CHAPTER XIII.

MISCELLANEOUS EXAMPLES OF THE EXPLANATION OF LAWS OF NATURE.

Sec. 1. The most striking example which the history of science presents, of the explanation of laws of causation and other uniformities of sequence among special phenomena, by resolving them into laws of greater simplicity and generality, is the great Newtonian generalization: respecting which typical instance so much having already been said, it is sufficient to call attention to the great number and variety of the special observed uniformities which are in this case accounted for, either as particular cases or as consequences of one very simple law of universal nature. The simple fact of a tendency of every particle of matter towards every other particle, varying inversely as the square of the distance, explains the fall of bodies to the earth, the revolutions of the planets and satellites, the motions (so far as known) of comets, and all the various regularities which have been observed in these special phenomena; such as the elliptical orbits, and the variations from exact ellipses; the relation between the solar distances of the planets and the duration of their revolutions; the precession of the equinoxes; the tides, and a vast number of minor astronomical truths.

Mention has also been made in the preceding chapter of the explanation of the phenomena of magnetism from laws of electricity; the special laws of magnetic agency having been affiliated by deduction to observed laws of electric action, in which they have ever since been considered to be included as special cases. An example not so complete in itself, but even more fertile in consequences, having been the starting point of the really scientific study of physiology, is the affiliation, commenced by Bichat, and carried on by subsequent biologists, of the properties of the bodily organs, to the elementary properties of the tissues into which they are anatomically decomposed.

Another striking instance is afforded by Dalton's generalization, commonly known as the atomic theory. It had been known from the very commencement of accurate chemical observation, that any two bodies combine chemically with one another in only a certain number of proportions; but those proportions were in each case expressed by a percentage--so many parts (by weight) of each ingredient, in 100 of the compound; (say 35 and a fraction of one element, 64 and a fraction of the other): in which mode of statement no relation was perceived between the proportion in which a given element combines with one substance, and that in which it combines with others. The great step made by Dalton consisted in perceiving, that a unit of weight might be established for each substance, such that by supposing the substance to enter into all its combinations in the ratio either of that unit, or of some low multiple of that unit, all the different proportions, previously expressed by percentages, were found to result. Thus 1 being assumed as the unit of hydrogen, if 8 were then taken as that of oxygen, the combination of one unit of hydrogen with one unit of oxygen would produce the exact proportion of weight between the two substances which is known to exist in water; the combination of one unit of hydrogen with two units of oxygen would produce the proportion which exists in the other compound of the same two elements, called peroxide of hydrogen; and the combinations of hydrogen and of oxygen with all other substances, would correspond with the supposition that those elements enter into combination by single units, or twos, or threes, of the numbers assigned to them, 1 and 8, and the other substances by ones or twos or threes of other determinate numbers proper to each. The result is that a table of the equivalent numbers, or, as they are called, atomic weights, of all the elementary substances, comprises in itself, and scientifically explains, all the proportions in which any substance, elementary or compound, is found capable of entering into chemical combination with any other substance whatever.

Sec. 2. Some interesting cases of the explanation of old uniformities by newly ascertained laws are afforded by the researches of Professor Graham. That eminent chemist was the first who drew attention to the distinction which may be made of all substances into two classes, termed by him crystalloids and colloids; or rather, of all states of matter into the crystalloid and the colloidal states, for many substances are capable of existing in either. When in the colloidal state, their sensible properties are very different from those of the same substance when crystallized, or when in a state easily susceptible of crystallization. Colloid substances pass with extreme difficulty and slowness into the crystalline state, and are extremely inert in all the ordinary

chemical relations. Substances in the colloid state are almost always, when combined with water, more or less viscous or gelatinous. The most prominent examples of the state are certain animal and vegetable substances, particularly gelatine, albumen, starch, the gums, caramel, tannin, and some others. Among substances not of organic origin, the most notable instances are hydrated silicic acid, and hydrated alumina, with other metallic peroxides of the aluminous class.

Now it is found, that while colloidal substances are easily penetrated by water, and by the solutions of crystalloid substances, they are very little penetrable by one another: which enabled Professor Graham to introduce a highly effective process (termed dialysis) for separating the crystalloid substances contained in any liquid mixture, by passing them through a thin septum of colloidal matter, which does not suffer anything colloidal to pass, or suffers it only in very minute quantity. This property of colloids enabled Mr. Graham to account for a number of special results of observation, not previously explained.

For instance, "while soluble crystalloids are always highly sapid, soluble colloids are singularly insipid," as might be expected; for, as the sentient extremities of the nerves of the palate "are probably protected by a colloidal membrane," impermeable to other colloids, a colloid, when tasted, probably never reaches those nerves. Again, "it has been observed that vegetable gum is not digested in the stomach; the coats of that organ dialyse the soluble food, absorbing crystalloids, and rejecting all colloids." One of the mysterious processes accompanying digestion, the secretion of free muriatic acid by the coats of the stomach, obtains a probable hypothetical explanation through the same law. Finally, much light is thrown upon the observed phenomena of osmose (the passage of fluids outward and inward through animal membranes) by the fact that the membranes are colloidal. In consequence, the water and saline solutions contained in the animal body pass easily and rapidly through the membranes, while the substances directly applicable to nutrition, which are mostly colloidal, are detained by them.[47]

The property which salt possesses of preserving animal substances from putrefaction is resolved by Liebig into two more general laws, the strong attraction of salt for water, and the necessity of the presence of water as a condition of putrefaction. The intermediate phenomenon which is interpolated between the remote cause and the effect, can here be not merely inferred but seen; for it is a familiar fact, that flesh upon which salt has been thrown is speedily found swimming in brine.

The second of the two factors (as they may be termed) into which the preceding law has been resolved, the necessity of water to putrefaction, itself affords an additional example of the Resolution of Laws. The law itself is proved by the Method of Difference, since flesh completely dried and kept in a dry atmosphere does not putrefy; as we see in the case of dried provisions, and human bodies in very dry climates. A deductive explanation of this same law results from Liebig's speculations. The putrefaction of animal and other azotised bodies is a chemical process, by which they are gradually dissipated in a gaseous form, chiefly in that of carbonic acid and ammonia; now to convert the carbon of the animal substance into carbonic acid requires oxygen, and to convert the azote into ammonia requires hydrogen, which are the elements of water. The extreme rapidity of the putrefaction of azotised substances, compared with the gradual decay of non-azotised bodies (such as wood and the like) by the action of oxygen alone, he explains from the general law that substances are much more easily decomposed by the action of two different affinities upon two of their elements, than by the action of only one.

