but that very kind of Abstraction which gives us our language. It is in fact a language which they possess, though simple and limited in its range.

A. As to the power of comparing, what is commonly called Reason, *par excellence*, comprising Judgment and Reasoning, this needs not detain us very long. The facts here are not well liable to dispute. There is no possibility of explaining the many cases which we began by going over without allowing this power. They all prove it in some degree. Several of them show it to exist in a very considerable degree. The acts of some birds and monkeys cannot be accounted for by Instinct; for they are the result of experience; and they are performed with a perfect knowledge of the end in view; they are directed peculiarly to that end; they vary according as the circumstances in which they are performed alter, and the alteration made is always so contrived as to suit the variation in the circumstances. Some of these acts show more sagacity, according to Mr. Locke's observation, than is possessed by many men. The existence of a comparing and contriving power is therefore plain enough. And on the whole I conceive that a rational mind cannot be denied to the animals, however inferior in degree their faculties may be to our own.

B. That inferiority is manifestly the cause why they have made so little progress, or rather have hardly made any at all. Some little is proved by such facts as Mr. Knight has collected, but they are only exceptions to the rule which has doomed them to a stationary existence. This difference, however, is merely the result of the inferior degree of their mental powers, as well as the different construction of their bodily powers. The want of fingers endowed with a nice sense of touch is an obstruction to the progress of all, or almost all, the lower animals. The elephant's trunk is no doubt a partial exception, and accordingly his sagacity is greater than that of almost any other beast. The monkey would have a better chance of learning the nature of external objects if his thumb were not on the same side of his hand with his fingers, whereby he cannot handle and measure objects as we do, whose chief knowledge of size and form is derived from the goniometer of the finger and thumb, the moveable angle which their motion and position give us. Insects work with infinite nicety by means of their antennæ; when these are removed they cease to work at all, as Huber clearly proved. Clearly this different external conformation, together with their inferior degree of reason, is sufficient to account for brutes having been stationary, and for their being subdued to our use, as the Deity intended they should, when He appointed this difference. To argue from the complex effect of all the faculties, bodily and mental, in giving different progress or power to our race and to theirs, and to infer from this difference that there is an essential and specific diversity in our mental structure, nay that they have not one single faculty the same with ours in kind, is highly unphilosophical. It is indeed contrary to one of the fundamental rules of philosophizing, that which forbids us needlessly to multiply causes. For we are thus driven to suppose two kinds of Intelligence, human and brutal, and two sets of faculties, a Memory and a Quasi Memory, as the lawyers would have it—an Abstraction and Reasoning, properly so called, and something in the nature of Abstraction and Reasoning, but, though like, yet not the same.

A. There is one matter to which we have not as yet adverted, but, after having considered the intelligent as well as instinctive powers, we may now as well do so. I mean the diversity in the operations of the latter, and the perfect sameness of the former—a sameness in all the operations of any given individual animal, and likewise of each of the species.

B. This is well worthy of consideration. When trying to explain instinctive operations upon the hypothesis of an intelligent principle acting under the impulse of sensations, I found in this perfect sameness and regularity of its operation a considerable difficulty, though not perhaps an insuperable one, not certainly so great a difficulty as those we have considered.

A. How did you endeavour to explain, on that hypothesis, the regularity of Reason or Intelligence?

B. The absolute sameness of moral and intellectual character, and the limited sphere of ideas and events, will account for much. We see far less diversity of action and speech among peasants of a very confined knowledge and very limited range of pursuits, than among persons of a higher degree of education and superior station in life. But still there is a great diversity. Taking, however, two men of most perfect resemblance in all their faculties, and all their feelings, similarly constituted in both body and mind, they would probably act nearly if not entirely alike. Whatever made one do a thing would make the other, and we must suppose them to be placed in perfectly similar circumstances, so that the same things would happen to both. Chance is here to be put out of view; because it only means ignorance of motives and circumstances, and assumes a diversity in these unknown to us, which by the supposition is here excluded. Suppose these two individuals thus placed in like circumstances as to food and building materials, why should they eat differently, or make different habitations? What is there to make the one choose a plant which the other does not choose? or form a hut in any particular different from the other? If one kind of food was nearer the one, and another nearer the other individual, they might choose differently; but this assumes that both kinds are agreeable to the constitution of their palates.

A. As long as providing for merely physical wants was their whole occupation, it is probable that both would act alike, except that, if any difficulty occurred to be vanquished, I am not at all sure of their adopting the very same means to overcome it. One might break a nut with his teeth, another with a stone, or by bruising two nuts together. But there is the same diversity in the conduct of animals where they act by intelligent principles. The general resemblance of their proceedings is explained by the consideration you are stating in the case you put of the boys. Their instinctive operations would never vary in the least particular. When they came to reason, or speculate, or converse, the sameness would probably cease. It seems inconsistent with imagination and with free will; yet of this I speak doubtingly, considering the hypothesis you have made of faculties and feelings perfectly alike in all respects.

B. Certainly, you ought to speak doubtingly, when such is the hypothesis that is now binding us. I do not see how, even in reasoning, anything should ever come into the mind of the one that did not suggest itself to the other. But our hypothesis is not easy to remain under. Suppose, to make the case like instinct, two untaught children in different parts of the country, viz., one in China and the other here, to be placed in a situation where the same kinds of food and building materials were placed, and a variety of each, we may assume that similar tastes and constitution of mind and body would make them eat the same things, perhaps choose to shelter themselves by building rather than by going into caves, possibly to build with the same materials selected out of a number; but it is much to say that they would exactly preserve the same figure and size and proportions in the huts they made. Each would certainly make blunders, and work inartificially; and it is difficult to fancy them exactly making the same blunders, deviating from the straight line or the circle by the same quantity of aberration, and from the perpendicular by the same angle: yet the bee in China and in England makes the same angles, and forms cells with the same proportions, and raises the grub the same height from the liquor provided for its nutriment, so as to let it have access to the liquor without incommoding or drowning it.

A. When instinct is interfered with by obstacles interposed, the animal's intelligent powers are brought into action, and then the uniformity and perfect regularity ceases. This seems to present under this head, as well as the other head of knowledge and design or intention, a sufficiently marked distinction.

B. Certainly: and it is to be observed that the more sagacious any animal is, the greater variety is perceived in his actions and habits. Thus the elephant and the dog present general resemblances throughout each species; but the instances of sagacity or reason which the different individuals exhibit are sufficiently various: whereas there is no more diversity in the ordinary working of the bee, than in the operations of crystallization, or the secretion of the sanguiferous or the lacteal system. In truth, we may compare the two cases together. Instinct seems to hold the same place in the mental which secretion and absorption do in the physical system. Intelligence or reason will sometimes interfere with Instinct, as our voluntary actions will interfere with the involuntary operations of secretion. But the instinctive operation proceeds whether the animal wills or no—proceeds without his knowledge, and beyond his design—as secretion goes on in our sleep without our knowledge and without any intention on our part. So as secretion goes on without any help from us, or any direct co-operation, Instinct works without any aid from Intelligence. But there is this difference in the connexion of will or Intelligence with Instinct, and the connexion of voluntary action with secretion—that the Instinct seems subservient to the intelligent will far more than the secreting power is to the voluntary action. The bee, when obstructed, applies his Instinct, as it were, to overcome the obstacle, whereas we cannot alter at will the course of secretion ; we have some direct power over it, but very little.

A. One thing seems quite clear, that upon any view of this great question, whatever theory we adopt, all leaves the inference of design untouched ; nay, the more we inquire, the more we perceive that all investigation only places in a stronger light the conclusion from the facts to a superintending Intelligence.

B. Beyond all doubt it is so. The whole question is one of relations and connexions. Adaptation—adjustment—mutual dependence of parts—conformity of arrangement—balance—and compensation—everywhere appear pervading the whole system, and conspicuous in all its parts. It signifies not in this view whether we regard Instinct as the result of the animal's faculties actuated by the impressions of his senses—or as the faint glimmerings of Intelligence working by the same rules which guide the operations of more developed reason—or as a peculiar faculty differing in kind from those with which man is endowed—or as the immediate and direct operation of the Great Mind which created and which upholds the universe. If the last be indeed the true theory, then we have additional reason for devoutly admiring the spectacle which this department of the creation hourly offers to the contemplative mind. But the same conclusion of a present and pervading Intelligence flows from all the other doctrines, and equally flows from them all. If the Senses so move the animal's mind as to produce the perfect result which we witness, those senses have been framed and that mind has been constituted, in strict harmony with each other, and their combined and mutual action has been adjusted to the regular performance of the work spread out before our eyes, the subject of just wonder. If it is Reason like our own which moves the animal mechanism, its modification to suit that physical structure and to work those effects which we are unable to accomplish, commands again our humble admiration, while the excellence of the workmanship performed by so mean an agent impresses us with ideas yet more awful of the Being who formed and who taught it. If to the bodily structure of these creatures there has been given a Mind wholly different from our own, yet it has been most nicely adapted to its material abode, and to the corporeal tools wherewith it works; so that while a new variety strikes us in the infinite resources of creative skill, our admiration is still raised as before by the manifestation of contrivance and of expertness which everywhere speaks of the governing power, the directing skill, the plastic hand. Nor is there upon any of these hypotheses room for doubting the identity of the Great Artificer of nature. The same peculiarity everywhere is seen to mark the whole workmanship. All comes from a Supreme Intelligence; that intelligence, though variously diversified, preserves its characteristic features, and ever shines another and the same.

NOTE TO THE DIALOGUES.

In Dialogue I. the Instinct of the duckling hatched under the hen and of the chicken in the oven is mentioned. The two following facts have occurred since that discussion was ended.

When a sow farrows, the pigs are expelled with some force, and to a little distance, by the action of the uterus and abdominal muscles. Each pig instantly runs up to one of the teats, which he ever after regards as his own peculiar property; and when more pigs than teats are produced, the latter ones run to the tail of some of the others, and suck till they die of inanition.

Mr. Davy in his account of Ceylon mentions a remarkable Instinct of the alligator. He saw an egg in the sand just ready to crack, and broke it with his stick. The animal came out, and made at once for the river. He held his stick before it, and immediately the reptile put itself in a posture of defence, as an adult alligator would have done in like circumstances.

In Dialogue III. there is some doubt expressed as to the water-moth loading its case, if too light in the water, with a kind of ballast. The larvæ of the *Phryganea* are stated by Mr. Lyell to do this habitually, and to use fresh-water shells for their ballast. This gives rise to many masses of calcareous matter in the tertiary formations. As many as 100 small shells are found surrounding one tube. (*Principles of Geology*, vol. ii. p. 232.)

In Dialogue IV. some remarks are made upon Hereditary Instincts. Mr. Roullin has related a similar instance of such Instinct in the hunting dogs of Mexico. Were they to attack the deer in front, whose weight exceeds their own sixfold, they would be destroyed and have their backs broken, as happens to other dogs ignorant of the manœuvre, which consists in attacking from behind or laterally, and seizing the very moment when the deer, in running, rests upon two legs. The dog then takes hold of him by the belly and throws him over. The dog of pure breed inherits this stratagem and never attacks otherwise. Should the deer come upon him unawares (from not seeing him), he steps aside and makes his attack at the proper time in the animal's flank; other dogs, however superior in sagacity and strength, make the attack in front, and have their necks broken by the deer. So too some of our English miners carried out greyhounds to hunt the hares in Mexico. The air on that elevated platform, 9000 feet above the level of the sea, is so rare that the mercury stands at 19 inches generally, and the dogs were soon exhausted with running in such an atmosphere; but their whelps are not at all incommoded by it, and hunt as easily as the dogs of the country.

Respecting the elephant, extraordinary accounts are told by military men who were in the Burmese war. They relate that when any extra task is to be performed by them, some favourite dainty is held up beforehand, and the sagacious animal, comprehending the promise of reward thus implied, exerts himself to earn it. This comes to the principle of barter as near as may be.

ON THE GLOW-WORM.

The facts relating to the light of this and other similar insects are by no means accurately known; and upon some material points able observers differ widely. Thus it was deemed very natural to suspect that some inflammable matter in a state of slow combustion caused the luminous appearance, the rather as it bears a striking resemblance to the light emitted by phosphorescent bodies. Accordingly the obvious course was pursued by different experimenters, of exposing the insects to heat and to oxygen gas, to see if the light was increased; and exposing them to carbonic acid and hydrogen gases, to see if the light was then extinguished. Forster and Spallanzani affirm that they have tried this experiment, and found the result to accord with the theory; they assert distinctly that in oxygen gas, and on the application also of heat, the light is more brilliant, and that none is given out in hydrogen and carbonic acid gases. But Sir H. Davy found that the light continued in the latter gases not sensibly diminished, and that oxygen did not increase its brightness;* Mr. Macartney observed the light in vacuo and under water,† while Dr. Hulme found that it was extinguished in hydrogen, carbonic acid, and nitrous gases, although he could not perceive that oxygen gas increased.‡ There seems reason to suspect that these able men made their experiments on different species of the insect, and that the animal or vital powers which regulate the secretion, or the use of the luminous matter, were affected by the gases applied. For it is admitted on all hands that the living insect has a power of extinguishing the light independent of any mechanical operation by which it may cover over the shining part; and although the fire-fly has that part usually covered with its wings, and therefore only shines when flying, the glow-worm's light is constant, unless she restrains or extinguishes it by a voluntary act.

That some luminous matter is secreted by the insect there can be no doubt. The fact that boys in South America rub their faces with bruised fire-flies, to make them shine, is asserted by travellers; and this seems to render it probable that the glow-worm likewise secretes such an oil. But the experiments of an able chemist, Mr. Murray, have set this question at rest. He examined a box in which glow-worms had been kept, and found several luminous specks which they had left behind them. Some of these yielded a steady light for five or

* Phil. Trans. 1810, p. 287. † Ib. 1810.
‡ Ib. 1801.

six hours. Mr. Murray says that the luminous matter is inclosed in a capsule of a transparent substance, which, when ruptured, lets out the matter in a liquid form of the consistency of cream. A French naturalist, M. Macaire, made some experiments upon this matter, the result of which differed materially in one respect from that of either Spallanzani, Davy, or Hulme; for he is said to have found that the presence of oxygen in the air prevents it from shining, a position not reconcileable with the worm shining in the atmosphere. But some of this author's experiments seem to furnish a solution of many difficulties; for their results refer the appearance to the animal functions. He found that the luminous matter is chiefly composed of albumen, and that any body which coagulates albumen destroys the shining quality; which it probably does by altering the albuminous state of the fluid. He also observed, that though a certain degree of temperature is necessary for it, a higher degree destroys it altogether; and also that common electricity has no effect in exciting it, but that voltaic electricity or galvanism does excite it. These observations, if accurate, are the most important that have been made upon this subject. They seem to indicate an immediate connection between the vital powers of the insect and its luminous quality; and they account satisfactorily for the diversity in the results of former observers, who operated upon the animal apparently without taking its vital functions into the account.

The glow-worm (Lampyris Noctiluca) is not the only luminous insect. There are several other kinds both winged and apterous. Of these the fire-fly, a species of the Elater and of the beetle tribe, has already been mentioned. Indeed all the species of the Lampyris genus are supposed to be more or less luminous. Several other species of the Elater, as well as the fire-fly, are also luminous. Some species of the Fulgaro (an hemipterous insect) shine so bright that they are called lantern flies. Of these the Fulgora Candelaria is a native of China, and the F. Lanternaria, which is two or three inches long, is a native of South America. The shining matter in these, and all others of the genus that shine at all, is confined in a transparent bulb projecting from the head.* Two species of centipes, the Geophilus Electricus and G. Phosphoreus, also shine; the former is a native of this country, the latter of Asia.

Several theories have been formed to explain the use of this luminous quality. It is observable that some of the insects which have it are apterous in one sex while the other is winged—as the glow-worm, the male of which is a fly, the female being a caterpillar. In others, both male and female are winged. Again, some have the light always in front, and it seems not to vary in brightness, as the Fulgora. Naturalists have supposed that in these it is serviceable in discovering their prey. But it has also been suggested that defensive or protective purposes may be the final cause of the light. Insects which prey on caterpillars have been observed running round the Geophilus Electricus as if afraid to approach it.† But there is one peculiarity in the glow-worm's light which seems to sanction the commonly received opinion of its use being chiefly, if not entirely, to attract and direct the approach of the male. Not only has the latter wings, and thus is by his habits little likely to be found near the unwinged female —there is also found to be much less light emitted by the male; insomuch that at one time the female alone was believed to shine at all, until Ray corrected this error. It is also remarked that the light is the strongest when the two are together, and that in some, if not all the species, the luminous quality is confined to the time when they are destined to meet. Nor is De Geer's objection, founded on the observation that the chrysalis and larva of the species have somewhat of the same luminous quality, of much force. For as the very learned entomologists just cited, Messrs. Kirby and Spence, have well observed, this instance may easily be set down with the analogous case of males having a kind of lacteal system in some animals, including our own species. It deserves further to be remarked, that in Brazil there is a glow-worm which is

* Kirby and Spence, ii. 413.

† Ib. ii. 225.

winged, both male and female, and the light given by this insect is not steady like that of our glow-worm, but sparkles or intermits. On the other hand, the fire-fly of Brazil is said to give a constant light.* But this may be owing to the greater luminousness of the tubercles in the thorax, which in the European fire-fly give so little light compared with the patches concealed by the cases (elytra) of the wings, that they seem only to shine when flying.

* Kirby, Bridgewater Treatise, ii. 366.

ANALYTICAL VIEW

OF THE

RESEARCHES ON FOSSIL OSTEOLOGY,

AND

THEIR APPLICATION TO NATURAL THEOLOGY.

ANALYTICAL VIEW

OF THE

RESEARCHES ON FOSSIL OSTEOLOGY,

AND

THEIR APPLICATION TO NATURAL THEOLOGY.

Fossil Osteology.

The great work of Cuvier stands among those rare monuments of human genius and labour, of which each department of exertion can scarcely ever furnish more than one, eminent therefore above all the other efforts made in the same kind. In the stricter sciences the 'Principia' of Newton, and in later times its continuation and extension in La Place's 'Mécanique Céleste,'—in intellectual philosophy, Locke's celebrated work,—in oratory, Demosthenes,—in poetry, Homer,—* leave all competitors behind by the common consent of mankind; and Cuvier's Researches on Fossil Osteology will probably be reckoned to prefer an equal claim to distinction among the works on Comparative Anatomy. That this great performance deserves to be attentively studied there can be no doubt.

* If English law were not a local learning merely, Fearne's work on Contingent Remainders would perhaps deserve to be thus ranked. In the eloquence of the pulpit, Hall comes nearer Massillon than either Cicero does, or Æschines, to Demosthenes.

But as its bulk, in seven quarto volumes, may be apt to scare many readers, there may be some use in giving a general account of the progress of the author's inquiries, and of the principal results to which they led him, and more particularly in showing their application to Natural Theology.

Long before his attention was called to the remains of animals found in various strata of the earth, in more superficial situations, in crevices of rocks, and in caves, he had, fortunately for science, been a skilful proficient in anatomy, both human and comparative. But the first steps of his inquiries concerning those fossil remains showed him how much he had yet to do before he could implicitly trust the received accounts of the animal structures. As regards the human subject, for obvious reasons, the knowledge possessed, and which the ordinary works of anatomy contain, is accurate enough and sufficiently minute. But it is far otherwise with the structure of other animals, and especially as regards their Osteology. Of this Cuvier found so many instances, that he began his investigations with examining minutely and thoroughly the bones of all those species which, or the resemblance of which, are supposed to have furnished the materials of the great deposits of fossil bones so abundant in almost every part of our globe. This, then, was the course which he invariably pursued; and he never attempted to draw any inferences respecting the fossil animal, until he had accurately ascertained the whole Osteology of the living species. There was obviously no other way of excluding mere fancy and gratuitous assumption from the inquiry, and making the science, of which he was really to lay the very foundation, one of pure reasoning from actual observation, in other words, one of strict induction.

In the course of his work there are to be found striking examples of the mistakes into which former inquirers had been led by neglecting this precaution. Partly by relying on incorrect, though generally received, descriptions,—partly by undervaluing the requisite comparisons of the fossil with the known bones,—partly, no doubt, by giving loose to fancy, observing the remains discovered with the bias of a preconceived opinion, and making the fact bend to a theory — authors had committed the most grievous errors, hastened to conclusions wholly unwarranted by the facts, and often drawn inferences which the facts themselves negatived instead of supporting. Thus M. Faujas de St. Fond, a geologist of great learning and experience, but who had upon a very scanty foundation erected a dogma, that all the fossil remains belonged to animals still found alive in different parts of the earth, and set himself to deny the novelty of all the fossil species of unknown animals, conceived that he had at length himself found among those remains two animals which, if they still existed at all, could only be found in the interior and remote parts of India. Of these supposed discoveries he published the drawings, representing two fossil heads. But Cuvier, upon examination, found one of them to be exactly the auroch or bison, and the other the common ox.* A more skilful naturalist, Daubenton, describes three sets of fossil teeth, in the King of France's cabinet, as belonging to the hippopotamus; and upon examination two of these sets are found to be teeth of two

* Recherches, vol. iv. p. 108.

new and unknown animals,* and the third alone those of the river horse; and Camper, one of the greatest anatomists of his age, fell into a similar error. Upon the discovery of some fossil bones in the Duchy of Gotha, there was a general belief that they were some *lusus naturæ*, and several medical men wrote tracts to prove it. But a nearer inspection proved them to be elephant's bones.† The town of Lucern took in earlier times for the supporters to its arms a giant, from the opinion pronounced by a very celebrated physician (Felix Plata), that the bones discovered in that canton were human and gigantic, though Blumenbach afterwards examined them, and found they belonged to the elephant. Finally, Scheutzer maintained that there were remains in different places of men who had perished in the general deluge, and supported his opinion by several instances to which he referred. Upon examination these have proved to be none of them human bones; but one set are those of a water salamander, while another belong to a newly discovered animal still less resembling our species, being something between a lizard and a fish.‡ When professional anatomists and professed naturalists could fall into such mistakes as these, there is little wonder that a statesman like Mr. Jefferson, however illustrious for higher qualities, should commit a similar blunder. He drew from the fossil bones discovered by General Washington near his seat in Virginia, and to which his attention was directed by that great man, the conclusion that they belonged to an enormous carnivorous animal, which he named

* Recherches, vol. i. p. 305. † Ib. p.120.
‡ Ib., vol. v. pp. 433 and 451.

the Megalonyx. Cuvier, from a more correct examination, showed the creature to have been a sloth of large dimensions, and which fed wholly upon the roots of plants.

If these examples, and they might be very greatly multiplied, evince the necessity of a cautious examination, and of a previous attention to the Osteology of animals with which we are fully acquainted, the success of Cuvier's inquiries also shows that, with due care and circumspection, the reward of the inquirer is sure. The connexion between the different parts of the animal frame is so fixed and certain, and the species run so little into one another, that it requires but a small portion of any animal' s remains to indicate its nature, and ascertain the class to which it belongs. Each small portion, so it be superficial, of bone—each little bony eminence—has its distinctive character in each species; and from one of these, or sometimes from a piece of horn, or of hoof, or a tooth, the whole animal may be determined. "If," says Cuvier, "you have but the extremity of a bone well preserved, you may by attention, consideration, and the aid of the resources which analogy furnishes to skill, determine all the rest quite as well as if you had the entire skeleton submitted to you."* Before placing entire reliance on such an induction, this great observer tried many experiments on fragments of the bones of known animals, and with a success so unvaried as gave him naturally implicit confidence in his method when he came to examine Fossil Remains.

* Recherches, vol. i. p. 52. We have used the expression skeleton; the author says animal, but manifestly, from what follows, this is incorrect.

Among those he discovered a number of animals wholly unknown, and of which no individuals have existed since the period when the authentic history of our globe and its inhabitants has been recorded. Out of the 150 which he investigated about 90 were either of new orders, or of new genera, or new species of genera still living on the earth. Consider, in respect to genera, there were in the 49 unknown species, 27 which belonged to unknown genera, and these genera amounted to seven. Of the remaining 22, 16 belonged to known genera or sub-genera; the total number of genera and sub-genera, to which he could reduce the whole of his fossil species, known or unknown, being 36. It must, however, be added, that it is very possible the remaining 60 also may be of new species; for as he only had the bones to examine, it does by no means follow that the living animal did not differ as much from the ones which have the same Osteology, as the mule, or the ass, or the zebra do from the horse, the jackall from the dog, or the wolf from the fox; for the skeletons of a zebra, an ass, and a horse, present the same appearance to the osteologist; so do those of the jackall, the dog, the fox, and the wolf; and yet the same bones clothed with muscle, cartilage, skin, and hair, are both to the common observer and to the naturalist animals of a different species or subdivision. This consideration is to be taken into the account as a deduction or abatement from the certainty which attends these researches; the certainty is only within certain limits; the fossil animals which now appear to resemble one another, because their Osteology is the same, may have differed widely when living; those which appear to have been of the same class with other animals that yet people the earth, may yet have been extremely different; and those which now seem to be in certain particulars different from any we or our predecessors have ever known, may differ from all that live or have lived on the earth we now inhabit, in many particulars far more striking than the varieties which their bony remains present to the osteologist's eye.*

The situations in which those remains were found, and are still to be met with in greater or less abundance, are various; but they may be reduced to three classes in one respect and to four in another: to three, if we regard only the kind of place where the bones are collected and found, in other words their mineral matrix; to four, if we regard the periods at which the earthy formations were effected, and the bones of animals living then, or immediately before, were deposited. In the former point of view, the remains are found either, *first*, imbedded in strata, at greater or less depth, and of various kinds, and at various inclinations; —or, *secondly*, mixed together, and with earthy matter, in caves, and in rents or fissures or breaches formed in rocks;—or, *thirdly*, scattered more sparingly, and as it were solitarily in alluvial soil or superficial detritus, in portions of the earth, apparently while it wore its present form, and was peopled by all or most of its present inhabitants. In the latter, and the more important point of view, those remains are either found, *first*, in the beds which were deposited by the waters of a world before the existence of either human beings or the

* Mr. C. once or twice adverts to this consideration; but he certainly does not bring it so prominently forward as would have been desirable.

greater number of living genera of animals—as in the copper slate of Thuringia, the lias of England, the clay of Honfleur, and the chalk—in these strata the remains of reptiles are found with extinct species of marine shells, but no vertebrated animal higher than fishes; or, *secondly*, in the strata deposited by the sea, after it had destroyed the first races, and covered the land they lived upon,—and in these beds, which at Paris lie on the chalk, are to be found only animals now extinct, and of which most of the genera and all the species differ from any we now see;—or, *thirdly*, in the strata deposited by the sea, or in fresh-water lakes,—and in these later tertiary beds are to be found animals now unknown, but resembling the present races, being different species of the same genera, or apparently of families still living, but not now inhabiting the same countries, or living under the same climates;—or, *fourthly*, in places where rivers, lakes, morasses, turf-bogs, have buried the remains of existing species; and as these changes of a limited extent have happened to the globe, constituted as it still is, those animals appear to have been for the most part identical with the animals which we still see alive in various parts of the world, at least as far as their skeletons can tell.

Paris is the centre of a most extraordinary geological district. It is a basin of twenty leagues, between fifty and sixty English miles, in diameter, extending in a very irregular form from the Oise near Compiegne on the north, to the Canal de Lory, beyond Fontainebleau on the south, and from Mantes on the Seine upon the west, to Montmirail on the east; comprehending within its circuit the towns of Paris, Versailles, Fontainebleau, Estampes, Meaux, Melun, Senlis, Nangis, and coming close to Soissons, Gisors, Beauvais, Montereau on the Yonne, Nogent on the Seine, and Condé; but not being continuous within these limits, for it is frequently cut off in islands, and every where towards the outline deeply indented with bays. This vast basin consists of six different formations, in part calcareous, but in some of which gypsum is so plentiful, that the quarries dug in it go by the common name of the Plaster of Paris quarries, and indeed gypsum has derived it common name from these. The lowest bed upon the chalk is composed of plastic clay, and it has covered both the plains and the caves of the district. This bed is full of fossil remains, very many of them belonging to unknown animals, and it also contains fragments of rock, which have come from a great distance. Above this bed is a layer of gritty limestone and shelly grit, of salt-water formation. Then come in succession silicious limestone, fresh-water gypsum, and sand and grit without shells. The fourth formation is sandy, and of marine origin. The fifth has fresh-water remains and animals. The disposition of the land around and forming this basin wears in all respects the appearance of having been broken in upon and hollowed out by a prodigious irruption of water from the south-east. Considerable corrections have since been made, especially as regards the second and third of these formations of Cuvier.

It appears that the base or bottom of the Paris Basin must have been originally covered with the sea. Different parts of the ground were then covered with fresh-water lakes, from which gypsum and marl were deposited, filled with the bones of animals that lived on their banks or in their islands, and died in the course of nature. After this deposition, the sea again occupied the ground, and deposited sand mixed with shells; and when it left the land dry for the last time, there were for a long while ponds and marshes over the greater part of the surface, which thus became covered with strata containing fresh-water shells, the base of those strata consisting of a peculiar stone found in fresh water, and occurring in many parts of France. The fossil remains in this great basin exhibit little variety of families; and the vegetable remains show that the plants were confined to palms and a few others now unknown in Europe. As the great continents, which offer a free communication throughout, are inhabited by a great variety of animals, while New Holland and the other islands in the South Seas have only a very few, and these almost all of the same family, we may conclude that the land forming the Paris Basin was originally surrounded by the sea.

The deposits in the rents or fissures of the strata may now be briefly mentioned, and they present a very singular subject of contemplation. They are found all around the Mediterranean, at Gibraltar, Cette, Antibes, Nice, Pisa; in Sicily, Sardinia, and Corsica; at the extremity of the kingdom of Naples; on the coast of Dalmatia; and in the island of Cerigo. The body of the deposit is calcareous, and of the same kind in all these gaps or fissures. The same, or nearly the same, bones are everywhere found imbedded in it; they are chiefly the bones of ruminating animals; and beside those of oxen and deer, there are found those of rodents, a kind of tortoise, and two carnivorous animals. In these fissures there are many land but no sea shells; and the matter that fills them is unconnected with other strata. It follows from the first fact that they must have been consolidated before, and at the time when, the sea came over those countries and deposited shell-fish in the other strata ; and from the second fact it follows that they must have been formed when the rocks, in the rents of which they are found, were already formed and dry. Hence these fissure deposits are modern compared to the strata which were formed at the bottom of the sea and of lakes. Nor does any operation now going on upon our globe bear the least resemblance, in Cuvier's judgment, to that by which those deposits must have been made. Upon this, however, great controversy has arisen among his successors.

It was necessary that we should shortly advert to the places where, for the most part, these fossil remains are found ; in doing so we have anticipated a few of the conclusions deduced from the consideration of the whole subject. We are now to see what results were afforded by Cuvier's careful examination of the remains, which he instituted after he had with equal care ascertained the exact Osteology of the living animals in each case where the fossil remains appeared to offer a resemblance with existing tribes.

The *first* part of Cuvier's researches is occupied with the *pachydermatous** animals whose remains are found in alluvial deposits.

The *second* part consists of two subdivisions—in one of which are given minutely the whole details of the Paris Basin—in the other subdivision the examination of the animal remains, beginning with the pachydermatous, and then the others that accom

* Animals with thick skins, as the elephant, horse, hog.

pany them, whether quadrupeds, reptiles, fishes, or birds. So that the Paris Basin is made the ground of this arrangement, and its Fossil Zoology is gone through without much regard to the general arrangement of the rest of the work.

The *third* part is occupied with the *ruminant* animals, unless in so far as one of its subdivisions, treating of the gaps or fissures of the Mediterranean, also treats of the few other animals which are there found beside the ruminant.

The *fourth* part is occupied with *carnivorous* animals—the *fifth* with *rodents*—the *sixth* with *toothless* or *edentate* animals—the *seventh* with *marine mammalia*—the *eighth* and last, and perhaps the most interesting of the whole, with *reptiles;* including the anomalous species newly discovered, which partake of the nature at once of the reptile and fish or of the reptile and bird.

As no arrangement is yet made of these fossil animals under any of the heads which we have stated, we are at liberty to adopt any order that may appear most convenient; and we shall accordingly begin with those which at first appeared to resemble the known species of the rhinoceros, the hippopotamus, and the elephant, and which a careless observer would unquestionably have confounded with these animals; but they were soon ascertained to be different.

I. Of the fossil rhinoceros four distinct species have been found;* and they are all distinguishable from the four known kinds of rhinoceros—those of India, Java, Sumatra, and the Cape. The fossil animal had a head both larger and narrower than

* Of these there are now nine species, five having been discovered since Cuvier's work.

the living kinds, and much larger in proportion to his body. He was also much lower, and a more creeping animal. He, for the most part, had either no incisive teeth or very small ones, but one species had these of a good size. One of the fossil species is distinguished from all the four known ones and from the other three fossil ones, by a still more marked peculiarity; his nostrils are divided from each other not by a gristly or cartilaginous, but by a bony partition, whence the name of *Tichorhinus** has been given to him, the three others being termed *Leptorhinus*,† *Incisivus*, and *Minutus*.

The grinding teeth of the Tichorhinus are also found to have a peculiarity which no other teeth either of any living or any fossil animal have. They are indented at the base in one of the ridges, after being worn down by use. This, as well as the bony partition, affords, therefore, the means of discovering the species. The use of the partition apparently was to support the weight of two large and heavy horns on the nose.

The history of the first of these species, the Tichorhinus, furnishes a remarkable example of the errors into which even able and expert observers may fall when they make more haste than good speed to reach a conclusion. A missionary named Campbell having sent home the head of a rhinoceros, being one of several killed close by his residence, and well known to have been so, Sir Everard Home compared it with a fossil head from Siberia, sent by the Emperor of Russia to Sir Joseph Bankes; and finding, as he thought, that it was of the same species, he very rashly inferred that the position which affirms the existence of unknown

* From Τειχος, a wall. † From Λεπτος, slender.

animals among the fossil remains was much weakened by this supposed discovery. Cuvier made a more accurate comparison, and found that the Cape skull was materially different from the fossil one, but resembled the head of the existing species, which Sir Everard Home had also denied. The most remarkable omission, however, of the latter was his never looking to see if there existed a bony partition between the nostrils. This Cuvier did, and found it cartilaginous and not bony. So that the most singular of the new and unknown fossil animals belonging to this class remained still a novelty, even if Sir Everard Home had been correct in all the comparative examinations which he ever did make; and his conclusion of fact from that comparison, even if admitted to be well founded, had no bearing whatever upon the general position against which he had pointed it.

The extraordinary fact of a portion of one of these ancient and lost animals' muscular substance and skin having been found, is further to be mentioned. In a block of ice on the banks of the Wilujii, a river of Siberia, there was discovered this huge mass of flesh, about the year 1770. It was found to have longish hair upon parts on which the existing rhinoceros has only leather; consequently it must have lived in a colder climate than the present animal inhabits. But it appears to have been killed by some sudden catastrophe, and then to have been immediately frozen, else it would have undergone decomposition like the other remains of which the bones alone are left.

There are two species of living elephants, the African and the Asiatic; the former distinguished from the latter chiefly by the length of his tusks, by a peculiar disposition of the enamel in the jaw teeth, and by never having been tamed, at least in modern times. The fossil elephant resembles the Asiatic species most, but differs in some material particulars. It has long tusks, sometimes exceeding nine feet in length; the jaw teeth are differently set; the under jaw of a different shape, as well as other bones; and from the length of the socket bones of the tusks the trunk must have been also very different. These remains* are found in great abundance both in Europe and in America, in neither of which parts of the globe are there now any living elephants of any species produced. In the same strata and caves other animals are also found both of the known and extinct classes; and occasionally shells also. The elephants' bones are chiefly discovered on plains of no considerable elevation and near the banks of rivers. They never could have been transported by the sea over the mountains of Tartary, upwards of 20,000 feet in height, which separate Siberia from the parts of Asia where the elephant now flourishes. It must be added, that, beside those bones, a still more perfect specimen of the softer parts has been preserved by the action of cold than we have of the rhinoceros. In the same country, near the mouth of the river Lena, a mass of ice was found in 1799 by a fisherman, which he could not break or move; but in the course of the next summer it partially melted, when it was found to contain an entire elephant frozen. The neighbouring Tartars with their dogs, and afterwards the bears, destroyed the greater part of the flesh, but the skin and bones were saved. It was found to

* There are now known eight species of this fossil elephant.

have hair, and even woolly hair or fur, upon different parts of the body. It must then have been calculated, like the animal of the Wilujii, for living in a climate much colder than that of India or Africa, and, like that rhinoceros, it must have been frozen immediately after its death. Its tusks were circular, and nine feet (near ten English) long.

Of the hippopotamus, two species * have been found among the fossil bones, both so different from all living animals, that every one bone of each differs from any other known bone; so that even if an error should have been committed in connecting the different bones together, there must be not only two, but more than two, new species thus discovered. These animals abound in the great deposit of fossil bones in Tuscany, in the valley of the Arno, and at Brentford in Middlesex. There are two other fossil species, of which, however, less is known; one of these is very small, not larger than a common hog.

Three pieces of a jaw-bone, with some fragments of teeth, have been found in Siberia; which upon examination prove to have belonged to a singular species, resembling both the rhinoceros and the horse, and forming probably the link between these two animals. The size is larger than the largest fossil rhinoceros. The discoverer, Mr. Fischer, has named it the *Elasmotherium*,† from the thin enamel plate which winds through the body of the tooth in a peculiar manner.

But much more is known of a lost species which approaches the elephant, although differing in some important respects both from the living and the

* Two more species have since been found.

† Ελασμος, thin plate.

fossil elephant. The most remarkable difference in the Osteology is presented by the jaw teeth, which have the upper surface mamellated or studded with nipples; from whence Cuvier named it the *Mastodon.** When these tubercles are worn down by use, the surface of the tooth has a uniformly plane or uniformly concave surface. The structure of the vertebræ shows it to have been a weaker animal than the elephant; and the belly was considerably smaller. The lower part of the fore-leg was longer, and the upper joint shorter; the shoulder one-ninth shorter too. The pelvis was more depressed; the tibia and thigh bones materially thicker; and the body a good deal longer in proportion to the height. As it fed upon vegetables, and had a short neck and feet unfit for living in the water, it must have had a trunk; and it also had tusks. It seems to have fed upon the softer parts of vegetables, and to have inhabited marshy ground. Six species† have been discovered of this animal, chiefly differing from each other in the teeth; and of these six, two only are well known. The mastodon was long supposed to be peculiar to America, and was sometimes called the Ohio animal; but there have since been found teeth in different parts of Europe, evidently belonging to the two better known species; and the other four kinds are, to all appearance, European.

In the same strata with the remains of elephants, rhinoceroses, and other animals both of extinct genera and species, are almost everywhere found the bones and teeth of horses, very nearly resembling

* Or Mastodonte, which is sometimes, but unnecessarily, rendered by Mastodonton: μαστος, mamilla.

† Five more species have since been discovered.

those of the animal now so well and universally known. It yet happens that for want of due attention to a branch of anatomy more familiar to us than any except the human, naturalists have constantly fallen into error in examining fossil bones. Thus Lang, in his history of the figured stones of Switzerland, took a horse's tooth for a hippopotamus's; and Aldrovandinus in one work describes teeth of that class as giants', and in another as horses'; while several authors have confessed that they could not tell to what tribe such remains had belonged. Cuvier did not, therefore,-deem himself released from the duty of fully examining the common horse's osteology, merely because of the frequent and minute descriptions which had previously been given of it; and his intimate acquaintance thereby obtained with the nature of every bone and tooth, has enabled him to pronounce with confidence upon the existence of horses like our own among the unknown animals which inhabited the earth before the vast revolutions that changed both its surface and its inhabitants. He has, however, justly noted the fact that there is no distinguishing the bones of the horse, the ass, the mule, and the quagga; so that very possibly these remains may have belonged to any of those animals; and very possibly also to none of them, but to some fifth species, now, with the mastodon and other contemporary animals, extinct. The same remark is of course applicable to the bones of the hog and the wild boar, found occasionally among other fossil remains.

