

## CHAPTER XIX

### **Laws Classified; Explanation; Co-Existence; Analogy**

Section 1. Laws are classified, according to their degrees of generality, as higher and lower, though the grades may not be decisively distinguishable.

First, there are Axioms or Principles, that is real, universal, self-evident propositions. They are—(1) real propositions; not, like ‘The whole is greater than any of its parts,’ merely definitions, or implied in definitions. (2) They are regarded as universally true of phenomena, as far as the form of their expression extends; that is, for example, Axioms concerning quantity are true of everything that is considered in its quantitative aspect, though not (of course) in its qualitative aspect. (3) They are self-evident; that is, each rests upon its own evidence (whatever that may be); they cannot be derived from one another, nor from any more general law. Some, indeed, are more general than others: the Logical Principle of Contradiction, ‘if A is B, it is not not-B’, is true of qualities as well as of quantities; whereas the Axioms of Mathematics apply only to quantities. The Mathematical Axioms, again, apply to time, space, mental phenomena, and matter and energy; whereas the Law of Causation is only true of concrete events in the redistribution of matter and energy: such, at least, is the strict limit of Causation, if we identify it with the Conservation of Energy; although our imperfect knowledge of life and mind often drives us to speak of feelings, ideas, volitions, as causes. Still, the Law of Causation cannot be derived from the Mathematical Axioms, nor these from the Logical. The kind of evidence upon which Axioms rest, or whether any evidence can be given for them, is (as before observed) a question for Metaphysics, not for Logic. Axioms are the upward limit of Logic, which, like all the special sciences, necessarily takes them for granted, as the starting point of all deduction and the goal of all generalisation.

Next to Axioms, come Primary Laws of Nature: these are of less generality than the Axioms, and are subject to the conditions of

methodical proof; being universally true only of certain forces or properties of matter, or of nature under certain conditions; so that proof of them by logical or mathematical reasoning is expected, because they depend upon the Axioms for their formal evidence. Such are the law of gravitation, in Astronomy; the law of definite proportions, in Chemistry; the law of heredity, in Biology; and in Psychology, the law of relativity.

Then, there are Secondary Laws, of still less generality, resulting from a combination of conditions or forces in given circumstances, and therefore conceivably derivable from the laws of those conditions or forces, if we can discover them and compute their united effects. Accordingly, Secondary Laws are either—(1) Derivative, having been analysed into, and deduced from, Primary Laws; or (2) Empirical, those that have not yet been deduced (though from their comparatively special and complex character, it seems probable they may be, given sufficient time and ingenuity), and that meanwhile rest upon some unsatisfactory sort of induction by Agreement or Simple Enumeration.

Whether laws proved only by the canon of Difference are to be considered Empirical, is perhaps a question: their proof derives them from the principle of Causation; but, being of narrow scope, some more special account of them seems requisite in relation to the Primary Laws before we can call them Derivative in the technical sense.

Many Secondary Laws, again, are partially or imperfectly Derivative; we can give general reasons for them, without being able to determine theoretically the precise relations of the phenomena they describe. Meteorologists can explain the general conditions of all sorts of weather, but have made little progress toward predicting the actual course of it (at least, for our island): Geologists know the general causes of mountain ranges, but not why they rise just where we find them: Economists explain the general course of a commercial crisis, but not why the great crises recurred at intervals of about ten years.

Derivative Laws make up the body of the exact sciences, having been assimilated and organised; whilst Empirical Laws are the

undigested materials of science. The theorems of Euclid are good examples of derivative laws in Mathematics; in Astronomy, Kepler's laws and the laws of the tides; in Physics, the laws of shadows, of perspective, of harmony; in Biology, the law of protective coloration; in Economics, the laws of prices, wages, interest, and rent.

