On certain modified forms assumed by the inductive process in different sciences : being an attempt to elucidate and extend some doctrines of the Novum organum / by Robert Mortimer Glover.

To H. Gavin Esq. M
with the compliments
(12.) of the Author

ON

CERTAIN MODIFIED FORMS

ASSUMED BY THE

INDUCTIVE PROCESS IN DIFFERENT SCIENCES;

BEING

AN ATTEMPT TO ELUCIDATE AND EXTEND SOME DOCTRINES OF THE NOVUM ORGANUM.

By ROBERT MORTIMER GLOVER, Esq.

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Of late, great importance has been rightly attached to the cultivation of those doctrines in primary philosophy, which regulate the formation of our practical rules of scientific inquiry. Indeed, as the doctrines alluded to are axioms including nearly all science in their relations, although in themselves of an abstractedly simple nature, it is very needful for the notions entertained with regard to them to be explicit. The proper functions of experiment and calculus, with other topics of no secondary consequence, can be thoroughly understood, only when investigated in their connexions with the theory of the Inductive Logic. And the Novum Organum itself exists as an everlasting memorial of the utility which may at any time result from the attention of scientific men being directed to the study of the laws that govern the mind in acquiring its knowledge, and the bearing of these upon actual inquiry:—for in the work is displayed the mode in which its immortal author was enabled to frame a code for future investigators, and perhaps to alter the bent of the energies of his time, from having

conceived more enlarged views of the province appertaining to induction, than those possessed by his predecessors. In the present day, the light derived from numerous successful efforts to explore nature, has been reflected upon the study of methods and systems; and many illustrious disciples of the Baconian school in this country and abroad, have thus been able to refine greatly the precepts of their master. It seems to be generally supposed, that the labours of Stewart, Playfair, Laplace, the present Herschel, and others nearly equally eminent, who have treated of the applications of the Baconian philosophy, have almost exhausted the subject, and that if little can receive further elucidation, still less remains to be explored. But we believe, if the opinions of writers on induction be rigidly examined, a greater want of unanimity among them, even on very essential points, will be detected, than could be credited before hand. In particular, writers on logic are often by no means in accord with those who have described induction not exactly as a form of mental procedure, but by the help of certain signs in nature correctly supposed to correspond with successive steps in the mental operation. Besides, much ill defined language is currently used in speaking of the inductive process, its character and relations,—thus, it is often said, that physical laws have the power of enabling events to be anticipated by means of *others* which *have been* observed; and this is asserted sometimes when perhaps no very clear ideas are entertained of the *character* of this curious property attributed to physical laws. Further, the category of inductive sciences seems not very accurately defined. Metaphysicians have debated among themselves whether the precepts of the Baconian philosophy are properly applicable to the science of mind,—and whether the investigation of mental phenomena can be considered to involve the practice of a method of procedure at all analogous to the experimental inquiries of physics. And although in the northern part of our island, these questions have been answered in the affirmative,—a response has not been so generally given by the English and Continental metaphysicians. In like manner, writers on the philosophy of medicine differ greatly as to the extent of application admitted in their science to precepts which

have been found invariably fertile in results, as applied in pure physics.

Our object in this essay is to make an effort to reconcile some of the above stated discrepancies, and to clear up (if possible) other portions of the theory of the inductive logic which appear to us in need of elucidation; and these intentions we purpose to effect, by detecting and defining certain forms which induction seems to assume in different sciences, when that process is regarded not in the mind, but through its corresponding signs in nature,—and which forms do not appear to be distinguished as yet in a clear manner by writers; while, at the same time, we endeavour to show how those varieties come to be, as it were, developed out of the fundamental process which is performed in mind,—which does never vary in essential character, whatever phases it may assume, when the indices correspondent to it are regarded in nature. As our space is necessarily somewhat limited, we shall only premise further, that our purposed divisions will regard methods of inductive procedure, and not individual instances, as in the classifications of Bacon, and that if the circumstances in the very constitution of the different sciences, which compel the inquirer to take diverse routes in arriving at their truths, have already been described, the subject, so far as we are aware, has not been treated as a whole in the particular way proposed.

It is perhaps scarcely proper to remind the reader, that all our knowledge is rendered available to the reasoning faculty by means of what is termed generalization:—for, as all processes of pure reasoning may be resolved into syllogisms, which can proceed only from generals to particulars,—until the mind has arrived at general notions, it cannot of course be capable of reasoning either on the subject-matter of the knowledge afforded by scientific inquiry, or on that of the information acquired in the ordinary relations of life. To that intellective faculty which has the power of forming general notions is given the name of abstraction; while its mode of procedure is termed induction or the inductive process. Abstraction is not regarded by metaphysicians of the present day as a simple faculty of the mind; but its real nature is of little concern here;—let it

be understood, however, that induction is its mode of procedure, and generalization its result. And, first, let us attend to the result, in order that a clear conception may be had of what is required in a method of procedure, the great object of which is that this result may be attained.

