THE SCIENCES AND PHILOSOPHY

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GIFFORD LECTURES, UNIVERSITY OF GLASGOW
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BY

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THERE appeared in 1883 a volume entitled *Essays in Philosophical Criticism,* written by ten men who were then young. It was edited by Andrew Seth (Professor A. S. Pringle-Pattison) and R. B. Haldane (Viscount Haldane), and contained essays by Pringle-Pattison, my brother and myself, Bernard Bosanquet, W. R. Sorley, D. G. Ritchie, W. P. Ker, Henry Jones, James Bonar, and T. R. Kilpatrick. Its keynote was the importance of distinguishing, and not confusing, the fundamental conceptions or axioms applied in different branches of knowledge. The common bond between the writers was the influence of Kantian and post-Kantian philosophy as it had come to them through the teaching of Hutchison Stirling, Thomas Hill Green, Edward Caird, and F. H. Bradley. The book was dedicated to the memory of Green, who had recently died, and there was a preface by Caird.

I was still a medical student at the time, after an Arts course during which, owing mainly to my brother's influence, my chief interest was in philosophy; and I had already seen that the mechanistic biology, which was then everywhere in the ascendant, was as radically unsound as vitalistic biology. We said so in our essay, but could only give general reasons for our conclusion that the real axioms of biology are neither mechanistic nor vitalistic. The truth was that in matters of detail many of the available data were so vague and unsatisfactory that mechanistic interpretations of them, though certainly not of the most characteristic data, were at least plausible.

I found my opinions extremely unpopular among my scientific brethren when I duly became a physiologist. Knowing, however, the weight of philosophical reasoning behind me, and encouraged by my brother and other philosophical friends, I went onwards, and gradually got to grips, using accurate quantitative methods, with the physiology of respiration and other bodily activities. I also came into touch with the work of Claude Bernard and Paul Bert, and saw how far away it was really pointing from mechanistic interpretations, as, indeed, was nearly all the best physiological work of the time. Such general conclusions as I reached were embodied, partly in ordinary scientific papers, partly in occasional addresses, and in a short book *Mechanism, Life, and Personality,* first published in 1913. Another book, *Respiration,* published in 1922, contains an account of the experiments carried out on this subject at Oxford by my pupils and myself.

Work in Physiology and Medicine brought me into more intimate contact with the mechanistic and vitalistic or animistic interpretations of life and conscious behaviour than was the case with various of my philosophical friends, and showed me the necessity of getting to closer grips with the subject than German post-Kantian idealism had got. Deeply as I am indebted to post-Kantian idealism, my own standpoint must be described as realistic rather than idealistic, though to me there is nothing truer than Hegel's saying, which my brother often quoted, " Das Geistige allein ist das Wirkliche."

In the first part of the present book, dealing with the axioms or general conceptions of different branches of knowledge or science, the keynote is the same as that of *Essays in Philosophical Criticism.* In the second part the different and apparently contradictory conceptions embodied in the Sciences and in Religion are discussed in their ultimate bearing on one another. The lecture form is retained, and the lectures are nearly as they were delivered, though they have all been revised carefully. I have tried to put into these lectures the matured conclusions of a scientific lifetime during which the philosophical questions raised by the Sciences have been constantly before me.

To the University of Glasgow I wish to express my very grateful appreciation of the honour it has done me by its invitation to give the Gifford Lectures for 1927-1928.

OXFORD,
December 1928.

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PART I

THE SCIENCES

LECTURE I

BIOLOGY AND THE PHYSICAL SCIENCES

THE subject of the present course of Gifford Lectures is the relation between the Sciences and Philosophy. I have chosen this subject because the issues which its discussion raises seem to me to be very urgent at the present time, and to enter into our lives and practical affairs at innumerable points. At the same time I am very conscious of the inherent difficulties of my task, and of the shortcomings in intellectual equipment which make it impossible for me to deal adequately with so great a subject. My only excuse for making the present attempt is that other persons would experience to perhaps as great an extent, though in other directions, the shortcomings which I feel so keenly. There may, however, be some advantages in the fact of my being a physiologist; for it is very specially in connection with physiology and its relations to other departments of knowledge that central questions concerning the relations of Science and Philosophy have come to the surface in recent times.

In any one of the Sciences we are dealing primarily with one aspect only of our experience, and confine our immediate scientific conclusions to that aspect only. Let me illustrate this statement, for perhaps it is not at first very evidently true. In the physical sciences, including both physics and chemistry, attention is confined primarily to what we distinguish, whether artificially or not, as inorganic phenomena. It is in the study of phenomena thus distinguished that certain principles seem to be forced upon us as the result of observation; and if we limit our view to the aspect of experience we are dealing with, no other principles may seem to be necessary or in place. But if physical and chemical principles are assumed to cover also the phenomena of life or conscious behaviour, controversy at once ensues, even among physicists and chemists themselves.

The difference between any branch of science and philosophy is that in formulating its conclusions philosophy attempts to take into consideration, not simply a part, but the whole of our experience. That experience includes, for instance, not merely the fact that a physical world is apparently presented to us in experience, but also the fact that this physical world is perceived, and that with the perception of it we perceive ourselves and numerous other living and sentient beings, as well as endless emotional and other experiences which cannot be interpreted as pertaining directly to physical objects. We also perceive what we call values, which are of the last importance in relation to conduct. The task of philosophy is to form as consistent as possible a general conception of this apparently confused collection of experiences, so that we can guide our conduct in accordance with the general conception.

Here philosophy comes into living contact with the principles of the sciences, as well as with religious beliefs. A widespread idea exists that the sciences simply supply incontrovertible facts for the philosophers to make what they can of in conjunction with other independently ascertained facts. A classical and extraordinarily important example of the application of this idea is furnished in Newton's *Principia.* In that great work the mechanical conception of the visible world is represented as "philosophical" truth. No one believed more firmly than Newton in the existence of an invisible spiritual reality coexistent with material reality; but for Newton physical reality, as he conceived it, was in actual fact reality. Most of the modern civilized world has agreed with him in this conclusion, which has thus become to such an extent part of the generally accepted intellectual outfit of modern times that it is only by great effort, and at the risk of being regarded as mere cranks, that we can bring ourselves to question it.

The practical usefulness within certain limits of Newton's "philosophical" conception of the visible world has been made evident in a thousand ways; but if we accept this conception as final we are at once confronted with difficulties which arise in combining it with the rest of our experience into a consistent whole. For Newton the visible world consisted of "bodies" existing independently of one another in independently existing space, and subject to changes following outside one another in steadily flowing time, the flow of which was assumed to be independent of these changes. For philosophy, however, one of the first questions, pressed home by Berkeley and Hume, was how such a world, if it really existed, could ever come to be perceived or known to exist; and their answer to this question was that such knowledge would be impossible, so that Newton's "philosophical" interpretation of the actually experienced visible world is likewise impossible.

The philosophical arguments of Berkeley, Hume, and their successors are so far removed from the details of what the sciences deal with that it is not from the standpoint of these arguments that I propose to enter upon the consideration of the relations of philosophy to the sciences. Nor do I propose to discuss at any length in this first course what may be called the internal difficulties of the Newtonian conception as applied only to inorganic phenomena, and the modifications which that conception has in recent years been undergoing at the hands of physicists and mathematicians themselves. What I shall attempt is to compare broadly the conclusions reached through observation in connexion with different branches of science or knowledge, and consider to what extent these conclusions are consistent with one another. After this comparison, which I shall endeavour to make in the first course of lectures, it will be possible to take up, as I propose to do in the second course, the question as to what assumptions are needed to harmonize the conclusions of the different sciences, and the relation of these assumptions to the nearer questions to which philosophical enquiry is usually directed, including questions which bear on social life and religious beliefs.