Sec. 3. Among the many important properties of the nervous system, which have either been first discovered or strikingly illustrated by Dr. Brown-Sequard, I select the reflex influence of the nervous system on nutrition and secretion. By reflex nervous action is meant, action which one part of the nervous system exerts over another part, without any intermediate action on the brain, and consequently without consciousness; or which, if it does pass through the brain, at least produces its effects independently of the will. There are many experiments which prove that irritation of a nerve in one part of the body may in this manner excite powerful action in another part; for example, food injected into the stomach through a divided oesophagus, nevertheless produces secretion of saliva; warm water injected into the bowels, and various other irritations of the lower

intestines, have been found to excite secretion of the gastric juice, and so forth. The reality of the power being thus proved, its agency explains a great variety of apparently anomalous phenomena; of which I select the following from Dr. Brown-Sequard's *Lectures on the Nervous System*.

The production of tears by irritation of the eye, or of the mucous membrane of the nose:

The secretions of the eye and nose increased by exposure of other parts of the body to cold:

Inflammation of the eye, especially when of traumatic origin, very frequently excites a similar affection in the other eye, which may be cured by section of the intervening nerve:

Loss of sight sometimes produced by neuralgia; and has been known to be at once cured by the extirpation (for instance) of a carious tooth:

Even cataract has been produced in a healthy eye by cataract in the other eye, or by neuralgia, or by a wound of the frontal nerve:

The well-known phenomenon of a sudden stoppage of the heart's action, and consequent death, produced by irritation of some of the nervous extremities: *e.g.*, by drinking very cold water; or by a blow on the abdomen, or other sudden excitation of the abdominal sympathetic nerve; though this nerve may be irritated to any extent without stopping the heart's action, if a section be made of the communicating nerves:

The extraordinary effects produced on the internal organs by an extensive burn on the surface of the body; consisting in violent inflammation of the tissues of the abdomen, chest, or head: which, when death ensues from this kind of injury, is one of the most frequent causes of it:

Paralysis and anaesthesia of one part of the body from neuralgia in another part; and muscular atrophy from neuralgia, even when there is no paralysis:

Tetanus produced by the lesion of a nerve; Dr. Brown-Sequard thinks it highly probable that hydrophobia is a phenomenon of a similar nature:

Morbid changes in the nutrition of the brain and spinal cord, manifesting themselves by epilepsy, chorea, hysteria, and other diseases, occasioned by lesion of some of the nervous extremities in remote places, as by worms, calculi, tumours, carious bones, and in some cases even by very slight irritations of the skin.

Sec. 4. From the foregoing and similar instances, we may see the importance, when a law of nature previously unknown has been brought to light, or when new light has been thrown upon a known law by experiment, of examining all cases which present the conditions necessary for bringing that law into action; a process fertile in demonstrations of special laws previously unsuspected, and explanations of others already empirically known.

For instance, Faraday discovered by experiment, that voltaic electricity could be evolved from a natural magnet, provided a conducting body were set in motion at right angles to the direction of the magnet: and this he found to hold not only of small magnets, but of that great magnet, the earth. The law being thus established experimentally, that electricity is evolved, by a magnet, and a conductor moving at right angles to the direction of its poles, we may now look out for fresh instances in which these conditions meet. Wherever a conductor moves or revolves at right angles to the direction of the earth's magnetic poles, there we may expect an evolution of electricity. In the northern regions, where the polar direction is nearly perpendicular to the horizon, all horizontal motions of conductors will produce electricity; horizontal wheels, for example, made of metal; likewise all running streams will evolve a current of electricity, which will circulate round them; and the air thus charged with electricity may be one of the causes of the Aurora Borealis. In the equatorial regions,

on the contrary, upright wheels placed parallel to the equator will originate a voltaic circuit, and waterfalls will naturally become electric.

For a second example; it has been proved, chiefly by the researches of Professor Graham, that gases have a strong tendency to permeate animal membranes, and diffuse themselves through the spaces which such membranes inclose, notwithstanding the presence of other gases in those spaces. Proceeding from this general law, and reviewing a variety of cases in which gases lie contiguous to membranes, we are enabled to demonstrate or to explain the following more special laws: 1st. The human or animal body, when surrounded with any gas not already contained within the body, absorbs it rapidly; such, for instance, as the gases of putrefying matters: which helps to explain malaria. 2nd. The carbonic acid gas of effervescing drinks, evolved in the stomach, permeates its membranes, and rapidly spreads through the system. 3rd. Alcohol taken into the stomach passes into vapour and spreads through the system with great rapidity; (which, combined with the high combustibility of alcohol, or in other words its ready combination with oxygen, may perhaps help to explain the bodily warmth immediately consequent on drinking spirituous liquors.) 4th. In any state of the body in which peculiar gases are formed within it, these will rapidly exhale through all parts of the body; and hence the rapidity with which, in certain states of disease, the surrounding atmosphere becomes tainted. 5th. The putrefaction of the interior parts of a carcase will proceed as rapidly as that of the exterior, from the ready passage outwards of the gaseous products. 6th. The exchange of oxygen and carbonic acid in the lungs is not prevented, but rather promoted, by the intervention of the membrane of the lungs and the coats of the blood-vessels between the blood and the air. It is necessary, however, that there should be a substance in the blood with which the oxygen of the air may immediately combine; otherwise instead of passing into the blood, it would permeate the whole organism: and it is necessary that the carbonic acid, as it is formed in the capillaries, should also find a substance in the blood with which it can combine; otherwise it would leave the body at all points, instead of being discharged through the lungs.

Sec. 5. The following is a deduction which confirms, by explaining, the old but not undisputed empirical generalization, that soda powders weaken the human system. These powders, consisting of a mixture of tartaric acid with bicarbonate of soda, from which the carbonic acid is set free, must pass into the stomach as tartrate of soda. Now, neutral tartrates, citrates, and acetates of the alkalis are found, in their passage through the system, to be changed into carbonates; and to convert a tartrate into a carbonate requires an additional quantity of oxygen, the abstraction of which must lessen the oxygen destined for assimilation with the blood, on the quantity of which the vigorous action of the human system partly depends.

