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I hereby recommend that the thesis prepared under my supervision by Theodore Adolph Bretscher *entitled* Explanatory Law in Mechanistic and Statistical Reasoning. *be accepted as fulfilling this part of the requirements for the degree of* Ph.D.

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EXPLANATORY LAW IN MECHANISTIE AND STATISTICAL REASONING.

A dissertation submitted in partial fulfillment of the requirements of the degree of

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"The fruit of Science, most delectably fair
Did urge all sages, in the days of old,
The solution of our Unknown Cause to snare.
With uncorporeal beauty do we flare;
As all worlds' first beginning are we held;
Our wondrous harmony, past all compare,
Charmed Plato, Pythagoras, and Euclid.
Fillers of the Primordeal Sphere are we;
So perfect is our form that our look did
Unto all bodies the Law and Size decree."

Leonardo da Vinci.

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EXPLANATORY LAW IN MECHANISTIC AND STATISTICAL REASONING.

CHAPTER I.

Science And The Particular.

I.

It is a paradoxical truism that the moment the attempt is made to bring our practical common sense experiences under the searchlight of scientific methodology, they dissolve themselves into dead and artificial abstractions. The paper which I touch and see is for the physicist nothing but a conglomeration of electrical charges, interacting with the electrical charges which are called, in less sophisticated terminology, my psycho-physical organism. For the chemist, whose terminology is one step closer to practical common sense experience, this paper which I touch and see is nothing but a cellulose compound, composed of certain organic elements. When science intrudes, the homely and familiar realm of naive common sense experiences becomes a strange and unfamiliar artifice. The reason for this artificial abstraction is that scientific methodology can concern itself only with a subject-matter which is but a tiny cross-section of our experience. And, it seems that the smaller this cross-section is, the more productive and fruitful a scientific methodology becomes, whereas the more comprehensive the subject-matter becomes the less it yields to any scientific methodology. Yet it is just the increasing interest and the more comprehensive problem of life in its biological, psychological and social aspects, which is today forcing philosophers and scientists to ask themselves the question whether scientific method is solely restricted to the field of physical phenomena or whether there is a scientific method applicable to the entire range of human experience, -- with a present tendency to advance functional explanation as a more adequate method.

In reducing the sensuous or qualitative to its lowest term--that of figure and motion, Galilean-Newtonian physics has given us the commonly accepted criterion as to what is and what is not a legitimate subject-matter for science. The only legitimate subject-matter for science from the traditional mechanistic point of view is that which yields itself to purely quantitative manipulation and where the particular datum under investigation can be wholly subsumed under a general process of law. But to talk of a legitimate subject-matter for a scientific investigation is to raise several questions. Have we any ground for bisecting our world of experience into a realm which forms the legitimate subject-matter of scientific investigation and into a realm which lies entirely outside the confines of any scientific methodology? Or may we not rather hope to bring under the control of scientific methodology the whole of our experience on the ground that this distinction between a legitimate and illegitimate subject-matter for science is based on a false and erroneous notion of what a true scientific methodology is? Do the categories by which modern physical science has manipulated its selected subject-matter proceed from the nature of the human understanding, or are they only arbitrary and artificial? In short, are we working or trying to work with a system which falsely dichotomizes our world of experience or is experience intrinsically of such a nature that it provides a subject-matter which lends itself to scientific investigation and another subject-matter which does not?

The answer to these questions has divided contemporary philosophers and scientists into two groups:

Those who are humbly satisfied in giving unto Caesar that which is Caesar's and unto God that which is God's; and the other group which deprives God of that which is God's in order to give it unto Caesar. Assuming that natural science must work within a restricted field, the first group is content with the consequent dichotomy of the world into a field of action and a field of contemplation and value; whereas for the latter group the realm of value and contemplation, being naturally continuous with the realm of action, ultimately must lend itself to scientific inspection or else scientific hope must be abandoned as futile. And hence, for this latter group we must devise new scientific categories and methods which will be applicable also to that larger portion of our experience, which mechanistic methodology has not been able to touch.

It is because mechanism can give an account of only a very small fraction of our experience that modern functionalistic philosophy and psychology have been at variance with traditional scientific methodology. All attempts to reduce life and mind to mechanical processes have failed. This inherent limitation of mechanism looms so big for those of our modern thinkers who place the emphasis on function or processes rather than on substance or structure, that they are almost ready to cast it overboard. Scientific methods cannot be restricted according to these thinkers to that limited and narrow subject-matter which yields itself to mechanical explanation, but must take into account the whole of our experience and not mere fragmentary aspects of them.

The whole issue seems to be reducible to this question: Can science wholly dispense with concepts of substantial elements and proceed to work solely with functional relations? If science cannot dispense with concepts of substance, then the particular nature of subject-matter (i.e., the degree of its relative complexity) becomes of importance. On the other hand, if science can dispense with concepts of substance and wholly focus its attention upon functional behavior, then the particular nature of the complexity of subject-matter becomes negligible.* Those who emphasize func-

* This question discussed in detail in Second Chapter.

tions and processes invariably choose the second alternative. They are in revolt against the "bifurcation" of nature into a realm which belongs to science and a realm which lends itself at best only to methodological description. The fact that the scientist, in crossing the borderline from the physical to the vital and mental world, runs up against an individual datum which cannot be linked into the causal chain of mechanical events, is one of the conditions in science which is ground for the dissatisfaction of the functionalists. Mechanism is unable to bridge the gap between mechanical process and vitalistic-mentalistic processes. Although organic chemistry has gone a far way in late years to synthesize so-called organic compounds, it has not been able to date to synthesize any substance which displays the vital processes of self-maintenance, growth, and reproduction. In crossing the line from a world determined wholly by mechanical laws into a world of vital and mental processes, the summation method based on mechanical schema or model seems to break down, or probably better, as some disconcerted critics would put it, has broken down. Consequently the question is raised--are we not after all laboring under a false notion of what scientific methodology ought to be? Since mechanistic methodology is able to satisfy human interests and curiosity in only a very limited and restricted field, it has no right, according to modern critics, to claim for itself the overlordship of knowledge. Thus the limitation of subject-matter of traditional science has led contemporary thinkers to question the validity of its method.

Another criticism is that the notion of restricting scientific methodology to a limited scope of subject-matter harks back to the old assumption of an ultimate substance of some nature. This concept of ultimate substance is too abstract, too far removed from the homely and familiar realm of common sense experience, with which the functionalist hopes to deal by a new scientific method.

In addition to these protests against a limitation of subject-matter, against an assumption of an underlying unchanging substance, the functionalist raises an objection to the traditional concept of law. He claims that the rationalsitic assumption that the laws of the universe are somehow or other discoverable through the method of a priori deduction is nothing but a hangover of seventeenth and eighteenth century rationalism, which modern thought has outgrown. He maintains that this is not a rationally ordered universe, all so-called scientific laws being wholly founded upon probabilities, and hence all so-called scientific laws are nothing but the laws of averages obtained by calculating the mean averages of similarities and variations existing between factual material under observation and experimentation.

This explicit and implicit dualism of a mechanized-quantified physical world and a world of qualities and values has led contemporary philosophers and scientists to discard the method founded largely on the old notion of an ultimate underlying material substance. The recent substitution of a method founded upon the notion of statistical correlation has given rise to several misconceptions of scientific methodology.

It is with some of these misconceptions of the range and scope of science that this paper proposes to deal. The purpose of this essay is to examine the claim that through statistical procedure science is able to extend the scope of a subject-matter in those fields which mechanistic methodology could not touch. In short, the

the problem centers around the question of scientific laws and their relation to the particular and individual. In this chapter, our attention shall be occupied with a brief review or contrast between Aristotelian class method, the Newtonian-mechanistic method, and the modern statistical or operational method. In the second chapter, we intend to deal with the general presupposition upon which these three methods rest, especially the mechanistic and statistical. This will involve an examination of the traditional concept of causality and a critical examination of the modern concept of law.

II.

In contrasting the Aristotelian method of approach with that of the Galilean-Newtonian method, several things must be taken into notice. 1. Under the old Aristotelian descriptive system, the individual or particular fell into certain classes. The classification was made either on the basis of formal logic or in accordance with certain peculiar similarities of structure. Both methods rested on a teleological and qualitative basis. Thus working wholly with logical categories in a teleological system, the location of membership of an object in a given class was of critical importance under the old Aristotelian descriptive system. A particular horse must share all the attributes and properties of the class equinity. It is equinity which makes the horse, even though no one has ever perceived equinity. Thus it is that the concrete-particular datum either falls into a class which determines its particular attributes or properties wholly in terms of their class; or, if it happens to be structurally dissimilar to that class, it is simply ignored or classified as a product of inexplicable chance.

Let us contrast with this the categories of modern quantitative physics, where classification according to formal and teleological categories has been replaced by continuous gradations. Substantial and qualitative concepts have been replaced by dynamic and quantitative concepts. For modern physics, the particular datum must be an individual empirical manifestation of a general mechanical process, under which it is subsumed.

It has often been said that the application of mathematical tools and the tendency towards minuteness and exactness is the earmark of modern science as contrasted with the ancient descriptive science. But as we have shown, the contrast between the old Aristotelian class method and the post-Galilean physics lies rather in the fact that the qualitative and teleological categories used by the scientists under the Aristotelian descriptive system inevitably led to class concepts; while the purely quantitative categories, used in the modern mechanistic system, lead to the concepts of a homogeneous process, wherein individual events are linked together by mechanical laws which are calculable through mathematical manipulation.

In passing, we may note another interesting comparison between these two systems. Modern mechanistic methodology has often been contrasted with the old descriptive class system by labeling the former empirical and the latter a priori. But these are certainly misnomers, if the terms 'empirical' and 'a priori' are taken on their popular face value. Ironical and paradoxical as it may seem, the old Aristotelian class system came, in a certain respect, closer to what Bacon calls the empirical method, than the modern mechanistic system. Despite the fact that the subject-matter under observation in the old Aristotelian descriptive system was wholly observed through the lenses of class-concepts, the Aristotelian method was in one sense more empirical than the modern Newtonian scientific method. True, the individual or particular found its only reality in the essential nature of the genus or species in which it happened to fall; nevertheless, these class-concepts, when founded on similarity of structure, always showed an immediate reference to the historical given reality and to the actual course of events. This is as K. Lewin points out, almost entirely lacking in modern physics. The law of falling bodies, under the Aristotelian descriptive system, was partly determined by the observed frequency and regularity with which bodies fall downward. But according to the Newtonian scientific methodology, falling bodies act in accordance with certain mathematical formulas which are determined by the general schema or model of homogeneous unity of the physical world.

Now, if we mean by an empirical method simply the gathering and pigeonholing of factual material on the basis of certain similarities of structure or behavior, then the old descriptive method is probably less a priori than modern scientific methodology. On the other hand, if we mean by empirical scientific method, the organization of subject-matter in harmony with an intelligible principle or schema by which we actually can manipulate the factual material under observation and experimentation, then modern mechanistic methodology is certainly less a priori than the old descriptive class system. In the old descriptive science, scientific method consists of simple enumeration and quasi-statistical classification of the bulky factual material as given to immediate qualitative and valuative experience, into heterogeneous systems or classes; while in modern science, scientific methodology is not complete until its factual material is organized into an all-embracing system of law under which it becomes intelligible and manipulative.

