CHAPTER SEVEN

SYSTEMATIC INFERENCE: INDUCTION AND DEDUCTION

1. The Double Movement of Reflection

The characteristic outcome of thinking we saw to be the organization of facts and conditions which, just as they stand, are isolated, fragmentary, and discrepant, the organization being effected through the introduction of connecting links, or middle terms. The facts as they stand are the data, the raw material of reflection; their lack of coherence perplexes and stimulates to reflection. There follows the suggestion of some meaning which, if it can be substantiated, will give a whole in which various fragmentary and seemingly incompatible data find their proper place. The meaning suggested supplies a mental platform, an intellectual point of view, from which to note and define the data more carefully, to seek for additional observations, and to institute, experimentally, changed conditions.

There is thus a double movement in all reflection: a movement from the given partial and confused data to a suggested comprehensive (or inclusive) entire situation; and back from this suggested whole—which as suggested is a meaning, an idea—to the particular facts, so as to connect these with one another and with additional facts to which the suggestion has directed attention. Roughly speaking, the first of these movements is inductive; the second deductive. A complete act of thought involves both—it involves, that is, a fruitful interaction of observed (or recollected) particular considerations and of inclusive and far-reaching (general) meanings.

This double movement to and from a meaning may occur, however, in a casual, uncritical way, or in a cautious and regulated manner. To think means, in any case, to bridge a gap in experience, to bind together facts or deeds otherwise isolated. But we may make only a hurried jump from one consideration to another, allowing our aversion to mental disquietude to override the gaps; or, we may insist upon noting the road traveled in making connections. We may, in short, accept readily any suggestion that seems plausible; or we may hunt out additional factors, new difficulties, to see whether the suggested conclusion really ends the matter. The latter method involves definite formulation of the connecting links; the statement of a principle, or, in logical phrase, the use of a universal. If we thus formulate the whole situation, the original data are transformed into premises of reasoning; the final belief is a logical or rationalconclusion, not a mere de facto termination.

The importance of connections binding isolated items into a coherent single whole is embodied in all the phrases that denote the relation of premises and conclusions to each other. (1) The premises are called grounds, foundations, bases, and are said to underlie, uphold, support the conclusion. (2) We "descend" from the premises to the conclusion, and "ascend" or "mount" in the opposite direction—as a river may be continuously traced from source to sea or vice versa. So the conclusion springs, flows, or is drawn from its premises. (3) The conclusion—as the word itself implies—closes, shuts in, locks up together the various factors stated in the premises. We say that the premises "contain" the conclusion, and that the conclusion "contains" the premises, thereby marking our sense of the inclusive and comprehensive unity in which the elements of reasoning are bound tightly together. Systematic inference, in short, means the recognition of definite relations of interdependence between considerations previously unorganized and disconnected, this recognition being brought about by the discovery and insertion of new facts and properties.

This more systematic thinking is, however, like the cruder forms in its double movement, the movement toward the suggestion or hypothesis and the movement back to facts. The difference is in the greater conscious care with which each phase of the process is performed. The conditions under which suggestions are allowed to spring up and develop are regulated. Hasty acceptance of any idea that is plausible, that seems to solve the difficulty, is changed into a conditional acceptance pending further inquiry. The idea is accepted as a working hypothesis, as something to guide investigation and bring to light new facts, not as a final conclusion. When pains are taken to make each aspect of the movement as accurate as possible, the movement toward building up the idea is known as inductive discovery (induction, for short); the movement toward developing, applying, and testing, as deductive proof (deduction, for short).

While induction moves from fragmentary details (or particulars) to a connected view of a situation (universal), deduction begins with the latter and works back again to particulars, connecting them and binding them together. The inductive movement is toward discovery of a binding principle; the deductive toward its testing—confirming, refuting, modifying it on the basis of its capacity to interpret isolated details into a unified experience. So far as we conduct each of these processes in the light of the other, we get valid discovery or verified critical thinking.

A commonplace illustration may enforce the points of this formula. A man who has left his rooms in order finds them upon his return in a state of confusion, articles being scattered at random. Automatically, the notion comes to his mind that burglary would account for the disorder. He has not seen the burglars; their presence is not a fact of observation, but is a thought, an idea. Moreover, the man has no special burglars in mind; it is the relation, the meaning of burglary—something general—that comes to mind. The state of his room is perceived and is particular, definite,—exactly as it is; burglars are inferred, and have a general status. The state of the room is a fact, certain and speaking for itself; the presence of burglars is a possible meaningwhich may explain the facts.

