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Verifiability

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[This paper was originally the second part of a Symposium in which the first symposiast was Mr. (now Professor) D. M. MacKinnon. It therefore naturally contained several polemical references to Professor MacKinnon's contribution. In tearing the present paper from that context in order to reprint it in this collection, we tried to remove as many of these references as possible; but unfortunately it was not practicable to remove them all without re-writing the entire paper. So we must apologize to Professor MacKinnon; and remind readers that in the interests of the unity of this book he has been denied the right to speak in his own cause.]

When we reflect on such a sentence as 'The meaning of a statement is the method of its verification', we should, first of all, be quite clear as to what we mean by the term 'method of verification'. From a logical point of view we are not interested in the various activities that are involved in verifying a statement. What, then, is it we have in mind when we talk of such things? Take an example. Suppose there is a metal ball in front of me, and I have the task of finding out whether the ball is charged with electricity. To do that I connect the ball with an electroscope and watch whether the gold leaves diverge. The statement 'The gold leaves of the instrument diverge' (s) describes the verification of the statement 'The ball is charged' (p). Now what exactly am I doing when I describe the verification of the statement p? I establish a connection between two statements by declaring that the one (s) is to follow from the other (p). In other words, I lay down a *rule of inference* which allows me to pass from the statement 'The ball is charged with electricity' to another that describes an observable situation. By doing this I connect the statement with another one, I make it part of a system of operations, I incorporate it into language, in short, I determine the way it is to be used. In this sense giving the verification of a statement is an important part of giving its use, or to put it differently, explaining its verification is a contribution, to its grammar.

In everyday life we understand sentences without bothering much as to the way they are verified. We understand them because we understand the single words which occur in them and grasp the grammatical structure of the sentence as a whole. The question of the verification arises only when we come across a new sort of combination of words. If, for instance, someone were to tell us that he owned a dog that was able to think, we should at first not quite understand what he was talking about and would ask him some further questions. Suppose he described to us in detail the dog's behaviour in certain circumstances, then we should say 'Ah, now we understand you, that's what you call thinking'. There is no need to inquire into the verification of such sentences as 'The dog

barks', 'He runs', 'He is playful', and so on, as the words are then used as we may say in their normal way. But when we say 'The dog thinks', we create a new context, we step outside the boundaries of common speech, and then the question arises as to what is meant by such a word series. In such cases explaining the verification is explaining the meaning, and changing the verification is changing the meaning. Obviously meaning and verification are connected -- so why say they are not?

But when I say that the statement p is connected with the statements $s_1, s_2 \dots s_n$ which describe evidences for it, I do not say that p is *identical* with $s_1, s_2 \dots s_n$ or their conjunction.¹ To say this would only be true if $s_1, s_2 \dots s_n$ or their conjunction entailed p . Now is that so? There may be statements which are nothing more than abbreviations for all that which is unfolded in their verification. There are, however, other sorts of statements of which this is certainly not true. Recent discussions on phenomenalism, for example, tend to show that no conjunction or disjunction of sense-datum statements, however complex, entails the existence or the non-existence of a certain material object. If that is so, a material object statement, though it is connected with sense-datum statements, is not just an abbreviation for them, rather has it a logical status of its own, and is not equivalent to any truth-function of the latter ones. I think that the result of these discussions is essentially right, and I ask for permission, to make my point quite clear, to add one word more.

The failure of the phenomenalist to translate a material object statement into terms of sense-data is not, as has been suggested, due to the poverty of our language which lacks the vocabulary for describing all the minute details of sense experience, nor is it due to the difficulties inherent in producing an infinite combination of sense-datum statements though all these things may contribute to it. In the main it is due to a factor which, though it is very important and really quite obvious, has to my knowledge never been noticed -- to the 'open texture'² of most of our empirical concepts. What I mean is this: Suppose I have to verify a statement such as 'There is a cat next door'; suppose I go over to the next room, open the door, look into it and actually see a cat. Is this enough to prove my statement? Or must I, in addition to it, touch the cat, pat him and induce him to purr? And supposing that I had done all these things, can I then be absolutely certain that my statement was true? Instantly we come up against the well-known battery of sceptical arguments mustered since ancient times. What, for instance, should I say when that creature later on grew to a gigantic size? Or if it showed some queer behaviour usually not to be found with cats, say, if, under certain conditions, it could be revived from death whereas normal cats could not? Shall I, in such a case, say that a new species has come into being? Or that it was a cat with extraordinary properties? Again, suppose I say 'There is my friend over there'. What if on drawing closer in order to shake hands with him he suddenly disappeared? 'Therefore it was not my friend but some delusion or other.' But suppose a few seconds later I saw him again, could grasp his hand, etc. What then? 'Therefore my friend was nevertheless there and his disappearance was some delusion or other.' But imagine after a while he disappeared again, or seemed to disappear -- what shall I say now? Have we rules ready for all imaginable possibilities?

An example of the first sort tends to show that we can think of situations in which we couldn't be certain whether something was a cat or some other animal (or a *jinni*). An example of the second sort tends to show that we can consider circumstances in which we couldn't be certain whether something was real or a delusion. The fact that in many cases there is no such thing as a conclusive verification is connected with the fact that most of our empirical concepts are not delimited in all possible directions. Suppose I come across a being that looks like a man, speaks like a man, behaves like a man, and is only one span tall -- shall I say it is a man? Or what about the case of a person who is so old as to remember King Darius? Would you say he is an immortal? Is there anything like an exhaustive definition that finally and once for all sets our mind at rest? 'But are there not exact definitions at least in science?' Let's see. The notion of gold seems to be defined with absolute precision, say by the spectrum of gold with its characteristic lines. Now what would you say if a substance was discovered that looked like gold, satisfied all the chemical tests for gold, whilst it emitted a new sort of radiation? 'But such things do not happen.' Quite so; but they might happen, and that is enough to show that we can never exclude altogether the possibility of some unforeseen situation arising in which we shall have to modify our definition. Try as we may, no concept is limited in such a way that there is no room for any doubt. We introduce a concept and limit it in *some* directions; for instance, we define gold in contrast to some other metals such as alloys. This suffices for our present needs, and we do not probe any farther. We tend to overlook the fact that there are always other directions in which the concept has not been defined. And if we did, we could easily imagine conditions which would necessitate new limitations. In short, it is not possible to define a concept like gold with absolute precision, i.e. in such a way that every nook and cranny is blocked against entry or doubt. That is what is meant by the open texture of a concept.