I shall begin this course by an attempt to compare the general principles which seem to be forced upon us in the isolated study of two great departments of natural science—the physical sciences and biology. The physical sciences, which include all that is comprised under the general titles of physics and chemistry, deal primarily with reality as it appears to us in what we distinguish as inorganic phenomena, and apart from the consideration of life, conscious activity, and all that seems to pertain to them specifically. The distinction between physics and chemistry is only one of practical convenience: for we can correctly call chemistry and physical chemistry the physics of atoms and molecules. In any case physics, in dealing with such phenomena as those of electricity, magnetism, radiation, and radio-activity, goes beyond and behind the atoms of ordinary chemical theory.

The biological sciences, on the other hand, deal with distinctive phenomena presented by living organisms and their activities, whether these organisms are classified as plants or animals. The biological sciences do not deal primarily, however, with what we distinguish as conscious activity. However prominently conscious activity seems to be associated with the lives of the higher organisms, we do not take it into account in what is ordinarily called biology. Conscious activity will, therefore, be considered separately in later lectures of this course; and only life in the sense in which we attribute it to what we regard as the unconscious phenomena distinctive of living organisms, whether classified as animal or plants, will be considered at first.

If we neglect for the moment certain of the quite recent developments of physical theory, the broad general assumption made in the physical sciences, and apparently forced on them by observation of inorganic phenomena, is that the visible and tangible world consists of independent and permanent "bodies" or masses, with equally permanent and unchangeable properties, though visible bodies are only aggregates of the elementary bodies known as atoms, or, pressing the analysis further, electrons and protons; that these bodies act upon one another in accordance with their properties; and that the sum of their mutual actions, expressed as energy, can and must be regarded as constant no less than the bodies themselves, expressed as mass. In other words, the principles of the conservation of matter and of energy are assumed to hold good, and can apparently be verified wherever the conditions are such that verification is possible. It is true that quite recent work has shown that the distinction between mass and energy cannot ultimately be upheld; but in ordinary physics and chemistry we interpret our observations in terms of the conceptions of matter and energy.

The first five lectures will be devoted to the consideration of how far the same fundamental conceptions are applicable to the phenomena of life as they ordinarily appear in biological investigation, or what other conceptions are necessary. A preliminary glance at this discussion and its outcome will, I think, be useful as a guide in the present introductory lecture.

It is of course quite evident, and has always been assumed by biologists, that up to a certain point the same general principles can be applied successfully to biological as to physical observations. All biological observations, for instance, are in full accord with the assumption that within living organisms there is neither creation nor loss of substance. Living organisms grow or waste through what we can describe as intake or output of material, and in no other way that has hitherto been demonstrated or is ever now suspected. Similarly, the energy output of an organism depends upon previous energy-intake, as was first pointed out in 1845 by J. R. Mayer,[1] in connexion with his general formulation of the principle of conservation of energy, though a satisfactorily exact experimental demonstration of this fact was first given by Rubner in 1893. We can discover no contradiction of these principles in organic phenomena. On the other hand, however, consideration of organic phenomena seems to force us to reconsider the whole conception which we derive from the isolated study of inorganic phenomena, since we find that it is incapable of expressing adequately our experience of organic phenomena.

Let us now see where, in rough outline, the application of that conception to organic phenomena is inadequate. The most striking differential feature of living organisms is what may be called their active and specific stability. The bodies which we ordinarily meet with in the inorganic world possess a greater or less amount of stability; but this is interpreted as being of a passive kind, not dependent on continuously maintained activity within them. In the body of a living organism the stability of form and composition is evidently due, not to passive resistance to changes in the environment, but to continuous activity so co-ordinated that, though its material is constantly

[1] *Die organische Chemie in ihrem Zusammenhange mit dem Stoffwechsel,* 1845.

changing, the specific form and composition of the living body are on the whole maintained, or that if changes in these are in progress, as during development, these changes are on the whole of a definite and specific character in each species of organism. We give recognition to this fundamental fact when we say that the organism is alive, and belongs to a species. The reactions of a living organism to changes in what we interpret as its physical and chemical environment are so co-ordinated that the organism tends to be maintained, or else only to undergo such changes in character as are specific to it. A distinguishing characteristic of fundamentally the same kind is the capacity an organism possesses of reproducing itself in every detail, the reproduction starting in part of itself. The significance of the co-ordination for the theoretical interpretation of biological observation cannot be overstated. If we neglect it, we neglect all that is characteristic of biological phenomena; and any general discussion of life which ignores it is simply irrelevant.

We find that organisms are in constant active relations with their environment; but that this activity is on the whole so directed as to maintain in each organism a *normal* or specific condition, expressing itself as actively maintained structure and composition. In other words, the properties or mode of action on one another of the parts involved in the life of an organism, whether these parts are within or outside its body, not only depend on their active relations to one another, but these relations are specific or normal for each organism. Moreover, the normality of an organism is absolutely bound up with its surrounding environment. Regarded from a physical standpoint, this environment may seem to be variable and constantly changing; but when we examine more closely the immediate environment of what we may be led to regard as the essentially living parts of an organism we find that this immediate environment is actively maintained just as is the supposed living structure itself. We see this very clearly in the case of the blood-plasma and other internal media of higher organisms. In fact we cannot distinguish between normal living structure and its normal environment, and consequently cannot say where living structure ends and environment begins. We can thus discover no spatial demarcation between what is living and not living. Physiological investigation soon forces us to this conclusion. As regards the less immediate environment, the influence which it exerts on the body is normally determined, like that of any part of the body itself, in such a way that the normal structure and activity of the body tends to be maintained. Thus the external environment participates in the normality expressed in life, and is thus not something outside life. We cannot regard the external environment as outside of life.

The essential independence of what we interpret as "bodies" in the physical sense seems, therefore, to disappear in connexion with biological phenomena. The parts of the actively maintained whole which constitutes a unit of life do not exist independently of one another and their environment. They are not things which can be separated without essential change of properties, as appears to be the case with what we interpret as inorganic bodies. We study the details of their specific spatial relations to one another in morphology, and the details of their specific mutual influence in physiology; but since their form, structure, and composition are the outcome of constant activity, and this activity expresses itself in the form, structure, and composition, it is only life itself that we are studying whether we approach it from the side of normal form and structure, or of normal activity, or of the chemical substances normal to organisms and their environment.

Let us now endeavour to regard life from a strictly physical standpoint. From this standpoint we must admit that living structure is nothing but an appearance, like that of a flowing stream, produced by a flow, or ebb and flow, of material. From the physical standpoint we are obliged to assume that the flow is a flow of molecules, atoms, and electrons, entering into various combinations with one another in the course of the flow; and that there is a corresponding flow and transformation of energy. When we measure and analyse the intake and output to and from a living organism of what we interpret as matter and energy the results agree as exactly as could be expected with the physical interpretation. There is, from the observations, no suggestion whatever of any real failure in agreement. We can also follow to some extent what we interpret as matter and energy in its course through living organisms; and in so far as we can do so we are apparently helping to a physical and chemical account of life. A view which has been held by certain philosophers and theologians from the time of Democritus onwards, is that if we had sufficient data we should be able to furnish a complete physical and chemical account of life; and many biologists, particularly in the latter part of last century, have accepted this view, which has now become thoroughly popularized.

