Chapter III: The Canons of Empirical Method.

An examination of insight ~~reveals~~ not only reveals the heuristic structures involved in empirical inquiry but also explains the rules or canons that govern the ~~xxx~~ fruitful unfolding of the anticipations of intelligence.

Six canons will be presented, namely, 1) selection, 2) operations, 3) relevance, 4) parsimony, 5) complete explanation, and 6) statistical residues. There is a canon of selection, for the ~~i~~ empirical inquirer is confined to insights into the data of sensible experience. There is a canon of operations, for he aims at an accumulation of such insights, and the ~~xxx~~ accumulation is reached, not in the mathematical circuit through insights, formulations, and symbolic images, but in the fuller circuit that adds observations, experiments, and practical applications. There is a canon of relevance, for pure science aims immediately at reaching the immanent intelligibility of data and leaves to applied science the categories of final, material, instrumental, and efficient causality. There is a canon of parsimony, for the empirical investigator may add to the data of experience only the laws verified in the data; in other words he is not free to form hypotheses in the style of Descartes' vortices; but must content himself with the laws and systems of laws, exemplified by Newton's theory of universal gravitation, and characterized generally by their verifiability. There is a canon of complete explanation: ~~xitixxtix~~ ultimately science must account for all data; hence one may not say that colors and sounds, heat and electrical phenomena, have to be explained, for they are merely apparent, secondary qualities, while experienced extensions and durations do not need any explanation, any physical or natural geometry, for they are the real and objective primary qualities. Finally, there is a canon of statistical residues; though all data must be explained, one must not jump to the conclusion that all will be explained by laws of the classical type; there exist ~~laws~~ statistical residues and their explanation is through statistical laws.

Before undertaking a fuller account of these canons, it may not be amiss to recall our viewpoint and purpose. The reader must not expect us to retail the history of the development of empirical method, nor look for descriptive accounts of what scientists do, nor anticipate an argument based on the authority of great names in science, nor hope for a summary of directives, precepts, and recipes to guide ~~thexpx~~ him in the practice of scientific investigation. Our aim still is an insight into the nature of insight. Our presumption is that empirical investigators are intelligent. Our supposition will be that the reader is already sufficiently familiar with scientific history and procedures, authoritative pronouncements and practical directives. Our single purpose is to reveal the intelligible unity that underlies and accounts for the diverse and apparently disconnected rules of empirical method. Our concern is not what is done, or how it is done, but why. And our interest in seeking the reason why, is not to extend methodology but to unify it, not to unify it that ~~mxkx~~ methodology may be improved, but to unify it in the hope of exhibiting still more clearly and convincingly the fact and the nature of insight.

~~Our study of empirical inquiry began with a consideration of Galileo's determination of the law of falling bodies. After pointing out the similarities and the differences between such an insight and, on the other hand, mathematical insights, we drew attention to the clues or hints that lead up to the insights of empirical science, and attempted outlines of the heuristic structures that develop into knowledge of classical and statistical laws. By advancing to a slightly more general viewpoint, let us now endeavor to formulate the principal canons of empirical method.~~ we/

The Canon of Selection

1\. First, there is a canon of selection.

If a correlation or hypothesis or law or probability expectation or theory or system pertains to empirical science, then 1) it involves sensible consequences, 2) such consequences can be produced or, at least, observed.

Inversely, empirical method prescinds from all questions and answers that do not involve distinctive, sensible consequences; and it discards all that involve such consequences logically yet fail to be confirmed by the results of observation or experiment.

The necessity of some canon of selection is obvious. Possible correlations, hypotheses, laws, probability expectations, theories, and systems form an indefinitely large group. They can be set up at will by the simple process of definition and postulation. But there is no reason why the empirical inquirer should investigate all the trees in this endless forest of possible thoughts, and so he needs some canon of selection.

The neatness of the canon of selection is no less clear. Not merely does it exclude at a stroke all the correlations and theories that cannot be relevant to empirical inquiry because they possess no sensible consequences. Also it operates progressively and cumulatively by discarding all the correlations and theories ~~that have been tried and found wanting~~ that possess sensible consequences by logical implication but have been tried and found wanting. Finally, the canon of selection has its positive aspect; besides ruling the irrelevant out of consideration, it directs the scientist's efforts to the issues that he can settle by the decisive evidence of observation and experiment.

However, the neatness and simplicity of the canon of selection can prove a trap for the unwary. If the canon demands sensible consequences, still it is satisfied when those consequences are so slight that only an expert equipped with elaborate apparatus can detect them. If the implied sensible consequences must be involved by the correlation or law or expectation, still grasping that implication may suppose a profound mastery of a field, a capacity to follow recondite and intricate mathematical operations, and the audacity necessary to form new, primitive concepts and to follow long chains of abstract reasoning. Hence, besides the hod-men of science that gather the facts, there are also the architects of theories and systems. If no theory and no system pertains to empirical science, unless it involves distinctive, sensible consequences, still an appropriate division of labor may well result in some empirical inquirers devoting most of their time and energy to the development of concepts and postulates, theorems and corollaries. Finally, as the canon of selection is not to be misinterpreted as a mere charter for obtuseness, still less is it to be taken as an excuse for logical fallacy. Questions that do not satisfy the canon of selection do not arise within the confines of empirical science, but it does not follow immediately that they do not arise at all. Issues that cannot be settled by observation or experiment cannot be settled by empirical method, but it does not follow immediately that they cannot be settled at all.

1.1 The Restriction to Sensible Data. Two further points call for consideration.

As we have formulated it, the canon of selection demands sensible consequences. But it may be urged that empirical method, at least in its essential features, should be applicable to the data of consciousness no less than to the data of sense. Now, on this matter a great deal might be said, but the present is not the time for it. We have followed the common view that empirical science is concerned with sensibly verifiable laws and expectations. If it is true that essentially the same method could be applied to the data of consciousness, then respect for ordinary usage would require that a method, which only in its essentials is the same, be named a generalized empirical method.

1.2 What are sensible Data? A more urgent issue is raised by the question, What are sensible data?

A datum of sense may be defined as the content of an act of seeing, hearing, touching, tasting, smelling. But the difficulty with that definition is that such contents do not occur in a cognitional vacuum. They emerge within a context that is determined by interests and preoccupations. Nor is this true merely of ordinary perception, of the milkmaid who laughed at Thales for falling into the well. It is more conspiculously true of the scientific Thales, so interested in the stars, that he did not advert to the well. Accordingly, it would be a mistake to suppose that scientific observation is some mere passivity to sense impressions. It occurs within its own dynamic context and the problem is to distinguish that cognitional orientation from the orientation of concrete living.

To be alive, then, is to be a more or less autonomous center of ~~a~~ activity. It is to deal with a succession of changing situations; it is to do so promptly, efficaciously, economically; it is to attend continuously to the present, to learn perpetually from the past, to anticipate constantly the future. Thus, the flow of sensations, as completed by memories and prolonged by imaginative acts of anticipation, becomes the flow of perceptions. It is of the latter, perceptual flow that we are conscious. It is only when the perceptual flow goes wrong that the mere sensation bursts into consciousness as, for example, in the experience of trying to go down another step when already one has reached the floor.

Now what differentiates the perceptual flow in one man from that of another, is found in the pattern of interests and objectives, desires and fears, that emphasize elements and aspects of sensible presentations, enrich them with the individual's associations and memories, and project them into future courses ~~of possible, fruitful activity. In this fashion~~

of possible, fruitful activity. In some such fashion, it would seem, must be explained the differences in the perceptions of men and women, of people in different occupations, different climates, different stages in human history.

Hence, to become a scientific observer is, not to put an end to perception, but to bring the raw materials of one's sensations within a new context. The interests and hopes, desires and fears, of ordinary living have to slip into a background. In their place the detached and disinterested exigences of inquiring intelligence have to enter and assume control. Memories will continue to enrich sensations, but they will be memories of scientific significance. Imagination will continue to prolong the present by anticipating the future, but ~~the~~ anticipations with a practical moment will give way to anticipations that bear on a ~~xxxxx~~ scientific issue. Just as the woodsman, the craftsman, the artist, the expert in any field acquires a spontaneous prceptiveness lacking in other men, so too does the scientific observer.