Vagueness should be distinguished from *open texture*. A word which is actually used in a fluctuating way (such as 'heap' or 'pink') is said to be vague; a term like 'gold', though its actual use may not be vague, is non-exhaustive or of an open texture in that we can never fill up all the possible gaps through which a doubt may seep in. Open texture, then, is something like *possibility of vagueness*. Vagueness can be remedied by giving more accurate rules, open texture cannot. An alternative way of stating this would be to say that definitions of open terms are *always* corrigible or emendable.

Open texture is a very fundamental characteristic of most, though not of all, empirical concepts, and it is this texture which prevents us from verifying conclusively most of our empirical statements. Take any material object statement. The terms which occur in it are non-exhaustive; that means that we cannot foresee completely all possible conditions in which they are to be used; there will always remain a possibility, however faint, that we have not taken into account something or other that may be relevant to their usage; and that means that we cannot foresee completely all the possible circumstances in which the statement is true or in which it is false. There will always remain a margin of uncertainty. Thus the absence of a conclusive verification is directly due to the open texture of the terms concerned.

This has an important consequence. Phenomenalists have tried to translate what we mean by a material object statement into terms of sense experience. Now such a translation would be possible only if the terms of a material object statement were completely definable. For only then could we describe completely all the possible evidences which would make the statement true or false. As this condition is not fulfilled, the programme of phenomenalism falls flat, and in consequence the attempts at analysing chairs and tables into patterns of sense-data -- which has become something of a national sport in this country -- are doomed to fail. Similar remarks apply to certain psychological statements such as 'He is an intelligent person'; here again it is due to the open texture of a term like 'intelligent' that the statement cannot be reduced to a conjunction or disjunction of statements which specify the way a man would behave in such-and-such circumstances.

It may have been a dim awareness of this fact that induced Locke to insist on corporeal, and Berkeley on mental substance. Doing away with their metaphysical fog, we may restate what seems to be the grain of truth in their views by saying that a material object statement, or a psychological statement has a logic of its own, and for this reason cannot be reduced to the level of other statements.

But there is a deeper reason for all that, and this consists in what I venture to call **the essential incompleteness of an empirical description**. To explain more fully: If I had to describe the right hand of mine which I am now holding up, I may say different things of it: I may state its size, its shape, its colour, its tissue, the chemical compound of its bones, its cells, and perhaps add some more particulars; but however far I go, I shall never reach a point where my description will be completed: logically speaking, it is always possible to extend the description by adding some detail or other. Every description stretches, as it were, into a horizon of open possibilities: however far I go, I shall always carry this horizon with me. Contrast this case with others in which completeness is attainable. If, in geometry, I describe a triangle, e.g. by giving its three sides, the description is *complete*: nothing can be added to it that is not included in, or at variance with, the data. Again, there is a sense in which it may be said that a melody is described completely in the musical notation (disregarding, for the moment, the question of its interpretation); a figure on a carpet, viewed as an ornament, may be described in some geometrical notation; and in this case, too, there is a sense in which the description may be called complete. (I do not mean the *physical* carpet, but its pattern.) The same applies to a game of chess: it can be described, move by move, from the beginning to the end. Such cases serve merely to set off the nature of an empirical description by the contrast: there is no such thing as completeness in the case in which I describe my right hand, or the character of a person; I can never exhaust all the details nor foresee all possible circumstances which would make me modify or retract my statement. (This was already seen by Leibniz when he said that anything actual is always inexhaustible in its properties and a true image of the Infinite Mind.)

The situation described has a direct bearing on the open texture of concepts. A term is defined when the sort of situation is described in which it is to be used. Suppose for a moment that we were able to describe situations completely without omitting anything (as in chess), then we could produce an exhaustive list of all the circumstances in which the term is to be used so that nothing is left to doubt; in other words, we could construct a *complete definition*, i.e. a thought model which anticipates and settles once for all every possible question or usage. As, in fact, we can never eliminate the possibility of some unforeseen factor emerging, we can never be quite sure that we have included in our definition everything that should be included, and thus the process of defining and refining an idea will go on without ever reaching a final stage. In other words, every definition stretches into an open horizon. Try as we may, the situation will always remain the same: no definition of an empirical term will cover all possibilities. Thus the result is that the incompleteness of our verification is rooted in the incompleteness of the definition of the terms involved, and the incompleteness of the definition is rooted in the incompleteness of empirical description; that is one of the grounds why a material object statement p can *not* be verified conclusively, nor be resolved into statements $s_1, s_2 \dots s_n$ which describe evidences for it. (In mathematics such a reduction is often possible: thus a statement about rational numbers can, without loss of meaning, be translated into statements about integers; but here you have complete description, complete definition and conclusive proof and refutation.)

One word more. Why is it that, as a rule, an experiential statement is not verifiable in a conclusive way? Is it because I can never exhaust the description of a material object or of a situation, since I may always add something to it -- something that, in principle, can be foreseen? Or is it because something quite new and unforeseen may occur? In the first case, though I know all the tests, I may still be unable to perform them, say, for, lack of time. In the second case I cannot even be sure that I know all the tests that may be required; in other words, the difficulty is to state completely what a verification would be in this case. (Can you foresee all circumstances which would turn a putative fact into a delusion?) Now the answer to the question is that *both factors combine* to prevent a verification from being conclusive. *But they play a very different part.* It is due to the first factor that, in verifying a statement, we can never finish the job. But it is the second that is responsible for the open texture of our terms which is so characteristic of all factual knowledge. To see this more clearly, compare the situation in mathematics: here a theorem, say Goldbach's hypothesis, which says that every even number can be represented as the sum of two primes, may be undecidable as we cannot go through all the integers in order to try it out. But this in no way detracts from the closed texture of the mathematical concepts. If there was no such thing as the (always present) possibility of the emergence of something new, there could be nothing like the open texture of concepts; and if there was no such thing as the open texture of concepts, verification would be incomplete only in the sense that it could never be finished (just as in the case of Goldbach).