The tapir family in many important particulars resembles the rhinoceros; and those are often found in the same tertiary strata with the rhinoceros, elephant, and mastodon, several species now wholly extinct, but allied to the tapir. Two of these must have been of prodigious size, the largest 18 feet ($19\frac{1}{4}$ English) long and 11 (nearly 12 English) high.* But there are other species, to the number of twelve at least, whose size differs little from that of the tapir; the bones are somewhat different, however, and particularly the teeth, which, from the eminences or ridges upon them, Cuvier made the ground of the genus, to which he gave the name of *Lophiodon*.† It is in different parts of France that all these species were first found: the smaller ones always in strata of fresh-water shells, and in company with remains of either unknown land animals, or crocodiles and other river animals now found in hot climates; and in several places the strata in which they occur, have been covered over, after they had been deposited and their bed consolidated, with strata of an origin unquestionably marine. By far the greater part of fossil remains, both those which have been already described, and those which we are afterwards to consider, having been found in sandy, or calcareous, or other earthy strata. But some few are also found in imperfect coal or lignite. In the part of the Appenines where that range meets the Alps there is a tertiary coal stratum, and in it have been found two new genera of pachydermatous animals, and a third in the fresh-water deposit near Agen. Cuvier calls these *Anthracotheria*.‡

The general conclusion which is to be derived from the important branch of the inquiry of which

* This is now better known, and is called the *Dinotherium*.
† Λοφιον, a small hill, eminence, or ridge
‡ Ανθραξ, coal. Of these seven species are now known.

we have been analyzing the resulting propositions, is partly zoological and partly appertains to geology. The former portion of it is, that more than thirty kinds of land animals have left their fossil remains in the strata now forming dry land, but deposited under water; that of these, seventeen or eighteen* are now extinct, and have been wholly unknown since the earth was peopled with its present inhabitants, six or seven being of a genus now unknown, the others being new species of known genera; that twelve or thirteen kinds have, as far as their bones are concerned, the appearance of having belonged to the species which still inhabit the globe, although their identity is far from certain, depending only upon the similarity of their skeletons; and that animals of genera now almost confined to the torrid zone used formerly to inhabit high and middling latitudes. The geological portion of the conclusion is that some of these fossil remains have been buried by the last or one of the last revolutions to which our planet has been subjected, as they are in loose and superficial strata, whilst other remains in the tertiary strata appear generally to have come from deaths in the course of nature, though some of these too must have perished by a sudden revolution.

II. The Paris Basin presents, in great abundance, the remains of herbivorous pachydermatous animals of two distinct genera, each comprehending several species, and all alike unknown in the living world. The animals to which some of them approach the nearest are the tapirs; but they differ even generically from these, and from every other known tribe. The inquiry into which Cuvier entered for

* According as the Elasmotherium is allowed to be sufficiently distinguished or not.

the purpose of ascertaining to which set of bones each particular piece belonged, so that he might be able to restore the entire skeletons by putting together all the parts of each, was long, painful, and difficult in the highest degree. He had first to connect the two bones of the hinder feet together, in each instance, by minutely examining the relation of the pieces to one another; and this process could only be conducted by deriving light from the analogies of other and known animals. He then had the different bones of the fore feet in like manner to put together, in order to restore those fore feet. Next the hinder and fore feet of each animal were to be connected together. Afterwards he had to mount upwards and connect the bones of the body with the several feet. The teeth and head must next be referred to the limbs. Then the vertebræ and then the trunks were to be restored; and then other bones, not yet accounted for, were to have their places found. The result of this most elaborate and perplexing investigation, the details of which occupy the fifth part of a large quarto volume, and are illustrated by between sixty and seventy admirable plates, containing between six hundred and seven hundred figures of bones, fragments of bones, and congeries of bones, may be stated shortly thus:—There are of the first genus, which he denominates ***Palæotherium***,* six, or perhaps seven, species† principally distinguished by the teeth and the size, as far as the bones are concerned, but which, probably, were much more widely different when alive. One of these resembled a tapir, but was only a foot and a half in length, being about

* Παλαιος, ancient; θηριον, wild beast.

† Eleven species are now known.

the size of a roebuck. Another was nearly three feet high, and the size of a hog. A third was between four and five feet in height, and about the size of the horse or the Java rhinoceros. It had feet thicker than a horse's, and a larger head; its eyes were very small, its head long, and it had a snout protruding much over its under jaw and lip. In a specimen of one of these species, the first now mentioned, there were actually found some of the animal's softer parts, certain flexible filaments, which, upon being burnt, gave an animal smell, and were manifestly portions of the nerves or blood-vessels. Besides these three species, three, and possibly four others, were distinguished, one the size of a hare.

The other genus was termed by Cuvier *Anoplotherium*,* and of these, two species, at least, are distinguishable.† The first, or *common* anoplotherium, is about the size of an ass, being four or five feet high, and its body four feet long, but with a tail of three feet long; it was probably an animal that lived partly in the water, as it appears made for swimming like an otter. But it has a peculiarity of structure which is to be found in no other animal whatever; its feet are cloven, but have two separate and distinct metacarpal and metatarsal bones, which are soldered together in other animals; it has also its teeth contiguous, while all other animals except man have them apart. The other species, or *secondary* anoplotherium, resembles the former, but is only the size of a common hog. But beside these anoplotheria properly so called, four other cognate species are found, one of the size and

*Ανοπλος, unarmed, without tusks.

† Six species are now ascertained.

appearance of a gazelle, one the size of a hare, and two of the size of a guinea pig. A curious specimen gives the very form of the anoplotherium's brain, a cast of it remaining in the earthy mass. Its size is extremely small, and Cuvier infers from this that the animal was exceedingly stupid.

All these animals are found in the Paris Basin; but bones of the palæotherium have been discovered elsewhere, namely, at Orleans, Aix in Provence, Montpelier, and Isell. As the specimens from those other places were extremely rare in Cuvier's time, he could not have the same certainty respecting them as from the more copious collections obtained in the Paris district. But he could distinguish at least three different species.

Beside these two new genera, the palæotherium and anoplotherium, the Paris Basin affords two other new genera of pachydermata, the one, called *Chœropotamas*,* resembling animals of the hog kind—the other, *adapis*, very small, being about a third larger than the hedgehog, which it also resembled in structure. There are found, too, the remains of five or six kinds of carnivorous animals, one of them being of enormous size, and resembling a tiger. Another has projecting bones to support a bag or purse as in the kangaroo kind; but it is of a genus of marsupial animals now found only in America, being a sort of opossum. The Basin, besides, affords a considerable number of tortoise remains, some fish bones, and even perfectly complete skeletons of fish, and ten species, at least, of birds, all now unknown, but one of which resembles the Egyptian ibis. It is very remarkable that in one specimen, brought to Cuvier

* There are now three species known.

while his work was printing, the windpipe was preserved, and the mark or mould of the brain appeared upon the surface of the gypsum.

III. Of ruminating animals the fossil deposits present many remains. There are of the deer, beside divers that closely resemble known species, no less than twelve* species wholly unknown among the existing inhabitants of our earth. One has enormous horns, six feet from tip to tip, and of this animal we know nothing among existing species, though it comes nearest the elk. Two kinds are somewhat like roebucks, and of that size. The fissures of the Mediterranean give six new species,† of which that found at Nice is like an antelope or sheep.‡

None of our common oxen are found in a fossil state, unless in morasses or peat bogs, where they have certainly been buried while the globe's surface was in its present condition, and peopled as we now find it. But animals of the same genus certainly existed in the age of the elephant and rhinoceros, and of the extinct species.§ There prevails no small uncertainty as to the identity of the

* No less than twenty-eight species are now known.

† In the Résumé to Parts III. and IV., Cuvier says, "Of the six deer found in alluvial deposits, one with large horns is entirely unknown; of the four in fissures, three are unknown, at least in any but most distant countries. Another, that of Orleans, is quite unknown, as are the two species of lagomys found in the fissures."

‡ A thirteenth new species was at one time supposed to have been found in the Swedish province of Scania; but Cuvier, before the last volume of his work was printed, had reason to believe that this animal belonged to one of the tribes formerly known, and still living in the north of Europe.

§ Of these there are now seven ascertained.

fossil bison and musk buffalo with the living species of the former in Europe and of the latter in America; but the remains which have been found of a kind of ox, appear different from any known species, and it appears that no buffalo resembling either that of the East Indies or that of the Cape has been found in any place.

The conclusions, both zoological and geological, from this part of the investigation and from the examination of the remains found in the Paris Basin, in every respect tally with those to which we were led by a consideration of the pachydermatous remains under the first head of the inquiry.

IV. There are found in caverns both in France, Germany, Yorkshire, and Devonshire, and in the fresh-water formation of Val d'Arno, in Tuscany, the remains of many animals, some extinct and others no longer inhabitants of the same temperate latitudes, but confined to the frozen and the torrid zones. By far the greater part of these animals belong to the carnivorous class, except in the Yorkshire caves, where many of the herbivorous kind are also to be found. In the foreign caves the bear is the most numerous, and presents extinct species. In the Yorkshire caves (at Kirkdale) the hyæna predominates. In the German caves hyænas are comparatively few, and in Val d'Arno not more numerous. In Kirkdale there are very few bears. The race of lions and tigers is much more rare than any of the others. Not above fifteen have been found in Germany, while there have been found hundreds of bears; and in Yorkshire, where hyænas abound, very few lions and tigers are traceable. Of the wolf and fox, some are found, but not so many in Yorkshire. There is also a very large kind of dog traced, which must have been five feet in height and eight in length from the mouth to the tail.

Of bears it appear, after a very close examination, that there are found, at least two species* larger than those now known, and a third which, both in size and other particulars, so nearly approaches the common bear, that Cuvier does not regard it as a new species. But it seems as if the one found in Tuscany formed a third kind of animal now extinct.

The hyæna† is found not only in the caverns and other quarries where the bear abounds, but also in the alluvial strata with the elephants and rhinoceroses. In Kirkdale cave his dung has been distinctly recognised by a comparison with that of living hyænas; and the particular crack which he makes in the bones of the beasts devoured by him to get at the marrow, has, in like manner, been identified by actual comparison. Nevertheless the fossil animal differs from the living one in some material respects, particularly in size, and in having his extremities both thicker and shorter. The caverns contain two species‡ of a huge animal of the felis (or cat) kind, considerably larger than the lion or the tiger, beside some few resembling living species in size. One is between one-eighth and one-ninth larger than the lion, and has its trunk more convex in the lower outline. A new, but smaller, species of the felis kind is also found in the Mediterranean fissures.

In the dog tribe there has been found a wolf or dog,§ but more probably the former, which differs,

* Seven more have since been added.

† Now eight species. ‡ Now fifteen.

§ Ten species are now known.

though slightly, from any known species, in having the muzzle shorter in proportion to the skull; and also a species has been observed clearly new of the same genus. We as yet only know of it by two of his jaw teeth, found at Avaray, near Beaugency. He must have been eight feet long and five high. The Paris Basin affords, likewise, another new species of the dog kind, but not materially varying in point of stature. The common fox, however, is found, and also the dog and wolf, in the caves.

The caves afford a considerable number of bones of the weasel and glutton,* closely resembling the existing species. The latter animal is only known now in the higher latitudes; but in the caves we find his remains mixed with those of animals belonging to the temperate and the torrid zones.

It is thus shown by the inquiries which comprise the third and fourth part of this great work, that the former inhabitants of these regions were wholly different from the present population. Even the animals of hot climates here found, and referable to existing genera, must have differed entirely from those species which survive in the torrid zone, because they could exist in a temperature now wholly foreign to their nature. The rein-deer and the lion, the sloth and the elephant, all found in the same places, show that the climate of those latitudes remains nearly the same, but that their inhabitants have been changed.

In all these researches one blank is immediately perceptible. There are not only no human remains whatever, but there are none of apes or of any of the genus of quadrumanes. Animals far less in size, and whose bones would much more easily have

* Of the fossil gulo two species are now ascertained.

perished, as rats and mice, have left their skeletons with those of the largest beasts; but of the monkey tribe no vestige whatever is to be discovered; and the conclusion is inevitable, that the strata were deposited, the fissures filled, the caverns strewed with bones, at an age anterior to the existence of that tribe, as well as to the creation of our own species. Thus it was when Cuvier wrote.*

V. Beside the animals of the *Rodent* description, found in the Paris Basin and the Mediterranean fissures, rabbits, lagomys, field mice, there are several others in the alluvial strata and caverns,—some apparently of known, and others, certainly, of unknown kinds. The hare has been traced at Kirkdale; the beaver near the Rhine; two new species† of the beaver near Rostoff, in the south of Russia; another species, also unknown, at Œningen.

VI. The toothless or *Edentate* animals afford some varieties still greater than those to which our attention has as yet been directed. None of the known species of this tribe are to be found in any of the strata, fissures, or caves in Europe. But three genera entirely new, with two of which at least there are ample materials for becoming acquainted, have been found in America, and these are deserving of our best attention.

The first is the animal named by Jefferson, from the size of his feet, or rather what he supposed claws, the *Megalonyx*,‡ and respecting which he

* This refers of course to the state of discovery in Cuvier's time. There are remains of the monkey said to have been lately discovered in the South of France and in the Himalaya Mountains; it is said also at Calcutta. But the proofs are not clear.

† Now four are known, and three of lagomys.

‡ Two species are now known.

fell into an error as we formerly stated. Cuvier preceded his examination of this as of all other animal remains by a thorough investigation of the osteology of living animals of this family; and it is the result of his careful enquiry that the bones found in America and described by Jefferson, and of which both casts and drawings were sent over, as well as a tooth, belonged to an animal of the sloth tribe, but wholly new, and now quite extinct. The tooth was cylindrical, and worn down on the top, but cased round with enamel like a sloth's, and not at all like a cat's. In the paw, the second phalangal bone was symmetrical. This bone is curved and not symmetrical in animals that raise up and draw back the claw, as all the cat kind do. The first phalangal bone, too, was the shortest; whereas the lion and others of the cat kind have that bone the longest. But from the known species of sloth it differs most strikingly in its stature, which was equal to that of the largest oxen, those of Hungary and Switzerland, and a sixth larger than the common kind.

The second of these new animals has been termed *Megatherium*, from his great size, and the remains are found in South America. From his teeth it appears that he lived on vegetables, but the structure of his very long fore paws and nails shows that it was chiefly on the roots. He possessed also good means of defence, and so was not swift of foot. His covering seems to have been a thick and bony coat of mail like the armadillo's. His length was twelve feet and a half (near thirteen feet and a half English), and his height seven feet (about seven feet and a half). From the sloth he differs not only in size but in other particulars; for example, his fore legs are much nearer the length of his hinder legs than in the sloth, which has the former double the latter. But, on the other hand, the thickness of the thigh bone in the megatherium is much greater than in any of the known sloth tribe, or indeed any other animal either known or extinct; for the thigh bone is about half as thick as it is long.

The third of these new animals was known to Cuvier only by one fragment which he examined. It was a toe; and from a careful discussion of its form and size he inferred that the animal belonged to the edentate tribe of Pangolins, and that, if so, its length must have been twenty-four feet (twenty-six English), and its height in the same enormous proportion. The bones were found in the Palatinate near Eppelsheim.*

VII. The course of our analysis has now brought us to the family of the *Sea Mammalia*, and these supply new food for wonder. So different from the bones of any living animals are those remains which have been examined, that a new genus is formed consisting of several species, and bearing the same relation to the cetacea, or animals of the whale tribe, that the mastodon, palæotherium, and anoplotherium do to the pachydermata, or that the megalonyx and megatherium do to the edentata. He terms the genus *Ziphius*, from its having a sword-like head. One of these was found near the mouths of the Rhone. The dimensions are not given by Cuvier, but from the drawing the head appears to have been about three feet in length. The remains of a second species of ziphius were found thirty feet under

* Subsequent discoveries have made it probable that this toe belonged to the Dinotherium.

ground at Antwerp, and between nine and ten under the level of the sea at low water. The head is considerably larger than that of the first mentioned species. The head of a third species is found in the museum at Paris, but with no account of its history.

Besides this new genus, there are other cetacea of new species discovered among the fossil bones. At Angers a Lamantin of an extinct species has been traced. The remains of a dolphin, which must have been twelve or thirteen feet long, and different from all the known species, have been found in Lombardy. In the Landes another dolphin, which must have been nine or ten feet in length, has been discovered. A third kind of dolphin, different from any now living, has been found in the department of L'Orne, while a fourth, also found in the Landes, nearly if not wholly resembles the ordinary dolphin. In Provence a cetaceous animal of an unknown species is found, somewhat like the hyperodons.

In the neighbourhood of the Ochil hills in Scotland the fragments of a whale's bones have been found in a recent alluvial stratum, at only eighteen inches' depth, with a part of a deer's horn near. It must have been a whale of some size, as the vertebræ were eighteen inches broad, and one of the ribs ten feet long. But it is most probably one of a kind still existing in our seas, from the place where it was found.

In the mountains near Piacenza there have been found the bones of a small whale. Its length was twenty-one feet (near twenty-three of ours) and its head was six feet (near six feet and a half) long. The place where these bones lay was a clay stratum with numberless shells all round, and oysters clinging to the bones. This animal was in a tertiary formation, six hundred feet above the plain of Italy. It appears to be of a new species.

In the very heart of the city of Paris have been found the bones of another whale, far larger, and of a species wholly unknown. Its head must have been fifteen or sixteen feet long, and its body fifty-four or fifty-five. It was found in a compact sandy bed in digging under the cellar of a wine-merchant.

The conclusion to which these Researches unavoidably lead is that the earth in its former state did not differ more widely in the races which inhabited it than the sea did—that ocean which was itself the great agent in producing many of the changes that have at various times swept away one race of living creatures from the surface of the globe, and mixed up their remains with those of animals engendered in its own bosom.

VIII. We have now reached the last and the most singular portion of these Researches; the examination of *Reptiles* whose relics are found in many of the stratified rocks of high antiquity.

In the calcareous schist, near Monheim, whence the stones used in lithography are gotten, a new species in the crocodile family is found, whose length must have been about three feet. At Boll, in Wirtemberg, another, apparently of the same kind, has been discovered. At Caen oolite quarries, a different and equally unknown species is traced; its body is between four and five feet long, and its whole length thirteen. Others of this family have been found in the Jura, and there they are accompanied by the fresh-water tortoise. At Honfleur another species is found, and the remains of two other unknown kinds have been discovered near Harfleur and Havre.

Beside the remains of crocodile animals found in these more ancient strata, there are many also found in the more recent beds, where the bones of the palæotheria and lophiodons are deposited. The Paris Basin, the marl pits of Argenton, Brentford, and other places have furnished these specimens. But whether they were of different species from those new ones found at Monheim, Caen, and Honfleur, the examination which they had undergone in Cuvier's time was too imperfect to determine. They have since been shown to be different.

It deserves to be remarked of the new species of crocodiles, that their difference from the known kinds exceeds in manifest distinctness that of almost any other animals which are of the same genus, and do not differ in size; for the vertebræ, instead of being, as they are in the crocodiles now alive, concave in the front and convex behind, are convex in front and concave behind. This at once furnishes a very triumphant answer to those doubts which have been raised as to the novelty of the species, and still more signally discomfits the speculations of those who fancy that the difference perceived in fossil bones has been caused by change of temperature or of diet, or by the passing from the living to the petrified state.

The examination of fresh-water tortoises, of the genus trionix, whose remains are found in the plaster quarries and other strata, offers similar results. Thus at Aix in Provence a trionix of a new species is found. Another species, also new, is found in the Gironde; and two others have been traced less distinctly in the gravel beds of Hautevigne (Lot et Garonne) and of Castelnaudary.*

Fossil fresh-water tortoises, of the genus emys, give the same results. They are found in the molasse of Switzerland, in the Sheppy clay near London, and in the limestone ridges of the Jura.

Fossil sea tortoises offer the like appearances. One of an unknown species is found near Maestricht, the genus being still living in the sea, and familiar to our observation. So that altogether the examination of tortoise remains leads to the same inferences of islands having existed in the ocean at a former period, inhabited chiefly by reptiles or oviparous quadrupeds, and before the creation of any considerable number of the viviparous orders.

As we proceed towards the close of these Researches the subject rises rather than falls off in curiosity and interest. We now come to the family of lizards, by which is here understood all the old genus of Lacerta (Lin.), excepting the crocodile and salamander tribes.

In the celebrated fossil-fish deposits of Thuringia are found the remains of a monitor, of a species somewhat varying from the known species in two particulars, a greater elevation of the vertebral apophyses, and a longer leg in proportion to the thigh and foot. Remains of a similar aspect occur in France near Autun, and in Connecticut in North America.

In the strata of fine and granular chalk near Maestricht, between 400 and 500 feet in thickness, are found the remains of a huge reptile, which Mr. Faujas represented as a crocodile, following the opinions of the people in that neighbourhood; but

* Eight species have now been traced.

so celebrated an anatomist as Adrian Camper was not to be thus deceived, and he proved it to be an animal of a new genus, related to the monitor, and also to the iguana; it seems to be placed between the fishes on the one hand and the monitors and iguanas on the other. But the size constitutes its most remarkable difference when compared with these. They have heads five or six inches long; his was four or five feet, and his body fifty. He was therefore a lizard exceeding the size of a crocodile; just as the extinct tapir was the size of an elephant, and the megalonyx was a sloth the size of a rhinoceros. It appears that, like the crocodile, he was aquatic and could swim; and that his tail was used as a scull, moving laterally in the water, and not up and down like the cetacea, an order to which the elder Camper at first rashly referred him.

In the canton of Meulenthal, at Monheim, ten feet below the surface, and near some kinds of crocodile remains, bones were discovered of another unknown sub-genus of the order Saurus, and which Cuvier calls Geosaurus, and places between the crocodile and the monitor. It was apparently twelve or thirteen feet long, that of Maestricht being fifty.

A large animal of this family is found to have been an inhabitant of the same ancient world. At Stonesfield, in the neighbourhood of Oxford, Dr. Buckland discovered his remains in a bed of oolitic calcareous schistus under a solid rock of forty feet thick. The thigh bone is two feet eight inches in length, which would seem to indicate a body in the whole forty-five feet long. But even if his tail were not in the proportion of the lizard's, as this calculation assumes, his length must be, according to the crocodile's proportions, thirty feet. This animal approaches the geosaurus of Monheim, and also, in other respects, has some affinity with the crocodile and monitor; but in size he greatly exceeds the crocodile, and comes nearer the whale. His voracity must, from his teeth and jaws, have been extreme. He was also an amphibious animal; for his remains are surrounded with marine productions. The genus has been called *Megalo-saurus*. Teeth and bones of the same genus have been since discovered in Tilgate Forest, Sussex. Mr. Mantel has found in the same place the thigh bone of a much larger animal. Other reptiles have been found in the Muschelkalk quarries near Luneville.

But there are animals of the family of saurus yet more strange, if not for their size, at least for their anomalous structure and habits. A reptile is found of a genus so extraordinary as to comprehend within itself the distinguishing nature both of the lizard and the bird. It has a very long neck, and the beak of a bird. It has not, however, like a bird, wings without fingers to strengthen them; nor has it wings in which the thumb alone is free like a bat; but the wings spread by a single long finger, while the other fingers are short, and with nails like the fingers of ordinary apterous (or unwinged) animals. From these circumstances Cuvier has named this genus* the *Pterodactylus*.† It was first discovered by the late Mr. Collini, a Florentine, settled at Manheim, and formerly attached to the family of Voltaire, of whom he published some memoirs. The skeleton, nearly perfect, was found in the marly stone beds of

* There are now ten species observed.

† Πτερον, wing; δακτυλος, finger.

Aichstadt in the county of Pappenheim; but Mr. Collini fell into very great mistakes respecting the genus of the animal, which he supposed to be of marine origin, from not accurately investigating its osteology. The celebrated Sœmmering contended that it was one of the mammalia, resembling a bat, and other naturalists held the same opinion. But Cuvier has most satisfactorily shown, chiefly from its jaws and vertebræ, its shoulder-blade and sternum, that it is between a bird and a reptile, a flying reptile. The tail is extremely short, and this indicates the animal to have used its wings chiefly for locomotion: indeed, from its very long neck, it must have had great difficulty in either walking or crawling. When at rest, it must have stood like a bird on its hind legs, and also, like some birds, have bent back its long neck in order to support its very large and heavy head. Another species of the same genus, having a much shorter beak (for that of the former is longer than the whole body), has also been found near the same spot. It is much smaller. Very scanty remains of a third species also occur, found in the same quarries. Its size must have been nearly four times greater than that of the kind first mentioned, and it must have presented one of the most monstrous appearances which can be conceived, according to our present experience of animal nature.

The two last discoveries among the animals of a former world, which these researches have disclosed, remain to be mentioned; and they are, in the eyes of the naturalist, the most wonderful of the whole, although to an unlettered observer they may appear less strange than the tribe we have just been surveying. One of them has the muzzle of a dolphin, the teeth of a crocodile, the head and breast of a lizard, the fins or paddles of a whale, but four instead of two, and the back or vertebræ of a fish. This has been named the *Ichthyosaurus*. The other, being apparently nearer to the lizard, has been called the *Plesiosaurus*;* and has also four paddles like those of a whale; the head of a lizard, and a long neck like that of a serpent. Both are found in the older secondary strata of the globe; in the limestone marl or greyish lias, filled with pyrites and ammonites, and in the oolite beds of the formation called Jurassic. They are both chiefly found in England, and were first discovered there.

Sir E. Home, in 1814, made the first step in the discovery of the Ichthyosaurus; having obtained some bones found on the Dorsetshire coast, thirty or forty feet above the level of the sea. He gradually obtained more of these remains, until 1819-20, when the discovery was completed. But he seems to have been unfixed and variable in his opinion respecting the animal; and after believing for some time that it was partly a fish, he ended by believing it to be no such thing, and changed its name from ichthyosaurus, which Mr. König had given it, as early as 1814, to *Proteosaurus*, supposing it to have some affinity with the proteus as well as the lizard.

The ichthyosaurus is most abundant in the lias strata in the lower region of the Jura formation. Its remains are not confined to Dorsetshire; they are found in Oxfordshire, Somersetshire, Warwickshire, and Yorkshire. But at Lyme they abound as much as those of the palæotherium do in the pits

* Πλησιος, near

of Montmartre at Paris. Some few specimens are found near Honfleur and at Altorf; in Wirtemberg, also, a nearly complete skeleton has been discovered. Four* distinct species were ascertained by Cuvier, chiefly differing from one another by their teeth, that is to say, as far as their osteology goes.† In the general features of their bones they all approximate to one another. The head resembles that of the lizard, although with material differences, and even having some other bones. The eyes are extremely large, differing in this from all the greater animals both sea and land. The cavity in some specimens is above a foot in diameter. Each eye is protected by a shield of bone, composed of several pieces knitted together. The vertebræ are very numerous. In some specimens as many as ninety-five are to be seen; and these differ entirely from the vertebral system of the lizard, resembling rather that of fishes, for they are flat like backgammon, and concave on both sides. The animal has four fins, or paddles, each composed of six rows of small bones, nearly one hundred in all, and so fitting into one another, that he could paddle about by means of them, moving with more elasticity than if the bones had formed a single

* Four species have since been added to these.

† It cannot be too steadily kept in mind that when a specific difference has once been ascertained, so as to distinguish one of these extinct races from another, the amount of that difference is no measure at all of the diversity which may have existed between the two animals. Tribes the most unlike have general resemblances in the bones, the substratum on which the muscular parts are placed. Witness the ease with which unlearned persons, nay, even naturalists carelessly observing, have taken the skeletons of lizards for those of men.

piece. The teeth are sharp. This creature could only breathe the air, and so must often have come up to the surface. Yet, again, he could only move in the water, and was still less able to crawl on land than even the sea-calf. The length, in some cases, reaches to twenty-four or twenty-five feet. In the strata where these bones are found there are many of the cornu ammonis and other marine shells, and remains of crocodiles exist in the same strata.

The plesiosaurus was first observed in 1821, by Mr. Conybeare and Mr. Delabeche ; and in Cuvier's time its remains had only been found in England, unless those discovered at Honfleur belong to this genus. The discovery was fully made in 1824. The distinguishing feature, the long neck, has many more vertebræ than even a swan's. In the fine specimen from Lyme there are in all eighty-seven vertebræ, of which thirty-five belong to the neck and twenty-five to the tail. The vertebræ, though their axis is very short, resemble the crocodile's more than the lizard's. The teeth are pointed and slender. The paddles consist of many bones, in rows like those of the ichthyosaurus ; but they taper more, consist of fewer pieces, not above fifty, and are longer than those of the ichthyosaurus, nor do they form a kind of pavement like his. Five species * of this animal were distinguished by Cuvier. That found at Lyme appears to have been seven or eight feet long ; but other species, from one jaw bone which has been discovered, must have reached the length of twenty-eight feet.

* Three have since been added.

The eighth and last part of these Researches which we have just surveyed, is remarkable, as regards the skill and diligence of the illustrious author, for two particulars. *First*, the extraordinary success of his indefatigable investigation from very scanty materials derives especial attention. In some cases he had only one or two bones to examine and to reason from. In others he had a far greater number; sometimes he had the whole skeleton in scattered parts; in a few instances the whole together in their natural juxtaposition and connexion. But he found where he had many bones, that from a single one, or from two, he could have reached the very same conclusions which the examination of the whole led him to. This was observable in a very remarkable manner when he investigated the mosasaurus, or saurus found at Maestricht. He had not examined more than the jaw bone and the teeth when he knew the whole animal; but he says that a single tooth discovered it to him: he had got the key; after that every other part fell in at once of itself into its proper place. *Secondly;* Although he was not the discoverer of either the ichthyosaurus or plesiosaurus, and had to tread on ground which his eminent and able predecessors had gone over, his researches even here were quite original. He collected all the evidence, whether by drawings, descriptions, or models, of what had been before them; but he also enlarged his collection of facts by numberless specimens both of the same kind which they had examined and of different kinds never submitted to their view. He investigated the whole as if the field had been still untrodden and the soil yet virgin; and accordingly his work, even in this subordinate branch, is far from being a repetition; his inquiries far from being a mere reiteration of theirs. Where he does not vary or extend the results at which they had arrived, he carefully confirms their propositions, and ascertains the truth of their learned conjectures; so that he adds to the precious monuments of his predecessors, by either enlarging the superstructure or strengthening the foundation.

That such a guide to our inquiries is worthy of all confidence, no one can doubt. That even his authority, the weight of his opinion, is very great would be a proposition as indisputably true, if in matters of science it were lawful for the learned to pay any deference to mere authority; yet even here ignorant men may bow to him, and receive his doctrine with a respect which they might be justified in withholding from others. But his system makes no such appeal, and requires not to be received upon terms like these. He has given us without any reserve every particular which his whole researches presented to his own view, and preferring the risk of being tediously minute to the chance of leaving any point unexplained, or any position without its needful proof, there is not a fragment of bone which he has ever examined, and on which he raises any portion of his philosophy, that he has not both described with the fulness of anatomical demonstration, and offered to the eye of his reader in the transcript of accurate and luminous engraving. His work is accompanied with between forty and fifty maps and sections of strata, above 250 plates representing upwards of 3800 skeletons, bones, teeth, and fragments. These are all presented to the examination of the expert, in their connexion with the author's description both of what the diagrams can, and of what they cannot, fully represent. But they are also presented to the uninformed, who can, by attentively considering them, institute a comparison between the structure of known and living animals, and those of which the earth's strata contain only the remains. Giving Cuvier only credit for having correctly written down what he observed, and accurately represented in his figures the subjects of his examination, we are enabled to see the whole ground of his reasoning: we can mark the points in which a fossil animal resembles a living one, and those in which the two differ; and we have even a higher degree of evidence in behalf of the author's conclusions than we have in reading Sir Isaac Newton's experiments upon light, because every thing in this case depends upon configuration, which a drawing can accurately represent, whereas much in the optical case must needs turn upon appearances observed by the experimenter, and which no drawing can convey to our apprehension.

If again we compare the certainty and fulness of the proof in this case with that which we have in examining any anatomical proposition, or any doctrine of natural history, whether of animals or of plants, we shall still find it of a separate and higher kind. For in those branches of science much more is necessarily left to description. The question here is always one purely osteological as regards the animals; and osteology is of all branches of anatomy, whether human or comparative, the one where most depends upon mere figure, and where of consequence the reader can approach most nearly to the observer in weighing the proofs on which his demonstration rests. The geological matter bears but a small proportion to the zoological in these inquiries. It is indeed of the highest importance; but it is incapable of much doubt, and admits of no mistake or imposition—for the strata where the different animal remains have been found are well known, and, in the very great majority of cases, are of easy access to all. The sciences of geology and mineralogy are sufficiently certain, at least for the main purposes of the inquiry; the names and description of the beds of the globe's surface are the portions of those sciences upon which no doubt or difficulty can exist; and the great body of Cuvier's results remains unaffected by any differences of opinion upon speculative geology.

Thus the comparison stands as to the degree in which the evidence is made plain to the reader of Cuvier's researches, and the reader of other records of discovery in the inductive sciences. But let us extend our view a little further, and compare the proofs before us in these volumes with those reasonings upon which the assent of mankind has been given, and is continued unhesitatingly, to the great truths of the mixed mathematical sciences. The reader of the "*Principia,*" if he be a tolerably good mathematician,* can follow the whole chain of demonstration by which the universality of gravitation is deduced from the fact that it is a power acting in-

* It is the object of the Analytical View of that great work in this volume to make the demonstration, the proof on which the Newtonian system rests, so easy as to be followed by persons little skilled in mathematical science; but the remarks in the text will, it is to be feared, always remain well founded. The like may still more be said of the Analysis of La Place's Mécanique Céleste.

versely as the square of the distance to the centre of attraction. Satisfying himself of the laws which regulate the motion of bodies in trajectories around given centres, he can convince himself of the sublime truths unfolded in that immortal work, and must yield his assent to this position, that the moon is deflected from the tangent of her orbit round the earth by the same force by which the satellites of Jupiter are deflected from the tangent of theirs, the very same force which makes a stone unsupported fall to the ground. The reader of the "*Mécanique Celeste*," if he be a still more learned mathematician, and versed in the modern improvements of the calculus which Newton discovered, can follow the chain of demonstration by which the wonderful provision made for the stability of the universe is deduced from the fact that the direction of all the planetary motions is the same, the eccentricity of their orbits small, and the angle formed by the plane of their ecliptic acute. Satisfying himself of the laws which regulate the mutual actions of those bodies, he can convince himself of a truth yet more sublime than Newton's discovery though flowing from it, and must yield his assent to the marvellous position that all the irregularities occasioned in the system of the universe, by the mutual attraction of its members, are periodical, and subject to an eternal law which prevents them from ever exceeding a stated amount, and secures through all time the balanced structure of a universe composed of bodies, whose mighty bulk and prodigious swiftness of motion mock the utmost efforts of the human imagination. All these truths are to the skilful mathematician as thoroughly known, and their evidence is as clear as the simplest proposition in arithmetic is to common understandings. But how few are there who thus know and comprehend them! Of all the millions that thoroughly believe those truths, certainly not a thousand individuals are capable of following even any considerable portion of the demonstrations upon which they rest, and probably not a hundred now living have ever gone through the whole steps of those demonstrations. How different is the case of the propositions discussed by Cuvier and his predecessors! How much more accessible are the proofs on which their doctrines repose! How vastly more easy is a thorough acquaintance with the "*Recherches*" than with the "*Principia*" and the "*Mécanique Céleste!*" How much more numerous are they who have as good reason for fully believing the propositions, because as great facility of thoroughly examining the proofs, as first rate mathematicians can have for assenting to Newton's third book, and La Place's great theorem, or as common readers have for admitting any of the most simple truths in the easiest of the sciences!

The extraordinary truths unfolded by the "*Recherches*" we have had an opportunity of stating in detail. But it is necessary to revert to some of the more general conclusions in their more immediate connexion with the great subject of these volumes. The Illustration derived to theological inquiry from the powers of inductive investigation in this branch of science, and the Analogy found between the two kinds of demonstration, was stated in the Introductory Discourse; but these form by no means the whole contribution which this new branch of knowledge furnishes to Natural Religion. Before the nature and extent of that aid could be understood, it was necessary that the details of the science itself should be considered, and its general principles unfolded, together with the grounds upon which they rest. We are now more particularly to make the application.

To the geologist, as Cuvier has well observed, the vast periods of time over which the phenomena that form the subject matter of his inquiries have extended, offer the same kind of obstruction as the astronomer finds from the immense space over which his researches stretch. The distance of time is to the one as great a difficulty as that of space is to the other in prosecuting his researches. Yet as the properties of light, and its relation to media artificial or natural, furnish a help to the senses of the astronomer, so the endurable nature of the principal portions that compose the framework of animal bodies give invaluable assistance to the labours of the geologist and anatomist, supplying records which it is as physically impossible he should have in any history of past changes on the globe, as it is that the naked eye of the astronomical observer should penetrate into boundless space. The most minute bones of small animals, even their cartilaginous parts, and the most delicate shells of sea or river fishes, are found in perfect preservation. These shells are found, too, on ground now and for ages lying high above the level of any waters, in the middle of the hardest rocks, reaching the summits of lofty mountains, lying in vast layers of a regular form and solid consistency, and which seem to demonstrate the proposition that the sea in former ages was spread over the regions where those strata were formed, and lay there long and quietly. The level parts of the earth, which to an observer who only regards its surface seems always to have been in its present state, can hardly be penetrated in any place without showing that it has undergone such revolutions and been under the sea for ages; while the bottom of the ocean has at those remote periods been dry land. But when we ascend to geater heights, we find the same proofs of former changes; marine remains often show themselves on Alpine summits, but their kinds vary much from those of the lower regions; they are exposed to view by the layers in which they lie imbedded being no longer horizontal and buried deep under ground, but nearly vertical, broken in pieces, and thrown variously about. These strata have for the most part been of a formation long prior to that of the horizontal ones, and were at one time displaced, and elevated and rolled about; the ocean was the great agent in their formation as in that of the strata which it afterwards deposited horizontally around them; the ocean, too, was the agent which, after having first deposited, afterwards dislocated and raised them into rocks, promontories, and islands, amidst which the strata still found horizontal were laid.

This ocean, at different times, not only held in solution different dead matter, but was inhabited by animals of kinds that exist no more. When it last left the earth and retreated into its present position, the only one in which we have ever known it by actual observation, its inhabitants nearly resembled those which still live and swarm in its waters. But at more remote periods, and when forming its more ancient deposits, it was the receptacle of animals of which not a living trace now remains; animals all whose species are extinct;

animals of genera absolutely different from any now known, and which sometimes united together in one individual frame, parts now only found separate in distant and unconnected tribes.

Again, the intermixture of land animals and of fish the inhabitants of fresh water only, with those of marine origin, shows that several successive irruptions of the ocean must have taken place, and that after it remained covering the land during successive periods, it retreated successively, and left that portion of the globe dry. Nor can there be any doubt that large portions of the earth now uncovered and inhabited by the human species and other tribes of living animals had, before it was last covered by the sea, been dry, and been inhabited by a race of animals of which their fossil remains are all that we can now trace.

It is probable, too, that many of these mighty revolutions have been sudden, and not effected by gradual incroachments upon the earth, to destroy its inhabitants. The examination of masses of flesh belonging to some of the race destroyed by the last change, and preserved by the frozen water in which they were imbedded, seems to prove that the death of the animals, and their envelopment in water, the coagulation of the water, and the introduction of a frozen climate, were simultaneous; for the putrefactive process had not commenced till thousands of years after the destruction of life, when, the ice being thawed, the exposure to heat and air began the decomposition. But the sudden violence by which these last changes were effected is equally conspicuous in the transport of huge blocks from one part of the country to another in which they were manifestly strangers.