So far there is an inductive tendency, suggested by particular and present facts. In the same inductive way, it occurs to him that his children are mischievous, and that they may have thrown the things about. This rival hypothesis (or conditional principle of explanation) prevents him from dogmatically accepting the first suggestion. Judgment is held in suspense and a positive conclusion postponed.

Then deductive movement begins. Further observations, recollections, reasonings are conducted on the basis of a development of the ideas suggested: if burglars were responsible, such and such things would have happened; articles of value would be missing. Here the man is going from a general principle or relation to special features that accompany it, to particulars,—not back, however, merely to the original particulars (which would be fruitless or take him in a circle), but to new details, the actual discovery or nondiscovery of which will test the principle. The man turns to a box of valuables; some things are gone; some, however, are still there. Perhaps he has himself removed the missing articles, but has forgotten it. His experiment is not a decisive test. He thinks of the silver in the sideboard—the children would not have taken that nor would he absent-mindedly have changed its place. He looks; all the solid ware is gone. The conception of burglars is confirmed; examination of windows and doors shows that they have been tampered with. Belief culminates; the original isolated facts have been woven into a coherent fabric. The idea first suggested (inductively) has been employed to reason out hypothetically certain additional particulars not yet experienced, that ought to be there, if the suggestion is correct. Then new acts of observation have shown that the particulars theoretically called for are present, and by this process the hypothesis is strengthened, corroborated. This moving back and forth between the observed facts and the conditional idea is kept up till a coherent experience of an object is substituted for the experience of conflicting details—or else the whole matter is given up as a bad job.

Sciences exemplify similar attitudes and operations, but with a higher degree of elaboration of the instruments of caution, exactness and thoroughness. This greater elaboration brings about specialization, an accurate marking off of various types of problems from one another, and a corresponding segregation and classification of the materials of experience associated with each type of problem. We shall devote the remainder of this chapter to a consideration of the devices by which the discovery, the development, and the testing of meanings are scientifically carried on.

2. Guidance of the Inductive Movement

Control of the formation of suggestion is necessarily indirect, not direct; imperfect, not perfect. Just because all discovery, all apprehension involving thought of the new, goes from the known, the present, to the unknown and absent, no rules can be stated that will guarantee correct inference. Just what is suggested to a person in a given situation depends upon his native constitution (his originality, his genius), temperament, the prevalent direction of his interests, his early environment, the general tenor of his past experiences, his special training, the things that have recently occupied him continuously or vividly, and so on; to some extent even upon an accidental conjunction of present circumstances. These matters, so far as they lie in the past or in external conditions, clearly escape regulation. A suggestion simply does or does not occur; this or that suggestion just happens, occurs, springs u If, however, prior experience and training have developed an attitude of patience in a condition of doubt, a capacity for suspended judgment, and a liking for inquiry, indirectcontrol of the course of suggestions is possible. The individual may return upon, revise, restate, enlarge, and analyze the facts out of which suggestion springs. Inductive methods, in the technical sense, all have to do with regulating the conditions under which observation, memory, and the acceptance of the testimony of others (the operations supplying the raw data) proceed.

Given the facts A B C D on one side and certain individual habits on the other, suggestion occurs automatically. But if the facts A B C D are carefully looked into and thereby resolved into the facts A´ B´´ R S, a suggestion will automatically present itself different from that called up by the facts in their first form. To inventory the facts, to describe exactly and minutely their respective traits, to magnify artificially those that are obscure and feeble, to reduce artificially those that are so conspicuous and glaring as to be distracting,—these are ways of modifying the facts that exercise suggestive force, and thereby indirectly guiding the formation of suggested inferences.

Consider, for example, how a physician makes his diagnosis—his inductive interpretation. If he is scientifically trained, he suspends—postpones—reaching a conclusion in order that he may not be led by superficial occurrences into a snap judgment. Certain conspicuous phenomena may forcibly suggest typhoid, but he avoids a conclusion, or even any strong preference for this or that conclusion until he has greatly (i) enlarged the scope of his data, and (ii) rendered them more minute. He not only questions the patient as to his feelings and as to his acts prior to the disease, but by various manipulations with his hands (and with instruments made for the purpose) brings to light a large number of facts of which the patient is quite unaware. The state of temperature, respiration, and heart-action is accurately noted, and their fluctuations from time to time are exactly recorded. Until this examination has worked out toward a wider collection and in toward a minuter scrutiny of details, inference is deferred.