Empirical Laws are such as Bode's law of the planetary distances; the laws of the expansion of different bodies by heat, and formul $\tilde{A}$ \_ expressing the electrical conductivity of each substance as a function of the temperature. Strictly speaking, I suppose, all the laws of chemical combination are empirical: the law of definite proportions is verifiable in all cases that have been examined, except for variations that may be ascribed to errors of experiment. Much the same is true in Biology; most of the secondary laws are empirical, except so far as structures or functions may be regarded as specialised cases in Physics or Chemistry and deducible from these sciences. The theory of Natural Selection, however, has been the means of rendering many laws, that were once wholly empirical, at least partially derivative; namely, the laws of the geographical distribution of plants and animals, and of their adaptation in organisation, form and colour, habits and instincts, to their various conditions of life. The laws that remain empirical in Biology are of all degrees of generality from that of the tendency to variation in size and in every other character shown by every species (though as to the reason of this there are promising hypotheses), down to such curious cases as that the colour of roses and carnations never varies into blue, that scarlet flowers are never sweet-scented, that bullfinches fed on hemp-seed turn black, that the young of white, yellow and dun pigeons are born almost naked (whilst others have plenty of down); and so on. The derivation of empirical laws is the greater part of the explanation of Nature (SectionSection 5, 6).

A 'Fact,' in the common use of the word, is a particular observation: it is the material of science in its rawest state. As perceived by a mind, it is, of course, never absolutely particular: for we cannot perceive anything without classing it, more or less definitely, with things already known to us; nor describe it without using connotative terms which imply a classification of the things

denoted. Still, we may consider an observation as particular, in comparison with a law that includes it with numerous others in one general proposition. To turn an observation into an experiment, or (where experiment is impracticable) to repeat it with all possible precautions and exactness, and to describe it as to the duration, quantity, quality and order of occurrence of its phenomena, is the first stage of scientific manufacture. Then comes the formulation of an empirical law; and lastly, if possible, deduction or derivation, either from higher laws previously ascertained, or from an hypothesis. However, as a word is used in various senses, we often speak of laws as 'facts': we say the law of gravitation is a fact, meaning that it is real, or verifiable by observations or experiments.

Section 2. Secondary Laws may also be classified according to their constancy into—(1) the Invariable (as far as experience reaches), and (2) Approximate Generalisations in the form—Most X's are Y. Of the invariable we have given examples above. The following are approximate generalisations: Most comets go round the Sun from East to West; Most metals are solid at ordinary temperatures; Most marsupials are Australasian; Most arctic animals are white in winter; Most cases of plague are fatal; Most men think first of their own interests. Some of these laws are empirical, as that 'Most metals are solid at ordinary temperatures': at present no reason can be given for this; nor do we know why most cases of plague are fatal. Others, however, are at least partially derivative, as that 'Most arctic animals are white'; for this seems to be due to the advantage of concealment in the snow; whether, as with the bear, the better to surprise its prey, or, with the hare, to escape the notice of its enemies.

But the scientific treatment of such a proposition requires that we should also explain the exceptions: if 'Most are,' this implies that 'Some are not'; why not, then? Now, if we can give reasons for all the exceptions, the approximate generalisation may be converted into an universal one, thus: 'All arctic animals are white, unless (like the raven) they need no concealment either to prey or to escape; or unless mutual recognition is more important to them than concealment (as with the musk-sheep)'. The same end of universal statement may be gained by including the conditions on

which the phenomenon depends, thus: 'All arctic animals to whom concealment is of the utmost utility are white.'

When statistics are obtainable, it is proper to convert an approximate generalisation into a proportional statement of the fact, thus: instead of 'Most attacks of plague are fatal', we might find that in a certain country 70 per cent. were so. Then, if we found that in another country the percentage of deaths was 60, in another 40, we might discover, in the different conditions of these countries, a clue to the high rate of mortality from this disease. Even if the proportion of cases in which two facts are connected does not amount to 'Most,' yet, if any definite percentage is obtainable, the proposition has a higher scientific value than a vague 'Some': as if we know that 2 per cent. of the deaths in England are due to suicide, this may be compared with the rates of suicide in other countries; from which perhaps inferences may be drawn as to the causes of suicide.

In one department of life, namely, Politics, there is a special advantage in true approximate generalisations amounting to 'Most cases.' The citizens of any State are so various in character, enlightenment, and conditions of life, that we can expect to find few propositions universally true of them: so that propositions true of the majority must be trusted as the bases of legislation. If most men are deterred from crime by fear of punishment; if most men will idle if they can obtain support without industry; if most jurymen will refuse to convict of a crime for which the prescribed penalties seem to them too severe; these are most useful truths, though there should be numerous exceptions to them all.