Still, there is a difference and to it the scientist alludes when he insists that scientific observation is a matter of seeing just what is there to be seen, hearing exactly whatever sounds are sounded, and so forth. This claim cannot, I think, be taken literally, for the impartial and accurate observer, no less than anyone else, is under the dominance of a guiding orientation. None the less, the claim does possess its element of truth, for the guiding orientation of the scientist is the orientation of inquiring intelligence, the orientation that of its nature is a pure, detached, disinterested desire simply to know. ~~It is, then, not by any inert passivity, but by effort and training that the scientific observer becomes an incarnation of inquiring intelligence and his percepts move into coincidence with the data of sense. There is an intellectual desire, an Eros of the mind; inasmuch as it is reinforced or inhibited by other desire, however specious, one may not expect perception data of sense.~~
For there is an intellectual desire, an Eros of the mind. Without it there would arise no questioning, no inquiry, no wonder. Without it there would be no real meaning for such phrases as scientific disinterestedness, scientific detachment, scientific impartiality. Inasmuch as this intellectual drive is dominant, inasmuch as the reinforcing or inhibiting tendencies of other drives are successfully excluded, in that measure the scientific observer becomes an incarnation of inquiring intelligence and his percepts move into coincidence with what are named the data of sense. Accordingly, it is not by sinking into some inert passivity but by positive effort and rigorous training that a man becomes a master of the difficult art of scientific observation.

The Canon of Operations.

2. ~~xxxx~~ Secondly, there is a ~~xxx~~ canon of operations.

Just as inquiry into the data of sense yields insights that are formulated in classical and statistical laws, so inversely the laws provide premises and rules for the guidance of human activity upon sensible objects. Such activity, in its turn, brings about sensible change to bring to light fresh data, raise new questions, stimulate further insights, and so ~~generates additional laws.~~

generate the revision or confirmation of existing laws and in due course the discovery of new laws.

In the first instance, then, the canon of operations is a principle of cumulative expansion. Laws guide activities, which bring forth new laws, which guide further activities, and so forth indefinitely.

Secondly, the canon of operations is a principle of construction. Man knows best what man makes for himself, and so we began our study of insight by examining that elementary artefact, the cart-wheel. But the development of science is followed by a technological expansion, by a vast increase of the things that man can make for himself and so can understand adequately because he has made them. Moreover, the more refined and resourceful technology becomes, the greater the frequency of the artificial synthesis of natural products. Thus, Nature itself becomes understood in the same fashion as man's own artefacts.

Thirdly, the canon of operations is a principle of analysis. Clearly man can analyse the objects that he himself can construct. But it is no less true that he can also analyse objects which, as yet, he cannot manage to construct. For analysis is a mental construction and, where operational control fails, theoretical knowledge can step in to account for the failure of control, to identify the uncontrolled factors, to determine and measure their activity and influence, to discount their perturbing effect, and so to extrapolate to the law that would hold did they not interfere.

Fourthly, the canon of operations is a principle of cumulative verification. For laws guide operations successfully in the measure that they are correct. Inversely, in so far as laws and their implications in a vast variety of situations are repeatedly found successful guides of operations, their initial verification is cumulatively confirmed.

Fifthly, the canon of operations provides a test of the impartiality and accuracy of observations. I do not mean that it makes intellectual detachment and disinterestedness superfluous for, as is clear, the power of the totalitarian state can ~~pack~~ both corrupt the judge and pack the jury. But, when a general conspiracy is absent, when ordinary good will can be presupposed, then the canon of operations, sooner or later, will exhibit on a grand scale in conspicuous failures ~~the mistakes and oversights~~ even slight mistakes and oversights in observation.

Sixthly, the canon of operations is a principle of systematization. Insights yield simple laws, but simple laws are applicable only in pure cases. The law of a free fall holds in a vacuum. But operations do not occur in a vacuum. Hence one is driven to determine the law of air resistance and the laws of friction. Similarly, Boyle's law has to be complemented with Charles' and Gay-Lussac's, and all three need to be corrected by Van der Waal's formula. Thus, the canon of operations is a perpetual recall from the abstract realm of laws to the complexity of the concrete and so to necessity of ever more laws. Nor is this all. A mere congeries of laws will not suffice. For if one is to operate upon the concrete, one must be able to employ at once several laws. To employ several laws at once, one must know the relations of each law to all the others. But to know many laws, not as a mere congeries of distinct empirical generalizations, but in the net-work of inter-relations of each to all the others, is to reach a system.

Seventhly, the canon of operations is a source of higher viewpoints. Already attention has been drawn (Chapter II, #2) to the difference between the circuit of the mathematician and the circuit of the empirical scientist. The mathematician mounts to higher viewpoints inasmuch as the symbolic representation of his previous terms and relations supply the image in which insight grasps the rules of a more comprehensive systematization. But the empirical scientist advances to higher viewpoints, not solely by the construction of symbolic images, but more fundamentally by the expansiveness, the constructiveness, the analyses, the constant checking, and the systematizing tendencies of the canon of operations. In virtue of that canon fresh data are ever being brought to light to force upon scientific consciousness the inadequacies of existing hypotheses and theories, to provide the evidence for their revision and, in the limit, when minor corrections no longer are capable of meeting the issue, to demand the radical transformation of concepts and postulates that is named a higher viewpoint.

3. The Canon of Relevance.

Thirdly, there is a canon of relevance.

The canon of selection and the canon of operations might be regarded as obverse and reverse of the same coin. Both are concerned with the elementary fact that the empirical inquirer is out to understand, not what he may imagine, but what he actually sees. The canon of relevance, on the other hand, aims at stating the type of understanding proper to empirical science.

Now it would be a mistake to say that the empirical scientist has no use whatever for final, material, instrumental, or efficient causes. Inasmuch as he praises the value and utility of science, he speaks of final causes. Inasmuch as he places that value and utility in the technological transformation of raw materials, he knows and acknowledges material and instrumental causes. Inasmuch as he accepts and acts upon the canon of operations, he is an efficient cause engaged in testing his knowledge by its consequences.

However, it also is clear that such types of causality lie not in the core but on the periphery of empirical science. They are the concern, not of pure, but only of applied science. They have to do with the use to which science may be put rather than with the inner constituents of science itself.

The canon of relevance regards such inner constituents. It states that empirical inquiry primarily aims at reaching the intelligibility immanent in the immediate data of sense. Once that intelligibility is reached, one can go on to ask about the value or utility of such knowledge, about the tools that can be fashioned under its guidance, about the transformations of materials man can effect with such tools. But the first step, on which all others rest, is to grasp the intelligibility immanent in the immediate data of sense.

What precisely does the canon mean?

First, it presupposes that the same data can provide a starting-point for different types of insight.

Secondly, it observes that questions about final, material, instrumental, and efficient causality automatically head one away from the data in hand. If I ask about the end of the cart-wheel, I turn to carts and carting and soon find myself involved in the economics of transportation. If I ask about the wood or iron of the cart-wheel, the issue is shortly transposed to forestry and mining. If I ask about the wheelwright's tools, I am led on to discuss technology. If I inquire into the wheelwright himself, I am confronted with the sociology of the division of labor and with the psychology of the motivation of craftsmen.

Thirdly, it also observes that there is a further type of insight that arises immediately from the data. Such is the grasp that precedes and grounds the definition of the circle. Such was Galileo's insight formulated in the law of falling bodies. Such was Kepler's insight formulated in the laws of planetary motion. Such was Newton's insight formulated in the ~~general~~ theory of universal gravitation. Such has been the point in the now well established technique of measuring and correlating measurements. Such is the goal of the classical heuristic structure that seeks to determine some unknown function by working out the differential equations, of which the unknown function will be a solution, and by imposing by postulation such principles as invariance and equivalence.

Fourthly, it notes that this intelligibility, immanent in the immediate data of sense, resides in the relations of things, not to our senses, but to one another. Thus, mechanics studies the relations of masses, not to our senses, but to one another. Physics studies the relations of types of energy, not to our senses, but to one another. Chemistry defines its elements, not by their relations to our senses, but by their places in the pattern of relationships named the periodic table. Biology has become an explanatory science by viewing all living forms as related to one another in that complex and comprehensive fashion that is summarily denoted by the single word, evolution.

Fifthly, it notes that this intelligibility is hypothetical. It does not impose itself upon us, as does the multiplication table or the binomial theorem. It announces itself as a possibility, as what could be the relevant correlation or function or law. Now the necessary must be, but the possible, though it can be, in fact may or may not be. Hence, empirical science rests upon two distinct grounds. As insight grasping possibility, it is science. As verification selecting the possibilities that in fact are realized, it is empirical.

There is, then, an intelligibility immanent in the immediate data of sense; it resides in the relations of things, not to our senses, but to one another; it consists, not in an absolute necessity, but in a realized possibility.

Ought there not be introduced a technical term to denote this type of intelligibility? The trouble is that the appropriate technical term has long existed but also has long been misunderstood. For the intelligibility that is neither final nor material nor instrumental nor efficient causality is, of course, formal causality. But when one speaks of formal causality, some people are bound to assume that one means something connected with formal logic; others are bound to assume that one means ~~many~~ merely the heuristic notion of the "nature of...," the "such as to...," the "sort of thing that...." If both of these misinterpretations are excluded, what we have called the intelligibility immanent in sensible data and residing in the relations of things to one another, might be named more briefly formal causality or, rather, perhaps, a species of formal causality.