Such a view fails completely to give recognition to the co-ordination manifested in the actively maintained, and actively reproduced, structure and physiological environment of living organisms. The fact that living organisms maintain and reproduce themselves in spite of great variations in their physical and chemical environment is of course evident. In order to account mechanically for this fact it is necessary to suppose that their structure is so arranged, or in theological language "designed," that it responds to changes in environment in such a way that, on the whole, the disturbing effects are annulled; that, for instance, effects which would otherwise be those of injury, disease, shortage of food or oxygen or water, or accumulation of waste products, are compensated for. We must thus assume an extremely complicated physico-chemical structure within the living body. In so far as we can discover such structure, the physico-chemical theory holds good; but if we stopped where such discoveries end, we should simply have ignored what is characteristic of life. It is not the mere reactions of a structure in the physical sense that we are dealing with, but the absolutely characteristic fact that specific structure and composition themselves are being constantly maintained and reproduced, as well as specific activity. To attribute the maintenance and origin of specific structure to specific structure itself is only to reason in an evident circle—to substitute mere words for ideas. It is impossible to maintain that the physical and chemical structure of a living organism accounts for its life.

We are thus forced to the conclusion that in the phenomena of life we are in presence of what cannot be interpreted physically, but implies a fundamental conception different from those of physical science. This conception is that of life, and biology is the science which uses the conception of life as its foundation. The widely spread popular belief that the physical and chemical structure of a living organism accounts for its specific behaviour is baseless.

In former times, when far less was definitely known about the metabolism of living organisms, their reproduction and embryology, and the evolution of species, the considerations to which I have just pointed did not assume their due weight. The structure of living organisms was either attributed to a supernatural act of creation in the past, or (as in the treatise *De Formatione Foetus* by Descartes) to causes now quite easily seen to be non-existent. With the advance of knowledge it has become more and more evident that unless we take refuge in what amounts to the theory of constant supernatural intervention within the body to help out the inadequacy of the physico-chemical theory of life, that theory is quite untenable.

Any theory implying so-called supernatural intervention is repugnant to science, since it implies the giving up of the endeavour, which is the inspiration of science and philosophy, to discover consistency and order. That any such theory is, in the last resort, also inconsistent with religion, will be maintained in later lectures. If, however, we adhere to the view that the physical or physico-chemical conception of the visible and tangible world expresses its reality, we seem to be driven into the assumption of some sort of non-natural interference with this world in the case of living organisms. But even this assumption is precluded, since we can show experimentally that any supposed supernatural influence is dependent on influences emanating from the assumed physical environment.

Thus we cannot dispense with the specific conception of Life, and are hence compelled to regard the physical conception of the inorganic world as in ultimate analysis only provisional and superficial. The ordinary physical conception of the visible and tangible world was framed without taking into account the phenomena presented in living organisms, which are part of the visible and tangible world which we call Nature. It was a mere matter of practical convenience that this exception was made, and when this exception is made we have a conception of very great practical utility in its own sphere. The actual world which we observe has all sorts of characteristics which were disregarded in framing the physical conception, and were set aside as belonging to what Locke called the "secondary qualities" of things, or to a supernatural world. The nemesis of the neglect of the organic meets us when we attempt to frame a physico-chemical biology. Our final conception of the visible and tangible world must cover organic as well as inorganic phenomena, and no general conception which falls short of this can be more than provisional.

On examining the framework of the ordinary conception of the inorganic world we find that "bodies" have been taken as things existing independently of their relations to one another, and of their activity and its specific character. They are thus different in kind from what the parts involved in life appear, on full examination, to be. If, however, we also regard the "bodies" of the inorganic world as existing in virtue only of their relations to one another and their specific activity, the gulf between the organic and the inorganic seems to be bridged. Chemistry has revealed to us the fact that visible bodies are aggregates of molecules or atoms; and until recently atoms were regarded as simply extremely minute bodies existing independently of their own activities and of other bodies. Not only, however, do we now know that atoms are compound bodies, but it appears that both the mass and specific properties of the electrons and protons of which they consist are inseparably bound up with their activity within the atom. This activity is specific in character and cannot be got rid of. If, moreover, it is increased or diminished, the changes only occur in specific steps.

The new conception of the atom, as revealed by the discovery of radio-activity, and the investigations of J. J. Thomson, Rutherford, Planck, Niels Bohr, and others, in conjunction with those of Einstein, bears striking resemblances to phenomena which biological investigation presents. But it is perhaps too early as yet to go further than point out that there is no need to assume in the case of life any ultimate inconsistency with what we call physical phenomena, however strongly we insist that the phenomena of life are inconsistent with the ordinary popular physico-chemical conception of visible and tangible reality which has come down to us from Galileo and Newton. It is reality with which all science, including biological science, ultimately deals, and not merely an idealized world, such as the world which, however usefully, Galileo and Newton represented to us appears now to be.

Bohr's conception of the atom, embodying as it also does the principle of relativity, implies a very radical recasting of the Newtonian conception of at any rate part of the physical world—apparently of the same nature, as the recasting which seems to be necessitated when we assume that life, with all its distinguishing characteristics, is simply a "natural" phenomenon. We know, as yet, but little about the genesis and disintegration of atoms, or how far these processes are comparable to the reproduction and death of organisms. Nor have we data for comparing organic with atomic variation. Nevertheless, on the new theory of the atom its form is specific, and the expression of specific activity, just as is apparently the case in a living organism; and since visible bodies are made up of atoms, and "cohere" in virtue of atomic properties, we are justified in assuming that behind all superficial appearances the inorganic world may in reality be constituted on principles similar to those which we seem to find exemplified when we study life. If so, the Newtonian conception, even if it were amended by introducing relativity into it, would no longer represent reality.

The fact that the principles of conservation of mass and of energy can ordinarily be verified so successfully is thus no proof that such separate entities as matter and energy exist or that in reality Nature obeys mechanical laws. In a universe of self-existent atoms or other minute units of mass to which self-existent energy had been unequally distributed, the inevitable tendency by the law of probabilities would be for the energy to become on an average equally distributed among the units, so that no sensibly evident part of this universe could do work on or influence any other sensibly evident part. This will no longer be the case, however, if the mass and energy are themselves the expression of an underlying reality which manifests itself in the variegated and specific forms of the observed physical world, corresponding to the variegated forms which life takes.

Enough has been said to indicate that in rejecting mechanical conceptions of life, and interpreting it in the manner which is directly required by the observation of life itself, we are not necessarily assuming the existence of any supernatural factor, or of anything different in kind from what can possibly be found in the so-called inorganic world when it is examined sufficiently closely. In the case of what we call organic phenomena we can see from the outset that mechanical interpretations are impossible. In the case of what we call inorganic phenomena, on the other hand, we can at present see only by dint of careful quantitative experiments that mechanical interpretations are ultimately not sufficient, though in ordinary cases mechanical interpretations are extremely useful and trustworthy for purposes of prediction, and can be applied without difficulty.

The conception of reality or Nature to which we are directly led by the study of life is very different from that to which, except on very exact and deep study, the isolated consideration of what we distinguish as inorganic phenomena leads us. For this reason biology must, it seems to me, be regarded for the present as an independent science, guided by a conception different from the mechanical conception which is ordinarily satisfactory in the physical sciences. In the next four lectures I propose to deal with the attempts which have been made, either to interpret life on ordinary physical and chemical assumptions alone, or to interpret it on these assumptions with the help of the assumption that living organisms are the seat of what may broadly be called supernatural influences.

LECTURE II

THE RISE OF MECHANISTIC BIOLOGY

SIDE by side with the development of physics and chemistry on the lines laid down by physicists and chemists from the time of Galileo onwards, there grew up a very fruitful and practically useful development in the application of physical and chemical conceptions to various phenomena observed in living organisms. This latter development originated with the rise of anatomy in the sixteenth century, and has been continued since then in the interpretation of observations on living or dead animals, plants, or men. We can trace this development throughout the progress of physiology up to the present day.

