6. Examples of Inference and Testing

We have in previous chapters given an outline account of the nature of reflective thinking. We have stated some reasons why it is necessary to use educational means to secure its development and have considered the intrinsic resources, the difficulties, and ulterior purpose of its educational training—the formation of disciplined logical ability to think. We come now to some descriptions of simple genuine cases of thinking, selected from the class papers of students.

I. Illustrations of Reflective Activity

We have had repeated occasion to notice that there are both external and internal circumstances that call out and that guide, to some extent, thought of the reflective kind. Practical needs in connection with existing conditions, natural and social, evoke and direct thought. We begin with an instance of that sort. We have noted also that curiosity is a strong drive from within, and accordingly our second example is drawn from that field. Finally, a mind that is already exercised in scientific subjects will have inquiry aroused by intellectual problems, and our third instance is of that type.

A CASE OF PRACTICAL DELIBERATION

The other day, when I was down town on 16th Street, a clock caught my eye. I saw that the hands pointed to 12:20. This suggested that I had an engagement at 124th Street, at one o'clock. I reasoned that as it had taken me an hour to come down on a surface car, I should probably be twenty minutes late if I returned the same way. I might save twenty minutes by a subway express. But was there a station near? If not, I might lose more than twenty minutes in looking for one. Then I thought of the elevated, and I saw there was such a line within two blocks. But where was the station? If it were several blocks above or below the street I was on, I should lose time instead of gaining it. My mind went back to the subway express as quicker than the elevated; furthermore, I remembered that it went nearer than the elevated to the part of 124th Street I wished to reach, so that time would be saved at the end of the journey. I concluded in favor of the subway, and reached my destination by one o'clock.

A CASE OF REFLECTION UPON AN OBSERVATION

Projecting nearly horizontally from the upper deck of the ferryboat on which I daily cross the river is a long white pole, bearing a gilded ball at its tip. It suggested a flagpole when I first saw it; its color, shape, and gilded ball agreed with this idea, and these reasons seemed to justify me in this belief. But soon difficulties presented themselves. The pole was nearly horizontal, an unusual position for a flagpole; in the next place, there was no pulley, ring, or cord by which to attach a flag; finally, there were elsewhere two vertical staffs from which flags were occasionally flown. It seemed probable that the pole was not there for flag-flying.

I then tried to imagine all possible purposes of such a pole, and to consider for which of these it was best suited: (*a*) Possibly it was an ornament. But as all the ferryboats and even the tugboats carried poles, this hypothesis was rejected. (*b*) Possibly it was the terminal of a wireless telegraph. But the same considerations made this improbable. Besides, the more natural place for such a terminal would be the highest part of the boat, on top of the pilot house. (*c*) Its purpose might be to point out the direction in which the boat is moving.

In support of this conclusion, I discovered that the pole was lower than the pilot house, so that the steersman could easily see it. Moreover, the tip was enough higher than the base, so that, from the pilot's position, it must appear to project far out in front of the boat. Moreover, the pilot being near the front of the boat, he would need some such guide as to its direction. Tugboats would also need poles for such a purpose. This hypothesis was so much more probable than the others that I accepted it. I formed the conclusion that the pole was set up for the purpose of showing the pilot the direction in which the boat pointed, to enable him to steer correctly.

A CASE OF REFLECTION INVOLVING EXPERIMENT

In washing tumblers in hot soapsuds and placing them mouth downward on a plate, I noticed that bubbles appeared on the outside of the mouth of the tumblers and then went inside. Why? The presence of bubbles suggests air, which I note must come from inside the tumbler. I see that the soapy water on the plate prevents escape of the air save as it may be caught in bubbles. But why should air leave the tumbler? There was no substance entering to force it out. It must have expanded. It expands by increase of heat or by increase of pressure, or by both. Could the air have become heated after the tumbler was taken from the hot suds? Clearly not the air that was already entangled in the water. If heated air was the cause, cold air must have entered in transferring the tumblers from the suds to the plate. I test to see whether this supposition is true by taking several more tumblers out. Some I shake so as to make sure of entrapping cold air in them. Some I take out, holding them mouth downward in order to prevent cold air from entering. Bubbles appear on the outside of every one of the former and on none of the latter. I must be right in my inference. Air from the outside must have been expanded by the heat of the tumbler, which explains the appearance of the bubbles on the outside.

But why do they then go inside? Cold contracts. The tumbler cooled and also the air inside it. Tension was removed, and hence bubbles appeared inside. To be sure of this, I test by placing a cap of ice on the tumbler while the bubbles are still forming outside. They soon reverse.

THESE THREE CASES FORM A SERIES

These three cases have been purposely selected so as to form a series from the more rudimentary to more complicated cases of reflection. The first illustrates the kind of thinking done by everyone during the day's business, in which neither the data nor the ways of dealing with them lie outside the limits of everyday experience. The last furnishes a case in which neither problem nor mode of solution would have occurred except to one with some prior scientific training. The second case forms a natural transition; its materials lie well within the bounds of everyday, unspecialized experience; but the problem, instead of being directly involved in the person's business, arises indirectly in connection with what he happened to be doing and appeals to a somewhat theoretic and impartial interest.

In the next chapter we shall give an analytic account of what the three instances exhibit in common. In what immediately follows we shall set forth, first, how they all illustrate the nature of that operation of *inference* which is the heart of all intelligent action, and second, how the aim and outcome of thinking in all cases is the transformation of a *dubious* and perplexing situation into a *settled*, or determinate, one.

II. Inference to the Unknown

NO THOUGHT WITHOUT INFERENCE

In every case of reflective activity, a person finds himself confronted with a given, present situation from which he has to arrive at, or conclude to, something else that is not present. This process of arriving at an idea of what is absent on the basis of what is at hand is *inference*. What is present *carries* or *bears* the mind over to the idea and ultimately the acceptance of something else. From the consideration of established facts of location and time of day, the person in the first case cited made an inference as to the best way to travel in order to keep an appointment, which is a future and, at first, uncertain event. From observed and remembered facts, the second person inferred the probable use of a long pole. From the presence under certain conditions of bubbles and from a knowledge of securely established physical facts and principles, the third person inferred the explanation or cause of a particular event, previously unknown;

namely, the movement of water in the form of bubbles from the outside to the inside of a tumbler.

INFERENCE INVOLVES A LEAP

Every inference, just because it goes beyond ascertained and known facts, which are given either by observation or by recollection of prior knowledge, involves a *jump from the known into the unknown.* It involves a leap beyond what is given and already established. As we have already noted,[1] the inference occurs via or through the suggestion that is aroused by what is seen and remembered. Now, while the suggestion pops into the mind, just *what* suggestion occurs depends first upon the experience of the person. This in turn is dependent upon the general state of culture of the time; suggestions, for example, that occur readily now could not possibly spring up in the mind of a savage. Second, suggestions depend upon the person's own preferences, desires, interests, or even his immediate state of passion. The inevitableness of suggestion, the lively force with which it springs before the mind, the natural tendency to accept it if it is plausible or not obviously contradicted by facts, indicate the necessity of controlling the suggestion which is made the basis of an inference that is to be believed.