To sum up: An experiential statement is, as a rule, not conclusively verifiable for two different reasons:

1. because of the existence of an unlimited number of tests;
2. because of the open texture of the terms involved.

These two reasons correspond to two different senses of 'incompleteness'. The first is related to the fact that I can never conclude the description of a material object, or of a situation. I may, for instance, look at my table from ever new points in space without ever exhausting all the possibilities. The second (and more exciting one) is due to the fact that our factual knowledge is incomplete in another dimension: there is always a chance that something unforeseen may occur. That again may mean two different things:

- a. that I should get acquainted with some totally new experience such as at present I cannot even imagine;
- b. that some new discovery was made which would affect our whole interpretation of certain facts.

An illustration of the first sort would be supplied by a man born blind who later obtained the experience of seeing. An illustration of the second sort would be the change brought about by the discovery of a new agent of nature, such as electricity. In this case we perceive that the data of observation are connected in a new and unforeseen way, that, as it were, new lines can now be traced through the field of experience. So we can say more exactly that the open texture of concepts is rooted in that particular incompleteness of our factual knowledge which I have just adumbrated.

What I have said modifies to a more or less extent the account I have given of verification. I said that in giving the method of verification we lay down a rule (or rules) of inference. We should, however, feel grave doubts whether that is so. **If a material object statement were to entail a sense datum statement, to entail it in a strictly *logical* sense, then the premiss would be cancelled together with the conclusion: or, to put it differently, a single negative instance would suffice to refute the premiss.** Suppose someone told me, 'Look, there is your friend, he is just crossing the street'. Now if I looked in the direction indicated, but failed to perceive the person who is my friend, would I say that the statement was refuted beyond the shadow of a doubt? There may be cases in which I may say that. But there are others in which I would certainly not think that the statement was refuted on the strength of such a single glance (for instance, when I was led to expect my friend at this hour, or received a letter from him saying that he will arrive at that time, and the like). A discrepancy between a material object statement and a single sense experience may always be explained away by some accessory assumption: I haven't looked thoroughly, my friend happened in this very second to be behind someone else, he just stepped into a doorway, and so on, not to mention more fanciful theories. I can never exclude the possibility that, though the evidence was against it, the statement may be true.

Whoever considers these facts with unbiassed eyes will, I trust, assent to the conclusion that a single sense experience, strictly speaking, never excludes a material object statement in the sense in which the negation of p excludes p . That means that no sense-datum statement s can ever come into *sharp logical conflict* with a material object statement p ; in other words: $p \sim s$ never represents a *contradiction* in the sense that $p \sim p$ does. In the light of this we can no longer adhere to the view that p entails s . **How, then, should we formulate the 'method of verification' -- that is, the connection between a proposition p and the statements $s_1, s_2 \dots s_n$ which are evidences for it? I propose to say that the evidences $s_1, s_2 \dots s_n$, *speak for or against* the proposition p , that they *strengthen or weaken* it, which does not mean that they prove or disprove it strictly.**

There is a striking analogy to that in the relation that holds between a law of nature L and certain observational statements $s_1, s_2 \dots s_n$, an analogy which may help to clarify the situation. It is often said that the statements of observation follow from the law (the latter being regarded as a sort of universal premiss). Since an unlimited number of consequences can be derived from a law, the ideal of complete verification is, of course, unattainable; whereas, on the other hand, a single counter observation seems to suffice to overthrow the law. From this it would follow that, while a law cannot be strictly verified, it can be strictly confuted; or that it can be decided only one way.³ That is unrealistic. What astronomer would abandon Kepler's laws on the strength of a single observation? If, in fact, some anomaly in a planet's behaviour were detected, the most varied attempts at explaining the phenomenon would first be made (such as the presence of unknown heavy masses, friction with rarefied gases, etc.). Only if the edifice of hypotheses thus erected has too little support in experience, if it becomes too complex and artificial, if it no longer satisfies our demand for simplicity, or again if a better hypothesis presents itself to us, such as Einstein's theory, would we resolve to drop those laws. And even then the refutation would not be valid finally and once for all: it may still turn out that some circumstance had escaped our notice which, when taken into consideration, would cast a different light upon the whole. Indeed, the history of science exhibits cases (Olaf Römer, Leverrier) in which the apparent defeat of a theory later turned into complete victory. Who can say that such a situation will not repeat itself?

Here again the view suggests itself strongly that the relationship between a statement and what serves to verify it was too crudely represented in the past; that it was a mistake to describe it in logical terms such as 'entailment'; that a law is not a sort of universal statement from which particular statements follow; that its logic is still unexplored, and that it may possibly take the form of rules according to which the law's truth-weight -- if I am allowed to use such a term -- is increased or lessened by the data of observation. Be that as it may, the mere fact that a single counter observation $\sim s$ can always be reconciled with a general law L by some accessory assumption shows that the true relation between a law and the experiential evidence for it is much more complicated and only superficially in accord with the customary account.

It will be said that this is due to our representing the case in too simple a manner. In reality the observational statement s does not follow from L alone, but from L plus a number of further premisses which are often not expressly stated. So that, if the observation s which we expected fails to materialize, we may say that any of the other premisses is false.