In a logical point of view, a science may be regarded as a collection of general terms, each of which in all sciences, except those generally considered abstract, expresses common circumstances possessed by a certain number of particulars, from the examination of which the genus has been formed. In the abstract sciences, as for example in geometry, and that department of mental science, which, by the disciples of Reid, is called the doctrine of first truths, the highest and most inclusive principles are ideas of relation which subsist solely in the mind itself, and are found therein; so far, therefore, in those sciences there is no occasion for an inductive process, since the most general facts are also the simplest elements of belief, and as in geometry the only further foundation requisite for the whole series of truths composing the science, is, that some purely intellectual forms be described by references to those elementary principles, the science is altogether independent of induction. But, in the study of nature, both external, and within ourselves, all science (except the above mentioned portion of mental science, and perhaps a corresponding part of the doctrine of ethics) requires an analysis of a mass of phenomena, which at first sight appear exceedingly heterogeneous and complicated, in order that they may be resolved into simpler combinations, which, however, are expressed in terms more inclusive the farther the analysis is pushed. In other words, after the whole of the universe has been resolved into separate and distinct parts, these are again combined by the mind, and arranged into mental *loci*, according to laws furnished by itself. The grand object of this system of arrangement is not that the purpose of distinctness may be answered, nor that knowledge may thus be properly treasured up, but it is that this knowledge may be reasoned upon, in order, in fact, that the intellective process, which is carried on in syllogisms, may take the place of that which constitutes induction; and that those wonderful effects may be produced which flow from comparing and combining the re-

sults of human inquiry.* Such being the case, it may be conceived, that in framing those genera, the mind is not compelled to take notice only of such properties as are believed most essential to the constitution of the individuals to be grouped together; on the contrary, the abstraction may be of whatever properties are chosen, according to the notions entertained of their fitness for an end in view. All that is absolutely necessary to be attended to in the formation of a law, being that the properties fixed on for its types have an actual existence in all the particular instances composing the included genus. Thus, the Linnæan arrangement of plants is as just a system, so far as the mind is concerned, as that of Jussieu. It is true, the one system takes cognizance of a greater number of characters in composing its genera than are considered in the classes and orders of the other, and also of such characters as are believed most essential to the very nature of the individual plants. This system is therefore physically the more perfect of the two, but it is not therefore more logical than the other. In that respect both are alike,—both sufficiently accurate in logical structure, but framed for different ends.

The preceding observations may in some degree illustrate a great maxim of the Kantians, which makes the fundamental principles of all science repose in the intellect itself;—asserting the human understanding rather to dictate the laws which regulate its acquisition of knowledge, than receive them from the external world.† Indeed all general notions are the workmanship of the mind, and often cannot be ascertained to correspond exactly with existences and actions of nature. And this, even, on the understanding that such notions are derived in all cases by an exercise of the intellective faculty from real impressions. For example, the intellectual forms which are the objects of

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* It is properly remarked by Whately, that those who propose in teaching logic, to substitute the Organon of Bacon for that of Aristotle, show a total want of comprehension of the intentions of either. This may be placed in a very strong light, when we reflect, that without the exercise of syllogistic reasoning, Watt would have been unable to apply the inductively raised laws of Black to the improvement of the steam-engine,—a fact which we could easily prove, were there space or occasion at the present time.

† Philosophie de Kant, par Villiers, p. 301, 8vo. Metz, 1801. The same truth is elaborately illustrated by Dr Brown in his 5th lecture.

geometrical reasoning, and which, being ideas of relation, have somewhat of the character of general notions, are not to be found pure in nature. And something similar, or at least analogous, holds of physical laws also; for these are either general terms signifying the agreement of a number of particular facts or phenomena in some common properties, or else abstractions of some actions of Nature from others with which they must in many cases be viewed in their real state, somewhat combined.

The characteristic, or what may be termed the logical characters of all physical laws are similar. For a definition of a physical law, in logic, it is enough to term it a statement implying a connexion observed between some properties and others, in any definite class of instances. It is quite essential, that the class of facts to which a law is applicable should be defined, but all the particular instances included in that class need not be known.* By the term property is meant a structure, a quality, or a function. Our observations with regard to laws apply to such general expressions as include *all their particulars* with logical certainty; and if in any place another meaning be attached to the term, it shall be stated explicitly.

On examination, the above definition will probably be found to include every thing absolutely requisite to constitute a physical law; and to be so general, that scarcely a law will be found without some physical or metaphysical properties superadded to those in the definition. But when illustrations are sought, they will doubtless be found in accordance with our

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* This distinction is believed to be of great importance; perhaps the following illustration may explain more fully its nature. The first law in the theory of gravitation was proved nearly as we are about to mention. Galileo found experimentally a few balls of different materials to obey the law of gravity within very short distances of the earth. Newton proved by calculation, that the same law extends to the moon. And by trials of very dissimilar substances on the surface of our planet, it seemed to be made out that the property of gravitation could belong to them only because it belongs to all matter in their circumstances; those bodies being so unlike, as that they could scarcely owe the property to anything, except a common material nature. Thus, when the law of gravity is stated as holding true of matter within certain limits, it includes in its expression (with logical propriety) innumerable individual instances, many of which probably may differ somewhat from the instances originally experimented on. But if the grounds of the original conclusion were correct, this latitude of expression cannot be objected to.

statement. Thus, to take two examples differing in some respects from each other; the series of laws composing the Newtonian doctrine of gravitation, and the generic terms of the method of natural families of plants, present laws expressing generally, in the one case, the fact, that matter, in separate masses, and within certain observed limits, has been found endued with the property of gravitation,* —and in the other, that in certain groups of plants, the individuals resembling one another in form, do also agree in respect of medicinal and culinary virtues.

Subordinate to the great logical characters of physical laws, there are other characters of a physical, or a metaphysical kind, which, not being all common to such expressions, but some of them peculiar to particular laws, serve to distinguish those. The chief of these characters depend upon the relations preserved between properties connected in laws, in time, and in space. Characters deduced from such relations, may be termed metaphysical: their existence was clearly pointed out by Dr Brown. The physical characters belonging to laws are very various; and in this inquiry may be considered accidental or contingent.