In view of the success attained in this direction it was only natural that attempts should be made to reach forward towards a complete mechanistic or physico-chemical conception of all the phenomena of what can be described as mere life. As is well known, such an attempt was made by Descartes in the seventeenth century. This attempt was one of extraordinary significance. The leadership of Descartes has been recognized on all hands by those who have subsequently maintained that the proper line to take in the study of biology is to aim at a complete physico-chemical account of the phenomena of life, thus placing biology in the position of a branch of physics and chemistry.

The attempt of Descartes is contained in his two short books *De Homine* and *De Formatione Foetus*. The aim of these books was to show that life may, in so far as it is not deliberately directed by the soul, be regarded as consisting of mechanical or physico-chemical processes, the living body itself being also produced from its material elements by mechanical processes. As regards the details of these processes, he says that they may be different from what he suggests, and that his only concern was to demonstrate that they may be regarded as mechanical processes of some sort. Thus his general argument was in no way compromised by the subsequent demonstration that many of the particular mechanical processes which he hypothetically suggested are non-existent. He had put forward a general hypothesis as to the nature of life, and this hypothesis has gained very widespread support. To many scientific men of the present time, and to a multitude of popular writers, its truth seems, indeed, to be self-evident.

Even in the time of Descartes it was already clear that much of what occurs within the living body is susceptible of clear mechanical explanation. Thus the movements, whether voluntary or involuntary, of the limbs, etc., had been rendered intelligible by showing how, when muscles contract, the tendons attached to them act on the bones to which they are also attached, thus bringing about mechanically the various voluntary and involuntary movements of the bodily parts attached to these bones. Kepler had shown how the crystalline lens of the eye, acting just like a glass lens, produces an image on the retina. Harvey had shown how the blood, driven mechanically by pressure from the heart, and guided by valves, is circulated round the body, carrying nutriment to and removing waste products from, all parts. No one questioned successfully the mechanical explanations applied in connexion with these and various other processes occurring within the living body. It therefore seemed natural enough to adopt the belief that all physiological processes are ultimately susceptible of similar mechanical or physico-chemical explanation. In the present and succeeding lecture I shall attempt to follow out the manner in which this belief has developed side by side with the advance of knowledge as to the facts of physiology and organic morphology.

The suggestions of Descartes as to the possible details of a mechanistic physiology applicable to the living bodies of men and higher animals were largely based on the discovery of the circulation of the blood. He supposed that in the development of the embryo the first thing formed is a rudimentary beating heart. He also assumed, regardless of the teaching and experiments of Harvey, that the active phase in the beating of the heart is the diastole. He regarded the diastole as an act of swelling or effervescence due to chemical action, the systole being merely a return of the heart to its natural size as blood escaped from it into the arteries and the effervescence died away. He also suggested that the embryonic heart and blood-vessels are perforated by a very large number of minute holes, through which material is forced out, which on becoming partially solidified forms the various fibres of which the structure of the adult body consists, the different sizes and shapes of these fibres being determined by the different sizes and shapes of the holes.

He supposed that the lighter parts of the blood projected from the heart tend to pass upwards, finally reaching the choroid plexus of the brain in a very attenuated state. This attenuated fluid then escapes into the first pair of ventricles, and constitutes the "animal spirit." When the animal spirit passes down the tubules assumed to exist in motor nerve-fibres, contraction of the corresponding muscles is produced by the distension of the muscles, which were also assumed to be hollow. The passage of the animal spirit down the nerve-tubules was supposed to be controlled by valves at their upper openings, and the valves in their turn were controlled by the afferent nerve-fibres passing from the surfaces of the body to the ventricles. Thus any sensory disturbance of the skin or sense-organs was responded to by an opening of certain valves, and consequent distension and contraction of muscles, this being a purely mechanical reflex response. All the other physiological processes in the body were supposed to occur also by various purely mechanical or chemical processes.

The soul itself was supposed to have its seat in the pineal gland, between the ventricles, and could contemplate the various reflex nervous responses, and to some extent control them by altering the inclination of the gland towards the valves. At this point, however, the physiology of Descartes became very vague, and it seems evident that the body could be conceived as working quite well without any interference from the soul. He in fact regarded the bodies of animals as acting mechanically and quite unconsciously; and the manner in which body and soul were connected in the case of man was in reality unintelligible, and became a fruitful source of contention among his successors.

It is easy to see how amazingly crude and ill-founded most of the details of the physiology of Descartes were; but he had at least sketched out the possible outlines of a thorough-going mechanistic physiology. For this he deserves full credit. How certain of these outlines were more correctly filled in by his successors we can now proceed to describe.

The weakest feature in the Cartesian physiology was the embryology. This was not based on any definite observations; but even if it had been it would have given no account whatever of the original formation of the heart and of the elaborate and very definite system of peculiarly shaped holes in its walls which were assumed by the theory. Perhaps the most plausible theory suggested by the mechanistic successors of Descartes was that the germ contains a complete model of the developed organism, so that all which occurs in development is a process of growth of this model, not associated with any increase in its structural complication. This, however, merely threw the problem back a stage, and did not simplify it in any way; nor is there any direct evidence in support of such a theory, which, indeed, was mainly a sop to current theological beliefs. All the anatomical and microscopical evidence is conclusively against it.

The problem of reproduction has hitherto remained an inscrutable one for the mechanistic theory of life. Our knowledge of the appearances which may be observed during all the stages of reproduction has increased enormously since Descartes wrote his *De Formatione Foetus*; but anything of the nature of a mechanistic theory of reproduction is still absent, as we shall see. In other directions, however, we can follow quite clearly the development of the mechanistic physiology.

For Descartes chemical processes occurring in the heart as a result of the mixture of different kinds of blood entering it were the source of all kinds of bodily activity, and of animal heat. The outlines, at least, of a far more satisfactory chemical theory were produced by the Oxford School of physiologists in the seventeenth century, shortly after Descartes wrote. By his experiments on animals subjected to a vacuum Boyle showed that air, and not merely breathing, is necessary to their life, as well as to ordinary combustion. Mayow then showed that it is only a certain constituent of air that is necessary in both cases, and connected this constituent with what is present in nitre and enables combustion to occur, as in gunpowder, without the presence of air. He called this constituent "nitro-aerial spirit," and put forward the theory that nitro-aerial spirit is absorbed from the air by the blood passing through the lungs, and separated from it in the brain in some such manner as Descartes had suggested; also that muscular contraction is due to an explosive combination in the muscles of nitro-aerial spirit and combustible material, with evolution of heat, the nitro-aerial spirit being allowed to pass down nerve-tubules and so reach the muscles.

This theory was a great advance on that of Descartes. It was not only consistent with Harvey's observations on the heart, but it definitely connected chemical processes outside the body with those occurring within it. It also connected muscular work with the increased breathing and increased heat production which accompany it, besides affording, just as the theory of Descartes did, an explanation of why section or ligature of a motor nerve causes paralysis of muscular movement. The contraction of the heart itself was now also regarded as an ordinary example of muscular contraction; and Lower, another member of the Oxford School, demonstrated the stoppage or disorganization of the heart-action on ligature of the vagus nerves going to the heart. This he attributed to interference with the supply of nitro-aerial spirit to the heart. He had in reality discovered what is now known as inhibition of the heart by stimulation of the vagus nerve.

Unfortunately the active study of physiology and most other branches of natural science was allowed to die out for nearly two centuries at Oxford. The early Oxford physiologists and chemists had practically discovered oxygen and its direct connexion with muscular work; but their work was forgotten, and it was not till 1845 that the direct connexion between muscular work and consumption of oxygen was finally pointed out by Mayer.