The instances of new theories agreeing with and explaining old empiricisms, are innumerable. All the just remarks made by experienced persons on human character and conduct, are so many special laws, which the general laws of the human mind explain and resolve. The empirical generalizations on which the operations of the arts have usually been founded, are continually justified and confirmed on the one hand, or corrected and improved on the other, by the discovery of the simpler scientific laws on which the efficacy of those operations depends. The effects of the rotation of crops, of the various manures, and other processes of improved agriculture, have been for the first time resolved in our own day into known laws of chemical and organic action, by Davy, Liebig, and others. The processes of the medical art are even now mostly empirical: their efficacy is concluded, in each instance, from a special and most precarious experimental generalization: but as science advances in discovering the simple laws of chemistry and physiology, progress is made in ascertaining the intermediate links in the series of phenomena, and the more general laws on which they depend; and thus, while the old processes are either exploded, or their efficacy, in so far as real, explained, better processes, founded on the knowledge of proximate causes, are continually suggested and brought into use.[48] Many even of the truths of geometry were generalizations from experience before they were deduced from first principles. The quadrature of the cycloid is said to have been first effected by measurement, or rather by weighing a cycloidal card, and comparing its weight with that of a piece of similar card of known dimensions.

Sec. 6. To the foregoing examples from physical science, let us add another from mental. The following is one

of the simple laws of mind: Ideas of a pleasurable or painful character form associations more easily and strongly than other ideas, that is, they become associated after fewer repetitions, and the association is more durable. This is an experimental law, grounded on the Method of Difference. By deduction from this law, many of the more special laws which experience shows to exist among particular mental phenomena may be demonstrated and explained:--the ease and rapidity, for instance, with which thoughts connected with our passions or our more cherished interests are excited, and the firm hold which the facts relating to them have on our memory; the vivid recollection we retain of minute circumstances which accompanied any object or event that deeply interested us, and of the times and places in which we have been very happy or very miserable; the horror with which we view the accidental instrument of any occurrence which shocked us, or the locality where it took place, and the pleasure we derive from any memorial of past enjoyment; all these effects being proportional to the sensibility of the individual mind, and to the consequent intensity of the pain or pleasure from which the association originated. It has been suggested by the able writer of a biographical sketch of Dr. Priestley in a monthly periodical,[49] that the same elementary law of our mental constitution, suitably followed out, would explain a variety of mental phenomena previously inexplicable, and in particular some of the fundamental diversities of human character and genius. Associations being of two sorts, either between synchronous, or between successive impressions; and the influence of the law which renders associations stronger in proportion to the pleasurable or painful character of the impressions, being felt with peculiar force in the synchronous class of associations; it is remarked by the writer referred to, that in minds of strong organic sensibility synchronous associations will be likely to predominate, producing a tendency to conceive things in pictures and in the concrete, richly clothed in attributes and circumstances, a mental habit which is commonly called Imagination, and is one of the peculiarities of the painter and the poet; while persons of more moderate susceptibility to pleasure and pain will have a tendency to associate facts chiefly in the order of their succession, and such persons, if they possess mental superiority, will addict themselves to history or science rather than to creative art. This interesting speculation the author of the present work has endeavoured, on another occasion, to pursue farther, and to examine how far it will avail towards explaining the peculiarities of the poetical temperament.[50] It is at least an example which may serve, instead of many others, to show the extensive scope which exists for deductive investigation in the important and hitherto so imperfect Science of Mind.

Sec. 7. The copiousness with which the discovery and explanation of special laws of phenomena by deduction from simpler and more general ones has here been exemplified, was prompted by a desire to characterize clearly, and place in its due position of importance, the Deductive Method; which, in the present state of knowledge, is destined henceforth irrevocably to predominate in the course of scientific investigation. A revolution is peaceably and progressively effecting itself in philosophy, the reverse of that to which Bacon has attached his name. That great man changed the method of the sciences from deductive to experimental, and it is now rapidly reverting from experimental to deductive. But the deductions which Bacon abolished were from premises hastily snatched up, or arbitrarily assumed. The principles were neither established by legitimate canons of experimental inquiry, nor the results tested by that indispensable element of a rational Deductive Method, verification by specific experience. Between the primitive method of Deduction and that which I have attempted to characterize, there is all the difference which exists between the Aristotelian physics and the Newtonian theory of the heavens.

It would, however, be a mistake to expect that those great generalizations, from which the subordinate truths of the more backward sciences will probably at some future period be deduced by reasoning (as the truths of astronomy are deduced from the generalities of the Newtonian theory), will be found, in all, or even in most cases, among truths now known and admitted. We may rest assured, that many of the most general laws of nature are as yet entirely unthought of; and that many others, destined hereafter to assume the same character, are known, if at all, only as laws or properties of some limited class of phenomena; just as electricity, now recognised as one of the most universal of natural agencies, was once known only as a curious property which certain substances acquired by friction, of first attracting and then repelling light bodies. If the theories of heat, cohesion, crystallization, and chemical action, are destined, as there can be little doubt that they are, to become deductive, the truths which will then be regarded as the *principia* of those sciences would probably, if

now announced, appear quite as novel[51] as the law of gravitation appeared to the cotemporaries of Newton; possibly even more so, since Newton's law, after all, was but an extension of the law of weight--that is, of a generalization familiar from of old, and which already comprehended a not inconsiderable body of natural phenomena. The general laws of a similarly commanding character, which we still look forward to the discovery of, may not always find so much of their foundations already laid.

These general truths will doubtless make their first appearance in the character of hypotheses; not proved, nor even admitting of proof, in the first instance, but assumed as premises for the purpose of deducing from them the known laws of concrete phenomena. But this, though their initial, cannot be their final state. To entitle an hypothesis to be received as one of the truths of nature, and not as a mere technical help to the human faculties, it must be capable of being tested by the canons of legitimate induction, and must actually have been submitted to that test. When this shall have been done, and done successfully, premises will have been obtained from which all the other propositions of the science will thenceforth be presented as conclusions, and the science will, by means of a new and unexpected Induction, be rendered Deductive.