A law, stating that the properties to which it applies preserve a relation one to another, so that the presence of none is antecedent to the appearance of the others, is an expression like the description of a natural family, or the theory of the circulation reduced to its utmost simplicity. For as, in this latter case, it is only stated that the performance of the circulation of the blood is a function essentially connected with a peculiar structure,—the prior presence, whether of structure or function, is left undetermined. But where one property precedes another in the order of time—one being a uniform antecedent, and the other a uniform consequent, *i. e.*, when this order is found to occur regularly in certain contingent physical circumstances, —the law is then one of cause and effect. Since the phenomena of gravitation are now found to be consequent upon the re-

* Dr Brown first shewed, in his usual forcible manner, that the law of gravity could not be extended with logical propriety or physical certainty, beyond observed limits. See sect. 8, p. 177 of the 1st vol. of his Lectures, 8vo ed., 1820.

lative position of gravitating masses, because the attractive influence requires time for its transmission, the law of gravity is one of cause and effect. Matter, in separate masses, and these at distances not extremely minute, being the uniform antecedent ;—the phenomena of gravitation the uniform consequent; and the occurrence of the law within certain definite distances (added to what is said just above), the contingent circumstances.

But besides the statement of an existing relation between properties, a physical law often carries with its terms the presumption of an existency in nature, more remote and subtile than the observed properties, and which causes those to preserve their known relations. In other words, the law excites in the mind the idea of something which not being really discoverable in nature, is nevertheless believed to exist. Thus, a law, expressing the relation of properties, as cause and effect, gives rise to an idea of power, or of a mutual adaptation between antecedent and sequent,—the cause of observed phenomena. This latent adaptation is meant when an attractive force, enabling the masses of matter to act on each other reciprocally, is spoken of. The law of gravity does not state the existence of any such adaptation, but merely tells a bare fact. As, however, the human intellect feels inclined to give a reason for everything it discerns, and the occurrence of gravitation being an inexplicable fact as beheld, by the invention of a hypothesis which does assign a reason for the fact, a mode is thus contrived to harmonize the actions of nature with the constitution of the mind. In like manner, when in the system of natural families, a very curious connexion has been established between outward conformation and internal properties, it is perhaps impossible to refrain from believing that this connexion has a cause in some more intimate organisation of the plants in which it may exist, or in the nature of the principle of life itself, which may thus hold together by an appropriate bond of union two sets of properties, which, in their known natures, furnish no reason for the actual relations they may maintain. The belief in the existence of ultimate principles is derived from experience ; it arises from the discovery of the causes of events in preceding cases ; and when any inexplicable connexion consisting in nature is

detected, there is an instant tendency in the mind to suppose a reason for it.*

Our opinion, as given above, is in a great measure opposed to the well known doctrine of cause and effect, promulgated with so much eloquence by Dr Brown: but it is now by no means an act of daring to venture the avowal of more speculative notions, with regard to cause and effect, than those published by that justly celebrated metaphysician. For at present his theory is generally dissented from; and we believe that it is not in accordance with the genuine spirit of the Philosophy of Bacon, nay, that brought to bear upon actual inquiry it would be found to have an effect extremely prejudicial.

According to Dr Brown, all that can be conceived, or rather all that should be conceived by the mind of cause and effect, is the invariable antecedence of one property with the consequence of another, under certain contingent circumstances. Besides this invariable relationship, no idea of power or force should be conceived. And, by way of illustration, he analyzes, with his wonted elaboration, the law of gravity, in which he says, all that can be rationally or philosophically conceived of the phenomena of gravitation is stated, viz. the simple fact. Or, to the statement of the simple fact, according to his doctrine of causation, a sound philosophy ought not to attach any hypothesis of the existence of a principle connecting together the properties which are the subjects of that law: the supposition that the phenomena of gravitation are owing to an attractive force exerted between masses of matter being unwarranted by the known facts. Such must be his meaning; and accordingly

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* It will be seen from what is said, that we are of those who assign to vital principles a place in physiological inquiry. There is not space here to enter into a discussion of that question, so involved in controversy; but we will ask those who deny that such ultimate principles can have *any* place in philosophical inquiry, how they can account for such a fact as that given in a recent paper on development, by Dr Barry, viz. that all animal germs are fundamentally the same,—or that, from structures essentially the same, exposed in the Universe to circumstances utterly unable from diversity to produce such diverse creatures (as can be found experimentally), all the varied forms of animalized beings are developed? There can only be one answer: —The differences amongst germs which give rise to such dissimilar beings, exist in their principles of life! or are differences in innate susceptibility.

he censures the query in which Newton couched *his* belief in the existence of an ultimate principle,—the cause of gravity.

Were one, unacquainted with the Newtonian Philosophy, and likewise with any theories of causation, to behold two masses of matter gravitating to one another, he would naturally ascribe the fact to the existence of an attractive force, or the exercise of a secret sympathy; and, if one of the bodies were drawn more towards the other than this one unto it, he would suppose the power residing in the one to preponderate over that power residing in the other; for the feeling in ourselves of what is required to produce analogous effects by muscular exertion, is alone sufficient to produce both convictions. The hypothesis of the existence of an attractive force is admitted by Condillac to be a forced conviction of the mind, and therefore allowable in a philosophical sense also.* Dr Brown himself nearly admits at one time all that the most speculative transcendalist could desire to have from him in favour of the legitimacy of researches into the nature of ultimate principles; for while lamenting the defection of Newton from sound philosophical views, with regard to the proper objects of physical inquiry indicated by the query as to the cause of gravity, this circumstance is attributed by him to the influence of a "human infirmity," from which the greatest minds are not exempt.† The advocates for transcendental or speculative inquiry, when inductive investigation is apparently pushed as far as possible, merely maintain, that, from the very constitution of the human mind, it is not possible for us to refrain from attempts to acquire some notion of existencies in the being of which we are compelled to believe, although they themselves be not before the senses. Both Dr Brown and Mr Stewart‡ regard a conviction of the existence of something to be explored, as the legitimate and necessary precursor of scientific inquiry: hypothesis is the stimulus to investigation which in the human race as a whole, and in individuals, has ever been urged on by the presumption of success thus afforded. And if the existence of some principle beyond such a law as that of gravity were not supposed,

* Traité des Systêms, vol. i. pp. 240–2.