Section 3. Secondary Laws can only be trusted in 'Adjacent Cases'; that is, where the circumstances are similar to those in which the laws are known to be true.

A Derivative Law will be true wherever the forces concerned exist in the combinations upon which the law depends, if there are no counteracting conditions. That water can be pumped to about 33 feet at the sea-level, is a derivative law on this planet: is it true in Mars? That depends on whether there are in Mars bodies of a liquid similar to our water; whether there is an atmosphere there,

and how great its pressure is; which will vary with its height and density. If there is no atmosphere there can be no pumping; or if there is an atmosphere of less pressure than ours, water such as ours can only be pumped to a less height than 33 feet. Again, we know that there are arctic regions in Mars; if there are also arctic animals, are they white? That may depend upon whether there are any beasts of prey. If not, concealment seems to be of no use.

An Empirical Law, being one whose conditions we do not know, the extent of its prevalence is still less ascertainable. Where it has not been actually observed to be true, we cannot trust it unless the circumstances, on the whole, resemble so closely those amongst which it has been observed, that the unknown causes, whatever they may be, are likely to prevail there. And, even then, we cannot have much confidence in it; for there may be unknown circumstances which entirely frustrate the effect. The first naturalist who travelled (say) from Singapore eastward by Sumatra and Java, or Borneo, and found the mammalia there similar to those of Asia, may naturally have expected the same thing in Celebes and Papua; but, if so, he was entirely disappointed; for in Papua the mammalia are marsupials like those of Australia. Thus his empirical law, 'The mammalia of the Eastern Archipelago are Asiatic,' would have failed for no apparent reason. According to Mr. Wallace, there is a reason for it, though such as could only be discovered by extensive researches; namely, that the sea is deep between Borneo and Celebes, so that they must have been separated for many ages; whereas it is shallow from Borneo westward to Asia, and also southward from Celebes to Australia; so that these regions, respectively, may have been recently united: and the true law is that similar mammalia belong to those tracts which at comparatively recent dates have formed parts of the same continents (unless they are the remains of a former much wider distribution).

A considerable lapse of time may make an empirical law no longer trustworthy; for the forces from whose combination it resulted may have ceased to operate, or to operate in the same combination; and since we do not know what those forces were, even the knowledge that great changes have taken place in the meantime cannot enable us, after an interval, to judge whether or not the law still holds true.

New stars shine in the sky and go out; species of plants and animals become extinct; diseases die out and fresh ones afflict mankind: all these things doubtless have their causes, but if we do not know what they are, we have no measure of the effects, and cannot tell when or where they will happen.

Laws of Concomitant Variations may hold good only within certain limits. That bodies contract as the temperature falls, is not true of water below 39°F. In Psychology, Weber's Law is only true within the median range of sensation-intensities, not for very faint, nor for very strong, stimuli. In such cases the failure of the laws may depend upon something imperfectly understood in the collocation: as to water, on its molecular constitution; as to sensation, upon the structure of the nervous system.

Section 4. Secondary Laws, again, are either of Succession or of Co-existence.

Those of Succession are either—(1) of direct causation, as that 'Water quenches fire,' or (more strictly) that 'Evaporation reduces temperature'; or (2) of the effect of a remote cause, as 'Bad harvests tend to raise the price of bread'; or (3) of the joint effects of the same cause, as that 'Night follows day' (from the revolution of the earth), or the course of the seasons (from the inclination of the earth's axis).

Laws of Co-existence are of several classes. (1) One has the generality of a primary law, though it is proved only by Agreement, namely, 'All gravitating bodies are inert'. Others, though less general than this, are of very extensive range, as that 'All gases that are not decomposed by rise of temperature have the same rate of expansion'; and, in Botany that 'All monocotyledonous plants are endogenous'. These laws of Co-existence are concerned with fundamental properties of bodies.