4. The Canon of Parsimony.

Fourthly, there is a canon of parsimony.

It is at once obvious and difficult. It is obvious inasmuch as it forbids the empirical scientist to affirm what, as an empirical scientist, he does not know. It is difficult inasmuch as knowing exactly what one knows and what one does not know has been reputed, since the days of Socrates, a rare achievement. None the less, some account of this fundamental canon must be attempted at once, even though its full meaning and implications can come to light only later.

On the previous analysis, then, empirical method involves four distinct elements, namely, 1) the observation of data, 2) insight into data, 3) the formulation of the insight or set of insights, and 4) the verification of the formulations.

Now, the empirical investigator cannot be said to know what is not verified and he cannot be said to be able to know the unverifiable. Because, then, verification is essential to his method, the canon of parsimony in its most elementary form excludes from scientific affirmation all statements that are unverified and, still more so, all that are unverifiable.

~~Next, what is verified is the formulation, and all formulations~~ may be reduced to terms and relations. Further, as has been seen, relations are of two kinds. There are the relations of things to our senses and the relations of things to one another. But all definition is some sort of relation. It follows that, in general, there will be two types of terms, namely, 1) terms defined by the relations of things to our senses, and 2) terms defined by the relations of things to one another.

Now at this point it would be extremely convenient if it were possible to say just what is meant by the name, "thing." Unfortunately that is a complex issue that must be postponed. So, to obviate this difficulty, let us introduce the technical term, "conjugate," and draw a distinction between "experiential" and "pure" conjugates.

In general, then, conjugates are terms implicitly defined by their relations to one another.

Experiential conjugates are terms implicitly defined by relations of the first type that hitherto have been referred to as relations of things to our senses.

Pure conjugates, on the other hand, are terms implicitly defined by relations of the second type that hitherto have been referred to as relations of things to one another.

The meaning of the expression, implicit definition, has been noted already (2.8).

Classical Laws.

4.1 Secondly, verification is of formulations, and formulations state 1) the relations of things to our senses and 2) the relations of things to one another. It follows that formulations contain two types of terms which may be ~~dens~~ named respectively experiential conjugates and pure explanatory conjugates.

Experiential conjugates are correlatives whose meaning is expressed, at least in the last analysis, by appealing to the content of some ~~x~~ human experience.

Thus, "colors" will be experiential conjugates when defined by appealing to visual experience; "sounds" when defined by appealing to auditory experiences; "heat" when defined by appealing to tactile experience; "force" when defined by appealing to an experience of effort, resistance, or pressure.

It is clear enough that experiential conjugates satisfy the canon of parsimony. The fundamental set of such terms is verified, not only by scientists, but also by the secular experience of humanity. Scientists add further terms in virtue of their specific preoccupation but as long as these terms satisfy the definition of the experiential conjugate, they will be in principle verifiable.

Pure explanatory conjugates, on the other hand, are correlatives defined implicitly by empirically established correlations, functions, laws, theories, systems.

Thus, masses might be defined as the correlatives implicit in Newton's law of inverse squares. Then, there would be a pattern of relationships constituted by the verified equation; the pattern of relationships would fix the meaning of the pair of coefficients, m_1, m_2; and the meaning so determined would be the meaning of the name, mass. In like manner heat might be defined implicitly by the first law of thermodynamics and the electric and magnetic field intensities, E and H, might be regarded as vector quantities defined by Maxwell's equations for the electro-magnetic field. (See on this point Lindsay and Margenau, p. 310).

Now such pure conjugates satisfy the canon of parsimony. For the equations are or can be established empirically. And by definition pure conjugates mean no more than necessarily is implicit in the meaning of such verified equations.

~~It may be well to draw attention to the versatility of the pure con~~jugate. Just as it is defined initially by selecting some verified equation as basic, so the definition may be modified or enriched by the addition of further verified equations. Thus, one might say that "mass" is defined implicitly by the laws of force, impact, the lever, and universal gravitation. Moreover, just as Newtonian mechanics as a whole may be said to define "mass" implicitly, so the shift from Newtonian to Relativity mechanics will automatically effect the necessary redefinition of the notion of "mass."

However, there does arise a difficulty. If experiential conjugates are obviously verifiable, pure conjugates, since they appear to be non-experiential, may seem to be non-verifiable as well. Let us attack this fallacy at its root, namely, in its plausible identification of the experiential and the verifiable. There are contents of experience and they are experiential in a rigorous sense. There~~x~~ are combinations of contents of experience, for instance, an extension and along it a yardstick. There are combinations of such combinations represented, for instance, by points plotted on a graph. Thus, in a secondary sense of the experiential, there are combinations ~~of combinations of combinations, &c., &c., of experiential~~

There is, however, a difference between the mode of verifying pure conjugates and the mode of verifying experiential conjugates. For the experiential conjugate is either a content of experience, such as seeing red or touching extension, or else a correlative to such a content, for instance, red as seen or extension as touched, of finally a derivative of such correlatives, as would be the red that could be seen or the extension that could be touched. On the other hand, the pure conjugate has its verification, not in contents of experience nor in their actual or potential correlatives, but only in combinations of such contents and correlatives. I see, for instance, a series of extensions and alongside each I see a yard-stick; from the series of combinations I obtain a series of measurements; from another series of combinations I obtain another series of measurements; from the correlation of the two series, together with the leap of insight, I am led to posit as probably realized some continuous function; pure conjugates are the minimal ~~correlatives~~ correlatives implicit in such functions; and their verification finds its ground, not in experiences as such, but only in the combination of combinations, &c., &c., of experiences.

As the reader will have noted, the definitions of pure and experiential conjugates drop all mention of things whether related to one another or to our senses. The reason for this omission is that the notion of the "thing" is highly ambiguous and, as yet, we are unprepared to apply the canon of parsimony to it (see Ch. VIII). However, though the notion of thing has been omitted, the point of the distinction between the relations of things to one another and to our senses remains. For in every experience one may distinguish between content and act, between the seen and the seeing, the heard and the hearing, the tasted and the tasting, and so forth. Let us represent, then, any series of experiences by the series of pairs, AA', BB', CC',..., where the unprimed letters denote contents and primed letters denote the corresponding acts. Now correlations may be reached by combining the unprimed components, A, B, C,..., or by combining the primed components, A', B', C',..., or by combining both primed and ~~unprimed~~ unprimed components. In the first case one will deal with the relations of contents to one another and one will prescind from the corresponding acts; and in this fashion, without any mention of things, one deals with what hitherto has been named the relations of things to one another. In the second case, one will prescind from contents and correlate acts, to obtain a psychological or cognitional theory. In the third case one will be employing experiential conjugates and further information will be needed to settle whether one is working towards the goal of natural science or of cognitional theory.

Further, as this analysis reveals, there are only three basic alternatives. Either one's terms are experiential conjugates or else they are pure conjugates based on combining contents/ alone/ or finally they are a special case of pure conjugates based on combining acts alone. Still, theoretical analysis is one thing, and concrete practice is another. Thus, one would be inclined to say that physicists move easily and unconsciously ~~from the~~ back and forth between the use of experiential and pure conjugates. When they are called upon to define their terms, commonly they will suppose that definition comes at the beginning and so offer definitions of experiential conjugates. On the other hand, methodologists and theorists of empirical science will be puzzled by the multiplicity of definitions available in a mature science and so they tend to disagree with one another.

Thus, E Cassirer in his well-known Substance and Function emphasizes the relational and serial aspect of scientific terms. V. Lenzen in his Nature of Physical Theory emphasizes the genetic process that begins from experiential contents of force, heat, extension, duration, &c., to move through a process of redefinition towards terms implicitly defined by empirically established principles and laws. Finally, Lindsay and Margenau in their Foundations of Physics, while they are more concerned with ideas than concepts, may be said to exhibit a preference for terms implicitly defined by equations.

For our purposes it would seem to be sufficient to reveal the materials which scientists and theorists of science employ in differ manners and to show that these materials, despite incidental variations, satisfy the canon of parsimony.

4.2 Statistical Laws. However, besides classical laws, there also are statistical laws; and since the latter as well as the former are verifiable, it would seem that, besides pure and experiential conjugates, one must also recognize events. When the demonstrator in a lecture room propounds a law of nature and proceeds to illustrate it by an experiment, he does not inform his class that the law will be refuted if the experiment does not work. On the contrary, he points out that the law retains its validity even if it happens that the experiment ~~xxxx~~ is ~~#~~ a failure. And members of the class may add interest to the proceedings by determining the statistical law of the demonstrator's successes. The law of nature, then, is one thing. The event of its illustration is another. And such events are subject to laws of a ~~diffe~~ different type which is named statistical.

What, then, is an event? The simplest answer is to say that it is a primitive notion too simple and obvious to be explained. Still, all primitive notions, however simple and obvious, are related to other equally primitive notions, and the set may be fixed by offering the data in which insight may grasp the relations.