FOOTNOTES:

[1] Dr. Whewell thinks it improper to apply the term Induction to any operation not terminating in the establishment of a general truth. Induction, he says (*Philosophy of Discovery*, p. 245), "is not the same thing as experience and observation. Induction is experience or observation *consciously* looked at in a *general* form. This consciousness and generality are necessary parts of that knowledge which is science." And he objects (p. 241) to the mode in which the word Induction is employed in this work, as an undue extension of that term "not only to the cases in which the general induction is consciously applied to a particular instance, but to the cases in which the particular instance is dealt with by means of experience in that rude sense in which experience can be asserted of brutes, and in which of course we can in no way imagine that the law is possessed or understood as a general proposition." This use of the term he deems a "confusion of knowledge with practical tendencies."

I disclaim, as strongly as Dr. Whewell can do, the application of such terms as induction, inference, or reasoning, to operations performed by mere instinct, that is, from an animal impulse, without the exertion of any intelligence. But I perceive no ground for confining the use of those terms to cases in which the inference is drawn in the forms and with the precautions required by scientific propriety. To the idea of Science, an express recognition and distinct apprehension of general laws as such, is essential: but nine-tenths of the conclusions drawn from experience in the course of practical life, are drawn without any such recognition: they are direct inferences from known cases, to a case supposed to be similar. I have endeavoured to show that this is not only as legitimate an operation, but substantially the same operation, as that of ascending from known cases to a general proposition; except that the latter process has one great security for correctness which the former does not possess. In Science, the inference must necessarily pass through the intermediate stage of a general proposition, because Science wants its conclusions for record, and not for instantaneous use. But the inferences drawn for the guidance of practical affairs, by persons who would often be quite incapable of expressing in unexceptionable terms the corresponding generalizations, may and frequently do exhibit intellectual powers quite equal to any which have ever been displayed in Science: and if these inferences are not inductive, what are they? The limitation imposed on the term by Dr. Whewell seems perfectly arbitrary; neither justified by any fundamental distinction between what he includes and what he desires to exclude, nor sanctioned by usage, at least from the time of Reid and Stewart, the principal legislators (as far as the English language is concerned) of modern metaphysical terminology.

[2] Supra, p. 214.

[3] *Novum Organum Renovatum*, pp. 72, 73.

[4] *Novum Organum Renovatum*, p. 32.

[5] *Cours de Philosophie Positive*, vol. ii. p. 202.

[6] Dr. Whewell, in his reply, contests the distinction here drawn, and maintains, that not only different descriptions, but different explanations of a phenomenon, may all be true. Of the three theories respecting the motions of the heavenly bodies, he says (*Philosophy of Discovery*, p. 231): "Undoubtedly all these explanations may be true and consistent with each other, and would be so if each had been followed out so as to show in what manner it could be made consistent with the facts. And this was, in reality, in a great measure done. The doctrine that the heavenly bodies were moved by vortices was successfully modified, so that it came to coincide in its results with the doctrine of an inverse-quadratic centripetal force.... When this point was reached, the vortex was merely a machinery, well or ill devised, for producing such a centripetal force, and therefore did not contradict the doctrine of a centripetal force. Newton himself does not appear to have been averse to explaining gravity by impulse. So little is it true that if one theory be true the other must be false. The attempt to explain gravity by the impulse of streams of particles flowing through the universe in all directions, which I have mentioned in the *Philosophy*, is so far from being inconsistent with the Newtonian theory, that it is founded entirely upon it. And even with regard to the doctrine, that the heavenly bodies move by an inherent virtue; if this doctrine had been maintained in any such way that it was brought to agree with the facts, the inherent virtue must have had its laws determined; and then it would have been found that the virtue had a reference to the central body; and so, the 'inherent virtue' must have coincided in its effect with the Newtonian force; and then, the two explanations would agree, except so far as the word 'inherent' was concerned. And if such a part of an earlier theory as this word *inherent* indicates, is found to be untenable, it is of course rejected in the transition to later and more exact theories, in Inductions of this kind, as well as in what Mr. Mill calls Descriptions. There is, therefore, still no validity discoverable in the distinction which Mr. Mill attempts to draw between descriptions like Kepler's law of elliptical orbits, and other examples of induction."

If the doctrine of vortices had meant, not that vortices existed, but only that the planets moved *in the same manner* as if they had been whirled by vortices; if the hypothesis had been merely a mode of representing the facts, not an attempt to account for them; if, in short, it had been only a Description; it would, no doubt, have been reconcileable with the Newtonian theory. The vortices, however, were not a mere aid to conceiving the motions of the planets, but a supposed physical agent, actively impelling them; a material fact, which might be true or not true, but could not be both true and not true. According to Descartes' theory it was true, according to Newton's it was not true. Dr. Whewell probably means that since the phrases, centripetal and projectile force, do not declare the nature but only the direction of the forces, the Newtonian theory does not absolutely contradict any hypothesis which may be framed respecting the mode of their production. The Newtonian theory, regarded as a mere *description* of the planetary motions, does not; but the Newtonian theory as an *explanation* of them does. For in what does the explanation consist? In ascribing those motions to a general law which obtains between all particles of matter, and in identifying this with the law by which bodies fall to the ground. If the planets are kept in their orbits by a force which draws the particles composing them towards every other particle of matter in the solar system, they are not kept in those orbits by the impulsive force of certain streams of matter which whirl them round. The one explanation absolutely excludes the other. Either the planets are not moved by vortices, or they do not move by a law common to all matter. It is impossible that both opinions can be true. As well might it be said that there is no contradiction between the assertions, that a man died because somebody killed him, and that he died a natural death.

So, again, the theory that the planets move by a virtue inherent in their celestial nature, is incompatible with either of the two others: either that of their being moved by vortices, or that which regards them as moving by a property which they have in common with the earth and all terrestrial bodies. Dr. Whewell says that the theory of an inherent virtue agrees with Newton's when the word inherent is left out, which of course it would be (he says) if "found to be untenable." But leave that out, and where is the theory? The word inherent *is* the theory. When that is omitted, there remains nothing except that the heavenly bodies move by "a virtue," *i.e.* by a power of some sort; or by virtue of their celestial nature, which directly contradicts the doctrine that terrestrial bodies fall by the same law.

If Dr. Whewell is not yet satisfied, any other subject will serve equally well to test his doctrine. He will hardly say that there is no contradiction between the emission theory and the undulatory theory of light; or that there can be both one and two electricities; or that the hypothesis of the production of the higher organic forms by development from the lower, and the supposition of separate and successive acts of creation, are quite reconcileable; or that the theory that volcanoes are fed from a central fire, and the doctrines which ascribe them to chemical action at a comparatively small depth below the earth's surface, are consistent with one another, and all true as far as they go.