Meanwhile Descartes's theory of muscular contraction had been attacked from other sides. It was shown experimentally by Glisson of Cambridge that muscles do not increase in volume when they contract, as they would do on the theory of Descartes, and the contraction of all muscles, including the heart, came to be attributed to a property inherent in them, and called excitability or irritability. Harvey's experiments had shown clearly that it is the heart-muscle itself which contracts actively and produces the circulation. Further investigation showed more and more clearly that all muscular structures are excitable independently of any immediate source of their energy from their physical or chemical surroundings; and the same conception was extended to nervous structures. For a considerable time, therefore, mechanistic developments in physiology did not make any further progress in connexion with muscular and nervous activity.

Mechanistic speculation was meanwhile not absent in other directions. Secretion by the kidneys and other glands was generally attributed to a mechanical process of filtration through very narrow pores, insufficiently large to permit the passage of blood-corpuscles; and owing to absence of knowledge of the chemical composition of these secretions and of the blood, these crude theories passed muster to a considerable extent, together with similar theories as to absorption from the intestine.

With the great development of chemistry towards the end of the eighteenth century mechanistic developments in physiology became more definite. The rediscovery by Priestley of identity in the chemical changes in respiration and in ordinary combustion, and more particularly Lavoisier's clear physical interpretation of what occurs in oxidation, whether inside or outside the body, were great steps forward. When, moreover, Lavoisier and Laplace showed experimentally that the heat produced by oxidation in the living body corresponds in amount with that produced by oxidation or combustion of carbonaceous material outside the body, a mechanistic explanation of the production of animal heat seemed to be reached.

On the discovery of the chemical composition of various food materials in the early nineteenth century there followed the definite identification of diastase, pepsin, and other enzymes or unorganized ferments. This brought to the front a purely chemical theory of digestion, and at the same time proved the existence of a class of chemical bodies capable of inducing otherwise unintelligible chemical changes within the living substance of the body.

Another very important step made early in the nineteenth century was the publication by Schwann in 1839 of his conclusion that the bodies of the higher animals are made up of the units which he, following Schleiden, who had made the corresponding discovery for the bodies of plants, called cells. This discovery was generally interpreted as showing that, whatever the nature of life may be, the processes occurring in any organ of an animal are nothing but the sum of those independently occurring in cells of the organ, while what occurs in the body as a whole is likewise only the sum of what occurs in its constituent cells. Subsequent investigation seemed to confirm in every respect the general conception of the body of any higher animal as a collection of a vast number of cell units; and this in itself appeared to be an important step towards a mechanistic conception of life.

From his microscopical observations Schwann drew the further conclusion that cells are formed from a mother liquid by a physical process akin to crystallization. This theory was a very definite attempt in the direction of a mechanistic theory of reproduction, and was at any rate somewhat less crude than the attempt of Descartes. Further investigation showed, however, that new cells are only produced by a process of division of pre-existing cells. At no step in the process of reproduction are we dealing with anything which we can interpret as non-living; and the reason why organisms reproduce their like remained as dark as ever from a physico-chemical standpoint. Thus Schwann's attempt at a mechanistic theory of reproduction failed as completely as that of Descartes.

Schwann was one of the senior leaders in a determined attempt, shared in by almost all the younger physiologists of his time, to get rid of what was known as vitalism in physiology. The celebrated physiologist and comparative anatomist Johannes Müller, whose assistant he was, supported vitalism strongly; but nearly all Müller's other assistants and pupils, including du Bois Reymond, Helmholtz, Ludwig, and Brücke, followed Schwann in rejecting vitalism and concluding that it is only along physico-chemical lines that real scientific progress can be looked for in physiology. This movement soon became general among physiologists in all European countries.

Schwann himself was an orthodox Catholic, and afterwards became a professor at the very orthodox Catholic university of Louvain. Like Descartes, and like many theologians, including for instance Paley, author of a well-known book on the arguments from design, Schwann believed that the living body itself is nothing but a physico-chemical machine, though in conscious action this machine is guided by the soul. Most of his physiological contemporaries, however, adopted a more thorough-going mechanistic standpoint, and concluded that whether or not consciousness accompanies the activity of the living body, it acts, and must act, as nothing but a physico-chemical mechanism, however difficult it may be to see in detail how the action is brought about.

This conclusion furnished a clear and intelligible working hypothesis in physiology, and continued for long to satisfy the great majority of workers in physiology. Experience seems always to show that if we investigate any physiological phenomenon we can discover by experiment some physical condition which can be interpreted as its cause, even though the precise connexion between the effect and the cause is still obscure. The presence, for instance, of moisture, warmth, or oxygen can be shown to be essential to physiological processes, or even to consciousness; and evidence of the same kind is constantly being added to as physiological knowledge advances.

A great stimulus to mechanistic physiology was afforded by the application to physiological phenomena of the principle of conservation of energy. This principle was first stated in general terms in 1842 by Mayer, a German country doctor. It was applied by him specifically to physiological phenomena in his book *Die organische Bewegung in ihrem Zusammenhange mit dem Stoffwechsel,* published in 1845, and was stated still more clearly two years later, by Helmholtz, then a young army doctor who was working in Johannes Müller's laboratory. It was now possible to trace back to potential chemical energy the energy which manifests itself in muscular work and other forms of vital activity. Not only animal heat, but also the energy manifested in muscular work, nervous activity, etc., could thus be interpreted as having its source in the fact that oxygen and oxidizable substances produce in their combination kinetic energy, in virtue of their potential energy in the uncombined state. By measuring the consumption of oxygen, production of resulting products, and liberation of kinetic energy, whether inside or outside of the body, it could be shown that the new interpretation was in complete accordance with physiological observation. The more accurate the observations and measurements the more complete did the accordance appear, although, as already mentioned, it was not till 1893 that extremely close accordance between the potential energy of oxidation and the total kinetic energy liberated within the body was finally demonstrated by Rubner. As to how exactly the various forms of energy are transformed in living organisms we are still very much in the dark; but it had at least become possible to state in physico-chemical terms the sources of the energy liberated or stored up in the bodies of living organisms, whether animals or plants, as well as the sources of the material present.

For Schwann and his early contemporaries the cell was a structure with a membranous wall, containing a liquid or plasma and a nucleus, the liquid being interpreted as a solution containing albumen. Botanical observation showed, however, that the liquid could often be distinguished into two parts, one of which behaved like an ordinary liquid, whereas the other showed what seemed to be independent movement, and came to be distinguished on v. Mohl's proposal as "protoplasm," since it, along with the nucleus which was contained in it, appeared to be the most primitive part of the cell, and was always present in cells showing signs of life, though the other liquid might be absent. Observations on animal cells showed also that the protoplasm and nucleus were the essential parts of a cell, other parts of cells being mere derivations from or else modification of the protoplasm. In pathology, under the vigorous lead of Virchow, various forms of abnormal structure were shown to be due to cell-proliferation.

In physiology there was a corresponding movement towards making the protoplasm the essential seat of active physiological processes, and moreover ascribing to this protoplasmic activity a large amount of apparent independence of immediate changes in the environment. Protoplasm in some form thus became the seat of the "excitability" so long known to physiologists.

We can, for instance, trace this new standpoint in the investigations of Pflüger on physiological oxidations. It had been shown by previous investigations that the blood passing through the lungs takes up oxygen in loose chemical combination with the haemoglobin of the blood-corpuscles, and also takes up carbon dioxide, as it is formed within the body, in somewhat similar loose combination with alkaline substances in the blood. Ludwig, and particularly Pflüger, had immensely improved the method of separating by means of the mercurial vacuum pump the gases of the blood for analysis. It had been very generally believed hitherto that the oxidation on which heat-production depends is carried out to a large extent in the blood; and indeed Ludwig and his pupils had brought some evidence pointing apparently in this direction. It was also very generally believed that the rate of oxidation, as in ordinary oxidation processes outside the body, must vary with the amount of oxygen brought to the blood by breathing. This teaching is, for instance, very clearly expressed in Liebig's writings.[1]

With his improved methods Pflüger showed very clearly that no appreciable amount of oxidation occurs in the blood itself, but that practically all of it occurs inside the living cells; also that the rate of oxidation is within considerable limits independent of the concentration of oxygen in the blood or blood-plasma. He thus showed that " the living cell regulates its own oxidation processes." Pflüger was no vitalist, though this quotation from him savours somewhat of vitalism; but he played a large part in the movement towards centring the elementary problems of physiology within the substance of living cells.