~~Consider, then, the classification of questions.~~ ~~There are questions~~ ~~mf~~ for intelligence and questions for reflection; the former ~~cannon~~ cannot, the latter can, be answered appropriately by a simple Yes or No; for example, What is the law of falling bodies? Do bodies fall according to Galileo's law?

Secondly, questions for reflection can be pure or mixed. They are mixed, if what is to be affirmed or denied is the answer to some question for intelligence. Thus, if I affirm that in a vacuum bodies fall according to Galileo's law, then I affirm the verification of the answer to the question, what is Galileo's law? On the other hand, questions for reflection are pure if what is to be affirmed or denied is simply what can be meant only by affirming or denying. Thus, ~~thexquestions~~ pure questions for ~~rela~~ reflection are illustrated by asking, Did the apple fall on Newton's head? Did any apple exist? For then I am asking about occurrence or existence, about pure fact, about the ultimate increment that accrues to knowledge through the assent of Yes or the dissent of No. Every occurrence and every existence has some specification, and that is known by asking the questions for intelligence, What is it? What happened? But once the specification is supposed, one can ask two questions, the mixed question whether the specification is correct, and the pure question whether an instance of the specification exists or occurs.

Events, then, are what are meant by ~~ask~~ answering pure questions ~~for reflection affirmatively.~~

Let us begin, then, by formulating our answer. Events stand to conjugates as questions for reflection stand to questions for intelligence.

What is meant by a conjugate has been explained.

Moreover, knowledge of conjugates results from a process of inquiry, of asking questions; and the relevant questions all have the peculiarity that none of them can be answered appropriately by simply saying either Yes or No. Thus, when one asks what is the "nature of...," the "sort of thing that...," the "such as to...," the correlation to be specified, the indeterminate function to be determined, it is always meaningless to answer either Yes or No. One is called upon to state the nature, specify the correlation, determine the function, and that can be done only by achieving the insights that ground the formulation, first, of experiential and, later, of pure conjugates.

But for every answer to a question for intelligence, there is a corresponding question for reflection; and all questions for reflection have the peculiarity that they c~~anxx~~ be answered appropriately simply by saying either Yes or No. If I ask what a body is, I can also ask whether there are bodies. If I ask how bodies fall, I can also ask whether bodies fall. If I ask how bodies would fall in a vacuum, I can also ask whether any bodies ever fall in a vacuum. Generally, the enunciation of every law can be followed by the question for reflection that asks whether the law is verified, and the definition of every term can be followed by the question for reflection whether the defined exists or occurs. Inversely, whenever one asserts verification or existence or occurrence, one may be asked what is verified, what exists, what occurs.

Thus, questions for intelligence and questions for reflection are universally concomitant and complementary.

There is a parallel concomitance and complementarity between conjugates and ~~xx~~ events. Without events, conjugates can be neither discovered nor verified. Without conjugates, events can be neither disinguished nor/related. Such, I submit, is the elementary scheme in which insight can grasp what is ~~mxmt~~ meant by the otherwise puzzling name, event.

Now formulations that concern events satisfy the canon of parsimony. For probability expectations or statistical laws are formulations that answer the question for intelligence, How often? They concern events, for the frequency they assign is a frequency of events. Finally, the frequency assigned by a statistical law is verifiable: for the assigned frequency is an ideal frequency; it is distinct from the actual frequencies that can diverge from it in non-systematic fashion; and it can be verified by appealing to those actual frequencies.

At this point our account of the canon of ~~paxx~~ parsimony must be brought to a close. As the reader will have observed, attention has been confined to the positive aspects of the canon, to the experiential conjugates, the pure conjugates, and the events that are the terms of verifiable formulations. Whether things and their existence satisfy the canon, is a further issue on which we have not touched. On the ~~xthxxh~~ other hand, the negative or exclusive aspects of the canon, though they constitute its chief significance and utility, are too numerous to be mentioned and can best be dealt with incidentally when occasion arises.

5. The Canon of Complete Explanation.

~~Ov85~~ Fifthly, there is a canon of complete explanation.

The goal of empirical method is commonly stated to be the complete explanation of all phenomena or data.

In a sense ~~thisxxaxx~~ perseverance in the pursuit of this goal is assured by the canon of selection es~~c~~ecially when it is implemented by the canon of operations. Any particular investigator may overlook or ignore certain data. But his oversight or disregard will normally be corrected by other investigators substantiating their hypotheses and refuting those of their predecessors by appealing to hitherto ~~xxgxx~~ neglected facts.

None the less, a separate enunciation of this canon is relevant particularly at the present time when a mistaken twist given to scientific method at the Renaissance ~~is~~ finally is being overcome.

Where we distinguished between experiential and pure conjugates, Galileo distinguished between secondary and primary qualities. Secondary qualities were the merely subjective appearances that arise in an animal's senses as a result of the action of other primary ~~qualitie~~ qualities; such appearances were illustrated by color as seen, sounds as heard, heat as felt, tickling as experienced, and the like. Primary qualities, on the other hand, were the mathematical dimensions of the real and objective, of matter in motion. Hence, while we would place scientific progress in the movement from experiential to pure conjugates, Galileo placed it in the reduction of the merely apparent secondary qualities to their real and objective source in primary qualities.

The crucial difference between the two positions regards space and time. For Galileo they were primary qualities, for there would be extension and duration if there were matter and motion and whether or not any ~~xxx~~ animals with their sensitive experiences existed. For us, on the other hand, ~~xxx~~ there is to be drawn the same distinction between extension and duration as experiential and as pure conjugates as there is to be drawn between the two formulations of colors or sound or heat or electric phenomena.

As experiential conju~~x~~gates, extensions and durations are defined as correlative to certain familiar elements within our experience.

As pure conjugates, extension and duration are defined implicitly by the postulate that the principles and laws of physics are invariant under ~~inxxxx~~ inertial or, generally, under continuous transformations.

Thus, on our analysis, the space-time of Relativity stands to the extensions and durations of experience in exactly the same relations as wave-lengths of light stand to experiences of color, as longitudinal waves in air stand to experiences of sound, as the type of energy defined by the first law of thermodynamics stands to experiences of ~~hxx~~ heat, &c., &c.

Moreover, in our analysis, this conclusion rests upon the canon of complete explanation. All data are to be explained. The explanation of data consists in a process from experiential conjugates towards pure conjugates. Therefore, from extensions and durations as experienced there must be a process to extensions and durations as implicitly defined by empirically established laws.

Further, as extension and duration, so also local movement has a preliminary definition in terms of experiential conjugates and an explanatory definition in terms of pure conjugates. It was an obvious and excusable procedure for Galileo and Kepler and Newton to conceive local movement in the two steps of determining a path or trajectory and then correlating points on the path with instants of time. After all, when a man crosses the street, we see at once the whole distance that he traverses but we apprehend the duration of his movement as concomitant with the duration of our watching. None the less, this account of local movement can be no more than preliminary for, ~~thought~~ throughout, it is in terms of movement as related to us, as in terms of experiential conjugates. What movement is, when movements are defined in terms of their relations to one another, is another ~~xxxxxx~~ question. The answer to it will depend upon the answer that determines extensions and durations as pure conjugates; and so it is that Relativity mechanics conceives a velocity, not as a function of three dimensions with time as a parameter, but as a function of four dimensions, of which three are spatial and the fourth temporal.

If we add the canon of parsimony to the canon of complete explanation, more fundamental objections to the Galilean theory of scientific explanation come to light.

Both experiential and pure conjugates are verifiable, and in so far as either ~~is~~ are verified, they possess an equal claim upon reasonable affirmation. It follows that Galileo's repudiation of secondary qualities as mere appearance is a rejection of the verifiable as mere appearance.

~~Inversely, Galileo does not base his affirmation of the xx reality and objectivity of primary qualities by claiming that empirical science has verified or will verify them as he understands and defines them. On the contrary, he does not await any pronouncement of scientific method on the issue; and if his followers do, then they have the choice.~~

Inversely, Galileo did not base his affirmation of the reality and objectivity of primary qualities upon a claim that these qualities, as he defined them, were verifiable or verified. Accordingly, his assertion of that reality and objectivity was extra-scientific, for it made no appeal to verification and so did not satisfy the canon of parsimony. On the other hand, anyone that today ~~will~~ might try to bring the Galilean position in line with the canon of parsimony, would first of all have to settle an account with Einstein who has made various proposals regarding the space-time of physics and has some grounds for considering his line of thought verifiable and, to some extent, verified.

Then follow pp 52a, 52b (written.

6. The Canon of Statistical Residues

Sixthly, there is a canon of statistical residues. It presupposes the existence of inquiry of the classical type and from that premise it concludes to the existence of residues that call for statistical inquiry.