(2) Next come laws of the Co-existence of those properties which are comprised in the definitions of Natural Kinds. Mill distinguished between ( $\alpha$ ) classes of things that agree among themselves and differ from others only in one or a few attributes (such as 'red things,' 'musical notes', 'carnivorous animals',

‘soldiers’), and ( $\beta$ ) classes of things that agree among themselves and differ from others in a multitude of characters: and the latter he calls Natural Kinds. These comprise the chemical elements and their pure compounds (such as water, alcohol, rock-salt), and the species of plants and animals. Clearly, each of these is constituted by the co-existence or co-inherence of a multitude of properties, some of which are selected as the basis of their definitions. Thus, Gold is a metal of high specific gravity, atomic weight 197.2, high melting point, low chemical affinities, great ductility, yellow colour, etc.: a Horse has ‘a vertebral column, mammae, a placental embryo, four legs, a single well-developed toe in each foot provided with a hoof, a bushy tail, and callosities on the inner sides of both the fore and the hind legs’ (Huxley).

Since Darwinism has obtained general acceptance, some Logicians have doubted the propriety of calling the organic species ‘Kinds,’ on the ground that they are not, as to definiteness and permanence, on a par with the chemical elements or such compounds as water and rock-salt; that they vary extensively, and that it is only by the loss of former generations of animals that we are able to distinguish species at all. But to this it may be replied that species are often approximately constant for immense periods of time, and may be called permanent in comparison with human generations; and that, although the leading principles of Logic are perhaps eternal truths, yet upon a detail such as this, the science may condescend to recognise a distinction if it is good for (say) only 100,000 years. That if former generations of plants and animals were not lost, all distinctions of species would disappear, may be true; but they are lost—for the most part beyond hope of recovery; and accordingly the distinction of species is still recognised; although there are cases, chiefly at the lower stages of organisation, in which so many varieties occur as to make adjacent species almost or quite indistinguishable. So far as species are recognised, then, they present a complex co-inherence of qualities, which is, in one aspect, a logical problem; and, in another, a logical datum; and, coming more naturally under the head of Natural Kinds than any other, they must be mentioned in this place.

(3) There are, again, certain coincidences of qualities not essential to any kind, and sometimes prevailing amongst many different



kinds: such as ‘Insects of nauseous taste have vivid (warning) colours’; ‘White tom-cats with blue eyes are deaf’; ‘White spots and patches, when they appear in domestic animals, are most frequent on the left side.’

(4) Finally, there may be constancy of relative position, as of sides and angles in Geometry; and also among concrete things (at least for long periods of time), as of the planetary orbits, the apparent positions of fixed stars in the sky, the distribution of land and water on the globe, opposite seasons in opposite hemispheres.

All these cases of Co-existence (except the geometrical) present the problem of deriving them from Causation; for there is no general Law of Co-existence from which they can be derived; and, indeed, if we conceive of the external world as a perpetual redistribution of matter and energy, it follows that the whole state of Nature at any instant, and therefore every co-existence included in it, is due to causation issuing from some earlier distribution of matter and energy. Hence, indeed, it is not likely that the problems of co-existence as a whole will ever be solved, since the original distribution of matter is, of course, unknown. Still, starting with any given state of Nature, we may hope to explain some of the co-existences in any subsequent state. We do not, indeed, know why heavy bodies are always inert, nor why the chemical elements are what they are; but it is known that “the properties of the elements are functions of their atomic weight,” which (though, at present, only an empirical law) may be a clue to some deeper explanation. As to plants and animals, we know the conditions of their generation, and can trace a connection between most of their characteristics and the conditions of their life: as that the teeth and stomach of animals vary with their food, and that their colour generally varies with their habitat.

Geometrical Co-existence, when it is not a matter of definition (as ‘a square is a rectangle with four equal sides’), is deduced from the definitions and axioms: as when it is shown that in triangles the greater side is opposite the greater angle. The deductions of theorems or secondary laws, in Geometry is a type of what is desirable in the Physical Sciences: the demonstration, namely, that all the connections of phenomena, whether successive or co-

existent, are consequences of the redistribution of matter and energy according to the principle of Causation.