Scientific induction means, in short, all the processes by which the observing and amassing of data are regulated with a view to facilitating the formation of explanatory conceptions and theories. These devices are all directed toward selecting the precise facts to which weight and significance shall attach in forming suggestions or ideas. Specifically, this selective determination involves devices of (1) elimination by analysis of what is likely to be misleading and irrelevant, (2) emphasis of the important by collection and comparison of cases, (3) deliberate construction of data by experimental variation.

(1) It is a common saying that one must learn to discriminate between observed facts and judgments based upon them. Taken literally, such advice cannot be carried out; in every observed thing there is—if the thing have any meaning at all—some consolidation of meaning with what is sensibly and physically present, such that, if this were entirely excluded, what is left would have no sense. A says: "I saw my brother." The term brother, however, involves a relation that cannot be sensibly or physically observed; it is inferential in status. If A contents himself with saying, "I saw a man," the factor of classification, of intellectual reference, is less complex, but still exists. If, as a last resort, A were to say, "Anyway, I saw a colored object," some relationship, though more rudimentary and undefined, still subsists. Theoretically, it is possible that no object was there, only an unusual mode of nerve stimulation. None the less, the advice to discriminate what is observed from what is inferred is sound practical advice. Its working import is that one should eliminate or exclude those inferences as to which experience has shown that there is greatest liability to error. This, of course, is a relative matter. Under ordinary circumstances no reasonable doubt would attach to the observation, "I see my brother"; it

would be pedantic and silly to resolve this recognition back into a more elementary form. Under other circumstances it might be a perfectly genuine question as to whether A saw even a colored thing, or whether the color was due to a stimulation of the sensory optical apparatus (like "seeing stars" upon a blow) or to a disordered circulation. In general, the scientific man is one who knows that he is likely to be hurried to a conclusion, and that part of this precipitancy is due to certain habits which tend to make him "read" certain meanings into the situation that confronts him, so that he must be on the lookout against errors arising from his interests, habits, and current preconceptions.

The technique of scientific inquiry thus consists in various processes that tend to exclude over-hasty "reading in" of meanings; devices that aim to give a purely "objective" unbiased rendering of the data to be interpreted. Flushed cheeks usually mean heightened temperature; paleness means lowered temperature. The clinical thermometer records automatically the actual temperature and hence checks up the habitual associations that might lead to error in a given case. All the instrumentalities of observation—the various -meters and -graphs and -scopes—fill a part of their scientific rôle in helping to eliminate meanings supplied because of habit, prejudice, the strong momentary preoccupation of excitement and anticipation, and by the vogue of existing theories. Photographs, phonographs, kymographs, actinographs, seismographs, plethysmographs, and the like, moreover, give records that are permanent, so that they can be employed by different persons, and by the same person in different states of mind, i.e. under the influence of varying expectations and dominant beliefs. Thus purely personal prepossessions (due to habit, to desire, to after-effects of recent experience) may be largely eliminated. In ordinary language, the facts are objectively, rather than subjectively, determined. In this way tendencies to premature interpretation are held in check.

(2) Another important method of control consists in the multiplication of cases or instances. If I doubt whether a certain handful gives a fair sample, or representative, for purposes of judging value, of a whole carload of grain, I take a number of handfuls from various parts of the car and

compare them. If they agree in quality, well and good; if they disagree, we try to get enough samples so that when they are thoroughly mixed the result will be a fair basis for an evaluation. This illustration represents roughly the value of that aspect of scientific control in induction which insists upon multiplying observations instead of basing the conclusion upon one or a few cases.

So prominent, indeed, is this aspect of inductive method that it is frequently treated as the whole of induction. It is supposed that all inductive inference is based upon collecting and comparing a number of like cases. But in fact such comparison and collection is a secondary development within the process of securing a correct conclusion in some single case. If a man infers from a single sample of grain as to the grade of wheat of the car as a whole, it is induction and, under certain circumstances, a sound induction; other cases are resorted to simply for the sake of rendering that induction more guarded, and more probably correct. In like fashion, the reasoning that led up to the burglary idea in the instance already cited () was inductive, though there was but one single case examined. The particulars upon which the general meaning (or relation) of burglary was grounded were simply the sum total of the unlike items and qualities that made up the one case examined. Had this case presented very great obscurities and difficulties, recourse might then have been had to examination of a number of similar cases. But this comparison would not make inductive a process which was not previously of that character; it would only render induction more wary and adequate. The object of bringing into consideration a multitude of cases is to facilitate the selection of the evidential or significant features upon which to base inference in some single case.