† See Brown's Lectures, vol. i. sect. 8, p. 167.

‡ See Stewart's Lectures, vol. ii. c. 4, p. 403.

there could be no inducement to inquire after such an entity. Now, the laws of chemical affinity are exactly correspondent with that of gravity; and Davy succeeded in determining the dependence of chemical affinity upon the electric states of bodies. Nay, of late, Mossotti has by abstract reasoning generalized all the phenomena of attraction and repulsion, whether of a mechanical or chemical character, into actions of a common hypothetical principle, which must coincide with the cause of gravity.

Physical inquiry may be regarded not improperly as a constant struggle on the part of the mind, to acquire such a perfect knowledge of the phenomena and scheme of external nature as it has of those ideas of relation generated within itself, which form the basis of geometrical science. Over such ideas its control is complete; it developes them into propositions according to the laws of its own constitution. Now, the formation of general notions is one step towards the reduction of physical science to so complete an intellectuality. But the real or essential principles of connexion between properties have not yet been discovered. Could they be known, physics would become a demonstrative science. But the mind endeavours to supply their place, by supposing the existence of such principles as the cause of gravity. And be it noticed, that those ideas of power or force are like the fundamental principles of geometry, ideas of relation which, according to Locke, have their birth in internal sensation or reflection, *i. e.* in the intellect itself.

It is generally believed that Bacon banished the study of causes from his philosophy. So far is this from being the real state of the case, that, on the contrary, he created a branch of philosophy, the express object of which he makes to be to inquire into their nature. In fact, while the ancients vainly endeavoured to arrive at a knowledge of ultimate principles by speculation, and from such principles assigned hypothetically to deduce effects, and thus to demonstrate all the real phenomena of nature out of their own unassisted reasoning, as was afterwards attempted by Descartes, Bacon proposed first to investigate the real existing and observable connexions among properties, and not to speculate until this investigation had been carried on as far as possible. He separated the study of causes from the study of observable actions, and assigned the former

to metaphysics, and the latter to physics.* And Newton, deeply imbued with the spirit of Bacon's philosophy, followed its precepts to the letter, when, having arrived at the law of gravity inductively, he began to speculate as to the nature of the cause of gravity; at the same time defining most distinctly in his 28th query, the true aim of philosophy to be the determination of such lofty inquiries as that which regards the cause of gravity.

Physical inquiry consists in seeking after connexions between properties existing in nature, or in endeavouring to discover where such connexions cannot exist. Hence there are negative and positive laws. But all definitions of laws, by an appropriate and slight change in expression can be made to apply to negative as well as to positive cases. Perhaps sufficient has now been said with regard to the results of inductive inquiry, to enable all the varieties of inductive procedure to be understood.

We turn, then, to view the objects of contemplation proposed on introducing our subject. And since a law framed by induc-

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* Since the above made statements may be supposed to involve controvertible matter, we shall support them as fully as our limits permit. In the first place, then, it is sometimes not very easy to get at Lord Bacon's meaning, even when that ought to be exceedingly clear. This has been remarked by Mr Stewart, who says, "In one passage he approves of the opinion of Plato, that the investigation of FORMS is the proper object of science, adding, however, that this is not true of the FORMS which Plato had in view, but of a different set, more suited to the grasp of our faculties." This is nearly the language of the Novum Organon, (Part 1, sect. 2, aph. 51). And elsewhere Bacon declares, that he understands by the word Form the law through which the actions of individual bodies are performed (Nov. Org. P. 2, s. 1, aph. 2). But elsewhere he evidently means by FORMS the most remote principles that we can conceive. Thus, he tells us, that the "FORM of any nature is such as, that where it is, the given nature must infallibly be;" (Nov. Org. P. 1, s. 2, aph. 4). And although, in the very next sentence in which the passage we have just rendered occurs, he seems to allude to something still more essential than a FORM, yet, as in the inquiry after the FORM of heat, he concludes heat to be an "expansive bridled motion, struggling in the small particles of bodies;" we think that his FORMS do also correspond with such principles as the cause of gravity, or the cause of light, but that he has another inferior set of FORMS, such as physical laws. And as he divides his philosophy into the study of FORMS or metaphysics, and the study of effects or actions up to the FORM which he calls physics, proposing, by means of the knowledge acquired in physics, to produce all sorts of mechanical actions, (Nov. Org. P 2, s. 1, aph. 9), his meaning is thought to accord with the interpretation above given.

tion should include the class of facts to which it is applicable, in a perfect manner, every legitimate species of induction must be capable of affording complete proof. But it is evident, that, in such a case as the law of gravity, every individual instance included in the expression cannot be examined, or the labour of proof would be illimitable: how, then, is the requisite degree of evidence in such a case obtained?

Aristotle believed it necessary, for every particular instance, subject to a law to be examined, before the expression could be logically certain: "Nam inductio fit ex omnibus singularibus."* But the examples of induction with which he was acquainted, were cases in which it is requisite to examine every instance belonging to a law before the due amount of evidence can be collected. As the subject is placed in an exceedingly favourable light by some sentences of Gassendi, we shall take the liberty of quoting those:—

"Etenim ipsa quoque inductio syllogismus reipsa est; et quadamtenus quidem mediæ inter enthymena et gradationem conditionis,—* * * hic cum dicitur, v. c. omne animal gressile vivit, omne item volatile vivit, omne etiam natatile, omne reptile, omne zoophytum; igitur omne animal vivit; assumptiones hinc plures sunt, justa generaliores species gradus animalis collectæ, et quasi in unam coadunatæ, quam ista propositio intelligatur præcedere, omne animal aut gressile, aut volatile, aut natatile, aut reptile, aut zoophytum est.