Now this would be perfectly correct if the system of premisses could be stated accurately and completely in every single case. But can it? Can we ever be certain of knowing all, really all the conditions on which the result of even the simplest experiment depends? Plainly not; what is stated is only a *part* of the conditions, viz., those which, e.g., can be isolated in experimental technique and subjected to our will, or which can readily be surveyed, etc. The others merge into one indistinct mass: the vague supposition that 'a normal situation subsists', that 'no disturbing factors are present' or in whatever way we may hint at the possibility of intervention of some unforeseen conditions. The relation between L and s , then, when exactly stated, is this: Given such-and-such laws $L_1, L_2 \dots L_m$, given such-and-such initial and boundary conditions $c_1, c_2 \dots c_n$ and *no other disturbing factors being present*, so-and-so will happen. And here it must be stressed that behind the words italicized a presupposition is concealed which cannot be split up into clear, separate statements. When actually deducing a consequence from a physical law we never make use of this premiss: it never forms part of the body of premisses: it does not enter the process of deduction. But then it should not be termed a premiss at all; what a queer sort of premiss this is, which is never made use of! What is, in fact, conveyed by these words is only that, in case of a conflict between theory and observation, we shall *search* for disturbing factors whilst considering ourselves free to adhere to the theory. The question at issue is *not* whether a certain system of assumption is sufficiently comprehensive -- that is a question of fact which may be left to the expert; the question is rather whether there is a criterion which assures us that a system of premisses is complete. To this there is no answer; nay, more, we cannot even form any conception of such a criterion; we cannot think of a situation in which a physicist would tell us, 'Well, I have finished the job; now I have discovered the last law of nature, and no more is to be found'. But if this is devoid of meaning, there is no point in insisting, '*If* all the conditions in the universe, and *if* all the laws governing them were known to us, then -- '. As the boundary regions of our knowledge are always enveloped in a dust cloud -- out of which something new may emerge -- we are left with the fact that s is not a strict logical consequence of L together with the initial conditions. Saying that the class of premisses is not 'closed' and that *therefore* the conclusion is lacking in stringency comes, in my view, to the same thing as saying that s is not a logical consequence of the premisses as far as they are stated. And that is all I wanted to say.

All this tends to suggest that the relation between a law of nature, and the evidences for it, or between a material object statement and a sense-datum statement, or again between a psychological statement and the evidence concerning a person's behaviour is a looser one than had been hitherto imagined. If that is correct, the application of logic seems to be limited in an important sense. We may say that the known relations of logic can only hold between statements which belong to a *homogeneous* domain; or that the deductive nexus never extends beyond the limits of such a domain.

Accordingly we may set ourselves the task of arranging the statements of our language in distinct strata, grouping in the same stratum all those statements linked by clearly apprehended logical relations. It is in this way, for instance, that the theorems of mechanics are organized in a system the elements of which stand in known logical relations with one another and where it is always possible to decide of two theorems in what logical relation they stand -- whether one is a consequence of the other, whether they are equivalent, or independent of, or in contradiction with each other. In like manner the statements of a physicist in describing certain data of observation (such as the position of a pointer on his gauges) stand in exactly defined relations to one another. Thus a pointer on a scale cannot possibly be opposite 3 and 5 at the same time: here you have a relation of strict exclusion. On the other hand, no statement of mechanics can ever come into sharp logical conflict with a statement of observation, and this implies that between these two kinds of statements there exist no relations of the sort supplied to us by classical logic. So long as we move only among the statements of a single stratum, all the relations provided by logic remain valid. The real problem arises where two such strata make contact, so to speak; it is the problem of these planes of contact which to-day should claim the attention of the logician. We may, in this context, speak of the looseness of the chains of inference which lead from statements of one stratum to those of another; the connection is no longer coercive -- owing to the incompleteness of all our data.

You will find that it is this fact to which the rise of philosophical troubles often can be traced. (Think of how confusing it is to assert or to dispute the statement, 'The floor is not solid', as it belongs to two quite distinct strata.) The fracture lines of the strata of language are marked by philosophical problems: the problem of perception, of verification, of induction, the problem of the relation between mind and body, and so on.

You will have noticed that I have used the term 'incompleteness' in very different senses. In one sense we may say of a description of a material object that it is incomplete; in another sense we may say that of our knowledge of the boundary conditions in a field of force. There is a sense in which we say that a list of laws of nature is always incomplete, and another sense in which even our knowledge of the agents of nature is so; and you may easily find more senses. They all combine, to a varying degree, to create what I have called the open texture of concepts and the looseness of inferences.

Incompleteness, in the senses referred to, is the mark of empirical knowledge as opposed to *a priori* knowledge such as mathematics. In fact, it is the criterion by which we can distinguish perfectly *formalized* languages constructed by logicians from *natural* languages as used in describing reality. In a formalized system the use of each symbol is governed by a definite number of rules, and further, all the rules of inference and procedure can be stated completely. In view of the incompleteness which permeates empirical knowledge such a demand cannot be fulfilled by any language we may use to express it.

That there is a very close relation between content and verification is an important insight which has been brought to light by empiricists. Only one has to be very careful how to formulate it. Far from identifying the meaning of a statement with the evidences we have for it, the view I tried to sketch leads to a sort of many-level-theory of language in which 'every sort of statement has its own sort of logic'.

II

In the second part of his paper Mr. MacKinnon is anxious to relate the notions of reality and causality by admitting as real only those objects (or events, or processes) which satisfy the conditions of causality. What he says is 'that the manner of discursive thought . . . reveals itself as an obstinate resolve . . . to admit nothing as real that does not manifest some ground of its occurrence'. That is part of Kant's doctrine according to which nothing can ever become object of our knowledge which did not conform to certain *a priori* forms of our intuition and our understanding. Such an attempt, if it succeeded, would be of tremendous importance. Think how miraculous it would be, using this method, to deduce from it causality, premisses of induction as well as other enjoyable things -- I had almost said to produce them out of the conjuror's hat called the Transcendental Argument. How comforting would be the belief that we know the nature of space and time through and through so that we are able to enunciate the principles of geometry without fear of ever being defeated by experience. How reassuring it would be to say that nature *must* obey causal laws -- and so on, you know the tune. The question is only whether Nature will conform to Kant. You will realize that such over-confidence is no longer permissible to-day, in the age of quantum mechanics. We are told by Mr. MacKinnon that 'we display an unwillingness to admit the completely random' (by the bye, what does he mean by that?) 'and discontinuous as objectively real'. But our protest, however strongly worded, would be of no avail if Nature was willing to baffle us. The words Mr. MacKinnon has been using state precisely the sort of situation with which we have come face to face in modern physics: things do happen without ground of their occurrence. May I be allowed to say a few words on this subject?