Accordingly, points of unlikeness are as important as points of likeness among the cases examined. Comparison, without contrast, does not amount to anything logically. In the degree in which other cases observed or remembered merely duplicate the case in question, we are no better off for purposes of inference than if we had permitted our single original fact to dictate a conclusion. In the case of the various samples of grain, it is the fact that the samples are unlike, at least in the part of the carload from which they are taken, that is important. Were it not for this unlikeness, their likeness in quality would be of no avail in assisting inference. If we are endeavoring to get a child to regulate his conclusions about the germination of a seed by taking into account a number of instances, very little is gained if the conditions in all these instances closely approximate one another. But if one seed is placed in pure sand, another in loam, and another on blotting-paper, and if in each case there are two conditions, one with and another without moisture, the unlike factors tend to throw into relief the factors that are significant (or "essential") for reaching a conclusion. Unless, in short, the observer takes care to have the differences in the observed cases as extreme as conditions allow, and unless he notes unlikenesses as carefully as likenesses, he has no way of determining the evidential force of the data that confront him.

Another way of bringing out this importance of unlikeness is the emphasis put by the scientist upon negative cases—upon instances which it would seem ought to fall into line but which as matter of fact do not. Anomalies, exceptions, things which agree in most respects but disagree in some crucial point, are so important that many of the devices of scientific technique are designed purely to detect, record, and impress upon memory contrasting cases. Darwin remarked that so easy is it to pass over cases that oppose a favorite generalization, that he had made it a habit not merely to hunt for contrary instances, but also to write down any exception he noted or thought of—as otherwise it was almost sure to be forgotten.

3. Experimental Variation of Conditions

We have already trenched upon this factor of inductive method, the one that is the most important of all wherever it is feasible. Theoretically, one sample case of the right kind will be as good a basis for an inference as a thousand cases; but cases of the "right kind" rarely turn up spontaneously. We have to search for them, and we may have tomake them. If we take cases just as we find them—whether one case or many cases—they contain much that is irrelevant to the problem in hand, while much that is relevant is obscure, hidden. The object of experimentation is the construction, by regular steps taken on the basis of a plan thought out in advance, of a typical, crucial case, a case formed with express reference to throwing light on the difficulty in question. All inductive methods rest (as already stated,) upon regulation of the conditions of observation and memory; experiment is simply the most adequate regulation possible of these conditions. We try to make the observation such that every factor entering into it, together with the mode and the amount of its operation, may be open to recognition. Such making of observations constitutes experiment.

Such observations have many and obvious advantages over observations—no matter how extensive—with respect to which we simply wait for an event to happen or an object to present itself. Experiment overcomes the defects due to (a) the rarity, (b) the subtlety and minuteness (or the violence), and (c) the rigid fixity of facts as we ordinarily experience them. The following quotations from Jevons's Elementary Lessons in Logic bring out all these points:

(i) "We might have to wait years or centuries to meet accidentally with facts which we can readily produce at any moment in a laboratory; and it is probable that most of the chemical substances now known, and many excessively useful products would never have been discovered at all by waiting till nature presented them spontaneously to our observation."

This quotation refers to the infrequency or rarity of certain facts of nature, even very important ones. The passage then goes on to speak of the minuteness of many phenomena which makes them escape ordinary experience:

(ii) "Electricity doubtless operates in every particle of matter, perhaps at every moment of time; and even the ancients could not but notice its action in the loadstone, in lightning, in the Aurora Borealis, or in a piece of rubbed amber. But in lightning electricity was too intense and dangerous; in the other cases it was too feeble to be properly understood. The science of electricity and magnetism could only advance by getting regular supplies of electricity from the common electric machine or the galvanic battery and by making powerful electromagnets. Most, if not all, the effects which electricity produces must go on in nature, but altogether too obscurely for observation."

Jevons then deals with the fact that, under ordinary conditions of experience, phenomena which can be understood only by seeing them under varying conditions are presented in a fixed and uniform way.

(iii) "Thus carbonic acid is only met in the form of a gas, proceeding from the combustion of carbon; but when exposed to extreme pressure and cold, it is condensed into a liquid, and may even be converted into a snowlike solid substance. Many other gases have in like manner been liquefied or solidified, and there is reason to believe that every substance is capable of taking all three forms of solid, liquid, and gas, if only the conditions of temperature and pressure can be sufficiently varied. Mere observation of nature would have led us, on the contrary, to suppose that nearly all substances were fixed in one condition only, and could not be converted from solid into liquid and from liquid into gas."

