"either analytical or synthetical. Of the latter, an elemen-
"tary example occurs in the algebraical demonstrations given
"by some editors of Euclid, of the propositions in his second
"Book *."

This misapplication of the words analysis and synthesis, is not, indeed, attended with any serious inconveniences, similar to the errors occasioned by the loose phraseology of Condillac. It were surely better, however, that mathematicians should cease to give it the sanction of their authority, as it has an obvious tendency,—beside the injustice which it involves to the inestimable remains of Greek geometry,—to suggest a totally erroneous theory, with respect to the real grounds of the unrivalled and transcendent powers possessed by the modern *calculus*, when applied to the more complicated researches of physics †.

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* Histoire des Mathématiques, par Montucla, Tome Premier, pp. 175, 176.

† In the ingenious and profound work of M. De Gerando, entitled, *Des Signes et de l'Art de Penser, considérés dans leur rapports mutuels*, there is a very valuable chapter on the Analysis and Synthesis of metaphysicians and of geometers. (See Vol. IV. p. 172.) The view of the subject which I have taken in the foregoing section, has but little in common with that given by this excellent philosopher; but in one or two instances, where we have both touched upon the same points, (particularly in the strictures upon the logic of Condillac) there is a general coincidence between our criticisms, which adds much to my confidence in my own conclusions.

Section IV.

The Consideration of the Inductive Logic resumed.

I.

Additional Remarks on the distinction between Experience and Analogy.—Of the grounds afforded by the latter for Scientific Inference and Conjecture.

In the same manner in which our external senses are struck with that resemblance between different *individuals* which gives rise to a common appellation, our superior faculties of observation and reasoning, enable us to trace those more distant and refined similitudes which lead us to comprehend different species under one common *genus*. Here, too, the principles of our nature, already pointed out, dispose us to extend our conclusions from what is familiar to what is comparatively unknown; and to reason from species to species, as from individual to individual. In both instances, the logical process of thought is nearly, if not exactly the same; but the common use of language has established a verbal distinction between them; our most correct writers being accustomed (as far as I have been able to observe) to refer the evidence of our conclusions, in the one case, to *experience*, and in the other to *analogy*. The truth is, that the difference between these two denominations of evidence, when they are accurately analyzed, appears manifestly to be a difference, not in *kind*, but merely

in *degree*; the discriminative peculiarities of individuals invalidating the inference, as far as it rests on experience solely, as much as the characteristical circumstances which draw the line between different *species* and different *genera* *.

This difference in point of degree (it must at the same time be remembered) leads, where it is great, to important conse-

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* In these observations on the import of the word *analogy*, as employed in philosophical discussions, it gives me great pleasure to find, that I have struck nearly into the same train of thinking with M. Prévost. I allude more particularly to the following passage in his *Essais de Philosophie*.

"Le mot *Analogie*, dans l'origine, n'exprime que la ressemblance. Mais l'usage "l'applique à une ressemblance éloignée: d'ou vient que les conclusions analogiques sont "souvent hasardées, et ont besoin d'être déduites avec art. Toutes les fois donc que, "dans nos raisonnemens, nous portons des jugemens semblables sur des objets qui n'ont "qu'une ressemblance éloignée, nous raisonnons analogiquement. La ressemblance pro- "chaine est celle qui fonde la première généralisation, celle qu'on nomme *l'espèce*. On "nomme éloignée la ressemblance qui fonde les généralisations superieures, c'est-à-dire, "le *genre* et ses divers degrès. Mais cette definition n'est pas rigoureusement suivie.

"Quoiqu'il en soit, on conçoit des cas, entre lesquels la ressemblance est si parfaite, "qu'il ne s'y trouve aucune différence sensible, si ce n'est celle du tems et du lieu. Et "il est des cas dans lesquels on apperçoit beaucoup de ressemblance, mais où l'on de- "couvre aussi quelques différences indépendantes de la diversité du temps et du lieu. "Lorsque nous ferons un jugement general, fondé sur la première espèce de ressem- "blance, nous dirons que nous usons de la *méthode d'induction*. Lorsque la seconde "espèce de ressemblance autorisera nos raisonnemens, nous dirons que c'est de la *mé- "thode d'analogie* que nous faisons usage. On dit ordinairement que la méthode d'in- "duction conclut du particulier au général, et que la methode d'analogie conclut du "semblable au semblable. Si l'on analyse ces definitions, on verra que nous n'avons "fait autre chose que leur donner de la précision." (Essais de Philosophie, Tome II. p. 202.)

See also the remarks on induction and analogy in the four following articles of M. Prevost's work.

quences. In proportion as the resemblance between two cases diminishes in the palpable marks which they exhibit to our senses, our inferences from the one to the other are made with less and less confidence; and therefore it is perfectly right, that we should reason with more caution from *species* to *species*, than from *individual* to *individual* of the same kind. In what follows, accordingly, I shall avail myself of the received distinction between the words *experience* and *analogy*; a distinction which I have hitherto endeavoured to keep out of view, till I should have an opportunity of explaining the precise notion which I annex to it. It would, in truth, be a distinction of important use in our reasonings, if the common arrangements, instead of originating, as they have often done, in ignorance or caprice, had been really the result of an accurate observation and comparison of particulars. With all the imperfections of these arrangements, however, a judicious inquirer will pay so much regard to prevailing habits of thinking, as to distinguish very scrupulously what common language refers to experience from what it refers to analogy, till he has satisfied himself, by a diligent examination, that the distinction has, in the instance before him, no foundation in truth. On the other hand, as mankind are much more disposed to confound things which ought to be distinguished, than to distinguish things which are exactly or nearly similar, he will be doubly cautious in concluding, that all the knowledge which common language ascribes to experience is equally solid; or that all the conjectures which it places to the account of analogy are equally suspicious.

A different idea of the nature of analogy has been given by some writers of note; and it cannot be denied, that, in certain instances, it seems to apply still better than that proposed above. The two accounts however, if accurately analyzed, would be found to approach much more nearly, than they appear to do at first sight; or rather, I am inclined to think, that the one might be resolved into the other, without much straining or over refinement. But this is a question chiefly of speculative curiosity, as the general remarks which I have now to offer, will be found to hold with respect to analogy, considered as a ground of philosophical reasoning, in whatever manner the word is defined; provided only it be understood to express some sort of correspondence or affinity between two subjects, which serves, as a principle of association or of arrangement, to unite them together in the mind.

According to Dr Johnson, (to whose definition I allude more particularly at present) analogy properly means "a re-"semblance between things *with regard to some circumstances* "*or effects*; as when learning is said to *enlighten* the mind;— "that is, to be to the mind what light is to the eye, by enabling "it to discover that which was hidden before." The statement is expressed with a precision and justness not always to be found in the definitions of this author; and it agrees very nearly with the notion of analogy adopted by Dr Ferguson,—that "things which have no resemblance to each "other may nevertheless be analogous; analogy consisting "in a resemblance or correspondence of relations*." As

* Principles of Moral and Political Science. Vol. I. p. 107.

an illustration of this, Dr Ferguson mentions the analogy between the fin of a fish and the wing of a bird; the fin bearing the same relation to the water, which the wing does to the air. This definition is more particularly luminous, when applied to the analogies which are the foundation of the rhetorical figures of metaphor and allusion; and it applies also very happily to those which the fancy delights to trace between the material and the intellectual worlds; and which (as I have repeatedly observed), are so apt to warp the judgment in speculating concerning the phenomena of the human mind.

The pleasure which the fancy receives from the contemplation of such correspondences, real or supposed, obviously presupposes a certain *disparity* or *contrast* in the natures of the two subjects compared; and, therefore, analogy forms an associating principle, specifically different from resemblance, into which Mr Hume's theory would lead us to resolve it. An additional proof of this is furnished by the following consideration, That a resemblance of *objects or events* is perceived by *sense*, and accordingly has some effect even on the lower animals; a *correspondence* (or, as it is frequently called, a *resemblance*) of *relations*, is not the object of sense, but of *intellect*, and consequently, the perception of it implies the exercise of reason.

Notwithstanding, however, the radical distinction between the notions expressed by the words resemblance and analogy, they may often approach very nearly to each other in their meaning; and cases may even be conceived in which they ex-

actly agree. In proof of this, it is sufficient to remark, that in objects, the parts of which respectively exhibit that correspondence which is usually distinguished by the epithet *analogous*, this correspondence always deviates, less or more, from an exact conformity or identity; insomuch, that it sometimes requires a good deal of consideration to trace in detail the parallel circumstances, under the disguises which they borrow from their diversified combinations. An obvious instance of this occurs when we attempt to compare the bones and joints in the leg and foot of a man with those in the leg and foot of a horse. Were the correspondence in all the *relations* perfectly exact, the *resemblance* between the two objects would be manifest even to sense; in the very same manner that, in geometry, the *similitude* of two triangles is a necessary consequence of a precise correspondence in the *relations* of their homologous sides *.

This last observation may serve, in some measure, to justify an assertion which was already hazarded,—That the two definitions of analogy formerly mentioned, are very nearly allied to each other;—inasmuch as it shows, by a more careful analysis than has commonly been applied to this subject, that the sensible *dissimilitude* between things of different *species* arises chiefly from the want of a palpable conformity in the *relations* of their constituent parts. Conceive *that* more remote correspondence which reason or fancy traces between the parts of the one and the parts of the other, gradually to approach,

* See Note (Q.)

nearer and nearer, to the same standard; and it is evident, that, in the course of the approximation, you will arrive at that degree of manifest resemblance, which will bring them under the same generic name; till at last, by continuing this process of the imagination, the one will become a correct picture or image of the other, not only in its great outlines, but in its minutest details.