There are people who think that physicists have just not succeeded in discovering laws which tell us why things happen in the atomic world, in the cheerful hope that someone some day will have a brain-wave which will enable him to fill the gaps in wave mechanics; on this day the latter will turn into a completely deterministic theory. Let these people realize how wide the cleavage is that separates us from the good old days. The hope they cherish is based on an illusion: it has been proved⁴ that the structure of quantum mechanics is such that no further laws can be added to it which would make the whole theory deterministic; for if we could, we should, owing to the uncertainty principle, get entangled in contradictions. (The situation is, in fact, more intricate, but this is not the place to go into it.) So we are faced with the dilemma that quantum mechanics is *either* self-consistent or deterministic: you can't have it both ways. The crack in the wall of Determinism is definitive, and there is no way out of the situation.

According to Kant causality is an inescapable form which the nature of our understanding imposes on any given material. If this were so, it would be inconceivable -- against the

conditions of possible experience -- ever to come across any events which did not conform to the principle of causality. Quantum phenomena, however, have forced physicists to depart from this principle, or better, to restrict it, whilst a torso of it is retained. Though the fate of a single electron is not governed by causal laws, the particle being free to move about, for instance, to 'jump' in a collision with light waves however it pleases, the behaviour of millions of electrons is statistically predictable. Not exactly that quantum mechanics confronts us with a mathematician's dream of chaos come true. For, as I said, there is a causal aspect in the new theory, namely this: there are certain waves connected with the motion of particles, the de Broglie waves, which obey rigorous 'causal' laws. That is, the propagation of these waves is governed by a differential equation of the respectable old type such as you find in the classical physics of fields. Hence we can, given the initial conditions and the values over the boundary of a region during a certain interval of time, predict with absolute precision the propagation of the waves. That is exactly what any causal theory achieves. What is new, however, is the interpretation we must give to these waves: they are a sort of 'probability clouds' the density of which at each point signifies the probability of the occurrence of a particle. So what we can deduce from the theory are only probability statements regarding the presence of a particle in a given place at a given time. Such a statement can be tested, not by making a single experiment such as observing a single electron through a microscope, but by repeating the experiment a large number of times, or observing a large number of electrons and forming the mean value of all the data thus obtained. Therefore we cannot say where exactly a certain electron will be, but only with what probability, i.e. in what percentage of cases we may expect to find it at a certain place. In other words, the theory can be used only to predict the average *behaviour* of particles. That is the statistical aspect of the theory.

To sum up: quantum mechanics is neither a theory of the causal, deterministic type nor an indeterministic theory, whatever this may be taken to mean. The new physics combines deterministic and indeterministic features. What is deterministic is the law for the propagation of the de Broglie waves. That is, the propagation of these waves is *causally determined* in much the same way as, e.g., the propagation of electromagnetic waves is in the classical theories. What is indeterministic is the *interpretation* of these waves, that is, their connection with the facts of observation. Such an interpretation can only be given in statistical terms, and any attempt at interpreting it differently so as to reinstate causality would only lead to conflict with other well-established parts of the theory. Thus we have the curious result that causality holds for the de Broglie waves, which are no more than a purely symbolic and formal representation of certain probabilities, whereas the particles themselves obey no causal laws.

To bring home the last point let me add this: If it were possible to repeat exactly the same experiment and to bring about exactly the same conditions, the result would each time be a different one. Therefore the principle 'Like causes -- like effects' no longer holds.

Lasciate ogni speranza . . .

But may not quantum mechanics one day be superseded by a better theory that meets our demand for causal explanation? Certainly; no theory is sacrosanct and infallible. This,

however, is not the point. What matters is, not whether quantum mechanics draws a true picture of reality, but only whether it draws a *permissible* one. About that there can be little doubt. Kant was of the opinion that if there was no such thing as causality science would simply break down. Now the important thing that has emerged is the *possibility* of constructing a theory along different lines, the *legitimacy* of departing from causality, while science has not died or committed suicide on that account. This suffices to disown any claim on the part of Kant to regard causality as an *indispensable* form of our knowledge of the world. Had he been right, we could not even *entertain* such views as physicists do today; to give up causality, even if in part, would mean robbing ourselves of the very condition for gaining knowledge; which could end in one result only, in complete confusion. But that is not so. Though causality has been severely limited, quantum mechanics is a useful tool. Kant did not foresee the possible forms of physical laws; by laying too much stress on the scheme of causality, by claiming for it an *a priori* status, he unduly narrowed the field of research.

The conclusion to be drawn for the preceding seems to me this: Even if quantum mechanics should one day be found wanting and be superseded by another theory, it still offers a *possible picture* of the material world. This picture is neither self-contradictory nor unintelligible, though it may not be the sort of picture to which we are accustomed; anyhow, it is a working hypothesis which serves its purpose in that it is fruitful, i.e. that it leads to new discoveries. Whether it contains the ultimate truth we cannot tell (nor can we in the case of the deterministic theories). It's only experience that can bring forward evidence against it. But the very fact that we can turn to experience is significant: in doing so we grant that quantum mechanics, and consequently the limits of causality, *can* be tested in experiment. Hence every attempt at raising the principle of causality to the status of a necessary truth is irreconcilable with the situation as it has emerged in science. No matter whether quantum mechanics will stand its ground or will have to undergo some modification or other, the mere fact that the construction of such a theory is legitimate should settle the dispute: it proves that Kant's argument is based on a fallacy.

It was indeed an important step when man learnt to ask, Why? But it was also a great step when he learnt to drop this question. But leaving quantum mechanics and turning to the common world of sense, I still fail to see any ground for accepting Kant's position. True, in order to get our bearings in the world we must presuppose that there is some sort of order in it so that we may anticipate the course of events and act accordingly. What I fail to see, however, is why this order should be a strictly causal one. Suppose, for the sake of argument, that the objects around us were, on the average, to display an orderly behaviour, then the world may still be a liveable place. Suppose, for instance, the behaviour of chairs and the support they give us could be foreseen with much the same accuracy as can the behaviour of Tory and Labour candidates in election times, may we then not make use of them just the same? Or suppose they were to conduct themselves as our best friends do -- they won't let us down, no; still, you never know -- then, as far as I can see, this would be quite enough for all our practical ends. And as to the theoretical ones -- well, go to the scientist and you will hear a sorry tale of nature's trickery. I cannot see why such a world should not be possible.

