REITH LECTURES 1950: Doubt and Certainty in Science

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Lecture 1: The Biologist's Approach to Man

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When I was asked whether I would consider undertaking the Reith Lectures, I said that it might be possible for me to give some idea of the methods of science by describing the various sorts of work at present in progress on the brain. Frankly I did not consider that this would be a piece of research. The scientist does not usually think of the writing of books or preparing lectures as research. Writing seems to him to be a rather boring and tiresome labour that he must do after the fun of laboratory research and discovery is over. I therefore sat down to use the time available more in hope of making a summary than a discovery. But when I began to do this I came to realise the extent to which having to describe the results of one's thoughts to others is a part of the process of discovery itself. We are social creatures, depending far more than we realise on communication with each other. I have come to see how we can understand better both the workings of the brain and the nature of scientific enquiry itself if we realise how deeply our whole life is influenced by this necessity of communication. In fact, the BBC has made me think in a way that is new and helpful to me, and I hope may be so for others also.

I have often thought that one of the characteristics of scientists and their work is a certain confusion, almost a muddle. This may seem strange if you have come to think of Science with a big S as being all clearness and light. There is indeed a most important sense in which science stands for law and certainty. Scientific laws are the basis of the staggering achievements of technology that have changed the western world, making it, in spite of all its dangers, a more comfortable and a happier place. But if you talk to a scientist you may soon find that his ideas are not all well ordered. He loves discussion, but does not think always with complete, consistent schemes, such as are used by philosophers, lawyers or clergymen. Moreover in his laboratory he does not spend much of his time thinking about scientific laws at all. He is busy with other things, trying to get some piece of apparatus to work, finding a way of measuring something more exactly, or making dissections that will show the parts of an animal or plant more clearly. You may feel that he hardly knows himself what law he is trying to prove. He is continually observing, but his work is a feeling out into the dark, as it were. When pressed to say what he is doing he may present a picture of uncertainty or doubt, even of actual confusion.

This mixture of doubting with the certainty of scientific laws is not a new phenomenon. We had a chance recently to see it stretching over three whole centuries in the celebrations of the third centenary of Newton's birth in 1642. The Royal Society asked a number of learned men to write about Newton. Some placed great emphasis on the fact that Newton would not speculate 'beyond the limits where quantitative confirmation could be sought from nature'. They quoted Newton's famous remark, '*hypotheses non fingo*' - 'I do not make hypotheses'. By this he meant that he only derived laws from observations of nature, a process that he considered to

be distinct from framing a hypothesis as to the causes of the phenomena. Those who are attracted by this side of Newton's character emphasise his constant work in the laboratory, how he made his own mirrors, his own experiments with light and endless other matters. He was one of the most exact, practical and knowledgeable persons who has ever lived. 'I do not deal in conjectures' he himself said. Evidently for some people this is the typical picture of a scientist. But wait a minute. When Newton said that he did not deal in conjectures he was eighty-one years old. Other learned men investigating his writings have proved that what he said about himself was not true. He *did* make hypotheses and conjectures; from his young and most fruitful period onwards he made them endlessly. Some of them were very good hypotheses - Newton developed a theory that matter is made of atoms, which could hardly be bettered today. But he could not prove it. He could neither see the atoms nor detect the forces that bind them together, as we can do today. His theory was therefore a sort of guess - a conjecture. He made another guess about an aether that pervades all space. And he puzzled over much more curious matters than these. He spent a great deal of time studying the writings of mystics, theologians and alchemists. For weeks on end he worked in his laboratory making experiments to find the philosophers' stone that would turn lead into gold. He left a mass of writing on these magical and alchemical subjects, writings so diffuse that they have never been published. The late Lord Keynes, commenting on these papers, suggested that Newton was not so much one of the first men of the age of reason as the last of the magicians. He seems to have thought of the universe as a riddle posed by God that could be solved if one looked hard enough for the clues. Some of the clues were to be sought in nature,- others had been revealed in sacred and occult writings. The search for the answers was a continual struggle and anxiety and it drove Newton to the edge of madness.

The point for us is that Newton did not spend his time simply observing nature. Besides doing that his brain tried to put all the observations together, to fit them into general schemes. This search is the process that I call doubting. It is a process of exploration and when significant resemblances are found we say that a new law has been promulgated, some degree of certainty has been achieved. What I hope to be able to demonstrate is that this mixture of doubt and certainty is not at all an accident. It is the very nature and essence of scientific method. Moreover it is not by any means a character peculiar to science. Science is only the latest product of the human brain which has been working in essentially the same way for the last 10,000 years: that is to say for the period of our history as a social animal. Still the matter does not end there. This method of proceeding is but a development of the way in which all brains work. Indeed, I shall try to show that there is something corresponding to the discovery of certainty through doubt in all the operations of living things.