But we ascend to greater heights on the surface of the globe, and we find the scene changed. We are now upon the vast and lofty chains of solid rock which traverse the central parts of the different continents, separate the rivers that water and drain them, veil their summits in the clouds, and are capped with never-melting snows. These are the primitive mountains; formed before any of the other new-made strata whereof we have already spoken, because they penetrate them vertically; and even these primeval rocks show by their crystallisation, and occasionally by their stratified forms, that they, too, were once in a liquid state, and deposited by waters which anciently held them in solution and covered the places they now fill. In these, as we ascend to the most ancient, no animal remains at all are found. The shells and other marine productions so abundant below, and in the more recent layers of the globe, here cease altogether to exist. The primeval rocks, therefore, were first held in a liquid state, and afterwards deposited, by an ocean which contained in its bosom no living thing; an ocean which before covered, or washed, a continent, or islands, on which life never had existed.

There is also little doubt, according to Cuvier, though we give not this as an incontestable proposition, that the prodigious changes which we have been contemplating must have been operated by a force wholly different from any that we now perceive in action upon any portion of the globe. The power employed to work some of the displacements of which we see the traces is shown remarkably in the insulated masses, found removed from great distances, and lying still at vast heights. On the

Jura, at near 4000 feet above the level of the sea, are found blocks of granite evidently carried from the Alps, one of which, containing 50,000 cubic feet of stone, has been removed and placed in its present position after the formation of the strata on or among which it lies,—strata, the materials of which do not fill its interstices, but have been rent and broken by its fall. None of the operations now observed on the earth's surface satisfactorily explain either this or the other revolutions in question. The effects of weather, either in the fall of rain, or in alternate freezing or thawing of water, though sufficiently powerful and very beneficial upon a small scale in decomposing stones and pulverising earths, are confined within comparatively narrow limits. The action of rivers in wearing down their banks, and changing the position of their beds, is restricted to those banks and beds, and is of slow and almost imperceptible operation, unless in some cases of rare occurrence, where a mountainous eminence being gradually undermined may fall and dam up a river and cause a lake to be formed, or where a lake may be let out of its reservoir by the wearing away of some ridge forming its dam or head, and so inundate the country below—events barely possible be it observed, and of which the period of authentic history records scarcely any instance. Then the incroachments of the sea are even more gradual than those of rivers; nor can any proof be found, in all the time over which authentic human annals reach, of a material change in position of the ocean with respect to its shores; the utmost it has ever done being to wear away an isthmus here and there,* or cover a mile or two of

* There seems reason, from some ancient authorities, to

low and flat coast.* The wonderful force of a column of compressed water, in a vertical fissure connected with a subterraneous sheet of it, however shallow, but filling a broad space—the resistless power of such a column to move about any superincumbent weight—has, perhaps, been too little taken into account as an agent in effecting changes on the earth's surface. But these operations must be all merely local. Volcanic action is still more topical in its sphere; and though violent enough within these narrow limits, produces consequences wholly confined to them, and unlike those which are under consideration. Lastly, whatever effect could be produced by the motion of the earth is of incomparably a more slow and gradual kind than any now enumerated. The motion of the poles round the plane of the ecliptic, and the nutation of the axis, are movements of this kind, and never exceeded certain narrow limits. The rotation of the earth has a regular and defined tendency to accumulate matter towards the equator, and flatten our globe at the two poles, but no other; and certainly neither a sudden nor a violent effect can be operated by this means.

The result of the Researches upon the fossil bones of land animals has demonstrated those changes still more incontestably than the examination of the remains which have been left by the

believe that the Isle of Wight was once a peninsula when the tide was out, to which tin, the staple of the ancient British exportation, was carried in waggons at low water to be shipped for Gaul.

* The estate of Earl Godwin in Kent, now covered by the sea, is one of the principal examples of this kind of change; and there must clearly be great exaggeration in the accounts given of it.

inhabitants of the ocean; both because, as they must have lived on dry land, their being found in strata deposited by water proves that water has covered parts of the continent formerly dry, and also because, their species being fewer in number and better known, we can now certainly tell whether or not the fossil animal is the same with any still living on the globe. Now of the one hundred and fifty quadrupeds examined by Cuvier, and whose remains are found deposited in different strata of our continent, more than ninety are at present wholly unknown in any part of the world; nearly sixty of these are of genera wholly unknown, the rest being new species of existing genera; only eleven or twelve are so like the present races as to leave no doubt of their identity, or rather of their osteology being the same; while the remaining fifty, though resembling in most respects the existing tribes, as far as the skeletons are concerned, may very possibly be found, on more close survey, and on examining more specimens, to differ materially even in their bones. Nor is it at all unlikely that, of the whole one hundred and fifty, every one would be found to be of a race now extinct, if we could see their softer parts as well as their bones and their teeth. But the relation which these different species of ancient animals bear to the different strata is still more remarkable and more instructive in every point of view.

In the *first* place, it appears that oviparous quadrupeds, as crocodiles and lizards, are found in earlier strata than those containing viviparous ones, as elephants and others. The earth which they inhabited must, therefore, have existed and been watered by rivers before the chalk formation, because they are found under the chalk in what is termed the Jurassic formation.—But, *secondly*, among the strata subsequent to the chalk formation, the unknown genera of animals, palæotheria, anoplotheria, are only found in the series of beds immediately over the chalk. A very few species of known genera of viviparous quadrupeds are found with them, and also some fresh-water fishes. —*Thirdly*. Certain extinct species of known genera, as elephants, rhinoceros, are not found with those more ancient animals of extinct genera. They are chiefly found in alluvial earth, and in the most recent tertiary strata, and all that we find with these extinct species are either unknown, or of more than doubtful identity with any now existing. Again, those remains which appear identical with the known species are found in recent alluvial earths, and places which seem to belong to the present world.—*Fourthly*. We have seen that the most ancient secondary strata contain reptiles and no other quadrupeds. None of the rocks at all contain any human remains; nor were any remains of the monkey tribe, or any of the family of quadrumanes found in Cuvier's time, if indeed they are observable even now. In turf-bogs, in rents and cavities, under ruins as well as in cemeteries, human skeletons are from time to time found; but not a vestige of them or of any human bone in any of the regular strata, or of the fissure deposits, or of the caves and caverns which abound with all the other animal remains. Whatever human bones have been found, were undoubtedly placed there by human agency in recent times.

For Cuvier has examined with the utmost care all the instances which were pretended to afford proofs of human remains. He closely investigated several thousands of the bones in the Paris basin, and in the deposits of Provence, Nice, and others. All which had ever been supposed to be human he found to be either animal bones, or bones of men accidentally placed among the others, or in some other manner satisfactorily accounted for. The skeleton supposed by Scheutzer to be a man's, and which he made the subject of his book "*Homo Diluvii Testis*," a century ago, has been already adverted to. Cuvier undertook the complete examination of it. The first skeleton which formed the subject of Scheutzer's argument was found near Amiens. Thirty years afterwards another was discovered, but its possessor, Gesner himself, raised grave suspicions that it was some lower animal's remains. A more complete one than either was afterwards found. Cuvier has engraved this, together with Scheutzer's copied from his own book —and how any person could, upon the bare inspection, ever have conceived that either was a human skeleton is truly incomprehensible. But Cuvier has further engraved a land salamander, whose osteology he had, after his admirable manner, thoroughly examined, and its likeness to the fossil remains shows it to be of the same genus, though of a wholly new species, above six times larger. He enters at large into the details of the difference between these remains and the human skeleton. But a further demonstration of their nature was reserved for him when, in 1811, at Leyden, he had access to the actual fossil itself of Scheutzer, and was permitted to remove a portion of the incrusting stone. He did this with the salamander by him, and predicted the kind of bones that would be discovered by the operation. The success of the experiment was complete; and to show the difference between this skeleton and a human subject, Cuvier had the satisfaction of also discovering a double row of small and sharp teeth, studding the fringe or border of the large circular mouth. In 1818, he had an opportunity of repeating this examination upon the last found specimen, which is now in the British Museum, and with exactly the same result. It is therefore demonstrated, as clearly as any fact in the whole compass of physical science, that these bones belong to a race wholly different from the human species, and indeed from any species now existing on the face of the globe. Finally, places where human bones have for many centuries been deposited with the remains of animals, as the ground under ancient fields of battle, have been examined, and it is found that the one are quite as well preserved as the other, and have not suffered more decay. The importance of establishing the conclusion that no human remains are to be found in the strata of the earth will presently appear, and is the reason why we have dwelt upon the evidence in some detail.

If we next inquire at what period the last great change took place, although of course no records can remain to fix it, yet we have some data on which to determine the limits of the question. The progress of attrition in the larger rivers, as the Dnieper and the Nile, and also the formation of downs where they approach from the sea, has been observed, as on the coast of the Atlantic in the south of France; and the results indicate no very remote antiquity as the age of the present terraqueous distribution; certainly not more than 5000 or 6000 years. Of these, history only goes back about 3000. Homer lived but 2800 years ago. Genesis cannot have been written earlier than 3300 years back. Even the earliest Chinese monuments that are authentic reach but 2255 years. The astronomical remains of the East, when closely examined, especially the Zodiac, prove nothing of that extreme antiquity which was at one time ascribed to them. Nor do the mines, such as those of Elba, from which similar inferences were formerly deduced, show, since their more accurate examination, anything of the kind. Indeed none of the conclusions they lead to can be regarded as at all of a certain kind. The general result of the Inquiry, then, is, that at a period not more remote than 5000 or 6000 years ago, a mighty convulsion covered with the ocean all those parts of the globe then inhabited by man and the other animals his contemporaries, and left dry those other portions of the earth which we now inhabit. The few remains of the races then destroyed have served to people this new world; it is only since this period began that we have entered upon the progressive state of improvement in which our race has advanced; and to this period whatever historical monuments we possess of the globe or its inhabitants are confined. But it is equally clear that this inhabited earth, then left dry for the last time, had previously undergone several revolutions, and had been alternately dry land and covered with the ocean, more than once, or even twice, before this last revolution. We have access more particularly to examine the condition and population of the earth when it was last inhabited, that is, when the sea left it the last time but one. We are now living in the fourth era or succession of inhabitants upon this earth. The first was that of reptiles; the second that of palæotheria; the third of mammoths and megatheria; and it is only in this present or fourth æra in succession that we find our own species and the animals which have always been our companions.

We are entitled then to affirm that, with respect to animal life, three propositions are proved, all of great curiosity, and still more, when taken either separately or together, all leading to conclusions of the highest importance—

First—that there were no animals of any kind in the ocean which deposited the primary strata, nor any on the continent which that ocean had left dry upon its retreat;

Secondly—that the present race of animals did not exist in the earlier successive stages and revolutions through which the globe has passed;

Thirdly—that our own species did not exist in those earlier stages either.

Now the conclusion to which these propositions leads, and which indeed follows from any one of them taken singly, but still more remarkably from the whole, and most especially from the last, is that a creative power must have interposed to alter the order of things in those early times. That an interposition of this kind took place, the last and most important, about 6000 years ago, is highly probable from the physical and natural evidence alone which is before us, and to which alone in this work reference can be made. But the date is not material. If at an uncertain period before the present condition of the earth and of its inhabitants, there were neither men nor the present race of creatures, wild and domestic, which people the globe, then it follows that between that period, whensoever it was, and the earliest to which the history of the world reaches back, an interposition of power took place to create those animals, and man among the rest. The atheistical argument, that the present state of things may have lasted for ever, is therefore now at an end. It can no longer be affirmed that all the living tribes have gone on from eternity continuing their species; and that while one generation of these passed away and another came up in endless and uninterrupted succession, the earth abided for ever. An interruption and a beginning of that succession has been proved. The earth has been shown not to have for ever abode in its present state; and its inhabitants are demonstrated, by the incontrovertible evidence of facts, to have at one time had no existence. Scepticism therefore can now only be allowed as to the time and manner of the creative interposition; and on these the facts shed no light whatever. But that an act of creation was performed at one precise time is demonstrated as clearly as any proposition in natural philosophy, and demonstrated by the same evidence, the induction of facts, upon which all the other branches of natural philosophy rest.

It is wholly in vain to argue that the sea or the earth, or the animals formerly existing and now extinct, or any other created beings, or any of the powers of nature, as we know it, or as it has ever been known, could have made the change. It is difficult enough to conceive how these known forces could ever have destroyed the earth's former inhabitants. But suppose the approach of some comet or other body at different times produced the vast tides by which the land was successively swept, this will not account for new species and new genera of living creatures having sprung up both to inhabit the land and to people the waters. An act of creation—that which would now be admitted as a direct interposition of a superior intelligence and power—must have taken place. This is the sublime conclusion to which these Researches lead, conducted according to the most rigorous rules of inductive philosophy, precluding all possibility of cavil, accessible to every one who will give himself the trouble of examining the steps of the reasoning upon which they repose, and removing doubt from the mind in proportion as their apprehension removes ignorance. It is an invaluable addition to the science of Natural Theology, and forms a chapter as new in kind as any of the new animal species are in Natural History.

Such are the benefits conferred upon the great and fundamental argument of Divine Intelligence and contrivance by the recent discoveries in Fossil Osteology. The evidence of design in the combination and mutual adaptation of the parts of extinct animals we pass over as only a multiplication of proofs sufficiently numerous before. But the other branch of Natural Theology, that which investigates the Divine Benevolence, also derives aid from this new quarter. We now refer to the argument maintained in the Dissertation upon the Origin of Evil, and also to the theories which were there very respectfully considered, and diffidently and reluctantly found to be unsatisfactory. The late interesting discoveries have thrown new light upon both these subjects of discussion, and the authors of some of the systems which we examined may appear to the improved state of our knowledge respecting the Chain of Being, as we certainly do make our appeal to it upon what appears to be a more solid ground of argumentation.

The doctrine respecting the Chain of Being is admitted to be incomplete as regards the matter of fact, inasmuch as we find many and large blanks in the series of animated creatures known upon our globe. Whatever other objections, therefore, were competent against this theory, an additional one was, that little appearance of a Chain of Being seems discernible in the universe. Now, the supporters of this doctrine have certainly a right to maintain that the blanks are filled up in a very remarkable manner by the recent discoveries. For the new species of animals discovered to have existed in former states of the globe, unquestionably fill up some of the most remarkable chasms in our series of living animals. Thus the chief blank was always observed in the pachydermatous animals, the fewest in number, the least approaching one another, and the whole tribe the most removed from others. Now most of the new and extinct kinds of quadrupeds belong to this class, and we have had occasion to observe how links are supplied between race and race hitherto appearing altogether distinct.

But although we may not be justified in reposing great confidence in the argument drawn from the plan of a Chain of Being as applied to the subject of positive evil, there is another point of view in which the subject may, with perfect safety, be considered. As far as regards mere defect, mere imperfection, it is most important to consider whether the plan of Divine Providence may not have been to create a succession of beings rising one above another in attributes; say merely of intelligent beings thus differing in their approaches to perfection. The importance of this consideration cannot fail to strike the observer when he reflects that there is no possibility of separating one of the greatest of all positive evils, death itself, from mere defect or imperfection, as was observed in the Dissertation already referred to; not to mention many other kinds of evils arising from mere imperfection,—as all that proceed from weakness, from ignorance, from defect of mental energy, as well as mental perspicacity. All these evils, and all their various consequences, originate in mere defect or imperfection. Therefore it is of no little moment in this important argument that we should be able to derive any new light to guide our steps upon that part of the ground which belongs to defect or imperfection.

Now the late discoveries certainly afford us some such lights. They show as plainly as the evidence of facts can show anything, that there was a time when this globe existed with animals to people it, but without any beings at all of the human kind. The sounder opinion certainly is, that there has been a succession of stages through which the earth has passed, with different races of animals belonging to each period; that in the earliest age of all no animal life existed; that this was succeeded by another in which reptiles were found to flourish, and that subsequent periods were marked by other successive races of animated beings. But as this is the subject of controversy, we shall only say that there have been two eras, one in which inferior animals only existed without man, and the other in which we now live, and in which our species are the principal inhabitants of the globe. This is admitted by all who have considered the evidence; and they who the most strenuously deny the other doctrines of Fossil Osteology avow their implicit belief in the great proposition, that the relics of an age are clearly discovered in which man had no existence.

Now this position is most important with a view to our present argument. It appears that there was a time when the Creator had not brought into existence any being above the rank of the lower animals. It follows that the divine wisdom had not then thought fit to create any animal endowed with the intelligence and capacity and other mental qualities of the human species. If an observer had been placed in that world, and been called upon to reason regarding it, what would have been his reflections on the imperfections of animated nature? Yet, after a lapse of some ages, those defects are all supplied, and a more accomplished animal is called into existence. The faculties of that animal, and his destinies, his endowments and his deficiencies, his enjoyments and his sufferings, are now the subjects of the observer's contemplation and of his reasoning. What ground has he now for affirming that a more perfect creature may not hereafter be brought into existence—a creature more highly endowed and suffering far less from the evils of imperfection under which our race now suffers so much? No one can tell but that as many of the former inhabitants of the globe are now extinct—tribes which existed before the human race was created—so this human race itself may hereafter be, like them, only known by its fossil remains; and other tribes found upon other continents, tribes as far excelling ours in power and in wisdom as we excel the mastodon and the megatherium of the ancient world.

It is to be further observed that no uncreated being can, by the nature of the thing, have any right to complain of not being brought into existence earlier. The human race cannot complain of having come so late into the world; nor can any of the tribes created before us complain that they were less perfect than a species, the human, which did not then exist. Have *we*, then, the inhabitants of the present world, any better reason to complain that the new, as yet unknown, possible creatures of a future period of the universe have not as yet come into existence? It must be confessed that the extraordinary fact, now made clearly and indisputably* known to us, of a world having existed in which there were abundance of inferior creatures, and none of our own race, gives us every ground for believing it possible that Divine Providence may hereafter supply our place on the globe with another race of beings as far superior to ourselves as we are to them which have gone before us. But how inconceivably does this consideration strengthen and extend the supposition broached in the Dissertation upon Evil! How strikingly does it prescribe to us a wise and wholesome distrust of the conclusions towards which human impatience is so prone to rush in the darkness of human ignorance! How loudly does it call upon us to follow the old homely maxim, "When you are in the dark, and feel uncertain which way to move, stand still!" How forcibly does it teach us that much—

* The kind of controversy which may be raised, but never has been raised on this point, is discussed in the next dissertation.

nay, that all which now we see as in a glass darkly, and therefore in distorted form and of discoloured hue, may, when viewed in the broad and clear light of day, fall into full proportion and shine in harmonious tints!*

* Dr. Paley, in his twenty-fifth chapter, assumes, that whenever a new country has been discovered, with new plants and animals, these are always found in company with plants and animals which are already known, and possessing the same general qualities. From hence he derives an argument for the unity of the First Cause. Mr. Dugald Stewart also infers from the supposed identity of animal instincts in all ages, that the laws of physical nature must have always been the same, otherwise these animals could not have continued to exist.

Now, *first* as to Dr. Paley's assumption. It certainly appears too large, even as regards the existing species and the present state of the globe; for there seem to be some places where all the animals are peculiar. But be that as it may, the fact assumed is by no means necessary for the support of Dr. Paley's conclusion in favour of the Divine Unity. It is extremely probable that in some former stages of our globe there were no animals whatever of the same tribes with those which to us are familiarly known. Yet can there be any doubt that in their structure the same degree of skill is observable as far as their only remains enable us to judge, and can we hesitate to believe, that were there other parts before us, we should in those find as much artist-like contrivance as in the existing races of animals? Indeed we may go further and assert, that there is every ground for supposing that the same kind, as well as an equal measure of skill, is to be traced in the lost as in the existing tribes, and that, consequently, the characteristic argument will equally apply here. The proof of this in the structure of the alimentary canal, which Cuvier was not acquainted with, will presently be considered.

Secondly. With respect to the observation upon instinct, unquestionably some doubt may be raised by the new discoveries; for we cannot feel any confidence in the assertion that the animals, whose skeletons alone remain, were endowed with instincts similar to those now in being, more especially the tribes of anomalous description, such as the pterodactylus and ichthyosaurus. We have never seen in life any animals combining the various forms which seem to have met in these extraordinary creatures. We cannot, therefore, feel entire confidence in the belief that their habits or instincts resembled those of any combination of animals so dissimilar,—still less can we comprehend a harmonious union of the instincts proper to birds with those peculiar to reptiles, which yet the pterodactyli seem formed to obey. Dark, however, as is this department of the subject, we have abundant ground, from the preponderating weight of analogy, for resting satisfied that all their instincts, whatever they may have been, were nicely adjusted to their bodily powers, and that both their bodies and their instincts were as nicely adapted to the laws of matter and of motion.

It would be improper not to mention at the close of this Analytical View, that the science of Palæontology was much indebted to some able and learned men who were contemporaries of Cuvier. The examination of the Paris Basin, as regards its mineral character, was almost wholly the work of Brongnart, and it is allowed to be a model in that kind. Cuvier's brother, also, ably assisted him in the botanical department. The labours of Lamarck in conchology are so universally known as to need no further mention; and among other names may be stated that of Miller of Bristol, as having made valuable contributions to these inquiries.

LABOURS OF CUVIER'S SUCCESSORS.

Many learned men were attracted by the discoveries of Cuvier, and devoted themselves to the cultivation of the same science. During the last twelve or fifteen years of his life they had joined in similar pursuits, and many of his opinions were modified, and many of his researches were materially aided, by their diligent and successful inquiries. As far as regards the general connexion between Organic Remains and Geology, indeed another inquirer had appeared in the field as early as himself, the laborious, modest, and sagacious William Smith, a civil engineer, who, unassisted and almost unknown, had been prosecuting his researches into the mineral state of England, and performed certainly the most extraordinary work that any single and private individual ever accomplished—the delineation of the strata of the whole country, in a set of underground maps, which he published in 1815, and followed afterwards with a work upon the relation between these strata and their Organic Remains. Although the results of his investigations were published thus late, he had many years before communicated the greater part of them freely to his private friends. It must be confessed that few men of greater merit, or more unassuming, have ever adorned any walk of science, and few have ever made a more important step in assisting the progress of discovery.

The other able persons who have cultivated this branch of science are certainly endowed with greater learning, that is, book learning, than Mr. Smith could boast of, beside attending closely to actual observation in the field. Some of them, too, may fairly claim a high place as men of profound and original views. Where so many excel and prefer claims so undeniable to the gratitude of the world, it is invidious as well as difficult to make a selection, the rather as, happily, we still have the great benefit of their continued assistance. In Italy, Brocchi; in Switzerland, Studer, Hugi, Charpentier, and Agassiz, the able and zealous disciple to whom Cuvier gave up the department of fossil ichthyology, when composing his work on Comparative Anatomy; in Germany, Von Buch, Kaup, Count Münster, Goldfuss, Rosenmuller, Wagner, and the justly celebrated Humboldt; in Russia, Fischer; in Belgium, Burtin, Omalius, Dumont; in France, Beaumont, Brongnart, Blainville, Prevost, Boué, Brochant, Geoffroy; and in England, Conybeare, Mantell, Lyell as incident to his Geological Treatise, Clift, Delabeche, König, Hibbert, Broderip, Fitton, Bakewell, Greenough, Owen, Murchison, Professor Sedgewick, and Dr. Buckland. These, it is believed, are all, except Brocchi, fortunately still alive, and still actively engaged in the same interesting inquiries, though some of them rather confine their study to the geological portion of the subject. If from the brilliant assemblage the names of Sedgewick and Buckland were selected, but, as regarding Fossil Osteology, the latter especially, private friendship could hardly be charged with officiously assuming to be the organ of the general voice—but, indeed, to record such merit might well seem presumptuous, where the panegyric is far less likely to reach aftertimes than the subject of its praise.

The labours of Cuvier's successors, as far as regards his doctrines, belong to one or other of three classes: to the progress which they have made in examining the fossil remains of former worlds, or conditions of our globe;* to the arguments which they have advanced in opposition to or in support of his theory respecting the relation that subsists between those animal remains and the strata in which they are found; and to the arguments adduced for or against his opinions respecting the formation and age of those strata. It may be proper to mention the things done under each of these heads, although the last is of comparatively little importance to the purpose of the present work, and the second is of considerably less moment, as regards Cuvier's proper subject, than the first.

I. Among the extinct mammalia of the pachydermatous order, we mentioned one which Cuvier referred to the tapir genus, but pronounced to have been of a gigantic size. He only had seen the jaw teeth of the animal. But since his time other important parts have been found, chiefly at Epplesheim, in Hesse Darmstadt: and a genus *Dinotherium* (having four species) has been established, of which this species is termed *giganteum*, his length having been apparently not less than eighteen or

* The notes to the Analysis of Cuvier contain statements of the numbers of new species discovered since his time.

nineteen feet. His distinguishing peculiarity is the having two enormous tusks, which are bent downwards like those of the walrus, but are placed at the front end of the lower jaw, so as to bend below the chin. Dr. Buckland has shown by most cogent arguments that he must have lived chiefly in the water, and these tusks in all probability were used in supporting him, anchored as it were, to the side of the river or lake while his huge body floated, as well as employed in digging for the roots upon which his teeth show that he fed.

Notwithstanding somewhat scanty materials, Cuvier had described and, as it were, restored the megatherium with extraordinary skill. But a further importation of bones from South America has enabled observers in this country to throw some additional light upon the structure and habits of this singular animal. These bones were found in the bed of the river Salados in Buenos Ayres, a succession of very dry seasons having brought the water unusually low. Mr. Clift, of the Surgeons' Museum, a most learned and skilful comparative anatomist, and pupil and assistant of John Hunter, examined them fully, and found many very singular particulars not before known respecting this animal. Among other things it appears to have a bony partition between its nostrils (septum narium) like the rhinoceros tichorhinus. The structure of its teeth indicates that they are formed by perpetual growth like the elephant's tusks, and not like his teeth by renewal. The enormous size of the tail never could have been conjectured from the analogy of the elephant and other pachydermatous animals. It was composed of vertebræ, of which the one at the root had a diameter of seven inches, and the diameter from the extremities of the processes was no less than twenty-one inches. If then allowance be made for the muscle and integuments, it could not have been less than two feet in diameter at the root, and six feet in girth. There can be little doubt that it was used both as a weapon of defence and to support the animal in conjunction with part of his large feet, while the others were employed in digging or scraping away the earth in quest of his food. The fore feet were a yard long, and the bones of the fore legs were so constructed that the limb could have a lateral or rotatory horizontal movement for the purpose of shovelling away the soil. The bone of the heel is also of extraordinary length. The proportion of his bones to those of the elephant is very remarkable. The first caudal vertebra in the megatherium being twenty or twenty-one inches, in the elephant it is barely seven. The circumference of the thigh in the former is two feet two inches, in the latter one foot. The expanse of the os illii in the former no less than five feet one inch, in the latter three feet eight inches. The bony cover of the hide has also been now more fully examined. It was about an inch in thickness, and so hard as to resist all external violence. The cumbrous movements of this unwieldy creature exposing it to many kinds of danger, the hide served to defend it from some enemies, and the weight and strength of its limbs and tail enabled it to destroy others; escape from any by flight being quite impossible. Mr. Clift informs me that he has found in the region of the pelvis small lumps of adipocire. So that we have here an additional instance of the softer parts of an extinct animal still preserved in a state to which flesh is now often reduced by decomposition in water.

Mr. Darwin (grandson of the celebrated physician and poet) has found in South America many interesting remains. Among these are the bones of an edentate, between the megatherium and armadillo (largest kind); those of a huge rodent in size equal to the hippopotamus; and those of an ungulate quadruped the size of a camel, and forming the link between that class and the pachydermata.

In the lias stratum of Lyme Regis there was found in 1828, by Miss Anning (to whose skill in drawing, as well as her geological knowledge, Cuvier often acknowledges his obligations), a new species of pterodactylus with very long claws, and hence Dr. Buckland gave it the name of *Pter. Macronyx*. It appears to have been the size of a raven.

In 1824, Mr. Mantell discovered in the Tilgate sandstone, in Sussex, the remains of an herbivorous reptile allied to the iguana genus, but vastly larger; and he gave it the name of *Iguanodon*.* Other parts of the animal have since been found in different places, as in Purbeck, and in the Isle of Wight. Mr. Murchison found a thigh bone three feet seven inches long; and in 1829, a metacarpal bone, of six inches long by five wide, was found in the iron sand, and a vertebra as large as an elephant's. The opinion of Cuvier referred the large thigh bone clearly to Mr. Mantell's reptile, whose dimensions must therefore have been enormous, though it was not carnivorous.

In 1834, a large proportion of the skeleton was

* This discovery had been made before the last edition of Cuvier's book, and is mentioned, though shortly, in the Analysis.

found in the Rag quarries near Maidstone. This confirmed all the previous conjectures as to the bones separately discovered. The length of this monstrous reptile is calculated to have been seventy feet from the snout to the tip of the tail, the tail to have been fifty-two feet long, and the body fourteen feet round.* Mr. Mantell also discovered in 1832, in Tilgate Forest, the remains of a lizard, which may have been twenty-five feet long, and was distinguished by a set of long, pointed, flat bones on its back, some rising from it as high as seventeen inches in length. He called it *Hylæosaurus*, from being found in the Weald.

There were found in 1836, a great collection of fossil bones in the department of Gers, in France, in a tertiary fresh-water formation. Above thirty species, all mammalia, were traced, and of these the greater part were new extinct animals, but all were of extinct kinds; two species of the dinotherium; five of the mastodon; a new animal allied to the rhinoceros, and another to the anthracotherium; a new edentate; and a new genus between the dog and racoon; but the most singular and new of the whole is the under jaw of an ape, which appears to have been thirty inches in height. But we must be very cautious in giving our assent to this, until we are better informed of the position where the jaw was found. It is certainly possible; but after the history of the Guadaloupe skeleton, clearly human, as clearly found among fossil remains, but now universally admitted to have been a recent deposit, we may pause before concluding that a deposit contrary to all other observations of

* Geol. Trans. N. S. vol. iii. pt. 2.

fossil bones should have occurred in any tertiary formation.*

In the time of Cuvier, at least before the completion of his great work, our knowledge was so scanty of the fossil osteology of the East, that we doubt if any allusion to it is ever made by him. Three most important contributions to this branch of science have since extended our knowledge in that direction, and a rich addition may soon be expected from Mr. Clift's labours upon a large recent arrival.

The first was by my excellent friend Mr. Craufurd, who, travelling in the Burman empire, was fortunate enough to discover a great number of fossil remains near the river Irawadi. These he generously gave to the Geological Society, and Mr. Clift proceeded to examine them with his wonted assiduity and skill. Among them were traced two new species of mastodon, in addition to the M. gigas, and M. angustidens, of Cuvier. One is termed by Mr. Clift *Latidens*, from the breadth of his jaw teeth; and the bones of his face exceed in size those of the largest Indian elephant. The other he calls *M. Elephantoides*, because his teeth approach much nearer the elephant's than those of Cuvier's species, or of the Latidens. This animal appears to have been smaller than the elephant. A hippopotamus smaller than the living animal, a rhinoceros, a tapir, and others, have also been

* I have lately seen an appearance of a stratum of calcareous matter, which a cursory observer would certainly have supposed to be a natural deposit in the ground; but its history was known from some rubbish through which lime had filtered, when part of Buckingham House was built, and there were bricks, tiles, &c., underneath it.

traced among these remains, as have a new lizard near the garial, and a crocodile near the common animal.*

The second of these discoveries was made on the north-east border of Bengal, at Carivari, near the Brahmaputra river. The remains were examined by Mr. Pentland. He traced a new species of anthracotherium, which he calls *Silicestre*, a new carnivorous animal of the weazel tribe, and a pachydermatous animal much smaller than any hitherto known, either living or fossil.†

The third and most remarkable of these collections is one discovered in the Markanda valley, and the Sivalik branch of the Himalaya mountains, in the year 1835. The curiosity of naturalists in India was immediately roused, and their industry directed towards the subject with that ardour which the relaxation of a sultry climate never abates, and that combined perseverance and ability which has ever marked the great men of our eastern settlements. Dr. Falconer and Captain Cautley have chiefly signalized themselves in this worthy pursuit; valuable aid has likewise been rendered by Lieut. Durand; and the result of their labours occupies one-half of the Asiatic Researches for 1836. They found first of all a new animal, of the ruminating class, whose skull is the size of a large elephant's, and which has two horns rising in a peculiar manner from between the orbits, with an orifice of great breadth and an extraordinary rising of the bones of the nose. They gave it the name of *Sivatherium*, from the place of its discovery, dedicated to the deity Siva. The breadth of the skull

* Geol. Trans. N.S. vol. ii. pt. 3. † Ib.

is twenty-two inches. Dr. Buckland has no doubt that it must have had a trunk, something intermediate between the elephant's and tapir's. They next found a hippopotamus of a new species, distinguished by having six incisive teeth, and a skull materially different from the other species, whether living or extinct. A new species of tiger was also discovered, which they called *Felis Cristata*, distinguished chiefly by the great height of the occipital bone. In the same place with these bones were found remains of the mastodon, and other known species of extinct animals; but the most interesting discovery was that of a camel, of which the skull and jaw were found. It is to be observed that no decisive proof of any of the Camelidæ, either camel, dromedary, or llama, had ever been hitherto found among fossil bones, although Cuvier had proved certain teeth brought from Siberia to be undoubtedly of this family, if they were really fossil, which he doubted. This discovery in India was therefore extremely interesting, as supplying a wanting genus. But for this very reason it became the more necessary to authenticate the position of this supposed camel's remains the more clearly, especially as there were abundance of existing camels in the country, which there could not be in Siberia. The Indian account is somewhat deficient in this respect, leaving us in doubt whether the bones admitted to bear a very close resemblance to the living species, were found in a stratum or loose and detached.*

* Asiatic Researches, vol. xix. pt. 1. Still more recently, it is said, a bone of the genus Simia has been found in the Sivalik Hills, and another in digging at Calcutta; but the particulars are unknown to me.

Besides all these additions to our knowledge of species and genera, two remarkable observations or sets of observations have been first made by osteologists since the time of Cuvier. The one of these is the tracing of footsteps, the print of which has been left by animals upon the sand, or other material of the strata, while in a soft state. The other is Dr. Buckland's study of the intestines from their fossil contents, which he has called *coprolites.** The first of these curious inquiries is conducted by observing the impressions which the softer and more destructible parts of animals, whose very race has been extinct for ages, made upon the earthy strata of a former world; it is the object of the other inquiry to ascertain from the petrified fæces bearing the impress of the alimentary canal, the internal structure of extinct animals; and both subjects are certainly calculated powerfully to arrest our attention.

The footsteps, it appears, were first observed by my reverend and learned friend, Dr. Duncan (to whom the country is also so deeply indebted as the author of savings' banks), in Dumfriesshire. On examining a sandstone quarry, where the strata lay one over the other, or rather against the other, for they had a dip of forty-five degrees, he found these prints not on one but on many successive layers of the stone; so that they must have been made at distant periods from each other, but when the strata were forming at the bottom of the sea. No bones whatever have been found in those quarries. Similar impressions, though of smaller animals, have been observed in the Forest marble

* Κοπρος, fæces; λιθος, stone.

beds near Bath. The marks found in Dumfriesshire, of which there were as many as twenty-four on a single slab, formed as it were a regular track with six distinct repetitions of each foot, the fore and hind feet having left different impressions, and the marks of the claws being discernible. They appear to have been made by some animal of the tortoise kind.* But similar marks have since been found in other parts of the world. At Hessberg, in Saxony, they have been discovered in quarries of grey and red sandstone alternating; the marks are much larger than those in Scotland, and more distinct. In one the hind foot measures twelve inches in length, and the fore foot is always much smaller than the hind. From this circumstance, and from the distance between the two being only fourteen inches, it is conjectured that the animal was a marsupial, like the kangaroo. But one of the most remarkable circumstances observed is, that the upper stratum has convex marks answering to the concavity of the lower slab on which it rests, clearly showing that the former was deposited soft after the latter had been first printed by the foot in a soft state and then somewhat hardened. Dr. Kaup has termed the large unknown animal *Chirotherium*,† from the supposed resemblance of the four toes and turned-out thumb to a hand. In the summer of 1838 similar footsteps of the chirotherium, and of four or five small lizards and tortoises, with petrified vegetables of a reedy kind, have been observed in the new red stone at Storeton Hill quarry in Cheshire, near Liverpool. A discovery has within the last two years been made in the

* Edin. R. S. Trans. 1828.

† Χειρ, hand.

state of Connecticut, near Northampton, where the footsteps of various birds, differing exceedingly in size, are found in inclined strata of sandstone, and evidently made before it assumed its present position. The marks are always in pairs, and the tracks cross each other like those of ducks on the margin of a muddy pond. One is the length of fifteen or sixteen inches, and a feathery spur or appendage appears to have been attached to the heel, eight or nine inches long, for the purpose of enlarging the foot's surface, and, like a snow-shoe, prevent the animal's weight from sinking it too deep. The distance between the steps is proportioned to their length, but in every case the pace appears to have been longer than that of the existing species of birds to which they approach nearest, the ostrich. Consequently, the animal must have been taller in proportion to his size. How much larger he was than the ostrich may be gathered from this, that the large African ostrich has only a foot of ten inches long, less than two-thirds of this bird, and yet stands nine feet high. These proportions would give a height of fourteen feet to the extinct animal. Some of the footsteps in the Storeton Hill quarry are eighteen inches in length. In the Forest marble of Bath the foot-marks of small marine animals are descried.

In examining the inside of the ichthyosaurus, the half-digested bones of the animals on which these ravenous creatures preyed are found in large masses. But there are also scattered in great abundance among their fossil remains the fæces which they voided; and these being in a petrified state have preserved the very form of the intestines in minute detail. The fæcal matter is generally disposed in folds, wrapt round a central axis spirally. Some of these coprolites exhibit the appearance of contortion, and show that the intestines of the animal were spirally twisted; others, especially the smaller ones, give no such indications. The scales and bones of the prey are distinctly to be traced in the mass; these are the remains, undigested, of contemporary fishes and reptiles, including smaller ones of the beast's own tribe, on which he appears to have fed, as well as on other species. The light which these coprolites throw upon the structure of the animal's intestinal canal is sufficiently remarkable. The intestines are proved to have been formed like an Archimedes screw, so that the aliment in passing through was exposed within the smallest space to the largest surface of absorbent vessels, and thus drained of all its juices, as we find in the digestive process of living animals. The similar structure of the intestinal canal in the sharks and dogfish now existing has been noticed by naturalists; and Dr. Paley expressly refers to it as making compensation by its spiral passage for its being straight, and consequently short, compared with the intestinal passage in other animals. We also can distinctly trace in these coprolites the size and form of the folds of the mucous membrane that lined the intestines, and of the vessels which ran along its surface. As there is no part of the animal frame more easily destructible than the mucous membrane and its vessels, the preservation of its casts is certainly a peculiar felicity for the physiologist. Similar observations have, since Dr. Buckland's discovery, been made upon the coprolites of fossil fishes, in the Lyme Regis lias, in Sussex, in Staffordshire, and near Edinburgh. In some places they take so fine a polish that lapidaries have used them for cutting into ornamental wares. One of the most singular coprolites was found by Lord Greenock (an assiduous and successful cultivator of natural science) between the laminæ of a block of coal near Edinburgh, and surrounded with the scales of a fish recognised by Professor Agassiz as of contemporary origin. To these observations a very curious addition has been made by the Professor, who found that the worm-like bodies described by Count Münster, in the lithographic slate of Solenhofen, are in fact the petrified intestines of fishes, and he has also found the same tortuous bodies occupying their ordinary position between the ribs in some fossil remains. He has named them *Coleolites*;* and certainly the representation given of them in the drawing resembles an actual intestine as accurately as if it were the portrait of it.

When Cuvier abandoned to Professor Agassiz the whole department of Fossil Ichthyology, he showed as happy and just a discernment of living character as he ever displayed in the arrangement and appropriation of animal remains. That admirable person has amply earned the honour thus bestowed on him by devoting his life to this extensive, obscure, and difficult study. The results of his laborious researches have been from time to time published in a great work upon fossil fishes; but as the arrangement followed as yet in the publication necessarily leaves the several parts incomplete, a distinct and satisfactory view of the whole cannot be formed until the work is finished. Some

* Κωλον, the great intestine.

of the discoveries, however, which bear upon the subject of our present inquiries may be shortly described. The importance of the study to fossil geology is manifest from this, that the class of fishes being continued through the successive periods of the different formations, while those of land animals are confined each within certain limits, and the fishes being also inhabitants of those waters in which all the aqueous deposits once were contained, we are enabled by Fossil Ichthyology, through various periods of the earth's formation, to pursue the comparison of a vertebrated animal's condition in each stage.