Another example of the same movement in physio-

[1] Liebig, *Die organische Chemie in ihrer Anwendung auf Physiologie und Pathologie*, 1842.

logy concerned the manner of regarding the consumption of material, or general metabolism of the body. Liebig treated the rate of consumption of non-living material in the body as dependent, on the one hand on the supply of food material, and on the other on the supply of oxygen. This would naturally be the case if the oxidation occurred in ordinary liquids existing within the body. In order to be able to measure the amount of albuminous material oxidized in the body he introduced a method for determining the urea in urine, since it was already known that none of the nitrogen of albuminous material leaves the body in the gaseous form, and it was apparent that nearly all of it must be excreted as urea. It was found that the excretion of urea went up and down with variation in the supply of albuminous material as food, though even after starvation for some time a certain minimum amount of urea continued to be excreted.

Other physiologists, and particularly Bidder and Schmidt, and Voit, now, however, proceeded to investigate the total metabolism, both of oxygen and carbon dioxide and of nitrogenous material. As soon as the gaseous exchange was determined it became evident that the excretion of urea was no real measure of the essential vital metabolism; for when the oxidation of albuminous material was cut down, the oxidation of fat and carbohydrate, as calculated from the respiratory exchange, increased, and after starvation for some time nearly the whole of the oxidation was of fat. Thus the body maintains its oxidation by substituting fat or carbohydrate for albumin when the latter is less readily available.

The investigations of Rubner finally showed that when proper experimental precautions are taken, albumin, carbohydrate, and fat can be shown to be substituted for one another by the living body in exact proportion to the heat produced in their oxidation outside the body to the same end-products as within the body, the total production of heat per unit of body-weight during rest being nearly the same as with a sufficient diet. This was a very remarkable conclusion, and is one of the foundations of human dietetics. The calorie or heat value of foodstuffs is now a very familiar conception; but perhaps few people are aware that the significance of this conception depends on the fact that in the living body the consumption of food material is normally regulated according to its energy value. Not only do the oxidation processes in the bodies of higher animals occur within living cells, but the regulation of these processes by the cells is an amazingly exact one.

Still another example of the same movement concerns the physiology of glandular secretion generally, including secretion of urine by the kidneys. As already mentioned, the idea that the kidneys and other glands act mechanically as filters of some kind was prevalent up to well on in the nineteenth century; but this theory in its original crude form was swept away by the microscopical investigations of Johannes Müller, who showed that the fine vessels or pores assumed by the theory do not in fact exist. The chemical analyses of Liebig and others showed, moreover, that as the concentration of urea and other substances in the urine, or of various other substances in other secretions, may be far higher than in the blood, no mere filtration theory of glandular secretion is possible.

In the course of the mechanistic movement of the middle of last century a modified filtration theory of urinary secretion was put forward by Ludwig. The connexion of the glomeruli with the tubules, and the general arrangement of the former, had been discovered by Bowman. Ludwig's theory was that the urine is separated in the glomeruli by a process of filtration through a membrane impermeable to the albumins of the blood, just as vegetable parchment is impermeable to them. According to the theory the dilute liquid thus separated is concentrated, as it passes onwards through the tubules, by a process of osmosis, the water being absorbed back into the blood until the urine takes on its characteristic concentration. In support of the filtration part of this theory he brought considerable experimental evidence.

The investigation of secretion was taken up later by Heidenham. He pointed out that urine could not be concentrated by osmosis, since as a general rule urine placed in contact with blood through a membrane permeable only to water would gain water by osmosis from the blood. This part of Ludwig's theory was clearly impossible, and it was only the rudimentary knowledge of physical chemistry which existed when he wrote that made such a theory ever seem possible. Bowman had, on purely anatomical grounds, suggested that the liquid of the urine is separated off in the glomeruli, while dissolved solid constituents are added as this dilute liquid passes down the tubules. Heidenham supported this general conception by various experiments and arguments, and insisted particularly on the necessity of the secreting cells being alive and supplied normally with oxygen. It is evident that the composition of the liquid flowing down the tubules may be modified either by the addition of substances separated from the blood by the cells forming the tubules, or else by the withdrawal from the liquid of water and other dissolved constituents which are returned to the blood from the liquid by the cells. Since Heidenham's time considerable evidence has accumulated in favour of the latter view; but on either view the normal functioning of the kidney depends on the living activity of the tubule cells. Heidenham's conclusions were sometimes regarded as a revival of vitalism, but they were only part of the general movement seen also in the conclusions of other physiologists whose work has just been referred to.

Closely connected with this movement towards centring physiological activity in living substance were the investigations of Pasteur and his school on the processes of fermentation, putrefaction, and infection. Pasteur made it clear that all these processes are centred in living organisms, and that just as the cells in higher organisms are derived directly from pre-existing cells, so the organisms of fermentation and infection are derived from pre-existing organisms.

For the mechanistic theory of life the essential mechanisms thus came to be located within living protoplasm. This mechanism could not be seen with the microscope, but its existence had to be assumed since no other possibility than its existence seemed open to the mechanistic theory. We cannot otherwise make even a start towards a physico-chemical theory of why each living cell behaves as it does. How the mechanism reproduces itself in successive generations of cells, or how its stability is maintained, had to be left an open question.

It is very generally supposed that on the publication in 1859 of Darwin's *Origin of Species* a mechanistic explanation of the origin of structure had been discovered. Darwin showed that the characters of a species are not fixed, but are subject to alteration. He also pointed out conditions on which the survival of any species or variation in it must depend, so that any variation which gives a species more chance of surviving must be perpetuated, with the extinction of competing organisms. Thus by a process of natural selection which is still in constant operation, species have become what they are. But the theory depends on the assumption of hereditary transmission from generation to generation of the new characters which have been evolved, together with all the other structural characters. We can imagine that in the course of long ages great variety of structure has been evolved in living organisms; but this throws no light whatever on the fundamental physiological question as to any physico-chemical process by which this structure is constantly reproduced and maintained.

The fact of evolution takes us not a step nearer to the answer to this question, however strongly we may be convinced that evolution is a "natural" process. Darwin made a final end of the science or theology which treated creation as an act by which a vast amount of structural machinery was at one stroke brought into being and then left to act. But he did not put in its place any mechanistic theory of how an organism not only maintains, but transmits from generation to generation its specific structure.

The real assumption behind the mechanistic physiology of last century was that the whole of the visible world of Nature can be interpreted as a physico-chemical system in the sense of Newton's mechanical interpretation of the inorganic world. If the phenomena of life are natural phenomena, they must on this assumption be mechanical phenomena. But the question for a biologist is whether the assumption will fit the data of his observations. In the discussion so far we have referred to a considerable mass of data which can be interpreted very successfully on the mechanistic theory, provided that the mechanisms concerned can be actually discovered or imagined, and provided also that explanation is not required as to the maintenance and reproduction of these mechanisms.

These provisions are essential; but they were simply ignored in the prevalent mechanistic physiology of the latter half of last century, and were not realized until physiology had reached a further stage of development, which will be discussed in the next lecture.