A Formidable Task

This is a formidable task, ridiculous you may feel, for anyone to attempt. Indeed I became conscious as I proceeded of how much I need to know of history, psychology, anthropology, mathematics and many other things. But to be able to see in perspective the range of phenomena from the nature of human thinking and scientific enquiry to the facts of evolution (and perhaps even of cosmology) would be such a clarification that it is worth the attempt. I feel that I have made some progress in this direction and I cannot do less than ask you to share the results, taking what may be wrong with anything that is right.

The method I have followed is simple enough. I have looked at man as a modem biologist looks at plants and animals. How do biologists work and what language do they use to describe their view of the world? We might say that they examine how each sort of animal and plant manages to keep its kind alive. Every creature maintains its organisation distinct from the surroundings. It prevents itself from returning to dust. Biologists study how even the humblest plant is a wonderfully organised system of roots, stem, leaves and flowers arranged to do this. These parts all act together to extract from the simple materials of soil and air the means to build the plant and propagate its kind. In animals similarly the various parts act together to nourish and protect the organisation and enable it to continue.

The biologists' question about man is, therefore, how does he get his living on the earth? What are the means by which the continuity of human life is ensured? In answering it some biologists might say: 'Man is an omnivorous, terrestrial bipedal mammal' or some such talk. Besides being pompous, I believe that such phrases show where we biologists have all been wrong. We have been concentrating on those features of man that are obviously like those of animals; his digestion, his locomotion and so on. We have been very much more loath to realise that we can apply the same methods also to his higher functions. Eating and walking are not the really important features of man. We all recognise that it is far more significant that he is, shall we say, a thinking creature, or a worshipping one. What we have not sufficiently considered is that it is just these traits of what we commonly call man's mind that are also his most peculiar and important biological characteristics. These are the features by which he gets his living. In fact, they are the very ones that should most attract our attention as biologists. Each animal has some special ways of conducting its life. The cow and sheep have special stomachs that digest grass. The tiger has its teeth, the elephant its trunk and its teeth, and so on.

What then are the special characteristics of modern man? Surely the chief one is that of co-operation between individuals. Man's large brain is used to develop an intricate social system, based mainly on communication by words. Man has many other special features, such as good eyes for getting information, and good hands for doing intricate things. But it is chiefly co-operation that enables him to obtain a living for more than 2,000,000,000 human beings scattered over nearly all regions of the earth. Sophocles expressed it long ago in a few words when he said: 'Of all the wonders none is more wonderful than man who has learned the arts of speech, of windswift thought, and of living in neighbourliness '. These are indeed the matters that must chiefly engage the serious student of man. Of course on this subject of human co-operation a vast mass of knowledge has been collected by generations of anthropologists, psychologists, sociologists and others. But there is, even yet, no coherent body of knowledge about the biology of man that sets him in his proper place in the living world. Biologists are only now beginning to study what may be called the higher attributes of man, his language, his social behaviour, his religion and his science. We may find valuable new ideas by applying the biological method to the very highest of our activities and correlating these with the study of the organ that mediates them-the brain.

Powers of Communication

The factor we have been ignoring 'is that these special features of man are all due to the fact that we have developed far beyond other animals in the power of

communication between individuals. Biologists have so far neglected to give full attention to the significance of communication to our species. The subject has been forced on their attention in recent years by the great development of mechanical aids to communication. There has already been some useful co-operation between biologists studying the brain and the engineers and mathematicians responsible for radio, television and similar new devices. One result has been the comparison of the brain with calculating machines. But that is really only a detail. What is much more important is that we are now beginning to understand the importance of communication itself as a human activity. By thinking about this we shall find, I believe, a remarkable clarification of our ideas. What I hope to show is that proper use of communication has been the chief secret of the success of human societies in the past, and that it will certainly be so in both the immediate and the more distant future. When I come to describe the brain I shall show how very extensive parts of it are concerned with speech. We are only beginning to understand, however, how the brain works to produce particular methods of speaking. Societies certainly change their methods of communication through the centuries. Recently the western world has developed a whole set of new techniques for the transfer of information. As a result, co-operation- between individuals has improved, and better and better tools and machines have been produced. Men have gradually learned the great advantages that come from being able to convey information fully and exactly to each other. The impact of new techniques of communication is felt in all sorts of ways. Everyone appreciates that the spread of education transforms society. When allied to science it gives great new powers to a community. It is perhaps not too much to say that we owe our survival to the radar communicating devices that won us the Battle of Britain. Modern armies, by making use of their well-trained brains and new equipment, can perform feats such as were seen in Normandy and Korea. They can overwhelm less developed organisations. These are particular examples of the power that comes from good communication.