This brings me to the topic in which Mr. MacKinnon is so much interested -- are there any necessary conditions which must be fulfilled if we are to attain knowledge of the external world? I propose to drop for the moment the subject of causality and to tackle the problem from a broader angle. Let me begin with some observations on the terms 'reality' and 'knowledge'.

Mr. MacKinnon, in his paper, repeatedly speaks of 'the real', 'the reality', he asks, for instance, whether 'the completely random' can be admitted as 'objectively real'. He blames Berkeley for having omitted 'to face the question of the rules whereby the inclusion in or exclusion from reality was determined; in consequence of which', we are told, 'his theory of knowledge flags'. In another passage he speaks of 'the task of compelling the actual to disclose itself. My impression is that he talks as if there was a clearly bounded domain called 'the real' or 'the actual' with the implication that it is one of the tasks of the philosopher to define it sharply. Unfortunately the belief that there is such a domain is very slender. Not that I deny for a minute that a word like 'reality' is a blessing; it definitely is. Look at such phrases as 'A tautology doesn't say anything about reality', 'Pure mathematics is not concerned with reality', 'In reality it was not Smith I saw but his brother'. It would be silly to put such a word on an *Index Prohibitorum Verborum* as though it were a sin to use it. It is very handy -- if it were not in use, we should have to invent it. On the other hand, when a philosopher looks closely at it, tears it from the context and asks himself, 'Now what is reality?' he has successfully manoeuvred himself into a fairly awkward position. For it is surprisingly easy to ask a number of questions which are more or less embarrassing; for instance, 'Is the elastic force present in a spring something real?' I suppose some people would answer Yes, some No. The fact is that there simply are no fixed rules that govern the use of the word. To go on -- 'Is a magnetic field something real?' 'Is energy? and entropy?' Again, I may ask, 'Is the power of my memory real?', 'Is the genius of a people, is the spirit of an age, is the beauty of a spring day real?' Now we begin to see how the idea is lost in indeterminacy. What we must understand is that such a word is used on many different levels and with many different shades of meaning. It has a *systematic ambiguity*. At the same time there is a sort of family likeness between all these uses, and it is that which makes us denote them by one word.

The same applies to a verb like 'to exist'. We use the word in many different senses: we may, for instance, say of a memory picture, an after-image, a mirror image, or again of a material object that it 'exists'; again, we may say of a wave-motion in a space of many dimensions, or of a law of nature, or of a number satisfying certain conditions that it 'exists'; and it is quite obvious that we do use the word in each case according to totally different criteria. So again we have a case of systematic ambiguity.

Next take the term 'knowledge'. Everyone is familiar with the distinction between knowledge by acquaintance and knowledge by description. This division is not fine enough. When I know something by acquaintance, I may know it in very different senses, as when I say 'I know sweetness' (meaning 'I am acquainted with the taste of sweetness'), 'I know misery', 'I know him', 'I know his writings'. In this series we go progressively farther away from simple acquaintance. In a case like 'I know his motives', it is doubtful

whether I should say this unless I had experienced some such motive myself. Moreover, there are cases which fall under none of the two groups; so, for instance, when I say 'I know French', 'I know how to deal with that man'. Again, we may speak in different senses of knowledge by description. Compare the case of a reporter who gained knowledge of some hush-hush affair with that of a scientist who claims to possess knowledge of nature. Now is this knowledge in the same sense? And mark, in the latter case there are again subtle differences. Compare knowledge of the history of certain birds as based on observation with knowledge of the history of our solar system as based on some hypothesis; again knowledge of a natural law of the causal type with knowledge of a statistical law. Quantum mechanics, though it is based on the assumption of a randomness in the behaviour of electrons (and other particles), leads to a lot of predictions. On this ground physicists do not hesitate to honour the newly discovered laws by awarding them the degree of knowledge; whereas Mr. MacKinnon thinks 'that we do concede the title unintelligible to any field . . . where such (causal) lines have not been traced'. Well, I shall not argue about that; my sole object is to call attention to the fact that the actual usage is unsettled, that there are many different types of knowledge, and that, by talking of knowledge *in general*, we are liable to overlook the very important differences between them. Suppose that someone has a vague awareness of the direction in which history moves -- shall, or shall I not call this knowledge? Can you draw a clear line to mark where such vague awareness ends and where true knowledge begins? Knowledge as supplied by quantum mechanics was unknown two or three decades ago. Who can tell what forms of knowledge may emerge in the future? Can you anticipate all possible cases in which you may wish to use that term? To say that knowledge is embodied in true propositions does not get you any farther; for there are many different structures that are called 'propositions' -- different, because they are verified in different senses of the word and governed by different sets of logical rules. (Incidentally speaking, the failure to draw a clear line between the meaningful and the meaningless is due to the fact that these terms have themselves a systematic ambiguity, and so has the term 'verifiable'.)

There is a group of words such as 'fact', 'event', 'situation', 'case', 'circumstance', which display a queer sort of behaviour. One might say of such words that they serve as pegs: it's marvellous what a lot of things you can put on them ('the fact that -- '). So far they are very handy; but as soon as one focusses on them and asks, e.g., 'What is a fact?' they betray a tendency of melting away. The peg-aspect is by far the most important of all. It's just as in the case of the word 'reality': in reality, e.g., 'in reality' is an adverb.

Again, there are many different types of fact; there are many different types of statement which are called 'empirical'; there are many different things which are called 'experience'; and there are many different senses of communication and clarity.

Now if I am to contribute to the main subject of this symposium, that is, to the question whether there are any *necessary conditions* for *gaining knowledge of reality* -- what am I to reply? Knowledge of reality! Of *what* sort of reality, and *what* sort of knowledge? As a logician I am bound to say that the notions of reality and knowledge have a systematic ambiguity and, moreover, that they are on each level extremely vague and hazy. I am

even not quite clear as to what a condition is, let alone a 'necessary condition'. How questionable all these ideas are! How can I be expected to answer a question which consists only of a series of question marks?

III

So far my criticism was mainly negative. In conclusion I should like to offer some constructive suggestions. Before doing so, I must warn you that I can't see any ground whatever for renouncing one of the most fundamental rights of man, the right of talking nonsense. And now I suppose I may go on.