Coincidences of Co-existence (Group (3)) may sometimes be deduced and sometimes not. That 'nauseous insects have vivid coloration' comes under the general law of 'protective coloration'; as they are easily recognised and therefore avoided by insectivorous birds and other animals. But why white tom-cats with blue-eyes should be deaf, is (I believe) unknown. When co-existences cannot be derived from causation, they can only be proved by collecting examples and trusting vaguely to the Uniformity of Nature. If no exceptions are found, we have an empirical law of considerable probability within the range of our exploration. If exceptions occur, we have at most an approximate generalisation, as that 'Most metals are whitish,' or 'Most domestic cats are tabbies' (but this probably is the ancestral colouring). We may then resort to statistics for greater definiteness, and find that in Hampshire (say) 90 per cent. of the domestic cats are tabby.

Section 5. Scientific Explanation consists in discovering, deducing, and assimilating the laws of phenomena; it is the analysis of that Heracleitan 'flux' which so many philosophers have regarded as intractable to human inquiry. In the ordinary use of the word, 'explanation' means the satisfying a man's understanding; and what may serve this purpose depends partly upon the natural soundness of his understanding, and partly on his education; but it is always at last an appeal to the primary functions of cognition, discrimination and assimilation.

Generally, what we are accustomed to seems to need no explanation, unless our curiosity is particularly directed to it. That boys climb trees and throw stones, and that men go fox-hunting, may easily pass for matters of course. If any one is so exacting as to ask the reason, there is a ready answer in the 'need of exercise.' But this will not explain the peculiar zest of those exercises, which is something quite different from our feelings whilst swinging dumb-bells or tramping the highway. Others, more sophisticated, tell us that the civilised individual retains in his nature the instincts of his remote ancestors, and that these assert themselves at stages

of his growth corresponding with ancestral periods of culture or savagery: so that if we delight to climb trees, throw stones, and hunt, it is because our forefathers once lived in trees, had no missiles but stones, and depended for a livelihood upon killing something. To some of us, again, this seems an explanation; to others it merely gives annoyance, as a superfluous hypothesis, the fruit of a wanton imagination and too much leisure.

However, what we are not accustomed to immediately excites curiosity. If it were exceptional to climb trees, throw stones, ride after foxes, whoever did such things would be viewed with suspicion. An eclipse, a shooting star, a solitary boulder on the heath, a strange animal, or a Chinaman in the street, calls for explanation; and among some nations, eclipses have been explained by supposing a dragon to devour the sun or moon; solitary boulders, as the missiles of a giant; and so on. Such explanations, plainly, are attempts to regard rare phenomena as similar to others that are better known; a snake having been seen to swallow a rabbit, a bigger one may swallow the sun: a giant is supposed to bear much the same relation to a boulder as a boy does to half a brick. When any very common thing seems to need no explanation, it is because the several instances of its occurrence are a sufficient basis of assimilation to satisfy most of us. Still, if a reason for such a thing be demanded, the commonest answer has the same implication, namely, that assimilation or classification is a sufficient reason for it. Thus, if climbing trees is referred to the need of exercise, it is assimilated to running, rowing, etc.; if the customs of a savage tribe are referred to the command of its gods, they are assimilated to those things that are done at the command of chieftains.

Explanation, then, is a kind of classification; it is the finding of resemblance between the phenomenon in question and other phenomena. In Mathematics, the explanation of a theorem is the same as its proof, and consists in showing that it repeats, under different conditions, the definitions and axioms already assumed and the theorems already demonstrated. In Logic, the major premise of every syllogism is an explanation of the conclusion; for the minor premise asserts that the conclusion is an example of the major premise.

In Concrete Sciences, to discover the cause of a phenomenon, or to derive an empirical law from laws of causation, is to explain it; because a cause is an invariable antecedent, and therefore reminds us of, or enables us to conceive, an indefinite number of cases similar to the present one wherever the cause exists. It classifies the present case with other instances of causation, or brings it under the universal law; and, as we have seen that the discovery of the laws of nature is essentially the discovery of causes, the discovery and derivation of laws is scientific explanation.

The discovery of quantitative laws is especially satisfactory, because it not only explains why an event happens at all, but why it happens just in this direction, degree, or amount; and not only is the given relation of cause and effect definitely assimilated to other causal instances, but the effect is identified with the cause as the same matter and energy redistributed; wherefore, whether the conservation of matter and energy be universally true or not, it must still be an universal postulate of scientific explanation.