"Scilicet, nisi hujusmodi propositio supponeretur, suppressare licet, subintelligeretur tamen, consequentioris vis nulla foret; cum si præter enumerata existeret aliud quodpiam animal, conclusio evaderet falsa.

"Unde et licet intelligi, debere inductionem, ut legitima sit, continere omnium specierum, partiumve enumerationem; ne si una quæpiam deficiat, ea exceptionem faciat, probationemque labefactet. Quanquam, quia ut superius semel, iterumque monuimus, difficile plerumque, aut impossibile etiam est enumerationem omnium fieri, dici, aliquibus enumeratio, solet, quod Lucretius, et Horatius, cætera de genera hoc; supponendo videlicet, præter membra enumerata occurrere nullum, quod secus se habeat."†

He goes on to say, that there may be an induction, concluding in the negative, as well as an induction concluding in the affirmative. Except the error of supposing induction to be a species of syllogism,‡ the above passages give a sufficient notion of the

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* De Inductione (Analyt. Prior. lib. 2, c. 23.)

† Institutionum Logic. P. 3, Canon 11.

‡ An error not confined to this writer, as is shewn in a very powerful article in the Edinburgh Review, vol. lvii.; but common to him with most au-

opinions entertained at present with regard to the mode of procedure proper in induction, in order that the evidence may warrant the conclusion. Dr Whately, in terms synonymous with those of Gassendi, asserts that an inductive inference, drawn from a part of a class with regard to the whole, can only be supposed legitimate through a species of logical fiction, in assuming that one or two of a small number of instances do adequately represent the class to which they belong.* Now, we maintain, that, in the greater number of inductions performed in physical inquiry, such a supposition involves no fiction, but rather a positive fact; a class of facts, the individuals of which are in external aspect somewhat dissimilar, being often sufficiently represented for all the purposes required in the induction by a very few instances.

The more essential properties of bodies are the objects of scientific investigation; and it is probably only where the induction has regard to such properties, that one fact can be taken as a specimen of others analogous with it. Now, there are instances created in nature with the properties common to their class, so highly developed in them, as that the relations of those can be more readily discerned. And often by the aid of experiment, those properties can be so tested as to enable it to be known, that, in the instance experimented on, where one property is placed in a certain situation, another will attend it in a certain order. And the mind having such a knowledge of a class as to be able to divest its individuals of their accidental properties, and to discover in them one essential arrangement, defines the whole class to possess that arrangement,—which be-

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thors on logic; although not participated in by Aristotle, according to the reviewer. We find Aristotle say, that "quodam modo opponitur inductio syllogismo." And in his chapter on Induction, he seems to assign distinctly the province of demonstrative reasoning to syllogism, and the discovery of physical truth to induction. When he says that syllogism is "natura prior et notior," he probably alludes to reasoning from an obscure and unanalyzed whole to its parts.

* See Whately's Logic, Art. Induction throughout; also some strictures of Mr Stewart in the 2d vol. of his Lectures, p. 345, upon a passage from Dr Wallis of Oxford.

ing found, in a certain number of well-marked cases, dependent upon the relationship of some properties, is supposed, upon the ground of an intuitive conviction of like effects being owing to like causes, to be dependent upon the same properties in all the other cases. If the primary definition did not include the whole class, neither should the last inference affect the whole class; in that case, the extension of the conclusions beyond the individuals known to possess a defined arrangement, would be a mere presumption. But let it be clearly understood that there is a power in induction to determine the nature of individual instances which may not have been wholly examined, by means of an investigation of other instances apparently only analogous. Thus, let us suppose, that a definition of the term animal were formed, stating that an animal is a being possessing sensation and voluntary motion; and that it could be found, by a comparison of some of the different grades of animalized being, that just in the ratio of the development of nervous matter, was the state of those functions, in an increasing or a decreasing ratio; and that where this nervous matter exists (as in the genus Echinus and the sub-kingdom Acrita, generally banished by naturalists of the present day from the animal kingdom) not in the form of filaments connected with a common centre, the functions are wanting; would we not be entitled to conclude, that, in all animals, the development of a nervous matter in the filamentous and radiated form, bears an exact ratio to the aforementioned functions? If we do not admit that a few instances can be taken as specimens of a class, containing individuals apparently dissimilar, then, indeed, the mode in which the mind arrives at laws in physical investigation is often incompatible with logical propriety,—a proposition truly monstrous!

But it will doubtless be asked, in what way a conviction can be got of the essential nature of connexions investigated in Nature, when, in the properties themselves, no reason for this essentiality can be detected. Our answer is the admitted aphorism, that we are compelled, by the very constitution of our minds, to take the constancy and invariableness of relations observed among properties, as warrants of the essentiality of the order of relationship. Could the true principles of essentiality,—

the FORMS of Bacon and of Aristotle—be discovered, we should then have reasons from which it might be possible to know the extent to which certain relations, observed in a single instance, could reach throughout Nature; and our knowledge of the external world would be a perfect knowledge, so far as it should go. But so long as those principles remain undiscovered, the logic of physics must owe its coincidence with fact to an admission, on empirical grounds, of the existence of an essential series of phenomena, where there is but the evidence of their observed order being constant. We have said, however, that the mind endeavours to supply this deficiency in its evidence with respect to the actions of Nature, by feigning the existence of such principles of essentiality, the want of which it must perceive. And thus the necessary defect in inductive evidence, which many writers on logic have misplaced, arises from no logical fiction or physical impropriety in regarding one individual of a class as a specimen of its brethren, but from an imperfection in the media of communication between the understanding and external nature.