The Professor's classification is founded upon the form of the scales, which are adapted to the structure of each tribe, and afford a perfectly scientific principle of arrangement. He thus divides the whole into four orders:—the *Placoïdeans*,* whose scales are irregular enamel plates more frequently broad, but varying in dimensions down to a point or prickle; the *Ganoïdeans*,† with angular scales of bone or horn thickly enamelled and shining; the *Ctenoïdeans*,‡ with comb-like scales having a jagged edge and no enamel;§ the *Cycloïdeans*,‖ whose scales are smooth at the edge, and composed of horn and bone, but unenamelled.¶

There were in all 8000 species of fish enumerated by Cuvier, of which more than three-fourths, or 6000, belong to the two last classes, and no one of either of these classes has ever been found in any formation anterior to the chalk; so that the whole of these 6000 kinds of fish have, to all appearance,

* Πλαξ, a tablet or plate. † Γανος, brilliancy.
‡ Κτεις, a comb. § Perch belong to this class.
‖ Κυκλος, a circle. ¶ Salmon and herring are of this class.

been called into existence at a period long after the primitive, the transition, and all but the latest secondary formations. On the other hand, and in the earlier times of the secondary and transition strata, there existed species of the other two orders, which have comparatively few representatives surviving to our days. The Professor has thoroughly examined 800 fossil species of these two orders, and finds not a single exception to the rule thus laid down for the relation between different species of animals and successive formations of strata.* His deductions received further corroboration by the examination of 250 species, all of new and extinct fishes, submitted to him in England, and which were, for the most part, found in this country. The analogy in this respect between the results of Fossil Ichthyology and those of Cuvier's Researches is striking throughout. In the lower deposits of the lias there are found the remains of the great sauroïd fishes analogous to the fossil lizards of the same strata. More than two-thirds of the fishes found in the chalk strata are of genera now extinct. These extinct genera, however, of the newest secondary strata approach more nearly to the fishes of the tertiary strata than the fishes found in the oolite or Jurassic formation; insomuch that the Professor is disposed to range the chalk and green-sand nearer to the tertiary than secondary formations on this account. Not a single genus even of those whose species are found in the Jurassic deposits is now known among existing fishes; nor is there a single species, and but few genera common to the chalk, and the older tertiary strata.

* Rapport sur les Poissons Fossiles, 1835, p. 38.

A third of those found in the strata of the later tertiary formation, as the London clay and the coarse limestone of the Paris Basin, are of extinct genera. The Norfolk crag and upper sub-appennine formation have, for the most part, genera found in the tropical seas; the tertiary formation generally approaches nearest to our living species, but the Professor affirms that, except one small fish, found in modern concretions on the coast of Greenland, not a single species exactly the same with those of our seas is to be found in a petrified state. This continued analogy is very important in a geological view.

In a zoological view it would be endless to attempt any analysis of the Professor's researches. Among the extinct species no less than 150 belonged to the family of sharks, whose services, in keeping down the increase, naturally so rapid, of fishes, have been required in all ages of the ocean. Different kinds of shark, however, appear to have belonged to different periods. Of the three sub-families into which the Professor divides the great class of sharks, the first is found in the earliest period of organic remains, the transition strata, and continues till the beginning of the tertiary, but there is now only one species of it existing, and that is found in New Holland. The second sub-family begins probably with the coal formations, and ceases when the chalk commences. The third begins with the chalk, and continues down through the tertiary formation to the present time. The form as well as the size of the extinct species differ in most things materially from the living, and in no respect do they vary more than in their covering or scales.

As the coprolites enable us to ascertain the interior structure of the extinct reptiles, so do they throw light upon that of fishes also, those especially of the sauroïd or lizard-like kind. We have even instances of their intestines being partially preserved by some fortunate accident. An example near Solenhofen has been mentioned already. A specimen was found in Sussex, where the stomach, with its different membranes, was retained. In a number of fishes found in the Isle of Sheppy the bony capsule of the eye was found entire; and in some other instances the plates forming the gills or branchiæ are perceivable.

It thus appears that great and important additions have been made to this interesting science since Cuvier, who may properly be termed its founder, ceased from his labours. But it would not be proper to pass from a consideration of the services rendered by his successors, without making mention of one illustrious inquirer, a man of truly original genius, who preceded him by a few years. John Hunter, whose unrivalled sagacity seemed destined to cast a strong light upon whatever walk of science he trod, had turned his attention, as early as 1793, to fossil bones, in consequence of a collection sent to this country by the Margrave of Anspach. He described and commented upon them in detail with his wonted acuteness; he adopted the same safe and natural course which Cuvier afterwards pursued with such signal success, of examining the known bones of existing species as well as those submitted to his consideration; and it appears, from some of his concluding remarks, that he perceived distinctly enough the specific difference of the fossil animals, at least of some among them. Thus, having compared the fossil skull of a supposed bear with that of a white bear which he had procured from the owner of the animal while alive, he gives an accurate drawing of both, and marks their diversities, indicating his opinion that the fossil animal differed from all known carnivorous animals.* Who does not perceive that he was on the right track, and would have reaped a plentiful harvest of discovery, had he devoted himself to the general investigation of the subject?†

II. The speculations of succeeding zoologists or comparative physiologists have not only made no impression upon the anatomical results of Cuvier's inquiries, but they never appear to have been pointed towards that object. Considering the numberless instances in which he had to draw his conclusions or to form his conjectures from a very imperfect collection of facts, it is wonderful how constantly the fuller materials of his followers have confirmed his inferences. But geological inquirers have occasionally impugned his doctrines respecting the relation of the classes of animals to the successive formations of the strata that incrust our globe. It has been denied by some that any such relation at all can be truly said to exist. There seems, however, no possibility of maintaining this position, whether we agree wholly with Cuvier or not in the detail of his statements. For the fact is undeniable that some strata, let them have been arranged in

* Phil. Trans. 1794, p. 411.

† In the Hunterian Museum there is a large collection of fossil organic remains, selected with consummate skill, and showing the attention bestowed by this great man on the most delicate parts of organization which they exemplify.

whatever succession, formed and placed by whatever causes, contain the remains of certain classes of animals which are not to be found in other strata. It is another fact equally indisputable, that no animals now exist of the same kind with the greater part of those found in any of the strata. This appears to connect the different races of animals with the different strata. But it is said that this is not a chronological connexion, and affords no evidence of strata having been formed rather in one age than another. If it were so, there still would remain a foundation for the position which merely affirms a relation between organic remains and strata. But is it true? The principal reason assigned is, that although no animals of a certain kind are found in certain strata, supposing those strata to have been formed at a given period, the animals of the kind in question may have perished so as not to have been washed into the sea or other water in which the earthy matter was mixed, and from which it was deposited. Now, not to mention that this bare possibility becomes improbable in the degree in which the facts are multiplied and the observations of animals and strata extended, the researches respecting fossil fishes seem to negative the objection entirely. For if the different strata were made by the sea, and contain totally different remains of marine animals, it is clear that each must have been formed respectively in a sea inhabited by different animal tribes. The strict parallelism, too, which is observed between the connexion of different races of animals and that of fishes with different strata, lends the strongest confirmation to Cuvier's doctrines.

Ingenious and laborious attempts have been made to show, that though many races of animals are now wholly extinct, the evidence fails to prove the non-existence of any race (except our own) at a preceding period; in other words, to disprove the proposition that many of the present races came for the first time into existence at a period subsequent to the time when we know that others existed, always excepting the human race, which it is admitted we have sufficient reason to believe did not exist in the earlier stages of the globe's formation. It cannot, however, be denied, *first*, that the extinction of many races of animals, which is admitted, affords a ground of itself for thinking it probable that new ones should be found to supply their places; *secondly*, that there seems nearly as little reason to regard the utter extinction of some classes as more improbable than the formation of others; *thirdly*, that the admitted creation of man destroys the whole support which the objection might derive from a supposed uniformity of natural causes, always acting, and removes the difficulty said to exist, of assuming different sets of principles to be in action at different periods of the world; *fourthly*, that the great number of facts which have been observed, all pointing uniformly in one direction, cannot be got over by suggesting mere possibilities for explanations. The improbability is extreme of one set of animals having existed at the same age with another set, when we find certain strata having the traces of the former without any of the latter, and *vice versâ*. This improbability increases in proportion to the number of the species. If these exceed hundreds, and even amount to many thousands, the improbability becomes so great as to reach what, in common language, we term a moral impossibility. Now, there are 6000 kinds of fishes, of which not one specimen is to be found in any of the formations preceding the chalk. But suppose we lay out of view all question of one formation being older than another, there are certain strata in which none of those species are found. There is no disposition to deny that these strata were formed in the water; therefore, at whatever time they were suspended in the water, that water at that time contained none of those 6000 kinds which now people it. Then from whence did they all come if they existed at that period, and yet were not in the water when the strata were formed? But it is equally admitted that the water in those days contained many other kinds of fish now extinct, and found only in certain strata, and it contained some few which we find in other strata, and some which are still to be found in the sea. Can anything be more gratuitous than to suppose that all the fishes of a certain class were destroyed at the formation of those strata, while all those of another class were afterwards brought from a different part of the sea to succeed the last ones, and a certain small number survived to mix with other strata, or even to last till now?

The only sound objection that can be taken to the theory, is that to which the absolute assertion of the fact is liable. We can easily ascertain that certain species are no longer to be found living on the globe. But we may not be so well able to affirm with certainty that certain fossil genera of one formation may not hereafter be found in another, or, which is the same fact in another form, that certain living species may not be traced among fossil remains. Thus the small family of the camel was wanting in all our fossil collections till the late discoveries in the Himalaya mountains have made it probable that a species of this class may be found to have existed there with the mastodon and other extinct mammalia. This is possible, perhaps likely. So an ape's jaw is supposed for the first time to have been found in a fossil bed in France with other races, and no quadrumane had ever been before traced in any part of the fossil world. The proof of this discovery is, however, as yet involved in some doubt, and even were it more precise, we should only have two instances in which the negative evidence had failed, leaving a multitude of others, hundreds of land and thousands of sea animals, of which no representatives are to be traced among the fossil remains of any country. It must always be recollected that the whole argument rests upon probability, more or less high. Even as regards the admitted non-existence of the human species, the mere evidence of osteological researches is not demonstrative; for although it is quite certain that among the thousands of animal remains which have been discovered and carefully examined, not a fragment of a human bone is to be found, it is barely possible that in some deposits as yet unexplored the skeleton of a man may be discovered. We have at present only to make our inference square with the facts; to affirm that, as far as our knowledge extends, there is no such relic of our race in the earlier strata of the globe; and to conclude that, considering the extent of past inquiries, the regularity of the connexion between other races of different kinds and various strata, and the portions of the earth over which our researches have been carried the very strong presumption is against any such contradictory discovery being hereafter made.

III. Whatever opinion men may form upon the question raised by some antagonists of Cuvier's geological doctrines, all must allow that considerable light has been thrown upon the subject of discussion by their labours. Indeed a considerable addition to our knowledge has been made by some of these able and learned men, even admitting that they have failed to impugn the theory, and taking the facts which they have ascertained as forming an addition, by no means inconsistent with it. Thus the valuable work of Mr. Lyell has, in two essential respects, greatly advanced geological knowledge. He has examined, with a much more minute attention than had ever before been given to the subject, the action of the physical agents actually at work before our eyes, and has shown how extensively these may operate upon the structure of the earth's surface. It may be admitted, perhaps, that Cuvier had somewhat underrated their power, although the reader may still retain his opinion, that the force ascribed from the facts to those ordinary physical powers is inadequate to produce the effects which the phenomena present; that all the violent and sudden actions known on the globe are topical, being confined within comparatively narrow limits, and that the supposition of sudden and even instantaneous change on a vast scale in former periods has been too lightly taken up. Indeed, unless we suppose such changes as might happen from the disruption of a continent united by a small neck of land, like that which may be found once to have joined Gibraltar and Ceuta, it seems hard to imagine how a tract of country, extending from Holland to beyond the Caspian, and from Scandinavia to the Carpathian mountains, could be drained of the sea, which certainly once covered it, or, having still more anciently been dry, could have been laid under water.*

But a much more important service has been rendered by Mr. Lyell's comparison between the different formations of the tertiary class; and although it is with unavoidable distrust of himself that any one little versed in geological science should venture to speak, it should seem that the division which he has thus succeeded in tracing of the tertiary period, may stand well with the previous system of Cuvier, and be received as a fact independent of the controverted matter with which it has been connected. With the important aid of several eminent conchologists, but especially of Mr. Deshayes, he examined the numbers of testaceous animals traced in different formations; and finding that in some strata the proportion of shells of living species was very different from others, he distributed the strata of this tertiary period into three classes accordingly; the earliest being those which contained the fewest of our living species. The latest of the three periods into which he thus subdivides the tertiary era he calls *pliocene*,† or more recent; the next before *miocene*,‡ or less recent; the earliest *eocene*,‖ or dawning. Seventeen species of shells are common to the three divisions, of which

* In Mr. Whewell's learned work on the History of the Inductive Sciences, there are some acute and important remarks on the two theories, that of Uniform Action, and that of Catastrophes. B. xviii. c. 8.

† Πλειων, more, and Καινος, recent.

‡ Μειων, less. ‖ Ηως, dawn.

thirteen still exist and four are extinct. In the pliocene the proportion of existing shells always exceeds one-third, and usually approaches one-half of the whole found. In the miocene, the existing shells fall considerably short of one-half, that is, the extinct species preponderate; indeed, of 1021 examined, less than a fifth were existing. There are 196 common to this and the last period, of which 82 are extinct. In the eocene period, the proportion of existing shells is much smaller, not exceeding three and a half per cent.; and there are only 42 common to this and the miocene. In the Paris Basin 1122 species have been found, of which only 38 are now known as living.

The theory of Cuvier and Brongnart respecting the successive formations in the Paris Basin, appears to require some modification in consequence of more recent examination. They considered that upon the chalk there was laid, first a fresh-water formation of clay, lignite, and sandstone; then a marine formation of coarse limestone; and then upon that a second fresh-water formation of silicious limestone, gypsum, and marl. The researches of Mr. Constant Prevost seem to show that instead of these three successive formations, there were laid on the chalk a clay formation of fresh-water origin, and then upon that, contemporaneously, three others, in different parts of the same Basin, namely, a fresh-water formation of silicious limestone, another of gypsum, and a marine formation of coarse limestone. In the rest of the series the two theories coincide.

It must, however, be observed that the more im portant doctrines of Fossil Osteology, even as regards their connexion with the history and structure of the globe, do not necessarily depend upon the opinions which may be entertained of the more controverted points of geological theory, while the science of comparative anatomy exists alone, self-contained and independent of geology. But all must agree in admitting the important service which Osteology has rendered to geological inquiries, and in rejoicing at the influence which it has had upon those who pursue such speculations, in promoting a more careful study of facts, and recommending a wise postponement of theoretical reasoning, until the season arrives when a sufficient foundation for induction shall have been laid by the patient observer.

NOTES ON THE FOSSIL OSTEOLOGY.

NOTE I.

As some learned men are satisfied with the proofs of an ape's jaw-bone having been found at Sansan, in the south-west of France, and an astragalus of the same genus in the Sivalik hills, it is very possible that this genus may be added to those found in the strata of the Miocene period; for it is only in the more recent formations that these remains are supposed to exist. That they should be found in any of the Pliocene formations is in a high degree improbable; and even then we have only got to the middle of the Tertiary period. No one contends that in the earlier formations any such remains are to be traced.

But in case any objection should be raised to the argument in the text, upon the supposition that, because quadrumanous animals were supposed by Cuvier not to be traceable in any but the present portions of the globe's crust, therefore human remains may likewise hereafter be found in earlier formations, we may remark that, even if they were, contrary to every probability, there found, no one pretends to expect such remains in those strata where no mammalia of any kind have been discovered; and the argument in the text is wholly independent of the particular period at which the non-existence of our race is admitted. These considerations are fit to be borne in mind, since learned men, like Mr. Schmerling, are inclined to think that some human bones found in the same caves with the remains of hyænas and other animals, are of contemporaneous origin. The great majority of geologists, however, refer the animals in question to the last geological era before the creation of man.

NOTE II.

The state of rapid and solid advancement in which the science of Palæontology now is, may make the summary of its doctrines in any one year little applicable to the next. The notes to the Analysis of Cuvier, and the subsequent account of the labours of his successors, may serve to show what inhabitants of the former surface of the earth are at present within our knowledge. But with respect to the two important classes of ichthyosaurus and plesiosaurus, the following abstract will prove convenient to the student who would compare the present state of our information upon these two fossil genera at present with what it was when Cuvier wrote. Nothing can better exhibit the rate, as it were, at which this science has been advancing. I am indebted to my learned, able, and excellent friend, Mr. Greenough, for this summary, which will be found to be marked with the accuracy, the clearness, and the conciseness which distinguish all his productions:—

ICHTHYOSAURUS.

1. Communis .... Cuvier, vol. ii. Lias—England and Wurtemberg.
2. Coniformis.... (See Journal of Acad. of Philadelphia.) Not known to Cuvier. Lias—Bath.
3. Grandipes..... (Geol. Proc., 1830.) Not known to Cuvier.
4. Intermedius... Lias—England and Wurtemberg.
5. Platyodon .... Lias—England and Wurtemberg.
6. Tenuirostris... Lias—England and Wurtemberg.
7. Ichthyosaurus . Kimmeridge clay.
8. Ichthyosaurus . Muschelkalk—Luneville and Mannsfield.

PLESIOSAURUS.

1. Goldfussii..... Quarries of Solenhofen. Not known to Cuvier.

2. Carinatus ..... Lias—England and Boulogne.
3. Dolichodeirus.. Muschelkalk — Germany ; and lias—England.
4. Pentagonus .... Jura beds—France.
5. Profundus ..... Variegated sandstone—Jura. Not known to Cuvier.
6. Recentior...... Kimmeridge clay.
7. Trigonus ...... Calvados—north of France.
8. Trigonus ...... Cuvier, vol. ii. p. 486. Lias, probably.

GENERAL NOTE RESPECTING EVIDENCES OF DESIGN.

All the inquiries in which we have been engaged lead to one conclusion of great importance. Notwithstanding the progress which has been made in various sciences, the things which have been discovered and ascertained bear an infinitely small proportion to those of which we are still either wholly ignorant, or imperfectly and dubiously informed. In a vast variety of instances, design and intelligence have been traced—instances so well deserving to be called innumerable, that we are entitled to believe in contrivance as the universally prevailing rule, and we never hesitate so to conclude. But the mode and manner of the working is still, in a prodigious number of cases, concealed from us; and we are entitled to infer that numberless things which now seem irregular, that is arranged according to no fixed rule, are nevertheless really disposed in an order which we have not discovered, which would, if we knew all, be as complete as that observed and traced in the cases known to us. Thus the regular working of bees, which we have been examining, is reducible to certain known rules; the figures formed by them are, in all their relations, familiar to mathematicians. The problems of maxima and minima, on the solution of which those operations proceed, may have parallels in the case of other animals; it is not at all improbable that the beaver forms his dike for protection against the water upon some such principle, namely, of the form which is better than any other conceivable form calculated to oppose a solid resistance to the pressure of water.* It appears probable that the works of spiders in concentric circles, and along their radii, are also regularly arranged in known figures, and upon similar principles. Many of the parts of plants wear the semblance of regular and symmetrical curve lines, insomuch that a mathematician once presented a paper to the Royal Society (on some propositions in the higher geometry), which he entitled, from the form of the lines investigated, "*Fasciculus Florum Geometricorum.*" The orbits in which the heavenly bodies move, come manifestly within the same remark still more certainly; for the forms of those paths, the relation of all their points to given straight lines, is in a great degree ascertained. But it seems very reasonable to conclude, that the small number of such regular figures which the state of science in its various branches has as yet enabled us to trace, is as nothing compared with those figures still so unknown to us, that in common speech we talk of them as irregular, while this is only a word, like chance, implying our own ignorance.

For the mathematical sciences, extraordinary as the progress already made may be reckoned, with regard to the difficulty of the subject, and the imperfect faculties

* The base of the dike being 12, the top 3 feet thick, and the height 6 feet, the face is the side of a right angled triangle, whose height is 8 feet; and if the materials were lighter than water in the proportion of 44 : 100, this construction would be the best one conceivable to prevent the dam from turning round. But the form flatter than that which would best serve this purpose when the materials are heavier than water, is probably taken to prevent the dam from being shoved forward.

of man, are most probably still in their infancy. Of the infinite variety of curve lines, we know but a very few with any particularity, to say nothing of our equal ignorance (connected with the former) of most of the laws of complex motion. In the parts of animal and vegetable bodies, especially of the larger kind, there are few symmetrical forms observed; greater convenience, in the former instance at least, is evidently attained by other shapes. Yet there seems no reason to doubt that all the forms which we see may be in reality perfectly regular, that is, that each outline is a curve, or portion of a curve, related to some axis, so that each of its parts shall bear the same relation to lines similarly drawn from it to this axis, which all its other points do. If we know little of algebraical curves, we know still less of those whose structure is not expressible by the relations of straight lines and numbers, the class called mechanical or transcendental, the forms of some of which are very extraordinary, but all whose points are related together by the same law. There is every reason to expect that the further progress of science will unfold to us much more of the principles upon which the forms of matter, both organic and inorganic, are disposed, so that the order pervading the system may be far more clearly perceived.

So of motion—In one most important branch, dynamics is still in its infancy; we know little or nothing of the minute motions by which the particles of matter are arranged, when bodies act chemically on each other. Even respecting the motions of fluids so much studied as electricity, and heat (if it be a fluid), and the operation of the magnetic influence, science is so imperfect, and our data from observation so scanty, that mathematical reasoning has as yet hardly ever been applied to the subject. It is the hope of men who reflect on these things, and it is probably the expectation of those who most deeply meditate upon them, that, in future times, a retrospect upon the fabric of our present knowledge, shall be the source of wonder and compassion—wonder at the advances made from such small beginnings—compassion for the narrow sphere within which our knowledge is confined:—and when the greater part of what we are now only able to believe regular and systematic from analogy and conjecture, will have fallen into an order and an arrangement certainly known and distinctly perceived.

THE END.

London:—Printed by W. Clowes and Sons, Stamford Street.

TWO DISCOURSES

OF THE

OBJECTS,

PLEASURES, AND ADVANTAGES,

I. OF SCIENCE:

II. OF POLITICAL SCIENCE.

BY

HENRY LORD BROUGHAM, F.R.S.

AND MEMBER OF THE NATIONAL INSTITUTE OF FRANCE.

LONDON:
CHARLES KNIGHT & CO., LUDGATE STREET.

1846.

London: Printed by W. Clowes and Sons, Stamford Street.

ADVERTISEMENT.

The Discourse of the 'Objects, Pleasures, and Advantages of Science,' was originally published as the Introductory Treatise to the 'Library of Useful Knowledge.' It was the first step in that remarkable advance in the Instruction of the People, by the means of cheap books, which was commenced by the Society for the Diffusion of Useful Knowledge nearly twenty years ago. The Discourse of the 'Objects, Pleasures, and Advantages of Political Knowledge' was published at a later period as the Introductory Treatise to Lord Brougham's 'Political Philosophy.' Both Discourses are reprinted in this Volume by permission of the noble author, under an arrangement with the Society for the Diffusion of Useful Knowledge as to the Copyright of each.

OBJECTS,

ADVANTAGES, AND PLEASURES

OF

SCIENCE.

INTRODUCTION.

In order fully to understand the advantages and the pleasures which are derived from an acquaintance with any Science, it is necessary to become acquainted with that Science; and it would therefore be impossible to convey a complete knowledge of the benefits conferred by a study of the various Sciences which have hitherto been cultivated by philosophers, without teaching all the branches of them. But a very distinct idea may be given of those benefits, by explaining the nature and objects of the different Sciences: it may be shown, by examples, how much use and gratification there is in learning a part of any one branch of knowledge; and it may thence be inferred, how great reason there is to learn the whole.

It may easily be demonstrated, that there is an advantage in learning, both for the usefulness and the pleasure of it. There is something positively agreeable to all men, to all at least whose nature is not most grovelling and base, in gaining knowledge for its own sake. When you see anything for the first time, you at once derive some gratification from the sight being new; your attention is awakened, and you desire to know more about it. If it is a piece of workmanship, as an instrument, a machine of any kind, you wish to know how it is made; how it works; and what use it is of. If it is an animal, you desire to know where it comes from; how it lives; what are its dispositions, and, generally, its nature and habits. You feel this desire, too, without at all considering that the machine or the animal may ever be of the least use to yourself practically; for, in all probability, you may never see them again. But you have a curiosity to learn all about them, because they are new and unknown. You accordingly make inquiries; you feel a gratification in getting answers to your questions, that is, in receiving information, and in knowing more,—in being better informed than you were before. If you happen again to see the same instrument or animal, you find it agreeable to recollect having seen it formerly, and to think that you know something about it. If you see another instrument or animal, in some respects like, but differing in other particulars, you find it pleasing to compare them together, and to note in what they agree, and in what they differ. Now, all this kind of gratification is of a pure and disinterested nature, and has no reference to any of the common purposes of life; yet it is a pleasure—an enjoyment. You are nothing the richer for it; you do not gratify your palate or any other bodily appetite; and yet it is so pleasing, that you would give something out of your pocket to obtain it, and would forego some bodily enjoyment for its sake. The pleasure derived from Science is exactly of the like nature, or, rather, it is the very same. For what has just been spoken of is, in fact, Science, which in its most comprehensive sense only means *Knowledge*, and in its ordinary sense means *Knowledge reduced to a System;* that is, arranged in a regular order, so as to be conveniently taught, easily remembered, and readily applied.

The practical uses of any science or branch of knowledge are undoubtedly of the highest importance; and there is hardly any man who may not gain some positive advantage in his worldly wealth and comforts, by increasing his stock of information. But there is also a pleasure in seeing the uses to which knowledge may be applied, wholly independent of the share we ourselves may have in those practical benefits. It is pleasing to examine the nature of a new instrument, or the habits of an unknown animal, without considering whether or not they may ever be of use to ourselves or to any body. It is another gratification to extend our inquiries, and find that the instrument or animal is useful to man, even although we have no chance of ever benefiting by the information: as, to find that the natives of some distant country employ the animal in travelling;—nay, though we have no desire of benefiting by the knowledge; as for example, to find that the instrument is useful in performing some dangerous surgical operation. The mere gratification of curiosity; the knowing more to-day than we knew yesterday; the understanding clearly what before seemed obscure and puzzling; the contemplation of general truths, and the comparing together of different things,—is an agreeable occupation of the mind; and, beside the present enjoyment, elevates the faculties above low pursuits, purifies and refines the passions, and helps our reason to assuage their violence.

It is very true, that the fundamental lessons of philosophy may to many, at first sight, wear a forbidding aspect, because to comprehend them requires an effort of the mind somewhat, though certainly not much, greater than is wanted for understanding more ordinary matters; and the most important branches of philosophy, those which are of the most general application, are for that very reason the less easily followed, and the less entertaining when apprehended, presenting as they do few particulars or individual objects to the mind. In discoursing of them, moreover, no figures will be at present used to assist the imagination; the appeal is made to reason, without help from the senses. But be not, therefore, prejudiced against the doctrine, that the pleasure of learning the truths which philosophy unfolds is truly above all price. Lend but a patient attention to the principles explained, and giving us credit for stating nothing which has not some practical use belonging to it, or some important doctrine connected with it, you will soon perceive the value of the lessons you are learning, and begin to interest yourselves in comprehending and recollecting them; you will find that you have actually learnt something of science, while merely engaged in seeing what its end and purpose is; you will be enabled to calculate for yourselves, how far it is worth the trouble of acquiring, by examining samples of it; you will, as it were, taste a little, to try whether or not you relish it, and ought to seek after more; you will enable yourselves to go on, and enlarge your stock of it; and after having first mastered a very little, you will proceed so far as to look back with wonder at the distance you have reached beyond your earliest acquirements.

The Sciences may be divided into three great classes: those which relate to *Number and Quantity*—those which relate to *Matter*—and those which relate to *Mind*. The first are called the *Mathematics*, and teach the property of numbers and of figures; the second are called *Natural Philosophy*, and teach the properties of the various bodies which we are acquainted with by means of our senses; the third are called *Intellectual* or

Moral Philosophy, and teach the nature of the mind, of the existence of which we have the most perfect evidence in our own reflections; or, in other words, they teach the moral nature of man, both as an individual and as a member of society. Connected with all the sciences, and subservient to to them, though not one of their number, is *History*, or the record of facts relating to all kinds of knowledge.

I. MATHEMATICAL SCIENCE.

THE two great branches of the *Mathematics*, or the two mathematical sciences, are *Arithmetic*, the science of number, from the Greek word signifying *number*, and *Geometry*, the science of figure, from the Greek words signifying *measure of the earth*,—land-measuring having first turned men's attention to it.

When we say that 2 and 2 make 4, we state an arithmetical proposition, very simple indeed, but connected with many others of a more difficult and complicated kind. Thus, it is another proposition, somewhat less simple, but still very obvious, that 5 multiplied by 10, and divided by 2 is equal to, or makes the same number with, 100 divided by 4—both results being equal to 25. So, to find how many farthings there are in 1000*l.*, and how many minutes in a year, are questions of arithmetic which we learn to work by being taught the principles of the science one after another, or, as they are commonly called, the *rules* of addition, subtraction, multiplication, and division. Arithmetic may be said to be the most simple, though among the most useful of the sciences; but it teaches only the properties of particular and known numbers, and it only enables us to add, subtract, multiply, and divide those numbers. But suppose we wish to add, subtract, multiply, or divide numbers which we have not yet ascertained, and in all respects to deal with them as if they were known, for the purpose of arriving at certain conclusions respecting them, and, among other things, of discovering what they are; or, suppose we would examine properties belonging to all numbers; this must be performed by a peculiar kind of arithmetic, called ***Universal*** arithmetic, or ***Algebra***.* The common arithmetic, you will presently perceive, carries the seeds of this most important science in its bosom. Thus, suppose we inquire what is the number which multiplied by 5 makes 10? This is found if we divide 10 by 5,—it is 2: but suppose that, before finding this number 2, and before knowing what it is, we would add it, whatever it may turn

* Algebra, from the Arabic words signifying the *reduction of fractions*; the Arabs having brought the knowledge of it into Europe.

out, to some other number; this can only be done by putting some mark, such as a letter of the alphabet, to stand for the unknown number, and adding that letter as if it were a known number. Thus, suppose we want to find two numbers which, added together, make 9, and, multiplied by one another, make 20. There are many which, added together, make 9; as 1 and 8; 2 and 7; 3 and 6; and so on. We have, therefore, occasion to use the second condition, that multiplied by one another they should make 20, and to work upon this condition before we have discovered the particular numbers. We must, therefore, suppose the numbers to be found, and put letters for them, and by reasoning upon those letters, according to both the two conditions of adding and multiplying, we find what they must each of them be in figures, in order to fulfil or answer the conditions. Algebra teaches the rules for conducting this reasoning, and obtaining this result successfully; and by means of it we are enabled to find out numbers which are unknown, and of which we only know that they stand in certain relations to known numbers, or to one another. The instance now taken is an easy one; and you could, by considering the question a little, answer it readily enough; that is, by trying different numbers, and seeing which suited the conditions; for you plainly see that 5 and 4 are the two numbers sought; but you see this by no certain or general rule applicable to all cases, and therefore you could never work more difficult questions in the same way; and even questions of a moderate degree of difficulty would take an endless number of trials or guesses to answer. Thus a shepherd sold his flock for 80*l.*; and if he had sold four sheep more for the same money, he would have received one pound less for each sheep. To find out from this, how many the flock consisted of, is a very easy question in algebra, but would require a vast many guesses, and a long time to hit upon by common arithmetic:* And questions infinitely more difficult can easily be solved by the rules of algebra. In like manner, by arithmetic you can tell the properties of particular numbers; as, for instance, that the number 348 is divided by 3 exactly, so as to leave nothing over: but algebra teaches us that it is only one of an infinite variety of numbers, all divisible by 3, and any one of which you can tell the moment you see it; for they all have the remarkable property, that if you add together the figures they consist of, the sum total is divisible by 3. You can easily perceive this in any one case, as in the number mentioned, for 3 added to 4 and that to 8 make 15, which is plainly divisible by 3; and if you divide 348 by 3, you find the quotient to be 116, with nothing over. But this does not at all prove that

* It is 16.

any other number, the sum of whose figures is divisible by 3, will itself also be found divisible by 3, as 741; for you must actually perform the division here, and in every other case, before you can know that it leaves nothing over. Algebra, on the contrary, both enables you to discover such general properties, and to prove them in all their generality.*

By means of this science, and its various applications, the most extraordinary calculations may be performed. We shall give, as an example, the method of *Logarithms*, which proceeds upon this principle. Take a set of numbers going on by equal differences; that is to say, the third being as much greater than the second, as the second is greater than the first, and the common difference being the number you begin with; thus, 1, 2, 3, 4, 5, 6, and so on, in which the common difference is 1: then take another set of numbers,

* Another class of numbers divisible by 3 is discovered in like manner by algebra. Every number of 3 places, the figures (or digits) composing which are in arithmetical progression, (or rise above each other by equal differences,) is divisible by 3: as 123, 789, 357, 159, and so on. The same is true of numbers of any amount of places, provided they are composed of 3, 6, 9, &c., numbers rising above each other by equal differences, as 289, 299, 309, or 148, 214, 280, or 307142085345648276198756, which number of 24 places is divisible by 3, being composed of 6 numbers in a series whose common difference is 1137. This property, too, is only a particular case of a much more general one.

such that each is equal to twice or three times the one before it, or any number of times the one before it, but the common multiplier being the number you begin with: thus, 2, 4, 8, 16, 32, 64, 128; write this second set of numbers under the first, or side by side, so that the numbers shall stand opposite to one another, thus,

1	2	3	4	5	6	7
2	4	8	16	32	64	128

you will find, that if you add together any two of the upper or first set, and go to the number opposite their sum, in the lower or second set, you will have in this last set the number arising from multiplying together the numbers of the lower set corresponding or opposite to the numbers added together. Thus, add 2 to 4, you have 6 in the upper set, opposite to which in the lower set is 64, and multiplying the numbers 4 and 16 opposite to 2 and 4, the product is 64. In like manner, if you subtract one of the upper numbers from another, and opposite to their difference in the upper line, you look to the lower number, it is the quotient found from dividing one of the lower numbers by the other opposite the subtracted ones. Thus, take 4 from 6 and 2 remains, opposite to which you have in the lower line 4; and if you divide 64, the number opposite to 6, by 16, the number opposite to 4, the quotient is 4. The upper set are called the *logarithms*, of the lower set, which are called *natural numbers;* and tables may, with a little trouble, be constructed, giving the logarithms of all numbers from 1 to 10,000 and more: so that, instead of multiplying or dividing one number by another, you have only to add or subtract their logarithms, and then you at once find the product or the quotient in the tables. These are made applicable to numbers far higher than any actually in them, by a very simple process: so that you may at once perceive the prodigious saving of time and labour which is thus made. If you had, for instance, to multiply 7,543,283 by itself, and that product again by the original number, you would have to multiply a number of 7 places of figures by an equally large number, and then a number of 14 places of figures by one of 7 places, till at last you had a product of 21 places of figures—a very tedious operation; but, working by logarithms, you would only have to take three times the logarithm of the original number, and that gives the logarithm of the last product of 21 places of figures, without any further multiplication. So much for the time and trouble saved, which is still greater in questions of division; but by means of logarithms many questions can be worked, and of the most important kind, which no time or labour would otherwise enable us to resolve.

Geometry teaches the properties of figure, or particular portions of space, and distances of points from each other. Thus, when you see a triangle, or three-sided figure, one of whose sides is perpendicular to another side, you find, by means of geometrical reasoning respecting this kind of triangle, that if squares be drawn on its three sides, the large square upon the slanting side opposite the two perpendiculars, is exactly equal to the smaller squares upon the perpendiculars, taken together; and this is absolutely true, whatever be the size of the triangle, or the proportions of its sides to each other. Therefore, you can always find the length of any one of the three sides by knowing the lengths of the other two. Suppose one perpendicular side to be 3 feet long, the other 4, and you want to know the length of the third side opposite to the perpendicular; you have only to find a number such, that if, multiplied by itself, it shall be equal to 3 times 3, together with 4 times 4, that is 25.* (This number is 5.)

Now only observe the great advantage of knowing this property of the triangle, or of perpendicular lines. If you want to measure a line passing over ground which you cannot reach—to know,

* It is a property of numbers, that every number whatever, whose last place is either 5 or 0, is, when multiplied into itself, equal to two others which are square numbers, and divisible by 3 and 4 respectively:—thus, $45 \times 45 = 2025 = 729 + 1296$, the squares of 27 and 36; and $60 \times 60 = 3600 = 1296 + 2304$, the squares of 36 and 48.

for instance, the length of one side, covered with water, of a field, or the distance of one point on a lake or bay from another point on the opposite side—you can easily find it by measuring two lines perpendicular to one another on the dry land, and running through the two points; for the line wished to be measured, and which runs through the water, is the third side of a perpendicular-sided triangle, the other two sides of which are ascertained. But there are other properties of triangles, which enable us to know the length of two sides of any triangle, whether it has perpendicular sides or not, by measuring one side, and also measuring the inclinations of the other two sides to this side, or what is called the two *angles* made by those sides with the measured side. Therefore you can easily find the perpendicular line drawn, or supposed to be drawn, from the top of a mountain through it to the bottom, that is, the height of the mountain; for you can measure a line on level ground, and also the inclination of two lines, supposing them drawn in the air, and reaching from the two ends of the measured line to the mountain's top; and having thus found the length of the one of those lines next the mountain, and its inclination to the ground, you can at once find the perpendicular, though you cannot possibly get near it. In the same way, by measuring lines and angles on the ground, and near, you can find the length of lines at a great distance, and which you cannot approach: for instance, the length and breadth of a field on the opposite side of a lake or sea; the distance of two islands; or the space between the tops of two mountains.

Again, there are *curve-lined* figures as well as straight, and geometry teaches the properties of these also. The best known of all the curves is the *circle*, or a figure made by drawing a string round one end which is fixed, and marking where its other end traces, so that every part of the circle is equally distant from the fixed point or centre. From this fundamental property, an infinite variety of others follow by steps of reasoning more or less numerous, but all necessarily arising one out of another. To give an instance; it is proved by geometrical reasoning, that if from the two ends of any diameter of the circle you draw two lines to meet in any one point of the circle whatever, those lines are perpendicular to each other.

Another property, and a most useful one, is, that the sizes, or areas, of all circles whatever, from the greatest to the smallest, from the sun to a watch-dialplate, are in exact proportion to the squares of their distances from the centre; that is, the squares of the strings they are drawn with: so that if you draw a circle with a string 5 feet long, and another with a string 10 feet long, the large circle is four times the size of the small one, as far as the space or area inclosed is concerned; the square of 10 or 100 being four times the square of 5 or 25. But it is also true, that the lengths of the circumferences themselves, the number of feet over which the ends of the strings move, are in proportion to the lengths of the strings; so that the curve of the large circle is only twice the length of the curve of the lesser.