This brings us to the conception of law or lawfulness, and to a second very important difference between the Aristotelian descriptive class method and modern mechanistic methodology. In the modern mechanistic system there can be no distinction between lawfulness and chance, so long as we keep within the narrow sphere within which modern science claims to supply its mechanical categories. Its deductive systematic structure determines a priori what shall be admitted within the system. Of what falls outside it has nothing to say. Hence, there is no such thing as chance, indeterminism, or the absence of any assignable and intelligible cause. In his restricted field, the physicist, as well as the chemist, finds no room for fortituous events. Chance, accident, indeterminism are simply synonymous with unintelligibility. A datum remains unintelligible, contingent, as long as it cannot be linked into the chain of events demanded by the methodological scientist's schema. Whereas the Aristotelian scientist, working wholly with logical categories, arrives at a concept of law or lawfulness which is throughout of a sort of quasi-statistical character. The criteria of lawfulness were found in the regularity and frequency with which the particular or individual happens to fit a certain class. The lawful was simply considered as equivalent to that which possessed the highest degree of generality. Hence, the regularity and frequency are the perfect antitheses of the infrequent, the individual, or particular event.

III.

It is against both these conceptions of law that the functionalists, as exponents of the <u>statistical</u> method, protest. Both the post-Galilean physics and the old Aristotelian class system are grounded upon a rationalistic conception of law, hence they fall back upon the old traditional notion of an underlying causal substance of some sort. Now the functionalist contends, so long as scientific methodology is shackled by the old notion of resting the concept of law on a rationalistic metaphysical footing, the particular or individual is really of secondary importance. Law, so they contend, is nothing but an empirical generalization of observed functions or behavior of particular objects or events. Their own position is that from the point of view of reason this is a lawless universe, all so-called scientific laws being wholly founded on the calculation of probabilities, and hence all laws are nothing more than recorded averages obtained by calculating the mean of similarity and variations existing between factual material under observation and experimentation.

Let us now briefly examine the proposed method of the functionalist as an exponent of the statistical method. Two points must be taken into notice: 1. The relative status of a causal explanatory theory and its relation to the particular subject-matter. 2. The relation of the particular or individual to laws derived through statistical generalization.

The fact that the scientist will never be able to dispense with a causal theory, which will serve him as a guide in his research, is a common assumption which no one will deny. The theories and principles, with which the scientist works, must serve him not only to organize the factual material already at his disposal, but also, to serve him as cues to further discoveries. Science, as science, must have certain hypothetical principles, which bring law and order into the mass of facts under observation. This does not mean, however, that science proceeds by mere predication, nor does it mean that observable data which have defied all efforts of bringing them under an intelligible and workable principle are necessarily outside of the general sphere of science. On the contrary, it is just these recalcitrant data which spur the scientist to the re-examination of his theory and hypothesis. It is one thing to speculate what the ultimate nature of reality may be; it is quite another thing to recheck and refine scientific schemas or principles in the light of observable facts. Principles and schemas in themselves do not lead to discoveries of new phenomena. The only part they play and can play is to visualize or account for a novel fact, and to serve as hints in the possible discovery of new facts. As a classical illustration of a scientific schema, serving accidentally as a cue leading to new discoveries, we may recall the discovery of Neptune in 1846. Both Leverrier and Adams, working independently, deduced from a series of recondite methematical calculations, that the long observed perturbations of Uranus must be due to a body beyond the planet Uranus, if the general schema of Newtonian gravitation is workable.* To make speculative leaps and to test and verify these leaps by observation and experimentation is the very business of science. Whether the new Einsteinian physics will replace the old Newtonian idea is not a matter of speculation as to the ulti-

* "It was just a 'lucky accident' that the newest planet Pluto was located where the late Percival Lowell figured that it would be (Time, March 24, 1930), declared A.A.S.'s retiring president, Professor Ernest William Brown of Yale. Pluto, he thinks, is not heavy enough to cause the Uranian disturbances upon which Lowell based his predictions." Time, January 11, 1932, page 32.

mate nature of things, but a matter of checking and re-checking its validity by observable and experimental evidence. In short, when the scientist speculates on his principles or schemas, he must have his face turned to the empirically given and not towards the clouds which veil the ultimate nature of reality. Speculating on the logical or rational implication inherent in the mechanistic concept is outside of the field of science. Such questions as whether reality is ultimately continuous or atomic, are a puzzle for the metaphysician to play with. In short, the scientist must always bear in mind that his principles and schemas are nothing but charts which guide his observations. The tendency of making a metaphysical principle more ultimate than the subject-matter forms the net in which so many of our scientists and philosophers become enmeshed.

With the refinement of methematical and mechanical instruments, the scientist has been able to shave off one splinter after another from the old primordeal, substantial form, until at last he has diminished it to mere relational processes. The atomic mass has been reduced to mere electrical vibrations or charges, and these again have been so rarified and desubstantialized that they defy the grasp of even the wildest flight of the imagination. This digging and cutting beneath the surface of scientific methodology has again led to a renewed and shocking discovery that science has neither a bottom nor a top.

It is just this groping after the unknowable on the part of our scientists and philosophers today, coupled with the desire to give scientific methodology a broader scope, which has led to the confusion of science with metaphysics. As a consequence of this, the inherent limitations of the mechanistic concept on which traditional scientific methodology rests, loom so big in the eyes of these thinkers that they entirely lose cognizance of the fact that scientific methodology is by its very nature confined to only a small and comparatively insignificant fragment of our experience.

The test for a workable scientific theory despite its limitation and partiality, is how far it serves the scientist in bringing order and law into the circumscribed subject-matter under his observation. The criterion of a good scientific principle or hypothesis has always been the effectiveness with which it handles its subject-matter. And it seems to be most effective when its working principle and subject-matter are least hampered by human equations. The greater the emphasis on the human equation, the less effective a scientific methodology seems to become.

This brings us to the second and chief point to be considered in connection with the statistical method: The relation of the particular or individual to laws derived through statistical generalization.

The functionalists' contention that all our so-called factual knowledge is ultimately statistical in origin is certainly true. To deny the fact that the greatest bulk, if not the whole, of factual material in physical science is the product of systematic observation and statistical tabulation, would be the height of obscurantism.

Now granting the fact that the so-called laws of physical science are nothing but empirical generalizations derived in the main through a sort of statistical average does it follow that the statistical method ever will obliterate the barrier which blocks the path for mechanistic methodology in throwing light upon the more complex particular or individual on the vital, mental and social plane of life? In other words, since the statistical method can only deal with a complex particular or individual on the basis of an isolated functional characteristic possessed by a group or an aggregate of individuals, it follows that the more complex the particular or individual becomes, the more functional variability will it display, which means that the greater are the probabilities of its deviations from the average. A method which proceeds by simple statistical tabulation of data under observation can at best only hope to reach a high correlation of particulars on the basis of averages. No matter how high the correlation may be, it will never represent the actual individual or the particular datum. The high correlation, for instance, between arthritis and teeth seems to establish a definite connection between the two. But the curiosity of medical research will never receive an answer on the basis of simple statistical tabulation, as to the nature of connection between tooth trouble and degenerative diseases, and as long as the nature of the connection is not known, the diagnoses of a particular case of arthritis is after all nothing but an average reading.

The germ theory, which is itself a product of observations and statistical tabulations, has given medical science a powerful instrument by which to detect the cause of a disease and its mode of transmission and, hence, to check its spread by specific preventive and curative agents. But, if we seek for a specific intelligible connection between a specific germ and a certain specific disease, our search is hopeless. Neither bacteriology nor histology can give us any light except a description which is based on statistical tabulations. To be sure, the principles of modern biological classification are diametrically opposite from the old principle on which the Aristotelian classification has been based. Modern biological classification is based on genetic principles rather than on external structure or form; nevertheless, the outcome in the final analysis is the same: heterogeneous classification without end.

Ironical as it may seem, the modern method of statistical tabulation when applied to a subject-matter of increasing complexity, inevitably shares the same weakness and defects of the old Aristotelian descriptive system. How statistical manipulations lead to nothing but the old Aristotelian class concepts is clearly seen when we enter the field of the so-called social and psychological sciences. As an example from child psychology: Three-year old children are very often found to be negativistic; ergo, negativism is inherent in the nature of three-year old children. The same applies to the so-called intelligence test, ability test, etc. The whole statistical procedure through which experimental psychology and the social sciences arrive at their concept of law or lawfulness is in the final analysis grounded upon the "dictum de omni et nullo." In order to exhibit the common features of a given group of facts the average is calculated. This class or average acquires a representative value, and is then used to characterize such things or ideas as mental age, negativism and a large host of so-called social and psychological laws.

The denial on our part that the particular or individual ever can come within the reach of statistical procedure may invite some counter attack on the part of its exponent. Let us look at some of the arguments of the proponents of the statistical method. In the first place, it may be argued that statistical tabulations are depended upon just as much to ascertain the deviations from the average as to ascertain the actual average reading. Hence, by a method of isolating all irrelevant deviations from the average, statistics lead to what is called probability judgments concerning the individual or particular. Granting this, we still ask the statistician what sort of an individual or particular this is. It certainly is not the concrete unified particular or individual of common sense experience. For statistics can deal only with functional variations on the basis of abstractions. Each deviation from an ascertained set of averages leads to a new set of averages. In again isolating the deviation from this new set of averages, it leads to another set of averages, and so on ad infinitum. As a result every refinement of statistical tabulation leads only to an increasing plurality of functional variations and each new set of these simply forms an additional set of class averages. Now, suppose for the sake of argument, that the statistician can get a perfect correlation, would not that fact give him ground for making a definite statement about the particular or individual? The question has already been answered by implication. The statistician is able to make a definite statement about the individual, only in so far as this particular individual displays a certain common functional characteristic abstracted from an aggregate group of heterogeneous individuals. Since the statistician can deal only with functional characteristics or relations, the concrete particular individual as a unified organic being has ceased to exist. The individual or particular is in the final analysis nothing but a bundle of discrete functional characteristics or relations which are accumulated through the mean or average reading.

To reach the particular datum, you must work with a homogeneous system, where the particular observed datum is an expression of a homogeneous process. If you haven't such a system or principle to work with, the individual either falls into a class or is left dangling as an unintelligible and inexplicable product of chance. It is interesting to note that statistical tabulation reaches its highest mark of efficiency just in that narrow and limited sphere of subject-matter where mechanistic methodology has been most effective. The chances of approximating the particular or individual seem to be greatest just in that field of subject-matter, where mechanistic methodology is most effective. In other words, the chances of discovering a constant correlation between events through statistical technique are the greatest in the sphere of the so-called purely quantitative sciences.

CHAPTER II.

Law And The Particular.

I.

We said, in the first chapter, that the distinguishing feature of post-Galilean physics is the concept of lawfulness or law. Conformity to law is its slogan. It was pointed out there also that the particular is outside of the field of scientific explanation as long as it cannot be subsumed under a general process of law. So far, the term lawfulness has vaguely been identified with mechanical causation. Founded upon the traditional notion that the complex whole is beyond the reach of scientific explanation so long as it cannot be analyzed into its ultimate, simple components, mechanism still clings to the old idea of substantial property rather than purely functional relations. Its laws being thus founded upon the substantive causality, it still is haunted, so its critics argue, by a classical, absolutistic metaphysical tradition. Now, since the term explanation, as science uses it, is in many respects closely related to the concepts of causality, we shall briefly take up this concept in its historical setting; but our attention will be chiefly focused upon the concept of law, treating this concept in three aspects: 1. Its status or meaning. 2. In its origin. 3. Its mode of operation or its relation to the particular or individual.