Instances which possess an organization so highly organized as to admit of them being taken for specimens of the class to which they belong, are termed by Bacon prerogative. And it is the chief merit of his philosophy, that he perceived their place and their power.* He has not, however, given any clear general definition of them, but abundant examples to shew their utility; and also a classification of individual instances, in which all the varieties of prerogative facts are minutely described. Here we shall consider them in general, since our object leads us to view them, not as they differ among themselves, but according to their place in the general theory of induction.

A good illustration of a prerogative fact is afforded by the famous experiment of the soap bubble, by which Newton discovered, in a single instance, the proximate structure upon which the various colours of all bodies are dependent. This instance is composed of several parts. In the first place, an appearance of coloured rings was observed upon the surface of the soap bubble, and their order of appearance in some degree

* Nov. Org. P. 2, s. 2, Aph. 22.

estimated and compared with the thickness of the bubble at different parts; in the second place, the instance was varied by using a layer of water placed between the object glass of a telescope and a flat surface; thus the thickness of the layer of water could be measured, where the different rings appeared, and also the order of their array became more regular; in the third place, it was found that the condition of the ambient body did not affect the order of appearance, although it did the strength and variety of the colours; in the next place, it was found that different transparent bodies would not, under the same thicknesses, exhibit the same colours; lastly, it was discovered that the transparent body viewed obliquely, did not exhibit the same colour at the same place, as when viewed directly, and that bodies undergo changes in colour by alterations in their mechanical condition (as well as can be observed) according to the law, which at this part of the inquiry might be supposed to exist. This famous experiment enabled Newton to frame a law, which states that the causes of the different colours of *bodies* exist in the sizes of their component particles.

When one instance does not afford a sufficient display of properties to allow of an extensive inference being drawn, other instances must be got together, which in a mass have such varied characters as to make up a strong case. Thus, in Dr Wells' theory of dew the great doctrine of which is, that in all bodies on the earth's surface, the dew-attracting power bears a uniform ratio to the power of radiating heat; the author proves his main fact, by taking platinum, gold, silver, lead, charcoal, grass, and gravel, with such like instances; cases which, put together, may be supposed to afford a fair specimen of the relations preserved by the properties in question throughout all bodies whatever, there being among these instances every conceivable variety in radiating power from the zero of burnished silver to the maximum of porous charcoal; and he finds, that, in the cases experimented on, the relation between the properties is regular. He therefore draws an inference for all bodies in the circumstances of those which he has tried.

When induction, therefore, takes cognizance of the more es-

sential properties of bodies, and investigates those by means of instruments, an inference including all facts in certain contingent circumstances can be drawn from a few analogous facts in such a condition; and the mind, in framing this it may be universal generalization, does not necessarily make use of any fiction, logical or physical, but proceeds upon what may often with reason be believed to be a sure fact.

But where the properties are not of this essential and intimate kind, and do not admit of being investigated experimentally, so as to allow of their relations being determined, a universal conclusion cannot be drawn without the use, by the mind, of that logical fiction of which so much is said by Dr Whately and others. Thus, to give an example which may perhaps illustrate an oversight of writers on induction, we quote the following from Dr Brown:—"If, by the term general law," he says, "be meant the agreement in some common circumstances of a number of events observed, there can be no question but the view is a just one, and that what we have already found in a number of events, may be applicable to that number of events; in the same manner, as, after having combined in the term animal the circumstances in which a dog, a horse, and a sheep agree, we cannot err in applying the term animal to a dog, a horse, or a sheep. But the only particulars to which we can, in this case, with perfect confidence apply the term animal, are the very particulars before observed by us."* Now, here we perfectly acquiesce with the argument of Dr Brown: but it is sufficiently obvious, from the examples already given, that his observations do not apply to all cases of inductive inference. Logicians generally give examples of inductive generalization, which do not shew the occasional and frequent power possessed by facts of exhibiting the properties of their class in a distinct point of view, as in the above instance of Dr Brown. But let the example produced by him be contrasted with the one given by us of the mode in which a correct notion of the connexions and relations of some properties in all animals could be attained, from an investigation of them in a few, and it will

* Brown's Lectures, vol. 1. sect. 8. p. 176.

appear that *his* example does not give a fair view of the entire character of the inductive process.

It may be inferred, therefore, that some distinctions should be drawn as to the methods of inductive procedure; and we shall now attempt to classify, and define, at least the more prominent modifications. These seem to be nearly as follows:—1. There is a form of procedure, in which, in order that a law may be expressed with logical precision, or possess physical certainty, it is absolutely necessary for every individual instance included in the original statement to be examined. Thus, in systematic Botany, when the external conformation of a class of plants has been described, and it is found, that, in some plants of that class, the particular configuration of the family exists along with a peculiar medicinal or culinary virtue; it yet cannot be stated, on the grounds of such a knowledge, what may be the virtues of other plants of the order. A presumption may be formed from the investigated cases, as to the nature of the relations of certain properties in the individuals not examined; but it must be a mere hypothesis. If, however, the botanist had the power of experimenting upon a cruciferous plant, so that he could find the four crosswise-placed petals and the peculiar shaped pod to be essentially connected with the virtues of a plant,—in such a manner, as that while the structure was modified, the other property should also undergo modification,—and in fact so that a certain not-to-be-doubted relation could be detected between the two sets of properties,—he might then conclude, on the conviction of the uniform order of nature derived from past experience, what were the virtues of all cruciferous plants. But he cannot perform such a precise experiment, and therefore must be content to collect every instance, before drawing a general conclusion. 2. There seems to be a class of sciences, of which we shall take Medicine as an example, in which most of the inductions are defective; or, more properly, where there cannot be formed in most cases any complete induction, as in all such cases logically defined genera cannot be procured, since new instances are being continually created,—beings with diverse constitutions; so that from the examination of already existing cases, no perfectly certain inference can be drawn as to the whole class of analogous cases; and where, besides, the differences between in-