The mere discovery of an empirical law of co-existence, as that 'white tom-cats with blue eyes are deaf', is indeed something better than an isolated fact: every general proposition relieves the mind of a load of facts; and, for many people, to be able to say—'It is always so'—may be enough; but for scientific explanation we require to know the reason of it, that is, the cause. Still, if asked to explain an axiom, we can only say, 'It is always so:' though it is some relief to point out particular instances of its realisation, or to exhibit the similarity of its form to that of other axioms—as of the Dictum to the axiom of equality.

Section 6. There are three modes of scientific Explanation; First, the analysis of a phenomenon into the laws of its causes and the concurrence of those causes.

The pumping of water implies (1) pressure of the air, (2) distribution of pressure in a liquid, (3) that motion takes the direction of least resistance. Similarly, that thunder follows forked lightning, and that the report of a gun follows the flash, are resolvable into (1) the discharge of electricity, or the explosion of gunpowder; (2) distance of the observer from the event; (3) that

light travels faster than sound. The planetary orbits are analysable into the tendency of planets to fall into the sun, and their tendency to travel in a straight line. When this conception is helped out by swinging a ball round by a string, and then letting it go, to show what would happen to the earth if gravitation ceased, we see how the recognition of resemblance lies at the bottom of explanation.

Secondly, the discovery of steps of causation between a cause and its remote effects; the interpolation and concatenation of causes.

The maxim 'No cats no clover' is explained by assigning the intermediate steps in the following series; that the fructification of red clover depends on the visits of humble-bees, who distribute the pollen in seeking honey; that if field-mice are numerous they destroy the humble-bees' nests; and that (owls and weasels being exterminated by gamekeepers) the destruction of field-mice depends upon the supply of cats; which, therefore, are a remote condition of the clover crop. Again, the communication of thought by speech is an example of something so common that it seems to need no explanation; yet to explain it is a long story. A thought in one man's mind is the remote cause of a similar thought in another's: here we have (1) a thought associated with mental words; (2) a connection between these thoughts and some tracts of the brain; (3) a connection between these tracts of the brain and the muscles of the larynx, the tongue and the lips; (4) movements of the chest, larynx and mouth, propelling and modifying waves of air; (5) the impinging of these air-waves upon another man's ear, and by a complex mechanism exciting the aural nerve; (6) the transfer of this excitation to certain tracts of his brain; (7) a connection there with sounds of words and their associated thoughts. If one of these links fail, there is no communication.

Thirdly, the subsumption of several laws under one more general expression.

The tendency of bodies to fall to the earth and the tendency of the earth itself (with the other planets) to fall into the sun, are subsumed under the general law that 'All matter gravitates.' The same law subsumes the movements of the tide. By means of the notion of specific gravity, it includes 'levitation,' or the actual

rising of some bodies, as of corks in water, of balloons, or flames in the air: the fact being that these things do not tend to rise, but to fall like everything else; only as the water or air weighs more in proportion to its volume than corks or balloons, the latter are pushed up.

This process of subsumption bears the same relation to secondary laws, that these do to particular facts. The generalisation of many particular facts (that is, a statement of that in which they agree) is a law; and the generalisation of these laws (that is, again, a statement of that in which they agree) is a higher law; and this process, upwards or downwards, is characteristic of scientific progress. The perfecting of any science consists in comprehending more and more of the facts within its province, and in showing that they all exemplify a smaller and smaller number of principles, which express their most profound resemblances.

These three modes of explanation (analysis, interpolation, subsumption) all consist in generalising or assimilating the phenomena. The pressure of the air, of a liquid, and motion in the direction of least resistance, are all commoner facts than pumping; that light travels faster than sound is a commoner fact than a thunderstorm or gun-firing. Each of the laws—'Cats kill mice,' 'Mice destroy humble-bees' nests,' 'Humble-bees fructify red clover'—is wider and expresses the resemblance of more numerous cases than the law that 'Clover depends on cats'; because each of them is less subject to further conditions. Similarly, every step in the communication of thought by language is less conditional, and therefore more general, than the completion of the process.