PROVING IS TESTING

This control of inference prior to, and on behalf of, belief constitutes *proof.* To prove a thing means primarily to *test* it. The guest bidden to the wedding feast excused himself because he had to *prove* his oxen. Exceptions are said to prove a rule; *i.e.*, they furnish instances so extreme that they try in the severest fashion its applicability; if the rule will stand such a test, there is no good reason for further doubting it. Not until a thing has been tried—"tried out," in colloquial language—do we know its true worth. Till then it may be pretense, a bluff. But the thing that has come out victorious in a test or trial of strength carries its credentials with it; it is approved, be-

1. See pages 119 and 145.

cause it has been proved. Its value is clearly evinced, shown; *i.e.*, demonstrated. So it is with inferences. The mere fact that inference in general is an invaluable function does not guarantee, nor does it even help out, the correctness of any particular inference. Any inference may go astray; as we have seen, there are standing influences ever ready to instigate it to go wrong. *What is important is that every inference be a tested inference;* or (since often this is not possible) *that we discriminate between beliefs that rest upon tested evidence and those that do not, and be accordingly on our guard as to the kind and degree of assent or belief that is justified.*

TWO KINDS OF TESTING

All three instances manifest the presence of testing operations that transform what would otherwise have been loose thinking into reflective activity. Examination reveals that the testing is of two kinds. Suggested inferences are tested in *thought* to see whether different elements in the suggestion are coherent with one another. They are also tested, after one has been adopted, by *action* to see whether the consequences that are anticipated in *thought* occur in *fact*. A good example of this second kind of proving is found in the first case cited, where reasoning had led to the conclusion that the use of the subway would bring the person to the place of his appointment in time. He tried or tested the idea by acting upon it, and the result confirmed the idea by bringing what was inferred actually to pass.

In the second case, the test by action could occur only as the person *imagined* himself in the place of the pilot who was using the pole to steer by. The test of coherence or consistency is markedly in evidence. Suggestions of flagpole, ornament, wireless, were rejected because, as soon as they were reflected upon, it was seen that they did not fit into some elements of the observed facts; they were dropped because they failed to agree with these elements. The idea that the pole was used to show the direction of movement of the boat, on the contrary, was found to agree with a number of important elements, such as (*a*) the need of the pilot, (*b*) the height of the pole, (*c*) the relative locations of its base and tip.

In the third instance, both kinds of testing are employed. After the conclusion was reached, it was acted upon by a further experiment, undertaken not only in imagination but also in fact. A cap of ice was placed upon the tumbler, and the bubbles behaved as they should behave if the inference was the correct one. Hence it was borne out, corroborated, verified. Other testing acts occurred in the process by using different ways of taking tumblers out of the water. The testing of consistency in thought occurred by reflecting upon the nature of expansion in its relation to heat and by considering whether the observed phenomena agreed with the facts that would have to follow from this principle. Obviously the use of both methods of proving a proposed inference is better than one alone. The two methods do not differ, however, in kind. Testing in thought for consistency involves acting in *imagination*. The other mode carries the imagined act out overtly. True inference is defined first as involving a leap to a suggested conclusion, and second as *trying* the suggestion to determine its agreement with the requirements of the situation. The original pattern of reflective action is set by cases in which the need for doing something is urgent, and where the results of what is done test the value of thought. As intellectual curiosity develops, connection with overt action becomes indirect and incidental. Yet it persists even if only in imagination.

III. Thinking Moves from a Doubtful to a Settled Situation

IT ARISES FROM A DIRECTLY EXPERIENCED SITUATION

Examination of the instances will show that in each case thinking arises out of a directly experienced situation. Persons do not just think at large, nor do ideas arise out of nothing. In one case a student is busy in a certain part of a city and is reminded of an engagement at another place. In the second case a person is engaged in riding on a ferryboat and begins to wonder about something in the construction of the boat. In the third case a student with prior scientific training is busy washing dishes. In each case the nature of the situation as it is actually experienced arouses inquiry and calls out reflection.

There is nothing in this fact peculiar to these special instances. Go through your own experience and you will not find a case where thinking started up out of nothing. Sometimes the train of thoughts will have taken you so far away from the starting point that you will have difficulty in getting back to that prior something out of which the thinking arose, but follow the thread far enough and you will find some situation that is directly experienced, something undergone, done, enjoyed, or suffered, and not just thought of. Reflection is occasioned by the character of this primary situation. It does not merely *grow out* of it, but it *refers back* to it. Its aim and outcome are decided by the situation out of which it arose.

Probably the most frequent cause of failure in school to secure genuine thinking from students is the failure to insure the existence of an experienced situation of such a nature as to call out thinking in the way in which these out-of-school situations do. A teacher was troubled by the failure of pupils, when dealing with arithmetical problems in multiplication involving decimals, to place the decimal point correctly. The numerical figures would be correct, but the values all wrong. One student might, for example, say $320.16; another, $32.016; and a third, $3201.60. This result showed that, while the pupils could manipulate figures correctly, they did not *think*. For if they had used thought, they would not vary so arbitrarily in grasping the values involved. Accordingly he sent the pupils to a lumberyard to purchase boards for use in the manual-training shop, having arranged with the dealer to let *them* figure the cost of their purchases. The same numerical operations were involved as in the textbook problems. No mistakes at all were made in placing the decimal. The situation itself induced them to think and controlled their grasp of the values involved. The contrast between the textbook problem and the requirements of the actual purchase in the lumberyard provides an excellent example of the necessity of a situation in order to induce and direct thought.

IT MOVES TOWARD A SETTLED SITUATION

Examination of the three cases also shows that each situation is in some fashion uncertain, perplexed, troublesome, if only in offering to the mind an unresolved difficulty, an unsettled question. It shows in each case that the function of reflection is to bring about a new situation in which the difficulty is resolved, the confusion cleared away, the trouble smoothed out, the question it puts answered. Any particular process of thinking naturally comes to its close when the situation before the mind is settled, decided, orderly, clear, for then there is nothing to call out reflection until a new bothersome or doubtful situation arises.

The function of reflective thought is, therefore, to transform a situation in which there is experienced obscurity, doubt, conflict, disturbance of some sort, into a situation that is clear, coherent, settled, harmonious.

The *stated* conclusion, the conclusion that is set forth in a proposition, is not the *final* conclusion but is the key to its formation. For example, the first person reached the conclusion "the best way to 124th Street is the subway train." But that conclusion was only the *key* to reaching the ultimate conclusion; namely, the keeping of an engagement. Thinking was the means of developing the original, perplexed situation into an eventual, satisfactory one. You can readily make similar analyses in the case of the other two illustrations. One great difficulty with the "logical," the exclusively formal type of which we spoke in the previous chapter, is that it begins and ends with mere propositions instead of bringing before the imagination the two actual life-situations to which the propositions refer; the one, which contains the doubt or difficulty, and the other, which is the final desired outcome and which was brought about by means of reflection.