From this view of the subject, too, as well as from the former, it appears, how vague and ill-defined the metaphysical limits are which separate the evidence of analogy from that of experience; and how much room is left for the operation of good sense, and of habits of scientific research, in appreciating the justness of that authority which, in particular instances, the popular forms of speech may assign to either.

The illustrations which I have to offer of this last remark, in so far as it relates to *experience*, may, I think, be introduced more usefully afterwards; but the vague conceptions which are generally annexed to the word *analogy*, together with the prevailing prejudices against it, as a ground of philosophical reasoning, render it proper for me, before proceeding any farther, to attempt the correction of some popular mistakes connected with the use of this obnoxious term.

It is not necessary, for the purposes which I have at present in view, to investigate very curiously the principles which, in the first instance, dispose the mind to indulge in analogical conjectures from the known to the unknown. It is sufficient

to observe, that this disposition, so far from being checked, receives additional encouragement from habits of philosophical study;—the natural tendency of these habits being only to guide it into the right path, and to teach it to proceed cautiously, according to certain general rules, warranted by experience.

The encouragement which philosophical pursuits give to this natural disposition, arises chiefly from the innumerable proofs they afford of that systematical unity and harmony of design which are everywhere conspicuous in the universe. On this unity of design is founded the most solid argument which the light of reason supplies for the unity of God; but the knowledge of *the general fact* on which that argument proceeds is not confined to the student of theology. It forces itself irresistibly on the thoughts of all who are familiarly conversant with the phenomena, either of the material or of the moral world; and is recognized as a principle of reasoning, even by those who pay little or no attention to its most sublime and important application.

It is well known to all who have the slightest acquaintance with the history of medicine, that the anatomical knowledge of the ancients was derived almost entirely from analogical conjectures, founded on the dissection of the lower animals*; and

* "If we read the works of Hippocrates with impartiality, and apply his accounts of "the parts to what we *now* know of the human body, we must allow his descriptions "to be imperfect, incorrect, sometimes extravagant, and often unintelligible, that of

that, in consequence of this, many misrepresentations of facts, and many erroneous theories (blended, however, with various important truths), were transmitted to the physiologists of modern Europe. What is the legitimate inference to be deduced from these premises? Not, surely, that analogy is an organ of *no* use in the study of nature; but that, although it may furnish a rational ground of conjecture and inquiry, it ought not to be received as direct evidence, where the fact itself lies open to examination; and that the conclusions to which it leads ought, in every case, to be distrusted, in proportion as the subjects compared depart from an exact coincidence in all their circumstances.

"the bones only excepted. He seems to have studied these with more success "than the other parts, and tells us, that he had an opportunity of seeing a human "skeleton." . . . . . .

"Erasistratus and Herophilus, two distinguished anatomists at Alexandria, were "probably the first who were authorised to dissect human bodies. Their voluminous "works are all lost; but they are quoted by Galen, almost in every page." . . .

"What Galen principally wanted was opportunities of dissecting human bodies: for his subject was most commonly some quadruped, whose structure was supposed to come nearest to the human." . . . . . .

"About the year 1540, the great Vesalius appeared. He was equally laborious in "reading the ancients, and in dissecting bodies; and in making the comparison, he "could not but see, that many of Galen's descriptions were erroneous.—The spirit of "opposition and emulation was presently roused, and many of his contemporaries en- "deavoured to defend Galen, at the expence of Vesalius. In their disputes they made "their appeals to the human body; and thus in a few years our art was greatly improved. "And Vesalius being detected in the very fault which he condemns in Galen, to wit, "describing from the dissections of brutes, and not of the human body, it exposed so "fully that blunder of the older anatomists, that, in succeeding times, there has been "little reason for such complaint."

Introductory Lectures, delivered by Dr William Hunter to his last course of anatomy, (London, 1784.) pp. 13, 19, 25, 40.

As our knowledge of nature enlarges, we gradually learn to combine the presumptions arising from analogy, with other general principles by which they are limited and corrected. In comparing, for example, the anatomy of different tribes of animals, we invariably find, that the differences in their structure have a reference to their way of life, and to the habits for which they are destined; so that, from knowing the latter, we might be able, on some occasions, to frame conjectures *a priori* concerning the former. It is thus, that the form of the teeth, together with the length and capacity of the intestines, vary in different species, according to the quality of the food on which the animal is to subsist. Similar remarks have been made on the different situation and disposition of the *mammæ*, according as the animal is uniparous, or produces many at a birth;—on the structure and direction of the external ear, according as the animal is rapacious, or depends for security on his speed;—on the mechanism of the pupil of the eye, according as the animal has to search for his food by day or by night,—and on various other organs in the bodily economy, when compared with the functions which they are intended to perform. If, without attending to circumstances of this sort, a person should reason confidently from the anatomy of one species to that of another, it cannot be justly said, that analogy is a deceitful guide, but that he does not know how to apply analogy to its proper purpose. In truth, the very consideration which gives to the argument from analogy its chief force, points here manifestly to the necessity of some modification of the original conclusion, suited to the diversity of the case to which it is to be applied.

It is remarked by Cuvier, that "a canine tooth, adapted to "tear flesh, was never found combined, in the same animal, "with a hoof, fit for supporting the weight of the body, but "totally useless as a weapon to a beast of prey."—"Hence, "(he observes) the rule that every hoofed animal is herbivo-"rous;—and hence (as corollaries from this general principle) "the maxims, that a hoofed foot indicates grinding teeth with "flat surfaces, a long alimentary canal, a large stomach, and "often more stomachs than one, with many other similar con-"sequences.

"The laws which regulate the relations between different "systems of organs, (continues this very ingenious and sound "philosopher), have the same influence on the different parts "of the same system, and connect together its different modi-"fications, by the same necessary principles. In the alimen-"tary system, especially, where the parts are large and nu-"merous, these rules have their most striking applications. "The form of the teeth, the length, the convolutions, the dila-"tations of the alimentary canal, the number and abundance "of the gastric liquors, are in the most exact adaptation to "one another, and have similar fixed relations to the chemical "composition, to the solid aggregation, and to the solubility "of the aliment; insomuch that, from seeing one of the parts "by itself, an experienced observer could form conclusions to-"lerably accurate, with respect to the conformation of the "other parts of the same system, and might even hazard more "than random conjectures with respect to the organs of other "functions.

"The same harmony subsists among the different parts of "the system of organs of motion. As all the parts of this sys- "tem act mutually, and are acted upon, especially when the "whole body of the animal is in motion, the forms of all the "different parts are strictly related. There is hardly a bone "that can vary in its surfaces, in its curvatures, in its protu- "berances, without corresponding variations in other bones; "and in this way, a skilful naturalist, from the appearance of "a single bone, will be often able to conclude, to a certain ex- "tent, with respect to the form of the whole skeleton to which "it belonged.

"These laws of co-existence (Cuvier adds) which have just "been indicated, are deduced by reasoning from our know- "ledge of the reciprocal influence of the functions, and of the "uses of the different organs of the body. Having confirmed "them by observation, we are enabled, in other circumstances, "to follow a contrary route; and, when we discover constant "relations of form between particular organs, we may safely "conclude, that they exercise some action upon one another; "and we may thus be frequently led to form just conjectures "with respect to their uses.—It is, indeed, chiefly from the at- "tentive study of these relations, and from the discovery of rela- "tions which have hitherto escaped our notice, that physiology "has reason to hope for the extension of her limits; and ac- "cordingly, the comparative anatomy of animals is to her one "of the most fruitful sources of valuable discovery *."

* See the Introduction to the *Leçons d'Anatomie comparée de G. Cuvier.* The

The general result of these excellent observations is, that the improvement of physiology is to be expected chiefly from lights furnished by analogy; but that, in order to follow this guide with safety, a cautious and refined logic is still more necessary than in conducting those reasonings which rest on the direct evidence of experience. When the ancient anatomists, without any examination of the facts within their reach, or any consideration of the peculiar functions likely to be connected with man's erect form and rational faculties, drew inferences concerning his internal frame, merely from the structure of the quadrupeds; the errors into which they fell,—so far from affording any solid argument against the use of analogy when judiciously employed,—have only pointed out to their successors, the necessity of a more discriminating and enlightened application of it in future; and have ultimately led to the discovery of those comprehensive Laws of the Animal Economy, which, by reconciling apparent anomalies with the consistency and harmony of *one grand design*, open, at every successive step of our progress, more enlarged and pleasing views of the beneficent wisdom of Nature.

This speculation might be carried farther, by extending it to the various analogies which exist between the Animal and the Vegetable kingdoms, contrasted with those characteristical peculiarities by which they are respectively adapted to the purposes for which they are destined. It is, however, of more

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above translation is taken from a very interesting tract, entitled, An Introduction to the Study of the Animal Economy. (Edinburgh, 1801.)

consequence, on the present occasion, to turn our attention to the analogies observable among many of the physical processes by which different effects are accomplished, or different phenomena produced, in the system of inanimate and unorganized matter. Of the existence of such analogies a satisfactory proof may be derived, from the acknowledged tendency of philosophical habits and scientific pursuits, to familiarize the mind with the order of nature, and to improve its penetration in anticipating future discoveries. A man conversant with physics and chemistry is much more likely than a stranger to these studies to form probable conjectures concerning those laws of nature which still remain to be examined. There is a certain character or *style* (if I may use the expression) in the operations of Divine Wisdom;—something which everywhere announces, amidst an infinite variety of detail, an inimitable unity and harmony of design; and in the perception of which *philosophical sagacity and genius* seem chiefly to consist. It is this which bestows a value so inestimable on the Queries of Newton*.