dividuals are such as to prevent one individual being taken as a sufficient example of another; so that the induction can only conclude with certainty as to an individual. And the history of medicine affords proof of the enormous difficulty thus opposing generalization. Suppose that the diseased structure of the intestinal glands could be found in one case to preserve a constant relation with the symptoms of fever; yet this invariableness of accompaniment should only afford a presumption as to what may exist in other cases; for, there can be no conviction in the uniformity of nature, when the actions of nature in each individual are known to differ.* 3. In this present division the groups of facts are arranged in genera, each of which is not illimitable throughout the known universe, but confined, and finding some similar, and many closely analogous to itself, so that the law framed of one group can easily be transferred to another; while in each group, the investigation is capable of being abridged by means of prerogative instances. By way of illustration, we shall take the doctrine of the circulation of the blood, introduced by Harvey, which at the same time will give a good example of the course of inductive procedure ordinarily pursued in the physical sciences. If, then, we take that celebrated doctrine, and spread it out, so as to display all its parts, and ask proof for every assertion made in it, we should demand such a knowledge of the structure of the heart and arteries as to be sure of their powers and capabilities to allow of the course alleged, and to perform the functions ascribed to them,—evidence that the heart sends the blood into the aorta, like evidence of it being sent along the arteries into the minute veins, of the return, and the same kind of proof of the lesser circulation as of the greater. It is believed that when Harvey announced the circulation, he

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* A paper was read before the members of the Royal Medical Society, on the 6th of April last; the object of which was to prove, that in medical reasoning, the only constant source of uncertainty is in idiosyncracy. There may be great complexity in the relations of properties—great difficulty and perplexity in the investigation; but the only constant source of uncertainty arises from individual peculiarities. See Dr Abercrombie on Certain and Uncertain Sciences; he classes together medicine, political economy, and ethics.

was not able to furnish all of those proofs, and, in particular, that he had not evidence of the actual passage of the blood from the small arteries into the small veins. Of the lesser circulation he probably could only offer the analogy of the parts performing it with those concerned in the greater. Yet his doctrines, founded on the proof he gave, must be acknowledged possessed of such evidence, as that, if more be added, it can only amplify the notion he gives of the circulation. Two grand facts are the proofs of this great theory: 1, the prerogative fact of the valves of the heart and veins; and, 2, the analogy of the parts engaged in the lesser circulation with those that perform the greater. But the adaptation of the valves to their function is the grand proof of the whole theory. Now, the theory of the circulation was proved originally on deer; and the extensive analogies, which in fact are but covert similarities, traceable throughout the animal kingdom, allow of physiological doctrines being transferred readily from one genus to another. Many inductive doctrines in Chemistry resemble very closely, or rather exactly, the law of the circulation, both in their original frame-work, and in the mode of transference they admit of to other genera apparently only analogous but essentially similar. 4. There is another modified form of induction, the most definite of all, which may be described as follows:—Here each law is not confined, as in the third species, to a single group of a few facts, nor do any exactly corresponding groups exist, to which the law when framed is applicable. But each law extends throughout the known universe, and although the class of facts to which it applies may, or rather must, be defined, the number of instances is illimitable. Each law, however, can be framed from the examination of a few prerogative cases. And as in this kind of inductive generalization, the laws themselves form again parts of a mightier whole, which is framed from them in much the same manner as they themselves from their facts, at length an axiomatic expression is reached, which, arrived at from the investigation of a very small number of instances comparatively, yet includes in its expression an immense array. Illustrative examples exist in Dr Wells' theory of dew, and the laws of gravity. We are aware, that all those different forms of inductive proce-

dure agree in kind, except, perhaps, the one particularised as practised in medical science; and also, that the divisions between them, however carefully drawn, are exceedingly nice, and perhaps such as, by a close analysis, might be found to disappear. Indeed, the mind gains all its inductive knowledge by one process viewed in connexion with its own functions, and that is by complete proof; the various steps of which we have endeavoured to relate as fully as the vast extent of the subject would permit within moderate limits. Complete enumeration of all the instances composing a law, is that degree of proof which would be always essential, were it not for the indices supplied by prerogative facts. Indeed, we may regard all those forms of inductive procedure but the third variety, as derived from that simple form, by the introduction of prerogative facts within the spheres of the different genera existing in nature. Thus, as the science becomes more elevated and complicated, there is the greater power possessed of arriving at extensive inferences by means of well related facts. But it must be borne in mind, that the prerogative facts are those needing most the resources of experiment and calculus, in order to make them known so as to be of use in drawing inductive inferences. Residual facts are those left in a genus, uninvestigated, or rather partially explored, in order that the prerogative facts may be studied; and that property of physical laws called anticipation, is nothing more than the power possessed in some cases of abridging inductions by means of the prerogative facts.

Thus, the great property of those prerogative facts is, that they admit of being experimented on, being indeed, when completely known, exactly similar to the results of experiment; since they then afford a view of the relations of the properties composing them in very varied circumstances; it follows, therefore, that to term a science an experimental science, is just as if we were to say, that it abounds in prerogative facts. So that if the science of mind be, or be not, an experimental science, the question can best be determined by seeing whether its facts admit of being classified into some such heads, as the prerogative instances of Bacon, contained in the Novum Organon.

Many applications might be made of the observations in this

essay, if these latter be founded on truth. In particular, the history of science might perhaps be elucidated still further through their means.