Many volumes would be required to describe in detail all the methods that investigators have developed in various subjects for analyzing and restating the facts of ordinary experience so that we may escape from capricious and routine suggestions, and may get the facts in such a form and in such a light (or context) that exact and far-reaching explanations may be suggested in place of vague and limited ones. But these various devices of inductive inquiry all have one goal in view: the indirect regulation of the function of suggestion, or formation of ideas; and, in the main, they will be found to reduce to some combination of the three types of selecting and arranging subject-matter just described.

4. Guidance of the Deductive Movement

Before dealing directly with this topic, we must note that systematic regulation of induction depends upon the possession of a body of general principles that may be applied deductively to the examination or construction of particular cases as they come u If the physician does not know the general laws of the physiology of the human body, he has little way of telling what is either peculiarly significant or peculiarly exceptional in any particular case that he is called upon to treat. If he knows the laws of circulation, digestion, and respiration, he can deduce the conditions that should normally be found in a given case. These considerations give a base line from which the deviations and abnormalities of a particular case may be measured. In this way, the nature of the problem at hand is located and defined. Attention is not wasted upon features which though conspicuous have nothing to do with the case; it is concentrated upon just those traits which are out of the way and hence require explanation. A question well put is half answered;i.e. a difficulty clearly apprehended is likely to suggest its own solution,—while a vague and miscellaneous perception of the problem leads to groping and fumbling. Deductive systems are necessary in order to put the question in a fruitful form.

The control of the origin and development of hypotheses by deduction does not cease, however, with locating the problem. Ideas as they first present themselves are inchoate and incomplete. Deduction is their elaboration into fullness and completeness of meaning (see). The phenomena which the physician isolates from the total mass of facts that exist in front of him suggest, we will say, typhoid fever. Now this conception of typhoid fever is one that is capable of development. Ifthere is typhoid, wherever there is typhoid, there are certain results, certain characteristic symptoms. By going over mentally the full bearing of the concept of typhoid, the scientist is instructed as to further phenomena to be found. Its development gives him an instrument of inquiry, of observation and experimentation. He can go to work deliberately to see whether the case presents those features that it should have if the supposition is valid. The deduced results form a basis for comparison with observed results. Except where there is a system of principles capable of being elaborated by theoretical reasoning, the process of testing (or proof) of a hypothesis is incomplete and haphazard.

These considerations indicate the method by which the deductive movement is guided. Deduction requires a system of allied ideas which may be translated into one another by regular or graded steps. The question is whether the facts that confront us can be identified as typhoid fever. To all appearances, there is a great gap between them and typhoid.

But if we can, by some method of substitutions, go through a series of intermediary terms (see), the gap may, after all, be easily bridged. Typhoid may mean p which in turn means o, which means n which means m, which is very similar to the data selected as the key to the problem.

One of the chief objects of science is to provide for every typical branch of subject-matter a set of meanings and principles so closely interknit that any one implies some other according to definite conditions, which under certain other conditions implies another, and so on. In this way, various substitutions of equivalents are possible, and reasoning can trace out, without having recourse to specific observations, very remote consequences of any suggested principle. Definition, general formulæ, and classification are the devices by which the fixation and elaboration of a meaning into its detailed ramifications are carried on. They are not ends in themselves—as they are frequently regarded even in elementary education—but instrumentalities for facilitating the development of a conception into the form where its applicability to given facts may best be tested.

The final test of deduction lies in experimental observation. Elaboration by reasoning may make a suggested idea very rich and very plausible, but it will not settle the validity of that idea. Only if facts can be observed (by methods either of collection or of experimentation), that agree in detail and without exception with the deduced results, are we justified in accepting the deduction as giving a valid conclusion. Thinking, in short, must end as well as begin in the domain of concrete observations, if it is to be complete thinking. And the ultimate educative value of all deductive processes is measured by the degree to which they become working tools in the creation and development of new experiences.