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* How very deeply Newton's mind was impressed with those ideas of analogy which I have here ventured to ascribe to him, appears from his own words. "Have not the "small particles of bodies certain powers, virtues, or forces, by which they act at a "distance, not only upon the rays of light for reflecting, refracting, and inflecting them, "but also upon one another, for producing a great part of the phenomena of nature? "For it is well known that bodies act one upon another, by the attractions of gravity, "magnetism and electricity; *and these instances shew the tenor and course of nature, and "make it not improbable but that there may be more attractive powers than these. For "nature is very consonant and conformable to herself.*" See the 31st Query, at the end of his Optics.

In a subsequent part of this Query, he recurs to the same principle. "And thus

This view of the numberless analogies displayed in that part of the universe which falls under our immediate notice, becomes more particularly impressive, when it is considered, that the same unity of design may be distinctly traced, as far as the physical researches of astronomers have extended. In the knowledge of this fact, we possess important moral lights, for which we are entirely indebted to the Newtonian school; the universal creed of antiquity having assumed as a principle, that the celestial phenomena are, in their nature and laws, essentially different from the terrestrial. The Persian Magi, indeed, are said to have laid down, as one of their maxims,—συμπαθῆ εἶναι τὰ ἄνω τοῖς κάτω;—but that no maxim could stand in more direct opposition to the tenets of the Grecian philosophers, appears sufficiently from the general strain of their physical and astronomical theories. The modern discoveries have shown, with demonstrative evidence, how widely, in this fundamental assumption, these philosophers erred from the truth; and, indeed, it was a conjecture *a priori*, originating in some degree of scepticism with respect to it, that led the way to the doctrine of gravitation. Every subsequent step which has been gained in astronomical science has tended more and more to illustrate the sagacity of those views by which Newton was guided to this fortunate anticipation of the truth; as well

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"*Nature will be very conformable to herself and very simple;* performing all the great "motions of the heavenly bodies by the attraction of gravity, which intercedes those "bodies; and almost all the small ones of their particles, by some other attractive and "repelling powers, which intercede the particles."

as to confirm, upon a scale which continually grows in its magnitude, the justness of that magnificent conception of uniform design, which emboldened him to connect the physics of the Earth with the hitherto unexplored mysteries of the Heavens.

Instructive and interesting, however, as these physical speculations may be, it is still more pleasing to trace the uniformity of design which is displayed in the economy of sensitive beings; to compare the arts of human life with the instincts of the brutes, and the instincts of the different tribes of brutes with each other; and to remark, amidst the astonishing variety of means which are employed to accomplish the same ends, a certain analogy characterize them all;—or to observe, in the minds of different individuals of our own species, the workings of the same affections and passions, manifesting, among men of every age and of every country, the kindred features of humanity. It is this which gives the great charm to what we call *Nature* in epic and dramatic composition,—when the poet speaks a language "to which every heart is an echo," and which, amidst the manifold effects of education and fashion, in modifying and disguising the principles of our constitution, reminds all the various classes of readers or of spectators, of the existence of those moral ties which unite them to each other, and to their common parent*.

Nor is it only in the material and moral worlds, when considered as separate and independent systems, that this unity of

* Outlines of Moral Philosophy, pp. 198. 199. 3d Edit.

design is perceptible. They mutually bear to each other numberless *relations*, which are more particularly remarkable, when we consider both, in their combined tendencies with respect to human happiness and improvement. There is also a more general analogy, which these two grand departments of nature exhibit, in the *laws* by which their phenomena are regulated, and a consequent analogy between the methods of investigation peculiarly applicable to each. I have already repeatedly taken notice of the erroneous conclusions to which we are liable, when we reason directly from the one to the other; or substitute the fanciful analogies between them, which language occasionally suggests, as a philosophical explanation of the phenomena of either. But it does not follow from this, that there is no analogy between the rules of inquiry, according to which they are to be studied. On the contrary, it is from the principles of inductive philosophising, which are applicable to both in common, that we infer the necessity of resting our conclusions in each, upon its own appropriate phenomena.

I shall only add, to what has been now stated on the head of analogy, that the numberless references and dependencies between the material and the moral worlds, exhibited within the narrow sphere of our observation on this globe, encourage and even authorize us to conclude, that they both form parts of one and the same plan;—a conclusion congenial to the best and noblest principles of our nature, and which all the discoveries of genuine science unite in confirming. Nothing, indeed, could be more inconsistent with that irresistible disposi-

tion which prompts every philosophical inquirer to argue from the known to the unknown, than to suppose that, while all the different bodies which compose the *material* universe are manifestly related to each other, as parts of a connected *whole*, the *moral* events which happen on our planet are quite insulated; and that the rational beings who inhabit it, and for whom we may reasonably presume it was brought into existence, have no relation whatever to other intelligent and moral natures. The presumption unquestionably is, that there is one great *moral system*, corresponding to the *material system*; and that the connections which we at present trace so distinctly among the sensible objects composing the one, are exhibited as so many intimations of some vast scheme, comprehending all the intelligent beings who compose the other. In this argument, as well as in numberless others, which analogy suggests in favour of our future prospects, the evidence is precisely of the same sort with that which first encouraged Newton to extend his physical speculations beyond the limits of the Earth. The sole difference is, that he had an opportunity of verifying the results of his conjectures by an appeal to sensible facts: but this accidental circumstance (although it certainly affords peculiar satisfaction and conviction to the astronomer's mind) does not affect the grounds on which the conjecture was *originally* formed, and only furnishes an experimental proof of the justness of the principles on which it proceeded. Were it not, however, for the palpable confirmation thus obtained of the Theory of Gravity, it would be difficult to vindicate against the charge of presumption, the mathematical accuracy with which the Newtonians pretend to compute the

motions, distances, and magnitudes of worlds, apparently so far removed beyond the examination of our faculties *.

The foregoing observations have a close connection with some reasonings hereafter to be offered in defence of the doctrine of *final causes*. They also throw additional light on what was remarked in a former chapter concerning *the unity of truth*;—a most important fact in the theory of the

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* "I know no author (says Dr Reid) who has made a more just and a more happy "use of analogical reasoning, than Bishop Butler, in his Analogy of Religion, Natural "and Revealed, to the Constitution and Course of Nature. In that excellent work, the "author does not ground any of the truths of religion upon Analogy, as their proper "evidence. He only makes use of Analogy to answer objections against them. When "objections are made against the truths of religion, which may be made with equal "strength against what we know to be true in the course of nature, such objections can "have no weight." (Essays on the Intell. Powers, p. 54.)

To the same purpose it is observed by Dr Campbell, that "analogical evidence is "generally more successful in silencing objections than in evincing truth. Though it "rarely refutes, it frequently repels refutation; like those weapons which, though they "cannot kill the enemy, will ward his blows." (Phil. of Rhet. Vol. I. p. 145.)

This estimate of the force of analogical reasoning, considered as a weapon of controversy, is discriminating and judicious. The occasion on which the logician wields it to the best advantage is, undoubtedly, in repelling the objections of an adversary. But after the foregoing observations, I may be permitted to express my doubts, whether both of these ingenious writers have not somewhat underrated the importance of analogy as a medium of proof, and as a source of new information.—I acknowledge, at the same time, that between the positive and the negative applications of this species of evidence, there is an essential difference. When employed to refute an objection, it may often furnish an argument irresistibly and unanswerably convincing: when employed as a medium of proof, it can never authorize more than a probable conjecture, inviting and encouraging farther examination. In some instances, however, the probability resulting from a concurrence of different analogies may rise so high, as to produce an effect on the belief scarcely distinguishable from moral certainty.

human mind, and a fact which must strike every candid inquirer with increasing evidence, in proportion to the progress which he makes in the *interpretation of Nature*. Hence the effect of philosophical habits in animating the curiosity, and in guiding the inventive powers; and hence the growing confidence which they inspire in the ever consistent and harmonious conclusions of inductive science. It is chiefly (as Bacon has observed) from partial and desultory researches that scepticism arises; not only as such researches suggest doubts which a more enlarged acquaintance with the universe would dispel, but as they withdraw the attention from those comprehensive views which combine into a symmetrical fabric—all whose parts mutually lend to each other support and stability—the most remote, and seemingly the most unconnected discoveries. "*Etenim symmetria scientiæ, singulis scilicet* "*partibus se invicem sustinentibus*, est, et esse debet, vera atque "expedita ratio refellendi objectiones minorum gentium: Con- "tra, si singula axiomata, tanquam baculos fascis seorsim ex- "trahas, facile erit ea infirmare, et pro libito, aut flectere, aut "frangere. Num non in aula spatiosa consultius foret, unum "accendere cereum, aut lychnuchum suspendere, variis lumi- "nibus instructum, quo omnia simul perlustrentur, quam in "singulos angulos quaquaversus exiguam circumferre lucer- "nam?"*

* De Augment. Scient. Lib. i.