There is no better way to decide whether genuine inference has taken place than to ask whether it terminated in the substitution of a clear, orderly, and satisfactory situation for a perplexed, confused, and discordant one. Partial and ineffectual thinking ends in conclusions that are formally correct but that make no difference in what is personally and immediately experienced. Vital inference always leaves one who thinks with a world that is experienced as different in some respect, for some object in it has gained in clarity and orderly arrangement. Genuine thinking winds up, in short, with an appreciation of new values.

7. Analysis of Reflective Thinking

I. Facts and Ideas

When a situation arises containing a difficulty or perplexity, the person who finds himself in it may take one of a number of courses. He may dodge it, dropping the activity that brought it about, turning to something else. He may indulge in a flight of fancy, imagining himself powerful or wealthy, or in some other way in possession of the means that would enable him to deal with the difficulty. Or, finally, he may face the situation. In this case, he begins to reflect.

REFLECTION INCLUDES OBSERVATION

The moment he begins to reflect, he begins of necessity to observe in order to take stock of conditions. Some of these observations are made by direct use of the senses; others by recollecting observations previously made either by himself or by others. The person who had the engagement to keep, notes with his eyes his present location, recalls the place where he should arrive at one o'clock, and brings back to mind the means of transportation with which he is acquainted and their respective locations. In this way he gets as clear and distinct a recognition as possible of the nature of the situation with which he has to deal. Some of the conditions are obstacles and others are aids, resources. No matter whether these conditions come to him by direct perception or by memory, they form the "*facts* of the case." They are the things that are *there*, that have to be reckoned with. Like all facts, they are stubborn. They cannot be got out of the way by magic just because they are disagreeable. It is no use to *wish* they did not exist or were different. They must be taken for just what they are. Hence observation and recollection must be used to the full so as not to glide over or to mistake important features. Until the habit of thinking is well formed, facing the situation to discover the facts requires an effort. For the mind tends to dislike what is unpleasant and so to sheer off from an adequate notice of that which is especially annoying.

REFLECTION INCLUDES SUGGESTIONS

Along with noting the conditions that constitute the facts to be dealt with, suggestions arise of possible courses of action. Thus the person of our illustration[1] thinks of surface cars, elevated trains, and the subway. These alternative suggestions compete with one another. By comparison he judges which alternative is best, which one is the more likely to give a satisfactory solution. The comparison takes place indirectly. The moment one thinks of a possible solution and holds it in suspense, he turns back to the facts. He has now a point of view that leads him to new observations and recollections and to a reconsideration of observations already made in order to test the worth of the suggested way out. Unless he uses the suggestion so as to guide to new observations instead of exercising suspended judgment, he accepts it as soon as it presents itself. Then he falls short of truly reflective thought. The newly noted facts may (and in any complex situation surely will) cause new suggestions to spring up. These become clews to further investigation of conditions. The results of this survey test and correct the proposed inference or suggest a new one. This continuous interaction of the facts disclosed by observation and of the suggested proposals of solution and the suggested methods of dealing with conditions goes on till some suggested solution meets all the conditions of the case and does not run counter to any discoverable feature of it.[2]

DATA AND IDEAS ARE CORRELATIVE AND INDISPENSABLE FACTORS IN REFLECTION

A technical term for the observed facts is *data.* The data form the material that has to be interpreted, accounted

1. See page 187.
2. The statements just made should be tested and illustrated by reference to the three cases set forth in the previous chapter.

for, explained; or, in the case of deliberation as to what to do or how to do it, to be managed and utilized. The suggested solutions for the difficulties disclosed by observation form *ideas*. Data (facts) and ideas (suggestions, possible solutions) thus form the two indispensable and correlative factors of all reflective activity. The two factors are carried on by means respectively of *observation* (in which for convenience is included memory of prior observations of similar cases) and *inference*. The latter runs beyond what is actually noted, beyond what is found, upon careful examination, to be actually present. It relates, therefore, to what is *possible*, rather than to what is actual. It proceeds by anticipation, supposition, conjecture, imagination. All foresight, prediction, planning, as well as theorizing and speculation, are characterized by excursion from the actual into the possible. Hence (as we have already seen) what is inferred demands a double test: first, the process of forming the idea or supposed solution is checked by constant cross reference to the conditions observed to be actually present; secondly, the idea *after* it is formed is tested by *acting* upon it, overtly if possible, otherwise in imagination. The consequences of this action confirm, modify, or refute the idea.

We shall illustrate what has been said by a simple case. Suppose you are walking where there is no regular path. As long as everything goes smoothly, you do not have to think about your walking; your already formed habit takes care of it. Suddenly you find a ditch in your way. You think you will jump it (supposition, plan); but to make sure, you survey it with your eyes (observation), and you find that it is pretty wide and that the bank on the other side is slippery (facts, data). You then wonder if the ditch may not be narrower somewhere else (idea), and you look up and down the stream (observation) to see how matters stand (test of idea by observation). You do not find any good place and so are thrown back upon forming a new plan. As you are casting about, you discover a log (fact again). You ask yourself whether you could not haul that to the ditch and get it across the ditch to use as a bridge (idea again). You judge that idea is worth trying, and so you get the log and manage to put it in place and walk across (test and confirmation by overt action).

If the situation were more complicated, thinking would of course be more elaborate. You can imagine a case in which making a raft, constructing a pontoon bridge, or making a dugout would be the ideas that would finally come to mind and have to be checked by reference to conditions of action (facts). Simple or complicated, relating to what to do in a practical predicament or what to infer in a scientific or philosophic problem, there will always be the two sides: the conditions to be accounted for, dealt with, and the ideas that are plans for dealing with them or are suppositions for interpreting and explaining the phenomena.

In predicting an eclipse, for example, a multitude of observed facts regarding position and movements of earth, sun, and moon, comes in on one side, while on the other side the ideas employed to predict and explain involve extensive mathematical calculations. In a philosophic problem, the facts or data may be remote and not susceptible of direct observation by the senses. But still there will be data, perhaps of science, or of morals, art, or the conclusions of past thinkers, that supply the subject matter to be dealt with and by which theories are checked. On the other side, there are the speculations that come to mind and that lead to search for additional subject matter which will both develop the proposed theories as ideas and test their value. Mere facts or data are dead, as far as mind is concerned, unless they are used to suggest and test some idea, some way out of a difficulty. Ideas, on the other hand, are *mere* ideas, idle speculations, fantasies, dreams, unless they are used to guide new observations of, and reflections upon, actual situations, past, present, or future. Finally, they must be brought to some sort of check by actual given material or else remain ideas. Many ideas are of great value as material of poetry, fiction, or the drama, but not as the stuff of knowledge. However, ideas may be of intellectual use to a penetrating mind even when they do not find any immediate reference to actuality, provided they stay in the mind for use when new facts come to light.