But the circle is only one of an infinite variety of curves, all having a regular formation and fixed properties. The *oval* or *ellipse* is, perhaps, next to the circle, the most familiar to us, although we more frequently see another curve, the line formed by the motion of bodies thrown forward. When you drop a stone, or throw it straight up, it goes in a straight line; when you throw it forward, it goes in a curve line till it reaches the ground; as you see by the figure in which water runs when forced out of a pump, or from a fire-pipe, or from the spout of a kettle or teapot. The line it moves in is called a *parabola;* every point of which bears a certain fixed relation to a certain point within it, as the circle does to its centre. Geometry teaches various properties of this curve: for example, if the direction in which the stone is thrown, or the bullet fired, or the water spouted, be half the perpendicular to the ground, that is, half way between being level with the ground and being upright, the curve will come to the ground at a greater distance than if any other direction whatever were given, with the same force. So that, to make the gun carry farthest, or the fire-pipe play to the greatest distance, they must be pointed, not, as you might suppose, level or point blank, but about half way between that direction and the perpendicular. If the air did not resist, and so somewhat disturb the calculation, the direction to give the longest range ought to be exactly half perpendicular.

The *oval*, or *ellipse*, is drawn by taking a string of any certain length, and fixing, not one end as in drawing the circle, but both ends to different points, and then carrying a point round inside the string, always keeping it stretched as far as possible. It is plain, that this figure is as regularly drawn as the circle, though it is very different from it; and you perceive that every point of its curve must be so placed, that the straight lines drawn from it to the two points where the string was fixed, are, when added together, always the same; for they make together the length of the string.

Among various properties belonging to this curve, in relation to the straight lines drawn within it, is one which gives rise to the construction of the *trammels*, or elliptic compasses, used for making figures and ornaments of this form; and also to the construction of lathes for turning oval frames, and the like.

If you wish at once to see these three curves, take a pointed sugar-loaf, and cut it any where clean through in a direction parallel to its base or bottom; the outline or edge of the loaf where it is cut will be a *circle.* If the cut is made so as to slant, and not be parallel to the base of the loaf, the outline is an *ellipse*, provided the cut goes quite through the sides of the loaf all round, or is in such a direction that it would pass through the sides of the loaf were they extended; but if it goes slanting and parallel to the line of the loaf's side, the outline is a *parabola;* and if you cut in any direction, not through the sides all round, but through the sides and base, and not parallel to the line of the side, being nearer the perpendicular, the outline will be another curve of which we have not yet spoken, but which is called an *hyperbola.* You will see another instance of it, if you take two plates of glass, and lay them on one another; then put their edge in water, holding them upright and pressing them together; the water, which, to make it more plain, you may colour with a few drops of ink or strong tea, rises to a certain height, and its outline is this curve; which, however much it may seem to differ in form from a circle or ellipse, is found by mathematicians to resemble them very closely in many of its most remarkable properties.

These are the curve lines best known and most frequently discussed; but there are an infinite number of others all related to straight lines and other curve lines by certain fixed rules: for example, the course which any point in the circumference of a circle, as a nail in the felly of a wheel rolling along, takes through the air, is a curve called the *cycloid*, which has many remarkable properties; and, among others, this, that it is, of all lines possible, the one in which any body, not falling perpendicularly, will descend from one point to another the most quickly. Another curve often seen is that in which a rope or chain hangs when supported at both ends: it is called the *Catenary*, from the Latin for chain; and in this form some arches are built. The form of a sail filled with wind is the same curve.

II. DIFFERENCE BETWEEN MATHEMATICAL AND PHYSICAL TRUTHS.

You perceive, if you reflect a little, that the science which we have been considering, in both its branches, has nothing to do with matter; that is to say, it does not at all depend upon the properties or even upon the existence of any bodies or substances whatever. The distance of one point or place from another is a straight line; and whatever is proved to be true respecting this line, as, for instance, its proportion to other lines of the same kind, and its inclination towards them, what we call the *angles* it makes with them, would be equally true whether there were anything in those places, at those two points, or not. So if you find the number of yards in a square field, by measuring one side, 100 yards, and then, multiplying that by itself, which makes the whole area 10,000 square yards, this is equally true whatever the field is, whether corn, or grass, or rock, or water; it is equally true if the solid part, the earth or water, be removed, for then it will be a field of air bounded by four walls or hedges; but suppose the walls or hedges were removed, and a mark only left at each corner, still it would be true that the space inclosed or bounded by the lines supposed to be drawn between the four marks, was 10,000 square yards in size. But the marks need not be there; you only want them while measuring one side: if they were gone, it would be equally true that the lines, supposed to be drawn from the places where the marks had been, inclose 10,000 square yards of air. But if there were no air, and consequently a mere void, or empty space, it would be equally true that this space is of the size you had found it to be by measuring the distance of one point from another, of one of the space's corners or angles from another, and then multiplying that distance by itself. In the same way it would be true, that, if the space were circular, its size, compared with another circular space of half its diameter, would be four times larger: of one-third its diameter nine times larger, and of one-fourth sixteen times, and so on always in proportion to the squares of the diameters; and that the length of the circumference, the number of feet or yards in the line round the surface, would be twice the length of a circle whose diameter was one half, thrice the circumference of one whose diameter was one-third, four times the circumference of one whose diameter was one-fourth, and so on, in the simple proportion of the diameters. Therefore, every property which is proved to belong to figures belongs to them without the smallest relation to bodies or matter of any kind, although we are accustomed only to see figures in connection with bodies; but all those properties would be equally true if no such thing as matter or bodies existed; and the same may be said of the properties of number, the other great branch of the mathematics. When we speak of twice two, and say it makes four, we affirm this without thinking of two horses, or two balls, or two trees; but we assert it concerning two of any thing and every thing equally. Nay, this branch of mathematics may be said to apply still more extensively than even the other; for it has no relation to space, which geometry has; and, therefore, it is applicable to cases where figure and size are wholly out of the question. Thus you can speak of two dreams, or two ideas, or two minds, and can calculate respecting them just as you would respecting so many bodies; and the properties you find belonging to numbers, will belong to those numbers when applied to things that have no outward or visible or perceivable existence, and cannot even be said to be in any particular place, just as much as the same numbers applied to actual bodies which may be seen and touched.

It is quite otherwise with the science which we are now going to consider, *Natural Philosophy*. This teaches the nature and properties of actually existing substances, their motions, their connections with each other, and their influence on one another. It is sometimes also called *Physics*, from the Greek word signifying *Nature*, though that word is more frequently, in common speech, confined to one particular branch of the science, that which treats of the bodily health.

We have mentioned one distinction between Mathematics and Natural Philosophy, that the former does not depend on the nature and existence of bodies, which the latter entirely does. Another distinction, and one closely connected with this, is, that the truths which Mathematics teach are *necessarily* such,—they are truths of themselves, and wholly independent of facts and experiments,—they depend only upon reasoning; and it is utterly impossible they should be otherwise than true. This is the case with all the properties which we find belong to numbers and to figures—2 and 2 must of *necessity*, and through all time, and in every place, be equal to 4: those numbers must *necessarily* be always divisible by 3, without leaving any remainder over, which have the sums of the figures they consist of divisible by 3; and circles must *necessarily*, and for ever and ever, be to one another in the exact proportion of the squares of their diameters. It cannot be otherwise; we cannot conceive it in our minds to be otherwise. No man can in his own mind suppose to himself that 2 and 2 should ever be more or less than 4; it would be an utter impossibility—a contradiction in the very ideas; and if stated in words, those words would have no sense. The other properties of number, though not so plain at first sight as this, are proved to be true by reasoning, every one step of which follows from the step immediately before, as a matter of course, and so clearly and unavoidably, that it cannot be supposed, or even imagined, to be otherwise; the mind has no means of fancying how it could be otherwise: the final conclusion, from all the steps of the reasoning or demonstration, as it is called, follows in the same way from the last of the steps, and is therefore just as evidently and necessarily true as the first step, which is always something self-evident; for instance, that 2 and 2 make 4, or that the whole is greater than any of its parts, but equal to all its parts put together. It is through this kind of reasoning, step by step, from the most plain and evident things, that we arrive at the knowledge of other things which seem at first not true, or at least not generally true; but when we do arrive at them, we perceive that they are just as true, and for the same reasons, as the first and most obvious matters; that their truth is absolute and necessary, and that it would be as absurd and self-contradictory to suppose they ever could, under any circumstances, be not true, as to suppose that 2 added to 2 could ever make 3, or 5, or 100, or anything but 4; or, which is the same thing, that 4 should ever be equal to 3, or 5, or 100, or anything but 4. To find out these reasonings, to pursue them to their consequences, and thereby to discover the truths which are not immediately evident, is what science teaches us: but when the truth is once discovered, it is as certain and plain by the reasoning, as the first truths themselves from which all the reasoning takes its rise, on which it all depends, and which require no proof, because they are self-evident at once, and must be assented to the instant they are understood.

But it is quite different with the truths which Natural Philosophy teaches. All these depend upon matter of fact; and that is learnt by observation and experiment, and never could be discovered by reasoning at all. If a man were shut up in a room with pen, ink, and paper, he might by thinking discover any of the truths in arithmetic, algebra, or geometry; it is possible at least; there would be nothing absolutely impossible in his discovering all that is now known of these sciences; and if his memory were as good as we are supposing his judgment and conception to be, he might discover it all without pen, ink, and paper, and in a dark room. But we cannot discover a single one of the fundamental properties of matter without observing what goes on around us, and trying experiments upon the nature and motion of bodies. Thus, the man whom we have supposed shut up, could not possibly find out beyond one or two of the very first properties of matter, and those only in a very few cases; so that he could not tell if these were general properties of all matter or not. He could tell that the objects he touched in the dark were hard and resisted his touch; that they were extended and were solid: that is, that they had three dimensions, length, breadth, and thickness. He might guess that other things existed besides those he felt, and that those other things resembled what he felt in these properties; but he could know nothing for certain, and could not even conjecture much beyond this very limited number of qualities. He must remain utterly ignorant of what really exists in nature, and of what properties matter in general has. These properties, therefore, we learn by experience; they are such as we know bodies to have; they happen to have them—they are so formed by Divine Providence as to have them—but they might have been otherwise formed; the great Author of Nature might have thought fit to make all bodies different in every respect. We see that a stone dropped from our hand falls to the ground; this is a fact which we can only know by experience; before observing it, we could not have guessed it, and it is quite *conceivable* that it should be otherwise: for instance, that when we remove our hand from the body it should stand still in the air; or fly upward, or go forward, or backward, or sideways; there is nothing at all absurd, contradictory, or inconceivable in any of these suppositions; there is nothing impossible in any of them, as there would be in supposing the stone equal to half of itself, or double of itself; or both falling down and rising upwards at once; or going to the right and to the left at one and the same time. Our only reason for not at once thinking it quite conceivable that the stone should stand still in the air, or fly upwards, is that we have never seen it do so, and have become accustomed to see it do otherwise. But for that, we should at once think it as natural that the stone should fly upwards or stand still, as that it should fall down. But no degree of reflection for any length of time could accustom us to think 2 and 2 equal to anything but 4, or to believe the whole of any thing equal to a part of itself.

After we have once, by observation or experiment, ascertained certain things to exist in fact, we may then reason upon them by means of the mathematics; that is, we may apply mathematics to our experimental philosophy, and then such reasoning becomes absolutely certain, taking the fundamental facts for granted. Thus, if we find that a stone falls in one direction when dropped, and we further observe the peculiar way in which it falls, that is, quicker and quicker every instant till it reaches the ground, we learn the rule or the proportion by which the quickness goes on increasing; and we further find, that if the same stone is pushed forward on a table, it moves in the direction of the push, till it is either stopped by something, or comes to a pause by rubbing against the table and being hindered by the air. These are facts which we learn by observing and trying, and they might all have been different if matter and motion had been otherwise constituted; but supposing them to be as they are, and as we find them, we can, by reasoning mathematically from them, find out many most curious and important truths depending upon those facts, and depending upon them not accidentally, but of necessity. For example, we can find in what course the stone will move, if, instead of being dropped to the ground, it is thrown forward: it will go in the curve already mentioned, the parabola, somewhat altered by the resistance of the air, and it will run through that curve in a peculiar way, so that there will always be a certain proportion between the time it takes and the space it moves through, and the time it would have taken, and the space it would have moved through, had it dropped from the hand in a straight line to the ground. So we can prove, in like manner, what we before stated of the relation between the distance at which it will come to the ground, and the direction it is thrown in; the distance being greatest of all when the direction is half way between the level or horizontal and the upright or perpendicular. These are mathematical truths, derived by mathematical reasoning upon physical grounds ; that is, upon matter of fact found to exist by actual observation and experiment. The result, therefore, is necessarily true, and proved to be so by reasoning only, provided we have once ascertained the facts; but taken altogether, the result depends partly on the facts learned by experiment or experience, partly on the reasoning from these facts. Thus it is found to be true by reasoning, and necessarily true, that *if* the stone falls in a certain way when unsupported, it must, when thrown forward, go in the curve called a parabola, provided there be no air to resist: this is a necessary or mathematical truth, and it cannot possibly be otherwise. But when we state the matter without any supposition,—without any "*if*," —and say, a stone thrown forward goes in a curve called a parabola, we state a truth, partly fact, and partly drawn from reasoning on the fact; and it might be otherwise if the nature of things were different. It is called a proposition or truth in Natural Philosophy; and as it is discovered and proved by mathematical reasoning upon facts in nature, it is sometimes called a proposition or truth in the *Mixed Mathematics*, so named in contradistinction to the *Pure Mathematics*, which are employed in reasoning upon figures and numbers. The man in the dark room could never discover this truth unless he had been first informed, by those who had observed the fact, in what way the stone falls when unsupported, and moves along the table when pushed. These things he never could have found out by reasoning: they are facts, and he could only reason from them after learning them by his own experience, or taking them on the credit of other people's experience. But having once so learnt them, he could discover by reasoning merely, and with as much certainty as if he lived in daylight, and saw and felt the moving body, that the motion is a parabola, and governed by certain rules. As experiment and observation are the great sources of our knowledge of Nature, and as the judicious and careful making of experiments is the only way by which her secrets can be known, Natural and Experimental Philosophy mean one and the same thing; mathematical reasoning being applied to certain branches of it, particularly those which relate to motion and pressure.

III. NATURAL OR EXPERIMENTAL SCIENCE.

NATURAL PHILOSOPHY, in its most extensive sense, has for its province the investigation of the laws of matter; that is, the properties and the motions of matter; and it may be divided into two great branches. The first and most important (which is sometimes, on that account, called *Natural Philosophy* by way of distinction, but more properly *Mechanical Philosophy*) investigates the sensible motions of bodies. The second investigates the constitution and qualities of all bodies, and has various names, according to its different objects. It is called *Chemistry*, if it teaches the properties of bodies with respect to heat, mixture with one another, weight, taste, appearance, and so forth; *Anatomy* and *Animal*

Physiology, (from the Greek word signifying *to speak of the nature* of any thing,) if it teaches the structure and functions of living bodies, especially the human; for, when it shows those of other animals, we term it *Comparative Anatomy; Medicine*, if it teaches the nature of diseases, and the means of preventing them and of restoring health; *Zoology*, (from the Greek words signifying *to speak of animals*,) if it teaches the arrangement or classification and the habits of the different lower animals; *Botany*, (from the Greek word for *herbage*,) including *Vegetable Physiology*, if it teaches the arrangement or classification, the structure and habits of plants; *Mineralogy*, including *Geology*, (from the Greek words meaning *to speak of the earth*,) if it teaches the arrangement of minerals, the structure of the masses in which they are found, and of the earth composed of those masses. The term *Natural History* is given to the three last branches taken together, but chiefly as far as they teach the classification of different things, or the observation of the resemblances and differences of the various animals, plants, and inanimate and ungrowing substances in nature.

But here we may make two general observations. The *first* is, that every such distribution of the sciences is necessarily imperfect; for one runs unavoidably into another. Thus, Chemistry shows the qualities of plants with relation to other substances, and to each other; and Botany does not overlook those same qualities, though its chief object be arrangement. So Mineralogy, though principally conversant with classifying metals and earths, yet regards also their qualities in respect of heat and mixture. So, too, Zoology, beside arranging animals, describes their structures, like Comparative Anatomy. In truth, all arrangement and classifying depends upon noting the things in which the objects agree and differ; and among those things, in which animals, plants, and minerals agree, or differ, must be considered the anatomical qualities of the one and the chemical qualities of the other. From hence, in a great measure, follows the *second* observation, namely, that the sciences mutually assist each other. We have seen how Arithmetic and Algebra aid Geometry, and how both the purely Mathematical Sciences aid Mechanical Philosophy. Mechanical Philosophy, in like manner, assists, though, in the present state of our knowledge, not very considerably, both Chemistry and Anatomy, especially the latter; and Chemistry very greatly assists both Physiology, Medicine, and all the branches of Natural History.

The first great head, then, of Natural Science, is Mechanical Philosophy; and it consists of various subdivisions, each forming a science of great importance. The most essential of these, and which is indeed fundamental, and applicable to all the rest, is called *Dynamics*, from the Greek word signifying *power* or *force*, and it teaches the laws of motion in all its varieties. The case of the stone thrown forward, which we have already mentioned more than once, is an example. Another, of a more general nature, but more difficult to trace, far more important in its consequences, and of which, indeed, the former is only one particular case, relates to the motions of all bodies, which are attracted (or influenced, or drawn) by any power towards a certain point, while they are, at the same time, driven forward, by some push given to them at first, and forcing them onwards, at the same time that they are drawn towards the point. The line in which a body moves while so drawn and so driven, depends upon the force it is pushed with, the direction it is pushed in, and the kind of power that draws it towards the point; but at present, we are chiefly to regard the latter circumstance, the attraction towards the point. If this attraction be uniform, that is, the same at all distances from the point, the body will move in a circle, if one direction be given to the forward push. The case with which we are best acquainted is when the force decreases as the squares of the distances, from the centre or point of attraction, increase; that is, when the force is four times less at twice the distance, nine times less at thrice the distance, sixteen times less at four times the distance, and so on. A force of this kind acting on the body, will make it move in an oval, a parabola, or an hyperbola, according to the amount or direction of the impulse, or forward push, originally given; and there is one proportion of that force, which, if directed perpendicularly to the line in which the central force draws the body, will make it move round in a circle, as if it were a stone tied to a string and whirled round the hand. The most usual proportions in nature, are those which determine bodies to move in an oval or ellipse, the curve described by means of a cord fixed at both ends, in the way already explained. In this case, the point of attraction, the point towards which the body is drawn, will be nearer one end of the ellipse than the other, and the time the body will take to go round, compared with the time any other body would take, moving at a different distance from the same point of attraction, but drawn towards that point with a force which bears the same proportion to the distance, will bear a certain proportion, discovered by mathematicians, to the average distances of the two bodies from the point of common attraction. If you multiply the numbers expressing the times of going round, each by itself, the products will be to one another in the proportion of the average distances multiplied each by itself, and that product again by the distance. Thus, if one body take two hours, and is five yards distant, the other, being ten yards off, will take something less than five hours and forty minutes.*

Now, this is one of the most important truths in the whole compass of science; for it does so happen, that the force with which bodies fall towards the earth, or what is called their *gravity*, the power that draws or attracts them towards the earth, varies with the distance from the Earth's centre, exactly in the proportion of the squares, lessening as the distance increases: at two diameters from the Earth's centre, it is four times less than at one; at three diameters, nine times less; and so forth. It goes on lessening, but never is destroyed, even at the greatest distances to which we can reach by our observations, and there can be no doubt of its extending indefinitely beyond. But, by astronomical observations made upon the motion of the heavenly bodies, upon that of the Moon for instance, it is proved that her movement is slower and quicker at different parts of her course, in the same manner as a body's motion on the earth would be slower and quicker, according to its distance from the point it was drawn towards,

* This is expressed mathematically by saying, that the squares of the times are as the cubes of the distances. Mathematical language is not only the simplest and most easily understood of any, but the shortest also.

provided it was drawn by a force acting in the proportion to the squares of the distance, which we have frequently mentioned; and the proportion of the time to the distance is also observed to agree with the rule above referred to. Therefore, she is shown to be attracted towards the Earth by a force that varies according to the same proportion in which gravity varies; and she must consequently move in an ellipse round the Earth, which is placed in a point nearer the one end than the other of that curve. In like manner, it is shown that the Earth moves round the Sun in the same curve line, and is drawn towards the sun by a similar force; and that all the other planets in their courses, at various distances, follow the same rule, moving in ellipses, and drawn towards the Sun by the same kind of power. Three of them have moons like the Earth, only more numerous, for Jupiter has four, Saturn seven, and Herschel six, so very distant, that we cannot see them without the help of glasses; but all those moons move round their principal planets, as ours does round the Earth, in ovals or ellipses; while the planets, with their moons, move in their ovals round the Sun, like our own Earth with its moon.

But this power, which draws them all towards the sun, and regulates their path and their motion round him, and which draws the moons towards the principal planets, and regulates their motion and path round those planets, is the same with the gravity by which bodies fall towards the earth, being attracted by it. Therefore, the whole of the heavenly bodies are kept in their places, and wheel round the sun, by the same influence or power that makes a stone fall to the ground.

It is usual to call the sun, and the planets which with their moons move round him (eleven in number, including the four lately discovered, and the one discovered by Herschel), the *Solar System*, because they are a class of the heavenly bodies far apart from the innumerable fixed stars, and so near each other as to exert a perceptible influence on one another, and thus to be connected together.

The *Comets* belong to the same system, according to this manner of viewing the subject. They are bodies which move in elliptical paths, but far longer and narrower than the curves in which the earth and the other planets and their moons roll. Our curves are not much less round than circles; the paths of the comets are long and narrow, so as, in many places, to be more nearly straight lines than circles. They differ from the planets and their moons in another respect; they do not depend on the sun for the light they give, as our moon plainly does, being dark when the earth comes between her and the sun; and as the other planets do, those of them that are nearer the sun than we are, being dark when they come between us and him, appearing to pass across his surface. But the comets give light always of themselves, being apparently vast bodies heated red-hot by coming in their course far nearer the sun than the nearest of the planets ever do. Their motion, when near the sun, is much more rapid than that of the planets; they both approach him much nearer, retreat from him to much greater distances, and take much longer time in going round him than any of the planets do. Yet even these comets are subject to the same great law of gravitation which regulates the motions of the planets. Their year, the time they take to revolve, is in some cases 75, in others 135, in others 300 of our years; their distance is a hundred times our distance when farthest off, and not a hundred and sixtieth of our distance when nearest the sun; their swiftest motion is above twelve times swifter than ours, although ours is a hundred and forty times swifter than a cannon ball's; yet their path is a curve of the same kind with ours, though longer and flatter, differing in its formation only as one oval differs from another by the string you draw it with having the ends fixed at two points more distant from each other: consequently the sun, being in one of those points, is much nearer the end of the path the comet moves in, than he is near the end of our path. Their motion, too, follows the same rule, being swifter the nearer the sun: the attraction of the sun for them varies according to the squares of the distances, being four times less at twice the distance, nine times less at thrice, and so on; and the proportion between the times of revolving and the distances is exactly the same, in the case of those remote bodies, as in that of the moon and the earth. One law prevails over all, and regulates their motions as well as our own; it is the gravity of the comets towards the sun, and they, like our own earth and moon, wheel round him in boundless space, drawn by the same force, acting by the same rule, which makes a stone fall when dropped from the hand.

The more full and accurate our observations are upon those heavenly bodies, the better we find all their motions agreeing with this great doctrine; although, no doubt, many things are to be taken into the account besides the force that draws them to the different centres. Thus, while the moon is drawn by the earth, and the earth by the sun, the moon is also drawn directly by the sun; and while Jupiter is drawn by the sun, so are his moons; and both Jupiter and his moons are drawn by Saturn: nay, as this power of gravitation is quite universal, and as no body can attract or draw another without being itself drawn by that other, the earth is drawn by the moon, while the moon is drawn by the earth; and the sun is attracted by the planets which he draws towards himself. These mutual attractions give rise to many deviations from the simple line of the ellipse, and produce many irregularities in the simple calculation of the times and motions of the bodies that compose the system of the universe. But the extraordinary powers of investigation applied to the subject by the modern improvements in mathematics, have enabled us at length to reduce even the greatest of the irregularities to order and system; and to unfold one of the most wonderful truths in all sciences, namely, that by certain necessary consequence of the simple fact upon which the whole fabric rests, the proportion of the attractive force to the distances at which it operates,—all the irregularities which at first seemed to disturb the order of the system, and to make the appearances depart from the doctrine, are themselves subject to a certain fixed rule, and can never go beyond a particular point, but must begin to lessen when they have slowly reached that point, and must then lessen until they reach another point, when they begin again to increase; and so on, for ever. Nay, so perfect is the arrangement of the whole system, and so accurately does it depend upon mathematical principles, that irregularities, or rather apparent deviations, have been discovered by mathematical reasoning before astronomers had observed them, and then their existence has been ascertained by observation, and found to agree precisely with the results of calculation.* Thus, the planets move in ovals, from gravity, the power that attracts them towards the sun, combined with the original impulse they received forwards; and the disturbing forces are continually varying the course of the curves or ovals, making them bulge out in the middle, as it were, on the sides, though in a very small proportion to the whole length of the ellipse. The oval thus bulging, its breadth increases by a very small quantity yearly and daily; and after a certain large number of years, the bulging becomes as great as it ever can be: then the alteration takes a contrary direction, and the curve gradually flattens as it had bulged; till, in the same number of years which it took to bulge,

* The application of mathematics to chemistry has already produced a great change in that science, and is calculated to produce still greater improvements. It may be almost certainly reckoned upon as the source of new discoveries, made by induction after the mathematical reasoning has given the suggestion. The learned reader will perceive that we allude to the beautiful doctrine of *Definite* or *Multiple Proportions.* To take an example; the probability of an oxide of arsenic being discovered is impressed upon us, by the composition of arsenious and arsenic acids, in which the oxygen is as 2 to 3; and therefore we may expect to find a compound of the same base, with the oxygen as unity. The extraordinary action of chlorine and its compounds on light leads us to expect some further discovery respecting its composition, perhaps respecting the matter of light.

it becomes as flat as it ever can be, and then it begins to bulge again, and so on for ever. And so, too, of every other disturbance and irregularity in the system: what at first appears to be some departure from the rule, when more fully examined, turns out to be only a consequence of it, or the result of a more general arrangement springing from the principle of gravitation; an arrangement of which the rule itself, and the apparent or supposed exception, both form parts.

The power of gravitation, which thus regulates the whole system of the universe, is found to rule each member or branch of it separately. Thus, it is demonstrated that the tides of the ocean are caused by the gravitation which attracts the water towards the sun and moon; and the figure both of our earth and of such of the other bodies as have a spinning motion round their axis, is determined by gravitation combined with that motion: they are all flattened towards the ends of the axis they spin upon, and bulge out towards the middle.

The great discoverer of the principle on which all these truths rest, Sir Isaac Newton, certainly by far the most extraordinary man that ever lived, concluded by reasoning upon the nature of motion and matter, that this flattening must take place in our globe; every one before his time had believed the earth to be a perfect sphere or globe, chiefly from observing the round shadow which it casts on the moon in eclipses; and it was many years after his death that the accuracy of his opinion was proved by measurements on the earth's surface, and by the different weight and attraction of bodies at the equator, where it bulges, and at the poles, where it is flattened. The improvement of telescopes has enabled us to ascertain the same fact with respect to the planets Jupiter and Saturn.

Besides unfolding the general laws which regulate the motions and figures of the heavenly bodies forming our Solar System, Astronomy consists in calculations of the places, times, and eclipses of those bodies, and their moons or *satellites* (from a Latin word signifying an *attendant*), and in observations of the Fixed Stars, which are innumerable assemblages of bodies, not moving round the Sun as our Earth and the other planets do, nor receiving the light they shine with from his light; but shining, as the Sun and the Comets do, with a light of their own, and placed, to all appearance, immoveable, at immense distances from our world, that is, from our Solar System. Each of them is probably the sun of some other system like our own, composed of planets and their moons or satellites; but so extremely distant from us, that they all are seen by us like one point of faint light, as you see two lamps placed a few inches asunder, only like one, when you view them a great way off. The number of the Fixed Stars is prodigious: even to the naked eye they are very numerous, about 3000 being thus visible; but when the heavens are viewed through the telescope, stars become visible in numbers wholly incalculable: 2000 are discovered in one of the small collections of a few visible stars called *Constellations;* nay, what appears to the naked eye only a light cloud, as the *Milky Way*, when viewed through the telescope, proves to be an assemblage of innumerable Fixed Stars, each of them in all likelihood a sun and a system like the rest, though at an immeasurable distance from ours.

The size, and motions, and distances of the heavenly bodies are such as to exceed the power of ordinary imagination, from any comparison with the smaller things we see around us. The Earth's diameter is nearly 8000 miles in length; but the Sun's is above 880,000 miles, and the bulk of the Sun is above 1,300,000 times greater than that of the Earth. The planet Jupiter, which looks like a mere speck, from his vast distance, is nearly 1300 times larger than the Earth. Our distance from the Sun is above 95 millions of miles; but Jupiter is 490 millions, and Saturn 900 millions of miles distant from the Sun. The rate at which the Earth moves round the Sun is 68,000 miles an hour, or 140 times swifter than the motion of a cannon-ball; and the planet Mercury, the nearest to the Sun, moves still quicker, nearly 110,000 miles an hour.

We, upon the Earth's surface, besides being carried round the Sun, move round the Earth's axis by the rotatory or spinning motion which it has; so that every 24 hours we move in this manner near 24,000 miles, beside moving round the Sun above 1,600,000 miles. These motions and distances, however, prodigious as they are, seem as nothing compared to those of the comets, one of which, when farthest from the Sun, is 11,200 millions of miles from him; and, when nearest the Sun, flies at the amazing rate of 880,000 miles an hour. Sir Isaac Newton calculated its heat at 2000 times that of red-hot iron; and that it would take thousands of years to cool. But the distance of the Fixed Stars is yet more vast: they have been supposed to be 400,000 times farther from us than we are from the Sun, that is 38 millions of millions of miles; so that a cannon-ball would take nearly nine millions of years to reach one of them, supposing there was nothing to hinder it from pursuing its course thither. As light takes about eight minutes and a quarter to reach us from the Sun, it would be above six years in coming from one of those stars; but the calculations of later astronomers prove some stars to be so far distant, that their light must take centuries before it can reach us; so that every particle of light which enters our eyes left the star it comes from three or four hundred years ago.

Astronomers have, by means of their excellent glasses, aided by Geometry and calculations, been able to observe not only stars, planets, and their satellites, invisible to the naked eye, but to measure the height of mountains in the Moon, by observations of the shadows which those eminences cast on her surface; and they have discovered volcanoes, or burning mountains, in the same body.

The tables, which they have by the like means been enabled to form of the heavenly motions, are of great use in navigation. By means of the eclipses of Jupiter's satellites, and by the tables of the Moon's motions, we can ascertain the position of a ship at sea; for the observation of the Sun's height at mid-day gives the *latitude* of the place, that is, its distance from the equinoctial or equator, the line passing through the middle of the Earth's surface equally distant from both poles; and these tables, with the observations of the satellites, or moons, give the distance east and west of the observatory for which the tables are calculated—called the *longitude* of the place: consequently the mariner can thus tell nearly in what part of the ocean he is, how far he has sailed from his port of departure, and how far he must sail, and in what direction, to gain the port of his destination. The advantage of this knowledge is therefore manifest in the common affairs of life; but it sinks into insignificance compared with the vast extent of those views which the contemplations of the science afford, of numberless worlds filling the immensity of space, and all kept in their places, and adjusted in their prodigious motions by the same simple principle, under the guidance of an all-wise and all-powerful Creator.

We have been considering the application of Dynamics to the motions of the heavenly bodies, which forms the science of *Physical Astronomy*. The application of Dynamics to the calculation, production, and direction of motion, forms the science of *Mechanics*, sometimes called *Practical Mechanics*, to distinguish it from the more general use of the word, which comprehends every thing that relates to motion and force. The fundamental principle of the science, upon which it mainly depends, flows immediately from a property of the circle already mentioned, and which, perhaps, appeared at the moment of little value,—that the lengths of circles are in proportion to their diameters. Observe how upon this simple truth nearly the whole of those contrivances are built by which the power of man is increased as far as solid matter assists him in extending it; and nearly the whole of those doctrines, too, by which he is enabled to explain the voluntary motions of animals, as far as these depend upon their own bodies. There can be nothing more instructive in showing the importance and fruitfulness of scientific truths, however trivial and forbidding they may at first sight appear. For it is an immediate consequence of this property of the circle, that if a rod of iron, or beam of wood, or any other solid material, be placed on a point, or pivot, so that it may move as the arms of a balance do round its centre, or a see-saw board does round its prop, the two ends will go through parts of circles, each proportioned to that arm of the beam to which it belongs: the two circles will be equal if the pivot is in the centre or middle point of the beam; but if it is nearer one end than the other, say three times, that end will go through a circular space, or arch, three times shorter than the circular space the other end goes through in the same time. If, then, the end of the long beam goes through three times the space, it must move with three times the swiftness of the short beam's end, since both move in the same time; and therefore any force applied to the long end must overcome the resistance of three times that force applied at the opposite end, since the two ends move in contrary directions: hence one pound placed at the long end would balance three placed at the short end. The beam we have been supposing is called a *Lever*, and the same rule must evidently hold for all proportions of the lengths of its arms. If, then, the lever be seventeen feet long, and the pivot, or *fulcrum* (as it is called, from a Latin word signifying *support*), be a foot from one end, an ounce placed on the other end will balance a pound placed on the near end; and the least additional weight, or the slightest push or pressure on the far end, so loaded, will make the pound weight on the other move upwards. If, instead of an ounce, we place upon the end of the long arm the short arm of a second beam or lever supported by a fulcrum, one foot from it, and then place the long arm of this second lever upon the short arm of a third lever, whose fulcrum is one foot from it; and if we put on the end of this third lever's long arm an ounce weight, that ounce will move upwards a pound on the second lever's long arm, and this moving upwards will cause the short arm to force downwards sixteen pounds at the long end of the first lever, which will make the short end of the first lever move upwards, though two hundred and fifty-six pounds be laid on it: the same thing continuing, a pound on the long arm of the third lever will move a ton and three-quarters on the short arm of the first lever; that is, will balance it, so that the slightest pressure with the finger, or a touch from a child's hand, will move as much as two horses can draw. The lever is called, on this account, a *mechanical power;* and there are five other mechanical powers, of most of which its properties form the foundation; indeed they have all been resolved into combinations of levers. The pulley seems the most difficult to reduce under the principle of the lever. Thus the *wheel and axle* is only a lever moving round an axle, and always retaining the effect gained during every part of the motion, by means of a rope wound round the butt end of the axle; the spoke of the wheel being the long arm of the lever, and the half diameter of the axle its short arm. By a combination of levers, wheels, pulleys, so great an increase of force is obtained, that, but for the obstruction from friction, and the resistance of the air, there could be no bounds to the effect of the smallest force thus multiplied; and to this fundamental principle Archimedes, one of the most illustrious mathematicians of ancient times, referred, when he boasted, that if he only had a pivot or fulcrum whereon he might rest his machinery, he could move the Earth. Upon so simple a truth, assisted by the aid derived from other sources, rests the whole fabric of mechanical power, whether for raising weights, or cleaving rocks, or pumping up rivers from the bowels of the earth; or, in short, performing any of those works to which human strength, even augmented by the help of the animals whom Providence has subdued to our use, would prove altogether inadequate.

The application of Dynamics to the pressure and motions of fluids, constitutes a science which receives different appellations according as the fluids are heavy and liquid like water, or light and invisible like air. In the former case it is called

Hydrodynamics, from the Greek words signifying *water*, and *power* or *force;* in the latter *Pneumatics*, from the Greek word signifying *breath* or *air;* and Hydrodynamics is divided into *Hydrostatics*, which treats of the weight and pressure of liquids, from the Greek words for *balancing* of *water;* and *Hydraulics*, which treats of their motion, from the Greek name for certain musical instruments played with *water* in *pipes.*

The discoveries to which experiments, aided by mathematical reasoning, have led, upon the pressure and motion of fluids, are of the greatest importance, whether we regard their application to practical purposes, or to their use for explaining the appearances in nature, or their singularity as the subjects of scientific contemplation. When it is found that the pressure of water or any other liquid upon the surface that contains it, is not in the least degree proportioned to its bulk, but only to the height at which it stands, so that a long small pipe, containing a pound or two of the fluid, will give the pressure of twenty or thirty tons; nay, of twice or thrice as much, if its length be increased and its bore lessened, without the least regard to the quantity of the liquid, we are not only astonished at so extraordinary and unexpected a property of matter, but we straightway perceive one of the great agents employed in the vast operations of nature, in which the most trifling means are used to work the mightiest effects. We likewise learn to guard against many serious mischiefs in our own works, and to apply safely and usefully a power calculated, according as it is directed, either to produce unbounded devastation, or to render the most beneficial service.

Nor are the discoveries relating to the Air less interesting in themselves, and less applicable to important uses. It is an agent, though invisible, as powerful as Water, in the operations both of nature and of art. Experiments of a simple and decisive nature show the amount of its pressure to be between 14 and 15 pounds on every square inch; but, like all other fluids, it presses equally in every direction: so that though, on one hand, there is a pressure downwards of above 250 pounds, yet this is exactly balanced by an equal pressure upwards, from the air pressing round and getting below. If, however, the air on one side be removed, the whole pressure from the other acts unbalanced. Hence the ascent of water in pumps, which suck out the air from a barrel, and allow the pressure upon the water to force it up 32 or 33 feet, that body of water being equal to the weight of the atmosphere. Hence the ascent of the mercury in the barometer is only 28 or 29 inches, mercury being between 13 and 14 times heavier than water. Hence, too, the motion of the steam-engine; the piston of which, until the direct force of steam was applied, used to be pressed downwards by the weight of the atmosphere from above, all air being removed below it by first filling it with steam, and then suddenly cooling and converting that steam into water, so as to leave nothing in the space it had occupied. Hence, too, the power which some animals possess of walking along the perpendicular surfaces of walls, and even the ceilings of rooms, by squeezing out the air between the inside of their feet and the wall, and thus being supported by the pressure of the air against the outside of their feet.

The science of *Optics*, (from the Greek word for *seeing*,) which teaches the nature of light, and of the sensation conveyed by it, presents, of itself, a field of unbounded extent and interest. To it the arts, and the other sciences, owe those most useful instruments which have enabled us at once to examine the minutest parts of the structure of animal and vegetable bodies, and to calculate the size and the motions of the most remote of the heavenly bodies. But as an object of learned curiosity, nothing can be more singular than the fundamental truth discovered by the genius of Newton,—that the light, which we call white, is in fact composed of all the colours, blended in certain proportions; unless, perhaps, it be that astonishing conjecture of his unrivalled sagacity, by which he descried the inflammable nature of the diamond, and its belonging, against all appearance of probability, to the class of oily substances, from having observed, that it stood among them, and far removed from all crystals, in the degree of its action upon light; a conjecture turned into certainty by discoveries made a century afterwards.

To a man who, for original genius and strong natural sense, is not unworthy of being named after this illustrious sage, we owe the greater part of *Electrical* science. It treats of the peculiar substance, resembling both light and heat, which, by rubbing, is found to be produced in a certain class of bodies, as glass, wax, silk, amber; and to be conveyed easily or *conducted* through others, as wood, metals, water; and it has received the name of *Electricity*, from the Greek word for *amber*. Dr. Franklin discovered that this is the same matter which, when collected in the clouds, and conveyed from them to the earth, we call *lightning*, and whose noise, in darting through the air, is *thunder*. The observation of some movements in the limbs of a dead frog gave rise to the discovery of *Animal Electricity*, or *Galvanism*, as it was at first called from the name of the discoverer; and which has of late years given birth to improvements that have changed the face of chemical philosophy; affording a new proof how few there are of the processes of nature incapable of repaying the labour we bestow in patiently and diligently examining them. It is to the results of the remark accidentally made upon the twitching in the frog's leg, not, however, hastily dismissed and forgotten, but treasured up and pursued through many an elaborate experiment and calculation, that we owe our acquaintance with the extraordinary metal, liquid like mercury, lighter than water, and more inflammable than phosphorus, which forms, when it burns by mere exposure to the air, one of the salts best known in commerce, and the principal ingredient in saltpetre.