II.

Use and Abuse of Hypotheses in Philosophical Inquiries.—Difference between Gratuitous Hypotheses, and those which are supported by presumptions suggested by Analogy.—Indirect Evidence which a Hypothesis may derive from its agreement with the Phenomena.—Cautions against extending some of these conclusions to the Philosophy of the Human Mind.

As some of the reasonings in the former part of this Section may, at first sight, appear more favourable to the use of Hypotheses than is consistent with the severe rules of the Inductive Logic, it may not be superfluous to guard against any such misapprehensions of my meaning, by subjoining a few miscellaneous remarks and illustrations.

The indiscriminate zeal against hypotheses, so generally avowed at present by the professed followers of Bacon, has been much encouraged by the strong and decided terms in which, on various occasions, they are reprobated by Newton *. But the language of this great man, when he happens to touch upon logical questions, must not always be too literally interpreted. It must be qualified and limited, so as to accord with the exemplifications which he himself has given of his general

* "Hypotheses non fingo. Quicquid enim ex phenomenis non deducitur hypothesis "vocanda est, et hypotheses, seu metaphysicæ, seu physicæ, seu qualitatum occultarum, "seu mechanicæ, in philosophia experimentali locum non habent." See the general *Scholium* at the end of the *Principia*.

rules. Of the truth of this remark, the passages now alluded to afford a satisfactory proof; for, while they are expressed in the most unconditional and absolute terms, so many exceptions to them occur in his own writings, as to authorize the conclusion, that he expected his readers would of themselves be able to supply the obvious and necessary comments. It is probable that, in these passages, he had more particularly in his eye the Vortices of Des Cartes.

"The votaries of hypotheses (says Dr Reid) have often "been challenged to shew one useful discovery in the works of "nature that was ever made in that way*." In reply to this challenge, it is sufficient, on the present occasion, to mention the theory of Gravitation, and the Copernican system †. Of the former, we have the testimony of Dr Pemberton, that it took its first rise from a conjecture or hypothesis suggested by *analogy*; nor indeed could it be considered in any other light, till that period in Newton's life, when, by a calculation founded on the accurate measurement of the earth by Picard, he evinced the

* Essays on the Intellectual Powers of Man, p. 88. 4to Edit. In another part of the same volume, the following assertion occurs. "Of all the discoveries that have been "made concerning the inward structure of the human body, never one was made by "conjecture.——The same thing may be said, with justice, of every other part of the "works of God, wherein any real discovery has been made. Such discoveries have "always been made by patient observation, by accurate experiments, or by conclusions "drawn by strict reasoning from observations and experiments; and such discoveries "have always tended to refute, but not to confirm, the theories and hypotheses which "ingenious men had invented." Ibid. p. 49.

† See Note (R.)

coincidence between the law which regulates the fall of heavy bodies, and the power which retains the Moon in her orbit. The Copernican system, however, furnishes a case still stronger, and still more directly applicable to our purpose; inasmuch as the only evidence which the author was able to offer in its favour, was the advantage which it possessed over every other hypothesis, in explaining, with simplicity and beauty, all the phenomena of the heavens. In the mind of Copernicus, therefore, this system was nothing more than a hypothesis;—but it was a hypothesis conformable to the universal *analogy* of nature, always accomplishing her ends by the simplest means. "C'est pour *la simplicité* (says Bailly) que Copernic "replaça le soleil au centre du monde; c'est pour elle que "Kepler va détruire tous les épicycles que Copernic avoit "laissés subsister: peu de principes, de grands moyens en "petit nombre, des phénomènes infinis et variés, voilà le ta-"bleau de l'univers *."

* Histoire de l'Astronomie Moderne, Tome II. p. 2.

From this anticipation of simplicity in the laws of nature (a logical principle not less universally recognized among ancient than among modern philosophers), Bailly has drawn an argument in support of his favourite hypothesis concerning the origin of the sciences. His words are these: "La simplicité n'est pas essentiellement un principe, un "axiôme, c'est le résultat des travaux; ce n'est pas une idée de l'enfance du monde, elle "appartient à la maturité des hommes; c'est la plus grande des vérités que l'observation "constante arrache à l'illusion des effets: ce ne peut être qu'un reste de la science pri-"mitive. Lorsque chez un peuple, possesseur d'une mythologie compliquée, et qui n'a "d'autre physique que ces fables, les philosophes, voulant réduire la nature à un seul "principe, annonceront que l'eau est la source de toutes choses, ou le feu l'agent univer-"sel, nous dirons à ces philosophes: vous parlez une langue que n'est pas la vôtre; vous "avez saisi par un instinct philosophique ces vérités au-dessus de votre siècle, de votre

According to this view of the subject, the confidence which we repose in Analogy rests ultimately on the evidence of Experience; and hence, an additional argument in favour of the former method of investigation, when cautiously followed; as well as an additional proof of the imperceptible shades by which Experience and Analogy run into each other.

Nor is the utility of hypothetical theories confined to those cases in which they have been confirmed by subsequent researches: it may be equally great, where they have com-

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" nation, et de vous-mêmes; c'est la sagesse des anciens qui vous a été transmise par tra-
" dition," &c. &c. &c.—Ibid, p. 4.

To the general remark which introduces this passage I readily subscribe. The confidence with which philosophers anticipate the simplicity of Nature's laws is unquestionably the result of experience, and of experience alone; and implies a far more extensive knowledge of her operations than can be expected from the uninformed multitude. The inference, however, deduced from this, by the ingenious and eloquent, but sometimes too fanciful historian, is not a little precipitate. The passion for excessive simplification, so remarkably exemplified in the physical systems of the Greeks, seems to be sufficiently accounted for by their scanty stock of facts, combined with that ambition to explain every thing from the smallest possible number of data, which, in all ages of the world, has been one of the most common infirmities of genius. On the other hand, the principle in question, when stated in the form of a proposition, is of so abstract and metaphysical a nature, that it is highly improbable it should have survived the shock of revolutions which had proved fatal to the memory of particular discoveries. The arts, it has been frequently observed, are more easily transmitted by mere tradition, from one generation to another, than the speculative sciences; and, for a similar reason, physical systems are far less likely to sink into oblivion, than abstract maxims, which have no immediate reference to objects of sense, or to the ordinary concerns of life.

pletely disappointed the expectations of their authors. Nothing, I think, can be juster than Hartley's remark, that "any hypothesis which possesses a sufficient degree of plausibility to account for a number of facts, helps us to digest "these facts in proper order, to bring new ones to light, and "to make *experimenta crucis* for the sake of future inquirers *." Indeed, it has probably been in this way that most discoveries have been made; for although a knowledge of facts must be prior to the formation of a legitimate theory; yet a hypothetical theory is generally the best guide to the knowledge of connected and of useful facts.

The first conception of a hypothetical theory, it must always be remembered, (if the theory possesses any plausibility whatever) presupposes a general acquaintance with the phenomena which it aims to account for; and it is by reasoning synthetically from the hypothesis, and comparing the deductions with observation and experiment, that the cautious inquirer is gradually led, either to correct it in such a manner as to reconcile it with facts, or finally to abandon it as an unfounded conjecture. Even in this latter case, an approach is made to the truth in the way of *exclusion*; while, at the same time, an accession is gained to that class of associated and kindred phenomena, which it is his object to trace to their parent stock †.

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* Observations on Man, Chap. i. Prop. v.

† "Illud interim monemus; ut nemo animo concidat, aut quasi confundatur, si expe-

In thus apologizing for the use of hypotheses, I only repeat in a different form the precepts of Bacon, and the comments of some of his most enlightened followers. "The prejudice "against hypotheses which many people entertain, (says the "late Dr Gregory) is founded on the equivocal signification "of a word. It is commonly confounded with theory:—but a "hypothesis properly means the supposition of a principle of "whose existence there is no proof from experience, but which "may be rendered more or less probable by facts which are "neither numerous enough, nor adequate to infer its existence. "When such hypotheses are proposed in the modest and dif- "fident manner that becomes mere suppositions or conjec- "tures, they are not only harmless, but even necessary for "establishing a just theory. *They are the first rudiments or an- "ticipations of Principles.* Without these, there could not be "useful observation, nor experiment, nor arrangement, because "there could be no motive or principle in the mind to form "them. Hypotheses then only become dangerous and censu- "rable, when they are imposed on us for just principles; be- "cause, in that case, they put a stop to further inquiry, by "leading the mind to acquiesce in principles which may as "probably be ill as well founded *."

"rimenta, quibus incumbit, expectationi suæ non respondeant. Etenim quod succedit, "magis complaceat; at quod non succedit, sæpenumero non minus informat. Atque "illud semper in animo tenendum, *experimenta lucifera* etiam adhuc magis, quam fructi- "fera ambienda esse. Atque de *literata experientia* hæc dicta sint; quæ *sagacitas* potius "est, et odoratio quædam venatica, quam *scientia*." De Augm. Scient. Lib. v. Cap. ii.

* Lectures on the Duties and the Qualifications of a Physician.

Another eminent writer has apologized very ingeniously, and I think very philosophically, for the hypotheses and conjectures which are occasionally to be found in his own works. The author I mean is Dr Stephen Hales, who, in the preface to the second volume of his Vegetable Statics, has expressed himself thus:

"In natural philosophy, we cannot depend on any mere "speculations of the mind; we can only reason with any to- "lerable certainty from proper data, such as arise from the "united testimony of many good and credible experiments.