II. The Essential Functions of Reflective Activity

We now have before us the material for the analysis of a complete act of reflective activity. In the preceding chapter we saw that the two limits of every unit of thinking are a perplexed, troubled, or confused situation at the beginning and a cleared-up, unified, resolved situation at the close. The first of these situations may be called *pre-reflective*. It sets the problem to be solved; out of it grows the question that reflection has to answer. In the final situation the doubt has been dispelled; the situation is *post-reflective*; there results a direct experience of mastery, satisfaction, enjoyment. Here, then, are the limits within which reflection falls.

FIVE PHASES, OR ASPECTS, OF REFLECTIVE THOUGHT

In between, as states of thinking, are (1) *suggestions*, in which the mind leaps forward to a possible solution; (2) an intellectualization of the difficulty or perplexity that has been *felt* (directly experienced) into a *problem* to be solved, a question for which the answer must be sought; (3) the use of one suggestion after another as a leading idea, or *hypothesis*, to initiate and guide observation and other operations in collection of factual material; (4) the mental elaboration of the idea or supposition as an idea or supposition (*reasoning*, in the sense in which reasoning is a part, not the whole, of inference); and (5) testing the hypothesis by overt or imaginative action.

We shall now take up the five phases, or functions, one by one.

THE FIRST PHASE, SUGGESTION

The most "natural" thing for anyone to do is to go ahead; that is to say, to *act* overtly. The disturbed and perplexed situation arrests such direct activity temporarily. The tendency to continue *acting* nevertheless persists. It is diverted and takes the form of an idea or a suggestion. The *idea* of what to do when we find ourselves "in a hole" is a substitute for direct action. It is a vicarious, anticipatory way of acting, a kind of dramatic rehearsal. Were there only one suggestion popping up, we should undoubtedly adopt it at once. But where there are two or more, they collide with one another, maintain the state of suspense, and produce further inquiry. The first suggestion in the instance recently cited was to jump the ditch, but the perception of conditions inhibited that suggestion and led to the occurrence of other ideas.

Some inhibition of *direct* action is necessary to the condition of hesitation and delay that is essential to thinking. Thought is, as it were, conduct turned in upon itself and examining its purpose and its conditions, its resources, aids, and difficulties and obstacles.

THE SECOND PHASE, INTELLECTUALIZATION

We have already noted that it is artificial, so far as thinking is concerned, to start with a ready-made problem, a problem made out of whole cloth or arising out of a vacuum. In reality such a "problem" is simply an assigned *task*. There is not at first a situation *and* a problem, much less just a problem and no situation. There is a troubled, perplexed, trying situation, where the difficulty is, as it were, spread throughout the entire situation, infecting it as a whole. If we knew just what the difficulty was and where it lay, the job of reflection would be much easier than it is. As the saying truly goes, a question well put is half answered. In fact, we know what the problem *exactly* is simultaneously with finding a way out and getting it resolved. Problem and solution stand out *completely* at the same time. Up to that point, our grasp of the problem has been more or less vague and tentative.

A blocked suggestion leads us to reinspect the conditions that confront us. Then our uneasiness, the shock of disturbed activity, gets stated in some degree on the basis of observed conditions, of objects. The width of the ditch, the slipperiness of the banks, not the mere presence of a ditch, is the trouble. The difficulty is getting located and defined; it is becoming a true problem, something intellectual, not just an annoyance at being held up in what we are doing. The person who is suddenly blocked and troubled in what he is doing by the thought of an engagement to keep at a time that is near and a place that is distant has the suggestion of getting there at once. But in order to carry this suggestion into effect, he has to find means of transportation. In order to find them he has to note his present position and its distance from the station, the present time, and the interval at his disposal. Thus the perplexity is more precisely located: just so much ground to cover, so much time to do it in.

The word "problem" often seems too elaborate and dignified to denote what happens in minor cases of reflection. But in every case where reflective activity ensues, there is a process of *intellectualizing* what at first is merely an *emotional* quality of the whole situation. This conversion is effected by noting more definitely the conditions that constitute the trouble and cause the stoppage of action.

THE THIRD PHASE, THE GUIDING IDEA, HYPOTHESIS

The first suggestion occurs spontaneously; it comes to mind automatically; it *springs* up; it "pops," as we have said, "into the mind"; it flashes upon us. There is no direct control of its occurrence; the idea just comes or it does not come; that is all that can be said. There is nothing *intellectual* about its occurrence. The intellectual element consists in *what we do with it*, how we use it, *after* its sudden occurrence as an idea. A controlled use of it is made possible by the state of affairs just described. In the degree in which we define the difficulty (which is effected by stating it in terms of objects), we get a better idea of the kind of solution that is needed. The facts or data set the problem before us, and insight into the problem corrects, modifies, expands the suggestion that originally occurred. In this fashion the suggestion becomes a definite supposition or, stated more technically, a *hypothesis*.

Take the case of a physician examining a patient or a mechanic inspecting a piece of complicated machinery that does not behave properly. There is something wrong, so much is sure. But how to remedy it cannot be told until it is known *what* is wrong. An untrained person is likely to make a wild guess—the suggestion—and then proceed to act upon it in a random way, hoping that by good luck the right thing will be hit upon. So some medicine that appears to have worked before or that a neighbor has recommended is tried. Or the person fusses, monkeys, with the machine, poking here and hammering there on the chance of making the right move. The trained person proceeds in a very different fashion. He *observes* with unusual care, using the methods, the techniques, that the experience of physicians and expert mechanics in general, those familiar with the structure of the organism or the machine, have shown to be helpful in detecting trouble.

The idea of the solution is thus controlled by the diagnosis that has been made. But if the case is at all complicated, the physician or mechanic does not foreclose further thought by assuming that the suggested method of remedy is certainly right. He proceeds to act upon it tentatively rather than decisively. That is, he treats it as a guiding idea, a working hypothesis, and is led by it to make more observations, to collect more facts, so as to see if the *new* material is what the hypothesis calls for. He reasons that *if* the disease is typhoid, *then* certain phenomena will be found; and he looks particularly to see if *just* these conditions are present. Thus both the first and second operations are brought under control; the sense of the problem becomes more adequate and refined and the suggestion ceases to be a *mere* possibility, becoming a *tested* and, if possible, a *measured* probability.

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THE FOURTH PHASE, REASONING (IN THE NARROWER SENSE)

Observations pertain to what exists in nature. They constitute the facts, and these facts both regulate the formation of suggestions, ideas, hypotheses, and test their probable value as indications of solutions. The ideas, on the other hand, occur, as we say, in our heads, in our minds. They not only occur there, but are capable, as well, of great development there. Given a fertile suggestion occurring in an experienced, well-informed mind, that mind is capable of elaborating it until there results an idea that is quite different from the one with which the mind started.