6.1 The General Argument.

The basic distinction is between abstract system and particular cases. Both are the objects of insight. But the particular case is the typical instance, presented by sense or imagination, and understood by insight into the presentation. In contrast, the abstract system is neither sensible nor imaginable; it is a conceptual object constituted by terms and relations that, at least in the last resort, are defined implicitly.

Particular cases are relevant both to the genesis and to the application of abstract system. For the formulation of system comes at the end of a cumulative series of insights into different particular cases. Again, once abstract system is formulated, it can be applied to concrete situations only in so far as there occur insights into the situations as sensibly given; for without such insights there cannot be selected the relevant laws of abstract system, there cannot be determined the mode in which the laws combine in the concrete situation, and there cannot be substituted ~~some~~ numerical values for the variables and undetermined constants of the general formulae.

Now let us suppose full knowledge of all classical principles and laws. Then we suppose full knowledge of abstract system; for principles and laws are relations; such relations necessarily involve the terms that they define implicitly; and abstract system consists in terms implicitly defined by the relations expressed in verified principles and laws.

However, if the full knowledge of abstract system is to be applied to the concrete universe, there will be needed a manifold of insights into particular cases. For, as was noted above, abstract system is applied to concrete situations only inasmuch as insight into the situations selects the relevant laws, determines the mode of their combination, and substitutes numerical values for the variables and undetermined constants of the laws.

Still the manifold of particular cases is enormous, and so there arises the question whether it can be ~~cast~~ cast into some ordered sequence. If it can, then knowledge of the sequence and of a few strategically chosen particular cases would suffice to transform mastery of abstract system into a scientific understanding of the universe. But if it cannot, if the manifold of particular cases does not form any kind of ordered sequence, then abstract system can be applied only to a limited range of particular cases, and new methods must be found if we are to reach an understanding of the concrete universe as a whole.

In fact, it can be shown that ~~they do~~ there do exist recurrent particular cases. For example, our planetary system is periodic; it is an individual set of masses; most of them are visible; and a relatively small number of concrete insights make it possible to determine an indefinite number of particular cases.

On the other hand, while such schemes of recurrence are many, not only in number but also in kind, still each presupposes materials in a suitable constellation that the scheme did not bring about, and each survives only as long as extraneous disrupting factors do not intervene. The periodicity of the planetary system does not account for its origin and cannot guarantee its survival.

Moreover, there does not seem to exist any universal scheme that controls the emergence and survival of the schemes that we know. Accordingly, in the last analysis we are driven to accept the second alternative. There does not exist a single ordered sequence that embraces the totality of particular cases through which abstract system might be applied to the concrete universe. In other words, though all events are linked ~~together by law~~ to one another by law, still the laws reveal only the abstract component in concrete relations; the further concrete component, though mastered by insight into particular cases, is involved in the empirical residue from which systematizing intelligence abstracts; it does not admit general treatment along classical lines; it is a residue left over after classical method has been applied, and it calls for the implementation of statistical method.

Such is the general argument, and a more detailed account of its meaning now has to be attempted.

6.2. The Notion of Abstraction. A first task ... etc

~~Such in outline is the canon of statistical residues.~~ It hews a middle course between determinism and ~~indeterm~~ indeterminism. It admits classical laws and grants them exactitude, but it confines this exactitude to an abstract order. It admits statistical laws and grants them an objective basis, but it finds this basis, not in an objective indeterminacy, but in an objective defect of systematic relationship.

The Notion of Abstraction

6.2 A first task is to clarify the notion of abstraction. On a simple and common view, the abstract is an impoverished replica of the concrete. "Red" means what is common to all instances of "red." "Man" means what is common to all instances of "man." That is all there is to it.

Now with this view of abstraction, one can admit classical laws and one can admit statistical laws but one will be at a loss to determine some coherent manner in which both classical and statistical laws can be acknowledged. This may be shown as follows.

Let A, B, C,... denote sensible data, and let a, a', a",... b, b', b",... c, c', c",... denote the totality of their impoverished replicas. Then, there is no aspect of sensible data without its impoverished replica; inversely, the totality of sensible data can be constructed out of the totality of impoverished replicas.

Hence, if one admits some classical laws, one admits that some impoverished replicas are related systematically. Moreover, if one admits the classical laws as objective, there must be systematic relations not only between the impoverished replicas but also between the concrete aspects of sensible data to which they correspond. It follows that the classical laws can be objective only if they hold in the concrete. Finally, it will ~~only~~ be only by denying the canon of complete explanation of all data, that one can admit systematic relations between some impoverished replicas and deny systematic relations between others. ~~The~~ It will follow that they only laws will be classical laws, and that statistical laws cannot be more than a cloak for ignorance.

Inversely, if one admits some statistical laws, then one denies systematic relations between some impoverished replicas. If the statistical laws are objective, there cannot be systematic relations between the corresponding aspects of sensible data. At least in those cases, classical laws are excluded. Moreover, to show that classical laws are not merely the macroscopic illusion resulting from a multitude of microscopic, random occurrences, a correct theory of the abstract is needed; and in the present hypothesis, that correct theory is lacking.

What is, then, the correct theory?

So far from being a mere impoverishment of the data of sense, abstraction in all its essential moments is enriching. Its first moment is an enriching anticipation of an intelligibility to be added to sensible presentations: there is something to be known by insight. Its second moment is the erection of heuristic structures and the attainment of insight to reveal in the data what is variously named as the significant, the relevant, the important, the essential, the idea, the form. Its third moment is the formulation of the intelligibility that insight has revealed. Only in this third moment does there appear the negative aspect of abstraction, namely, the omission of the insignificant, the irrelevant, the negligible, the incidental, the merely empirical residue. Moreover, this omission is neither absolute nor definitive. For the empirical residue possesses the universal property of being what intelligence abstracts from. Such a universal property provides the basis for a second set of heuristic procedures that take their stand on the simple premise that the non-systematic cannot be systematized.

Now our whole effort has been to draw attention to the fact of insight, to the enriching moments on which abstraction follows. Accordingly, it is in this sense that we affirm classical laws to be abstract, and it is in this sense that a canon of statistical residues transforms the issue of ~~cuts a middle path between~~ determinism ~~and~~ indeterminism. So far from being an impoverishment of sensible data, abstraction is an enrichment that goes beyond them. Because abstraction goes beyond the sensible field, the frontiers of the abstract are not coterminous with the frontiers of the experienced. Hence, full and exact knowledge of the systems to be reached by abstraction by no means denies the existence of an empirical residue that is non-systematic. Again, just as in abstraction we prescind from that empirical residue, so when we come to the concrete applications of abstract principles and laws, we are forced to take into account the non-systematic conditions under which the systematic has its concrete realization.

The Abstractness of Classical Laws.

6.3 In the second place, it may be well to recall that classical laws are abstract 1) in their heuristic anticipation, 2) in the experimental techniques of their discovery, 3) in their formulation, and 4) in their verification.

They are abstract in their heuristic anticipation. For that anticipation rests on the detached and disinterested drive of inquiry, and it consists in a pure desire to understand. Hence the canon of relevance demands that one seek the immanent intelligibility of the data; the canon of parsimony demands that one add to the data no more than the formulation of what is grasped by understanding and verified; and the canon of complete explanation demands that this parsimonious addition of intelligibility be effected for all data. Moreover, this anticipated enrichment is seen to be universal: the nature to be known will be the same for all data that are not significantly different, and the correlation to be specified is reached only if it holds for all parallel instances.

Secondly, classical laws are abstract in the experimental techniques of their discovery. For the experimenter makes no pretence to deal with concrete situations in their native complexity; on the contrary, he aims overtly at reducing that complexity to a minimum and so he does all he can to bring the concrete into some approximation to an ideal, typical, definable conjunction of materials and agents. Accordingly, as he begins with an effort to secure materials from which all impurities have been removed, so he ends with an argument that rests on their theoretical definitions. As he begins by requiring instruments constructed in accord with accurate specifications, so he ends by interpreting their performance on the basis of their ideal, often schematic, structure. He measures, but he does so many times, and his accepted result is just the probable mean of actual results. He reaches a conclusion with which others agree, but the agreement makes particular

particular

one

allowance for the intrusion of extraneous factors and it acknowledges no more than a limited number of significant decimal places. At every turn it seems apparent that the concern of experiment is to determine, not the ~~observale~~ observable qualities of the materials with which ~~he~~ deals, but a theoretical correlation between definable and abstract entities.

Thirdly, classical laws are abstract in their formulation. As laws, they are correlations linking correlatives, and the correlatives are never the unique data of some particular time and place. Indeed, they are not even generalized data, but generalized combinations of combinations of combinations of data. Nor may one suppose that the data, taken in these serial combinations, uniquely determine what the law must be. For the discontinuous ~~serx~~ set of observations, represented, say, by ~~x~~ points on a graph, can be satisfied by any number of laws, of which the scientist ~~h~~ chooses the one that, all things considered, he reputes to be the simplest. Enriching abstraction is still at work.