"Yet it seems not unreasonable, on the other hand, though "not far to indulge, to carry our reasonings a little farther than "the plain evidence of experiments will warrant; for since at "the utmost boundaries of those things which we clearly know, "a kind of twilight is cast on the adjoining borders of *Terra* "*Incognita*, it seems reasonable, in some degree, to indulge "conjecture *there*; otherwise we should make but very slow "advances, either by experiments or reasoning. For new ex- "periments and discoveries usually owe their first rise only "to lucky guesses and probable conjectures; and even disap- "pointments in these conjectures often lead to the thing sought "for."

To these quotations I shall add two short extracts from Dr Hooke (the contemporary or rather the predecessor of Newton), whose acute and original remarks on this subject reflect the greater credit on his talents, that they were published at a

period, when the learned body of which he was so illustrious an ornament, seem plainly to have been more disposed to follow the letter of some detached sentences, than to imbibe the general spirit of Bacon's logic.

"There may be use of method in the collecting of materials, "as well as in the employment of them; for there ought to be "some end and aim; some pre-designed module and theory; "some purpose in our experiments. And though this Society "have hitherto seemed to avoid and prohibit preconceived "theories and deductions from particular and seemingly acci- "dental experiments; yet I humbly conceive, that such, if "knowingly and judiciously made, are matters of the greatest "importance; as giving a characteristic of the aim, use, and "signification thereof; and without which many, and possibly "the most considerable particulars, are passed over without re- "gard and observation *.

"Where the *data* on which our ratiocinations are founded "are uncertain and only conjectural, the conclusions or de- "ductions therefrom can at best be no other than probable, "but still they become more and more probable, as the "consequences deduced from them appear, upon examina- "tions by trials and designed observations, to be confirmed by "fact or effect. So that the effect is that which consummates "the demonstration of the invention; and the theory is only

* Hooke's Posthumous Works, p. 280.

"an assistant to direct such an inquisition, as may procure "the demonstration of its existence or non-existence *."

As an illustration of this last remark, Hooke mentions his anticipation of Jupiter's motion upon his axis, long before he was able, by means of a good telescope, to ascertain the fact. A much more remarkable instance, however, of his philosophical sagacity, occurs in his anticipation of that theory of the planetary motions, which, soon after, was to present itself, with increased and at length demonstrative evidence, to a still more inventive and powerful mind. This conjecture (which I shall state in his own words), affords, of itself, a decisive reply to the undistinguishing censures which have so often been bestowed on the presumptuous vanity of attempting, by means of hypotheses, to penetrate into the secrets of nature.

"I will explain (says Hooke, in a communication to the "Royal Society in 1666) a system of the world very different "from any yet received. It is founded on the three following "positions.

"1. That all the heavenly bodies have not only a gravita- "tion of their parts to their own proper centre, but that they "also mutually attract each other within their spheres of ac- "tion.

"2. That all bodies having a simple motion, will continue

* Ibid. p. 537. For another extract from the same work, See Note (S.)

" to move in a straight line, unless continually deflected from " it by some extraneous force, causing them to describe a cir- " cle, an ellipse, or some other curve.

" 3. That this attraction is so much the greater as the bodies " are nearer. As to the proportion in which those forces di- " minish by an increase of distance, I own I have not disco- " vered it, although I have made some experiments to this pur- " pose. I leave this to others, who have time and knowledge " sufficient for the task."

The argument in favour of Hypotheses might be pushed much farther, by considering the tentative or *hypothetical* steps by which the most cautious philosophers are often under the necessity of proceeding, in conducting inquiries strictly experimental. These cannot be better described than in the words of Boscovich, the slightest of whose logical hints are entitled to peculiar attention.—" In some instances, observations and experi- " ments at once reveal to us all that we wish to know. In other " cases, we avail ourselves of the aid of *hypotheses;—by which* " *word, however, is to be understood, not fictions altogether arbitra-* " *ry, but suppositions conformable to experience or to analogy.* By " means of these, we are enabled to supply the defects of our " *data*, and to conjecture or divine the path to truth; always " ready to abandon our hypothesis, when found to involve " consequences inconsistent with fact. And indeed, in most " cases, I conceive this to be the method best adapted to physics; " a science in which the procedure of the inquirer may be com- " pared to that of a person attempting to decypher a letter writ-

"ten in a secret character; and in which, legitimate theories "are generally the slow result of disappointed essays, and "of errors which have led the way to their own detec- "tion *."

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* De Solis ac Lunæ Defectibus. Lond. 1760. pp. 211, 212. (For the continuation of the above passage, See Note (T.)

Many remarks to the same purpose may be found in Bacon. The following happen at present to occur to my memory.

"Deo (*formarum* inditori et opifici) et fortasse angelis competit, formas per affirma- "tionem immediate nosse, atque ab initio contemplationis. Sed certe supra hominem "est; cui tantum conceditur, procedere primo per *negativas*, et postremo loco desinere "in *affirmativas*, post omnimodam exclusionem. . . . . Post *rejectionem* et "*exclusionem* debitis modis factam, secundo loco (tanquam in fundo) manebit (abeun- "tibus in fumum opinionibus volatilibus) *forma* affirmativa, solida, et vera. Atque hoc "brevi dictu est, sed per multas ambages ad hoc pervenitur." (Nov. Org. Lib. II. Aphor. XV. XVI.)

"Prudens *interrogatio*, quasi dimidium scientiæ. Idcirco quo amplior et certior "fuerit anticipatio nostra; eo magis directa et compendiosa erit investigatio." (De Aug. Scient. Lib. V. Cap. 3.)

"Vaga experientia et se tantum sequens mera palpatio est, et homines potius stupe- "facit, quam informat." (Nov. Org. Lib. I. Aphor. C.)

The reader who wishes to prosecute farther this speculation concerning the use of hypotheses, may consult with advantage three short but interesting memoirs upon Method, by the late M. Le Sage of Geneva, which M. Prevost has annexed as a supplement to his *Essais de Philosophie*. That I may not be supposed, however, to acquiesce in *all* this author's views, I shall mention two strong objections to which some of them appear to me to be liable.

1. In treating of the method of Hypothesis, Le Sage uniformly contrasts it with that of Analogy, as if the two were radically distinct, and even opposite in their spirit; whereas it seems evident, that some perception of analogy must have given birth to every hypothesis which possesses a sufficient degree of plausibility to deserve farther examination.

Nor is it solely by the erroneous results of his *own* hypotheses, that the philosopher is assisted in the investigation of truth. Similar lights are often to be collected from the errors of his predecessors; and hence it is, that accurate histories of the different sciences may justly be ranked among the most effectual means of accelerating their future advancement. It was from a review of the endless and hopeless wanderings of preceding inquirers, that Bacon inferred the necessity of avoiding every beaten track; and it was this which encouraged him,—with a confidence in his own powers amply justified by the event—to explore and to open a new path to the mysteries of nature: *Inveniam viam, aut faciam.* In this respect, the maturity of reason in the *species* is analogous to that in the *individual*; not the consequence of any sudden or accidental cause, but the fruit of reiterated disappointments correcting the mistakes of youth and inexperience. "There is no subject (says Fonte-"nelle) on which men ever come to form a reasonable opinion, "till they have once exhausted all the absurd views which it "is possible to take of it. What follies (he adds) should we "not be repeating at this day, if we had not been anticipated "in so many of them by the ancient philosophers!"—Those systems, therefore, which are false, are by no means to be regarded as altogether useless. That of Ptolemy (for example)

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2. In applying the rules of Mathematical Method to Physics, he makes far too little allowance for the essential difference between the two sciences. This is more particularly remarkable in his observations on the aid to be derived, in investigating the laws of nature, from *the method of Exclusions*,—so happily employed by Frenicle de Bessy (a French mathematician of the 17th century) in the solution of some very difficult problems relating to numbers.—See Note (U.)

as Bailly has well observed, is founded on a prejudice so natural and so unavoidable, that it may be considered as a necessary step in the progress of astronomical science; and if it had not been proposed in ancient times, it would infallibly have preceded, among the moderns, the system of Copernicus, and retarded the period of its discovery.

In what I have hitherto said in defence of the method of Hypothesis, I have confined myself entirely to its utility as an organ of investigation; taking all along for granted, that, till the principle assumed has been fairly inferred as a law of nature, from undoubted facts, none of the explanations which it affords are to be admitted as legitimate theories. Some of the advocates for this method have however gone much farther; asserting, that if a hypothesis be sufficient to account for all the phenomena in question, no other proof of its conformity to truth is necessary. "Supposing (says Dr Hartley) the existence of *the æther* to be destitute of all direct evidence, still, if "it serves to explain and account for a great variety of phenomena, it will, by this means, have an indirect argument in "its favour. Thus, we admit the key of a cypher to be a true "one, when it explains the cypher completely; and the decypherer judges himself to approach to the true key, in proportion as he advances in the explanation of the cypher; and "*this* without any direct evidence at all *." On another occasion, he observes, that "Philosophy is the art of *decyphering* "the mysteries of nature; and that every theory which can

* Observations on Man, Vol. I. pp. 15. 16. (4th Edit.)

"explain all the phenomena, has the same evidence in its fa-
"vour, that it is possible the key of a cypher can have from its
"explaining that cypher *."