If different explanations of the same fact cannot both be true, still less, surely, can different predictions. Dr. Whewell quarrels (on what ground it is not necessary here to consider) with the example I had chosen on this point, and thinks an objection to an illustration a sufficient answer to a theory. Examples not liable to his objection are easily found, if the proposition that conflicting predictions cannot both be true, can be made clearer by any examples. Suppose the phenomenon to be a newly-discovered comet, and that one astronomer predicts its return once in every 300 years--another once in every 400: can they both be right? When Columbus predicted that by sailing constantly westward he should in time return to the point from which he set out, while others asserted that he could never do so except by turning back, were both he and his opponents true prophets? Were the predictions which foretold the wonders of railways and steamships, and those which averred that the Atlantic could never be crossed by steam navigation, nor a railway train propelled ten miles an hour, both (in Dr. Whewell's words) "true, and consistent with one another"?

Dr. Whewell sees no distinction between holding contradictory opinions on a question of fact, and merely employing different analogies to facilitate the conception of the same fact. The case of different Inductions belongs to the former class, that of different Descriptions to the latter.

[7] *Phil. of Discov.* p. 256.

[8] *Essays on the Pursuit of Truth.*

[9] In the first edition a note was appended at this place, containing some criticism on Archbishop Whately's mode of conceiving the relation between Syllogism and Induction. In a subsequent issue of his *Logic*, the Archbishop made a reply to the criticism, which induced me to cancel part of the note, incorporating the remainder in the text. In a still later edition, the Archbishop observes in a tone of something like disapprobation, that the objections, "doubtless from their being fully answered and found untenable, were silently suppressed," and that hence he might appear to some of his readers to be combating a shadow. On this latter point, the Archbishop need give himself no uneasiness. His readers, I make bold to say, will fully credit his mere affirmation that the objections have actually been made.

But as he seems to think that what he terms the suppression of the objections ought not to have been made "silently," I now break that silence, and state exactly what it is that I suppressed, and why. I suppressed that alone which might be regarded as personal criticism on the Archbishop. I had imputed to him the having omitted to ask himself a particular question. I found that he had asked himself the question, and could give it an answer consistent with his own theory. I had also, within the compass of a parenthesis, hazarded some remarks on certain general characteristics of Archbishop Whately as a philosopher. These remarks, though their tone, I hope, was neither disrespectful nor arrogant, I felt, on reconsideration, that I was hardly entitled to make; least of all, when the instance which I had regarded as an illustration of them, failed, as I now saw, to bear them out. The real matter at the bottom of the whole dispute, the different view we take of the function of the major premise, remains exactly where it was; and so far was I from thinking that my opinion had been "fully answered" and was "untenable," that in the same edition in which I cancelled the note, I not only enforced the opinion by further arguments, but answered (though without naming him) those of the Archbishop.

For not having made this statement before, I do not think it needful to apologize. It would be attaching very

great importance to one's smallest sayings, to think a formal retractation requisite every time that one commits an error. Nor is Archbishop Whately's well-earned fame of so tender a quality as to require, that in withdrawing a slight criticism on him I should have been bound to offer a public *amende* for having made it.

[10] But though it is a condition of the validity of every induction that there be uniformity in the course of nature, it is not a necessary condition that the uniformity should pervade all nature. It is enough that it pervades the particular class of phenomena to which the induction relates. An induction concerning the motions of the planets, or the properties of the magnet, would not be vitiated though we were to suppose that wind and weather are the sport of chance, provided it be assumed that astronomical and magnetic phenomena are under the dominion of general laws. Otherwise the early experience of mankind would have rested on a very weak foundation; for in the infancy of science it could not be known that *all* phenomena are regular in their course.

Neither would it be correct to say that every induction by which we infer any truth, implies the general fact of uniformity *as foreknown*, even in reference to the kind of phenomena concerned. It implies, *either* that this general fact is already known, *or* that we may now know it: as the conclusion, the Duke of Wellington is mortal, drawn from the instances A, B, and C, implies either that we have already concluded all men to be mortal, or that we are now entitled to do so from the same evidence. A vast amount of confusion and paralogism respecting the grounds of Induction would be dispelled by keeping in view these simple considerations.

[11] Infra, chap. xxi.

[12] Infra, chap. xxi. xxii.

[13] Dr. Whewell (*Phil. of Discov.* p. 246) will not allow these and similar erroneous judgments to be called inductions; inasmuch as such superstitious fancies "were not collected from the facts by seeking a law of their occurrence, but were suggested by an imagination of the anger of superior powers, shown by such deviations from the ordinary course of nature." I conceive the question to be, not in what manner these notions were at first suggested, but by what evidence they have, from time to time, been supposed to be substantiated. If the believers in these erroneous opinions had been put on their defence, they would have referred to experience: to the comet which preceded the assassination of Julius Caesar, or to oracles and other prophecies known to have been fulfilled. It is by such appeals to facts that all analogous superstitions, even in our day, attempt to justify themselves; the supposed evidence of experience is necessary to their hold on the mind. I quite admit that the influence of such coincidences would not be what it is, if strength were not lent to it by an antecedent presumption; but this is not peculiar to such cases; preconceived notions of probability form part of the explanation of many other cases of belief on insufficient evidence. The *a priori* prejudice does not prevent the erroneous opinion from being sincerely regarded as a legitimate conclusion from experience; though it improperly predisposes the mind to that interpretation of experience.

Thus much in defence of the sort of examples objected to. But it would be easy to produce instances, equally adapted to the purpose, and in which no antecedent prejudice is at all concerned. "For many ages," says Archbishop Whately, "all farmers and gardeners were firmly convinced--and convinced of their knowing it by experience--that the crops would never turn out good unless the seed were sown during the increase of the moon." This was induction, but bad induction: just as a vicious syllogism is reasoning, but bad reasoning.