5. Some Educational Bearings of the Discussion

Some of the points of the foregoing logical analysis may be clinched by a consideration of their educational implications, especially with reference to certain practices that grow out of a false separation by which each is thought to be independent of the other and complete in itself. (i) In some school subjects, or at all events in some topics or in some lessons, the pupils are immersed in details; their minds are loaded with disconnected items (whether gleaned by observation and memory, or accepted on hearsay and authority). Induction is treated as beginning and ending with the amassing of facts, of particular isolated pieces of information. That these items are educative only as suggesting a view of some larger situation in which the particulars are included and thereby accounted for, is ignored. In object lessons in elementary education and in laboratory instruction in higher education, the subject is often so treated that the student fails to "see the forest on account of the trees." Things and their qualities are retailed and detailed, without reference to a more general character which they stand for and mean. Or, in the laboratory, the student becomes engrossed in the processes of manipulation,—irrespective of the reason for their performance, without recognizing a typical problem for the solution of which they afford the appropriate method. Only deduction brings out and emphasizes consecutive relationships, and only when relationships are held in view does learning become more than a miscellaneous scrap-bag.

(ii) Again, the mind is allowed to hurry on to a vague notion of the whole of which the fragmentary facts are portions, without any attempt to become conscious of how they are bound together as parts of this whole. The student feels that "in a general way," as we say, the facts of the history or geography lesson are related thus and so; but "in a general way" here stands only for "in a vague way," somehow or other, with no clear recognition of just how.

The pupil is encouraged to form, on the basis of the particular facts, a general notion, a conception of how they stand related; but no pains are taken to make the student follow up the notion, to elaborate it and see just what its bearings are upon the case in hand and upon similar cases. The inductive inference, the guess, is formed by the student; if it happens to be correct, it is at once accepted by the teacher; or if it is false, it is rejected. If any amplification of the idea occurs, it is quite likely carried through by the teacher, who thereby assumes the responsibility for its intellectual development. But a complete, an integral, act of thought requires that the person making the suggestion (the guess) be responsible also for reasoning out its bearings upon the problem in hand; that he develop the suggestion at least enough to indicate the ways in which it applies to and accounts for the specific data of the case. Too often when a recitation does not consist in simply testing the ability of the student to display some form of technical skill, or to repeat facts and principles accepted on the authority of text-book or lecturer, the teacher goes to the opposite extreme; and after calling out the spontaneous reflections of the pupils, their guesses or ideas about the matter, merely accepts or rejects them, assuming himself the responsibility for their elaboration. In this way, the function of suggestion and of interpretation is excited, but it is not directed and trained. Induction is stimulated but is not carried over into the reasoning phase necessary to complete it.

In other subjects and topics, the deductive phase is isolated, and is treated as if it were complete in itself. This false isolation may show itself in either (and both) of two points; namely, at the beginning or at the end of the resort to general intellectual procedure.

(iii) Beginning with definitions, rules, general principles, classifications, and the like, is a common form of the first error. This method has been such a uniform object of attack on the part of all educational reformers that it is not necessary to dwell upon it further than to note that the mistake is, logically, due to the attempt to introduce deductive considerations without first making acquaintance with the particular facts that create a need for the generalizing rational devices. Unfortunately, the reformer sometimes carries his objection too far, or rather locates it in the wrong place. He is led into a tirade against all definition, all systematization, all use of general principles, instead of confining himself to pointing out their futility and their deadness when not properly motivated by familiarity with concrete experiences.

(iv) The isolation of deduction is seen, at the other end, wherever there is failure to clinch and test the results of the general reasoning processes by application to new concrete cases. The final point of the deductive devices lies in their use in assimilating and comprehending individual cases. No one understands a general principle fully—no matter how adequately he can demonstrate it, to say nothing of repeating it—till he can employ it in the mastery of new situations, which, if they are new, differ in manifestation from the cases used in reaching the generalization. Too often the text-book or teacher is contented with a series of somewhat perfunctory examples and illustrations, and the student is not forced to carry the principle that he has formulated over into further cases of his own experience. In so far, the principle is inert and dead.

(v) It is only a variation upon this same theme to say that every complete act of reflective inquiry makes provision for experimentation—for testing suggested and accepted principles by employing them for the active construction of new cases, in which new qualities emerge. Only slowly do our schools accommodate themselves to the general advance of scientific method. From the scientific side, it is demonstrated that effective and integral thinking is possible only where the experimental method in some form is used. Some recognition of this principle is evinced in higher institutions of learning, colleges and high schools. But in elementary education, it is still assumed, for the most part, that the pupil's natural range of observations, supplemented by what he accepts on hearsay, is adequate for intellectual growth. Of course it is not necessary that laboratories shall be introduced under that name, much less that elaborate apparatus be secured; but the entire scientific history of humanity demonstrates that the conditions for complete mental activity will not be obtained till adequate provision is made for the carrying on of activities that actually modify physical conditions, and that books, pictures, and even objects that are passively observed but not manipulated do not furnish the provision required.