Fourthly, classical laws are abstract in their verification. For verification is reached, not by appealing to this or a that isolated instance, but by securing as large and various range of instances as both direct and indirect procedures make possible. It follows that what is verified is, not this or that particular proposition, but the general, abstract formulation that alone admits the large and various range of applications. Again, to repeat the argument from another viewpoint, what is verified is what can be refuted or revised. What can be refuted or revised, is the general, abstract formulation~~x~~. And so what is verified is the general, abstract formulation.

~~6.4 In the third place, an objection must be met. Granted that classical laws, as we know them, are abstract, still we do not possess complete and exact knowledge of all classical laws. As long as knowledge is incomplete, it cannot but disregard certain aspects of the data. But by the sole fact that it is complete, no aspects of the data will be overlooked; and if no aspects are overlooked, Taken singly, classical laws are abstract~~

Systematic Unification and Imaginative Synthesis

6.4 In the third place, an objection must be met. Taken singly, classical laws are abstract. But what is true of single laws, need not be true of the totality of laws. The single laws are abstract because they do not cover the totality of aspects of the data. But the totality of laws would cover that totality of aspects, and so the totality would be not abstract but ~~complete~~ concrete.

Now this objection may be merely a reversion to the assumption that abstraction ~~is~~ yields merely an impoverished replica of sensible data. In that case, it has been ~~mt~~ met already. For the totality of aspects of data explained by the totality of classical laws will not include the aspects that we have named an empirical residue (see Chapter I, §5). Even when all classical laws are known, individuality and continuity, particular place and particular time, will ~~be~~ be not explained but abstracted from.

However, the objection may be advanced by those that grant abstraction to be not impoverishing but enriching. They will point out that the canon of operations forces empirical inquiry to go beyond the mere aggregation of isolated laws to the development of systems. It is not enough to know the law of falling bodies, the law of air resistance, the law of friction. One also has to know how to apply these laws simultaneously if one is to solve/practical problems. Hence, the ~~discovxyxs~~ discovery of laws has to be accompanied by the ~~discovery~~ discovery of correlations between laws and, ~~of~~ no less, of correlations between the correlations. There exists, then, a movement towards the systematic unification of ~~all laws~~ classical laws and, as this unification is prompted by concrete problems, one may expect that, when all laws are known exactly and completely, there ~~will~~ also will be known a systematic unification commensurate with world process~~x~~ in its concrete, historical unfolding.

This consideration is, I think, impressive. But, strangely enough, world process in its concrete, historical unfolding rather conspicuously makes a large and generous use of the statistical techniques of large numbers and long intervals of time; it exhibits not a rigid but a fluid stability; it brings forth novelty and ~~eve~~ development; it ~~also~~ makes false starts and suffers break-downs. It would seem, then, that an understanding of the concrete unfolding of world process ~~will be, not exclusively in terms of classical laws,~~ will not be based exclusively on classical laws, however exactly and completely known, but in a fundamental manner will appeal to statistical laws.

~~Facts force us to a scrutiny~~

Accordingly, facts force us to a closer scrutiny of the argument from the systematic unification of laws, and the scrutiny brings to light an underlying ambiguity. It is one thing to attain a systematic unification; it is another to reach an imaginative synthesis. Thus, Riemannian geometry is a systematic unification, for it provides a single set of principles and techniques for dealing with n-dimensional manifolds of various curvatures. But Riemannian geometry is not an imaginative synthesis for we cannot imagine more than three dimensions and we normally imagine only flat space. Again, Ptolemy and Copernicus possessed imaginative syntheses of celestial movements; but the laws of those movements were discovered by Galileo and Kepler, and the systematic unification of the laws was the achievement of Newtonian mechanics. To offer another example, nineteenth century physicists made a notable series of efforts to construct an imaginable model of the aether (see E. T. Whittaker, A History of the Theories of Aether and Electricity, Dublin University Press, Longmans, London, 1911). But the fruit of their labors was a systematic set of equations verifiable in pointer readings. Today one may prefer Einstein, who clings to determinist views, or one may join the majority, who regard Quantum Mechanics as satisfactory. But neither alternative offers an imaginative synthesis. For Einstein offers a set of unsolved differential equations for a four-dimensional, curved manifold, and Quantum Mechanics, as it originated by giving up the attempt to carry through N. Bohr's model of the atom, so now it refuses to portray the objective process that leads up to observables.

There is, then, a difference between systematic unification and imaginative synthesis. Systematic unification is effected in the logical or conceptual order. It is attained when the totality of laws is reduced to minimum sets of defined terms and postulates, so that any law can be related to any other, and any aggregate of laws can be intelligibly combined and simultaneously employed. On the other hand, an imaginative synthesis is secured when images, informed by insight, are altered in accord with known laws. In this fashion one may imagine the sun, the planets, and their satellites in appropriate collocations and understand their imagined movements in accord with mechanical laws. Clearly, such imaginative synthesis goes beyond the abstract content of the laws and supposes that certain bodies exist in certain relative positions with velocities less than the velocity of escape. One has passed from the tasks of pure science; one has introduced the suppositions and the facts that pertain to applied science. Now the ultimate attainment of a systematic unification of classical laws will not settle any particular matters of fact, and so that ultimate attainment cannot include an imaginative synthesis.

As systematic unification does not include imaginative synthesis, so it does not even guarantee its possibility. It is true enough that images are necessary for the emergence of insights, but the images may be not representative but symbolic, not pictures of the visible universe but mathematical notations on pieces of paper. Even if one supposed that, just as the image of the cart-wheel approximates to the definition of the circle, so some representative image approximated to every classical law, none the less it would not follow that the aggregate of approximate images might somehow coalesce into a composite picture that approximated to the systematic unification of all laws.

~~Accordingly, against the objection, there stands its internal inconclusiveness~~

The objection, then, breaks down on two points. In itself, it is inconclusive. Knowledge of all classical laws would be an understanding of the concrete only if it included a vast imaginative synthesis. It is true that empirical inquiry heads for a systematic unification of its laws. But there is no evidence that such a systematic unification ensures the possibility of any imaginative synthesis. Moreover, if the totality of classical laws provided an understanding of the concrete, statistical laws would be superfluous. But the conspicuous use of statistical techniques in world process shows that statistical laws are not superfluous in an understanding of our universe.

The Existence of Statistical Residues

6.5 In the fourth place, an attempt must be made to indicate more precisely both the indeterminacy of ~~the~~ abstract classical laws and the consequent statistical residues. Hence it will be argued 1) that classical laws hold in concrete instances only inasmuch as conditions are fulfilled, 2) that the conditions to be fulfilled form diverging series, and 3) that the patterns of such diverging series are a non-systematic aggregate.

Classical Laws Conditional

6.51 First, it is possible to apply classical laws to concrete situations and thereby reach conditioned predictions.

For example, if two motor-cars are headed for the same spot, if their distances from the spot and their speeds are equal, then they will collide, provided they do not alter their directions or speeds, and provided that no obstacles force them to do so.

Similarly, in the general case, an event, Z, can be concluded from prior circumstances, Y, provided some P, Q, R,... continue to occur and provided some U, V, W,... do not intervene.

Secondly, the necessity of positing conditions is universal. For the link between the antecedent circumstances and the consequent event ~~is~~ rests on abstract classical law. Just as the discovery of such laws rests on an experimental exclusion of extraneous factors, just as their verification stands despite contrary instances in which extraneous factors are not excluded, so when one returns from the abstract to concrete applications, the possible existence of extraneous factors has to be taken into account.

Thirdly, when the deduced or predicted event is fully determinate, then the conditions must be fulfilled right up to the occurrence of the event.

To return to the example of the two motor-cars, it is one thing to infer or predict a collision, and it is quite another to infer or predict that a first contact will be between a very small area, P, on one car and a similar very small area, Q, on the other. If the cars are travelling at sixty miles an hour and at the present instant they are just one inch apart, one might say that a collision is inevitable. No matter what happens in the remaining fraction of a second, there will be some impact. But under the same assumptions one cannot offer to drop all provisos and yet predict a first contact between specified ~~areas~~ small areas. For in the last fraction of a second there could occur some alteration of the speed or direction or swaying of either car; and that alteration would upset the prediction.

The Diverging Series of Conditions

6.52 Next, in the general case, conditions form a diverging series.

For in the general case, any event, Z, is deducible from antecedent circumstances, Y, provided some P, Q, R,... continue to occur and provided some U, V, W,... do not intervene.

It follows that the occurrence of the P, Q, R,... and the non-occurrence of the U, V, W,... are similarly deducible.

It follows further that the occurrence of, say, P is conditioned by the occurrences, A, B, C,... and the non-occurrences, G, H, I,... Similarly, there will be series of positive and negative conditions for Q, R,... and for U, V, W,... Similarly, each term in these series will have its series of positive and negative conditions, and so forth.