In order to explain the nature and objects of those branches of Natural Science more or less connected with the mathematics, some details were necessary, as without them it was difficult immediately to perceive their importance, and, as it were, relish the kind of instruction which they afford. But the same course needs not be pursued with respect to the other branches. The value and the interest of chemistry is at once perceived, when it is known to teach the nature of all bodies; the relations of simple substances to heat and to one another, or their combinations together; the composition of those which nature produces in a compound state; and the application of the whole to the arts and manufactures. Some branches of philosophy, again, are chiefly useful and interesting to particular classes, as surgeons and physicians. Others are easily understood by a knowledge of the principles of

Mechanics and Chemistry, of which they are applications and examples; as those which teach the structure of the earth and the changes it has undergone; the motions of the muscles, and the structure of the parts of animals; the qualities of animal and vegetable substances; and that department of Agriculture which treats of soils, manure, and machinery. Other branches are only collections of facts, highly curious and useful indeed, but which any one who reads or listens, perceives as clearly, and comprehends as readily, as the professed student. To this class belongs Natural History, in so far as it describes the habits of animals and plants, and its application to that department of Agriculture which treats of cattle and their management.

IV. APPLICATION OF NATURAL SCIENCE TO THE ANIMAL AND VEGETABLE WORLD.

But, for the purpose of further illustrating the advantages of Philosophy, its tendency to enlarge the mind, as well as to interest it agreeably, and afford pure and solid gratification, a few instances may be given of the singular truths brought to light by the application of Mathematical, Mechanical, and Chemical knowledge to the habits of animals and plants; and some examples may be added of the more ordinary and easy, but scarcely less interesting observations, made upon those habits, without the aid of the profounder sciences.

We may remember the curve line which mathematicians call a Cycloid. It is the path which any point of a circle, moving along a plane, and round its centre, traces in the air; so that the nail on the felly of a cart-wheel moves in a Cycloid, as the cart goes along, and as the wheel itself both turns round its axle and is carried along the ground. Now this curve has certain properties of a peculiar and very singular kind with respect to motion. One is, that if any body whatever moves in a cycloid by its own weight or swing, together with some other force acting upon it all the while, it will go through all distances of the same curve in exactly the same time; and, accordingly, pendulums have sometimes been contrived to swing in such a manner, that they shall describe cycloids, or curves very near cycloids, and thus move in equal times, whether they go through a long or a short part of the same curve. Again, if a body is to descend from any one point to any other, not in the perpendicular, by means of some force acting on it together with its weight, the line in which it will go the quickest of all will be the cycloid; not the straight line, though that is the shortest of all lines which can be drawn between the two points; nor any other curve whatever, though many are much flatter, and therefore shorter than the cycloid—but the cycloid, which is longer than many of them, is yet, of all curved or straight lines which can be drawn, the one the body will move through in the shortest time. Suppose, again, that the body is to move from one point to another, by its weight and some other force acting together, but to go through a certain space,—as a hundred yards,—the way it must take to do this, in the shortest time possible, is by moving in a cycloid; or the length of a hundred yards must be drawn into a cycloid, and then the body will descend through the hundred yards in a shorter time than it could go the same distance in any other path whatever. Now, it is believed that Birds, as the Eagle, which build in the rocks, drop or fly down from height to height in this course. It is impossible to make very accurate observations of their flight and path; but there is a general resemblance between the course they take and the cycloid, which has led ingenious men to adopt this opinion.

If we have a certain quantity of any substance, a pound of wood, for example, and would fashion it in the shape to take the least room, we must make a globe of it; it will in this figure have the smallest surface. But suppose we want to form the pound of wood, so that in moving through the air or water it shall meet with the least possible resistance; then we must lengthen it out for ever, till it becomes not only like a long-pointed pin, but thinner and thinner, longer and longer, till it is quite a straight line, and has no perceptible breadth or thickness at all. If we would dispose of the given quantity of matter, so that it shall have a certain length only, say a foot, and a certain breadth at the thickest part, say three inches, and move through the air or water with the smallest possible resistance which a body of those dimensions can meet, then we must form it into a figure of a peculiar kind called the *Solid of least resistance*, because, of all the shapes that can be given to the body, its length and breadth remaining the same, this is the one which will make it move with the least resistance through the air, or water, or other fluid. A very difficult chain of mathematical reasoning, by means of the highest branches of algebra, leads to a knowledge of the curve which, by revolving on its axis, makes a solid of this shape, in the same way that a circle, by so revolving, makes a sphere or globe; and the curve certainly resembles closely the face or head part of a fish. Nature, therefore, (by which we always mean the Divine Author of nature,) has fashioned these fishes so, that, according to mathematical principles, they swim the most easily through the element they live and move in.*

Suppose upon the face part of one of these fishes a small insect were bred, endowed with faculties sufficient to reason upon its condition, and upon the motion of the fish it belonged to, but never to have discovered the whole size and shape of the face part; it would certainly complain of the form as clumsy, and fancy that it could have made the fish so as to move with less resistance. Yet if the whole shape were disclosed to it, and it could discover the principle on which that shape was preferred, it would at once perceive, not only that what had seemed clumsy was skilfully contrived, but that, if any other shape whatever had been taken, there would have been an error committed; nay, *that there must of necessity* have been an error; and that the very best possible arrangement had been adopted. So it may be with man in the universe, where, seeing only a part of the great system, he fancies there is evil; and yet, if he were permitted to survey the whole, what had seemed imperfect might appear to be necessary for the general perfection, insomuch that any other arrangement, even of that seemingly imperfect part, must needs have rendered the whole less perfect.

* The feathers of the wings of birds are found to be placed at the *best possible* angle for helping on the bird by their action on the air.

The common objection is, that what seems evil *might have* been avoided; but in the case of the fish's shape, it *could not* have been avoided.

It is found by optical inquiries, that the particles or rays of light, in passing through transparent substances of a certain form, are bent to a point where they make an image or picture of the shining bodies they come from, or of the dark bodies they are reflected from. Thus, if a pair of spectacles be held between a candle and the wall, they make two images of the candle upon it; and if they be held between the window and a sheet of paper when the sun is shining, they make a picture on the paper of the houses, trees, fields, sky, and clouds. The eye is found to be composed of several natural magnifiers which make a picture on a membrane at the back of it, and from this membrane there goes a nerve to the brain, conveying the impression of the picture, by means of which we see. Now, white light was discovered by Newton to consist of differently-coloured parts, which are differently bent in passing through transparent substances, so that the lights of several colours come to a point at different distances, and thus create an indistinct image at any one distance. This was long found to make our telescopes imperfect, insomuch that it became necessary to make them of reflectors or mirrors, and not of magnifying glasses, the same difference not being observed to affect the reflection of light. But another discovery was, about fifty years afterwards, made by Mr. Dollond,—that, by combining different kinds of glass in a compound magnifier, the difference may be greatly corrected; and on this principle he constructed his telescopes. It is found, too, that the different natural magnifiers of the eye are combined upon a principle of the same kind. Thirty years later, a third discovery was made by Mr. Blair, of the greatly superior effect which combinations of different liquids have in correcting the imperfection; and, most wonderful to think, when the eye is examined, we find it consists of different liquids, acting naturally upon the same principle which was thus recently found out in optics by many ingenious mechanical and chemical experiments.

Again, the point to which any magnifier collects the light is more or less distant as the magnifier is flatter or rounder, so that a small globe of glass or any transparent substance makes a microscope. And this property of light depends upon the nature of lines, and is purely of a mathematical nature, after we have once ascertained by experiment, that light is bent in a certain way when it passes through transparent bodies. Now birds flying in the air, and meeting with many obstacles, has brances and leaves of trees, require to have their eyes sometimes as flat as possible for protection; but sometimes as round as possible, that they may see the small objects, flies and other insects, which they are chasing through the air, and which they pursue with the most unerring certainty. This could only be accomplished by giving them a power of suddenly changing the form of their eyes. Accordingly, there is a set of hard scales placed on the outer coat of their eye, round the place where the light enters; and over these scales are drawn the muscles or fibres by which motion is communicated; so that, by acting with these muscles, the bird can press the scales, and squeeze the natural magnifier of the eye into a round shape when it wishes to follow an insect through the air, and can relax the scales, in order to flatten the eye again, when it would see a distant object, or move safely through leaves and twigs. This power of altering the shape of the eye is possessed by birds of prey in a very remarkable degree. They can thus see the smallest objects close to them, and can yet discern larger bodies at vast distances, as a carcass stretched upon the plain, or a dying fish afloat on the water.

A singular provision is made for keeping the surface of the bird's eye clean—for wiping the glass of the instrument, as it were—and also for protecting it, while rapidly flying through the air and through thickets, without hindering the sight. Birds are, for these purposes, furnished with a third eyelid, a fine membrane or skin, which is constantly moved very rapidly over the eyeball by two muscles placed in the back of the eye. One of the muscles ends in a loop, the other in a string which goes through the loop, and is fixed in the corner of the membrane, to pull it backward and forward. If you wish to draw a thing towards any place with the least force, you must pull directly in the line between the thing and the place; but if you wish to draw it as quickly as possible, and with the most convenience, and do not regard the loss of force, you must pull it obliquely, by drawing it in two directions at once. Tie a string to a stone, and draw it straight towards you with one hand; then, make a loop on another string, and running the first through it, draw one string in each hand, not towards you, but sideways, till both strings are stretched in a straight line: you will see how much more easily the stone moves quickly than it did before when pulled straight forward. Again, if you tie strings to the two ends of a rod, or slip of card, in a running groove, and bring them to meet and pass through a ring or hole, for every inch in a straight line that you draw both together below the ring, the rod will move onward two. Now this is proved, by mathematical reasoning, to be the necessary consequence of forces applied obliquely: there is a loss of power, but a great gain in velocity and convenience. This is the thing required to be gained in the third eyelid, and the contrivance is exactly that of a string and a loop, moved each by a muscle, as the two strings are by the hands in the cases we have been supposing.

A third eyelid of the same kind is found in the horse, and called the *haw;* it is moistened with a pulpy substance (or mucilage) to take hold of the dust on the eyeball, and wipe it clear off; so that the eye is hardly ever seen with anything upon it, though greatly exposed from its size and posture. The swift motion of the haw is given to it by a gristly elastic substance placed between the eyeball and the socket, and striking obliquely, so as to drive out the haw with great velocity over the eye, and then let it come back as quickly. Ignorant persons, when this haw is inflamed from cold, and swells so as to appear, which it never does in a healthy state, often mistake it for an imperfection, and cut it off: so nearly do ignorance and cruelty produce the same mischief.

If any quantity of matter, as a pound of wood or iron, is fashioned into a rod of a certain length, say one foot, the rod will be strong in proportion to its thickness; and, if the figure is the same, that thickness can only be increased by making it hollow. Therefore hollow rods or tubes, of the same length and quantity of matter, have more strength than solid ones. This is a principle so well understood now, that engineers make their axles and other parts of machinery hollow, and therefore stronger with the same weight than they would be if thinner and solid. Now the bones of animals are all more or less hollow; and are therefore stronger with the same weight and quantity of matter than they otherwise would be. But birds have the largest bones in proportion to their weight; their bones are more hollow than those of animals which do not fly; and therefore they have the needful strength without having to carry more weight than is absolutely necessary. Their quills derive strength from the same construction. They possess another peculiarity to help their flight. No other animals have any communication between the air-vessels of their lungs and the hollow parts of their bodies; but birds have it; and by this means they can blow out their bodies as we do a bladder, and thus become lighter when they would either make their flight towards the ground slower, or rise more swiftly, or float more easily in the air; while, by lessening their bulk and closing their wings, they can drop more speedily if they wish to chase or to escape. Fishes possess a power of the same kind, though not by the same means. They have *air-bladders* in their bodies, and can puff them out, or press them closer, at pleasure: when they want to rise in the water, they fill out the bladder, and this lightens them; when they would sink, they squeeze the bladder, pressing the air into a smaller space, and this makes them heavier. If the bladder breaks, the fish remains at the bottom, and can be held up only by the most laborious exertions of the fins and tail. Accordingly, flat fish, such as skaits and flounders, which have no air-bladders, seldom rise from the bottom, but are found lying on banks in the sea, or at the bottom of rivers.

If you have a certain space, as a room, to fill up with closets or little cells, all of the same size and shape, there are only three figures which will answer, and enable you to fill the room without losing any space between the cells; they must either be squares, or figures of three equal sides, or figures of six equal sides. With any other figures whatever, space would be lost between the cells. This is evident upon considering the matter; and it is proved by mathematical reasoning. The six-sided figure is by far the most convenient of those three shapes, because its corners are flatter, and any round body placed in it has therefore more space, less room being lost in the corners. This figure, too, is the strongest of the three; any pressure from without or from within will hurt it least, as it has something of the strength of an arch. A round figure would be still stronger, but then room would be lost between the circles, whereas with the six-sided figure none is lost. Now, it is a most remarkable fact, that *Bees* build their cells exactly in this shape, and thereby save both room and materials beyond what they could save if they built in any other shape whatever. They build in the very best possible shape for their purpose, which is to save all the room and all the wax they can. So far as to the shape of the walls of each cell; but the roof and floor, or top and bottom, are built on equally true principles. It is proved by mathematicians, that, to give the greatest strength, and save the most room, the roof and floor must be made of three square planes meeting in a point; and they have further proved, by a demonstration belonging to the highest parts of Algebra, that there is one particular angle or inclination of those planes to each other where they meet, which makes a greater saving of materials and of work than any other inclination whatever could possibly do. Now, the Bees actually make the tops and bottoms of their cells of three planes meeting in a point; and the inclinations or angles at which they meet are precisely those found out by the mathematician to be the best possible for saving wax and work.*

* Koenig, pupil of Bernoulli, and Maclaurin, proved by very refined investigations, carried on with the aid of the fluxional calculus, that the obtuse angle must be 109° 28′, and the acute 70° 32′, to save the most wax and work possible. Maraldi found by actual measurement, that the angles are *about* 110° and 70°. These angles never vary in any place; and it is scarcely less singular, that the breadth of all bees' cells are everywhere precisely the same, the drone or male cells being $\frac{5}{18}$ths and the worker or female cells $\frac{13}{60}$ths of an inch in breadth, and this in all countries and times.

Who would dream of the bee knowing the highest branch of the Mathematics—the fruit of Newton's most wonderful discovery—a result, too, of which he was himself ignorant, one of his most celebrated followers having found it out in a later age? This little insect works with a truth and correctness which are perfect, and according to the principles at which man has arrived only after ages of slow improvement in the most difficult branch of the most difficult science. But the Mighty and All-wise Creator, who made the insect and the philosopher, bestowing reason on the latter, and giving the former to work without it—to Him all truths are known to all eternity, with an intuition that mocks even the conceptions of the sagest of human kind.

It may be recollected, that when the air is exhausted or sucked out of any vessel, there is no longer the force necessary to resist the pressure of the air on the outside; and the sides of the vessels are therefore pressed inwards with violence: a flat glass would thus be broken, unless it were very thick; a round one, having the strength of an arch, would resist better; but any soft substance, as leather or skin, would be crushed or squeezed together at once. If the air was only sucked out slowly, the squeezing would be gradual; or, if it were only half sucked out, the skin would only be partly squeezed together. This is the process by which *Bees* reach the fine dust and juices of hollow flowers, like the honeysuckle, and some kinds of long fox-glove, which are too narrow for them to enter. They fill up the mouth of the flower with their bodies, and suck out the air, or at least a large part of it; this makes the soft sides of the flower close, and squeezes the dust and juice towards the insect as well as a hand could do, if applied to the outside.

We may remember this pressure or weight of the atmosphere as shown by the barometer and the sucking-pump. Its weight is near fifteen pounds on every square inch, so that if we could entirely squeeze out the air between our two hands, they would cling together with a force equal to the pressure of double this weight, because the air would press upon both hands; and if we could contrive to suck or squeeze out the air between one hand and the wall, the hand would stick fast to the wall, being pressed on it with the weight of above two hundredweight, that is, near fifteen pounds on every square inch of the hand. Now, by a late most curious discovery of Sir Everard Home, the distinguished anatomist, it is found that this is the very process by which *Flies* and other insects of a similar description are enabled to walk up perpendicular surfaces, however smooth, as the sides of walls and panes of glass in windows, and to walk as easily along the ceiling of a room with their bodies downwards and their feet over head. Their feet, when examined by a microscope, are found to have flat skins or flaps, like the feet of web-footed animals, as ducks and geese; and they have by means of strong folds the power of drawing the flap close down upon the glass or wall the fly walks on, and thus squeezing out the air completely, so as to make a vacuum between the foot and the glass or wall. The consequence of this is, that the air presses the foot on the wall with a very considerable force compared to the weight of the fly; for if its feet are to its body in the same proportion as ours are to our bodies, since we could support by a single hand on the ceiling of the room (provided it made a vacuum) more than our whole weight, namely, a weight of above fifteen stone, the fly can easily move on four feet in the same manner by help of the vacuum made under its feet.

It has likewise been found that some of the larger *Sea-animals* are by the same construction, only upon a greater scale, enabled to climb the perpendicular and smooth surfaces of the ice hills among which they live. Some kinds of *Lizard* have a like power of climbing, and of creeping with their bodies downwards along the ceiling of a room; and the means by which they are enabled to do so are the same. In the large feet of those animals, the contrivance is easily observed, of the toes and muscles, by which the skin of the foot is pinned down, and the air excluded in the act of walking or climbing; but it is the very same, only upon a larger scale, with the mechanism of a fly's or a butterfly's foot; and both operations, the climbing of the sea-horse on the ice, and the creeping of the fly on the window or the ceiling, are performed exactly by the same power, the weight of the atmosphere, which causes the quicksilver to stand in the weather-glass, the wind to whistle through a key-hole, and the piston to descend in an old steam-engine.

Although philosophers are not agreed as to the peculiar action which light exerts upon vegetation, and there is even some doubt respecting the decomposition of air and water during that process, one thing is undeniable,—the necessity of light to the growth and health of plants: without it they have neither colour, taste, nor smell; and accordingly they are for the most part so formed as to receive it at all times when it shines on them. Their cups, and the little assemblages of their leaves before they sprout, are found to be more or less affected by the light, so as to open and receive it. In several kinds of plants this is more evident than in others; their flowers close entirely at night, and open in the day. Some constantly turn round towards the light, following the sun, as it were, while he makes or seems to make his revolution, so that they receive the greatest quantity possible of his rays. Thus clover in a field follows the apparent course of the sun. But all leaves of plants turn to the sun, place them how you will, light being essential to their thriving.

The lightness of inflammable gas is well known. When bladders of any size are filled with it, they rise upwards, and float in the air. Now, it is a most curious fact, ascertained by Mr. Knight, that the fine dust, by means of which plants are impregnated one from another, is composed of very small globules, filled with this gas—in a word, of small air-balloons. These globules thus float from the male plant through the air, and striking against the females, are detained by a glue prepared on purpose to stop them, which no sooner moistens the globules than they explode, and their substance remains, the gas flying off which enabled them to float. A provision of a very simple kind is also, in some cases, made to prevent the male and female blossoms of the same plant from breeding together, this being found to hurt the breed of vegetables, just as breeding in and in spoils the race of animals. It is contrived that the dust shall be shed by the male blossom before the female of the same plant is ready to be affected by it; so that the impregnation must be performed by the dust of some other plant, and in this way the breed be crossed. The light gas with which the globules are filled is most essential to the operation, as it conveys them to great distances. A plantation of yew-trees has been known, in this way, to impregnate another several hundred yards off.

The contrivance by which some creeper plants are enabled to climb walls, and fix themselves, deserves attention. The *Virginia creeper* has a small tendril, ending in a claw, each toe of which has a knob, thickly set with extremely small bristles; they grow into the invisible pores of the wall, and swelling, stick there as long as the plant grows, and prevent the branch from falling; but when the plant dies, they become thin again, and drop out, so that the branch falls down.

The *Vanilla* plant of the West Indies climbs round trees likewise by means of tendrils; but when it has fixed itself, the tendrils drop off, and leaves are formed.

It is found by chemical experiments, that the juice which is in the stomachs of animals (called the *gastric* juice, from a Greek word signifying *the belly*) has very peculiar properties. Though it is for the most part a tasteless, clear, and seemingly a very simple liquor, it nevertheless possesses extraordinary powers of dissolving substances which it touches or mixes with; and it varies in different classes of animals. In one particular it is the same in all animals; it will not attack living matter, but only dead; the consequence of which is, that its powers of eating away and dissolving are perfectly safe to the animals themselves, in whose stomachs it remains without ever hurting them. This juice differs in different animals according to the food on which they subsist; thus, in birds of prey, as kites, hawks, owls, it only acts upon animal matter, and does not dissolve vegetables. In other birds, and in all animals feeding on plants, as oxen, sheep, hares, it dissolves vegetable matter, as grass, but will not touch flesh of any kind. This has been ascertained by making them swallow balls with meat in them, and several holes drilled through to let the gastric juice reach the meat: no effect was produced upon it. We may further observe, that there is a most curious and beautiful correspondence between this juice in the stomach of different animals and the other parts of their bodies, connected with the important operations of eating and digesting their food. The use of the juice is plainly to convert what they eat into a fluid, from which, by various other processes, all their parts, blood, bones, muscles, &c., are afterwards formed. But the food is first of all to be obtained, and then prepared by bruising, for the action of the juice. Now birds of prey have instruments, their claws and beaks, for tearing and devouring their food (that is, animals of various kinds), but those instruments are useless for picking up and crushing seeds; accordingly they have a gastric juice which dissolves the animals they eat;

while birds which have only a beak fit for pecking, and eating seeds, have a juice that dissolves seeds, and not flesh. Nay more, it is found that the seeds must be bruised before the juice will dissolve them: this you find by trying the experiment in a vessel with the juice; and accordingly the birds have a gizzard, and animals which graze have flat teeth, which grind and bruise their food, before the gastric juice is to act upon it.

We have seen how wonderfully the *Bee* works, according to rules discovered by man thousands of years after the insect had been following them with perfect accuracy. The same little animal seems to be acquainted with principles of which we are still ignorant. We can, by crossing, vary the forms of cattle with astonishing nicety; but we have no means of altering the nature of an animal once born, by means of treatment and feeding. This power, however, is undeniably possessed by the bees. When the queen bee is lost by death or otherwise, they choose a grub from among those which are born for workers; they make three cells into one, and placing the grub there, they build a tube round it; they afterwards build another cell of a pyramidal form, into which the grub grows; they feed it with peculiar food, and tend it with extreme care. It becomes, when transformed from the worm to the fly, not a worker, but a queen bee.

These singular insects resemble our own species in one of our worst propensities, the disposition to war; but their attention to their sovereign is equally extraordinary, though of a somewhat capricious kind. In a few hours after their queen is lost, the whole hive is in a state of confusion. A singular humming is heard, and the bees are seen moving all over the surface of the combs with great rapidity. The news spreads quickly, and when the queen is restored, quiet immediately succeeds. But if another queen is put upon them, they instantly discover the trick, and, surrounding her, they either suffocate or starve her to death. This happens if the false queen is introduced within a few hours after the first is lost or removed; but if twenty-four hours have elapsed, they will receive any queen, and obey her.

The labours and the policy of the *Ants* are, when closely examined, still more wonderful, perhaps, than those of the *Bees*. Their nest is a city consisting of dwelling-places, halls, streets, and squares into which the streets open. The food they principally like is the honey which comes from another insect found in their neighbourhood, and which they, generally speaking, bring home from day to day as they want it. Late discoveries have shown that they do not eat grain, but live almost entirely on animal food and this honey. Some kinds of ants have the foresight to bring home the insects on whose honey they feed, and keep them in particular cells, where they guard them to prevent their escaping, and feed them with proper vegetable matter which they do not eat themselves. Nay, they obtain the eggs of those insects, and superintend their hatching, and then rear the young insect until he becomes capable of supplying the desired honey. They sometimes remove them to the strongest parts of their nest, where there are cells apparently fortified for protecting them from invasion. In those cells the insects are kept to supply the wants of the whole ants which compose the population of the city. It is a most singular circumstance in the economy of nature, that the degree of cold at which the ant becomes torpid is also that at which this insect falls into the same state. It is considerably below the freezing-point; so that they require food the greater part of the winter, and if the insects on which they depend for food were not kept alive during the cold in which the ants can move about, the latter would be without the means of subsistence.

How trifling soever this little animal may appear in our climate, there are few more formidable creatures than the ant of some tropical countries. A traveller, who lately filled a high station in the French government, Mr. Malouet, has described one of their cities, and, were not the account confirmed by various testimonies, it might seem exaggerated. He observed at a great distance what seemed a lofty structure, and was informed by his guide that it consisted of an ant-hill, which could not be approached without danger of being devoured. Its height was from fifteen to twenty feet, and its base thirty or forty feet square. Its sides inclined like the lower part of a pyramid, the point being cut off. He was informed that it became necessary to destroy these nests, by raising a sufficient force to dig a trench all round, and fill it with fagots, which were afterwards set on fire; and then battering with cannon from a distance, to drive the insects out and make them run into the flames. This was in South America; and African travellers have met them in the same formidable numbers and strength.

The older writers of books upon the habits of some animals abound with stories which may be of doubtful credit. But the facts now stated, respecting the Ant and Bee, may be relied on as authentic. They are the result of very late observations, and experiments made with great accuracy by several most worthy and intelligent men; and the greater part of them have the confirmation arising from more than one observer having assisted in the inquiries.* The habits of *Beavers* are equally

* A singular circumstance occasioned this in the case of Mr. Huber, by far the most eminent of these naturalists: he was quite blind, and performed all his experiments by means of assistants.

well authenticated, and, being more easily observed, are vouched by a greater number of witnesses. These animals, as if to enable them to live and move either on land or water, have two web-feet like those of ducks or water-dogs, and two like those of land animals. When they wish to construct a dwelling-place, or rather city, for it serves the whole body, they choose a level ground with a stream running through it; they then dam up the stream so as to make a pond, and perform the operation as skilfully as we could ourselves. Next they drive into the ground stakes of five or six feet long in rows, wattling each row with twigs, and puddling or filling the interstices with clay, which they ram close in, so as to make the whole solid and water-tight. This dam is likewise shaped on the truest principles; for the upper side next the water slopes, and the side below is perpendicular: the base of the dam is ten or twelve feet thick; the top or narrow part two or three, and it is sometimes as long as one hundred feet.* The pond

* If the base is twelve, and the top three feet thick, and the height six feet, the face must be the side of a right-angled triangle whose height is eight feet. This would be the exact proportion which there ought to be, upon mathematical principles, to give the greatest resistance possible to the water in its tendency to turn the dam round, provided the materials of which it is made were lighter than water in the proportion of 44 to 100. But the materials are probably more than twice as heavy as water, and the form of so flat a

being thus formed and secured, they make their houses round the edge of it; they are cells, with vaulted roofs, and upon piles: they are made of stones, earth, and sticks; the walls are two feet thick, and plastered as neatly as if the trowel had been used. Sometimes they have two or three stories for retreating to in case of floods; and they always have two doors, one towards the water and one towards the land. They keep their winter provisions in stores, and bring them out to use; they make their beds of moss; they live on the bark of trees, gum, and crawfish. Each house holds from twenty to thirty, and there may be from ten to twenty-five houses in all. Some of their communities are larger than others, but there are seldom fewer than two or three hundred inhabitants. In working they all bear their shares; some gnaw the trees and branches with their teeth to form stakes and beams; others roll the pieces to the water; others, diving, make holes with their teeth to place the piles in; others collect and carry stones and clay; others beat and mix the mortar; and

dike is taken, in all likelihood, in order to guard against a more imminent danger—that of the dam being carried away by being shoved forwards. We cannot calculate what the proportions are which give the greatest possible resistance to this tendency, without knowing the tenacity of the materials, as well as their specific gravity. It may very probably be found that the construction is such as to secure the most completely against the two pressures at the same time.

others carry it on their broad tails, and with these beat it and plaster it. Some superintend the rest, and make signals by sharp strokes with the tail, which are carefully attended to; the beavers hastening to the place were they are wanted to work, or to repair any hole made by the water, or to defend themselves or make their escape, when attacked by an enemy.

The fitness of different animals, by their bodily structure, to the circumstances in which they are found, presents an endless subject of curious inquiry and pleasing contemplation. Thus, the *Camel*, which lives in sandy deserts, has broad spreading hoofs to support him on the loose soil; and an apparatus in his body by which water is kept for many days, to be used when no moisture can be had. As this would be useless in the neighbourhood of streams or wells, and as it would be equally so in the desert, where no water is to be found, there can be no doubt that it is intended to assist in journeying across the sands from one watered spot to another. There is a singular and beautiful provision made in this animal's foot, for enabling it to sustain the fatigue of journeys under the pressure of its great weight. Besides the yielding of the bones and ligaments, or bindings, which gives elasticity to the foot of the deer and other animals, there is in the Camel's foot, between the horny sole and the bones, a cushion, like a ball, of soft matter, almost fluid, but in which there is a mass of threads extremely elastic, interwoven with the pulpy substance. The cushion thus easily changes its shape when pressed, yet it has such an elastic spring, that the bones of the foot press on it uninjured by the heavy body which they support, and this huge animal steps as softly as a cat.

Nor need we flee to the desert in order to witness an example of skilful structure: the limbs of the *Horse* display it strikingly. The bones of the foot are not placed directly under the weight; if they were in an upright position, they would make a firm pillar, and every motion would cause a shock. They are placed slanting or oblique, and tied together by an elastic binding on their lower surfaces, so as to form springs as exact as those which we make of leather and steel for carriages. Then the flatness of the hoof, which stretches out on each side, and the frog coming down in the middle between the quarters, adds greatly to the elasticity of the machine. Ignorant of this, ill-informed farriers nail the shoe in such a manner as to fix the quarters, and cause permanent contraction of the bones, ligaments, and hoof—so that the elasticity is destroyed; every step is a shock; inflammation and lameness ensue.*

* Mr. Bracey Clarke has contrived an expanding shoe, which, by a joint in front, opens and contracts so as to obviate the evils of the common process.

The *Rein-deer* inhabits a country covered with snow the greater part of the year. Observe how admirably its hoof is formed for going over that cold and light substance, without sinking in it or being frozen. The under side is covered entirely with hair, of a warm and close texture; and the hoof, altogether, is very broad, acting exactly like the snow-shoes which men have constructed for giving them a larger space to stand on than their feet, and thus avoid sinking. Moreover, the deer spreads the hoof as wide as possible when it touches the ground: but, as this breadth would be inconvenient in the air, by occasioning a greater resistance while he is moving along, no sooner does he lift the hoof than the two parts into which it is cloven fall together, and so lessen the surface exposed to the air, just as we may recollect the birds doing with their bodies and wings. The shape and structure of the hoof are also well adapted to scrape away the snow, and enable the animal to get at the particular kind of moss (or *lichen*) on which he feeds. This plant, unlike others, is in its full growth during the winter season; and the Rein-deer accordingly thrives, from its abundance, at the season of his greatest use to man, notwithstanding the unfavourable effects of extreme cold upon the animal system.

There are some insects, of which the males have wings, and the females are grubs or worms. Of these, the *Glow-worm* is the most remarkable: it is the female, and the male is a fly, which would be unable to find her out, creeping as she does in the dark lanes, but for the shining light which she gives to attract him.

There is a singular fish found in the Mediterranean, called the *Nautilus*, from its skill in navigation. The back of its shell resembles the hulk of a ship; on this it throws itself, and spreads two thin membranes to serve for two sails, paddling itself on with its feet or feelers, as oars.

The *Ostrich* lays and hatches her eggs in the sands: her form being ill-adapted for sitting on them, she has a natural oven furnished by the sand, and the strong heat of the sun. The *Cuckoo* is known to build no nest for herself, but to lay in the nests of other birds; but late observations show that she does not lay indiscriminately in the nests of all birds; she only chooses the nests of those which have bills of the same kind with herself, and therefore feed on the same kind of food. The *Duck*, and other birds breeding in muddy places, have a peculiar formation of the bill: it is both made so as to act like a strainer, separating the finer from the grosser parts of the liquid, and it is more furnished with nerves near the point than the bills of birds which feed on substances more exposed to the light; so that being more sensitive, it serves better to grope in the dark stream for food.

The bill of the *Snipe* is covered with a curious network of nerves for the same purpose; but the most singular provision of this kind is observed in a bird called the *Toucan*, or *Egg-sucker*, which chiefly feeds on the eggs found in birds' nests, and in countries where these are very deep and dark. Its bill is broad and long; when examined, it appears completely covered with branches of nerves in all directions; so that, by groping in a deep and dark nest it can feel its way as accurately as the finest and most delicate finger could. Almost all kinds of birds build their nests of materials found where they inhabit, or use the nests of other birds; but the *Swallow of Java* lives in rocky caverns on the sea, where there are no materials at all for the purpose of building. It is therefore so formed as to secrete in its body a kind of slime with which it makes a nest, much prized as a delicate food in Eastern countries.

Plants, in many remarkable instances, are provided for by equally wonderful and skilful contrivances. There is one, the *Muscipula*, *Fly-trap*, or *Fly-catcher*, which has small prickles in the inside of two leaves, or half leaves, joined by a hinge; a juice or syrup is provided on their inner surface, which acts as a bait to allure flies. There are several small spines or prickles standing upright in this syrup, and upon the only part of each leaf that is sensitive to the touch. When the fly, therefore, settles upon this part, its touching, as it were, the spring of the trap, occasions the leaves to shut and kill and squeeze the insect; whose juices and the air arising from their rotting serve as food to the plant.

In the West Indies, and in other hot countries of South America, where rain sometimes does not fall for a great length of time, a kind of plant called the *Wild-pine* grows upon the branches of the trees, and also on the bark of the trunk. It has hollow or bag-like leaves so formed as to make little reservoirs of water, the rain falling into them through channels which close at the top when full, and prevent it from evaporating. The seed of this useful plant has small floating threads, by which, when carried through the air, it catches any tree in the way, and falls on it and grows. Wherever it takes root, though on the under side of a bough, it grows straight upwards, otherwise the leaves would not hold water. It holds in one leaf from a pint to a quart; and although it must be of great use to the trees it grows on, to birds and other animals its use is even greater.

"When we find these pines," says Dampier, the famous navigator, "we stick our knives into the leaves just above the root, and the water gushing out, we catch it in our hats, as I myself have frequently done to my great relief."

Another tree, called the *Water-with*, in Jamaica, has similar uses: it is like a vine in size and shape, and though growing in parched districts, is yet so full of clear sap or water, that by cutting a piece two or three yards long, and merely holding it to the mouth, a plentiful draught is obtained. In the East there is a plant somewhat of the same kind, called the *Bejuco*, which grows near other trees and twines round them, with its end hanging downwards, but so full of juice, that, on cutting it, a good stream of water spouts from it; and this, not only by the stalk touching the tree so closely must refresh it, but affords a supply to animals, and to the weary herdsman on the mountains. Another plant, the *Nepenthes distillatoria*, is found in the same regions, with a yet more singular structure. It has natural mugs or tankards hanging from its leaves, and holding each from a pint to a quart of very pure water. Two singular provisions are to be marked in this vegetable. There grows over the mouth of the tankard, a leaf nearly its size and shape, like a lid or cover, which prevents evaporation from the sun's rays; and the water that fills the tankard is perfectly sweet and clear, although the ground in which the plant grows is a marsh of the most muddy and unwholesome kind. The process of vegetation filtrates or distils the liquid, so as to produce from the worst, the purest water.* The *Palo de Vaca*, or cow-tree, grows in South

* A specimen of this curious plant, though of a small size, is to be found in the fine collection at Wentworth, reared by Mr. Cooper.

America, upon the most dry and rocky soil, and in a climate where for months not a drop of rain falls. On piercing the trunk, however, a sweet and nourishing milk is obtained, which the natives gladly receive in large bowls. If some plants thus furnish drink, where it might least be expected, others prepare, as it were, in the desert, the food of man in abundance. A single *Tapioca* tree is said to afford, from its pith, the whole sustenance of several men for a season.

V. ADVANTAGES AND PLEASURES OF SCIENCE.

After the many instances or samples which have now been given of the nature and objects of Natural Science, we might proceed to a different field, and describe in the same way the other grand branch of human knowledge, that which teaches the properties or habits of *Mind* — the *intellectual faculties* of man, or the powers of his understanding, by which he perceives, imagines, remembers, and reasons;—his *moral faculties*, or the feelings and passions which influence him;—and, lastly, as a conclusion or result drawn from the whole, his *duties* both towards himself as an individual, and towards others as a member of society: which last head opens to our view the whole doctrines of *political science*, including the nature of *govern-*

ments, of *policy*, and generally of *laws*. But we shall abstain at present from entering at all upon this field, and shall now take up the subject more particularly pointed at through the course of the foregoing observations, and to illustrate which they have been framed, namely, — the Use and Pleasure of Scientific Studies.

Man is composed of two parts, body and mind, connected indeed together, but wholly different from one another. The nature of the union—the part of our outward and visible frame in which it is peculiarly formed—or whether the soul be indeed connected or not with any particular portion of the body, so as to reside there—are points as yet wholly hid from our knowledge, and which are likely to remain for ever concealed. But this we know, as certainly as we can know any truth, that there is such a thing as the *Mind*; and that we have at the least as good proof of its existence, independent of the Body, as we have of the existence of the Body itself. Each has its uses, and each has its peculiar gratifications. The bounty of Providence has given us outward senses to be employed, and has furnished the means of gratifying them in various kind, and in ample measure. As long as we only taste those pleasures according to the rules of prudence and of our duty, that is, in moderation for our own sakes, and in harmlessness towards our neighbours, we fulfil rather than thwart the purpose of our being. But the same bountiful Providence has endowed us with the higher nature also—with understandings as well as with senses—with faculties that are of a more exalted order, and admit of more refined enjoyments, than any to which the bodily frame can minister; and by pursuing such gratifications, rather than those of mere sense, we fulfil the most exalted ends of our creation, and obtain both a present and a future reward. These things are often said, but they are not therefore the less true, or the less worthy of deep attention. Let us mark their practical application to the occupations and enjoyments of all branches of society, beginning with those who form the great bulk of every community, the working classes, by what names soever their vocations may be called—professions, arts, trades, handicrafts, or common labour.

1. The first object of every man who has to depend upon his own exertions must needs be to provide for his daily wants. This is a high and important office; it deserves his utmost attention; it includes some of his most sacred duties, both to himself, his kindred, and his country; and although, in performing this task, he is only influenced by a regard to his own interest, or by his necessities, yet it is an employment which renders him truly the best benefactor of the community he belongs to. All other pur-

suits must give way to this; the hours which he devotes to learning must be after he has done his work; his independence, without which he is not fit to be called a man, requires first of all that he should have insured for himself, and those dependent on him, a comfortable subsistence before he can have a right to taste any indulgence, either of his senses or of his mind; and the more he learns—the greater progress he makes in the sciences—the more will he value that independence, and the more will he prize the industry, the habits of regular labour, whereby he is enabled to secure so prime a blessing.

In one view, it is true, the progress which he makes in science may help his ordinary exertions, the main business of every man's life. There is hardly any trade or occupation in which useful lessons may not be learnt by studying one science or another. The necessity of science to the more liberal professions is self-evident; little less manifest is the use to their members of extending their knowledge beyond the branches of study with which their several pursuits are peculiarly conversant. But the other departments of industry derive hardly less benefit from the same source. To how many kinds of workmen must a knowledge of Mechanical Philosophy be useful! To how many others does Chemistry prove almost necessary! Every one must with a glance perceive that to engineers, watch-makers, instrument-makers, bleachers, and dyers, those sciences are most useful, if not necessary. But carpenters and masons are surely likely to do their work better for knowing how to measure, which Practical Mathematics teaches them, and how to estimate the strength of timber, of walls, and of arches, which they learn from Practical Mechanics; and they who work in various metals are certain to be the more skilful in their trades for knowing the nature of those substances, and their relations to both heat and other metals, and to the airs and liquids they come in contact with. Nay, the farm servant, or day-labourer, whether in his master's employ, or tending the concerns of his own cottage, must derive great practical benefit,—must be both a better servant, and a more thrifty, and therefore comfortable, cottager, for knowing something of the nature of soils and manures, which Chemistry teaches, and something of the habits of animals, and the qualities and growth of plants, which he learns from Natural History and Chemistry together. In truth, though a man be neither mechanic nor peasant, but only one having a pot to boil, he is sure to learn from science lessons which will enable him to cook his morsel better, save his fuel, and both vary his dish and improve it. The art of good and cheap cookery is intimately connected with the principles of chemical philosophy, and has received much, and will yet receive more, improvement from their application. Nor is it enough to say, that philosophers may discover all that is wanted, and may invent practical methods, which it is sufficient for the working man to learn by rote without knowing the principles. He never will work so well if he is ignorant of the principles; and for a plain reason :—if he only learn his lesson by rote, the least change of circumstances puts him out. Be the method ever so general, cases will always arise in which it must be varied in order to apply ; and if the workman only knows the rule without knowing the reason, he must be at fault the moment he is required to make any new application it. This, then, is the *first* use of learning the principles of science: it makes men more skilful, expert, and useful in the particular kinds of work by which they are to earn their bread, and by which they are to make it go far and taste well when earned.