For example, the idea of heat in the third instance in the earlier chapter[3] was linked up with what the person already knew about heat—in his case, its expansive force—and this in turn with the contractive tendency of cold, so that the idea of expansion could be used as an explanatory idea, though the mere idea of heat would not have been of any avail. Heat was quite directly suggested by the observed conditions; water was felt to be hot. But only a mind with some prior information about heat would have reasoned that heat meant expansion, and then used the idea of expansion as a working hypothesis. In more complex cases, there are long trains of reasoning in which one idea leads up to another

3. See page 189.

idea known by previous test to be related to it. The stretch of links brought to light by reasoning depends, of course, upon the store of knowledge that the mind is already in possession of. And this depends not only upon the prior experience and special education of the individual who is carrying on the inquiry, but also upon the state of culture and science of the age and place. Reasoning helps extend knowledge, while at the same time it depends upon what is already known and upon the facilities that exist for communicating knowledge and making it a public, open resource.

A physician to-day can develop, by reasoning from his knowledge, the implications of the disease that symptoms suggest to him as probable in a way that would have been impossible even a generation ago; just as, on the other hand, he can carry his observation of symptoms much farther because of improvement in clinical instruments and the technique of their use.

Reasoning has the same effect upon a suggested solution that more intimate and extensive observation has upon the original trouble. Acceptance of a suggestion in its first form is prevented by looking into it more thoroughly. Conjectures that seem plausible at first sight are often found unfit or even absurd when their full consequences are traced out. Even when reasoning out the bearings of a supposition does not lead to its rejection, it develops the idea into a form in which it is more apposite to the problem. Only when, for example, the conjecture that a pole was an index pole had been thought out in its implications could its particular applicability to the case in hand be judged. Suggestions at first seemingly remote and wild are frequently so transformed by being elaborated into what follows from them as to become apt and fruitful. The development of an idea through reasoning helps supply intervening or intermediate terms which link together into a consistent whole elements that at first seemingly conflict with each other, some leading the mind to one inference and others to an opposed one.

Mathematics as Typical Reasoning. Mathematics affords the typical example of how far can be carried the operation of relating ideas to one another, without having to depend upon the observations of the senses. In geometry we start with a few simple conceptions, line, angle, parallel, surfaces formed by lines meeting, etc., and a few principles defining equalities. Knowing something about the equality of angles made by parallel lines when they intersect a straight line, and knowing, by definition, that a perpendicular to a straight line forms two right angles, by means of a combination of these ideas we readily determine that the sum of the interior angles of a triangle is equal to two right angles. By continuing to trace the implications of theorems already demonstrated, the whole subject of plane figures is finally elaborated. The manipulation of algebraic symbols so as to establish a series of equations and other mathematical functions affords an even more striking example of what can be accomplished by developing the relation of ideas to one another.

When the hypothesis indicated by a series of scientific observations and experiments can be stated in mathematical form, that idea can be transformed to almost any extent, until it assumes a form in which a problem can be dealt with most expeditiously and effectively. Much of the accomplishment of physical science depends upon an intervening mathematical elaboration of ideas. It is not the mere presence of measurements in quantitative form that yields scientific knowledge, but that particular kind of mathematical statement which can be developed by reasoning into other and more fruitful forms—a consideration which is fatal to the claim to scientific standing of many educational measurements merely because they have a quantitative form.

THE FIFTH PHASE, TESTING THE HYPOTHESIS BY ACTION

The concluding phase is some kind of testing by overt action to give *experimental corroboration*, or *verification*, of the conjectural idea. Reasoning shows that *if* the *idea* be adopted, certain consequences follow. So far the conclusion is hypothetical or conditional. If when we look we find present all the conditions demanded by the theory, and if we find the characteristic traits called for by rival alternatives to be lacking, the tendency to believe, to accept, is almost irresistible. Sometimes direct observation furnishes corroboration, as in the case of the pole on the boat. In other cases, as in that of the bubbles, experiment is required; that is, *conditions are deliberately arranged in accord with the requirements of an idea or hypothesis to see whether the results theoretically indicated by the idea actually occur.* If it is found that the experimental results agree with the theoretical, or rationally deduced, results, and if there is reason to believe that *only* the conditions in question would yield such results, the confirmation is so strong as to induce a conclusion—at least until contrary facts shall indicate the advisability of its revision.

Of course, verification does not always follow. Sometimes consequences show failure to confirm instead of corroboration. The idea in question is refuted by the court of final appeal. But a great advantage of possession of the habit of reflective activity is that failure is not *mere* failure. It is instructive. The person who really thinks learns quite as much from his failures as from his successes. For a failure indicates to the person whose thinking has been involved in it, and who has not come to it by mere blind chance, what further observations should be made. It suggests to him what modifications should be introduced in the hypothesis upon which he has been operating. It either brings to light a new problem or helps to define and clarify the problem on which he has been engaged. Nothing shows the trained thinker better than the use he makes of his errors and mistakes. What merely annoys and discourages a person not accustomed to thinking, or what starts him out on a new course of aimless attack by mere cut-and-try methods, is a stimulus and a guide to the trained inquirer.

THE SEQUENCE OF THE FIVE PHASES IS NOT FIXED

The five phases, terminals, or functions of thought, that we have noted do not follow one another in a set order. On the contrary, each step in genuine thinking does something to perfect the formation of a suggestion and promote its change into a leading idea or directive hypothesis. It does something to promote the location and definition of the problem. Each improvement in the idea leads to new observations that yield new facts or data and help the mind judge more accurately the relevancy of facts already at hand. The elaboration of the hypothesis does not wait until the problem has been defined and adequate hypothesis has been arrived at; it may come in at any intermediate time. And as we have just seen, any particular overt test need not be final; it may be introductory to new observations and new suggestions, according to what happens in consequence of it.

There is, however, an important difference between test by overt action in practical deliberations and in scientific investigations. In the former the practical commitment involved in overt action is much more serious than in the latter. An astronomer or a chemist performs overt actions, but they are for the sake of knowledge; they serve to test and develop his conceptions and theories. In practical matters, the main result desired lies outside of knowledge. One of the great values of thinking, accordingly, is that it defers the commitment to action that is irretrievable, that, once made, cannot be revoked. Even in moral and other practical matters, therefore, a thoughtful person treats his overt deeds as experimental so far as possible; that is to say, while he cannot call them back and must stand their consequences, he gives alert attention to what they teach him about his conduct as well as to the non-intellectual consequences. He makes a problem out of consequences of conduct, looking into the causes from which they probably resulted, especially the causes that lie in his own habits and desires.

In conclusion, we point out that the five phases of reflection that have been described represent only in outline the indispensable traits of reflective thinking. In practice, two of them may telescope, some of them may be passed over hurriedly, and the burden of reaching a conclusion may fall mainly on a single phase, which will then require a seemingly disproportionate development. No set rules can be laid down on such matters. The way they are managed depends upon the intellectual tact and sensitiveness of the individual. When things have come out wrong, it is, however, a wise practice to review the methods by which the unwise decision was reached, and see where the misstep was made.

