Of the Composition of Causes (1859)

John Stuart Mill

§1. To complete the general notion of causation on which the rules of experimental inquiry into the laws of nature must be founded, one distinction still remains to be pointed out: a distinction so fundamental, and of so much importance, as to require a chapter to itself.

The preceding discussions have rendered us familiar with the case in which several agents, or causes, concur as conditions to the production of an effect; a case, in truth, almost universal, there being very few effects to the production of which no more than one agent contributes. Suppose, then, that two different agents, operating jointly, are followed, under a certain set of collateral conditions, by a given effect. If either of these agents, instead of being joined with the other, had operated alone, under the same set of conditions in all other respects, some effect would probably have followed; which would have been different from the joint effect of the two, and more or less dissimilar to it. Now, if we happen to know what would be the effects of each cause when acting separately from the other, we are often able to arrive deductively, or *à priori,* at a correct prediction of what will arise from their conjunct agency. To enable us to do this, it is only necessary that the same law which expresses the effect of each cause acting by itself, shall also correctly express the part due to that cause, of the effect which follows from the two together. This condition is realized in the extensive and important class of phenomena commonly called mechanical, namely, the phenomena of the communication of motion (or of pressure, which is tendency to motion) from one body to another. In this important class of cases of causation, one cause never, properly speaking, defeats or frustrates another; both have their full effect. If a body is propelled in two directions by two forces, one tending to drive it to the north, and the other to the east, it is caused to move in a given time exactly as far in both directions as the two forces would separately have carried it; and is left precisely where it would have arrived if it had been acted upon first by one of the two forces, and afterwards by the other. This law of nature is called, in mechanical philosophy, the principle of the Composition of Forces: and in imitation of that well-chosen expression, I shall give the name of the Composition of Causes to the principle which is exemplified in all cases in which the joint effect of several causes is identical with the sum of their separate effects.

This principle, however, by no means prevails in all departments of the field of nature. The chemical combination of two substances produces, as is well known, a third substance with properties entirely different from those of either of the two substances separately, or of both of them taken together. Not a trace of the properties of hydrogen or of oxygen is observable in those of their compound, water. The taste of sugar of lead is not the sum of the tastes of its component elements, acetic acid and lead or its oxide; nor is the color of green vitriol a mixture of the colors of sulphuric acid and copper. This explains why mechanics is a deductive or demonstrative science, and chemistry not. In the one, we can compute the effects of all combinations of causes, whether real or hypothetical, from the laws which we know to govern those causes when acting separately; because they continue to observe the same laws when in combination, which they observed when separate: whatever would have happened in consequence of each cause taken by itself, happens when they are together, and we have only to cast up the results. Not so in the phenomena which are the peculiar subject of the science of chemistry. There, most of the uniformities to which the causes conformed when separate, cease altogether when they are conjoined; and we are not, at least in the present state of our knowledge, able to foresee what result will follow from any new combination, until we have tried it by specific experiment.

If this be true of chemical combinations, it is still more true of those far more complex combinations of elements which constitute organized bodies; and in which those extraordinary new uniformities arise, which are called the laws of life. All organized bodies are composed of parts, similar to those composing inorganic nature, and which have even themselves existed in an inorganic state; but the phenomena of life, which result from the juxtaposition of those parts in a certain manner, bear no analogy to any of the effects which would be produced by the action of the component substances considered as mere physical agents. To whatever degree we might imagine our knowledge of the properties of the several ingredients of a living body to be extended and perfected, it is certain that no mere summing up of the separate actions of those elements will ever amount to the action of the living body itself. The tongue, for instance, is, like all other parts of the animal frame, composed of gelatine, fibrin, and other products of the chemistry of digestion, but from no knowledge of the properties of those substances could we ever predict that it could taste, unless gelatine or fibrin could themselves taste; for no elementary fact can be in the conclusion, which was not first in the premisses.

There are thus two different modes of the conjunct action of causes; from which arise two modes of conflict, or mutual interference, between laws of nature. Suppose, at a given point of time and space, two or more causes, which, if they acted separately, would proclaim effects contrary, or at least conflicting with each other; one of them tending to undo, wholly or partially, what the other tends to do. Thus, the expansive force of the gases generated by the ignition of gunpowder tends to project a bullet towards the sky, while its gravity tends to make it fall to the ground. A stream running into a reservoir at one end tends to fill it higher and higher, while a drain at the other extremity tends to empty it. Now, in such cases as these, even if the two causes which are in joint action exactly annul one another, still the laws of both are fulfilled; the effect is the same as if the drain had been for half an hour first,[i] and the stream had flowed in for as long afterwards. Each agent produced the same amount of effect as if it had acted separately, though the contrary effect which was taking during the same time obliterated it as fast as it was produced. Here, then, we have two causes, producing by their joint operation an effect which at first Seems quite dissimilar to those which they produce separately, but which on examination proves to be really the sum of those separate effects. It will be noticed that we here enlarge the idea of the sum of two effects, so as to include what is commonly called their difference, but which is in reality the result of the addition of opposites; a conception to which, as is well known, mankind are indebted for that admirable extension of the algebraical calculus, which has so vastly increased its powers as an instrument of discovery, by introducing into its reasonings (with the sign of subtraction prefixed, and under the name of Negative Quantities) every description whatever of positive phenomena, provided they are of such a quality in reference to those previously introduced, that to add the one is equivalent to subtracting an equal quantity of the other.