In all the above cases, again, each law into which the phenomenon (whether pumping or conversation) is resolved, suggests a host of parallel cases: as the modifying of air-waves by the larynx and lips suggests the various devices by which the strings and orifices of musical instruments modify the character of notes.

Subsumption consists entirely in proving the existence of an essential similarity between things where it was formerly not observed: as that the gyrations of the moon, the fall of apples, and the flotation of bubbles are all examples of gravitation: or that the

purifying of the blood by breathing, the burning of a candle, and the rusting of iron are all cases of oxidation: or that the colouring of the underside of a red-admiral's wings, the spots of the giraffe, the shape and attitude of a stick-caterpillar, the immobility of a bird on its nest, and countless other cases, though superficially so different, agree in this, that they conceal and thereby protect the organism.

Not any sort of likeness, however, suffices for scientific explanation: the only satisfactory explanation of concrete things or events, is to discover their likeness to others in respect of Causation. Hence attempts to help the understanding by familiar comparisons are often worse than useless. Any of the above examples will show that the first result of explanation is not to make a phenomenon seem familiar, but to put (as the saying is) 'quite a new face upon it.' When, indeed, we have thought it over in all its newly discovered relations, we feel more at home with it than ever; and this is one source of our satisfaction in explaining things; and hence to substitute immediate familiarisation for radical explanation, is the easily besetting sin of human understanding: the most plausible of fallacies, the most attractive, the most difficult to avoid even when we are on our guard against it.

Section 7. The explanation of Nature (if it be admitted to consist in generalisation, or the discovery of resemblance amidst differences) can never be completed. For—(1) there are (as Mill says) facts, namely, fundamental states or processes of consciousness, which are distinct; in other words, they do not resemble one another, and therefore cannot be generalised or subsumed under one explanation. Colour, heat, smell, sound, touch, pleasure and pain, are so different that there is one group of conditions to be sought for each; and the laws of these conditions cannot be subsumed under a more general one without leaving out the very facts to be explained. A general condition of sensation, such as the stimulating of the sensory organs of a living animal, gives no account of the special characters of colour, smell, etc.; which are, however, the phenomena in question; and each of them has its own law. Nay, each distinct sensation-quality, or degree, must have its own law; for in each ultimate difference there is something that

cannot be assimilated. Such differences amount, according to experimental Psychologists, to more than 50,000. Moreover, a neural process can never explain a conscious process in the way of cause and effect; for there is no equivalence between them, and one can never absorb the other.

(2) When physical science is treated objectively (that is, with as little reference as possible to the fact that all phenomena are only known in relation to the human mind), colour, heat, smell, sound (considered as sensations) are neglected, and attention is fixed upon certain of their conditions: extension, figure, resistance, weight, motion, with their derivatives, density, elasticity, etc. These are called the Primary Qualities of Matter; and it is assumed that they belong to matter by itself, whether we look on or not: whilst colour, heat, sound, etc., are called Secondary Qualities, as depending entirely upon the reaction of some conscious animal. By physical science the world is considered in the abstract, as a perpetual redistribution of matter and energy, and the distracting multiplicity of sensations seems to be got rid of.

But, not to dwell upon the difficulty of reducing the activities of life and chemistry to mechanical principles—even if this were done, complete explanation could not be attained. For—(a) as explanation is the discovery of causes, we no sooner succeed in assigning the causes of the present state of the world than we have to inquire into the causes of those causes, and again the still earlier causes, and so on to infinity. But, this being impossible, we must be content, wherever we stop, to contemplate the uncaused, that is, the unexplained; and then all that follows is only relatively explained.

Besides this difficulty, however, there is another that prevents the perfecting of any theory of the abstract material world, namely (b), that it involves more than one first principle. For we have seen that the Uniformity of Nature is not really a principle, but a merely nominal generalisation, since it cannot be definitely stated; and, therefore, the principles of Contradiction, Mediate Equality, and Causation remain incapable of subsumption; nor can any one of them be reduced to another: so that they remain unexplained.