The prime merit of Newtonian physics, as pointed out in the first chapter, lies in the fact that the anthropomorphic or the human equation is eliminated and the sensuous or the qualitative reduced to its lowest terms.* By means of categories which have been stripped of all anthropomorphic implications, explanations in terms of final causes have been ruled out entirely. But by retaining what may be called a sort of skeleton of the sensuous in the form of an immutable substratum, mechanics still clings to the old notion that science and scientific laws must ultimately be grounded on substantive causality.

Now, since it is the business of science to take its point of departure from natural phenomena them-

* The meaning of force, which Newton construed to be an imponderable what-not residing in matter and as acting from within bodies through space to draw or pull them together, may be said to be an indispensable remnant of the anthropomorphic or the qualitative, which ever you prefer to call it.

selves, and to describe what really happens, the question may legitimately be asked, why should scientific method be dominated by the notion of an ultimate immutable substance? It is of greater importance to ascertain the determination of phenomena in terms of their dependence on an orderly relation to other phenomena and to rest our causality concept on the discovery of these orderly relations, than to shackle scientific methods with the old assumption of an existential material substance. If change is the brute and ultimate fact of experience, why not make it the terminus a quo and terminus ad quem of all scientific investigation? Being forced to assume ultimate immutable components, mechanism will always be hampered more or less by the traditional notion of a causal substance. In the Newtonian system, which rests upon the concept of inert mass particles, the concept of gravitation -- according to which the motion of every particle of the universe is continually and instantly responsive to the position and mass of every other particle in the universe -- is simply anomalous from the point of view of substantive causality. Furthermore, since the categories of the Newtonian physics include the principle of force which is in itself nothing but the last remnant of the anthropomorphic or the qualitative, why not take the last step and permit the seed which the post-Galilean revolution has sown to sprout in all its glory by turning science and philosophy into nothing but quantitative and mathematical formulation of law? When this is done, physics no more can arrogate to itself the prerogative of being the elect of the gods as a final arbiter of scientific method. Since science will consist in nothing but a methodological description of observed frequency and regularity of behavior, there will be no dichotomy into a subject-matter that yields itself to scientific investigation and a subject-matter which does not. The Newtonian concept of inert matter, on which the laws of mechanics are founded, is nothing but a convenient conditional "reference-frame" serving to bring the mechanical categories into an intelligible unity. Hence, the concepts or categories of physics have no intrinsic priority over those of any other field of methodological investigation. At best they only serve the scientist as temporary tools by which he manipulates his bulky, factual material until he is able to fit his subject-matter into the moulds of the general law which seem to, or at least are assumed to govern natural phenomena.

What is the issue here? We have talked about anti-absolutism as opposed to mechanism. The term mechanism has attained in current philosophical and acientific literature a variety of meanings. Thus mechanism may refer to the simple and basic laws of mechanics or it may refer to an underlying principle of identity, in terms of which change and motion are explained. As for instance, the immutable atom which is, so to say, the ultimate changeless component of the cosmic machine. Ever since the time of the Renaissance, science has been primarily concerned in reducing reality to mathematical terms. But since explanation in terms of purely quantitative or mathematical relations were thought to be beyond the grasp of the imagination, post-Galilean physics has also been interested in the search for an ultimate determining principle which would somehow yield itself to purely mathematical calculations. By stripping reality of all qualitative and anthropomorphic attributes and reducing it to bare figure and motion, science thought it at least had discovered a method which would give an answer to both the what and the how of reality.

There seems to be in current scientific and philosophical literature some confusion as to the adverbial usage of the terms "the why", "the what", and "the how." Before proceeding with our discussion of the causal concept in its traditional setting and the concept of law in its three-fold aspect, let us pause a moment and examine these three troublesome and ambiguous terms. The whole issue of this paper largely hinges upon a definite meaning of these three terms. What do these three terms really denote?

The usage of the term "why" is probably the most troublesome, for some of our most eminent writers and critics use it in the sense of either rational or empirical demonstrative knowledge. It is said that science not only is concerned to know how things change, but also why things change.* Now a little reflection will show immediately its

* Meyerson's Identity and Reality. Page 335.

rather obvious finalistic and teleological denotation. The question why certain chemicals combine, requires a teleological and finalistic explanation. To answer this question would mean nothing less than knowledge of the ultimate grounds of existence and reality. Hence, the term "why" has no meaning in the realm of scientific discourse, for science can concern itself only with "the how" and "the what." Now what do we mean by "the how" and "the what"?

If you ask what is X, you may receive two quite distinct answers. I may describe or explain X in terms of its substantial properties, or I may describe it in terms of its functional relations. Let us first note the "what" and the "how" of a thing when described in terms of substantial property.

Describing a thing in terms of its substantial properties usually involves reductive analysis. Suppose you ask me about the "whatness" of this paper or what this paper is. I may answer that it is a cellulose compound. But in defining this paper as a cellulose compound, I have only whetted your intellectual appetite to know what a cellulose compound is. The desire for explanation will never be satisfied until we arbitrarily accept an ultimate substratum, in reference to which the "whatness" of phenomena is explained. Thus whatever may be the nature of this substratum, whether it be material, electrical, neutral, etc. would largely depend upon the problem in question. One of the major aims of science is to analyze composite things into substantial elements. According to Newtonian physics a thing is said to be explained when analysis has been pushed as far as it is intelligible. Reducing reality to matter and motion, post-Galilean physics has worked with a material substratum in terms of which it has been able to arrive within a very narrow limit, of course, at a formal explanation of how phenomena operate. Two things must be noted here. To say what the thing is, necessitates an explanation in terms of its material or substantial properties. Aristotle called this the material cause. The particular nature or structure of this material substratum will determine our explanation of phenomena so that "how" a thing operates is determined by what we conceive to be the ultimate nature of this thing. The "how" may be said to be concerned with the operation or the laws which follow from the intrinsic nature of the conceived "whatness" of our substratum. Thus, whether we conceive ultimate reality to be material, electrical or what-not, will largely determine our concept of mechanical and physical laws. The point to be kept in mind is this: That the "whatness" of a thing refers to its material nature or composition. The "howness" has to do with the function or operation of this material. Thus the term mechanism as we here use it may be said to have two aspects. It may refer to its structural aspect or to a functional aspect. The "whatness" is concerned with the description of the ultimate structure: the "howness" with the function or operation of this structure. Now a mechanism of whatever variety it may be is meaningless without the assumption that its operation is somehow or other dependent upon the nature of its component elements. Furthermore, and this is a point of the greatest importance, the simpler or the more homogeneous the component of a mechanism is the more is it within the reach of the imagination. In other words, the simpler its form or structure the more intelligible is it in its actual operation.

Let us now turn to the question as to what is meant when "the what" and "the how" are both defined in terms of functional relations. In describing the "what" of a thing in terms of its functional relations, there is no need of any reductive analysis. The "what-ness" of this paper simply consists in the immediate role it is playing or may play in experience. Right now it is a thing to write on. It is also instrumental in performing the function of conveying my ideas to you. The question is not what is X in and for itself, but what is X in its functional relation to Y. Hence, here the "what" of a thing is always some form of meaning with which the immediately perceived data are invested and these are only definable in terms of the functional relation with each other. The chemist from this point of view is not so much interested in the ultimate nature or sensuous character of an element as he is in ascertaining the functional behavior which certain elements display when brought into specially conditioned relations. Knowing the things in its functional relation is to know the "how"; knowing it as meaning is to know the "what." Given then data unanalyzed as to inherent nature, but serving as the new material or "whatness" of any situation, the explicit formulation of the relations in which these data enter constitute the "howness."

To compare these views more concisely: The "whatness" of substantial property is the ultimate element to which the raw material of the situation is reduced by analysis. The "whatness" in terms of functional explanation refers directly to the whole unanalyzed data of the situation. The "howness" of substantial property is the expression of the inherent natural capacities of ultimate elements in the Aristotelian sense of the true function of a creature being the true expression of its own natural activity, i.e. how it naturally acts; the "howness" in terms of functional explanation is simply the explicit formulation of relations subsisting between unanalyzed data as they perform in conditioned situations.*

Note then, as long as scientific categories are founded upon substantial properties, explanations do not

* Contrast molecular theory of gases and law of gravitation. Sometimes the "how" is deduced from the "what"; sometimes not, sometimes you have a "what" which resembles a substantial property (mass or force) and a "how" which is reached by inductive generalization.

merely consist in a de facto knowledge of the law under which phenomena manifest themselves, but in the knowledge or understanding of the underlying substantial components in terms of which it is explained. In other words, the "howness" of the thing is conceived in terms of the nature and constitution of the "whatness." Dealing solely with functional relations on the other hand, the nature and constitution of the substantial "whatness", namely the thing, is of secondary if not wholly negligible importance. It need only be recognized, not analyzed. Scientific explanations are here founded on mere description of functional relations which an object or thing displays when brought into certain conditioned situations with other objects or things. Since by this hypothesis the "whatness" of a thing does not consist in its intrinsic, substantial constitution, but in its function or behavior, science has no need to base its explanation on its underlying substantial components. The "whatness" of a thing consists here in a de facto relation of certain functional characteristics or unanalyzed meanings which a thing invariably displays when brought into relation with other things. Thus the "whatness" of oxygen or any other element does not consist in its inner or intrinsic constitution but in the oxygen qua datum in an almost infinite number of combinations. Knowing the functional relationships in which a datum significantly figures, is to know the "howness" of its laws. Knowing the laws under which phenomena thus operate, science is said to be able to explain phenomena.

Now what do we mean by explanation? The term is ambiguously used in scientific literature and this ambiguity is closely bound up with the equivocal uses of the terms, the "what" and the "how." In saying that the law of chemical affinity explains, or that such physical laws as heat or freezing explain phenomena, we surely do not mean explanation here in the sense of a purely abstract rational understanding. That is, law here simply denotes a brute de facto connection existing between certain data. This connection is beyond the grasp of human imagination. We have already intimated that the greater portion of physical laws are founded upon non-rational or non-imaginable bases. And, as we shall see, all laws in their origin and status are of an irrational nature. But granting that laws in their genesis and status do rest upon nothing else but the observed frequency and regularity with which phenomena behave, does it follow that law in its actual function and operation is equally non-rational? In short, does scientific explanation consist in the mere description of functional behavior of phenomena; or does intellect in the sense of understanding and not in the sense of mere "acquaintance-with" still have a role to play on the scientific stage?