LECTURE III

THE FATE OF MECHANISTIC BIOLOGY

THE further stage of development to which I have referred as characterizing more recent physiology concerns the attention now directed on the co-ordination, or, as it is often termed, regulation of life-processes. The development of physical chemistry and accurate methods of physical measurement, and of analysis of blood and other liquids, have made it possible to see far more clearly certain outstanding facts with regard to the exact co-ordination of familiar physiological processes, and the essential importance of this co-ordination. To some of these facts attention was first clearly directed by the experiments and writings of Claude Bernard; and since then their importance has come to stand out more and more prominently in every department of physiology.

In experiments on the oxidation of sugar in the living body Bernard started with the expectation that when sugar and the other carbohydrates which are converted into sugar by the digestive ferments are withheld from an animal, the sugar which he had found to be present in the blood would disappear. He found, however, that this was not the case: the sugar was still present in the blood after prolonged starvation. Moreover, if very large amounts of sugar were given, there was only a slight increase in the percentage present in the blood, since rise in this percentage was prevented owing to the disappearance of the sugar, or its copious excretion by the kidneys. He was thus led, on the one hand to the search for and discovery of glycogen as an immediate source of and repository for sugar in the body, and on the other hand to the conception that the blood, and particularly its plasma, is a general internal medium which is kept remarkably constant in composition and amount, owing to the co-ordinated regulating influence upon it of various organs, such as the kidneys, liver, lungs, etc. On a wide survey of what was then known of animal physiology he even went so far as to conclude that " all the vital mechanisms, varied as they are, have only one object, that of preserving constant the conditions of life in the internal environment."

The conception embodied in these words has proved an extraordinarily useful one in guiding physiological work into fruitful channels, and in uniting together what would otherwise be no better than a chaotic collection of isolated observations. Side by side with increased knowledge of the co-ordination of physiological activities in maintaining the " conditions of life " there has grown up a correspondingly increased knowledge of the physiological importance of these conditions being maintained accurately. The whole matter is so important as to require illustration in some detail.

As one example we may take the physiology of excretion of urine. The rate of excretion, and amount excreted, of each urinary constituent depends quite evidently on the extent to which that constituent is in excess of or falls below a normal proportion in the blood. Let us consider, as a case in point, the excretion of water. When excess of pure water is drunk voluntarily it is rapidly absorbed from the intestines, but almost as rapidly excreted by the kidneys, so that at no time is there more than a very minute excess in the proportion or amount of water in the blood, and very little excess in the tissues as a whole.[1] The presence of this minute excess is evidently sufficient to evoke a very great increase in the excretion of water. Thus the rate of excretion of water may be temporarily increased ten times or more above normal, though the increase in the proportion of water in the blood-plasma is so small as to be only measurable with the greatest difficulty. Moreover, the increase in the rate of excretion of dissolved constituents is extremely small, the excreted urine becoming dilute in proportion to its increased volume. What is excreted in excess is practically speaking water alone, other substances, such as chlorides, which are present in abundance ordinarily, being only present in a dilution which may be only a minute fraction of their concentration in the blood-plasma. In extreme cases not even a demonstrable trace may be present in the urine, as when, owing to excessive loss of salt by sweating, the concentration of salt in the blood has been slightly reduced.

The excretion of water is far less rapid if a solution containing about one per cent. of sodium chloride is drunk in excess, instead of pure water. The principles of physical chemistry render this fact quite in-

[1] Quantitative experiments bearing on this point are described by Haldane and Priestley, *Journ. of Physiol.*, vol. l., p. 296.

telligible provided that we assume Bernard's general principle and interpret it as meaning, when applied to the water of the internal medium, that the diffusion pressure of this water is constantly being kept as nearly normal as possible in the blood-plasma.[1] Since this pressure is about the same in blood-plasma and one per cent. sodium chloride solution, we can understand why the response of the kidneys is so much less active. We can also understand why very copious and dilute urine with a high diffusion pressure of water is excreted when there is a tendency for the diffusion pressure of water in the blood to be raised above normal, while only scanty and concentrated urine is excreted when there is an opposite tendency. Whichever of the normal constituents of urine is considered, we find the same sort of relation between the variations in their concentrations in the urine and in the blood. The kidneys are evidently engaged constantly in excreting water and other crystalloid constituents which are present in abnormal concentration, and at the same time in actively retaining within the blood constituents which are not present in excess. The blood, for instance, is normally very slightly alkaline, but the kidney responds to the minutest change of the blood towards the acid or alkaline side by a relatively enormous increase in excretion of acid or alkali, thus keeping the blood normal in reaction,

[1] In my book, *Gases and Liquids*, 1928, it is shown that what is at present known, in the language of van 't Hoff's confused theory of osmotic pressure, as the osmotic pressure of the blood, is in reality deficiency in the diffusion pressure of water as compared with the diffusion pressure of pure water.

though acid substances, or occasionally alkaline substances, are constantly being discharged into it.

The advances of physical chemistry and its applications to the liquids present in the body have made it possible to see more and more clearly how closely Bernard's principle agrees with the facts relating to renal activity. This principle summarizes the known facts, and suggests directions in which to carry investigation further. Without it we should be lost in a maze of unrelated observations. It has, moreover, shown us how far-reaching, effective, and exact is the co-ordination of physiological activity as revealed by exact analysis of the blood-plasma under varying external conditions.

For another illustration of Bernard's principle we may go to the physiology of respiration. The act of breathing may be regarded as nothing but a mechanical process leading to a further mechanical process by which oxygen passes into the blood, and carbon dioxide passes out of it. For recent physiology, however, the act of breathing has come to signify a very precisely co-ordinated process, comparable in every way to the precisely co-ordinated action of the kidneys; and the regulation of breathing is now simply a part of that regulation of the internal medium which Bernard drew attention to.[1]

That the breathing is so co-ordinated as to maintain within the lungs during rest a definite concentration of carbon dioxide can be demonstrated easily in short experiments by analyses of samples of air from

[1] See my book *Respiration*, 1922.

the lung alveoli as obtained at the end of a deep expiration. However irregular the rhythm of breathing may be, and however much its rate may alter, provided that its depth is allowed to adjust itself naturally, this concentration remains steady but for a very slight diminution on inspiration, and increase on expiration. We can, for instance, increase the rate of breathing threefold, or diminish it to a third, without disturbing the concentration of carbon dioxide, since the depth naturally adjusts itself in such a way as to keep the concentration steady. At ordinary atmospheric pressure and for men this concentration is usually about 5.6 per cent. of carbon dioxide in the lung air, but varies appreciably in different individuals. If two or three per cent. of carbon dioxide is already present in the inspired air, the depth of breathing becomes naturally so much increased that the lung air contains only very slightly more carbon dioxide than before. Thus with an increase of three per cent. in the carbon dioxide of the inspired air there is only an increase of about 0.2 per cent. in the air within the lungs. Similarly, when, during even very moderate muscular exertion, the production of carbon dioxide within the body is increased five times or more, there is only a very small increase in the percentage of carbon dioxide in the lung air, since the ventilation of the lungs is increased during the exertion to nearly five times. By observations on the breathing at different atmospheric pressures we can easily show that it is not the percentage of carbon dioxide, but its partial pressure or diffusion pressure that is exactly regulated.

The diffusion pressure of carbon dioxide in the gaseous medium with which the blood is in contact during its passage through the lungs is thus kept nearly, but not quite, constant; and since other evidence shows that diffusion between the blood and this gaseous medium is perfectly free and complete, the diffusion pressure of *free* carbon dioxide in the arterial blood leaving the lungs and heart is also nearly constant. But, other things being equal, the alkalinity of the blood diminishes or increases as the pressure of free carbon dioxide in it increases or diminishes; and by the application of extremely delicate methods of measurement by Hasselbalch and others it has been shown that what is kept nearly constant by the breathing at different times and under various physiological conditions is not the mere percentage of carbon dioxide, but the reaction, or hydrogen ion pressure, of the arterial blood. We find, for instance, that the carbon dioxide pressure to which the lung air is approximately regulated varies distinctly at different times in the same individual; but the hydrogen ion pressure remains the same. When, however, acid or alkaline substances are added rapidly to the blood, the regulation becomes imperfect owing to imperfect exchange of ions between the blood and the protoplasm of the tissues.