ONE PHASE MAY BE EXPANDED

In complicated cases some of the five phases are so extensive that they include definite subphases within themselves. In this case it is arbitrary whether the minor functions are regarded as parts or are listed as distinct phases. There is nothing especially sacred about the number five. For example, in matters of practical deliberation where the object is to decide what to do, it may be well to undertake a scrutiny of the underlying desires and motives that are operating; that is, instead of asking what ends and means will best satisfy one's wish, one may turn back to the attitudes of which the wish is the expression. It is a matter of indifference whether this search be listed as an independent problem, having its own phases, or as an additional phase in the original problem.

REFERENCE TO THE FUTURE AND TO THE PAST

Again, it has been suggested that reflective thinking involves a look into the future, a forecast, an anticipation, or a prediction, and that this should be listed as a sixth aspect, or phase. As a matter of fact, every intellectual suggestion or idea is anticipatory of some possible future experience, while the final solution gives a definite set toward the future. It is both a record of something accomplished and an assignment of a future method of operation. It helps set up an enduring habit of procedure. When a physician, for example, has diagnosed a case, he usually makes also a *prognosis*, a forecast, of the probable future course of the disease. And not only is his treatment a verification—or the reverse—of the idea or hypothesis about the disease upon which he has proceeded, but the result also affects his treatment of future patients. In some cases, the future reference may be so important as to require special elaboration. In this case, it may be presented as an added, distinct phase. Some of the investigations of an astronomical expedition to watch an eclipse of the sun may be directly intended, for example, to get material bearing on Einstein's theory. But the theory, itself, is so important that its confirmation or refutation will give a decided turn to the future of physical science, and this consideration is likely to be uppermost in the minds of scientists.

Of equal importance is the reference to the *past* involved in reflection. Of course, suggestions are dependent in any case upon one's past experience; they do not arise out of nothing. But while sometimes we go ahead with the suggestion without stopping to go back to the original experience of which it is the fruit, at other times we go consciously over the past experience in considerable detail as part of the process of testing the value of the suggestion.

For example, it occurs to a man to invest in real estate. Then he recalls that a previous investment of this kind turned out unfortunately. He goes over the former case, comparing it bit by bit with the present, to see how far the two cases are alike or unlike. Examination of the past may be the chief and decisive factor in thought. The most valuable reference to the past is likely, however, to come at the time the conclusion is reached. We noted earlier[4] the importance of a final survey to secure a net formulation of the exact result and of the premises upon which it logically depends. This is not only an important part of the process of *testing*, but, as was stated in the earlier discussion, is almost necessary if good habits are to be built up. Ability to *organize* knowledge consists very largely in the habit of reviewing previous facts and ideas and relating them to one another on a new basis; namely, that of the conclusion that has been reached. A certain amount of this operation is included in the testing phase that has been described. But its influence upon the attitude of students is so important that it may be well at times so to emphasize it that it becomes a definite function, or phase, on its own account.

4. See page 174.

13. Empirical and Scientific Thought

I. What Is Meant by Empirical

Many of our ordinary inferences, in fact all of them that have not been regulated by scientific method, are empirical in character; that is to say, they are in effect habits of expectation based upon some regular conjunction or coincidence in the experience of the past. Whenever two things are associated together, like, say, thunder and lightning, there is a tendency on the part of the mind to expect that, when one occurs, the other will happen too. When the conjunction is frequently repeated, the tendency to expect becomes a positive belief that the things are so connected that it is safe to reason that when one happens, the other is sure, or almost sure, to accompany it.

For example, A says, "It will probably rain to-morrow." B asks, "Why do you think so?" and A replies, "Because the sky was lowering at sunset." When B asks, "What has that to do with it?" A responds, "I don't know, but it generally does rain after such a sunset." He does not know of any objective *connection* between the appearance of the sky and coming rain; he is not aware of any continuity in the facts themselves—any law or principle, as we usually say. From frequently recurring conjunctions of the two events, he has associated them so that, when he sees one, he thinks of the other. One *suggests* the other or is *associated* with it. A man may believe it will rain to-morrow because he has consulted the barometer; but if he has no conception how the height of the mercury column (or the position of an index moved by its rise and fall) is connected with variations of atmospheric pressure, and how these in turn are connected with a tendency toward precipitation, his belief in the likelihood of rain is purely empirical. When men lived in the open and got their living by hunting, fishing, or pasturing flocks, the detection of the signs and indications of weather changes was a matter of great importance. A body of proverbs and maxims, forming an extensive section of traditionary folklore, was developed. But as long as there was no understanding *why* or *how* certain events were signs, as long as foresight and weather shrewdness rested simply upon repeated conjunction among facts, beliefs about the weather were thoroughly empirical.

EMPIRICAL THINKING IS USEFUL IN SOME MATTERS

In similar fashion wise men in the Orient learned to predict, with considerable accuracy, the recurrent positions of the planets, the sun, and the moon, and to foretell the time of eclipses, without understanding in any degree the laws of the movements of heavenly bodies—that is, without having a notion of the continuities existing among the facts themselves. They had learned from repeated observations that things happened in about such and such a fashion. Till a comparatively recent time, the truths of medicine were mainly in the same condition. Experience had shown that "upon the whole," "as a rule," "generally or usually speaking," certain results followed certain remedies, when certain symptoms were given. Most of our beliefs about human nature in individuals (psychology) and in masses (sociology) are still of a largely empirical sort. Even the science of geometry, now frequently reckoned a typical rational science, began, among the Egyptians, as an accumulation of recorded observations about methods of approximate mensuration of land surfaces and only gradually assumed, among the Greeks, scientific form.

IT HAS THREE OBVIOUS DISADVANTAGES

The *disadvantages* of purely empirical thinking are obvious. Attention may be called to three of them: (1) its tendency to lead to false beliefs, (2) its inability to cope with the novel, and (3) its tendency to engender mental inertia and dogmatism.

False Beliefs. First, while many empirical conclusions are, roughly speaking, correct; while they are exact enough to be of great help in practical life; while the presages of a weatherwise sailor or hunter may be more accurate, within a certain restricted range, than those of a scientist who relies wholly upon scientific observations and tests; while, indeed, empirical observations and records furnish the raw or crude material of scientific knowledge, yet the empirical method affords no way of discriminating between right and wrong conclusions. Hence it is responsible for a multitude of *false* beliefs. The technical designation for one of the commonest fallacies is *post hoc, ergo propter hoc*; the belief that because one thing comes *after* another, it comes *because* of the other. Now this weakness in method is the animating principle of empirical conclusions, even when they are correct—the correctness being almost as much a matter of luck as of method. That potatoes should be planted only during the crescent moon, that near the sea people are born at high tide and die at low tide, that a comet is an omen of danger, that bad luck follows the cracking of a mirror, that a patent medicine cures a disease—these and a thousand like notions are asseverated on the basis of empirical coincidence and conjunction.