The same very ingenious and plausible reasoning is urged by Le Sage in one of his posthumous fragments †; and, long before the publication of Hartley's work, it had struck Gravesande so strongly, that, in his *Introductio ad Philosophiam*, he has subjoined to his chapter on the Use of Hypotheses, another on the Art of Decyphering. Of the merit of the latter it is no slight proof, that D'Alembert has inserted the substance of it in one of the articles of the *Encyclopedie* ‡.

In reply to Hartley's comparison between the business of the philosopher and that of the decypherer, Dr Reid observes, that "to find the key requires an understanding equal or supe-
"rior to that which made the cypher. This instance, there-

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* Ibid, p. 350. The section from which this quotation is taken (entitled "Of Pro-
"positions and the nature of Assent") contains various ingenious and just observations, blended with others strongly marked with the author's peculiar turn of thinking. Among these last may be mentioned his Theory of Mathematical Evidence, coinciding exactly with that which has since been proposed by Dr Beddoes. Compare Hartley with pp. 189 and 190 of this volume.

† "N'admettons-nous pas pour vraie, la clef d'une lettre écrite en chiffres, ou celle
"d'une logogryphe; quand cette clef s'applique exactement à tous les caracteres dont
"il faut rendre raison?" Opuscules de G. L. Le Sage, relatifs a la Methode. See M. Prevost's Essais de Philosophie.

‡ Article *Déchiffrer*. See also D'Alembert's Oeuvres Posthumes. Tome II. p. 177.—Gravesande's Logic was published in 1736.

"fore, (he adds) will *then* be in point, when he who attempts "to decypher the works of nature by a hypothesis, has an un- "derstanding equal or superior to that which made them *."

This argument is not stated with the author's usual correctness in point of logic; inasmuch as the first proposition contrasts the sagacity of the decypherer with that of the contriver of the *cypher*; and the second, with that of the author of the *composition* decyphered. Nor is this all. The argument proceeds on the supposition, that, if the task of the scientific inquirer be compared to that of the decypherer, the views of the author of nature may, with equal propriety, be compared to those of the inventor of the cypher. It is impossible to imagine that this was Hartley's idea. The object of true philosophy is, in no case, presumptuously to divine an alphabet of *secret* characters or cyphers, purposely employed by infinite Wisdom to *conceal* its operations; but, by the diligent study of facts and analogies legible to all, to discover the key which infinite Wisdom has itself prepared for the interpretation of its own laws. In other words, its object is, to concentrate and to cast on the unknown parts of the universe, the lights which are reflected from those which are known.

In this instance, as well as in others, where Reid reprobates hypotheses, his reasoning uniformly takes for granted, that they are wholly arbitrary and gratuitous. "If a thousand of the "greatest wits (says he) that ever the world produced, were, "*without any previous knowledge in anatomy*, to sit down and

* Essays on the Intell. Powers, p. 88.

"contrive how, and by what internal organs, the various func-
"tions of the human body are carried on—how the blood is
"made to circulate, and the limbs to move—they would not, in
"a thousand years, hit upon any thing like the truth *." Nothing can be juster than this remark; but does it authorize the conclusion, that, to an experienced and skilful anatomist, conjectures founded on analogy, and on the consideration of *uses*, are of no avail as media of discovery? The logical inference, indeed, from Dr Reid's own statement, is, not against anatomical conjectures in general, but against the anatomical conjectures of those who are ignorant of anatomy.

The same reply may be made to the following assertion of D'Alembert; another writer, who, in my opinion, has, on various occasions, spoken much too lightly of analogical conjectures. "It may be safely affirmed, that a mere theorist *(un "Physicien de Cabinet)* who, by means of reasonings and cal-
"culations, should attempt to divine the phenomena of nature,
"and who should afterwards compare his anticipations with
"facts, would be astonished to find how wide of the truth almost
"all of them had been †." If this observation be confined to those system-builders who, without any knowledge of facts, have presumed to form conclusions *a priori* concerning the universe, its truth is so obvious and indisputable, that it was hardly worth the while of this profound philosopher so formally to

* Ibid. p. 49.

† Mélanges de Litterature, &c. Tome V. § 6. (entitled Eclaircissement sur ce qui a été dit, &c. de l'art de conjecturer.)

announce it. If extended to such men as Copernicus, Kepler, and Newton, and to the illustrious train who have issued from the Newtonian school, it is contradicted by numberless examples, of which D'Alembert could not fail to be perfectly aware *.

The sagacity which guides the Philosopher in conjecturing the laws of nature, has, in its metaphysical origin, a very near affinity to that *acquired perception* of human character, which is possessed by Men of the World. The conclusions of one individual with respect to the springs of action in the breast of another, can never, on the most favourable supposition, amount to more than to a Hypothesis supported by strong analogies; yet how different is the value of the Hypothesis, according to the intellectual habits of him by whom it is formed! What more absurd and presumptuous than the theories of the cloistered schoolman concerning the moral or the political phenomena of active life! What more interesting and instructive than the slightest characteristical sketches from the hand of a Sully or of a Clarendon!

To these suggestions in vindication of hypotheses it may be added, that some of the reasonings which, with propriety, were urged against them a century ago, have already, in consequence

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* Accordingly, in another part of the same article, he has said: "L'analogie, c'est-"à-dire, la ressemblance plus ou moins grande des faits, le rapport plus ou moins sen-"sible qu'ils ont entr'eux, est l'unique regle des physiciens, soit pour expliquer les faits "connus, soit pour en découvrir de nouveaux."

of the rapid progress of knowledge, lost much of their force. It is very justly remarked by M. Prevost, that "at a period "when science has advanced so far as to have accumulated an "immense treasure of facts, the danger of hypotheses is less, "and their advantages greater, than in times of comparative "ignorance." For this he assigns three reasons. "1. The "multitude of facts restrains Imagination, by presenting, in "every direction, obstacles to her wanderings; and, by over-"turning her frail edifices. 2. In proportion as facts multi-"ply, the memory stands in greater need of the aid of connec-"ting or associating principles *. 3. The chance of discovering "interesting and luminous relations among the objects of our "knowledge increases with the growing number of the objects "compared †."—The considerations already stated suggest a 4th reason in confirmation of the same general proposition:—That, by the *extension* of human knowledge, the scale upon which the Analogies of Nature may be studied, is so augmented as to strike the most heedless eye; while, by its *diffusion*, the perception of these analogies (so essential an element in the composition of inventive genius) is insensibly communicated to all who enjoy the advantages of a liberal education. Justly, therefore, might Bacon say, "Certo sciant homines, artes in-"veniendi solidas et veras adolescere et incrementa sumere "cum ipsis inventis."

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* With respect to the utility of hypothetical theories, as *adminicles* to the natural powers of memory, see the former volume of this work, Chap. vi. Sections 3 and 4.

† See Note (X.)

But although I do not think that Reid has been successful in his attempt to refute Hartley's argument, I am far from considering that argument as sound or conclusive. My chief objections to it are the two following.

1. The cases compared are by no means parallel. In that of the *cypher*, we have *all* the facts before us; and, if the key explains them, we may be certain, that nothing can directly contradict the justness of our interpretation. In *our physical researches*, on the other hand, we are admitted to see only a few detached sentences extracted from a volume, of the size of which we are entirely ignorant. No hypothesis, therefore, how numerous soever the facts may be with which it tallies, can completely exclude the possibility of exceptions or limitations hitherto undiscovered.

It must, at the same time, be granted, that the probability of a hypothesis increases in proportion to the number of phenomena for which it accounts, *and to the simplicity of the theory by which it explains them*;—and that, in some instances, this probability may amount to a moral certainty. The most remarkable example of this which occurs in the history of science is, undoubtedly, the Copernican system. I before observed, that at the period when it was first proposed, it was nothing more than a hypothesis; and that its only proof rested on its conformity, in point of simplicity, to the general economy of the Universe. "When Copernicus (says "Mr Maclaurin) considered the form, disposition and motions "of the system, as they were then represented after Ptolemy,

" he found the whole void of order, symmetry, and proportion; " like a piece (as he expresses himself) made up of parts " copied from different originals, which, not fitting each other, " should rather represent a monster than a man. He therefore " perused the writings of the ancient philosophers, to see " whether any more rational account had ever been proposed " of the motions of the Heavens. The first hint he had was " from Cicero, who tells us, in his Academical Questions, that " Nicetas, a Syracusian, had taught that the earth turns round " on its axis, which made the whole heavens appear to a spec- " tator on the earth to turn round it daily. Afterwards, from " Plutarch he found that Philolaus the Pythagorean had taught " that the earth moved annually round the sun. He imme- " diately perceived, that, by allowing these two motions, all the " perplexity, disorder, and confusion he had complained of in " the celestial motions, vanished; and that, instead of these, a " simple regular disposition of the orbits, and a harmony of the " motions appeared, worthy of the great Author of the world *.

Of the truth of this hypothesis, the dicoveries of the last century have afforded many new proofs of a direct and even demonstrative nature; and yet, it may be fairly questioned, whether to Copernicus and Galileo, the analogical reasoning

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* Account of Newton's Philosophical Discoveries, p. 45. (2d Edit.)