The crux of the whole matter seems to lie in the phrase"rational explanation." If substantial properties are of any concern to science then explanations are ultimately grounded upon some form of substantive causality. In other words, science is not merely interested in ascertaining de facto laws governing phenomena, but also in the venture of trying to give a rational explanation of those laws. In this case, scientific explanations do contain a rational causal element in the old traditional sense. Thus the issue seems to resolve itself into these alternatives. Either the logic of science does in part at least consist in the old classical method of rational reductive analysis, i.e., reducing phenomena to its ultimate substantial structure, or science is solely founded and grounded on a logic of statistics. Either science must willy-nilly somehow satisfy our causal instinct by offering some form of rational explanation of the nature and origin of phenomena, or the sole business of science consists in the observation and tabulation of data, the formulated results being called law. In the former case, scientific explanations do rest in part at least on substantial concepts, while in the latter case, science is solely and wholly concerned in the functional behavior or the process of phenomena. In the first alternative, the criteria of science rests upon explanatory laws which are partly founded upon the substantial "whatness" of phenomena, while in the second alternative, scientific explanations are founded wholly upon functional "howness" or on the methodological description of observed regularity of sequences of events. Before we are able to come to any agreement on this point, it is necessary to consider briefly the concepts of causality and of functional law in their traditional historical setting. This will involve a brief examination of the metaphysical and logical presuppositions upon which rest the three methods already discussed in the foregoing chapter.

II.

In taking an historical retrospect, we may distinguish three general periods of scientific thinking. First, the concepts of causality and of law were both closely identified with some rational, metaphysical system. Second, the concept of law was sharply differentiated from the causal concept. The concept of law took on a new meaning, while the concept of causality has been more or less confounded with the old rationalistic and absolutistic tradition. Third, the attempt in contemporary thought to reunite the concepts of cause and of law to a new synthesis on the basis of a relativistic metaphysic. Our attention here will be focused chiefly upon the first two, reserving for a later work a more critical examination of the third. To separate each period by any sharp line of historical demarcation would be folly. Just as Greek or medieval culture is not a matter of mere chronological order, but rather an expression of a dominant attitude toward the problems of life, so an arbitrary division of scientific method into chronological periods must not be taken too literally. All that is meant is that a certain attitude toward the nature of scientific problems prevailed. A particular type of thought or belief may be said to enjoy a certain priority in a particular historical period; but it never can be said that it entirely monopolized that period to the exclusion of every other type of thought or method of approach. Bearing this in mind, we may say that almost up to the time of French positivism in the 19th century, the attempt to explain phenomena on the basis of some causal principle, rather than trying to describe phenomena on the basis of functional law, has occupied a large part of the energies of scientists and philosophers of science. Since it was the prime business of science to explain the initiation of changing phenomena, its major occupation consisted in the search for an underlying perdurable principle in terms of which phenomena must be explained. Proceeding on the assumption that changing phenomena must somehow be explicable in terms of rational laws founded upon a causal metaphysical system, scientific inquiries envisaged the world of phenomena as a rational system which somehow or other must yield to a method of logical reductive analysis. Apodictic certainty was the end and aim of science. Causal connections were synonomous with rational connections, which meant, in other words, the concept of law and the concept of causality were confusingly combined with the notion that existence must ultimately be rooted in a rational ground. The wedge which gradually separated the causal concept from the old notion of a rational ground was made by Hume in his revolt against metaphysical speculation. Causal connections turn out to be beyond the sphere of human knowledge. Since no rational connections or binding causal principles are anywhere to be found in nature, scientific and philosophical investigations must be rigidly confined, as Comte would say, to the analysis of phenomena with a view to the discovery of the actual law, i.e., their constant relations of sequence or similarity. But along with the search for causal explanations, the phenomenalistic movement continually gained ground. Always influential in post-Galilean science, and particularly in Newton, it found full expression in the philosophies of Hume and Mill.

The basic characteristic of the positivistic movement, ushered in by Hume and Mill, lies in the fact that all metaphysical speculations are taboo. Scientific as well as philosophical investigations must begin and end with concrete empirical facts. This positivistic doctrine, coupled with other influences which we shall bring out later, completely revolutionized scientific thinking. Where formerly science was chiefly concerned in trying to explain phenomena in terms of rational, immutable principles, the sole business of science next consisted in giving a methodological or descriptive summary of observed regularities in the sequences of events.

This brings us to several obvious though important observations with reference to the concepts of law and of causality, which we must briefly take into account here. One of the paradoxical consequences of the positivistic movement is that the concept of causality has been left in midair. To identify causality with mere sequences and co-existence of events is certainly doing just as much if not more violence to the term, as it is to identify it with sufficient reason or rational ground. From a purely sensationalistic point of view, Hume and his followers are undoubtedly right in holding that the mere impression of an antecedent state and the concomitant impression of a subsequent state reveal no real connection or necessary relations other than psychological habits. The trouble, however, with this doctrine is its one-sidedness. The rational life of man cannot live and prosper by mere empirical impressions alone. Merely to describe changing phenomena on the basis of observed regularities and frequency with which phenomena manifest themselves in succession of time is just as unsatisfactory to scientific thinking as the old metaphysical search for the immutable. It is true, as far as my empirical acquaintance with explosives is concerned, that the only connection between the spark and the powder is a mere habitual association of a certain antecedent state with certain invariable subsequent states. But no scientist, I am sure, will accept the statement, without any protest, that scientific method consists in nothing but an elaboration and refinement of this crude, empirical method. To be sure, the concept of law, as we shall see later, is founded upon the Humeian and positivistic principles of co-existence and sequences. But this surely does not mean, at least for the scientist, that the causal concept which is closely knitted with the concept of law has no other material to deal with than spatial or temporal proximity.

III.

We have so far spoken about the concept of causality and the concept of law without giving any clear-cut definition of them. In discussing the equivocal usages of the terms "what" and "how" it was said that the ambiguities in the use of these terms are due to an indiscriminate confusion between what we have called substantial properties and functional relations. When X is described or explained in terms of substantial properties its "whatness" consists in its inner constitutive nature. On the other hand, when X is described in terms of its functional relations, its essence consists in its immediate functional relation to other things. Now let us tentatively lay down two propositions to be established later: 1. That the causal concept in order to be intelligible must rest on some form of substantial property. 2. That the concept of law as a systematic description of the functional behavior of phenomena has no need to take into account substantial properties. Bearing this in mind, let us first briefly distinguish these two concepts, and secondly, take up the origin and status of the second concept.

To distinguish the concept of causality from the concept of functional law, let us say that the former is primarily concerned with explaining phenomena in terms of some homogeneous principle of identity; while the latter is merely interested in describing phenomena on the basis of external similarity of qualitative structure, or on the basis of correlated behavior. In speaking about describing phenomena on the basis of similarity of qualitative structure, we have in mind the old Aristotelian class-method. But since this particular question will come up later, let us define law here as a descriptive formula of the order or pattern under which certain properties or characteristics of phenomena manifest themselves.

The term lawfulness is probably one of the most treacherous terms in contemporary thought. Yet conformity to law is one of the major tenets on which modern science rests. That nature is uniform and orderly is a common assumption of science and common sense. The old schools of philosophy were chiefly concerned, as already stated, to account for this observed orderliness in nature on abstract rational grounds, while contemporary thought is concerned in describing the mode of behavior under which natural phenomena manifest this order in empirical experience. In other words, contemporary thought is disposed to turn its back upon all speculative attempts to explain phenomena in terms of underlying, causal principles or agents. It has focused its attention upon the observation and description of the conditions under which phenomena display peculiar modes of behavior. Thus the chemist is primarily interested in the invariably subsequent result which supervenes when his elements have been brought into a peculiar relation. In his experimentation the chemist or any other scientist is more interested in discovering new properties or functional relations and the formulation of law on the basis of these discoveries than in the speculation as to the ultimate nature of his elements.

In discussing the genesis of this concept of law it becomes a prerequisite to distinguish in the first place what may be called the ideal aspect of law from the objective or ontological aspect of law. If law is a descriptive formula, then it is an ideal construct and not an external, ontological reality. In saying this, however, we do not mean in any way to imply that law is subjective or mental in the old idealistic sense. We are not interested here in any epistemological problem. To call law an ideal construct simply means that law, whatever its existential status, receives its formulation from beings who are endowed with the power or faculty of generalization. Man, in his practical and work-a-day walk in life, implicitly assumes the uniformity and orderliness of nature. This common-place assumption is generated by our every-day, perceptual, practical experience. That a body invariably falls downward and not upward unless propelled by a counteracting force has been such an invariable observation to ordinary common sense experience, that the exception to this would be styled a miracle. But miracles and the common-place have reality only for an animal endowed with the power of looking before and after. An animal lacking this power may instinctively behave in such a manner that he adjusts himself to a periodic demand from his environment or inner constitution, but it would hardly be in accordance with fact to say that the animal is conscious of a uniform order of sequences. Neither the common-place nor the miraculous is distinguishable by a being who lacks the power of generalization.

From the total mass of undifferentiated experience, man has gradually learned to distinguish and select certain properties and attributes for the purpose of experimental inquiries. Out of this chaos of unreflective experiences, man has learned to generalize the selected data into rules or laws. Long before the law of the lever was formulated, he had constructed such artifices, as for instance the shovel or the ax, which served him in his practical life. Thus, in groping his way through a jungle of fortuitous perceptual experience, man gradually learned, more or less unconsciously at first, to observe and apply certain general principles. The method of thought which advances science and which results in the generalization of abstracted properties into rules or laws in no way differs in kind from that of the most hardheaded man of common sense, who in practical problems is not dominated by individual whims and caprice. The elimination of the anthropomorphic or the personal equation was what made possible a method wholly confined to purely quantitative measurements. So long as scientific method is hampered by an anthropocentric outlook, quantitative measurements and mathematical calculations become merely secondary and piece-meal.

It is this quantitative or mathematical interest which distinguishes the post-Galilean from the old faculty physics. In contrasting the Aristotelian descriptive method with the modern statistical method, we have noticed in the previous chapter that the former proceeds to classify the subject-matter on the basis of similarity in external qualitative structure or in accordance to logical categories; while the latter method consists in a methodological or purely quantitative descriptive summary of the modes or conditions, under which phenomena manifest themselves. The Aristotelian system or method may be said to rest on a purely qualitative or antrhopomorphic basis, while the modern statistical method proceeds on the basis of purely quantitative measurements and mathematical calculations. The arrangement of objects in a class which had been in vogue prior to the time of Descartes, and the formulation of a law expressing the relationship or functional behavior of objects on the basis of certain abstracted properties turn out to be two quite distinguishable results in scientific activity.

IV.

Two rather obvious historical facts must always be borne in mind in the proper understanding of the shift of emphasis from the absolutistic type of thought which dominated philosophy up to the time of Locke. The first was a shift of emphasis from a transcendent world of ideas to the concrete, work-a-day, practical experience. The effort and ingenuity which were formerly spent on giving man a unified and systematic picture of an ideal world were gradually shifted to the external, empirically verifiable aspect of life. The Aristotelian type of thought, with its emphasis upon inner, logical organic unity, gave way to the Newtonian conception of a world ultimately reducible to inert mass particles. All explanation in terms of theological and of teleological causes has been ruled out by post-Galilean physics. And the dictum sets forth that natural processes, natural phenomena must be explained solely in terms of themselves. Closely bound up with this shift of emphasis from the internal world of logical self-consistency to the external or practical world was the new role which mathematics and quantitative measurements played in physical investigations.

But if Newtonian physics discarded the anthropomorphic, it still retains a skeleton-like ghost of the sensuous in the form of figure or extension. In eliminating all final causes as explanatory categories of phenomena, it has, nevertheless, not dispensed with causal categories. Being a child of rationalism, it has founded its system on substantive causality. Logical analysis and mathematical calculation were only a means toward a rational, causal explanation. Nature was interpreted in terms of itself, to be sure, but this nature was stripped of all qualitative attributes and reduced to bare figure and motion. Dealing only with inert particles, science could freely construct mechanical models which served to illustrate causal explanatory principles. In eliminating the anthropomorphic from its system and reducing the sensuous to its lowest terms, those of figure and motion, mechanism has worked with categories which yielded to mathematical or quantitative measurements.