There is, then, one mode of the mutual interference of laws of nature in which, even when the concurrent causes annihilate each other's effects, each exerts its full efficacy according to its own law, its law as a separate agent. But in the other description of cases, the two agencies which are brought together cease entirely, and a totally different set of phenomena arise: as in the experiment of two liquids which, when mixed in certain proportions, instantly become a solid mass, instead of merely a larger amount of liquid.

§ 2. This difference between the case in which the joint effect of causes is the sum of their separate effects, and the case in which it is heterogeneous to them; between laws which work together without alteration, and laws which, when called upon to work together, cease and give place to others; is one of the fundamental distinctions in nature. The former case, that of the Composition of Causes, is the general one; the other is always special and exceptional. There are no objects which do not, as to some of their phenomena, obey the principle of the Composition of Causes; none that have not some laws which are rigidly fulfilled in every combination into which the objects enter. The weight of a body, for instance, is a property which it retains in all the combinations in which it is placed. The weight of a chemical compound, or of an organized body, is equal to the sum of the weights of the elements which compose it. The weight either of the elements or of the compound will vary, if they be carried further from their centre of attraction, or brought nearer to it; but whatever affects the one affects the other. They always remain precisely equal. So again, the component parts of a vegetable or animal substance do not lose their mechanical and chemical properties as separate agents, when, by a peculiar mode of juxtaposition, they, as an aggregate whole, acquire physiological or vital properties in addition. Those bodies continue, as before, to obey mechanical and chemical laws, in so far as the operation of those laws is not counteracted by the new laws which govern them as organized beings. When, in short, a concurrence of causes takes place which calls into action new laws, bearing no analogy to any that we can trace in the separate operation of the causes, the new laws may supersede one portion of the previous laws but coexist with another portion, and may even compound the effect of those previous laws with their own.

Again, laws which were themselves generated in the second mode, may generate others in the first. Though there be laws which, like those of chemistry and physiology, owe their existence to a breach of the principle of Composition of Causes, it does not follow that these peculiar, or as they might be termed, *heteropathic* laws, are not capable of composition with one another. The causes which by one combination have had their laws altered, may carry their new laws with them unaltered into their ulterior combinations. And hence there is no reason to despair of ultimately raising chemistry and physiology to the condition of deductive sciences; for though it is impossible to deduce all chemical and physiological truths from the laws or properties of simple substances or elementary agents, they may probably be deducible from laws which commence when these elementary agents are brought together into some moderate number of not very complex combinations. The Laws of Life will never be deducible from the mere laws of the ingredients, but the prodigiously complex Facts of Life may all be deducible from comparatively simple laws of life; which laws (depending indeed upon combinations, but upon comparatively simple combinations, of antecedents), may in more complex circumstances be strictly compounded with one another, and with the physical and chemical laws of the ingredients. The details of the vital phenomena even now afford innumerable exemplifications of the Composition of Causes; and in proportion as these phenomena are more accurately studied, there appears more and more reason to believe that the same laws which operate in the simpler combinations of circumstances do, in fact, continue to be observed in the more complex.[ii] This will be found equally true in the phenomena of mind; and even in social and political phenomena, the result of the laws of mind. It is in the case of chemical phenomena that the least progress has yet been made in bringing the special laws under general ones from which they may be deduced; but there are even in chemistry many circumstances to encourage the hope that such general laws will hereafter be discovered. The different actions of *a* chemical compound will never, undoubtedly, be found to be the sum of the actions of its separate elements; but there may exist, between the properties of the compound and those of its elements, some constant relation, which if discoverable by a sufficient induction, would enable us to foresee the sort of compound which will result from a new combination before we have actually tried it, and to judge of what sort of elements some new substance is compounded before we have analyzed it: a problem, the solution of which has been propounded by M. Comte as the ideal aim and purpose of chemical speculation. The great law of definite proportions, first discovered in its full generality by Dalton, is a complete solution of this problem in one single aspect (of secondary importance it is true), that of quantity: and in respect to quality, we have already some partial generalizations sufficient to indicate the possibility of ultimately proceeding further. We can predicate many common properties of the kind of compounds which result from the combination, in each of the small number of possible proportions, of any acid whatever with any base. We have also the very curious law, discovered by Berthollet, that two soluble salts mutually decompose one another whenever the new combinations which result produce an insoluble compound: or one less soluble than the two former. Another uniformity has been observed, commonly called the law of isomorphism; the identity of the crystalline forms of substances which possess in common certain peculiarities of chemical composition. Thus it appears that even heteropathic laws, such laws of combined agency as are not compounded of the laws of the separate agencies, are yet, at least in some cases, derived from them according to a fixed principle. There may, therefore, be laws of the generation of laws from others dissimilar to them; and in chemistry, these undiscovered laws of the dependence of the properties of the compound on the properties of its elements, may, together with the laws of the elements themselves, furnish the premisses by which the science is destined one day to be rendered deductive.