Note.—It is proposed to term the forms of induction described above in their order. 1. Simple. 2. Enumerative. 3. Prerogative; and 4. Complex. The following formulas will express the simple and prerogative forms. 1. Of the Simple form. Let there be any number of instances, as $n\ A$; and of these some are found possessing the property a; before it can be said that this a exists in all $n\ A$, they must be all examined; and also the same must be the case should a be found connected with the property b in any of $n\ A$, before it could be said that $a + b$ exists in all $n\ A$. And if a, or $a + b$, should not be found in $m\ A$; then the law states that $\overline{n - m}\ A$ contain a or $a + b$. 2. Of the Prerogative form. Properly speaking we should start here with the knowledge of the existence of the property a in $n\ A$, or $\overline{n - m}\ A$; let $n\ A$ then contain a; here, instead of seeking to enumerate every instance before obtaining a law for the class, it is enough to know that in A', A'', or A''',—the prerogative instances, a is connected in a manner believed essential with b, or $b + c$, or $b + c + d$ in order to frame the law—"All $n\ A$ contain $a + b$, or $a + b + c$, or $a + b + c + d$." One sufficient prerogative instance can enable a negative conclusion to be drawn, just as in the case of a positive law. The downward application of laws framed from the study of prerogative facts furnishes the means of verifying the observations already made.

We are informed by an eminent authority in logical science, who honours these pages with his general approval, that Duns Scotus distinguished two species of induction, corresponding with our first and second forms. Bacon confounded the induction given by way of example by Aristotle, and which therefore was our first form, with the second or uncertain form practised in medicine.* The great improvements effected by Bacon on the views of his predecessors with regard to induction, consisted in the extensive grasp he took of the province in the cultivation of science appropriated to induction; and also in shewing the power possessed by particular well chosen facts. These, the most important and original of his notions have yet received a too *implicit* attention from those who have written on his philosophy. Until about the epoch of the Novum Organon, philosophers were not in possession of such instruments as are requisite to make known fully the relations of most of those instances termed prerogative. Till then, therefore, induction was described as a mode of mental procedure; Bacon described it by its corresponding signs in nature. Therefore it was, that his precepts were so powerful in displaying the advantages attendant upon the cultivation of science, inductively.

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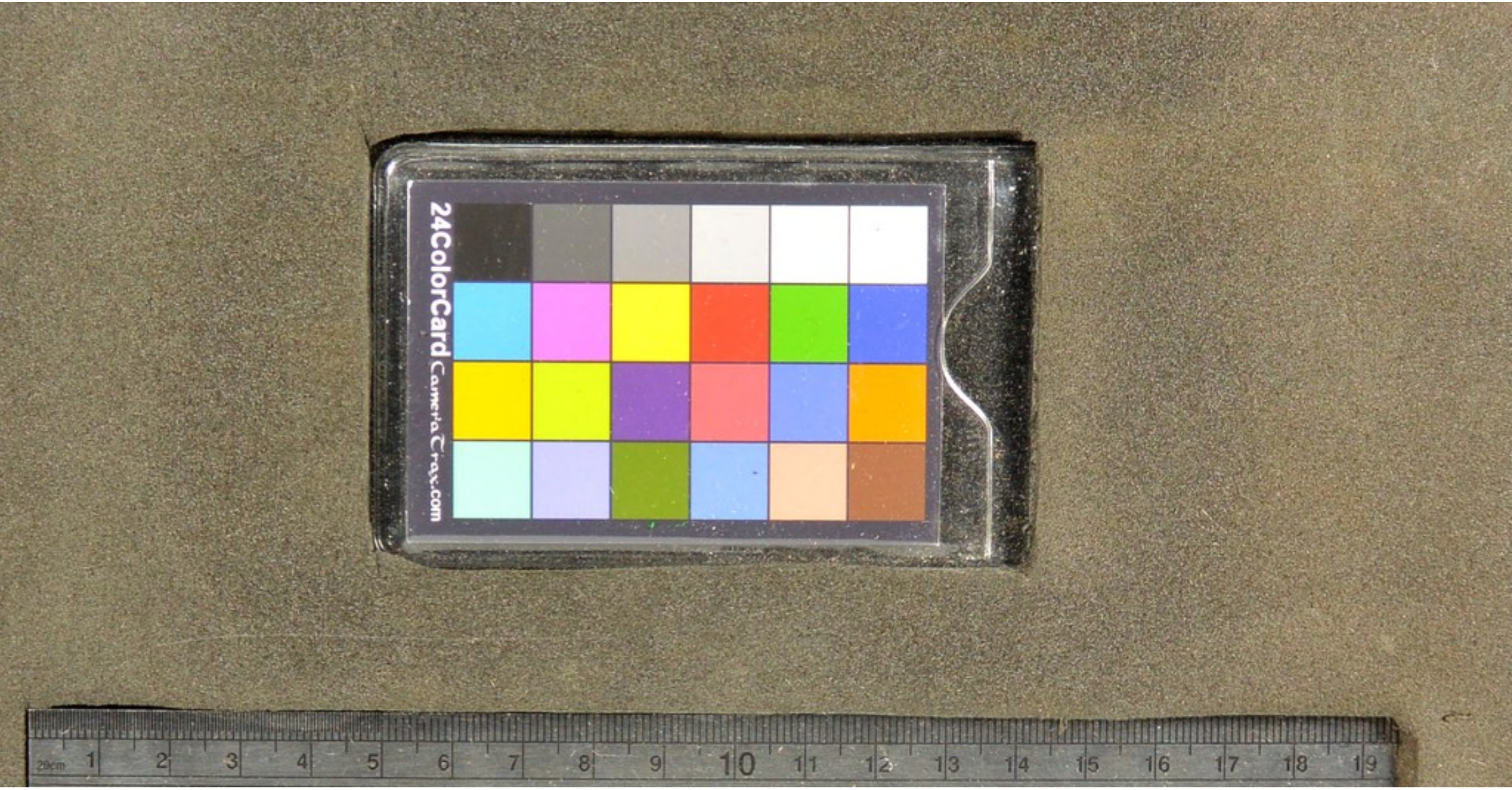
* Nov. Org. P. 1, s. 6, Aph. 105.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