V.

The secondary position which contemporary positivistic thought has given the concept of causality in science, and the exaltation of mere descriptive laws as the aim and end of scientific and philosophical inquiry are traceable to two sources. In the first place, the concept of causality always has been identified with an underlying principle of permanence or self-identity. In the second place, the notion of the absolutistic principle of immutability and perdurability has been discarded by modern relativistic philosophy, with the logical result that the concept of causality in the sense implying fixity or permanence ceases to have any meaning. Before discussing this problem, let us briefly re-examine the traditional tenets on which the concept of causality has rested.

Explanation, in terms of causal categories, has in traditional philosophy usually been identified with what is called a priori determination. Aside from other meanings which the term a priori may have, it generally denotes in rationalistic and absolutistic philosophical thinking, a determinate ground from which reality is deducible. Up to the time of Locke, the power of the human mind to penetrate into the inner recesses of ultimate reality by logical or rational analysis was implicitly taken for granted, with the result that the concrete empirical world was left in the background. Logical self-consistency and thinking in harmony with abstract principles were the two canons which governed the absolutistic and rationalistic philosophy. Taking its point of departure from some assumed immutable rational ground, it strove to eliminate all factors which it was impotent to explain on these rational grounds. Since qualitative diversity and change are beyond the scope of rational deductive analysis, they are cast into a realm of non-being. The practical and mundane aspect of life could not be permitted to pollute the waters of clear logical and rational analysis. What good can come out of Nazareth! The empirical was even for such men as Kant and Hume nothing but an unavoidable obstacle which blocks the path of true knowledge. Despite the fact that the post-Galilean science embraced this changing sense world as the sole and only sphere in which it can live and strive, it, nevertheless, explains this world of sense in the light of the world of reason. Whatever defies explanation by mere mechanical impact or quantitative spatial arrangement is simply discarded into the limbo of mystery and illusion.

VI.

Sensory qualities have played a peculiar role in the history of metaphysical thought, but our interest is the peculiar part which sensory qualities have played in causal explanation. Both in the Aristotelian and the Democritean tradition, causal explanations are grounded upon what we have called above substantial properties. Consequently, the whatness, the whyness, and the howness of things are always interpreted or explained in terms of some ultimate or essence.

Perhaps the most important feature in the old Aristotelian faculty physics was the tacit presupposition that the sensuous must be explained in terms of qualitative differences. It was the late hypostatization of such sense qualities, as Aristotle's hot and cold, moist and dry, into absolute properties of things or independent material substances which served as a basis for explanatory theories of nature. Now, so long as the complex sensuous thing is made the determining factor, even though the sensuous is reduced to a bundle of abstract and simple qualities, quantitative measurements and mathematical calculations are largely left in the background. And this means, of course, as already pointed out in the first chapter, that classification is a logically implied goal of investigation.

In saying, however, that the Aristotelian descriptive method is founded upon static qualities, we have told only a partial truth. It was not so much the static properties according to which individual objects were classified or pigeon-holed, as the essence which each object possessed in common with other objects or a general class. Now what is implied in the old Aristotelian and medieval concept of essence? The appreciation of this concept of essence, in particular its implication, is very important to the real distinction between the class concept and the modern quantitative concept of law. Merely to say that the one is qualitative and the other quantitative is telling half the story, and the least important half at that. The primary distinction between the modern statistical method with its concept of quantitative laws and the old descriptive method with its class concept, lies in the fact that the latter contains a causal element which is totally absent in the former. It is this causal element which we must take into account.

Just as everything in the old absolutistic tradition must ultimately be reducible to a rational, metaphysical ground, so we may say that the Aristotelian logical concept of essence rests on a metaphysical basis. The concept of essences under the Aristotelian class system is meaningless, unless one associates it with the Stagirite's explanation of change and motion. In the hylozoic cosmology which generally prevailed throughout Greek and medieval thought, natural phenomena were thought to move and change of their own accord. The solution, however, of the problem of motion and change was not as simple as the above statement seems to imply. For Greek and medieval thinkers have always made a distinction between a propelling or activating agent and that which is propelled or is acted upon, namely, the static and the dynamic. If animism implies a vital or psychical motivating agent, then nature or natural phenomena cannot be conceived to be simple or undifferentiated, but must be thought of as being sundered into activity and passivity, to use the language of Aristotle. We are not here concerned with the long history of this implicitly and explicitly implied dualism between the mover and the moved in Greek and medieval thought, nor with the intricate nature of this problem. What we are interested in is the nature of the causal element which by its dominance in the Greek and medieval class concept has exerted such a persistent influence.

The fullest realization of the thing's own intrinsic nature or essence may be said to be the fundamental notion of Greek and medieval metaphysics. The statement: "Realizing its own nature or essence," logically implies that the essence or nature of a thing is something fixed and immutable, while the process of realization is something transitive. In the previous chapter, we have contrasted the principle of spontaneity with the principle of inertia. To say that a thing acts or behaves spontaneously means that it acts freely out of its own nature. But in saying that it acts of its own nature is simply to beg the question. We immediately ask: What do we mean by the "thing's own nature or essence?" Pushing this query further and further, we finally end by defining the "thing's own essence" in terms of fixity and immutability. Thus the evolutionary processes, i.e. transitive change and motion, are secondary from the point of view of causal explanation. The effect of change is potential in the cause. Whether this cause is conceived in terms of ends, (i.e. short of the external Final End of all), or, in terms of form or structure, the point to be noticed here is that the causal concept in the Aristotelian as well as in the Newtonian doctrine, is reduced to a single term: immutability or fixity.

Endless change, without any permanent goal or without any ultimate principle of identity or perdurability, is inconceivable to reason and the understanding. This inconceivability of endless changing without any fixity or identity may be said to be the specter which has haunted metaphysicians at all times. As an illustration of the old classical method of reasoning on the problem of causality, I shall give a quotation from Aristotle, although many others may be cited to the same effect. In the Metaphysics 994 $^{a}1$ - $^{b}31$, he writes in part: "evidently there is a first principle, and the causes of things are neither an infinite series nor infinitely various in kind. For (1), on the one hand, one thing cannot proceed from another, as from matter, ad infinitum, e.g. flesh from earth, earth from air, air from fire, and so on without stopping;

nor on the other hand can the efficient causes form an endless series, man for instance being acted on by air, air by the sun, the sun by Strife, and so on without limit. Similarly the final causes cannot go on *ad infinitum*, -- walking for the sake of health, this for the sake of happiness, happiness for the sake of something else, and so one thing always for the sake of another .... so that if there is no first there is no cause at all."

Searching for an ultimate principle in terms of which the whatness, the whyness, and the howness of the sensory flux is to be defined, the old rationalistic tradition both of the Aristotelian and Democritian variety was more interested in logical consistency or in thinking in terms of abstract principles rather than in actual observation and experimentation. The whatness and the whyness of things were thought to be rooted in an ultimate primordeal ground in terms of which the howness must be explained. Since this whatness of reality was identified with permanence or immutability, the sensory flux became either illusory or an inexplicable miracle. Causal explanation here takes its point of departure from some ultimate, immutable term. This immutable term may either be at the beginning or at the end of a series as in the case of efficient or final causality. In a metaphysic, where the ultimate term in a series is put at either end, the cosmic or ontological reality, if you wish, becomes an organic interrelated complex whole where change and motion are nothing but spatial and temporal illusions or appearances when rationally conceived from the eternal whole. Since the sense objects are bound together by infinite causal series, the task of causal reasoning is never completed until that ultimate something is found which is the cause itself. (Causa sui), or that of which the essence involves its existence. (Spinoza-Natura naturans). The world must be rational, and since perceptual experiences do not reveal any causal relation in the sense of rational connection, but mere sequences of events (Hume and Mill) they are outside of the sphere of knowledge or understanding. As W. P. Montague puts it: "A world of non-sense is preferable to a world of unreason."

The shift from teleological causality to mechanical causality was made at a time of implicit confidence in the power of human reason to lift the veil which hides ultimate reality. But curiously enough, the activating forces which produced this shift were rather pragmatic than rationalistic. As long as science was encumbered by a method which takes the complex whole as its subject-matter, quantitative exactitude was out of the question. By ruling out all final purposes and other supernatural influences and reducing the sensuous to the simplest term, that is atomic mass, post-Galilean physics seems to have arrived at last at a method which both satisfies the rational and the practical. But paradoxically enough, the rational has been bought at the price of the practical. The concept of inert mass particles, which may be satisfactory to our wavering imagination, makes change and motion an inexplicable miracle which has to be taken simply as a brute and irreducible fact. Change under the Aristotelian metaphysics could be explained in terms of an organic whole. But to explain change by simply displacement or rearrangement of inert atomic mass particles is a mockery to reason.

Now inconsistency and apparent contradiction between a theory and fact are not necessarily fatal. The question is not whether a theory ultimately fits into a coherent logical system, but whether it is useful in supplying the scientist with some form of imagery in his experimental procedure. Thus the physicist uses the atomic hypothesis which regards matter as discrete, and then may turn right around and use any other hypothesis which presupposes material bodies to be continuous as regards the space they occupy. To say that a hypothesis is supplying the scientist with some form of imagery does not mean that it gives him a picture of existence, but rather that it serves him as a cue which promotes experimental research.

VII.

The confusion between an imagery as a definite picture or model of existence, and an imagery denoting only a hypothetical cue which is useful in promoting scientific research, harks back to the old confusion.

of causality with a logical or rational ground.

Paradoxical as it may seem, the identification of causality with some underlying rational ground, or in other words, the confusion of the causal with the rational or logical may be said to be in a certain respect the progenitor of the various forms of so-called anti-rationalism which are running rampant in the present day. Now, it is a truth not to be made light of, that some thinkers have at all times been conscious of the fact that logical or rational thought cannot be identified with ontological existence. Aristotle was fully conscious of the fact that defining a thing is very different from proving its existence. But the light which flickered in this sporadic instance has always been smothered by other dominant interests of which the old ontological proof for the existence of God is a classical example. This particular phase of the problem is, of course, quite outside of our present field. The point to be noted here is simply this, that anti-rationalism may be said to be in one respect traceable to this old historical fallacy. The rationalistic tendency in contemporary thought may be traced to three general sources. First, the substitution of some irrational principle, either in the form of will or in the form of life-urge as an ultimate ground of reality, is in the final analysis nothing but a certain species of the search for the immutable. Secondly, what else is the empirical positivistic dogma, which we have already touched upon above, but a sort of quasi-pathological-negativism which has never really come to the realization and appreciation that intelligible explanation may be rooted in a purely methodological soil? Thirdly, the present-day confusion and speculation in the so-called sub-atomic region is largely motivated by the persistent predisposition of searching for the ultimate ground of reality. Finding that the traditional, accepted laws of physics are as inapplicable in the sub-atomic regions as they are in the so-called higher, vital and mental area, anti-rationalism with its shibboleth about dynamic energy, organic life force, etc. is ready to discard a method which is intelligible or at least imaginable within its restricted field of subject-matter for a method which, at best, can only lure our unrestrained appetite for explanatory theories into regions where it may be there simply is no explanation.