People are inclined to think that there is a world of facts as opposed to a world of words which describe these facts. I am not too happy about that. Consider an example. We are accustomed to see colour as a 'quality' of objects. That is, colour cannot subsist by itself, but must inhere in a thing. This conception springs from the way we express ourselves. When colour is rendered by an adjective, colour is conceived as an attribute of things, i.e. as something that can have no independent existence. That, however, is not the only way of conceiving colour. There are languages such as Russian, German, Italian, which render colour by means of verbs. If we were to imitate this usage in English by allowing some such form as 'The sky blues', we should come face to face with the question, Do I mean the same fact when I say 'The sky blues' as when I say 'The sky is blue'? I don't think so. We say 'The sun shines', 'Jewels glitter', 'The river shimmers', 'Windows gleam', 'Stars twinkle', etc.; that is, in the case of phenomena of lustre we make use of a verbal mode of expression. Now in rendering colour phenomena by verbs we assimilate them more closely to the phenomena of lustre; and in doing so we alter not only our manner of speaking but our entire way of apprehending colour. We see the blue differently now -- a hint that language affects our whole mode of apprehension. In the word 'blueing' we are clearly aware of an active, verbal element. On that account 'being blue' is not quite equivalent to 'blueing', since it lacks what is peculiar to the verbal mode of expression. The sky which 'blues' is seen as something that continually brings forth blueness -- it radiates blueness, so to speak; blue does not inhere in it as a mere quality, rather is it felt as the vital pulse of the sky; there is a faint suggestion of the operating of some force behind the phenomenon. It's hard to get the feel of it in English; perhaps it may help you to liken this mode of expression to the impressionist way of painting which is at bottom a new way of seeing: the impressionist sees in colour an immediate manifestation of reality, a free agent no longer bound up with things.

There are, then, different linguistic means of rendering colour. When this is done by means of adjectives, colour is conceived as an attribute of things. The learning of such a language involves for everyone who speaks it his being habituated to see colour as a 'quality' of objects. This conception becomes thus incorporated into his picture of the world. The verbal mode of expression detaches colour from things: it enables us to see colour as a phenomenon with a life of its own. Adjective and verb thus represent two different worlds of thought.

There is also an adverbial way of talking about colour. Imagine a language with a wealth of expressions for all shades of lustre, but without adjectives for colours; colours, as a rule, are ignored; when they are expressed, this is done by adding an adverb to the word that specifies the sort of lustre. Thus the people who use this sort of language would say, 'The sea is glittering golden in the sunshine', 'The evening clouds glow redly', 'There in the depth a shadow greenly gleams'. In such phrases colour would lose the last trace of independence and be reduced to a mere modification of lustre. Just as we in our language cannot say 'That's very', but only some such thing as 'That's very brilliant', so in the language considered we could not say 'That's bluish', but only, e.g., 'That's shining bluishly'. There can be little doubt that, owing to this circumstance, the users of such language would find it very hard to see colour as a quality of things. For them it would not be the *things* that are coloured, rather colour would reside in the lustre as it glows and darkens and changes -- evidence that they would see the world with different eyes.

'But isn't it still true to say that I have the same experience whenever I look up at the sky?' You would be less happy if you were asked, 'Do you have the same experience when you look at a picture puzzle and see a figure in it as before, when you didn't see it?' You may, perhaps, say you see the same lines, though each time in a different arrangement. Now what exactly corresponds to this different arrangement in the case when I look up at the sky? One might say: we are aware of the blue, but this awareness is itself tinged and coloured by the whole linguistic background which brings into prominence, or weakens and hides certain analogies. In this sense language does affect the whole manner in which we become aware of a fact: the fact articulates itself differently, so to speak. In urging that you must have the same experience whenever you look at the sky you forget that the term 'experience' is itself ambiguous: whether it is taken, e.g., to include or to exclude all the various analogies which a certain mode of expression calls up.

Again, consider this case: Suppose there is a number of languages A, B, C . . . in each of which a proposition is used according to a slightly different logic. Consequently a proposition in the language A is not a proposition in exactly the same sense as a proposition in the language B, etc. And not only this: what is described by a statement in the language A, i.e., if you like, the 'fact', is not a fact in the same sense as a fact described in the language B, etc.; which tends to show that what is called a fact depends on the linguistic medium through which we see it.

I have observed that when the clock strikes in the night and I, already half asleep, am too tired to count the strokes, I am seized by an impression that the sequence will never end - - as though it would go on, stroke after stroke, in an unending measureless procession. The whole thing vanishes as soon as I count. Counting frees me, as it were, from the dark formlessness impending over me. (Is this not a parable of the rational?) It seems to me that one could say here that counting *alters* the quality of the experience. Now is it the same fact which I perceive when counting arid when not counting?

Again, suppose there is a tribe whose members count 'one, two, three, a few, many'. Suppose a man of this tribe looking at a flock of birds said 'A few birds' whereas I should say 'Five birds' -- is it the same fact for him as it is for me? If in such a case I pass to a language of a different structure, I can no longer describe 'the same' fact, but only another one more or less resembling the first. What, then, is the objective reality supposed to be described by language?

What rebels in us against such a suggestion is the feeling that the fact is there objectively no matter in which way we render it. I perceive something that exists and put it into words. From this it seems to follow that fact is something that exists independent of, and prior to language; language merely serves the end of communication. What we are liable to overlook here is that the way we see a fact -- i.e. what we emphasize and what we disregard -- is our work. 'The sunbeams trembling on the floating tides' (Pope). Here a fact is something that emerges out from, and takes shape against a background. The background may be, e.g., my visual field; something that rouses my attention detaches itself from this field, is brought into focus and apprehended linguistically; that is what we call a fact. A fact is noticed; and by being noticed it becomes a fact. 'Was it then no fact before you noticed it?' It was, if I could have noticed it. In a language in which there is only the number series 'one, two, three, a few, many', a fact such as 'There are five birds' is imperceptible.