This presumptive argument, as it presented itself to the mind of Copernicus, is thus stated by Bailly. " Les hommes sentent que la nature est simple; les stations et les " rétrogradations des planetes offroient des apparences bizarres; le principe, qui les ra- " menoit à une marche simple, et naturelle, *ne pouvoit être qu'une vérité.*" Hist. de l'Astron. Mod. Tom. I. p. 351.

stated in the preceding quotation, did not, of itself, appear so conclusive, as to supersede the necessity of any farther evidence. The ecclesiastical persecutions which the latter encountered in defence of his supposed heresy, sufficiently evinces the faith which he reposed in his astronomical creed.

It is, however, extremely worthy of remark, with respect to the Copernican system, that it affords no illustration whatever of the justness of Hartley's logical maxim. The Ptolemaic system was not demonstrably *inconsistent* with any phenomena known in the sixteenth century; and, consequently, the presumption for the new hypothesis did not arise from its exclusive coincidence with the facts, but from the simplicity and beauty which it possessed as a theory. The inference to be deduced from it is, therefore, *not* in favour of hypotheses in general, but of hypotheses sanctioned by analogy.

The fortunate hypothesis of a Ring encircling the body of Saturn, by which Huyghens accounted, in a manner equally simple and satisfactory, for a set of appearances which, for forty years, had puzzled all the astronomers of Europe, bears, in all its circumstances, a closer resemblance than any other instance I know of, to the key of a cypher. Of its *truth* it is impossible for the most sceptical mind to entertain any doubt, when it is considered, that it not only enabled Huyghens to explain all the *known* phenomena, but to predict those which were afterwards to be observed. This instance, accordingly, has had much stress laid upon it by different writers, particularly by

Gravesande and Le Sage*. I must own, I am somewhat doubtful, if the discovery of a key to so limited and insulated a class of optical facts, authorizes any valid argument for the employment of mere hypotheses, to decypher the complicated phenomena resulting from the general laws of nature. It is, indeed, an example most ingeniously and happily selected; but would not perhaps have been so often resorted to, if it had been easy to find others of a similar description.

2. The chief objection, however, to Hartley's comparison of the theorist to the decypherer is, that there are few, if any, physical hypotheses, which afford the *only* way of explaining the phenomena to which they are applied; and therefore, admitting them to be perfectly consistent with all the known facts, they leave us in the same state of uncertainty, in which the decypherer would find himself, if he should discover a variety of keys to the same cypher. Des Cartes acknowledges, that the same effect might, upon the principles of his philosophy, admit of manifold explanations; and that nothing perplexed him more than to know which he ought to adopt, in preference to the others. "The powers of nature (says he) I must con-" fess, are so ample, that no sooner do I observe any particular " effect, than I immediately perceive that it may be deduced " from *my* principles, in a variety of different ways; and no-

* Gravesande, Introd. ad Philosoph. §§ 979. 945.

Opuscules de le Sage, published by M. Prevost. Premier Mémoire, § 25. The latter writer mentions the theory in question, as a hypothesis which received no countenance whatever from the analogy of any preceding astronomical discovery.

" thing, in general, appears to me more difficult, than to ascer-
" tain by which of these processes it is really produced *." The same remark may (with a very few exceptions) be extended to every hypothetical theory which is unsupported by any collateral probabilities arising from experience or analogy; and it sufficiently shews, how infinitely inferior such theories are, in point of evidence, to the conclusions obtained by the art of the decypherer. The principles, indeed, on which this last art proceeds, may be safely pronounced to be nearly infallible.

In these strictures upon Hartley, I have endeavoured to do as much justice as possible to his general argument, by keeping entirely out of sight the particular purpose which it was intended to serve. By confining too much his attention to this, Dr Reid has been led to carry, farther than was necessary or reasonable, an indiscriminate zeal against every speculation to which the epithet *hypothetical* can in any degree, be applied. He has been also led to overlook the essential distinction between hypothetical inferences from one department of the Material World to another, and hypothetical inferences from the Material World to the Intellectual. It was with the view of apologizing for inferences of the latter description, that Hartley ad-

* Dissertatio de Methodo. In the sentence immediately following, Des Cartes mentions the general rule which he followed, when such an embarrassment occurred. " Hinc aliter me extricare non possum, quàm si rursus aliqua experimenta quæram; " quæ talia sint, ut eorum idem non sit futurus eventus, si hoc modo quam si illo expli-
" cetur." The rule is excellent; and it is only to be regretted, that so few exemplifications of it are to be found in his writings.

vanced the logical principle which gave occasion to the foregoing discussion; and therefore, I apprehend, the proper answer to his argument is this:—Granting your principle to be true in all its extent, it furnishes no apology whatever for the Theory of Vibrations. If the science of mind admit of any illustration from the aid of hypotheses, it must be from such hypotheses alone as are consonant to *the analogy of its own laws*. To assume, as a fact, the existence of analogies between these laws and those of matter, is to sanction that very prejudice which it is the great object of the inductive science of mind to eradicate.

I have repeatedly had occasion, in some of my former publications, to observe, that the names of almost all our mental powers and operations are borrowed from sensible images. Of this number are intuition; the discursive faculty; attention; reflection; conception; imagination; apprehension; comprehension; abstraction; invention; capacity; penetration; acuteness. The case is precisely similar with the following terms and phrases, relative to a different class of mental phenomena;—inclination; aversion; deliberation; pondering; weighing the *motives* of our actions; yielding to that *motive* which is the strongest;—expressions (it may be remarked in passing,) which, when employed, without a very careful analysis of their import, in the discussion concerning the liberty of the will, gratuitously prejudge the very point in dispute; and give the semblance of demonstration, to what is, in fact, only a series of identical propositions, or a sophistical circle of words *.

* "Nothing (says Berkeley) seems more to have contributed towards engaging

That to the apprehensions of uneducated men such metaphorical or analogical expressions should present *the images* and *the things typified*, inseparably combined and blended together, is not wonderful; but it is the business of the philosopher to conquer these casual associations, and, by *varying* his metaphors, when he cannot completely lay them aside, to accustom himself to view the phenomena of thought in that naked and undisguised state in which they unveil themselves to the powers of consciousness and reflection. To have recourse therefore to the analogies suggested by popular language, for the purpose of *explaining* the operations of the mind, instead of advancing knowledge, is to confirm and to extend the influence of vulgar errors.

After having said so much in vindication of analogical conjectures as steps towards physical discoveries, I thought it right to caution my readers against supposing, that what I have stated admits of any application to analogical theories of the human mind. Upon this head, however, I must not enlarge farther at present. In treating of the inductive logic, I have studiously confined my illustrations to those branches of knowledge in which it has already been exemplified with indisputable suc-

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" men in controversies and mistakes with regard to the nature and operations of the " mind, than the being used to speak of those things in terms borrowed from sensible " ideas. For example, the will is termed the *motion* of the soul. This infuses a belief, " that the mind of man is as a ball in motion, impelled and determined by the objects " of sense, as necessarily as that is by the stroke of a racket." (Principles of Human Knowledge.)

cess; avoiding, for obvious reasons, any reference to sciences in which its utility still remains to be ascertained.

III.

Supplemental Observations on the words INDUCTION *and* ANALOGY, *as used in Mathematics.*

BEFORE dismissing the subjects of induction and analogy, considered as methods of reasoning in Physics, it remains for me to take some slight notice of the use occasionally made of the same terms in pure Mathematics. Although, in consequence of the very different natures of these sciences, the induction and analogy of the one cannot fail to differ widely from the induction and analogy of the other, yet, from the general history of language, it may be safely presumed, that this application to both of a common phraseology, has been suggested by certain *supposed* points of coincidence between the two cases thus brought into immediate comparison *.

It has been hitherto, with a very few if any exceptions, the universal doctrine of modern as well as of ancient logicians,

* I have already observed (See p. 347 of this volume) that mathematicians frequently avail themselves of that sort of induction which Bacon describes "as proceeding by simple enumeration." The induction, of which I am now to treat, has very little in common with the other, and bears a much closer resemblance to that recommended in the Novum Organon.

that "no mathematical proposition can be proved by induc-"tion." To this opinion Dr Reid has given his sanction in the strongest terms; observing, that "although in a thousand cases, "it should be found by experience, that the area of a plane "triangle is equal to the rectangle under the base and half the "altitude, this would not prove that it must be so in all cases, "and cannot be otherwise, which is what the mathematician "affirms*."

That some limitation of this general assertion is necessary, appears plainly from the well-known fact, that *induction* is a species of evidence on which the most scrupulous reasoners are accustomed, in their mathematical inquiries, to rely with implicit confidence; and which, although it may not *of itself* demonstrate that the theorems derived from it are *necessarily* true, is yet abundantly sufficient to satisfy any reasonable mind that they hold *universally*. It was by induction (for example) that Newton discovered the algebraical *formula* by which we are enabled to determine any power whatever, raised from a binomial root, without performing the progressive multiplications. The formula expresses a relation between the exponents and the co-efficients of the different terms, which is found to hold in all cases, as far as the table of powers is carried by actual calculation;—from which Newton inferred, that if this table were to be continued *in infinitum*, the same *formula* would correspond equally with every successive power. There is no reason to suppose that he ever attempted to prove the theorem in any other way;

* Essays on the Intell. Powers, p. 615. 4to edit.

and yet, there cannot be a doubt, that he was as firmly satisfied of its being *universally* true, as if he had examined all the different demonstrations of it which have since been given *. Numberless other illustrations of the same thing might be borrowed, both from arithmetic and geometry †.