It would seem, therefore, that there is no class of phenomena in which the Composition of Causes does not obtain: that as a general rule, causes in combination produce exactly the same effects as when acting singly: but that this rule, though general, is not universal; that in some instances, at some particular points in the transition from separate to united action, the laws change, and an entirely new set of effects are either added to, or take the place of, those which arise from the separate agency of the same causes; the laws of these new effects being again susceptible of composition, to an indefinite extent, like the laws which they superseded.

§ **3.** That effects are proportional to their causes is laid down, by some writers, as an axiom in the theory of causation; and great use is sometimes made of this principle in reasonings respecting the laws of nature, although it is encumbered with many difficulties and apparent exceptions, which much ingenuity has been expended in showing not to be real ones. This proposition, in so far as it is true, enters as a particular case into the general principle of the Composition of Causes: the causes compounded being, in this instance, homogeneous; in which case, if in any, their joint effect might be expected to be identical with the sum of their separate effects. If a force equal to one hundred weight, will raise a certain body along an inclined plane, a force equal to two hundred weight will, we know, raise two bodies exactly similar, and thus the effect is proportional to the cause. But does not a force equal to two hundred weight, actually contain in itself two forces each equal to one hundred weight, which, if employed apart, would separately raise the two bodies in question? The fact, therefore, that when exerted jointly they raise both bodies at once, results from the Composition of Causes, and is a mere instance of the general fact that mechanical forces are subject to the law of Composition. And so in every other case which can be supposed. For the doctrine of the proportionality of effects to their causes cannot of course be applicable to cases in which the augmentation of the cause alters the *kind* of effect; that is, in which the surplus quantity superadded to the cause does not become compounded with it, but the two together generate an altogether new phenomenon. Suppose that the application of a certain quantity of heat to a body merely increases its bulk, that a double quantity melts it, and a triple quantity decomposes it: these three effects being heterogeneous, no ratio, whether corresponding or not to that of the quantities of heat applied, can be established between them. Thus we see that the supposed axiom of the proportionality of effects to their causes fails at the precise point where the principle of the Composition of Causes also fails; viz., where the concurrence of causes is such as to determine a change in the properties of the body generally, and render it subject to new laws, more or less dissimilar to those to which it conformed in its previous state of existence. The recognition, therefore, of any such law of proportionality, is superseded by the more comprehensive principle, in which as much of it as is true implicitly asserted.

The general remarks on causation, which seemed necessary as an introduction to the theory of the inductive process, may here terminate. That process is essentially an inquiry into cases of causation. All the uniformities which exist in the succession of phenomena, and most of those which prevail in their coexistence, are either, as we have seen, themselves laws of causation, or consequences resulting from, and corollaries capable of being deduced from, such laws. If we could determine what causes are correctly assigned to what effects, and what effects to what causes, we should be virtually acquainted with the whole course of nature. All those uniformities which are mere results of causation, might then be explained and accounted for; and every individual fact or event might be predicted, provided we had the requisite data, that is, the requisite knowledge of the circumstances which, in the particular instance, preceded it.

To ascertain, therefore, what are the laws of causation which exist in nature; to determine the effects of every cause, and the causes of all effects, is the main business of Induction; and to point out how this is done is the chief object of Inductive Logic.

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[i] I omit, for simplicity, to take into account the effect, in this latter case, of the diminution of pressure, in diminishing the flow of the water through the drain; which evidently in no way affects the truth or applicability of the principle.

[ii] For abundant illustrations of this remark, I may refer to the writings of Dr. W.B. Carpenter, of Bristol, and especially his treatise on *General Physiology,* in which the highest generalizations which the science of life has yet reached, and the best modem conception of that science as a whole, are exhibited in a manner equally perspicuous and philosophical. On the details of such a treatise the present writer would be an incompetent witness; these however have been sufficiently vouched for by some of the highest living authorities; while of the genuinely scientific spirit which pervades it, those may be permitted to express an opinion, who would not be entitled to offer to a work on such a subject, any other praise.

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