2. But another use of such knowledge to handicraftsmen is equally obvious: it gives every man a chance, according to his natural talents, of becoming an improver of the art he works at, and even a discoverer in the sciences connected with it. He is daily handling the tools and materials with which new experiments are to be made; and daily witnessing the operations of nature, whether in the motions and pressures of bodies, or in their chemi-

cal actions on each other. All opportunities of making experiments must be unimproved, all appearances must pass unobserved, if he has no knowledge of the principles; but with this knowledge he is more likely than another person to strike out something new which may be useful in art, or curious or interesting in science. Very few great discoveries have been made by chance and by ignorant persons, much fewer than is generally supposed. It is commonly told of the steam-engine, that an idle boy being employed to stop and open a valve, saw that he could save himself the trouble of attending and watching it, by fixing a plug upon a part of the machine which came to the place at the proper times, in consequence of the general movement. This is possible, no doubt; though nothing very certain is known respecting the origin of the story; but improvements of any value are very seldom indeed so easily found out, and hardly another instance can be named of important discoveries so purely accidental. They are generally made by persons of competent knowledge, and who are in search of them. The improvements of the Steam-engine by Watt resulted from the most learned investigation of mathematical, mechanical, and chemical truths. Arkwright devoted many years, five at the least, to his invention of spinning-jennies, and he was a man perfectly conversant in everything that relates to the construction of machinery: he had minutely examined it, and knew the effects of each part, though he had not received any thing like a scientific education. If he had, we should in all probability have been indebted to him for scientific discoveries as well as practical improvements. The most beautiful and useful invention of late times, the Safety-lamp, was the reward of a series of philosophical experiments made by one thoroughly skilled in every branch of chemical science. The new process of Refining Sugar, by which more money has been made in a shorter time, and with less risk and trouble, than was ever perhaps gained from an invention, was discovered by a most accomplished chemist,* and was the fruit of a long course of experiments, in the progress of which, known philosophical principles were constantly applied, and one or two new principles ascertained. But in so far as chance has anything to do with discovery, surely it is worth the while of those who are constantly working in particular employments to obtain the knowledge required, because their chances are greater than other people's of so applying that knowledge as to hit upon new and useful ideas: they are always in the way of perceiving what is wanting, or what is amiss in the old methods; and they have a better chance of making the improvements. In a word, to use a common expression, they are in the way of good

* Edward Howard, brother of the Duke of Norfolk.

luck; and if they possess the requisite information, they can take advantage of it when it comes to them. This, then, is the *second* great use of learning the sciences: it enables men to make improvements in the arts, and discoveries in philosophy, which may directly benefit themselves and mankind.

3. Now, these are the *practical* advantages of learning; but the *third* benefit is, when rightly considered, just as practical as the other two—the pleasure derived from mere knowledge, without any view to our own bodily enjoyments: and this applies to all classes, the idle as well as the industrious, if, indeed, it be not peculiarly applicable to those who enjoy the inestimable blessing of having time at their command. Every man is by nature endowed with the power of gaining knowledge; and the taste for it, the capacity to be pleased with it, forms equally a part of the natural constitution of his mind. It is his own fault, or the fault of his education, if he derives no gratification from it. There is a satisfaction in knowing what others know—in not being more ignorant than those we live with: there is a satisfaction in knowing what others do not know—in being more informed than they are. But this is quite independent of the pure pleasure of knowledge—of gratifying a curiosity implanted in us by Providence, to lead us towards the better understanding of the universe in which our lot is cast,

and the nature wherewithal we are clothed. That every man is capable of being delighted with extending his information upon matters of science will be evident from a few plain considerations.

Reflect how many parts of the reading, even of persons ignorant of all sciences, refer to matters wholly unconnected with any interest or advantage to be derived from the knowledge acquired. Every one is amused with reading a story: a romance may divert some, and a fairy tale may entertain others; but no benefit beyond the amusement is derived from this source: the imagination is gratified; and we willingly spend a good deal of time and a little money in this gratification. rather than in resting after fatigue, or in any other bodily indulgence. So we read a newspaper, without any view to the advantage we are to gain from learning the news, but because it interests and amuses us to know what is passing. One object, no doubt, is to become acquainted with matters relating to the welfare of the country; but we also read the occurrences which do little or not at all regard the public interests, and we take a pleasure in reading them. Accidents, adventures, anecdotes, crimes, and a variety of other things amuse us, independent of the information respecting public affairs, in which we feel interested as citizens of the state, or as members of a particular body. It is of little importance to inquire how and why these things excite our attention, and wherefore the reading about them is a pleasure; the fact is certain; and it proves clearly that there is a positive enjoyment in knowing what we did not know before; and this pleasure is greatly increased when the information is such as excites our surprise, wonder, or admiration. Most persons who take delight in reading tales of ghosts, which they know to be false, and feel all the while to be silly in the extreme, are merely gratified, or rather occupied with the strong emotions of horror excited by the momentary belief, for it can only last an instant. Such reading is a degrading waste of precious time, and has even a bad effect upon the feelings and the judgment.* But true stories of horrid crimes, as murders, and pitiable misfortunes, as shipwrecks, are not much more instructive. It may be better to read these than to sit yawning and idle—much better than to sit drinking or gaming, which, when carried to the least excess, are crimes in themselves, and the fruitful parents of many more. But this is nearly as much as can be said for such vain and unprofitable reading. If it be a

* *Children's books* have at all times been made upon the pernicious plan of exciting wonder, generally horror, at whatever risk. The folly and misery occasioned by this error, it would be difficult to estimate. The time may come when it will be felt and understood. At present, the inveterate habits of parents and nurses prevent the children from benefiting by the excellent lessons of Mrs. Barbauld and Miss Edgeworth.

pleasure to gratify curiosity, to know what we were ignorant of, to have our feelings of wonder called forth, how pure a delight of this very kind does Natural Science hold out to its students! Recollect some of the extraordinary discoveries of Mechanical Philosophy. How wonderful are the laws that regulate the motions of fluids! Is there anything in all the idle books of tales and horrors more truly astonishing than the fact, that a few pounds of water may, by mere pressure, without any machinery—by merely being placed in a particular way, produce an irresistible force? What can be more strange, than that an ounce weight should balance hundreds of pounds, by the intervention of a few bars of thin iron? Observe the extraordinary truths which Optical Science discloses. Can any thing surprise us more, than to find that the colour of white is a mixture of all others—that red, and blue, and green, and all the rest, merely by being blended in certain proportions, form what we had fancied rather to be no colour at all, than all colours together? Chemistry is not behind in its wonders. That the diamond should be made of the same material with coal; that water should be chiefly composed of an inflammable substance; that acids should be, for the most part, formed of different kinds of air, and that one of those acids, whose strength can dissolve almost any of the metals, should consist of the self-same ingredients with the common air we breathe; that salts should be of a metallic nature, and composed, in great part, of metals, fluid like quicksilver, but lighter than water, and which, without any heating, take fire upon being exposed to the air, and by burning, form the substance so abounding in saltpetre and in the ashes of burnt wood: these, surely, are things to excite the wonder of any reflecting mind —nay, of any one but little accustomed to reflect. And yet these are trifling when compared to the prodigies which Astronomy opens to our view: the enormous masses of the heavenly bodies; their immense distances; their countless numbers, and their motions, whose swiftness mocks the uttermost efforts of the imagination.

Akin to this pleasure of contemplating new and extraordinary truths, is the gratification of a more learned curiosity, by tracing resemblances and relations between things, which, to common apprehension, seem widely different. Mathematical science to thinking minds affords this pleasure in a high degree. It is agreeable to know that the three angles of every triangle, whatever be its size, howsoever its sides may be inclined to each other, are always, of necessity, when taken together, the same in amount: that any regular kind of figure whatever, upon the one side of a right-angled triangle, is equal to the two figures of the same kind upon the two other sides, whatever be the size of the triangle: that the properties of an oval curve are extremely similar to those of a curve which appears the least like it of any, consisting of two branches of infinite extent, with their backs turned to each other. To trace such unexpected resemblances is, indeed, the object of all philosophy; and experimental science, in particular, is occupied with such investigations, giving us general views, and enabling us to explain the appearances of nature, that is, to show how one appearance is connected with another. But we are now considering only the gratification derived from learning these things. It is surely a satisfaction, for instance, to know that the same thing, or motion, or whatever it is, which causes the sensation of heat, causes also fluidity, and expands bodies in all directions; that electricity, the light which is seen on the back of a cat when slightly rubbed on a frosty evening, is the very same matter with the lightning of the clouds;—that plants breathe like ourselves, but differently by day and by night;—that the air which burns in our lamps enables a balloon to mount, and causes the globules of the dust of plants to rise, float through the air, and continue their race—in a word, is the immediate cause of vegetation. Nothing can at first view appear less like, or less likely to be caused by the same thing, than the processes of burning and of breathing,—the rust of metals and burning,—an acid and rust,—the influence of a plant on the air it grows in by night, and of an animal on the same air at any time, nay, and of a body burning in that air; and yet all these are the same operation. It is an undeniable fact, that the very same thing which makes the fire burn, makes metals rust, forms acids, and enables plants and animals to breathe; that these operations, so unlike to common eyes, when examined by the light of science are the same,—the rusting of metals,—the formation of acids,—the burning of inflammable bodies,—the breathing of animals,—and the growth of plants by night. To know this is a positive gratification. Is it not pleasing to find the same substance in various situations extremely unlike each other;—to meet with fixed air as the produce of burning, of breathing, and of vegetation;—to find that it is the choke-damp of mines, the bad air in the grotto at Naples, the cause of death in neglecting brewers' vats, and of the brisk and acid flavour of Seltzer and other mineral springs? Nothing can be less like than the working of a vast steam-engine, of the old construction, and the crawling of a fly upon the window. Yet we find that these two operations are performed by the same means, the weight of the atmosphere, and that a sea-horse climbs the ice-hills by no other power. Can anything be more strange to contemplate? Is there in all the fairy-tales that ever were fancied anything more calculated to arrest the attention and to occupy and to gratify the mind, than this most unexpected resemblance between things so unlike to the eyes of ordinary beholders? What more pleasing occupation than to see uncovered and bared before our eyes the very instrument and the process by which Nature works? Then we raise our views to the structure of the heavens; and are again gratified with tracing accurate but most unexpected resemblances. Is it not in the highest degree interesting to find, that the power which keeps this earth in its shape, and in its path, wheeling upon its axis and round the sun, extends over all the other worlds that compose the universe, and gives to each its proper place and motion; that this same power keeps the moon in her path round our earth, and our earth in its path round the sun, and each planet in its path; that the same power causes the tides upon our globe, and the peculiar form of the globe itself; and that, after all, it is the same power which makes a stone fall to the ground? To learn these things, and to reflect upon them, occupies the faculties, fills the mind, and produces certain as well as pure gratification.

But if the knowledge of the doctrines unfolded by science is pleasing, so is the being able to trace the steps by which those doctrines are investigated, and their truth demonstrated: indeed you cannot be said, in any sense of the word, to have learnt them, or to know them, if you have not so studied them as to perceive how they are proved. Without this you never can expect to remember them long, or to understand them accurately; and that would of itself be reason enough for examining closely the grounds they rest on. But there is the highest gratification of all, in being able to see distinctly those grounds, so as to be satisfied that a belief in the doctrines is well founded. Hence to follow a demonstration of a grand mathematical truth—to perceive how clearly and how inevitably one step succeeds another, and how the whole steps lead to the conclusion—to observe how certainly and unerringly the reasoning goes on from things perfectly self-evident, and by the smallest addition at each step, every one being as easily taken after the one before, as the first step of all was, and yet the result being something not only far from self-evident, but so general and strange, that you can hardly believe it to be true, and are only convinced of it by going over the whole reasoning—this operation of the understanding, to those who so exercise themselves, always affords the highest delight. The contemplation of experimental inquiries, and the examination of reasoning founded upon the facts which our experiments and observations disclose, is another fruitful source of enjoyment, and no other means can be devised for either imprinting the results upon our memory, or enabling us really to enjoy the whole pleasures of science. They who found the study of some branches dry and tedious at the first, have generally become more and more interested as they went on; each difficulty overcome gives an additional relish to the pursuit, and makes us feel, as it were, that we have by our work and labour established a right of property in the subject. Let any man pass an evening in vacant idleness, or even in reading some silly tale, and compare the state of his mind when he goes to sleep or gets up next morning with its state some other day when he has passed a few hours in going through the proofs, by facts and reasoning, of some of the great doctrines in Natural Science, learning truths wholly new to him, and satisfying himself by careful examination of the grounds on which known truths rest, so as to be not only acquainted with the doctrines themselves, but able to show why he believes them, and to prove before others that they are true;—he will find as great a difference as can exist in the same being,—the difference between looking back upon time unprofitably wasted, and time spent in self-improvement: he will feel himself in the one case listless and dissatisfied, in the other comfortable and happy: in the one case, if he do not appear to himself humbled, at least he will not have earned any claim to his own respect; in the other case, he will enjoy a proud consciousness of having, by his own exertions, become a wiser and therefore a more exalted creature.

To pass our time in the study of the sciences, in learning what others have discovered, and in extending the bounds of human knowledge, has, in all ages, been reckoned the most dignified and happy of human occupations; and the name of Philosopher, or Lover of Wisdom, is given to those who lead such a life. But it is by no means necessary that a man should do nothing else than study known truths, and explore new, in order to earn this high title. Some of the greatest philosophers, in all ages, have been engaged in the pursuits of active life; and an assiduous devotion of the bulk of our time to the work which our condition requires, is an important duty, and indicates the possession of practical wisdom. This, however, does by no means hinder us from applying the rest of our time, beside what nature requires for meals and rest, to the study of science; and he who, in whatever station his lot may be cast, works his day's work, and improves his mind in the evening, as well as he who, placed above such necessity, prefers the refined and elevating pleasures of knowledge to the low gratification of the senses, richly deserves the name of a True Philosopher.

One of the most delightful treats which science affords us is the knowledge of the extraordinary powers with which the human mind is endowed. No man, until he has studied philosophy, can have a just idea of the great things for which Providence has fitted his understanding—the extraordinary disproportion which there is between his natural strength and the powers of his mind and the force he derives from them. When we survey the marvellous truths of Astronomy, we are first of all lost in the feeling of immense space, and of the comparative insignificance of this globe and its inhabitants. But there soon arises a sense of gratification and of new wonder at perceiving how so insignificant a creature has been able to reach such a knowledge of the unbounded system of the universe—to penetrate, as it were, through all space, and become familiar with the laws of nature at distances so enormous as to baffle our imagination—to be able to say, not merely that the Sun has 329,630 times the quantity of matter which our globe has, Jupiter $308\frac{9}{10}$, and Saturn $93\frac{1}{2}$ times; but that a pound of lead weighs at the Sun 22 lbs. 15 ozs. 16 dwts. 8 grs. and $\frac{3}{4}$ of a grain! at Jupiter 2 lbs. 1 oz. 19 dwts. 1 gr. $\frac{20}{43}$; and at Saturn 1 lb. 3 ozs. 8 dwts. 20 grs. $\frac{1}{11}$ part of a grain! And what is far more wonderful, to discover the laws by which the whole of this vast system is held together and maintained through countless ages in perfect security and order. It is surely no mean reward of our labour to become acquainted with the prodigious genius of those who have almost exalted the nature of man above its destined sphere, when, admitted to a fellowship with these loftier minds, we discover how it comes to pass that, by universal consent, they hold a station apart, rising over all the Great Teachers of mankind, and spoken of reverently, as if NEWTON and LAPLACE were not the names of mortal men.

The highest of all our gratifications in the contemplations of science remains: we are raised by them to an understanding of the infinite wisdom and goodness which the Creator has displayed in his works. Not a step can we take in any direction without perceiving the most extraordinary traces of design; and the skill everywhere conspicuous is calculated, in so vast a proportion of instances, to promote the happiness of living creatures, and especially of our own kind, that we can feel no hesitation in concluding that, if we knew the whole scheme of Providence, every part would be found in harmony with a plan of absolute benevolence. Independently, however, of this most consoling inference, the delight is inexpressible of being able to follow, as it were, with our eyes, the marvellous works of the Great Architect of Nature —to trace the unbounded power and exquisite skill which are exhibited in the most minute, as well as the mightiest parts of his system. The pleasure derived from this study is unceasing, and so various, that it never tires the appetite. But it is unlike the low gratifications of sense in another respect: while those hurt the health, debase the understanding, and corrupt the feelings, this elevates and refines our nature, teaching us to look upon all earthly objects as insignificant, and below our notice, except the pursuit of knowledge and the cultivation of virtue; and giving a dignity and importance to the enjoyment of life, which the frivolous and the grovelling cannot even comprehend.

Let us, then, conclude, that the Pleasures of Science go hand in hand with the solid benefits derived from it; that they tend, unlike other gratifications, not only to make our lives more agreeable, but better; and that a rational being is bound by every motive of interest and of duty, to direct his mind towards pursuits which are found to be the sure path of Virtue as well as of Happiness.

OBJECTS,

PLEASURES, AND ADVANTAGES

OF

POLITICAL SCIENCE.

OBJECTS, &c.

THE Sciences which form the subject of our most useful study, and which, next to the cultivation of religion and the practice of virtue, are the source of our purest enjoyments in this world, may be divided into three great classes or branches, according to their several objects. Those objects are—the Relations of Abstract Ideas—the Properties of Matter—the Qualities of Mind. All the subjects of scientific research may be classed under one or other of these three heads; and all the sciences may, accordingly, be ranged under one or other branch of a corresponding threefold division.

To the first branch belong the abstract ideas of quantity—that is, of space in its different forms and portions; and of these the science of Geometry treats;—the abstract ideas of number, which form the subject of Arithmetic, general or particular, the one called Algebra, the other Common Arithmetic, the comparison and classification of all ideas, generally, whether abstract or not, and whether relating to matter or mind; and this forms the subject of Logic, or the science of reasoning and classification.

The first branch deals with mere abstract ideas, and has no necessary reference to actual existences; these form the subjects of the other two, which, accordingly, do not, like the former, rest wholly upon reasoning, but depend upon experience also. The one branch relating to matter, its properties and motions, is termed Physics,* or Natural Philosophy; the other, relating to the nature and affections of the mind, is termed Metaphysics or Psychology,† or Moral or Mental Philosophy.

Physical or Natural Philosophy is subdivided into various branches: one, for example, treating of weight and motion, is called Dynamics, or Mechanics and Statics; another, treating of the heavenly bodies, is termed Astronomy; another, of light, is termed Optics; another, of the qualities and composition of substances, called Chemistry; another, of the properties of living bodies, called Anatomy and Physiology; another, of the classification of substances and animals, called Natural History. To all of these accurate observation and experiment may be applied, and to some of them mathematical principles, by which extraordinary

* From the Greek word signifying natural objects or qualities.

† From the Greek word signifying to discourse of the soul or mind.

progress has been made in extending our knowledge of the laws of nature.

Moral or Mental Philosophy consists of two great subdivisions: one treating of the powers, faculties, and affections of the mind—that is, its intellectual as well as its moral or active powers—the faculties of the understanding and those of the will, or our appetites and feelings as well as our intellects—and this branch treats of all spiritual existences, from the Great First Cause, the Creator and Preserver of the universe, to the mind of man and his habits, and down to the faculties and the instincts of the lower animals. This division is sometimes called Psychology, when that phrase is not used for the whole of moral science. The other subdivision treats of our duties towards the Deity and towards our fellow-creatures, and is generally termed Ethics.* But perhaps the better and more correct division of the whole of Moral Philosophy is to consider it in two points of view—as it treats of man in his individual capacity; and man as a member of society. This last branch is termed Political † Science, and forms the subject of the following Discourse.

We have already adverted to one important cir-

* From the Greek for morals.

† From the Greek for city or state—the different communities in Greece having originally been cities and their adjoining territories.

cumstance which distinguishes both the two branches of science which treat of actual existences from those which treat of abstract ideas and their relations. The truths of both Natural and Moral Philosophy differ from those of abstract science in this important particular, that they partly depend on experience and not exclusively on reasoning; they are contingent, and not necessary; the world, moral and material, might have been so constructed as to render untrue all things now known to be true respecting it; whereas the truths of abstract science, arithmetic for example, are independent of all contingencies, and do not result from any experience, and could not possibly have been different from what they are. It is easy to conceive a world in which bodies should attract each other by a wholly different law from that of gravitation; but we cannot form to ourselves the idea of any state of things in which two and two should not be equal to four, nor the three angles of a triangle equal to two right angles. It follows that, in the sciences both of matter and of mind, we must be content with evidence of an inferior kind to that which the mathematical sciences employ; and resting satisfied with as high a degree of probability as we can attain, must draw our practical conclusions with the hesitation which such a liability to error naturally prescribes.

The first, or abstract branch, is capable of application to the other two. The precision with which the qualities and the functions of matter are observable, and the ease with which these may be subjected to experiment, enable us to investigate them with great facility, and to draw our general conclusions with much certainty. But this power is greatly increased by the use of mathematical principles, which enable us to deduce general inferences from observed facts, the truth of which facts being admitted, those inferences follow as absolute and necessary, and not as matter of contingent truth. Thus the observations of astronomers show certain appearances of the heavenly bodies; the observations of mechanicians show certain things respecting falling bodies on our globe. But suppose the truth of such observations to be admitted, mathematical reasoning shows, without the possibility of error or of doubt, that the power of gravitation extends to the heavens, and that the planets wheel round the sun as their centre by the same power which makes a stone fall to the ground if unsupported. This inference is a certain and necessary truth, if the facts be true which our observation teaches; and such a mixture of necessary with contingent truths, forms a very large portion of Physics, or Natural Philosophy. But it is only in a few cases that we can obtain the aid of mathematical reasoning to render our inferences certain and necessary from facts observed in the science of mind, as it is also comparatively few observations and experiments that we are enabled to make upon its qualities. Hence there is a far less degree of certainty in this than we can attain in the physical sciences, and hence we ought to be doubly on our guard against dogmatism and intolerance of other men's opinions in all the departments of this less exact philosophy. The controversies which have oftentimes arisen among metaphysicians, strongly illustrate how little the positive dogmatism and exclusive intolerance of men holding one class of opinions towards those who held another, was in proportion to the degree of evidence upon which their inquiries proceeded. Mathematicians who run hardly any risk of error—naturalists who run but little more—have never been so bigoted and so uncharitable as those whose speculations are fated to be always involved in more or less of doubt; and when we come to political reasoners, we find, beside the intolerance of metaphysicians, a new source of error and of fault in the excitement which the interests of men, real or supposed, lend to their passions.

It would, however, be an equally groundless and a very pernicious error to run from the extreme of dogmatism into the extreme of scepticism, and to suppose that because the evidence upon which our conclusions in moral science rest is inferior to the proofs of mathematical, and even of physical truth, therefore we cannot trust the deductions of ethical principles, or their applications to the affairs of men as members of political communities. The more nice and subtle points of metaphysical philosophy are those upon which the chief doubts prevail. Some portions of psychology are placed above the reach of the human faculties, as indeed are some of the more intimate qualities of matter; and it is eminently improbable that we shall ever be able to ascertain the essential nature of mind; but so no more are we ever likely to ascertain the ultimate cause of gravitation, or to penetrate into the laws which govern the primary combinations of material particles. Still, the more important, because the more practical, subjects of our inquiries into the nature of the human mind, the laws which govern man's habits as an individual, and the principles of human action upon which the structure of society and its movements depend, are not placed on such unapproachable heights. Within certain limits, safe conclusions can be drawn respecting these important matters. Facts may be observed, collected, and generalized, not, certainly, with the perfect accuracy which can be attained in the inductions of physical science, yet still with sufficient correctness to form the groundwork of safe practical inferences. General principles of Moral and Political Science may thus be established, by reasoning upon the results of experience; and from those principles, rules for our guidance may be drawn, highly useful both in the regulation of the individual understanding, and in managing the concerns of communities of men. To deny that Morals and Politics may be reduced to a science, because the truths of Natural Philosophy rest upon more clear evidence and assume a more precise form, would be as absurd as to deny that experimental science is deserving of the name, because its proofs are more feeble, and its propositions less definite and less closely connected together than those of pure mathematics.

But it is more especially with Political Philosophy that we have now to do; and there are many reasons why its truths should be better capable of clear demonstration and of distinct statement than those of the other branches of Moral or Ethical Science.

1. In the first place, although each individual by his consciousness is continually in a situation that enables him to make observations on the human faculties by attending to the operations of his own mind, yet we know that hardly any habit is later acquired by the few who ever learn it at all, than the habit of turning the observation inwards, and making the mind the subject of its own contemplations. It is a process, indeed, which not one person in a hundred thousand ever thinks of undertaking. But the bulk of mankind are political observers. The operations of government, the habits and pro-

ceedings of the people, the conduct of communities, their fortunes and their fate, form the daily subject of reflection with all persons even of an ordinary degree of intelligence in every civilized country, and do not escape the observation of the bulk of the people, even in communities subject to such restraints from the structure of their governments, as to render the open discussion of such matters hardly possible in any class of society. Hence the observation of facts on political subjects is performed almost universally at all times, whether these facts are collected and classified or not.

2. It follows, in the next place, that the appetite for knowledge of this description is far more generally diffused than for either moral or ethical knowledge; that numberless bodies of men in every country conceive themselves interested in political subjects, who would regard metaphysical speculations as wholly foreign to their concerns; and that there prevails everywhere a strong desire for such information, unless in places where misgovernment may have actually reduced the minds of the community to a state bordering upon the dulness and insensibility of the brute creation.

3. Thirdly. The facts on which Political Science rests are more plain, manifest, and tangible, than those which form the subject of Moral Philosophy in its other branches. Those facts are more obvious; they are perceptible in most cases to the senses;

they are reducible to number and measure. The accumulation or diminution of public wealth,—the prosperity or suffering of the people,—the progress of population,—the quiet or disturbed state of a country,—the prevalence of one portion or order of a state over the others,—the effect of a particular form of government,—the changes consequent upon its altered structure; all these are matters of distinct observation, and most of them subject to exact calculation. But these, and such as these, are the facts upon which the doctrines of Political Science are grounded, and these doctrines are the results of reasoning upon such facts.

4. Fourthly. The mere facts themselves connected with political science are far more important and far more interesting than those on which the other branches of moral philosophy rest. The peculiar action of the intellectual faculties, or of the feelings and passions, is not a subject of great extent. All we know of it is soon told, and there is but little variety in different individuals as far as it is concerned. Different characters may be described, and the history of individuals affords great entertainment, as well as the matter of much interesting reflection; but unless their actions are also comprehended in the narrative, the interest flags, and the story can scarcely go on; and those actions almost always come within the province of Political Science. The intellectual or moral habits

of men as individuals, apart from their conduct, form a small and not an extremely interesting chapter in the history of man. But how different are those facts with which the political observer is concerned! The mere history of national affairs—the narrative of those public events which take place—the changes in the condition and fortunes of whole communities—their relations with each other, whether in peace or war—the rise and decay of great institutions affecting the welfare of millions—the progress of a policy upon which the happiness, nay, the very existence of whole nations depends—the varieties in the governments under which they live—the influence of those Governments upon the condition of the people—the effects which they produce upon their intercourse with other countries,—all these are subjects of most interesting contemplation in themselves, as mere facts, wholly independent of any general views to which they may lead, or of any practical conclusions which may be derived from them.

Mr. Hume has written an ingenious and a sound dissertation, to prove that Politics—meaning the branch which treats of the structure of governments—may be reduced to a science; and he illustrates this by deducing from Political History certain general principles which must at all times and in all circumstances hold true. But whether he be right or not, even if there were no means of drawing such strictly and universally true inferences, at least the importance of the facts which the political reasoner deals with must be confessed, and the great interest which attaches to the mere knowledge of those facts cannot be doubted.

5. Lastly. We may observe that, the facts in question being of a public nature, and so known to the world at large, a better security is afforded for their being accurately observed and truly recorded. History, statistics, the narrative of public events, the details of national affairs,—these are the sources from which the political reasoner draws his facts. Established institutions, bodies of law, universally known customs, wars, treaties, the manifest state of the world in its various regions at different times, these are the facts upon which the political philosopher reasons, which he generalizes, from which he draws his conclusions, on which he builds his systems. But we shall be the better able to appreciate the peculiar excellence of this study if we now take a survey of the science itself, and thus present, as it were, a map of it to the eye, with the natural limits and boundaries of the various provinces into which it is divided.

The great family of mankind dispersed over the earth occupy its various portions in various bodies or communities, each bound together by certain ties, and bearing in those portions a general resemblance to, or having distinctive features in which they differ from, the rest. These communities differ in their customs, character, and institutions; in their general circumstances and degree of civilization. The nature of their institutions,—of the various establishments for public purposes which exist for the management of their common affairs,—of the regimen under which and the rules by which the members of each community, whether compelled by force, or agreeing voluntarily, continue to live;—in a word, the Domestic Management of each state—forms the subject of the first great branch or province of Political Science. The second relates to the intercourse of different communities with each other; the mutual relations of the different communities; the principles or rules established for their demeanour towards one another;—in a word, the external affairs of each state, but the national concerns of the whole considered as one general community, the members of which are not individuals but separate states. The former province is called Domestic Policy—the latter, Foreign or International Policy.

Domestic Policy is subdivided into two branches.

Each community must be subject to some kind of rule, or regimen, or government; some force established for restraining the excesses of individuals, for preventing wrongs and creating and protecting rights, and for superintending those things which are necessary to the public security and conducive to the public benefit, but which, if left to individuals, never could be accomplished at all, and finally, for representing the community in its intercourse with other states. The nature of this rule or government differs in different countries from the accidents of events, and from the peculiarities of natural situation and of national character. The different forms of government,—the distribution in each state of the power by which its people are ruled,—the arrangements which result from these diversities,—their influence upon the security, improvement, comfort, and happiness of the people in each—are the facts from which the principles must be drawn which constitute the Science of Government.

This science, then, forming the first great subdivision of Domestic and National Polity, treats of two important matters,—first, the Principles relating to the establishment of all Government generally, and on which the establishment of the social relation, the formation of any connection between the ruler and the people, depends; and, secondly, the principles relating to the distribution of power in different states,—in other words, the different Constitutions or Forms of Government in different countries.

But there is another great subdivision of Domestic Polity, not inferior in importance to the former, and, although intimately connected with it, yet easily distinguishable from it. The manner in which men manage their private concerns,—the course they pursue in their dealings with each other,—their way of exerting their industry for their subsistence, or comfort, or indulgence,—these proceedings may take place independent of the form of government under which they live; and, indeed, as no ruler has anything to do with them, if each government did its duty, these proceedings would go on nearly in the same way under all governments, and only be affected incidentally by the difference in the form of each. Although, therefore, the interference of governments directly, and their influence indirectly, may affect men's conduct of their own affairs, still the principles which regulate that conduct, and the effects resulting from it, form a subject of consideration evidently distinguishable from that of government. This subject, then, relates to the wealth, the population, the education, of the people; and the conduct of the government, in respect to these particulars, forms an important part of the discussion. This branch of the subject is termed Economics, or Political Economy, because it relates to the management of a nation's domestic affairs as private economy does to the affairs of a family. The most important subject of Political Economy is the accumulation and distribution of wealth in all its branches, including foreign and colonial as well as domestic commerce. But it also treats of the principles which regulate the maintenance, increase, or diminution of population,—the religious and civil education of the people,—the provisions necessary for securing the due administration of justice, civil and criminal, and, as subservient to these, the maintenance of police—the measures required for supporting the public expenditure or the financial system—the precautions necessary for the public defence or the military system—and generally all institutions, whether supported by private exertions or by the state, the objects of which are of a public nature.*

Intimately connected with Political Economy, and, indeed, running as it were through all its subdivisions, is Political Arithmetic, or the application of figures to the various subjects of which Political Economy treats,—as the details of public wealth, commerce, education, finance, population, civil and military establishments, all of which may be made more or less the subject of calculation from given facts. Statistics, or the record of all the facts relating to the actual situation of different countries, in these several respects, is, properly speaking, a branch of Political Arithmetic.

The function of making those laws which are

* These subjects may be separated from Political Economy and treated under the head of Functions of Government; they come under what the French call *le Droit Administratif.*

required from time to time for the government of a community, is vested in the supreme power of the State ; and the important office of Legislation, accordingly, is variously performed in different countries according to the different constitutions of each. In all States a great portion of the law is derived from custom, handed down by tradition and acted upon in practice, through a succession of ages. This is called Common or Unwritten Law, as contradistinguished from Statute or Written Law; and though some nations have from time to time reduced to writing the provisions of the Common Law, thus furnishing themselves with Codes which comprehended all their laws, yet in all Systems of Law the distinctions between the two species may be traced ; and even where a Code exists, it is known what portions of it were once Customary or Common Law, because the other, or Statutory enactments, are known to have been first introduced at a particular time, whereas the Common Law had been used before it was reduced into writing. The different laws of each State range themselves under the various heads to which they belong, those heads being the different subdivisions of the two great branches of Domestic Policy—the Political and Economical—already referred to. But there are certain general principles of Legislation which are of universal application, just as there are certain principles relating to Government, and certain principles relating to Economics, which are general, and do not depend upon the particular institutions established, or the particular systems adopted in different countries. The science of Jurisprudence treats of those general principles, and may be reckoned an appendix, but a most important one, to the branch of Domestic Policy.

The other main branch of Political Science considers nations as individuals forming a portion of a larger community—a community of nations; and treats of the principles which ought to govern them in their mutual intercourse. Those views which form the foundation of this science of Foreign or International Policy, are evidently, from their nature, a refinement introduced in a late period of society, because those views assume that communities, each of which is supreme and can have no superior on earth, are willing to regard themselves as subject to certain rules in their intercourse with other nations,—rules which no common chief can enforce, but the observance of which is rendered expedient by the interests of all, and which, therefore, are generally regarded as binding.

These rules are either those of sound policy or those of strict justice. The former class presents certain maxims as useful in regulating the conduct of nations towards each other, in order to provide for the general security, by preventing any one from becoming too powerful, and thus dangerous to the independence of the others. The latter class acknowledges certain rights as belonging to each community, and denounces the infraction of these rights as a public wrong, giving the injured party a title to seek redress by force. Thus this Second Branch of political science consists of two subdivisions,—the one treats of the principles of *policy* which should guide nations in their mutual intercourse of peace and war, in the negotiation of treaties, the formation of alliances offensive and defensive, the combination of weak States to resist a stronger one, the precautions necessary for preventing too great acquisition of strength by any one State to the derangement of what is termed the general Balance of Power. These principles form the subject of Foreign Policy. The other subdivision treats of the *rights* of nations,—those rights in peace and war which are by common consent admitted to belong to each, because the common interests of humanity, the prevention of war, and the mitigation of its evils when it does occur, require some such general understanding and consent; and the rules relating to this second subdivision are called the Law of Nations or International Law—of which the true description is, that it forms the code by which the great community of nations are governed, or ought to be governed, in their conduct towards each other, as Municipal Law is the code by which the individual members of any particular community are governed in their intercourse with one another. It is a very common error to confound with this branch of law many of the general principles of jurisprudence applicable to all nations, and to term these a portion of the Law of Nations.*

It is obvious that of all sciences which form the subject of human study, none is calculated to afford greater pleasure, and few so great to the student, as the important one of which we have just been describing the nature and the subdivisions. In common with the different branches of Natural Philosophy, it possesses all the interest derived from the contemplation of important truths, the first and the purest of the pleasures derived from any department of science. There is a positive pleasure in that exercise of the mental faculties which the investigation of mathematical and physical truth affords. The contemplation of mathematical and physical truths is, in itself, always pleasing and wholesome to the mind. There is a real pleasure in tracing the relations between

* In the following series the subject of Jurisprudence and International Law will be only treated incidentally, as the other matters to which they relate require, and not under separate heads. The same may be said of the other division of the second branch, namely, Foreign Policy, a conduct prescribed to nations by their mutual interests in their mutual intercourse.

figures and between substances, the resemblances unexpectedly found to exist among those which seem to differ, the precise differences found to exist between one figure and another, or one body and another. Thus, to find that the sum of the angles of all triangles, be their size or their form what it may, is uniformly the same, or that all circles, from the sun down to a watch-dial, are to each other in one fixed proportion, as the squares of their diameters, is a matter of pleasing contemplation which we are glad to learn and to remember from the very constitution of our minds. So there is a great, even an exquisite pleasure in learning the composition of bodies, in knowing, for instance, that water, once believed to be a simple element, is composed of the more considerable of two substances, which make, when united with heat in a certain form, the air we burn and the air we breathe; that rust is the combination of this last substance with metals; that flame is supported by it; that respiration is performed by means of it; that rusting, breathing, and burning, are all processes of the same kind; that two of the alkaline salts are themselves rusts of metals, one of these metals being lighter than water, burning spontaneously when exposed to the air, without any heat, and forming the salt by its combination. To know these things, and to contemplate such relations between bodies or operations seemingly so unlike, is in a high degree delightful, even if no practical use could be made of such knowledge. So the sublime truths of astronomy afford extensive gratification to the student. To find that the planets and the comets which wheel round the sun with a swiftness immensely greater than that of a cannon-ball, are retained in their vast orbits by the same power which causes a stone to fall to the ground; that this power, with their various motions, moulds those bodies into the forms they have assumed; that their motions and the arrangement of their paths cause their mutual action to operate in such a manner, as to make their course constantly vary, but also to prevent them from ever deviating beyond a certain point, and that the deviation being governed by fixed rules, never can exceed in any direction a certain amount, so as to preserve the perpetual duration of the system;—such truths as these transport the mind with amazement, and fill it with a pure and unwearying delight. This is the first and most legitimate pleasure of philosophy. As much and the like pleasure is afforded by contemplating the truths of Moral Science. To trace the connection of the mental faculties with each other; to mark how they are strengthened or enfeebled; to observe their variety or resemblance in different individuals; to ascertain their influence on the bodily functions, and the influence of the body upon them; to compare the human with the brute mind; to pursue the various forms of animal instinct; to examine the limits of instinct and reason in all tribes;—these are the sources of as pleasing contemplation as any which the truths of abstract or of physical science can bestow; from these contemplations we reap a gratification unalloyed with any pain, and removed far above all risk of the satiety and disgust to which the grosser indulgences of sense are subject. But the study of Political Science is equally fertile in the materials of pleasing contemplation. The examination of those principles which bind men together in communities, and enable them to exercise their whole mental powers in the most effectual and worthy manner; the knowledge of the means by which their happiness can be best secured and their virtues most promoted; the examination of the various forms in which the social system is found to exist; the tracing all the modifications which the general principles of ethics and of polity undergo in every variety of circumstances, both physical and moral; the discovery of resemblances in cases where nothing but contrasts might be expected; the observation of the effects produced by the diversities of political systems; the following of schemes of polity from their most rude beginnings to their greatest perfection, and pursuing the gradual development of some master-principle through all the stages of its progress—these are studies which would interest a rational being, even if he could never draw from them any practical inference for the government of his own conduct, or the improvement of the society he belonged to—nay, even if he belonged to another species and was merely surveying the history and the state of human society as a curious observer, in like manner as we study the works of the bee, the beaver, and the ant. How prodigiously does the interest of such contemplations rise when it is the political habits of our own species that we are examining, and when, beside the sympathy naturally felt in the fortunes of our fellow-creatures of other countries, at every step of our inquiry we enjoy the satisfaction of comparing their institutions with our own, of marking how far they depart from the same model, and of tracing the consequences of the variety upon the happiness of millions of beings like ourselves! How analogous is this gratification to the kindred pleasure derived from Comparative Anatomy, which enables us to mark the resemblances and the differences in structure and in functions between the frame of other animals and our own!