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* "The truth of this theorem was long known only by trial in particular cases, and "by *induction* from *analogy*; nor does it appear that even Newton himself ever at- "tempted any direct proof of it." (Hutton's Mathematical Dictionary, Art. Binomial Theorem.) For some interesting information with respect to the history of this discovery, see the very learned Introduction prefixed by Dr Hutton to his edition of Sherwin's Mathematical Tables; and the second volume (p. 165) of the *Scriptores Logarithmici*, edited by Mr Baron Maseres.

† In the *Arithmetica Infinitorum* of Dr Wallis, considerable use is made of the Method of Induction. "A l'aide d'une *induction* habilement ménagée (says Montucla) et "du fil de *l'analogie* dont il sçut toujours s'aider avec succès, il soumit à la géométrie "une multitude d'objets qui lui avoient échappé jusqu' alors." (Hist. des Mathem. Tome II. p. 299.) This innovation in the established forms of mathematical reasoning gave offence to some of his contemporaries; in particular, to M. de Fermat, one of the most distinguished geometers of the 17th century. The ground of his objection, however, (it is worthy of notice) was not any *doubt* of the conclusions obtained by Wallis; but because he thought that their truth might have been established by a more legitimate and elegant process. "Sa façon de demontrer, qui est fondée sur *induction* plu- "tot que sur un raisonnement à la mode d'Archimede, fera quelque peine aux novices, "qui veulent des syllogismes demonstratifs depuis le commencement jusqu'à la fin. Ce "n'est pas que je ne l'approuve, mais toutes ses propositions pouvant être demontrées "*viâ ordinariâ, legitimâ, et Archimedæâ*, en beaucoup moins de paroles, que n'en conti- "ent son livre, je ne sçai pas pourquoi il a préferé cette manière à l'ancienne, qui est "plus convainquante et plus elegante, ainsi que j'espere lui faire voir à mon premier "loisir." Lettre de M. de Fermat a M. le Chev. Kenelme Digby. (See Fermat's *Varia Opera Mathematica*, p. 191.) For Wallis's reply to these strictures, see his *Algebra*, Cap. lxxix; and his *Commercium Epistolicum*.

In the *Opuscules* of M. le Sage, I find the following sentence quoted from a work of

Into what principles, it may be asked, is the validity of such a proof in mathematics ultimately resolvable?—To me it appears to take for granted certain general logical maxims; and to imply a secret process of legitimate and conclusive reasoning, though not conducted agreeably to the rules of mathematical demonstration, nor perhaps formally expressed in words. Thus, in the instance mentioned by Dr Reid, I shall suppose, that I have first ascertained experimentally the truth of the proposition in the case of an equilateral triangle; and that I afterwards find it to hold in all the other kinds of triangles, whether isosceles or scalene, right-angled, obtuse-angled, or acute-angled. It is impossible for me not to perceive, that this property, having no connection with any of the particular circumstances which discriminate different triangles from each other, *must* arise from something common to all triangles, and *must* therefore be a universal property of that figure. In like manner, in the *binomial theorem*, if the formula correspond with the table of powers in a variety of particular instances, (which instances agree in no other respect, but in being powers raised from the same binomial root,) we must conclude—and, I apprehend that our conclusion is perfectly warranted by the soundest logic,—that it is *this* common property which renders the theorem true in all these cases, and conse-

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La Place, which I have not had an opportunity of seeing. The judgment of so great a master, on a logical question relative to his own studies, is of peculiar value. "La "methode d'induction, *quoique excellente pour découvrir des verités générales*, ne doit pas "dispenser de les démontrer avec rigueur." (Leçons données aux Ecoles Normales, Prem. Vol. p. 380.)

quently, that it *must necessarily* hold in every other. Whether, on the supposition that we had never had any previous experience of demonstrative evidence, we should have been led, by the mere inductive process, to form the idea of *necessary truth*, may perhaps be questioned; but the slightest acquaintance with mathematics is sufficient to produce the most complete conviction, that whatever is *universally* true in that science, must be true *of necessity*; and, therefore, that a universal, and a necessary truth, are, in the language of mathematicians, synonymous expressions. If this view of the matter be just, the evidence afforded by mathematical induction must be allowed to differ radically from that of physical; the latter resolving ultimately into our instinctive expectation of the laws of nature, and consequently, never amounting to that demonstrative certainty, which excludes the possibility of anomalous exceptions.

I have been led into this train of thinking by a remark which La Place appears to me to have stated in terms much too unqualified;—"Que la marche de Newton, dans la découverte "de la gravitation universelle, a été *exactement* la même, que "dans celle de la formule du binome." When it is recollected, that, in the one case, Newton's conclusion related to a *contingent*, and in the other to a *necessary* truth, it seems difficult to conceive, how the logical procedure which conducted him to both should have been *exactly* the same. In one of his queries, he has (in perfect conformity to the principles of Bacon's logic) admitted the possibility, that "God may vary the "laws of nature, and make worlds of several sorts, in several

"parts of the universe." "At least, (he adds) I see nothing "of contradiction in all this*." Would Newton have expressed himself with equal scepticism concerning the universality of his binomial theorem; or admitted the possibility of a single exception to it, in the indefinite progress of actual involution? In short, did there exist the slightest shade of difference between the degree of his assent to this *inductive result*, and that extorted from him by a demonstration of Euclid?

Although, therefore, the mathematician, as well as the natural philosopher, may, without any blameable latitude of expression, be said to reason by *induction*, when he draws an inference from the known to the unknown, yet it seems indisputable, that, in all such cases, he rests his conclusions on grounds essentially distinct from those which form the basis of experimental science.

The word *analogy*, too, as well as *induction*, is common to physics, and to pure mathematics. It is thus we speak of the analogy running through the general properties of the different conic sections, with no less propriety than of the analogy running through the anatomical structure of different tribes of animals. In some instances, these mathematical analogies are collected by a species of *induction*; in others, they are inferred as consequences from more general truths, in which they are included as particular cases. Thus, in the curves which have just been mentioned, while we content ourselves (as many ele-

* Query 31.

mentary writers have done)* with deducing their properties from mechanical descriptions on a plane, we rise experimentally from a comparison of the propositions which have been separately demonstrated with respect to each curve, to more comprehensive theorems, applicable to all of them; whereas, when we begin with considering them in their common origin, we have it in our power to trace from the source, both their generic properties, and their specific peculiarities. The satisfaction arising from this last view of the subject can be conceived by those alone who have experienced it; although I am somewhat doubtful whether it be not felt in the greatest degree by such as, after having risen from the contemplation of particular truths to other truths more general, have been at last conducted to some commanding station, where the mutual connections and affinities of the whole system are brought, at once, under the range of the eye. Even, however, before we have reached this vantage-ground, the contemplation of the analogy, considered merely as a *fact*, is pleasing to the mind; partly, from the mysterious wonder it excites, and partly from the convenient generalization of knowledge it affords. To the experienced mathematician this pleasure is farther enhanced, by the assurance which the analogy conveys, of the existence of yet undiscovered theorems, far more extensive and luminous than those which have led him, by a process so indirect, so tedious, and comparatively so unsatisfactory, to his general conclusions.

* L'Hospital, Simson, &c.

In this last respect, the pleasure derived from analogy in mathematics, resolves into the same principle with that which seems to have the chief share in rendering the analogies among the different departments of nature so interesting a subject of speculation. In both cases, a powerful and agreeable *stimulus* is applied to the curiosity, by the encouragement given to the exercise of the inventive faculties, and by the hope of future discovery, which is awakened and cherished. As the analogous properties (for instance) of the conic sections, point to some general theorems of which they are corollaries; so the analogy between the phenomena of Electricity and those of Galvanism irresistibly suggests a confident, though vague anticipation of some general physical law comprehending the phenomena of both, but differently modified in its sensible results by a diversity of circumstances*. Indeed, it is by no means impossible, that the pleasure we receive even from those analogies which are the foundation of poetical metaphor and simile, may be found resolvable, in part, into the satisfaction connected with the *supposed* discovery of truth, or the *supposed* acquisition of knowledge; the faculty of imagination giving to these illusions a momentary ascendant over the sober conclusions of experience; and gratifying the understanding with a flattering consciousness of its own force, or at least with a consolatory forgetfulness of its own weakness.

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* See Note (Y.)

SECTION V.

Of certain misapplications of the words Experience and Induction in the phraseology of Modern Science.—Illustrations from Medicine and from Political Economy.

In the first Section of this Chapter, I endeavoured to point out the characteristical peculiarities by which the Inductive Philosophy of the Newtonians is distinguished from the hypothetical systems of their predecessors; and which entitle us to indulge hopes with respect to the permanent stability of their doctrines, which might be regarded as chimerical, if, in anticipating the future history of science, we were to be guided merely by the analogy of its revolutions in the ages that are past.

In order, however, to do complete justice to this argument, as well as to prevent an undue extension of the foregoing conclusions, it is necessary to guard the reader against a vague application of the appropriate terms of *inductive science* to inquiries which have not been rigorously conducted, according to the rules of the *inductive logic*. From a want of attention to this consideration, there is a danger, on the one hand, of lending to sophistry or to ignorance the authority of those illustrious names whose steps they profess to follow; and, on the other, of bringing discredit on that method of investigation, of which the language and other technical arrangements have been thus perverted.