The two little words "how" and "why" in their equivocal usage have already been cited as examples of this old confusion between the logical and the rational ground. The loose use of these two terms by many writers of the present day is probably the best illustration of the fact that the concept of causality is confusingly and unconsciously identified with the old classical notion of a rational or super-rational system. Thus even as eminent and acute a thinker as Emile Meyerson invariably seems to identify causality with the why of a thing and law with the how of a thing, and yet the problem of causality is left in midair. For instance, in his book, Identity and Reality, page 335, he says in part: "We wish to know not only how things change, but also why they change." In another place he says, "Chemistry cannot be a purely empirical science. Mere demonstration of the phenomena leaves it as incomprehensible as it was before. The chemist must also be interested in the rational or theoretical that explains why the properties of matter result from those of the elements which compose them."

Now, if we ask for the howness and the whyness of the thing in the literal sense,* we certainly expect quite different answers. If you ask me, for instance, why I get up and go to the door, the question calls for an immediate teleological explanation. I may answer it from the point of view of my immediate interest, and you, not being disturbed at the present moment by any further Socratic curiosity, would accept my immediate answer as final or ultimate. But suppose the Socratic curiosity would lead you on to analyze critically my immediate answer as to shy I get up from the chair and go to the door, where is the halting point in your further questioning-analysis? You will find yourself entangled in an endless series of either final or efficient causal explanations. The only way that you are able to free yourself from the uncomfortable and embarrassing network of causal series in which you are entrapped is by cutting the knot and accepting any arbitrary theory which may appeal to you as a causal explanation. But

* Or in reference to the thing's substantial property as over and against its functional relations, noted on Page 31.

now suppose we turn the tables, and I begin to question you as to how you arrive at a certain explanatory theory. Immediately the question takes on a different aspect. I now ask you to give an account as to how you arrive at your present explanatory theory of why I get up and go to the door. It is now up to you to give an explanatory account of the underlying mechanism which produces your present explanatory theory. While the former Socratic inquiry led both of us to pursue the problem of the whyness in a finalistic or forward direction, the question, as now put, would force us to pursue it in a backward movement. The full answer to the first query as to my purpose in getting up and going to the door is never reached until the ultimate and final purpose of reality is known. Since this is beyond the power and capacity of human reasoning, the metaphysical and theological systems which are the product of this quest are nothing but an arbitrary closing of the door to reason. Thus, whether you picture the universe as an organic or pantheistic whole or as governed and regulated by a Divine Being is, after all, nothing but a product of your reasoning power. It is now up to you to give me an explanatory account of the mechanism underlying this reasoning process. In doing this there is a large variety of explanatory categories at your command. You may choose, if you wish, the shortest and most direct route by resorting to many forms of supernatural categories. But suppose you choose to remain on a strictly naturalistic plane by choosing categories that are somehow within reach of our human understanding. Where would you begin in your analysis of the reasoning process?

Suppose you begin on the anthropological or social-psychological level by saying that the reasoning process is explainable in terms of some purely social mechanism -- say that of habit, imitation, suggestion, etc. At once the question will be asked, what are the components of this social mechanism? Remember we are here wholly concerned in explaining how phenomena come about, and this from the point of view of substantive causality is impossible without the assumption of an underlying structural mechanism. Again this structural mechanism is only intelligible when conceived in terms of its components. So in asking what are the components of the social-mechanism, we are forced to take into account the next level, which is that of the so-called psycho-physical individual. But no sooner have we reached this level than the inquiry proceeds to take us downward again. Omitting for the sake of simplicity the old aggravating and perplexing problems of the psychical and vital factors, without which our psycho-physical individual has no reality, let us at once reduce it to its physical and chemical basis. Our search for the homogeneous component of the mechanism underlying a psycho-physical individual turns out to be just another mirage. For the physiological processes of the brain and nervous system are dependent upon highly complex and heterogeneous components and our search for an explanatory mechanism is never completed until we know its homogeneous components. In analyzing this neural mechanism, we again find it to be composed of highly heterogeneous physical and chemical components. For on reaching the physico-chemical level, we still are far away from all homogeneous components for which we are searching. The chemical compound is highly heterogeneous and the atom which was supposed to be homogeneous is, according to modern speculation, a highly complex microcosm.

VIII.

So long as scientific explanations are based upon a causality concept which has its historical setting in what might be called the Apollinian tradition, they proceed on the two general presuppositions: that every event is ultimately the effect of a determinate cause and that everything has a rational ground for its being and existence.

Now, this old rationalistic tradition, as we saw above, has been given its deathblow by the post-Humeian and positivistic revolution in science and philosophy. The revival of the Dionysian temper or world view in modern philosophy has dethroned the intellect from its sovereign position and reduced it to the artifice of an irrational will. The old classical point of view, with its emphasis upon logical and rational self-consistency, has given way to the romantic temper which emphasizes action and adventure into the irrational rather than contemplation or rational analysis. As a consequence of all this, the concept of causality has been reduced to nothing but laws of recurrence and succession in time. In the old Apollinian or rational tradition, the causal concept had been founded upon the principle of identity or immutability. The whyness of a thing received its complete meaning in terms of the complex and interrelated organic whole. (Telology, vitalism.) The "whatness" and the "howness" of a thing must be explained in terms of its underlying, substantial components of homogeneous elements. (Mechanism.) Since, according to contemporary thought, there is no absolute or closed system nor homogeneity, the whatness, the whyness, and the howness of a thing have lost their original and traditional meaning. The essence or the whatness of a thing does not consist in its intrinsic constitution or makeup, but in its role in a functional situation. Since, scientific explanations do not rest on substantial properties, the knowledge of the whatness and the howness do not consist in the apprehension of any substantial structure, but in the knowledge of the characteristic behavior which an object displays when brought into relation with other objects or things. In short, scientific knowledge consists in the acquaintance with law. We have defined law as an expression of relationship or functional behavior of objects on the basis of certain abstracted properties. That is, law is a description of the rules or conditions under which phenomena display a recurrent functional relation. Taking their departure from change and motion, scientific laws are wholly concerned with the process of phenomena and not with the intrinsic nature of phenomena themselves. In so far as law is a descriptive formula of a unique behavior on the part of phenomena, it only deals with a phenomenon on the basis of its functional relations and ignores more or less the substantial nature of the thing. Consequently, we attain laws only by doing violence to the concrete object by isolating, more or less artificially, certain unique properties of the complex whole. Let X stand for the substantial constitution of a thing, in this case oxygen and Y for another thing in its substantial constitution, here, two parts of hydrogen. Law, as such, is neither concerned with the substantial nature of X and Y, but wholly and alone in the interaction or behavior when X is brought in a peculiar relation to Y. Law merely formulates the manner in which change occurs when X is brought in relation with Y; and not with Y nor with X, as denoting static substance or objects as such. This generalization of the observed regularity of sequential happenings when X is brought into relation with Y may be called the essence of functional law.

Being but a methodological or descriptive summary of observed regularity in the sequences of events, law can tell us only that things happen in a fixed order. Yet, according to Meyerson, it is said that the cause of phenomena is the law. Knowing the law under which certain phenomena manifest themselves, means to be able to describe them, which in turn means, that on the assumption of the uniformity of nature, we are able to predict their future behavior. Now, if law describes a constant mode of behavior to such an extent that we, on the assumption that nature acts uniformly, are able to predict the future, what is all the fuss about explanations in terms of "the how" or "the why" ? If science, by systematic and methodical observation and mathematical tabulation is able to discover the rules or modes under which phenomena invariably reveal themselves, why worry about explaining them in terms of any underlying substantial component which the old traditional substantive causality always assumes? So long as the old notion of thinghood, which always is defined in terms of its substantial property, is uppermost in our mind, then the old bugbear of explanations in terms of an underlying, substantial mechanism will haunt us. Hence, the slogan of contemporary relativistic and functionalistic methodology is that scientific concepts must be defined in terms of their operation rather than in terms of any intrinsic substantial property.

IX.

Let us examine this so-called operational method a little more closely.* Several questions must

* Since this chapter is limited to the practical aspect of scientific methods, we shall not concern ourselves here with any logical or theoretical implications.

now be considered. 1. If science can deal only with a plurality of functionally ordered data, i.e., a plurality of whatnesses in terms of which it seeks to get at the howness or the law of phenomena, how far does this method give us what may be called an explanation of phenomena? 2. What do we mean by saying that law explains a particular phenomenon? 3. Does rationality, in the sense of conceivability or imaginability, play any role on the modern scientific stage? If so, what office and role does it perform?

According to traditional mechanism, physical change could be interpreted only as variation of spatial relation among unchangeable elements. That is, change is simply the rearrangement or displacement of immutable elements. (Democritus.) In explaining phenomena in terms of substantial properties, we are forced to assume a mechanism composed of homogeneous parts. Now, since the supposed indestructible atoms which were believed to be the homogeneous elements have been found, according to modern physics, to be highly complex and heterogeneous, discursive thought finds itself threatened with bankruptcy in offering explanation in terms of rational or intelligible underlying mechanism. Hence, causal explanation in the sense of an assumed underlying principle of identity had to be abandoned and science must be contented with abstracting certain functional properties for the sake of observation, experiment and tabulation. Now, just what do we mean when we say that the law explains a phenomena?

The question is complicated by the hypothetical principles which serve the scientist as a preliminary guide in collecting and organizing his data. Without some sort of hypothesis, the scientist would not get very far in his work. In using hypothesis, the scientist is forced to encumber his problem by the intrusion of a causal element in a quasi-qualitative or even anthropocentric form. That qualitative theory still plays and always will play a tremendous role in scientific research, is seen the moment we step outside the realm of the physical science. And even here many hypotheses of physics rest upon substantial properties which are quasi-qualitative in nature. Thus ridding science of all qualitative and anthropomorphic elements is nothing but an ideal which can only be approximated. If this is true, the aim of the operational method to rid science of all so-called substantial properties and turn it into a purely quantitative manipulation of functional property is a pious dream, the realization of which is as yet far off. But let us suppose that this ideal of science is attainable. What would be the result from a purely positivistic point of view?

If our definition of scientific law is well-founded, it is perfectly obvious that law as law can deal only with the abstract functional relations which phenomena display. When the scientist deals with a particular phenomenon, he breaks it apart and extracts or isolates a certain functional property or character for observation and experimentation. In doing so, he must ignore all the other properties which the object may possess or display under different relational conditions. Now observe that the more complex an object becomes, the more numerous are its functional relations. Since it is the aim of law to isolate a particular functional relation for experimental purposes, all other irrelevant connections, which the object under experimentation possesses, are ignored.* This means, to put it tersely, that the greater the number of functional relations which an individual or particular possesses or displays, the less it is covered in its entirety by the law. Or, to put it a little differently, the more complex a particular object is, that is, the more functional variability it displays, the further is law removed from the particular object.