The more numerous the experienced instances and the closer the watch kept upon them, the greater is the trustworthiness of constant conjunction as evidence of connection among the things themselves. Many of our most important beliefs still have only this sort of warrant. No one can yet tell, with certainty, the necessary cause of old age or of death, which are empirically the most certain of all expectations.

Confronting the Novel. Second, even the most reliable beliefs of this type fail when they confront the *novel.* Since they rest upon past uniformities, they are useless when further experience departs in any considerable measure from ancient incident and wonted precedent. Empirical inference follows the grooves and ruts that custom wears and has no track to follow when the groove disappears. So important is this aspect of the matter that Clifford found the difference between ordinary skill and scientific thought right here. "Skill enables a man to deal with the same circumstances that he has met before, scientific thought enables him to deal with different circumstances that he has never met before." And he goes so far as to define scientific thinking as "the application of old experience to new circumstances."

Mental Inertia and Dogmatism. Third, we have not yet made the acquaintance of the most harmful feature of the empirical method. Mental inertia, laziness, unjustifiable conservatism, are its probable accompaniments. Its general effect upon mental attitude is more serious than even the specific wrong conclusions in which it has landed. Wherever the chief dependence in forming inferences is upon the conjunctions observed in past experience, failures to agree with the usual order are slurred over, cases of successful confirmation are exaggerated. Since the mind naturally demands some principle of continuity, some connecting link between separate facts and causes, forces are arbitrarily invented for that purpose. Fantastic and mythological explanations are resorted to in order to supply missing links. The pump brings water because nature abhors a vacuum; opium makes men sleep because it has a dormitive potency; we recollect a past event because we have a faculty of memory. In the history of the progress of human knowledge, out-and-out myths accompany the first stage of empiricism, while hidden "essences" and occult "forces" mark its second stage. By their very nature these "causes" escape observation, so that their explanatory value can be neither confirmed nor refuted by further observation or experience. Hence belief in them becomes purely traditionary. They give rise to doctrines that, inculcated and handed down, become dogmas; subsequent inquiry and reflection are actually stifled.[1]

Certain men or classes of men come to be the accepted guardians and transmitters—instructors—of established doctrines. To question the beliefs is to question their authority; to accept the beliefs is evidence of loyalty to the powers that be, a proof of good citizenship. Passivity, docility, acquiescence, come to be primal intellectual virtues. Facts and events presenting novelty and variety are slighted or are sheared down till they fit into the Procrustean bed of habitual belief. Inquiry and doubt are silenced by citation of ancient laws or a multitude of miscellaneous and unsifted cases. This attitude of mind generates dislike of change, and the resulting aversion to novelty is fatal to progress. What will not fit into the established canons is outlawed; men who make new discoveries are objects of suspicion and even of persecution. Beliefs that perhaps originally were the products of fairly extensive and careful observation are stereotyped into fixed traditions and semi-sacred dogmas, accepted simply upon authority, and are mixed with fantastic conceptions that happen to have won the acceptance of authorities.

1. See pages 133–134.

II. Scientific Method

SCIENTIFIC METHOD EMPLOYS ANALYSIS

In contrast with the empirical method stands the scientific. Scientific method replaces the repeated conjunction or coincidence of separate facts by discovery of a single comprehensive fact, effecting this replacement by *breaking up the coarse or gross facts of observation into a number of minuter processes not directly accessible to perception.*

If a layman were asked why water rises from the cistern when an ordinary pump is worked, he would doubtless answer, "By suction." Suction is regarded as a force like heat or pressure. If such a person is confronted by the fact that water rises with a suction pump only about thirty-three feet, he easily disposes of the difficulty on the ground that all forces vary in their intensities and finally reach a limit at which they cease to operate. The variation with elevation above the sea level of the height to which water can be pumped is either unnoticed, or, if noted, is dismissed as one of the curious anomalies in which nature abounds.

Now the scientist advances by assuming that what seems to observation to be a single total fact is in truth complex. He attempts, therefore, to break up the single fact of water-rising-in-the-pipe into a number of lesser facts, in short, into data.[2] His method of proceeding is by *varying conditions one by one* so far as possible, and noting just what happens when each given condition is eliminated. In this way a fact too coarse and too extensive to be explained as a whole is resolved into a set of minor facts. Each minor fact is understood because it states a connection of cause and effect.

TWO METHODS OF VARYING CONDITIONS

There are two methods of varying conditions.[3] The first is an extension of the empirical method of observation. It consists in comparing very carefully the results of a great number of observations that have occurred accidentally under *different* con-

2. See pages 197–198.
3. The next two paragraphs repeat, for purposes of the present discussion, what we have already noted in a different context. See page 257.

ditions. The difference in the rise of the water at different heights above the sea level and its total cessation when the distance to be lifted is, even at sea level, more than thirty-three feet, are emphasized, instead of being slurred over. The purpose is to find out what *special conditions* are present when the effect occurs and are absent when it fails to occur. These special conditions are then substituted for the gross fact. Some of these more definite and exact data will give the key to understanding the event.

The method of analysis by comparing cases is, however, badly handicapped; it can do nothing until a certain number of diversified cases happen to present themselves. And even when such cases are at hand, it will be questionable whether they vary in just these respects in which it is important that they should vary in order to throw light upon the question at issue. The method is passive and dependent upon external accidents. Hence the superiority of the active, or experimental, method. Even a small number of observations may suggest an explanation—a hypothesis, or theory. Working upon this suggestion, the scientist then *intentionally* varies conditions and notes what happens. If the empirical observations have suggested to him the possibility of a connection between air pressure on the water and the rising of the water in the tube where air pressure is absent, he deliberately empties the air out of the vessel in which the water is contained and notes that "suction" no longer works, or he intentionally increases atmospheric pressure on the water and notes the result. He institutes experiments to calculate the weight of air at the sea level and at various levels above and compares the results of reasoning based upon the pressure of air of these various weights upon a certain volume of water with the results actually obtained by observation. *Observations formed by variation of conditions on the basis of some idea or theory constitute experiment.* Experiment is the chief resource in scientific reasoning because it facilitates the picking out of significant elements in a gross, vague whole.