Such, then, is the diverging series of conditions. Any event, Z, will occur on the fulfilment of a set of conditions. Each condition in the set will be fulfilled on the fulfilment of its additional set of conditions. Since there are no unconditioned events, there are no unconditioned fulfilments of conditions. Since there are no unconditioned fulfilments of conditions, the diverging series has as many removes as one cares to explore. Finally, since each event ordinarily has several conditions, the series ~~always~~ ordinarily diverges.

Certain further properties of the diverging series of conditions may be noted immediately.

Just as the series diverges when one goes back from an event, Z, to its antecedents, so it converges when one advances from the antecedents to the event. Accordingly, if one were to suppose that the concrete pattern of the diverging series had been worked out to some nth remove and if one ascertained the fulfilment of all the conditions at that remove, then one's enormous labor would yield no more than the deduction of the event, Z, and the intervening occurrences and non-occurrences. So far from promising the deduction of all world situations from a single situation, this structure offers no more than the deduction of a converging series of events from ~~a world situation~~ as large a set of initial observations as one pleases.

Moreover, the conditions of any event, Z, at any nth remove are scattered in space and in time. They are scattered in space, inasmuch as the occurrences and non-occurrences conditioning the event, Z, whether directly or indirectly, proximately or remotely, may be found in any direction and at any distance from the event, Z. They are scattered in time, inasmuch as the influence from the condition to the conditioned is propagated with a finite velocity and, in different cases, traverses either different distances with equal speeds or unequal distances with equal speeds. Evidently, this scattering of the conditions makes it imperative to know beforehand the aggregate of concrete patterns of diverging series of conditions for events of all kinds; otherwise, one would not know which observations to assemble into the conditions at some nth remove for some specific event.

~~6.53 Unfortunately, the aggregate of concrete patterns of diverging series of conditions for events of all kinds~~

The Non-Systematic Aggregate of Diverging Series

6.53 Unfortunately there is no system to the aggregate of concrete patterns of diverging series of conditions for all kinds of events. Full and exact knowledge of all classical laws assures only a systematic unification of the laws. ~~It~~ Such a systematic unification is not an imaginative synthesis. On the other hand, each of the concrete patterns of diverging series is an imaginative synthesis. It follows that singly and together these concrete patterns are non-systematic, for the totality of systematic relations is included in the totality of abstract laws.

there follows pp. 150-152.
omitting the old & longer 60-64.

Pp 60-64 of ch. 3
in MSA

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of Batch IV

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Dec. 4/90

observations to make and it would be only by luck that one hit upon those that were relevant.

6.53 The Non-systematic Aggregate of Diverging Series.

It was shown in Chapter II that coincidental aggregates can be investigated with scientific generality only by statistical methods. But statistical methods reveal states and probabilities. They tell us nothing about concrete patterns of diverging series of conditions for particular determinate events. It follows that if such concrete patterns are to be investigated with scientific generality then they must not be coincidental aggregates.

However, in the general case, concrete patterns of diverging series of conditions are coincidental aggregates. For any event, say Z, occurs if positive conditions, P, Q, R ...., occur and negative conditions, U, V, W,..., do not occur. What is true of Z is true of all its conditions. Nor, in the general case, can anything beyond the fulfilment of these conditions be required. On the other hand, to demand that the diverging series of conditions is not a coincidental aggregate is to add to the conditions necessary for the occurrence of Z; and to introduce such an addition is to depart from the general case and set up a particular case.

Further, even when particular cases exist, they cannot be explained completely along classical lines. For there exists a particular case if there exists an orderly sequence of sets of events such that, other things being equal, the events, P_i, result from the events, P_{i+1}, for all positive integral values of i from 1 to n, where either n is as great a positive integer as one cares to assign or else there is a final set of events, P_n, that is similar in all respects to an initial set, P_1. Clearly, the diverging series of conditions is brought to heel by any such scheme of perpetual continuity or of perpetual recurrence. Still such a scheme holds x only under the proviso that other things are equal and the introduction of defensive mechanisms cannot eliminate the proviso since the mechanisms themselves will depend on classical laws. Moreover, as schemes cannot guarantee their own survival, so they cannot explain their own origin. For if there is a first instance of a set of events, P_1, then there is no prior instance in the sequence or circle to account for the first instance; and if there is no first instance, then the origin of the sequence or circle, so far from being explained, is merely denied.

~~Still it will be urged that world process as a whole may be systematic so that the total concrete pattern of all diverging series of conditions is in fact orderly~~

Still it may be urged that, perhaps, world process as a whole is systematic and so, perhaps, the total concrete pattern of diverging series of conditions is in fact orderly. But, in the first place, this is merely a hypothesis. In the second place, it is an extremely doubtful hypothesis, for world process as a whole seems marked by the characteristically statistical devices of large numbers and long intervals of time. Finally, while this doubtful hypothesis implies that statistical method is ultimately mistaken, there is no difficulty in framing opposite hypotheses of equal value which, if true, would imply that ultimately classical method is mistaken.

In the present subsection (§6.5) we set out to indicate an exact meaning for both the indeterminacy of classical laws and the consequent canon of statistical residues. It has been argued that classical laws are indeterminate because they are abstract and so can become determinate premises for the deduction of determinate events only if sets of positive and negative conditions are fulfilled. Moreover, from this indeterminacy of the abstract there follows a canon of statistical residues because in the general case such sets of conditions are coincidental aggregates and coincidental aggregates can be investigated with scientific generality only by statistical methods.

In conclusion, two points may be noted. The root fallacy in determinist opposition to ~~statistical~~ the objectivity of statistical knowledge is an oversight of insight. The determinist begins by overlooking the fact that a concrete inference from classical laws supposes an insight that mediates between the abstract laws and the concrete situation; and once that oversight occurs there is precluded ~~the~~ a discovery of the difference between systematic processes and coincidental aggregates.

Secondly, our analysis prescinds from all questions regarding the intellectual capacity of Laplace's demon and other non-human beings. Clearly such issues have no bearing on the nature of empirical science or, indeed, of human understanding. Finally, this restriction ~~is easily~~ seems contained in our definition of an orderly sequence; for a sequence is orderly if it can be mastered by an insight that can be expressed in general terms and, ~~presumably~~ it would seem, only human insights can be so expressed.

6.6 The General Character of Statistical Theories.

The statistical heuristic structure, worked out in Chapter II (§4.4), may now be determined more fully in the light of the six canons of empirical method.

6.61 Events.

First, then, statistical theories deal with

The General Character of Statistical Theories.

6.6 Finally, the canon of ~~empirical~~ statistical residues, in conjunction with the other canons of empirical method, makes it possible to complement our account of the notion of probability (Chapter II, §4) with a derivation of the general characteristics of statistical theories.

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6.61 *Events.* First, statistical theories will deal with events. For it is the event, the occurrence, the actual happening that cannot be settled by classical laws without ~~the introduction of further determinations that~~ the introduction of a concrete, non-systematic manifold of further determinations.

6.62 *Not Processes.* Secondly, statistical theories will not analyse processes. For the processes that lead up to events fall under the patterns of diverging series of conditions. Such patterns form a non-systematic aggregate, and the non-systematic as such is not open to investigation.

Only Observable Events

6.63 Thirdly, statistical theories will deal only with observable events. For the canon of parsimony restricts scientific utterance to the verifiable. And only the frequencies of observable events are verifiable. Hence, if one were to suppose that some type of event occurred nine times on every ten occasions yet only one of the nine occurrences and only seven of the ten occasions were observable, then the correct frequency would be, not 9/10, but 1/7. For the scientist is restricted to the verifiable, and so he defines his frequencies, not of events in general, but of observable events.

Special not General Relativity

6.64 Accordingly ~~thus~~ there will be a formal opposition between a statistical theory and, on the other hand, a classical theory satisfying the principle of equivalence.

For the principle of equivalence abstracts from the relations of things to us to determine the relations of things to one another.

But statistical theory necessarily deals with only observable events and so must include the relations of things to our senses.

It is to be noted that this formal opposition excludes the possibility of a contradiction between such theories. For contradictory statements must regard not only the same things but also the same aspects of things. But the formal opposition excludes the possibility of statistical theory and fully invariant classical theory referring to the same aspects of the same things.

It is to be recalled that we based the invariance of Special Relativity, not on the fully general principle of equivalence, but on the same grounds as Newton's First Law of Motion, namely, distinct causes or grounds or reasons cannot be assigned for each of a non-countable infinity of differences (see Chapter II, §~~4~~2.5). Hence, the formal opposition between the principle of equivalence and statistical theory does not preclude the use of Special Relativity in Quantum Mechanics (see Lindsay and Margenau, pp. 501 ff)

Use of Classical Concepts.