Permit me to illustrate the point concretely. Suppose we start with the most heterogeneous object or individual that we know of, which is a fully developed, particular John Smith. John Smith displays an infinite number of functional relations. Suppose we roughly classify these relations as social, psychical, vital, chemical and physical. In the previous chapter, we have drawn a vertical line between the so-called pure and exact science and the biological and social science which we have called descriptive. Let us here now turn this into a horizon-

* This difficulty seems comparable to that which Whewell noted in his criticism of Mill's Canons. See J.S. Mill, A System of Logic, Longmans, Green & Co., 1930, p.282.

tal division. This means that our John Smith, from the scientific point of view, is an object possessing an infinite variety of functional relations, which we have, for mere convenience sake, grouped into five general classes. Now, if we remember what has been said above in dealing with a particular or individual on the basis of substantial properties, the old scientists were primarily interested in reducing this highly complex object to its ultimate simple components. So long as the traditional scientist could not find these ultimate simple components, he could not construct a mechanism in terms of which he sought to explain his complex object. In other words, he was interested in the "what" and the "how" in their literal, substantive sense.

Now observe what happens. All substantial properties or attributes are supposed to have been eliminated. The scientist is now chiefly interested, not in dissecting the complex whole in order to find an underlying explanatory mechanism, but rather in extracting certain functional relations for the sake of observation and tabulation. Observation and experimentation are now directed toward a mean or average reading rather than toward a serach for an underlying, explanatory mechanism. Science consists from this point of view in a methodological perfection in establishing a high coefficient of correlation in relations. Experimental scientific progress consists in the perfection of method, which consists in nothing else but the elimination or reduction of probable errors involved in all measurements and tabulations up to, or at least approximating zero.

Since the scientist is merely interested in functional relations, he is free to begin his investigation anywhere along the scale of ascending complexity or heterogeneity. For theoretically speaking, the terms homogeneous cease to have any other but descriptive or methodological meaning. Hence, the particular or individual as such has ceased to exist. The physicist can no more reach his particular by the ideal of exactitude demanded by logical reasoning than can any other scientist. So, why should not the subject-matter of the anthropologist, sociologist, psychologist and biologist, etc. be just as susceptible to methodical observation and quantitative tabulation as the subject-matter of the physicist or chemist?

Let us look at these arguments of the so-called exponent of the operational method or, if you like, the logic of statistics. Several curious confusing and paradoxical consequences, both theoretical and practical, are here involved. In the first place, the argument that the physicist or mechanist can only approximate the real magnitude of a thing is, in the final analysis, nothing but the old Zeno puzzle popping up in a new dress. That the actually perceived metal bar only approximates the unperceived ideal bar is so obvious that it seems perfectly silly even to bring it forth as an argument. To take it seriously in any sense would mean nothing less than to become another victim of the error of confusing thought with ontological existence, which Aristotle and many other thinkers warned us against long ago. Since we have above defined law as an ideal construct, it follows from the very definition of it that it can only approximate the particular or individual. But the degree of this approximation of law to the particular is of preeminent importance, as we have already noticed. On page 25, it was stated that the chances of approximating the particular or individual seem to be greatest in that field of subject-matter, where mechanistic methodology is most effective. In other words, the chances of discovering a constant correlation between events through statistical technique are greatest in the sphere of the co-called purely quantitative sciences.

Suppose we grant, as in fact we already have done, that all scientific laws are the same in their status and origin. Does it follow that in their actual operation they are on the same plane? The methods by which the physicist or chemist derives the law may be essentially the same as the means by which the sociologist or psychologist obtains his laws. The psychologist can just as ably isolate certain factors for the sake of experiment and tabulation as the natural scientist. In measuring capacity by mental and educational test and scale, the psychologist is only concerned with those factors relevant to his purpose, ignoring all other irrelevant variables. But note that the properties which the biologist, psychologist, anthropologist, etc., are forced to ignore, in establishing a particular law, are essential to the makeup of the whole individual. Testing capacities like motor response or the ratio of different types of plant and animal in cross-breeding, the psychologist and the biologist arrive at something which seems constant over a relatively large number of individual cases, for example, the so-called I. Q. or Mendelian ratio. But this constant is a highly artificial thing in comparison to that constant of chemical affinities, or more exactly, that constant which is expressed in the simple laws of mechanics.

Law, as we define it above, simply states the way a certain phenomenon behaves under certain uniform conditions. But by stating the functional behavior, it must take into account some form of substantial property. Phenomena cannot be reduced to a bundle or an aggregate of functional relations. To reduce reality to purely functional relations would make the phrase "functional relation" meaningless. Some form of substantiality or thinghood is implied in the phrase "functional relation." Otherwise the law revealing the mode of behavior between phenomena would be meaningless. To speak about the acceleration of gravitation without taking into account mass and distance, would be talking sheer nonsense. To speak about functional relations without at least assuming some form of "whatness" or thinghood to begin with, would be nothing but a reductio ad absurdum. But we are not concerned here with the theoretical side of the question; what we are interested in is its practical application. If the concept of thinghood cannot be crowded out of the logical sphere, it certainly cannot be eliminated from the sphere of science. This means that even from the point of view of the operational method, the subject-matter must be taken into account. If this is true, then the statement which was made above, --that scientific progress consists in the perfection of method, or, in other words, in the elimination of probable errors to a minimum point -- is true only in so far as the subject-matter under investigation is taken into consideration. Law dealing only with the functional relations which phenomena display is in the final analysis most effective in that subject-matter which by its very nature is limited to the least variety of relations. This means, in short, that the operational or statistical method can attain a high degree of effectiveness only in the field of the so-called physical sciences. Of the ridiculous consequences in contemporary thought which result from the worship of method for method's sake, we shall have a few words to say at the end of the chapter. The point to be noted here is: that in the actual operation of law the particular nature of the subject-matter will be of the utmost importance.

The mere reading of the mean or average would never have fired the enthusiasm of an Archimedes or a Leonardo da Vinci. It was the simplicity of the laws of the lever and the fulcrum in their almost identical approximation to actual concrete nature, which stimulated and nourished their imagination. Working with these simple principles not only enables the physical scientist actually to explain his circumscribed phenomena by visualizing the determined connection, but also to draw far-reaching deductions, which would not have been possible with law dealing with a more heterogeneous subject-matter. Let us once more repeat our former dictum: the more homogeneous functional relations become, the closer the law approaches determinate connection; and the closer the determinate connections are, the more they yield to intelligible explanation. Suppose you ask me how I move my arm. We have above classified functional relations--on an ascending scale of complexity or heterogeneity--into five general groups: physical, chemical, vital, mental and social. All the properties are, undoubtedly, somehow involved in this process. But I am able here to ignore the more heterogeneous properties and to give you a perfect, intelligible explanation on the basis of purely physical or mechanical properties. Applying the simple law of the lever, I am able to give you an intelligible explanation as to how I move my arm. The bones act as levers. The fulcrum is the joint. The weight is the member that is moved, and whatever is holds. The power is the pull produced by the end of the muscle or tendon at the place where it is attached to the bone. To lift my forearm the biceps muscle of the upper arm contracts and pulls upon the radius bone a few inches below the elbow. The power is between the fulcrum and the weight. (Power x power distance = weight x weight distance.)

X.

In the light of the foregoing, let us again ask, what is meant by the statement that law explains phenomena? This brings us to the crux of the whole issue. Functional law, as we have defined it, is concerned with the relations subsisting between elements of fact which can be concretely observed and controlled. When I say that water freezes at 32°F, I am only affirminging a series of facts which every chemist and physicist can verify. Now, if law, according to our definition, can only concern itself with certain functional relations subsisting between "whatnesses", why is it that we still draw distinction between so-called pure and exact sciences, like chemistry and physics, and those sciences which merely attempt to describe their subject-matter on the basis of observed regularity of behavior? Both seek facts which can be verified by observation and experimentation. Furthermore, if our definition of laws is well-founded, why should not the social scientist be just as able to describe his factual material in terms of law as the physicist? For instance, why should not social behavior, as, let us say, adaptive response to any environmental stimuli, be just as susceptible to law as those physical properties of temperature and pressure, varying only in degree of exactness? Since, by hypothesis, the law holds only in reference to certain isolated properties, to the exclusion of all others entering into a particular or individual, why is not a method which is merely concerned in selecting and isolating certain functional relations for experimental purposes just as effective in one field of human interest as in another? Suppose we are dealing with such a property as mental capacity. The experimental educational psychologist can select a characteristic relational situation for this property which, in this case, is the capacity of efficient response to social environmental stimuli for the purpose of measurements and tabulation. Let us grant that he may be able to establish through statistical procedure a high degree of correlation of this particular type of reaction which is found to be relatively uniform or constant in a large number of cases. Furthermore, suppose that both the methods and the conditions do approximate as closely to mathematical exactitude as is humanly possible, why is it that the statistical laws of sociology, psychology, etc. can never attain as great a degree of reliability or constancy as a physical law or the law of chemical affinity?

The question has in part already been answered. Throughout the discussion we have treated law under three headings: 1. Its status or meaning. 2. Its genesis or origin. 3. Its actual operation. In the definition of functional law as established rules of uniform behavior existing between things or events, we have laid down the general proposition that all scientific laws ultimately have the same genesis or origin. But we have said that in their actual operation, or, if you will, in their application, there exists a wide gulf between so-called physical or chemical laws and those laws covering such subject-matters as psychology and the various social sciences. In examining scientific laws in their modes of operation, two things must be noticed: 1. Law and its relation to the particular or individual. 2. The two-fold meaning of explanatory law.

From the preceding discussion, the first point, pertaining to law and its relation to the particular or individual should be obvious. It simply follows from the dictum which we must repeat here, -- the more complex a particular subject-matter under investigation is, the fewer are the possibilities that it can be covered in its entirety by a law. However, before we discuss the second point in reference to the actual operation of law, that is, the two-fold meaning of law as a causal explanation of phenomena, let us linger -- even at the risk of tedious repetition on what has already been said in this and the first chapter -- on the so-called fact-finding mania, which is a direct outgrowth of the statistical or operational method.

That scientific knowledge is ultimately derived through a sort of statistical procedure is a common opinion of many modern and contemporary writers.* But curiously enough, there is a certain vagueness in regard to the distinction between statistical methods and that which is called unchanging law or scientific law per se. Statistical method may be said to deal with assemblages, or groups, in terms of which the

* See Merz, History of European Thought in the Nineteenth Century, Vol. II. Chapter XII. P. 548-626. Boas, Our New Ways of Thinking. Harpers.

averages or correlations are described. In other words, it deals with relatively uniform behavior of certain isolated functional relations belonging to an aggregate of things or events. It pertains to the mean or average reading. The individual or particular has reality only in so far as he or it displays a certain functional habit approximating the average. While statistical method may be said to deal with a certain characteristic or a functional relation, if you like, belonging to an aggregate of things or events, law may be said to be an expression of the appearance of a certain unique mode of invariable behavior. Statistics may be said to be the preliminary technique through which we learn how things behave or operate in relation to other things or events, or, in other words, the preliminary through which we become acquainted with the operation of law. To speak of statistical law in contrast to physical or mechanical law as if the distinction were a matter of kind leads only to confusion and ambiguity.** Laws, as we stated, are all on the

** See C. F. Mills, On Measurement of Economics. From The Trend Of Economics, p. 37-66.

same level as far as their status and origin is concerned. It is only when we come to the actual operation of law that there is a difference, but this difference once more is not a matter of kind but of degree.

In discussing law in its relation to the particular or individual, probably the shortest route leading to our destination is again to take refuge in the "what" and the "how". When scientific concepts are founded upon substantial properties, then the "whatness" of a thing consists in its ultimate, substantial structure, and the "howness" consists in the function or operation of the components of this substantial structure. On the other hand, when scientific concepts rest wholly upon functional relation, then the "whatness" of the thing consists in its specific functional relation to other things; and the "howness" is simply the law or rule expressing this functional relation.