EXPERIMENT INVOLVES BOTH ANALYSIS AND SYNTHESIS

Experimental thinking, or scientific reasoning, is thus a conjoint process of *analysis and synthesis*, or, in less technical language, of discrimination and identification. The gross fact of water rising when the suction valve is worked is resolved or discriminated into a number of independent variables, some of which had never before been observed or even thought of in connection with the fact. One of these facts, the weight of the atmosphere, is then selectively seized upon as the key to the entire phenomenon. This disentangling constitutes *analysis*. But atmosphere and its pressure or weight is a fact not confined to this single instance. It is a fact familiar, or at least discoverable as operative, in a great number of other events. In fixing upon this imperceptible and minute fact as the essence or key to the elevation of water by the pump, the pump-fact has thus been assimilated to a whole group of ordinary facts from which it was previously isolated. This assimilation constitutes *synthesis*. Moreover, the fact of atmospheric pressure is itself a case of one of the commonest of all facts—weight, or gravitational force. Conclusions that apply to the common fact of weight are thus transferable to the consideration and interpretation of the *relatively* rare and exceptional case of the suction of water. The suction pump is seen to be a case of the same kind or sort as the siphon, the barometer, the rising of the balloon, and a multitude of other things with which at first sight it has no connection at all. This is another instance of the synthetic, or integrative, function of thinking.

If we revert to the advantages of scientific over empirical thinking, we find that we now have the clue to them.

Lessened Liability to Error. The increased security, the added factor of certainty or proof, is due to the substitution of the *detailed and specific fact* of atmospheric pressure for the gross and total and relatively miscellaneous fact of suction. The latter is complex, and its complexity is due to many unknown and unspecified factors; hence, any statement about it is more or less random and likely to be defeated by any unforeseen variation of circumstances. *Comparatively*, at least, the minute and detailed fact of air pressure is a measurable and definite fact—one that can be picked out and managed with assurance.

Ability to Manage the New. As analysis accounts for the added certainty, so synthesis accounts for ability to cope with the novel and variable. Weight is a much commoner fact than atmospheric weight, and this in turn is a much commoner fact than the workings of the suction pump. To be able to substitute the common and frequent fact for that which is relatively rare and peculiar is to reduce the seemingly novel and exceptional to cases of a general and familiar principle and thus to bring them under control for interpretation and prediction.

As Professor James says:

> Think of heat as motion and whatever is true of motion will be true of heat; but we have a hundred experiences of motion for every one of heat. Think of rays passing through this lens as cases of bending towards the perpendicular, and you substitute for the comparatively unfamiliar lens the very familiar notion of a particular change in direction of a line, of which notion every day brings us countless examples.[4]

Interest in the Future. The change of attitude from conservative reliance upon the past, upon routine and custom, to faith in progress through the intelligent regulation of existing conditions is, of course, the reflex of the scientific method of experimentation. The empirical method inevitably magnifies the influences of the past; the experimental method throws into relief the possibilities of the future. The empirical method says, "*Wait* till there is a sufficient number of cases"; the experimental method says, "*Produce* the cases." The former depends upon nature's accidentally happening to present us with certain conjunctions of circumstances; the latter deliberately and intentionally endeavors to bring about the conjunction. By this method the notion of progress secures scientific warrant.

SCIENTIFIC THINKING IS FREED FROM CONSIDERATIONS OF THE IMMEDIATE AND THE FORCEFUL

Ordinary experience is controlled largely by the direct strength and intensity of various occurrences. What is bright, sudden, loud, secures notice and is given a conspicuous rating. What is dim, feeble, and continuous gets ignored, or is regarded as of slight importance. Customary experience tends to the control of thinking by considerations of *direct and immediate*

4. *Psychology*, vol. II, p. 342.

strength rather than by those of importance in the long run. Animals without the power of forecast and planning must, upon the whole, respond to the stimuli that are most urgent at the moment or cease to exist. These stimuli lose nothing of their direct urgency and clamorous insistency when the thinking power develops; and yet thinking demands the subordination of the immediate stimulus to the remote and distant. The feeble and the minute may be of much greater importance than the glaring and the big. The latter may be signs of a force that is already exhausting itself; the former may indicate the beginnings of a process in which the whole fortune of the individual is involved. The prime necessity for scientific thought is that the thinker be freed from the tyranny of sense stimuli and habit, and this emancipation is also the necessary condition of progress.

Consider the following quotation:

> When it first occurred to a reflecting mind that moving water had a property identical with human or brute force; namely, the property of setting other masses in motion, overcoming inertia and resistance,—when the sight of the stream suggested through this point of likeness the power of the animal,—a new addition was made to the class of prime movers; and when circumstances permitted, this power could become a substitute for the others. It may seem to the modern understanding, familiar with water wheels and drifting rafts, that the similarity here was an extremely obvious one. But if we put ourselves back into an early state of mind, when running water affected the mind *by its brilliancy, its roar and irregular devastation*, we may easily suppose that to identify this with animal muscular energy was by no means an obvious effort.[5]

THE VALUE OF ABSTRACTION

If we add to these obvious sensory features the various social customs and expectations that fix the attitude of the individual, the evil of the subjection of free and fertile suggestion to

5. Bain, *The Senses and Intellect*, third American ed., 1879, p. 492 (italics not in original).

empirical considerations—that is, to the *past* and to more or less uncontrolled experience—becomes evident.

Abstraction is an indispensable element in even ordinary thinking. It is found in all analysis, in all observation that detaches a quality from a vague blur in which it has been absorbed so as to give it distinctness. But scientific abstraction lays hold upon *relations* that could not in any case be perceived by sense. Its character is well brought out in the quotation just made from Bain. Some man got away from the almost overpowering conspicuous traits of running water to grasp a relation, that of carrying power.

A notion of abstraction is sometimes advanced that neglects this property and makes it intellectually insignificant. It is supposed to be simply the power of attending to some quality that an object is already known to possess to the exclusion of all other traits and features. But while this act is, under some circumstances, of practical value, the logical value of abstraction consists in seizing upon some quality or relation not previously grasped at all, making it stand out. It was an act of abstraction when the wing of a bird was seen to be identical, morphologically, with the forearm or foreleg, of other mammals; when the pod of peas and beans was seen to be a modified form of leaf and stem. Abstracting gets the mind emancipated from conspicuous familiar traits that hold it fixed by their very familiarity. Thereby it acquires ability to dig underneath the already known to some unfamiliar property or relation that is intellectually much more significant because it makes possible a more analytic and more extensive inference.

THE MEANING OF "EXPERIENCE"

The term *experience* may thus be interpreted with reference either to the *empirical* or to the *experimental* attitude of mind. Experience is not a rigid and closed thing; it is vital, and hence growing. When dominated by the past, by custom and routine, it is often opposed to the reasonable, the thoughtful. But experience also includes the reflection that sets us free from the limiting influence of sense, appetite, and tradition. Experience may welcome and assimilate all that the most exact and penetrating thought discovers. Indeed, the business of education might be defined as an emancipation and enlargement of experience. Education takes the individual while he is relatively plastic, before he has become so indurated by isolated experiences as to be rendered hopelessly empirical in his habit of mind. The attitude of childhood is naïve, wondering, experimental; the world of man and nature is new. Right methods of education preserve and perfect this attitude, and thereby short-circuit for the individual the slow progress of the race, eliminating the waste that comes from inert routine and lazy dependence on the past. Abstract thought is imagination seeing familiar objects in a new light and thus opening new vistas in experience. Experiment follows the road thus open and tests its permanent value.