[14] The assertion, that any and every one of the conditions of a phenomenon may be and is, on some occasions and for some purposes, spoken of as the cause, has been disputed by an intelligent reviewer of this work in the *Prospective Review* (the predecessor of the justly esteemed *National Review*), who maintains that "we always apply the word cause rather to that element in the antecedents which exercises *force*, and which would *tend* at all times to produce the same or a similar effect to that which, under certain conditions, it would actually produce." And he says, that "every one would feel" the expression, that the cause of a surprise was

the sentinel's being off his post, to be incorrect; but that the "allurement or force which *drew* him off his post, might be so called, because in doing so it removed a resisting power which would have prevented the surprise." I cannot think that it would be wrong to say, that the event took place because the sentinel was absent, and yet right to say that it took place because he was bribed to be absent. Since the only direct effect of the bribe was his absence, the bribe could be called the remote cause of the surprise, only on the supposition that the absence was the proximate cause; nor does it seem to me that any one (who had not a theory to support) would use the one expression and reject the other.

The reviewer observes, that when a person dies of poison, his possession of bodily organs is a necessary condition, but that no one would ever speak of it as the cause. I admit the fact; but I believe the reason to be, that the occasion could never arise for so speaking of it; for when in the inaccuracy of common discourse we are led to speak of some one condition of a phenomenon as its cause, the condition so spoken of is always one which it is at least possible that the hearer may require to be informed of. The possession of bodily organs is a known condition, and to give that as the answer, when asked the cause of a person's death, would not supply the information sought. Once conceive that a doubt could exist as to his having bodily organs, or that he were to be compared with some being who had them not, and cases may be imagined in which it might be said that his possession of them was the cause of his death. If Faust and Mephistopheles together took poison, it might be said that Faust died because he was a human being, and had a body, while Mephistopheles survived because he was a spirit.

It is for the same reason that no one (as the reviewer remarks) "calls the cause of a leap, the muscles or sinews of the body, though they are necessary conditions; nor the cause of a self-sacrifice, the knowledge which was necessary for it; nor the cause of writing a book, that a man has time for it, which is a necessary condition." These conditions (besides that they are antecedent *states*, and not proximate antecedent *events*, and are therefore never the conditions in closest apparent proximity to the effect) are all of them so obviously implied, that it is hardly possible there should exist that necessity for insisting on them, which alone gives occasion for speaking of a single condition as if it were the cause. Wherever this necessity exists in regard to some one condition, and does not exist in regard to any other, I conceive that it is consistent with usage, when scientific accuracy is not aimed at, to apply the name cause to that one condition. If the only condition which can be supposed to be unknown is a negative condition, the negative condition may be spoken of as the cause. It might be said that a person died for want of medical advice: though this would not be likely to be said, unless the person was already understood to be ill, and in order to indicate that this negative circumstance was what made the illness fatal, and not the weakness of his constitution, or the original virulence of the disease. It might be said that a person was drowned because he could not swim; the positive condition, namely, that he fell into the water, being already implied in the word drowned. And here let me remark, that his falling into the water is in this case the only positive condition: all the conditions not expressly or virtually included in this (as that he could not swim, that nobody helped him, and so forth) are negative. Yet, if it were simply said that the cause of a man's death was falling into the water, there would be quite as great a sense of impropriety in the expression, as there would be if it were said that the cause was his inability to swim; because, though the one condition is positive and the other negative, it would be felt that neither of them was sufficient, without the other, to produce death.

With regard to the assertion that nothing is termed the cause, except the element which exerts active force; I wave the question as to the meaning of active force, and accepting the phrase in its popular sense, I revert to a former example, and I ask, would it be more agreeable to custom to say that a man fell because his foot slipped in climbing a ladder, or that he fell because of his weight? for his weight, and not the motion of his foot, was the active force which determined his fall. If a person walking out in a frosty day, stumbled and fell, it might be said that he stumbled because the ground was slippery, or because he was not sufficiently careful; but few people, I suppose, would say, that he stumbled because he walked. Yet the only active force concerned was that which he exerted in walking: the others were mere negative conditions; but they happened to be the only ones which there could be any necessity to state; for he walked, most likely, in exactly his usual manner, and the negative conditions made all the difference. Again, if a person were asked why the army of

Xerxes defeated that of Leonidas, he would probably say, because they were a thousand times the number; but I do not think he would say, it was because they fought, though that was the element of active force. To borrow another example, used by Mr. Grove and by Mr. Baden Powell, the opening of floodgates is said to be the cause of the flow of water; yet the active force is exerted by the water itself, and opening the floodgates merely supplies a negative condition. The reviewer adds, "there are some conditions absolutely passive, and yet absolutely necessary to physical phenomena, viz. the relations of space and time; and to these no one ever applies the word cause without being immediately arrested by those who hear him." Even from this statement I am compelled to dissent. Few persons would feel it incongruous to say (for example) that a secret became known because it was spoken of when A. B. was within hearing; which is a condition of space: or that the cause why one of two particular trees is taller than the other, is that it has been longer planted; which is a condition of time.

[15] There are a few exceptions; for there are some properties of objects which seem to be purely preventive; as the property of opaque bodies, by which they intercept the passage of light. This, as far as we are able to understand it, appears an instance not of one cause counteracting another by the same law whereby it produces its own effects, but of an agency which manifests itself in no other way than in defeating the effects of another agency. If we knew on what other relations to light, or on what peculiarities of structure, opacity depends, we might find that this is only an apparent, not a real, exception to the general proposition in the text. In any case it needs not affect the practical application. The formula which includes all the negative conditions of an effect in the single one of the absence of counteracting causes, is not violated by such cases as this; though, if all counteracting agencies were of this description, there would be no purpose served by employing the formula, since we should still have to enumerate specially the negative conditions of each phenomenon, instead of regarding them as implicitly contained in the positive laws of the various other agencies in nature.

[16] I mean by this expression, the ultimate laws of nature (whatever they may be) as distinguished from the derivative laws and from the collocations. The diurnal revolution of the earth (for example) is not a part of the constitution of things, because nothing can be so called which might possibly be terminated or altered by natural causes.

[17] I use the words "straight line" for brevity and simplicity. In reality the line in question is not exactly straight, for, from the effect of refraction, we actually see the sun for a short interval during which the opaque mass of the earth is interposed in a direct line between the sun and our eyes; thus realizing, though but to a limited extent, the coveted desideratum of seeing round a corner.

[18] *Second Burnett Prize Essay*, by Principal Tulloch, p. 25.

[19] *Letters on the Philosophy of the Human Mind*, First Series, p. 219.