But much more important in the long run are the ways in which large groups of people are knit together. It is only by proper communication that human societies retain he adherence of their members. Perhaps nothing is more important for our future than to discover the best ways of using knowledge about these matters. We are apt to do it at present for the interest of particular groups, classes or countries. These are indeed natural units of communication and it would be unrealistic to ignore their importance. But we must try to find ways of making as many as possible of them interact for the benefit of mankind as a whole. Whether we like it or not we can be sure that societies that use to the full the new techniques of communication, by both better words and better machines, will eventually replace those that do not.

What I am going to discuss, therefore, is the way the brain makes communication between human beings possible. Here we come against a difficulty that is bound to worry us a lot. We seem to hay two ways of talking about these matters. On t t one hand each of us knows that he or she has what seem to be their private experiences, sensations, thoughts, pleasures and pains. These are, in some sense, for' each of us our own. They seem to occur in us, and yet are not part of our physical body. On the other hand, when we talk about communication we are also obviously discussing what we call a physical system; there is a transmitter (the brain, tongue and larynx) in one person and a receiving system (the ears and brain) in the other. This is the famous dualism of mind and matter, which is perhaps the central problem of modern

philosophy, religion and science. No doubt most of us have felt the block to our thinking imposed by the obscurity of the relation of mind and matter. The consideration of this problem by philosophers in recent years has shown how easily we are deceived in the way we use such words as 'mind'. I propose to try to show how we can perceive one main source of these confusions. We may perhaps even devise a way of speaking that avoids the dilemma altogether.

Consider first that without leaving the topic of the brain, we can at least begin' to discuss many, perhaps all, human activities. The method that I am going to suggest as a working basis is to organise all our talk about human powers and capacities around knowledge of what the brain does. When the philosopher studies the way in which-people think, let him consider what activity this represents in the brain; for certainly there is some. When the theologian studies the fact that human beings tend to organise their activities around statements about gods, let him consider the activity that this 'involves in the brain. When the educationist and psychologist follow the ways in which the child grows to his mature powers and later perhaps goes astray, let them consider the processes of the development and decay of the activities of the brain.

This is a very simple, straightforward way of proceeding and yet it may seem strange and new. People are curiously unwilling to accept and use the simple and obvious idea that all the things that they do, including the more complicated ones (say painting a picture) involve activity in their brains. Indeed many of -you may deny what I have just said. 'But it's not true that my brain paints the picture—it is I who do that. I am not just a mass of whitish stuff inside my skull ' But at least you will agree that in painting a picture the eye is receiving light and sending messages to the brain. Then after appropriate activity the brain sends other messages back to the hands. 'Yes', you may reply, 'I agree about that, but what about thinking, when it's all internal? 'There, too, I am prepared to say that there are some brain processes at work whenever anyone thinks. Moreover, I propose to show that it is not impossible that these could be detected. Then I could literally read your thoughts. 'Unpleasant prospect', you might reply, 'but in any case where is all this getting us? What about my pains and pleasures, hopes and fears, all my experience? They still remain mine, don't they? However much I share them with you, that does not alter the fact that there is a me experiencing them, who am in some way distinct from my body. Surely this experience is for me the ultimate reality '.

I agree that there is a sense in which we can say that this is so. But it is important to realise how extraordinarily difficult it is going to be to find that sense. As the biologist sees it our brains are so constituted that we have learned to speak always in terms of self and otherness. From babyhood onwards we learn to satisfy our needs by communicating with others and eliciting their co-operation. Our brains therefore come to act in ways that are effective for this purpose. We soon acquire, for instance, the habit of focussing attention on certain sorts of objects around us and naming them. The brain has remarkable powers of comparing each new object with some familiar one and this tendency can be seen at work in the growth of the habit of speaking of I, of oneself, the habit that gives rise to so much of the confusion over mind and body. In order to speak about ourselves we use the convention that placed in some way within us there is an agent who is said to act as we describe other men acting. This habit of postulating active creatures within bodies, the habit of animism, is an extremely convenient device for communication. It enables us to speak of the actions

of all sorts of things in terms of the actions of other people, which are easily described. It has become an integral part of our western system of communication. We do not find it easy to talk without speaking of some entity, the self, communicating with others. Our brains have become so arranged that we organise nearly all our experience into these forms in order to talk about it. We can say if we like that our experience is our own and that it is real. But we are so built that we must try to communicate it. To do this we put this so-called raw experience into the form that there is something called 'me' here, communicating with a something 'not me'.