From the contemplation of political truth our minds rise naturally, and by a process also of legitimate reasoning like that which discovers those truths, towards the great Creator of the universe, the Source of all that we have been surveying by the light of science—the Almighty Being who made the heavens and the earth, and sustains the frame of the world by the word of His power. But He also created the mind of man, bestowed upon him a thinking, a reasoning, and a feeling nature, placed him in a universe of wonders, endowed him with faculties to comprehend them, and to rise by his meditation to a knowledge of their Great First Cause. The Moral world, then, affords additional evidence of the creating and preserving power, and its contemplations also raise the mind to a communion with its Maker. Shall any doubt be entertained that the like pleasing and useful consequences result from a study of Man in his political capacity, and a contemplation of the structure and functions of the Political world? The nice adaptation of our species for the social state; the increase of our powers, as well as the multiplication of our comforts and our enjoyments, by union of purpose and action; the subserviency of the laws governing the nature and motions of the material world to the uses of man in his social state; the tendency of his mental faculties and moral feelings to further the progress of social improvement; the predisposition of political combinations, even in unfavourable circumstances, to produce good, and the inherent powers by which evil is avoided, compensated, or repaired; the singular laws, partly physical and partly moral, by which the numbers of mankind are maintained, and the balance of the sexes preserved with unerring certainty ;—these form only a portion of the marvels to which the eyes of the political observer are pointed, and by which his attention is arrested ; for there is hardly any one political arrangement which by its structure and functions does not shed a light on the capacities of human nature, and illustrate the power and the wonders of the Providence to which man looks as his Maker and Preserver. Such contemplations connected with all the branches of science, and only neglected by the superficial or the perverted, are at once the reward of philosophic labour, the source of true devotion, the guide of wise and virtuous conduct: they are the true end of all our knowledge, and they give to each portion of it a double value and a higher relish.

The last—but in the view of many, probably most men, the most important—advantage derived from the sciences is their practical adaptation to the uses of life. It is not correct—it is the very reverse of the truth—to represent this as the only real, and, as it were, tangible profit derived from scientific discoveries or philosophical pursuits in general. There cannot be a greater oversight or greater confusion of ideas than that in which such a notion has its origin. It is nearly akin to the fallacy which represents profitable or productive labour as only that kind of labour by which some substantial or material thing is produced or fashioned. The labour which of all others most benefits a community, the superior order of labour which governs, defends, and improves a state, is by this fallacy excluded from the title of productive, merely because, instead of bestowing additional value on one mass or parcel of a nation's capital, it gives additional value to the whole of its property, and gives it that quality of security without which all other value would be worthless. So they who deny the importance of mere scientific contemplation, and exclude from the uses of science the pure and real pleasure of discovering, and of learning, and of surveying its truths, forget how many of the enjoyments derived from what are called the practical applications of the sciences, resolve themselves into gratifications of a merely contemplative kind. Thus, the steam-engine is confessed to be the most useful application of machinery and of chemistry to the arts. Would it not be so if steam-navigation were its only result, and if no one used a steam-boat but for excursions of curiosity or of amusement? Would it not be so if steam-engines had never been used but in the fine arts? So a microscope is a useful practical application of optical science as well as a telescope—and a telescope would be so, although it were only used in examining distant views for our amusement, or in showing us the real figures of the planets, and were of no use in navigation or in war. The mere pleasure, then, of tracing relations, and of contemplating general laws in the material, the moral, and the political world, is the direct and legitimate value of science; and all scientific truths are important for this reason, whether they ever lend any aid to the common arts of life or no. In like manner the mental gratification afforded by the scientific contemplations of Natural Religion are of great value, independent of their much higher virtue in mending the heart and improving the life,—towards which important object, indeed, all the contemplations of science more or less directly tend,—and in this higher sense all the pleasures of science are justly considered as Practical Uses.

But the applications to the common affairs of life, which generally go by that name, are also of great value. The Physical Sciences are profusely rich in these. The speculations of the moralist are also of great value in teaching us the discipline of the understanding, in improving the feelings, and in cultivating virtuous sentiments; they are of still greater service in helping those concerned about the government of men. But the study of Political Philosophy is certainly, of all others, the most fruitful in beneficial results of what is usually called a practical kind. If almost proverbially "the proper study of mankind is man," the most important application of the doctrines which moral science teaches respecting his nature is unquestionably that whereby we learn his position, habits, interests, rights, and duties as the member of a civil community. The science which treats of the structure of government, which makes the experience of one age or nation benefit another, and save it the price, and inconvenience, and delay of failure, pointing out the errors committed in various systems of civil or commercial polity, showing how these are to be corrected or shunned, and showing how such systems may most effectually and most safely be improved so as to secure the happiness of the people—the science which expounds the best modes of legislation, the true principles of jurisprudence, the more efficacious manner of executing, as well as of making laws—which defines the rights of the people and their duties, as well as those of their rulers, explains the rights of one nation with respect to another, and shows both the duty and the wisdom of combining order with freedom at home, and independence with peace abroad:—surely this science, if it be not, of all others, the most useful to every state, nay to every individual citizen at every period, at least yields to none in real practical importance. The benefits which it helps us to obtain, the errors which it leads us to correct, the dangers which it enables us to avoid, are the most important, because those benefits, and errors, and dangers affect the whole affairs of nations, and nearly concern every individual member of the community directly or indirectly. Nothing can be more plain than this proposition; but incidentally it will derive additional illustration when we now proceed to consider the objections which have been sometimes raised against teaching it. To take only one illustration at present—how nearly does the advantage resulting from the examination of foreign constitutions resemble the benefits derived to human Physiology from studying the anatomy of the lower animals! This branch of Political Science may be justly termed the Comparative Anatomy of Government; and if studied with a constant regard to general principles of policy, their illustration from the structure and functions of various systems of polity, and the modification they undergo by the diversities of each, this science is calculated to throw useful light on the general subject of Political Philosophy, and lend us valuable improvement to the knowledge of our own system, exactly as the Comparative Anatomy of the body extends our knowledge of Physiology, and improves our acquaintance with the human frame.

No one has ever, in any free state, hardly in any civilized country, denied the advantages of Political Science, or objected to its being learnt by certain classes; nothing so absurd was ever yet attempted.

But an opinion at one time prevailed, and it still has some adherents, that political subjects are not fit for discussion among the great body of the people, and that, therefore, many who do not deny the propriety of instructing them in other branches of knowledge, have objected to their being taught the doctrines of Political Philosophy. The rich and the powerful might study such matters; the rulers and the lawgivers of the country, or the upper classes of the community, might learn them, and treatises might be written for, or lectures delivered to, them and their children, or addressed to other select circles, upon the great subjects of National Polity: but the people were to care for none of these things,—they might read a newspaper or attend an election meeting; but political knowledge was a thing above their reach and out of their line,—a thing for their betters, and with which it was both useless and perilous for the working classes to meddle. The time is certainly past and gone, never to return, when such preposterous doctrines could find any general acceptance in this country or in France; though in other parts of Europe they still are found to pass current. Yet even in France, Germany, and England herself, a modification of the same fallacy is to be traced as influencing the judgments of many respectable men, even of some whose general opinions are not bigoted or illiberal: it leads to the entertaining a strong prejudice against the diffusion of political knowledge, to a wish that the people at large could be cured of their taste for it, and to an alarm at the dangers likely to result from it to the peace and good order of society. It becomes a duty, therefore, to examine a little more closely this objection, and see whether it really has any force. Let us begin by stating the argument used by the objectors; but, first of all, let us observe that the main objection is to Politics, as contradistinguished from Political Economy; that is, to the first subdivision of the great branch of Domestic Policy. Of its other subdivisions, Economic Science, and of the second branch, International Policy, the objectors are more careless, and some would rather have the former of these—Political Economy—taught, provided Politics, commonly so called,—that is, the principles, and structure, and functions of government, were exempt from the public scrutiny, and withdrawn from the province of the popular teacher.

The argument of the objectors is this,—No human institution is or can be perfect: and the governments established in all the countries of Europe having their origin in early and unenlightened times, necessarily partake more or less largely of the imperfection incident to the works of man. They present, therefore, many points of objection to those who live in a more refined period of society; nor is it possible to deny that many things would be avoided as absurd or pernicious in the present times, if we had now to frame, for the first time, our political institutions. It thus becomes impossible to examine either our own or other systems of government without pointing out many faults in them; nor can the sound principles of civil polity be unfolded without leading to inferences disparaging to the system we live under. Nay, it would be impossible, and, if it were possible, it would be dishonest to shun the reference to existing circumstances and the established order of things in explaining the fundamental principles of sound policy, against which the institutions of the state are found clearly to sin. Hence it is argued, that the people, being thus taught, are rendered discontented with their government, and excited to a desire of change.

1. We may begin by observing that much of the real force of this objection is presented against a factious, unfair, exaggerated discussion of political subjects, undertaken in the disguise of a fair and honest course of instruction. That treatises, and still more, lectures to the people, may have a pernicious effect if the teacher abuses his office, and makes himself a partisan or a demagogue, is not denied. But it by no means follows that the science of government may not safely be taught. For, after all, it is a practical, an experimental

science. If there be no real mischiefs occasioned by any alleged defects in any given system of polity,—if the evils charged upon it are merely speculative and almost nominal,—if the people do not feel any inconvenience from them,—if they produce no consequences which are generally seen, and by all who observe them freely admitted,—nay, if the evils be not actually felt as well as remarked and confessed,—we may be well assured that the allegation of the defects existing will be received as groundless, because, practically speaking, the arrangement called in question is not defective. No argument in a speech, no exhortation in a treatise or a lecture, can make men think they are oppressed, or ill governed, or suffering in any way, when they are in reality free and happy; or can succeed to a considerable extent in persuading the audience or the disciples that they are uncomfortably circumstanced, and ought to be discontented, when they know and feel that they are living at their ease and ought to be satisfied.

2. But suppose the defects do exist, and that the people suffer under them, it is fit and proper that the causes of the evil should be probed, and should be pointed out without any reserve. It is certain that the not doing so will never prevent the people from feeling discontented; on the contrary, if they are left to feel the pressure, and do not know distinctly from whence it proceeds, both their discon-

tent is likely to be increased beyond its just amount, and it is likely to take a wrong direction. The lessons taught by honest and skilful instructors will both reduce the complaint within the bounds of moderation, and prevent blame from being imputed to harmless measures, inoffending men, and unexceptionable institutions. If any illustration were wanting of the dangers to which the peace as well as the general prosperity of a country may be exposed from popular ignorance, we might instance the disturbances so often arising in all parts of the world from the popular indignation against the exporters of corn during a scarcity, or the use of machinery in times of manufacturing distress. But ignorance of the nature of government may produce the like mischiefs.

The necessity of some considerable degree of restraint to the well-being of society—the impossibility of the supreme power being left in the hands of the whole people—the fatal effects of disregarding the right of property, the great corner-stone of all civil society—the interest which all classes down to the humblest have in the protection afforded by law to the accumulation of capital—the evils of resistance to established government unless in extreme and therefore very rare cases—the particular interest which the whole people, low as well as high, must ever have in general obedience to the supreme power in the state—the almost uniform necessity of making all changes, even the most salutary, in any established institution, gradually and temperately—all these are the very first lessons which every political teacher must inculcate if he be fit for his office, and commonly honest, and he cannot move many steps in any direction through his subject, without finding occasion to illustrate and to enforce these fundamental lessons by the constant experience of mankind. But what are these lessons? They are the very doctrines of good order and of peaceful conduct; they are the most powerful incentives to submission—a submission the more to be relied on, because it is rational, and results from an appeal to men's reason, not from an overruling force—the well considered submission of well-informed and therefore well-disposed men, not the blind obedience of ignorant slaves. Let the body of the people be kept ever so much in the dark upon the nature of government and the state of their own concerns, the existence of evils being admitted, the smarting under them will come without any teaching; but the more they learn the better they will be able quietly to bear them. Let the people be ever so ignorant, the sense of their own exclusion from a power which they see their superiors exercise, one of the hardest things to bear—the comparison of the poor man's lot with that of his wealthy neighbour, the very hardest portion of their lot, and that which must ever expose society to its greatest perils—will be always sure to strike their minds; and unless they are curbed by an overwhelming force, can never operate without the most mischievous tendency to the peace of society, until the foundations of government and the nature of the social compact, as well as the principles of Economical Science, are fully learnt by the mass of the people. There wants no teacher to make a poor man begrudge his powerful and wealthy neighbour both his actual share in the government and his disproportionate share in the good things of this life: but the teacher must have ill performed his task if he has left any doubt in the mind of the poorest man who hears or who reads him, that the misery of all classes must follow from insurrection and anarchy; that unequal distribution of power is necessary for all government, and unequal distribution of property essential to its very existence, the idea of too much and too little being utterly inconsistent with its very nature; that upon its existence depends the whole fabric of society; and that a general division of possessions would make the country a scene of profligate extravagance for one year, and of universal desolation the next—a bedlam for one short season, and a charnel-house ever after.

3. The contemplation of the structure of other governments as well as of that under which we live, and the comparison of the defects and advantages of

our own with those of other systems, can hardly fail to produce a happy effect upon the dispositions of any people in tolerably happy circumstances. Our countrymen, for example, when they perceive the immeasurable superiority of the British over so many other forms of government, cannot avoid drawing from the comparison powerful motives for contentment, and strong reasons why they should bear with subordinate evils rather than run the risk of losing a great good. All foreign experience, too, and all past history, inculcates the necessity of sober and cautious proceeding, where admitted evils are to be removed, or valuable improvements to be introduced. Nor can it escape observation, that many of those things which the superficial and ignorant are prone to regard as improvements, are easily shown, by a deeper examination of the subject, to be either useless or hurtful. Hence untaught men often long after some foreign institution about which they know little; whereas a full and systematic acquaintance with the subject would show them that the different habits and various circumstances of the foreign nation, in other particulars, render the thing in question beneficial there, which here would be noxious.

4. It would be endless to show in how many particulars a people would be more easily and safely governed, if political knowledge were fully and widely diffused among them. The first instances

that occur are drawn from the evil influence of ignorance and prevailing errors upon subjects of Economical Science. The great mischief arising from the labouring part of the community being unacquainted with the nature of *wages*, and the principles on which their rate depends, are well known. The unlimited supply of labour which their imprudent marriages, and repugnance to change their residence or their occupation, are constantly bringing into the market, really is the main cause of the depression of the working classes; for it keeps down their earnings to the very lowest amount of subsistence on which human life can be maintained. Could anything be more happy, both for themselves and for the peace of society, than such a thorough knowledge of this subject as would check the master evil which now pervades all the lower ranks of society?—In like manner, the outcry raised in favour of unlimited provision for the poor, and against the reasonable, indeed the necessary rule which would confine each man to living upon the produce of his own industry, or the income of his own property, never could arise, at least never could have any success, but among the the most ignorant of mankind.—So, the strange delusions propagated by some wild visionaries, and by some ill-disposed men, that labour alone gives a right to enjoyment, and that the existence of accumulated capital is a grievance and an abuse, could not have the least success with men who had been taught to reflect that the accumulation of capital is the necessary consequence of the existence of property and its secure possession, and that no classes have a stronger interest in the protection of capital than the labourers whom it must necessarily always be employed in supporting.—The rage against machinery; the objections to a free export of grain; nay, the exaggerated views of even just and true doctrines, as that which condemns the corn laws; afford additional illustrations of the mischiefs which ignorance of economical science is calculated to produce.—To take one more example, but a very striking one, —the popular prejudice against usury, and the notion that limiting the rate of interest protects distressed borrowers, prevented any attempt to amend the law in that important particular for many years after Mr. Bentham had demonstrated that the distressed borrower suffers far more under this pressure than the wealthy lender, and after the first mercantile authority in the world* had pronounced Mr. Bentham's 'Defence of Usury' unanswered, because unanswerable. Nor have the higher classes yet thrown off these prejudices so far as to remove altogether one of the greatest practical defects in our commercial jurisprudence.

* The late Sir Francis Baring.

But the teaching of other branches of Political Science is equally beneficial to the cause of good government. It may safely be affirmed that no outcry against any impost required for the public service ever could be raised among a people well informed on the necessity of maintaining the establishments required for the public service; and that such schemes as the Excise never could for years have been defeated, and afterwards made for half a century the object of popular hatred, sometimes the ground of insurrection, in a well-informed community. So the vulgar prepossession in favour of law-taxes, as tending to check litigiousness, could only among a very ill-informed people have supported, till a late period, an impost notoriously the very worst that ever was invented, and the direct tendency of which is to prevent justice from being obtained by the poor man.—The cry of sacred chartered rights being violated by a reform in a monopolizing Company's administration of India, drove a ministry from power three score years ago; and assuredly it could never have seduced any but a very ignorant people. Accordingly, there was just as much violence done to the Company's charter, the year after, by the successors of that ministry, without any kind of umbrage being given to the most sensitive persons in the country.—The classes of society were among the most ignorant of mankind, which about the same time were seized with such an alarm lest Popery should be made, by main force, the religion of the people, that they attempted to fire London, did burn the Catholic chapels in Edinburgh, and drove into retirement the most accomplished member of the Scottish Church,—the illustrious historian whose works shed a lustre on the name of his country.* Nor were those better informed who, thirty years later, helped a party in the state to remove their adversaries from the government, and seize upon their places, upon the outcry of a like danger threatening the religion of the country in consequence of a very insignificant bill, which its adversaries passed into a law a few years afterwards without one word being ever whispered against it.—But let us consider only how many measures every government is compelled to postpone, contrary to its fixed and clear opinions, merely because the public mind will not bear them in its present state of information. Men may differ, for example, as to the propriety of retaining certain colonial possessions at a vast expense, with great loss to our trade, and with considerable risk of hostile operations becoming necessary. But even if all statesmen of any note were agreed that those distant possessions should be abandoned, what minister would venture to give up the country where Wolfe gained his victory and met his end,—an

* Robertson.

event that has consecrated the spot in the affections of the people, and makes them blind to all consequences and deaf to all reason?—So it might be of great benefit to give up Gibraltar; but the people must have learnt many a lesson of political wisdom before it would be safe for any administration to propose its cession, how ample soever might be the benefits of the measure. Lord Chatham was as bold a minister, and one as regardless of consequences when he saw his course clear before him, as ever presided over the affairs of this country;—yet, when, in order to gain the invaluable co-operation of the Spanish branch of the Bourbons, and rescue Europe from the depression consequent upon its disjointed state, he perceived the expediency of offering up Gibraltar for Minorca, a letter from him to our ambassador at Madrid remains, in which he broaches the subject with a degree of fear and trembling that indicates how frightful he deemed the risk he ran of exciting the national feelings of England against him to overwhelm his government. Such alarms could have no place among a people, the bulk of whom, well informed upon political subjects, were accustomed to consult the real interests of the country, and incapable of being led astray either by vague apprehensions, or the clamours which designing knaves might raise to delude them.—But of the many evils which popular ignorance creates in human society, there is none so pernicious as its influence upon those national feelings in which commercial restraints, and, above all, wars, have their origin. The fear of benefiting other nations, and aiding our competitors by our trade, is at the bottom of the former; the latter are too frequently occasioned by national animosities, by hatred of our neighbours merely because they are our neighbours; and it may be remarked that both commercial and political jealousies chiefly operate against those who, for the very reason that they are our near neighbours, are our best customers, and should, for the benefit of both parties, be our firmest friends. The history of our species is a history of the evils that have flowed from a source as tainted as it is abundant. To go no further back than a century ago,—Walpole was first hurried into a war which its chief supporters afterwards admitted* to have been as groundless as it was impolitic, by a senseless cry against the Spaniards, raised by a few smugglers, who took advantage of our people's ignorance to excite their feelings of honour and revenge, and profligately encouraged

* Mr. Burke relates this striking instance of the crimes of party: to turn out Walpole, his adversaries raised the war-whoop; they broke the peace of twenty years to obtain power. This those party-leaders admitted to him in discussing this disgraceful passage of party history.

by a political party who turned to their own personal advantage the greatest injury they could inflict upon their country.—The most unfortunate and impolitic war ever waged by this country was popular in the extreme at first; and no minister could have stood up against the supremacy of the mother-country over thirteen colonies, while all the ignorant members of the community believed that they had an interest in levying taxes by force from the American colonies in aid of the mother-country. —Nor is it any diminution of the evils which are produced by want of political knowledge, that wars, in themselves just and necessary, may at first be favoured by the people, and then abandoned at a time when the best interests of the state require them to be persevered in. An unreflecting, because an uninformed, nation is at all times liable to commit this error, than which none can be greater excepting that most grievous of all faults, the rushing into a contest without cause.

5. It may be said that there is this peculiar to a course of political instruction, that many of the principles explained in it are those which the existing parties in the state are at the time appealing to, and disputing about,—many of the illustrations used in expounding those principles are the very topics of most vehement discussion among the practical statesmen and factions of the day. The whole subject, it may be argued, is more or less contro-

versial, and the controversy is one in which, as it involves men's real or supposed interests, and consequently engages their passions deeply, no instructor can easily avoid taking a side, and no audience can help being swayed by the prevailing sentiments of the times; so that instruction becomes difficult, from the interference of party prejudice in both the teacher and the pupil, while a factious spirit is sure to be fostered, and unkindly feelings to be exacerbated, if not engendered. In this remark there is, unquestionably, much truth; it refers to the principal difficulty that attends political instruction. But it can never be allowed to prove that no such instruction should be conveyed; it only warns us to guard as much as possible against falling into the error which it points out. If it were suffered to operate as a conclusive reason against teaching politics, this would follow—that upon the things most necessary to be known ignorance is better than knowledge,—that in proportion as the subject is more interesting to men, they should take the less pains to understand it. But that is not all: it would also follow that, upon topics calculated to excite strong feelings, it is better and safer for the people to be kept in the dark. For by the supposition which forms the ground of the whole objection, you cannot keep the people from taking an interest in these subjects; you cannot help their being excited and split into parties; their being so is the very origin of the remark with which we are dealing. Then, because such excitement and such party differences prevail, is there any common sense in prescribing an entire ignorance of the questions those dissensions relate to, as a likely means of allaying them? Are political differences the more sure to be reconciled by keeping those who are split by them in ignorance of the subjects under dispute? Are men more likely to agree upon any matter the less they know about it? The people, it seems, feel strongly upon certain subjects, and are much divided in opinion, many being for a certain course of policy, many against it. The argument is, that for the purpose of bringing about an understanding, and making all in its favour, or all join in rejecting it, or all unite in preferring some middle course safely placed at a distance from either extreme, the parties should be prevented from comprehending the nature of the measure in question, and kept in ignorance of all the arguments for it, all the arguments against it, and all the arguments for a middle course. Once upon a time, says the old fable, two gallant knights met upon a plain where a shield stood upright; and one of them having called it a white shield, the other asserted it to be black, whereupon they prepared to fight after the manner of that age, still somewhat in vogue at the present day. But a dervise or priest came up, and, having learnt the cause of their quarrel, suggested that each had better look at both sides of the buckler—when they found that each knight was right—the one side being pure white, the other jet black. The minister of peace performed his duty wisely; but our objectors, and some of them nominally of the same vocation with the dervise, have no better expedient to propose than that the shield should be covered up from both combatants, and the fight go on.

It must on all hands be admitted that there is no greater evil in any country than party violence—the abuse of that which, if kept within due bounds, is an advantage, and may be the means of preserving public liberty and promoting general improvement, namely, the honest combination of statesmen for patriotic purposes. This becomes an intolerable evil when it is made the mere engine of selfish men for giving power and profit to themselves at the expense of the public good, and by the subservient agency of the people whose interests are sacrificed to the views of their leaders. Opinions are then assumed, in order to marshal politicians in bands and separate them from others. Place is the real object; principle the assumed pretext. The people, instead of thinking for themselves, are made the dupes and the tools of others,—hurried into all the follies of which thoughtless men are capable, and into as many excesses as their designing leaders dare let them commit consistently with their own safety, and without the least regard for that of their followers. Now, nearly the whole influence of such party chiefs is grounded upon the political ignorance of the people at large; and the permission thus assumed to make and dictate their opinions. In such a state of things Dean Swift's saying is correct, that "Party is the madness of many for the gain of a few;" and such a state of things could not exist among a people politically educated. As the navigators who first visited the South Sea Islands could purchase the lands, goods, and chattels of the natives for a red feather, our ancestors four centuries ago could butcher one another by thousands, and extirpate nine-tenths of the nobility of the country in a few years for a red or a white rose; but the wars of Lancaster and of York could no more be waged in our time, than the South Sea islanders, after being civilized, can be induced to barter their property for nothing; and the day will come when other party differences will be regarded with the same contempt with which we now regard the factions of the Henrys and the Edwards.

6. This leads to the important remark, that the question is no longer left open to us whether the people shall be taught politics or not. Taught they must be; and the only question is, whether they shall be well taught, or ill instructed and misinformed. Do what you will, somebody will take the part of public instructor. It is an office

that any man in a free country may assume, and it is one which almost every one thinks himself qualified to fill. If the people are not taught sound doctrine upon the subject, by calm and tolerably impartial men, they will inevitably listen to guides of a far different description, and will fall a prey to the more violent and the more interested class of politicians, to the incentives of agitators, the arts of impostors, and the nostrums of quacks. If, indeed, a teacher so far violates his duty, as to give partial, inflamed, untrue accounts of the subject he handles—if he keeps out of view the facts which history has stored up in illustration of the tendency of particular systems—if he inflames the passions of an unthinking multitude, and converts a course of instruction into an engine of faction,—then he may do mischief, as all men may who are guilty of fraudulent and mischievous actions upon false pretences. But this possibility only furnishes a reason against misinstructing the people, not against teaching them; it warns us to avoid impostors, not instructors; it shows that politics may be ill and dishonestly taught, as religion, or even morality itself may be; not that politics should be left untaught any more than morals and religion. And assuredly we may rest satisfied of one thing; the difficulty is far greater, of making a course of lectures the means of propagating, by foul means, any system of opinions, than the difficulty of deceiving the people in any other way. The shame, upon the detection of such a design, is far greater, and the chances of its being detected are more numerous. The good dervise, of whom the legend speaks, took the honest and the rational course; he was a fair as well as a wise teacher. Had he, like the Levite in the parable, kept aloof and passed on the other side, while the work of death was going on, he would have been a weak, and a timid, and a selfish man. But had he interfered to prevent the combatants looking on both sides—had he, who saw the shield in either direction, persuaded each knight that he was in the right, and that the other was in the wrong, he would have been justly execrated as a dishonest guide—his treachery would have been speedily discovered—and both parties would have joined in scorning and in punishing him. Let it not, however, be supposed that any course of political lessons can be given with no leaning to one set of doctrines rather than another. Such a thing is hardly possible, consistently with honesty; and, were it possible, it would not be at all desirable. On a subject like this every one who has well considered it must have formed his opinions; and he must, therefore, conscientiously believe those opinions to be right—nay, to be the only right and safe ones for the people to entertain. It is therefore his bounden duty to declare his sentiments; and it is infinitely more fair, more honest, and more useful, as well as safer, that he should declare them openly, distinctly, and manfully, after stating the whole case, and the reasons on both sides, than that he should give a partial view of the argument, and leave the audience to draw its own conclusions—that is, his own conclusions. He is a teacher, not a partisan; he is fairly to expound the views and the arguments of others with whom he differs; and he is to give his reasons for retaining his own sentiments. From so open and honest a course of proceeding no mischief whatever can be apprehended, and no other course can be called Instruction. Can any one doubt that it is best for the people and safest for the government that this course should be pursued upon all political subjects, and most of all upon those subjects which are the most calculated to excite deep interest and rouse strong feelings? What better means can be devised of showing the public how much it is their interest to inquire and judge for themselves? What better security can be devised against the efforts of violent and intriguing men? What more sure remedy against the arts of political empirics, whose natural prey is, and ever will be, the ignorant vulgar—but who in vain display their wares before well-informed and reasoning men?

These considerations may serve to show, not merely that the Political Education of the people is attended with none of the danger to the peace of society which the objectors apprehend, but that a positive security is afforded by it against the very worst dangers to which the cause of good order in any community can be exposed. But we must go yet a step further, and observe that the right of the people to be instructed as to the public interests, and the duty of their superiors to educate them in Political Science, rests upon higher ground than has yet been taken.

The force of public opinion must be acknowledged in every government, save only that of the most purely despotic form. It has more or less a direct influence, according to the nature of the constitution under which the people live; and the momentum with which it acts varies, under the same kind of constitution, according to the degree in which the people are educated. But even in countries that enjoy little constitutional freedom, the public voice, when raised, is effectual; and even the most ignorant nation has a will which its rulers must not venture entirely to disobey: nay, in absolute monarchies, where public opinion forms the only check on misgovernment, and the people seldom exert any influence, yet, when they do interfere, it is oftentimes with terrible effect. Nor is any interposition likely to be withheld merely because, from the popular ignorance, it happens to be uncalled for or exerted in a wrong direction. How important, therefore, is it, with a view to the people's only safeguard, and the ruler's only curb, that they should be well-informed upon their political interests! But how immeasurably more important is it in countries living under a free government, that those whom the constitution recognises as sharers, more or less directly, in the supreme power, should have a correct knowledge of the state of their own affairs, and the principles upon which their rights and their interests depend! It must be observed that no government, even the freest, can be in the hands of the people at large; and that grand improvement of modern times, the representative system, by which extent of territory can be safely combined with a popular constitution, still leaves the exercise of supreme power in the hands of persons delegated to govern—even where there are none but elective magistrates, that is, even in republican constitutions. Those delegates, then, be they executive, or judicial, or legislative, require the vigilant superintendence of the community, in order to prevent errors or abuses, to quicken their diligence or to control their faults, during the term of their office. This superintendence is most wholesome if exercised by an enlightened people, and affords the only effectual security for constant good government—the only real safeguard for popular rights. How many fatal errors would rulers of all kinds, and in all ages—whether

Consuls and Senates, or Archons and Assemblies of the people, or Monarchs and their Councils, or Kings and their Parliaments, or Presidents and Chambers, have been prevented from falling into; and how many foul crimes, both against the interests of their subjects, and against the peace and happiness of the world, would they have been deterred from committing had the nations submitted to their care been well instructed in the science of public policy, acquainted with their true interests, aware of the things most dangerous to their liberties, and impressed with that sense of duty to their species which an enlarged knowledge of Political Philosophy can alone bestow! Take, again, the instance of war—that game, as has been well said, at which kings could never play were their subjects wise—how melancholy is it to reflect that nearly all the devastation which it has spread over the earth would have been spared, with the countless mischiefs following in its train, had only the same enlightened views prevailed which have already resulted partly from sad experience, partly from diffused information, and which seem, at the present day, to have, at least for a while, taught men the guilt as well as the folly of war! But experience is a costly as well as an effectual teacher; and the same lesson might have been wholly learnt without the heavy price that has been paid for it. Experience, too, is a teacher whose lessons are forgotten in the course of a little time; as the memory of wounds and the fear of fighting wear out with the pain they occasion. Nothing, then, can effectually and permanently instil the sound doctrines of peace and of justice into any people but an extensive Political Education, to instruct them in their interests and their duties. It is the same with the frauds as with the oppressions of statesmen. The sacrifice of the many to the few would be impossible in a well-informed country. That game of party, in which the interests of the people are the counters, and the power and pelf of the gamesters themselves the only thing they play for, though not the only stake they risk, never could be played to the destruction of public virtue and the daily peril of the general good, were the people well acquainted with the principles which should govern the administration of their concerns; and possibly it is an instinctive apprehension of this truth that has made all parties so averse to the general diffusion of political knowledge.

But it is not merely as a control on the mismanagement of their affairs, and a check to encroachments on their rights, that the interposition of the people is required in every country, and is the very life and soul of each constitutional system; they ought to promote the progress of improvement, by urging their rulers to better by all means the condition of those under their care, and, above everything, to amend the errors of their political system. As all government is made for the benefit of the community, the people have a right, not only to be governed, but to be well governed; and not only to be well governed, but to be governed as well as possible; that is, with as little expense to their natural freedom and their resources as is consistent with the nature of human affairs. Towards this point of perfection all nations ought constantly to be directing their course. But the rulers having no interest of the kind—nay, rather an interest in keeping things as they are, if not making them go backwards—unless the people interfere, little progress will be made in that direction, and some risk always incurred of losing the ground already gained. Surely, then, nothing can be more manifest than that full and sound political information is necessary for those whose strongly pronounced desire of improvement is the best security for the progress of all national reform. The diffused knowledge of the general principles of policy, and an intimate acquaintance with what has been done in other countries, and with the results produced, becomes as sure a source of political improvement as the diffused knowledge of mechanical science, and an acquaintance with the inventions of foreigners, is the source of almost all improvement in the arts. The education of particular classes alone may, no doubt, be better than the general prevalence of political ignorance; but as those classes for the most part have particular interests, and each has its own purposes to serve, the only security for improvements which may benefit the whole body of the people, is for the whole body of the people to understand in what their true interests consist.

In truth a greater absurdity cannot well be imagined, than attempting to keep the bulk of mankind in ignorance of all that appertains to State Affairs. State affairs are their own affairs. An absolute Prince* once exclaimed, "The State! I am the State!" But the people may most justly exclaim, "We are the State." For them laws are made; for them governments are constituted. To secure their peace, and protect them from injury without and within the realm, rules are appointed, revenues raised, police established, armies levied. To exclude them from the superintendence of their own affairs is as if the owner of an estate were refused the inspection of his accounts by his steward. To prevent them from understanding the principles on which their affairs are administered, is as if the owner of an estate were suffered to know what his steward was doing, but debarred from all understanding of what he ought to do. To prevent them from knowing what are the institutions and the condition of

* Louis XIV.

foreign nations, is as if the owner of an estate were precluded from knowing how his neighbour's property was managed, what rent he got for his land, what salaries he paid his agents. In every country, whatever be the form of its government, and however little of a popular cast, this is the amount, and this is the aspect of the absurdity propounded by those who would prohibit the Political Education of the People. But incomparably grosser is the absurdity of keeping the people in ignorance where the constitution of the government is of a popular kind. There, the people are called upon to bear a share in the management of their own affairs, to attend public meetings, to serve in offices, to vote in the choice of lawgivers. There may be some consistency in excluding them from all the knowledge that would fit them for performing those high political functions, while you also exclude them from all exercise of the functions themselves. But to make them political functionaries, and to leave them in ignorance of political subjects, is little less absurd than it would be to keep the owner of an estate ignorant of farming, and expect him to superintend the management of his farms. But if it be said that there is no occasion for all the community learning Political Philosophy any more than there is for all a landowner's family inspecting his accounts and understanding agriculture; the answer is obvious, that all the community, and not particular classes, are the parties interested in State affairs; and that if any family can be found in which all the members, servants included, have their several shares in the property of the estate, then, beyond all question, each member, down to the humblest menial, however inconsiderable his share of the property, would be entitled to inspect the accounts—would be directly interested in superintending the management—and would be unspeakably foolish to remain in ignorance of the principles on which farms should be managed, and the condition and management of the other estates in the neighbourhood.

Nor can any the least risk arise to the peace and good order of society from the humbler classes occupying themselves with such pursuits; any, the least, risk of their grudging their superiors the benefits and the privileges of their station, or seeking to displace them, and shake the stability of the national system. Imperfect knowledge of Political Philosophy, a superficial acquaintance with what is passing in other countries, and what has, in past times, been the history of their own, may expose them to be misled by designing men, or to become the dupes of their own irregular desires and groundless fancies. Such errors are inseparable from all learning, because they are the consequences of the imperfect information with which learners must begin; they overshadow the dawn of all intellectual improvement; they cloud the mind before the sun has yet arisen; but they offer the same obstacles to knowledge in all its branches, and are as much objections to moral, and even to religious, instruction, as to the study of Political Science. The risk—the temporary and inconsiderable risk—is admitted; the guarantee is certain, and it is easy. An imperfect light is dangerous. In the twilight men's steps falter; and, as they dimly see, they doubtfully grope their way. Then let in more light! That is the cure for the evil; and that is the answer to the objection. But of one thing we may be well assured: be the dangers ever so great of instructing the people on that which it most concerns them to know—be the hazards arising from the circulation of free opinions and the diffusion of political knowledge among the people a thousand times more imminent than they have ever been painted by alarmed and short-sighted men; we cannot prevent the evil, be it ever so appalling, and are left to apply the only remedy—"Let there be light." In vain you seek to put down such doctrines by force; even to quell the uproar of admitted errors by force is of no avail in maintaining quiet. Rather say, force alone has the power greatly and widely to disseminate falsehood. Doctrines ever so fantastical, ever so wild—tenets as dull as they are groundless, as revolting as they are untrue—systems as rotten as they are deformed—follies which, left to themselves, must quickly die a natural death—all are capable of being forced onward to success by injudicious attack. The rod of power, like the magician's wand, can change deformity into beauty, lend strength to the rottenness, give currency to the dulness, and life to the decay of errors, which nothing else could recommend, or circulate, or preserve. To oppose the progress of truth—to suppress the communication of opinions—to obstruct the diffusion of knowledge—is not so pernicious, but is quite as ineffectual an exercise of the persecuting power.

It remains to mark the most salutary effects of an extensive diffusion of Political Knowledge—the most salutary, because unalloyed by even any the least and most transient inconvenience. An enlarged view of their own best interests must give the people sound and enlightened feelings respecting the merits of human conduct, and form in them the habit of justly estimating the character and the conduct of the men who guide the affairs of nations. The mischiefs are incalculable which have resulted to our species, from the habitual false judgments formed on this important subject by the bulk of mankind; and it must in fairness be confessed that the great crimes which have been committed by statesmen in all ages, have been mainly caused by the encouragement which the people have given to the criminals. Dazzled by success, subdued by the spectacle of triumphant force, stricken with wonder at the mere exercise of great faculties, and the sight of the events which they brought about, men have withdrawn their eyes from the means used to attain those ends, and lost their natural hatred of vice in their admiration of genius and their sense of power. No disgust at meanness, no scorn of treachery, no horror of cruelty, has hitherto availed against the false lustre shed over despicable and detestable deeds by brilliant capacity crowned with victory. But that is not all the folly committed by unreflecting men. The most absolute disregard to their own interests has been coupled with their misplaced admiration of successful guilt.

The crimes which dazzled them were perpetrated at their cost; the price paid was their own long, and boundless, and bitter suffering. For all that was done amiss and for all themselves admired, they themselves paid. Their own best interests were sacrificed quite as much as principle and duty were violated. They have lavished upon tyrants, and conquerors, and intriguers, who were their worst enemies, their loudest applause; for those pests of the world reserving the fame that should have been kept sacred to virtuous and beneficent deeds; and confining the title of "Great"—the prize that all generous natures strive after—to those whose lives were spent in working their misery and their ruin. This preposterous combination in which the people have so long been leagued to call things by their wrong names, to praise the wrong men, to suffer that the scourges of their kind, the enemies of peace and freedom and virtue, should not merely escape reprobation, but should monopolize all the places in the Temple of Fame, has been the fruitful source of human misery and national crimes, and it has been the result of nothing but the darkest ignorance. The knowledge of Political Science, which teaches the people their true interests, can alone rescue them from the error of ages—restore public virtue to the pedestal which successful vice has so long usurped—and secure on a lasting foundation the peace and the happiness of the world.

THE END.

INDEX

TO THE

TWO DISCOURSES OF THE OBJECTS, PLEASURES, AND ADVANTAGES OF SCIENCE, AND OF POLITICAL SCIENCE.

London: Printed by William Clowes and Sons, Stamford street.