Since law in its origin is nothing but an empirical generalization of the way phenomena behave under uniform conditions, it has no need to postulate a substantial essence in terms of which the behavior of phenomena is explained, for the essence or the "whatness" of a thing consists in the unanalyzed data of the situation and not in its intrinsic substantial properties. The "whatness" of hydrogen here does not consist in its intrinsic material or electronic nature, but in its behavior or function in relation to other elements. Knowing the specific function or behavior of X in relation to Y, we know its "whatness". The simpler a subject-matter under observation is, the fewer functional relations does it possess. Take a simple phenomenon like freezing. Its "whatness" consists in temperature and pressure and the unanalyzed thing to be frozen. Now, if we examine phenomena on the basis of increasing complexity, we find that the "whatness" becomes a complex of heterogeneous, functional relations, which defy all effort to bring them into harmonious unity. It is just this difference in the relative complexity of subject-matter that biology, psychology and the social sciences deal with, which forever will bar these sciences from approximating the particular thing or event to that degree reached by the laws of physical science. Thus, the psychologist or social scientist may be said to deal with a plurality of heterogeneous "whatnesses" or functional relations, which he cannot bring into a homogeneous unity; hence, he does not deal with the concrete particular or individual.

Paradoxical as it may seem, the application of the statistical method in fields outside of the natural sciences, tends to remove the concrete individual more and more out of the picture. Aside from the almost insurmountable difficulty of eliminating the personal whim and caprice which enters into the so-called mean reading on this plane of research, the real barrier blocking the path toward an objective treatment of psychological and social phenomena lies in the fact that the concrete individual is nothing but a bundle of disconnected averages which he supposedly shares with a selected group. The fact that the application of the operational method, in the field of so-called social sciences, leads to a sort of revival of the old Aristotelian class concept already has been discussed in the first chapter.

Now it is true that many of our social scientists and psychologists in various fields of investigation fully recognized the limitation that statistical measurements can only deal with an individual on the basis of the average. But the difficulty or limitation of statistical investigation seem for these scientists to be traceable to two sources: 1. The difficulty which confronts every scientist in eliminating the personal equation and treating his subject-matter objectively is greater and becomes more prominent in the field of psychological and social sciences than in the sphere of strictly physical science. 2. The difficulty which the psychologist and social scientist encounter in the methodological treatment of their subject-matter. This last point particularly has been emphasized. Progress in the investigation of social and psychological phenomena lies in the direction of a gradual refinement of method. Hence, we are living in the day where the sole emphasis seems to be put on the exaltation of method for method's sake. Just as the old school of scientific thought worshipped at the shrine of some ultimate metaphysical system, so our contemporary friends, particularly in the field of education and social philosophy have exalted methods as their god for worship. Of the ridiculous and deplorable consequences of this worship of method for method's sake, we cannot concern ourselves. But one point must be noticed. No amount of effort on the part of scientists to extricate the personal equation entering into the mean reading nor any mathematical refinement of statistical method ever will overcome the obstacle which blocks the path toward scientific knowledge of the particular or individual outside the field of natural science.

Curiously enough the very refinement of method tends to remove more and more the concrete individual and substitute for this individual an aggregate or conglomeration of what we have called functional relations. Women, according to statistical figures, are said to excel in speed of reading, both oral and silent, in amount of information given in describing an object or in making a report, in memory span for words, in memory for logical verbal material; while men and boys are said to be superior in motor capacity, such as tapping, quickness of reaction, arithmetical reasoning, and in resistance to suggestion as indicated by the size-weight illusion and the use of such suggestive questions in testimonies. But what are these so-called characteristic differences between the two sexes obtained through statistical counting, but abstracted, functional distinctions derived through the mean reading? Now, we are not concerned here with the value of such statistical knowledge. That is beside the question. The point is that such isolated, functional characteristics as sex-differences do not characterize any particular individual either in whole or in part. And no psychologist or social scientist would, when sobered by common sense, pass judgment on a particular case in terms of these abstracted characteristics acquired through the mean reading. If he does judge a particular individual in accordance with these characters, his eyes are not on the concrete individual before him, but on abstractions which are derived through the mean reading. The concrete individual has ceased to be an organic unity and has become an aggregate of functional relations or functional "whatnesses" which are equated on the basis of the group average. In other words, the individual, as you and I see him, has ceased to exist in the eyes of the so-called professional expert and is nothing but a bundle of disconnected averages or correlations -- coefficients which are registered on the tabulating sheet. Our forefathers were said to be worshippers of logical and qualitative essences, but isn't it probably true that we in the modern age have upset the balance in the other direction by becoming worshippers of number and equation idols, which may be said to have usurped the place of the old logical and qualitative essences? Intellect, in the old days, was invested with the divine power of unravelling the mystery of reality, but intellect in the modern day seems to have become nothing else but a sort of adding and tabulating machine. This brings us to the second point to be considered with reference to the actual operation of law, and that is the two-fold meaning of explanatory law.

XI.

The question of explanation is in many respects closely related to the causality concept. We have in the earlier part of this chapter discussed the causality concept in its historical setting. We have further disengaged the concept of law from the concept of causality. The sundering of the two concepts is artificial but possible as long as law is discussed from the point of view of status and origin, but when it comes to an examination of the actual operation or function of law, we inevitably invite an exposition of the causal concept. Now, we cannot again go into any expository treatment on the concept of causality. This has been done as far as it is pertinent to our problem in the earlier part of the chapter. But two points must be briefly considered in our conclusion. Law, as we have defined it, is a descriptive formula of the behavior of phenomena. When the law invariably approximates the behavior of a particular phenomenon, we talk about an actual connection existing between elements of facts. When two chemical elements are said to invariably combine, we assume the existence of a causal connection between them. Now the two points to be briefly considered revolve around the question as to the nature or status of this connection.

Is there a relation between the degree in which law approximates the particular and the rationality or imaginability of the mode of its operation? If so, what is the relation? We are treading on very dangerous ground. The question becomes complicated and involved by the conflict between, what we may call, rational motives vs. instrumental motives.

Intellect is inclined toward simplification or, what according to Meyerson appears to be the reduction of the irrational to a minimum. On the other hand, the flux of actual perception has defied all effort on the part of scientists and philosophers to reduce it to simple terms. "No teaching of physics," says Duhem, "can be given under a form which leaves nothing to be desired from a logical point of view."* Law, as we have stated above, is founded upon change, which means that law rests upon an irrational basis. Motion by impact and action at a distance are two irreconcilable contradictions from the point of reason as well as common sense. Nevertheless, the atomic theory,

* Quoted from Meyerson, Identity And Reality, p.409.

grounded upon the concept of inertia, has given physics a substantial "whatness" in terms of which the "howness" or the laws could within a certain limit be made intelligible, or at least imaginable. Now, it is true that intelligibility or imaginability are not necessary ingredients of a hypothetical explanatory theory. The very fact that the complexity or heterogeneity of natural phenomena has resisted and always will resist the effort on the part of intellect to reduce it to any simple and ultimate formula is a truth which every scientific investigator always has realized. Hence, the acid test of the truth of a causal explanatory theory does not lie necessarily in the question whether it is ultimately satisfactory to logical reasoning, but in the question as to its utility in giving us a better control of phenomena. In contemporary scientific thinking, the veridicality of an explanatory theory lies in its approximation to the actual observable phenomena, and not in its conformability to reason.

With the abandonment by science of the search for the ultimate metaphysical nature of the "whatness", scientific interest, ever since the time of the Renaissance, has been focused more and more upon the "howness" or upon law; hence, the concept of causation, in the old traditional absolutistic sense, gave way to the concept of law. The search for law governing natural phenomena has become the foundation upon which modern science rests. The concept of the substantial "whatness" of reality, whether it is ultimately material, electrical, or what not, rests more upon pragmatic than upon rational grounds. The question is, how well does a hypothetical theory as to the nature of ultimate reality explain the operation of law, and not whether this theory gives us an intelligible explanation of reality itself. The interest in law is primary. Interest in causality, in the old traditional sense discussed above, is only secondary and pragmatic. The concept of substantial "whatness" and "howness" gradually gave way to the concept of the functional "whatness."

Scientific explanatory theories as to the ultimate nature of the "whatness" are looked upon as purely instrumental in helping the scientist in the organization of his knowledge on the basis of law. This increasing emphasis upon the "howness", or law under which phenomenon manifests itself, has increased our knowledge of the actual properties of matter tremendously. By concentrating the actual behavior of phenomena rather than on their ultimate, substantial nature, science has not only revolutionized our mode of living, but has been instrumental in revolutionizing our mode of thinking. Thinghood may be said to be the primary categories of the old school, while relations, change, function and operation are the chief interests to contemporary thought. The validity of a theory as to the substantial "whatness" is not founded on any rational basis, but purely upon the question of how well does it serve the scientist in explaining phenomena? A substantial "whatness" is said to be valid when it is instrumental; that is, when it actually enables us to bring a given particular under the control of the experimental facts of specific investigation. Displacement or rearrangement of mass particles does not explain the emergence of new qualitative properties. The theory of ether vibrations does not permit the scientist to say that color is derived from or are due to these vibrations, but it does enable him to describe and predict variations in color in quantitative terms. This means that substantial concepts cannot be wholly banished from the scientific sphere.

If in the process of measuring and establishing purely quantitative correlations, some imagery is required to make the operation of measurements picturable, then the question as to the nature of this imagery is not necessarily foreign or negligible to science. By reducing the sensuous to its lowest terms, -- figure and motion, post-Galilean physics has worked with categories that have lent themselves within a restricted field to the grasp of the imagination.

Since mathematical tabulations of observed behavior of phenomena will always be considered as more or less preliminary in finding a causal and connecting principle, the particular nature of this principle will not be merely secondary to science. By its emphasis and slogan that theories and hypotheses must always conform to the concrete empirical datum, and not vice versa, the sequential theory as a subsidiary to the operational method has enabled the scientist to discover laws which may come closer to describing the actual process of phenomena than the old causal theories which were more or less shackled by rationalistic absolutism. But the real effectiveness of the sequential and operational methods as a scientific program has been limited to just that narrow and circumscribed subject-matter of physical phenomena where mechanistic methodology has been effective.

So long as it is partly the business of science to offer some explanation of phenomena, its interest will consist in something more than mere acquaintance with de facto connections between phenomena discovered through the method of observation and tabulation. It must also be interested, at least tentatively, in the knowledge of the substantial "whatness" of these connections. Now, the "whatness" here cannot denote mere functional relation, which would be nothing else than de facto connections, for in that case the entire notion of explanatory theory would be meaningless. Hence, the "whatness" here must denote substance or thinghood in some form.

Now it may be true that all our knowledge of the characteristic laws of inorganic matter is derived through statistical averages resulting from what Whitehead called the "confused aggregate." The ultimate substantial "whatness" of this "confused aggregate", or the ultimate nature of the individual or particular making up this aggregate, may be forever hidden from science. Nevertheless, the "whatness" with which science deals can no more consist merely in abstract relations than can the world of solid objects perceived by common sense. True, the object that science deals with is highly artificial and abstract compared to that of common sense. But no matter how artificial and abstract its categories may become, science can no more live and prosper in a totally desubstantialized universe than a fish can live out of water.

SYNOPSIS.

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