I do not propose to pursue the question further here. Philosophers can do it far better than I can, but it seemed to me to be essential to raise it in my very first lecture, difficult though it may be to grasp. I am going to ask you to listen to me talking about all our highest thoughts and aspirations as functions of the brain. This would seem absurd f I did not make it clear that for all of us in some sense what we call our inner experience is the central fact. I hope that it will gradually appear how this central fact of living becomes in modern man translated, as it were, to reveal what we agree to call a world outside ourselves. The world is like that for us because we put as much as possible of our experience into a form suitable far communication to others. I shall try to show how it comes about that we speak of ourselves as distinct entities, set in our bodies, able to communicate with others like ourselves. I shall try to show how our brains make us able to communicate by comparing one thing with another. In early stages of human communication man described the action of all bodies as caused by spirits or powers resident within them. Recently we have learned that it is better not to use this animistic way of speaking about other things. Perhaps therefore we do not even need to do it when talking about ourselves or each other. We may be able ultimately to dispense with the concept of mind altogether.

Science has discovered that it can do without animistic models. Instead it speaks about whatever part of the world it is studying by comparison with man-made machines. Further, science has developed all sorts of other special techniques of communication, such as mathematics. It will be my aim in these lectures to try to show how the brain works, using these new models. I shall discuss their advantages and their limitations. Certainly we have considerably improved our ways of speaking in recent years, so that we come to talk in greater and greater detail about phenomena and hence to control them better. Such improvement has been going on by fits and starts ever since the beginning of human history. We shall be able to follow how man has improved in this respect. He has gradually given up speaking about almost all aspects of the world as consisting of entities that are moved by capricious spirits. He has reached a state where all men can agree about the occurrence of many marvellous phenomena that were previously not understood or even were wholly unknown. But we remain men and not supermen. We must use the natures and habits that we inherit, including those of language. Let us then try to see what the biologist can tell us about men.

This will mean that I must spend some time describing what has been found out about nerves and the brain. We speak about such matters, as about most other things, mainly by comparison. I shall do this in the case of the brain, discussing, for instance, in what ways it is like a calculating machine. This procedure of finding analogies is a characteristic human method. It suggests, as we shall often see, new ways of looking that actually lead us to new discoveries. The brain is continually searching for fresh

information about the, rhythm and regularity of what goes on around us. This is the process that I call doubting, seeking for significant new resemblances. Once they are found they provide us with our system of—law, of certainty. We decide that this is what the world is like and proceed to talk about it in those terms. Then sooner or later someone comes along who doubts, someone who tries to make a new comparison; when he is successful mankind learns to communicate better and to see more.
So I shall have much to say about how the brain makes comparisons. We shall find that its mode of doing so is continually modified by the happenings that occur to it. This is the process that we call learning. I shall discuss what little is known of the actual changes that learning involves in the brain. I shall follow how the child learns its system of certainty, its laws of acting, by the- process of a series of operations of doubt. After that I shall try to trace how human society has developed its plan of brain action that is handed on from generation to generation. I shall give examples of how the earliest systems of brain action were modified to produce those current in the Middle Ages. These in turn gave rise by gradual development to the ways of acting that we call scientific. Finally I shall discuss how earlier scientific ways have themselves become modified and enlarged, by a continuation of the same process.
But of course it is no good our hoping to understand all the functions of the brain in a series of radio lectures. You would not expect me in this time to teach you how to analyse and make a wireless set, or even how to drive a railway engine. The human brain is enormously more complicated than such machines. To understand it we shall need a collection of specialists at least as numerous as our present engineers and shall have to learn to use words, I am afraid, at least as obscure as theirs. At present there are relatively few people at work on the subject of the brain and little is known. Of course the reason for that is not just short-sightedness. It is literally that the study of the human brain has seemed so difficult that few have liked to attempt it. Not many people have been able to see even that there could be wide and powerful generalisations made about the brain, still less that there could be practical applications of that knowledge.

But this short-sightedness is not a new phenomenon. In just the same way there were only a few people in the Middle Ages who could see that it was worth while to study physical science or astronomy. When they did begin to do so they found that it showed them how to navigate and to do all sorts of practical things. Man has been gradually learning the possibility of using new techniques of communication ever since his earliest days. The information we have collected about the brain is now at last sufficient to be of some use to us. We are beginning already to see the sources of some of our more crude brain disorders. Surgeons can help us to overcome epilepsy and perhaps a few of the difficulties of communication, that twenty years ago would have been called purely mental. Two hundred years ago these same conditions would have led to suspicion of possession of evil spirits, perhaps even to execution for witchcraft. But even more fundamental than these practical medical applications of knowledge about the brain is the advantage of the greatly increased understanding it gives us about ourselves. I hope that I shall be able in this way to show you that by further study of these matters we may see the connection between our doubts, longings and highest aspirations and the processes that have been going on in animals for hundreds of millions of years; perhaps with the eternal processes of the stars. High aims, you may say. Would you expect less from the study of man's unique feature, his brain?