[20] *Essays*, pp. 206-208.

[21] To the universality which mankind are agreed in ascribing to the Law of Causation, there is one claim of exception, one disputed case, that of the Human Will; the determinations of which, a large class of metaphysicians are not willing to regard as following the causes called motives, according to as strict laws as those which they suppose to exist in the world of mere matter. This controverted point will undergo a special examination when we come to treat particularly of the Logic of the Moral Sciences (Book vi. ch. 2). In the mean time I may remark that these metaphysicians, who, it must be observed, ground the main part of their objection on the supposed repugnance of the doctrine in question to our consciousness, seem to me to mistake the fact which consciousness testifies against. What is really in contradiction to consciousness, they would, I think, on strict self-examination, find to be, the application to human actions and volitions of the ideas involved in the common use of the term Necessity; which I agree with them in objecting to. But if they would consider that by saying that a person's actions *necessarily* follow from his character, all that is really meant (for no more is meant in any case whatever of causation) is that he invariably *does* act in conformity to his

character, and that any one who thoroughly knew his character would certainly predict how he would act in any supposable case; they probably would not find this doctrine either contrary to their experience or revolting to their feelings. And no more than this is contended for by any one but an Asiatic fatalist.

[22] *Lectures on Metaphysics*, vol. ii. Lect. xxxix. pp. 391-2.

I regret that I cannot invoke the authority of Sir William Hamilton in favour of my own opinions on Causation, as I can against the particular theory which I am now combating. But that acute thinker has a theory of Causation peculiar to himself, which has never yet, as far as I know, been analytically examined, but which, I venture to think, admits of as complete refutation as any one of the false or insufficient psychological theories which strew the ground in such numbers under his potent metaphysical scythe. (Since examined and controverted in the sixteenth chapter of *An Examination of Sir William Hamilton's Philosophy*).

[23] Unless we are to consider as such the following statement, by one of the writers quoted in the text: "In the case of mental exertion, the result to be accomplished is preconsidered or meditated, and is therefore known *a priori*, or before experience."--(Bowen's *Lowell Lectures on the Application of Metaphysical and Ethical Science to the Evidence of Religion*, Boston, 1849.) This is merely saying that when we will a thing we have an idea of it. But to have an idea of what we wish to happen, does not imply a prophetic knowledge that it will happen. Perhaps it will be said that the *first time* we exerted our will, when we had of course no experience of any of the powers residing in us, we nevertheless must already have known that we possessed them, since we cannot will that which we do not believe to be in our power. But the impossibility is perhaps in the words only, and not in the facts; for we may *desire* what we do not know to be in our power; and finding by experience that our bodies move according to our *desire*, we may then, and only then, pass into the more complicated mental state which is termed will.

After all, even if we had an instinctive knowledge that our actions would follow our will, this, as Brown remarks, would prove nothing as to the nature of Causation. Our knowing, previous to experience, that an antecedent will be followed by a certain consequent, would not prove the relation between them to be anything more than antecedence and consequence.

[24] Reid's *Essays on the Active Powers*, Essay iv. ch. 3.

[25] *Prospective Review* for February 1850.

[26] Vide supra, p. 270, note.

[27] *Westminster Review* for October 1855.

[28] See the whole doctrine in Aristotle *de Anima*: where the [Greek: threptike psyche] is treated as exactly equivalent to [Greek: threptike dynamis].

[29] It deserves notice that the parts of nature, which Aristotle regards as presenting evidence of design, are the Uniformities: the phenomena in so far as reducible to law. [Greek: Tyche] and [Greek: to automaton] satisfy him as explanations of the variable element in phenomena, but their occurring according to a fixed rule can only, to his conceptions, be accounted for by an Intelligent Will. The common, or what may be called the instinctive, religious interpretation of nature, is the reverse of this. The events in which men spontaneously see the hand of a supernatural being, are those which cannot, as they think, be reduced to a physical law. What they can distinctly connect with physical causes, and especially what they can predict, though of course ascribed to an Author of Nature if they already recognise such an author, might be conceived, they think, to arise from a blind fatality, and in any case do not appear to them to bear so obviously the mark of a divine will. And this distinction has been countenanced by eminent writers on Natural Theology, in particular by Dr. Chalmers: who thinks that though design is present everywhere, the irresistible evidence of it is to be found

not in the *laws* of nature but in the collocations, *i.e.* in the part of nature in which it is impossible to trace any law. A few properties of dead matter might, he thinks, conceivably account for the regular and invariable succession of effects and causes; but that the different kinds of matter have been so placed as to promote beneficent ends, is what he regards as the proof of a Divine Providence. Mr. Baden Powell, in his Essay entitled "Philosophy of Creation," has returned to the point of view of Aristotle and the ancients, and vigorously reasserts the doctrine that the indication of design in the universe is not special adaptations, but Uniformity and Law, these being the evidences of mind, and not what appears to us to be a provision for our uses. While I decline to express any opinion here on this *vexata quaestio*, I ought not to mention Mr. Powell's volume without the acknowledgment due to the philosophic spirit which pervades generally the three Essays composing it, forming in the case of one of them (the "Unity of Worlds") an honourable contrast with the other dissertations, so far as they have come under my notice, which have appeared on either side of that controversy.

[30] In the words of Fontenelle, another celebrated Cartesian, "les philosophes aussi bien que le peuple avaient cru que l'ame et le corps agissaient reellement et physiquement l'un sur l'autre. Descartes vint, qui prouva que leur nature ne permettait point cette sorte de communication veritable, et qu'ils n'en pouvaient avoir qu'une apparente, dont Dieu etait le Mediateur."--*Oeuvres de Fontenelle*, ed. 1767, tom. v. p. 534.

[31] I omit, for simplicity, to take into account the effect, in this latter case, of the diminution of pressure, in diminishing the flow of water through the drain; which evidently in no way affects the truth or applicability of the principle, since when the two causes act simultaneously the conditions of that diminution of pressure do not arise.

[32] Unless, indeed, the consequent was generated not by the antecedent, but by the means employed to produce the antecedent. As, however, these means are under our power, there is so far a probability that they are also sufficiently within our knowledge, to enable us to judge whether that could be the case or not.

[33] *Discourse on the Study of Natural Philosophy*, p. 179.