6.65 Scientifically significant statistical theory will define events by introducing the pure conjugates of classical laws.

For events must be defined if they are to be assigned any frequency but unity. In other words, only the defined type of event is not occurring always and everywhere.

The definition of events must be sought ~~i~~ in conjugates. For the event corresponds to the Yes in answer to a question for reflection, and the question for reflection has its content from an answer to a question for intelligence. By the canon of parsimony, verifiable answers to questions for intelligence are in terms of experiential or of pure conjugates.

But statistical investigations in terms of experiential conjugates contain no promise of scientific significance. For experience is within the reach of everyone, but a significant contribution to science rests upon knowledge of previous achievement./ Hence, Quantum Mechanics defines its observables by appealing to classical physics, which developed the notions of Cartesian coordinate, linear and angular momentum, energy, and so forth.

Such knowledge in one way or another involves pure conjugates, and so pure conjugates will be used in defining the events of scientifically significant statistical laws. /

Images and Parsimony

6.66 The canon of parsimony excludes any problem concerning the picture of objects too small to be sensed. For the image as image can be verified only by the occurrence of the corresponding sensation. Thus, the visual image of a small ball can be verified only by seeing a small ball, and the visual image of a wave can be verified only by seeing a wave. ~~Thus~~ When the sensations neither occur nor can occur, all that can be verified are certain equations and the terms implicitly defined by such equations.

It is to be noted that this conclusion rests on a divergence from Galilean assumptions. For on those assumptions, secondary qualities such as color, sound, heat, and the like, are merely apparent; they are to be attributed not to objects but to our subjectivity. On the other hand, the mathematical dimensions of matter in motion are constitutive of the real and objective, so that to deny them is to eliminate the object. Hence, on the Galilean view, electrons cannot be red or green or blue, hard or soft, hot or cold, but they must have dimensions either of little balls or of waves or of some other compatible set of primary qualities.

A Principle of Uncertainty.

6.67 An axiomatic structure for statistical laws will involve an uncertainty principle.

For the concrete ~~is~~ includes a non-systematic component, and so the concrete cannot be deduced in its full determinacy from any set of systematic premises.

But an axiomatic structure *for statistical laws would be* ~~is~~ a set of systematic premises. Its implications *would* reach to the concrete, for ~~they regard~~ statistical laws ~~that~~ deal with ~~fully concrete~~ events, and events ~~x~~ are always fully concrete.

Therefore the axiomatic structure for statistical laws must have some means of cutting short its implications before the full determina*cy* ~~tion~~ of the concrete *is* ~~are~~ reached. And any such means *falls under/* ~~is~~ the general case of an uncertainty principle.

→ 66 a, b.

(66a)

On this analysis, then, indeterminacy is a general characteristic of statistical investigations. So, prior to the measured uncertainty of Heisenberg's equation, there was the unmeasured uncertainty inherent in classical statistics in which predictions were unique but, none the less, were not expected to be correct in every case [See Lindsay and Margenau, p398].

Nor is this generality surprising. It runs parallel to the possibility of deducing Heisenberg's Principle from a general axiomatic structure. It follows from the fact that the deduction of conclusions supposes systematic relations so that, if some relations are not systematic, the field of possible conclusions must be restricted.

6.7. Indeterminacy and the Non-Systematic.

The foregoing account of the general character of statistical investigations must not be mistaken for a description of Quantum Mechanics. The canon of statistical residues is methodological. Its generality is not that of recent physics but of statistical method. Its basis lies, not in the conclusions of subatomic investigation but in the analysis of the cognitional process that begins from data and inquiry, proceeds through insight and formulation, and recommences when experiments yield significantly new data. Its technical terms are derived, not from the usage that scientists have found suitable for their purposes ~~by~~ but from the exigencies of a quite different study. Accordingly, as already we have had occasion to insist, only a further critical and creative effort can bring our conclusions into contact with the ~~dear~~ diverse interpretations of the results of contemporary physics.

For the canon of statistical residues involves three elements, and all three can be stated only in cognitional terms. The first element is <u>the indeterminacy of the abstract</u>: classical laws can be applied to concrete situations only by adding further determinations derived from the situation. The second element is <u>the non-systematic ~~element of the~~ character of the further determinations</u>. It does not mean that the further determinations are not related to one another by law; it means that the law is only an abstract part in a concrete relation of determinate numbers, magnitudes, relative positions, etc. It does not mean that these concrete relations cannot be mastered by insight into relevant presentations; ~~it means that such a conceptual account bogs down in an unmanageable infinity of cases~~ it means that the concrete insight has a fuller object than the abstract formulation. It does not mean that no attempt can be made at a conceptual account of the concrete relations; it means that such a conceptual account bogs down in an unmanageable infinity of cases.

It does not mean that concrete relations are never recurrent or that accurate prediction is never possible; it means that schemes of recurrence do not fall under some overarching scheme, that they are merely instances in which law triumphs over the empirical residue, that such triumphs of law do not occur in accord with some further classical law. The third element, finally, is the inverse insight; if the intelligibility of abstract system is not to be had, still generality is not to be renounced; for there is the generality of the ideal frequency of events; and from such an ideal frequency the non-systematic cannot diverge in any systematic fashion.

Not only is the canon of statistical residues methodological but also it stands in a context of other canons that involve a transposition of current issues. A canon of relevance has fixed attention on what insight adds to data. A canon of parsimony has restricted scientific affirmation to defined types of verifiable propositions. A canon of complete explanation has placed space and time in much the same position as sensible qualities. Within that context there is no need to attempt to exorcize the images of the older determinists with the images of the new indeterminists. It is true enough that data are hazy, that measurements are not perfectly accurate, that measuring can distort the measured object. But those truths miss the methodological point. One can affirm them yet continue to misconceive classical laws. The law of falling bodies is not a statement of what would happen in a perfect vacuum; it is the statement of an element in an abstract system, and the complete system can be applied to any particular case. Again, Einstein's differential equations are not statements about positions and velocities in defiance of Heisenberg's principle; they are statements of the abstractness and so invariance of classical laws. The proper answer to the old determinism is an affirmation, not of an indeterminism on the same imaginative level, but of the indeterminacy of the abstract.

Finally, may we claim that this transposition hits the mark? Between indeterminism and probability the only apparent link is a common lack of precision and definiteness. But the indeterminacy of the abstract brings to light the non-systematic character of the ~~con~~ concrete. And the ~~con~~ essence of probability is that it sets an ideal norm from which actual frequencies can diverge but not systematically.

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On this analysis, then, indeterminacy arises, not because in some cases measurements cannot be performed, nor because there is some haziness inherent in all data, but because some of the determinate relations of determinate data are non-systematic. We do not affirm, of course, that fully accurate measurements are always possible. Nor do we affirm that there is no haziness in the presentations of sense. Rather our position is that, even if measurements were always possible, ~~to~~ even if data were as clear and distinct as geometrical images are sometimes mistakenly thought to be, none the less there would remain an indeterminacy of conclusions. For the deduction of conclusions supposes systematic relations; some relations are not systematic; and so the field of possible conclusions is, not universal, but restricted. Such a restriction does not appear in the axiomatic structure of classical laws, for all such laws and all their implications are already under the restriction, other things being equal. But statistical laws in their general form refer to frequencies of events. One might say that their purpose is to formulate how often other things will be equal. It follows that their axiomatic structures must be such that fully determinate conclusions do not exceed the premises provided by incompleteness of system in objective relations.

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6.7 In conclusion, let us point out that our account of probability and of statistical theories finds a middle path between the older determinism and the more recent indeterminism. For we agree neither with the determinist view that statistical laws are a mere cloak for ignorance nor with the indeterminist view that classical laws represent macroscopic approximations to microscopic but random occurrences. Behind the determinist position is the Galilean assumption that classical laws refer, if not to visible, then at least to imaginable primary qualities of matter in motion; in other words, imaginative synthesis is always possible and, even in the last analysis, there is not a non-systematic aggregate of diverging series of conditions. Again, behind the ~~indet~~ indeterminist view there seems a mistaken diagnosis of the error of determinism; instead of affirming a lack of ~~system~~ complete system in relations between data, or between images, it has taken the opposite course of denying complete determinacy in the data to be systematized.

Our middle course transposes the issue from determinacy and indeterminacy to the systematic and the non-systematic. Because the non-systematic is verifiable, it is objective in the scientific sense. Because it is objective, statistical laws are not a mere cloak for ignorance. They represent a grasp of what intelligibility there is to be grasped in appropriate domains of data. On the other hand, indeterminacy is merely an indeterminacy of conclusions. It arises because deductions suppose systematic relations and such relations are not the only relations. It implies no indeterminacy in things or events or data and by that implication it has the favor of the canon of parsimony. For it seems impossible to distinguish between the observation of an indeterminate thing, or event, or datum and, on the other hand, a failure to observe determinately.