To make my meaning still clearer consider a language in which description does not take the form of sentences. Examples of such a description would be supplied by a map, a picture language, a film, the musical notation. A map, for instance, should not be taken as a conjunction of single statements each of which describes separate fact. For what, would you say, is the boundary of a fact? Where does the one end and the other begin? If we think of such types of description, we are no longer tempted to say that a country, or a story told in a film, or a melody must consist of 'facts'. Here we begin to see how confusing the idea is according to which the world is a cluster of facts -- just as if it were a sort of mosaic made up of little coloured stones. Reality is undivided. What we may have in mind is perhaps that *language* contains units, viz. sentences. In describing reality, by using sentences, we draw, as it were, lines through it, limit a part and call what corresponds with such a sentence a fact. In other words, language is the knife with which we cut out facts. (This account is over-simplified as it doesn't take notice of *false* statements.)

Reality, then, is not made up of facts in the sense in which a plant is made up of cells, a house of bricks, a stone of molecules; rather, if you want a simile, a fact is present, in much the same sense in which a character manifests itself in a face. Not that I invent the character and read it into the face; no, the character is somehow written on the face but no one would on that account say that a face is 'made up' of features symbolic of such-and-such traits. Just as we have to interpret a face, so we have to interpret reality. The elements of such an interpretation, without our being aware of it, are already present in language -- for instance, in such moulds as the notion of thinghood, of causality, of number, or again in the way we render colour, etc.

Noticing a fact may be likened to seeing a face in a cloud, or a figure in an arrangement of dots, or suddenly becoming aware of the solution of a picture puzzle: one views a complex of elements as one, reads a sort of unity into it, etc. Language supplies us with a means of comprehending and categorizing; and different languages categorize differently.

'But surely noticing a face in a cloud is not inventing it?' Certainly not; only you might not have noticed it unless you had already had the experience of human faces somewhere else. Does this not throw a light on what constitutes the noticing of facts? I would not dream for a moment of saying that I invent them; I might, however, be unable to perceive them if I had not certain moulds of comprehension ready at hand. These forms I borrow from language. Language, then, *contributes to the formation and participates in the constitution* of a fact; which, of course, does not mean that it produces the fact.

So far I have dealt with perceptual situations only. This, I am afraid, will not satisfy Mr. MacKinnon. What he wants to know is whether there are any *general* conditions of the possibility of factual knowledge. We have seen some of the fallacies involved in putting this question. Still we may ask ourselves whether there are any methodological rules which guide us in gaining knowledge. All I can hope to do here is to throw out some hints.

The empiricist has a let-the-facts-speak-for-themselves attitude. Well, this is his faith; what about his works? Remember, a scientific theory is never a slavish imitation of certain features of reality, a dead, passive replica. It is essentially a construction which to a more or less degree reflects our own activity. When, for instance, we represent a number of observations made in the laboratory by a corresponding number of dots and connect them by a graph, we assume, as a rule, that the curve is continuous and analytic. Such an assumption goes far beyond any possible experience. There will always be infinitely many other possible curves which accord with the facts equally well; the totality of these curves is included within a certain narrow strip. The ordinary mathematical treatment substitutes an exact law for the blurred data of observation and deduces from such laws strict mathematical conclusions. This shows that there is an element of convention inherent in the formulation of a law. The way we single out one particular law from infinitely many possible ones shows that in our theoretical construction of reality we are guided by certain principles -- *regulative principles* as we may call them. If I were asked what these principles are, I should tentatively list the following:

1. Simplicity or economy -- the demand that the laws should be as simple as possible.
2. Demands suggested by the requirements of the symbolism we use -- for instance, that the graph should represent an analytic function so as to lend itself readily to the carrying out of certain mathematical operations such as differentiation.
3. Aesthetic principles ('mathematical harmony' as envisaged by Pythagoras, Kepler, Einstein) though it is difficult to say what they are.

4. A principle which so regulates the formation of our concepts that as many alternatives as possible become decidable. This tendency is embodied in the whole structure of Aristotelian logic, especially in the law of excluded middle.⁵
5. There is a further factor elusive and most difficult to pin down: a mere tone of thought which, though not explicitly stated, permeates the air of a historical period and inspires its leading figures. It is a sort of field organizing and directing the ideas of an age. (The time from Descartes to Newton, for instance, was animated by an instinctive belief in an Order of Things accessible to the human mind. Though the thinkers of that time have tried to render this tone of thought into a rationalistic system, they failed: for that which is the living spark of rationalism is irrational.)

Such, I think, are some of the regulative principles. The formulation of some of them is very vague, and advisedly so: it wouldn't be good policy to reduce mathematical harmony, consonance with the whole background of an age, etc., to fixed rules. It's better to have them elastic. Principle (5) should perhaps better be described as a condition for making -- and missing -- discoveries.

Now none of these principles is *indispensable*, imposed on us by the nature of our understanding. Kant has tried to condense the tone of thought of the Newtonian age into strict rules -- into *necessary conditions* of factual knowledge; with what success can be seen from the subsequent development: the belief in synthetic *a priori* judgements soon became something of a brake to research, discouraging such lines of approach as non-Euclidean geometry, and later non-causal laws in physics. Let this be a warning.

Writers on the history of philosophy are inclined to attend too exclusively to one aspect only -- to the ideas explicitly stated, canvassing their fabric, but disregarding the tone of thought which gives them their impetus. The deeper significance of rationalism, for instance, lies in the fact that it corresponds to what the scientist *does*, strengthening his belief that, if he only tries hard, he *can* get to the bottom of things. But slowly and gradually the mental climate changes, and then a philosophy may find itself out of tune with its time.

I do not think for a minute that what I have said is a conclusive refutation of Kant. On the other hand -- you may confute and kill a scientific theory; a philosophy dies only of old age.

Notes

1 This symbolism, and the other symbolism used in this article, is explained as it is introduced, and no knowledge of technical logic is required to understand it. -- Editor.

2 I owe this term to Mr. Kneale who suggested it to me as a translation of *Porosität der Begriffe*, a term coined by me in German.

3 See Karl Popper, *Logik der Forschung*.

4 See, for instance, J. v. Neumann, *Mathematische Grundlagen der Quantenmechanik*.

5 A more detailed account of this is given in my article on 'Alternative Logics' in *Proceedings of the Aristotelian Society*, 1945-6.