(3) Another limit to explanation lies in the infinite character of



every particular fact; so that we may know the laws of many of its properties and yet come far short of understanding it as a whole. A lump of sandstone in the road: we may know a good deal about its specific gravity, temperature, chemical composition, geological conditions; but if we inquire the causes of the particular modifications it exhibits of these properties, and further why it is just so big, containing so many molecules, neither more nor less, disposed in just such relations to one another as to give it this particular figure, why it lies exactly there rather than a yard off, and so forth, we shall get no explanation of all this. The causes determining each particular phenomenon are infinite, and can never be computed; and, therefore, it can never be fully explained.

Section 8. Analogy is used in two senses: (1) for the resemblance of relations between terms that have little or no resemblance—as The wind drives the clouds as a shepherd drives his sheep—where wind and shepherd, clouds and sheep are totally unlike. Such analogies are a favourite figure in poetry and rhetoric, but cannot prove anything. For valid reasoning there must be parallel cases, according to substance and attribute, or cause and effect, or proportion: e.g. As cattle and deer are to herbivorousness, so are camels; As bodies near the earth fall toward it, so does the moon; As 2 is to 3 so is 4 to 6.

(2) Analogy is discussed in Logic as a kind of probable proof based upon imperfect similarity (as the best that can be discovered) between the data of comparison and the subject of our inference. Like Deduction and Induction, it assumes that things which are alike in some respects are also alike in others; but it differs from them in not appealing to a definite general law assigning the essential points of resemblance upon which the argument relies. In Deductive proof, this is done by the major premise of every syllogism: if the major says that ‘All fat men are humorists,’ and we can establish the minor, ‘X is a fat man,’ we have secured the essential resemblance that carries the conclusion. In induction, the Law of Causation and its representatives, the Canons, serve the same purpose, specifying the essential marks of a cause. But, in Analogy, the resemblance relied on cannot be stated categorically.

If we argue that Mars is inhabited because it resembles the datum,

our Earth, (1) in being a planet, (2) neither too hot nor too cold for life, (3) having an atmosphere, (4) land and water, etc., we are not prepared to say that 'All planets having these characteristics are inhabited.' It is, therefore, not a deduction; and since we do not know the original causes of life on the Earth, we certainly cannot show by induction that adequate causes exist in Mars. We rely, then, upon some such vague notion of Uniformity as that 'Things alike in some points are alike in others'; which, plainly, is either false or nugatory. But if the linear markings upon the surface of Mars indicate a system of canals, the inference that he has intelligent inhabitants is no longer analogical, since canals can have no other cause.

The cogency of any proof depends upon the character and definiteness of the likeness which one phenomenon bears to another; but Analogy trusts to the general quantity of likeness between them, in ignorance of what may be the really important likeness. If, having tried with a stone, an apple, a bullet, etc., we find that they all break an ordinary window, and thence infer that a cricket ball will do so, we do not reason by analogy, but make instinctively a deductive extension of an induction, merely omitting the explicit generalisation, 'All missiles of a certain weight, size and solidity break windows.' But if, knowing nothing of snakes except that the viper is venomous, a child runs away from a grass-snake, he argues by analogy; and, though his conduct is prudentially justifiable, his inference is wrong: for there is no law that 'All snakes are venomous,' but only that those are [Pg 309]venomous that have a certain structure of fang; a point which he did not stay to examine.

The discovery of an analogy, then, may suggest hypotheses; it states a problem—to find the causes of the analogy; and thus it may lead to scientific proof; but merely analogical argument is only probable in various degrees. (1) The greater the number and importance of the points of agreement, the more probable is the inference. (2) The greater the number and importance of the points of difference, the less probable is the inference. (3) The greater the number of unknown properties in the subject of our argument, the less the value of any inference from those that we do know. Of course the number of unknown properties can itself be estimated

only by analogy. In the case of Mars, they are probably very numerous; and, apart from the evidence of canals, the prevalent assumption that there are intelligent beings in that planet, seems to rest less upon probability than on a curiously imaginative extension of the gregarious sentiment, the chilly discomfort of mankind at the thought of being alone in the universe, and a hope that there may be conversable and 'clubable' souls nearer than the Dog-star.