[34] For this speculation, as for many other of my scientific illustrations, I am indebted to Professor Bain, of Aberdeen, who has since, in his profound treatises entitled "The Senses and the Intellect," and "The Emotions and the Will," carried the analytic investigation of the mental phenomena according to the methods of physical science, to the most advanced point which it has yet reached, and has worthily inscribed his name among the successive constructors of an edifice to which Hartley, Brown, and James Mill had each contributed their part.

[35] This view of the necessary coexistence of opposite excitements involves a great extension of the original doctrine of two electricities. The early theorists assumed that, when amber was rubbed, the amber was made positive and the rubber negative to the same degree; but it never occurred to them to suppose that the existence of the amber charge was dependent on an opposite charge in the bodies with which the amber was contiguous, while the existence of the negative charge on the rubber was equally dependent on a contrary state of the surfaces that might accidentally be confronted with it; that, in fact, in a case of electrical excitement by friction, four charges were the minimum that could exist. But this double electrical action is essentially implied in the explanation now universally adopted in regard to the phenomena of the common electric machine.

[36] Pp. 159-162.

[37] Infra, book iv. ch. ii. On Abstraction.

[38] I must, however, remark, that this example, which seems to militate against the assertion we made of the comparative inapplicability of the Method of Difference to cases of pure observation, is really one of those

exceptions which, according to a proverbial expression, prove the general rule. For in this case, in which Nature, in her experiment, seems to have imitated the type of the experiments made by man, she has only succeeded in producing the likeness of man's most imperfect experiments; namely, those in which, though he succeeds in producing the phenomenon, he does so by employing complex means, which he is unable perfectly to analyse, and can form therefore no sufficient judgment what portion of the effects may be due, not to the supposed cause, but to some unknown agency of the means by which that cause was produced. In the natural experiment which we are speaking of, the means used was the clearing off a canopy of clouds; and we certainly do not know sufficiently in what this process consists, or on what it depends, to be certain *a priori* that it might not operate upon the deposition of dew independently of any thermometric effect at the earth's surface. Even, therefore, in a case so favourable as this to Nature's experimental talents, her experiment is of little value except in corroboration of a conclusion already attained through other means.

[39] In his subsequent work, *Outlines of Astronomy* (Sec. 570), Sir John Herschel suggests another possible explanation of the acceleration of the revolution of a comet.

[40] Discourse, pp. 156-8, and 171.

[41] *Outlines of Astronomy*, Sec. 856.

[42] *Philosophy of Discovery*, pp. 263, 264.

[43] See, on this point, the second chapter of the present Book.

[44] Ante, ch. vii. Sec. 1.

[45] It seems hardly necessary to say that the word *impinge*, as a general term to express collision of forces, is here used by a figure of speech, and not as expressive of any theory respecting the nature of force.

[46] *Essays on some Unsettled Questions of Political Economy*, Essay V.

[47] *Vide* Memoir by Thomas Graham, F.R.S., Master of the Mint, "On Liquid Diffusion Applied to Analysis," in the *Philosophical Transactions* for 1862, reprinted in the *Journal of the Chemical Society*, and also separately as a pamphlet.

[48] It was an old generalization in surgery, that tight bandaging had a tendency to prevent or dissipate local inflammation. This sequence, being, in the progress of physiological knowledge, resolved into more general laws, led to the important surgical invention made by Dr. Arnott, the treatment of local inflammation and tumours by means of an equable pressure, produced by a bladder partially filled with air. The pressure, by keeping back the blood from the part, prevents the inflammation, or the tumour, from being nourished: in the case of inflammation, it removes the stimulus, which the organ is unfit to receive; in the case of tumours, by keeping back the nutritive fluid, it causes the absorption of matter to exceed the supply, and the diseased mass is gradually absorbed and disappears.

[49] Since acknowledged and reprinted in Mr. Martineau's *Miscellanies*.

[50] *Dissertations and Discussions*, vol. i., fourth paper.

[51] Written before the rise of the new views respecting the relation of heat to mechanical force; but confirmed rather than contradicted by them.

END OF VOL. I.

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Transcriber's Notes

Spelling irregularities where there was no obviously preferred version were left as is. Variants include: "alkalies" and "alkalis;" "apprise" and "apprize;" "coexistent" and "co-existent" (along with derivatives); "coextensive" and "co-extensive;" "e. g." and "e.g."; "encumbered" and "incumbered;" "formulae" and "formulas;" "i. e." and "i.e."; "nonentity" and "non-entity;" "recal" and "recall" (and derivatives); "rectilinear" and "rectilineal;" "stopt" and "stopped."

Changed "3" to "4" on page xiii: "4. --and from descriptions."

Inserted missing page number, "167," for Chapter VIII, section 7 on page xiii.

Moved the semi-colon inside the quotation marks in the footnote on page 14: "the Science of the Formal Laws of Thought;".

Changed "sub-divisions" to "subdivisions" on page 59: "three subdivisions."

Changed "pre-supposed" to "presupposed" on page 75: "they are presupposed."

In the footnote to page 122, changed the Greek character upsilon with dasia and oxia to upsilon with psili and oxia, making the transliteration "deuterai ousiai."

Changed "he" to "be" on page 189: "to which it may be reduced."

Changed "cb." to "ch." in footnote on page 227: "Theory of Reasoning, ch. iv."

Changed "reconcilable" to "reconcileable" on page 240: "not easily reconcileable."

Preserved the hyphen in "counter-acting" on page 280. Usually this is spelled without the hyphen, but this instance is in a quotation.

Moved parenthesis that was after "to" to before it on page 321: "(to return to a former example)."

Put "i.e." in italics on page 335: "*i.e.* by a power of some sort."

Changed "paralyzed" to "paralysed" on page 389: "nerves of motion were paralysed."

The footnote from page 396 refers to the footnote on page 270. There is no such footnote. The intent may be to refer to the footnote on page 268. However, the text was not changed.

Added the dropped "w" in "which" on page 420: "which the progress of the inquiry."

Changed "developes" to "develops" on page 456: "the prime conductor develops."

Removed the additional period at the end of the footnote on page 457: "Pp. 159-162."

Added the dropped "l" to "essential" on page 515: "an essential requisite."

Removed extra opening quotation mark before "gum" on page 532: "vegetable gum is not digested."

In the Latin-1 text version, the oe-ligature was replaced by the two characters, "oe" (or "Oe" when capitalized).

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