The fact that the reaction of the blood is regulated by the breathing connects the breathing with the action of the kidneys in regulating the blood reaction. The reaction depends partly on the alkaline salts present in the blood, and partly on the concentration of free carbon dioxide in it; and unless the kidneys could be relied on to keep approximately steady the alkalinity dependent on the salts, the reaction would not be steady with a steady concentration of carbon dioxide, as is approximately the case. Thus there is close co-ordination between the activities of respiration and of the kidneys, with, as a result, amazingly exact constancy in the hydrogen ion pressure of the arterial blood under normal conditions.

The breathing not only removes carbon dioxide from the lungs, but supplies the blood with oxygen; and if the breathing is sufficient to keep the carbon dioxide pressure approximately steady in the lung air, it will also be sufficient, as a rule, to keep the arterial blood normally saturated with oxygen, assuming that, as is normally the case, diffusion is perfectly free between the lung air and blood. If, however, owing to a low oxygen percentage in the air inspired, or owing to very low atmospheric pressure such as exists at considerable altitudes, the arterial blood is not normally saturated with oxygen, the breathing is stimulated by the want of oxygen. The increase of breathing can only be small, since increased breathing lowers the carbon dioxide pressure in the lung air, and this, in its turn, tends to diminish the breathing by increasing the alkalinity of the blood. Thus two opposing influences are in play; but in the course of time the kidneys, reacting normally to the slightly increased alkalinity of the blood, make considerably increased breathing possible without more than a trifling residual increase in the normal alkalinity of the blood. This is one important factor in acclimatization to high altitudes, which will be discussed further in Lecture V.

The respiratory movements are controlled by the central nervous system, and it has now become quite clear that the stimuli which ordinarily determine the whole of this nervous control, including that exercised through the vagus nerves, are carried by the arterial blood passing to the central nervous system. Two of these stimuli—diminished alkalinity and diminished concentration of free oxygen—have already been referred to. Various other changes of an abnormal character in the blood are known to affect the nervous control; and, reasoning from analogy, we may be certain that the nervous system would not respond normally to the usual respiratory stimuli unless the composition of the arterial blood remained normal apart altogether from variations in the ordinary respiratory stimuli. Into the regulation, therefore, of the responses of the nervous system to the respiratory stimuli there thus enter all sorts of other conditions which experimental investigation is gradually revealing, and the regulation of which must in reality be essential to the normal responses of the nervous system to ordinary respiratory stimuli.

The activity of the nervous system in so controlling respiratory movements as to maintain in certain definite respects constancy in the character of the internal medium leads naturally to a more general consideration of nervous activity. In accordance with Bernard's conception, the whole of that activity is so co-ordinated as to contribute towards maintaining the constancy of the internal medium. We have only to glance through what has been revealed by experiment as to the activities of the nervous system in order to see how fully this conception is borne out. It is, for instance, through the nervous activity that the circulation through the skin, the secretion of sweat, and the production of heat are so controlled as to maintain almost constant the internal blood temperature. It is also largely through nervous activity that a sufficient arterial blood pressure is maintained to render possible a proper distribution of blood and hence a proper maintenance of the composition of the internal medium in different parts of the body. Were it not for constant adjustment of the circulation in accordance with varying local activity the composition of the internal medium would vary beyond the limits which are consistent with normal maintenance of such local activity. This follows from the mere fact that all continued local activity is bound up with the consumption of oxygen, to mention only one substance which is consumed or produced in excess. If the local circulation failed to meet the consumption of oxygen the activity would soon be brought to an end.

Looking at the activity of the nervous system from the standpoint of conscious, as well as unconscious activity, Bernard's principle still holds good: for conscious as well as unconscious activities may be regarded as so co-ordinated as to maintain the internal medium in a normal state or provide for its reproduction. In so acting as to avoid hunger or thirst, excessive heat or cold, or injuries of any kind, we are contributing, albeit consciously, to keeping the internal medium normal, and if we did not do so life would soon come to an end.

When individual nervous reactions are investigated in detail, as has been done in many cases by Sherrington, the co-ordinated, or, as he expresses it, "integrated," character of these reactions stands out prominently. Here, as elsewhere in recent physiology, the fact of co-ordination has been the keynote of recent work.

Let us now, however, examine Bernard's conclusion somewhat more closely. When we do so we find that it is primarily the arterial blood, and only indirectly the blood as a whole, that is regulated so evenly. In different parts of the body the venous blood varies in composition and temperature, and must do so, considering the varying exchanges of material and of heat which are known to occur between the blood and various organs. So far, however, as our present knowledge goes, the composition of the blood is kept nearly constant in each individual organ. This is brought about with the help of local regulation of the circulation. During extra muscular work, or extra secretory work, for instance, the local circulation is so increased as to neutralize the local changes in blood-composition which would otherwise occur, so that in each individual part the composition of the blood remains normal.

The fact that the arterial blood remains so constant in its main features is nevertheless significant as tending to limit the variations in the blood passing through different organs. For instance, the constancy in temperature of the arterial blood tends to prevent the temperature in different internal organs from varying at all considerably. It has also been found that through the agency of various "buffering" substances present in the blood and tissues, and of local variations in the rate of circulation, the gas pressures and hydrogen ion pressures in the blood of different parts of the body tend to be prevented from deviating to more than a limited amount from what they are normally. Thus various factors act together in maintaining a normal composition.

The buffering has been not uncommonly confused with the direct and active regulation which is everywhere evident. Owing to the presence of buffering substances we can add a quite considerable amount of acid or alkali to blood without producing more than a small disturbance in its reaction, whereas if the blood were simply water or an ordinary salt solution the disturbance would be a far greater one. Similarly, owing to the very peculiar behaviour of the oxyhaemoglobin in the red corpuscles, we can, within certain limits, withdraw or add a considerable amount of oxygen without more than a limited disturbance in the oxygen pressure of the blood-plasma. These, however, are very different matters from direct active physiological regulation through the action of the lungs and kidneys, and it is nothing but sheer ignorance of, or disregard of, observation that has led to the confusion. Were it not for the active regulation the constancy of the conditions in the arterial blood would disappear rapidly, in spite of all the buffering.

Let us now glance at the physiological importance of the regulation of the arterial blood. We can judge of this from the effects of deviations from this constancy, whether produced experimentally or in disease.

The amount of knowledge so gained in recent times is very large. As a simple and easily intelligible case we may take a deficiency in the concentration of oxygen in the plasma of the arterial blood. This is easily and quite commonly brought about in disease or under certain abnormal conditions, and can also be studied experimentally in a simple and uncomplicated manner. When the pressure of oxygen in the inspired air is rapidly reduced by about a third, either by reducing the total atmospheric pressure or by reducing the oxygen percentage of the air, the oxygen pressure in the arterial blood is reduced. There is also a reduction in the total oxygen present in the loosely combined form in oxyhaemoglobin, though this latter reduction is only slight, since the haemoglobin can still saturate itself in the lungs to not far from the normal extent with oxygen. The immediate effect on the breathing is only slight, for the reason already explained; but if the exposure is continued for long enough a train of marked pathological symptoms is produced—the symptoms known to mountaineers as "mountain sickness" and consisting of headache, nausea, vomiting, pain referred to the heart, and marked depression. In the absence of other illness these symptoms are usually recovered from in the course of two or three days, when sufficient acclimatization has had time to take place; and they do not occur at all if the reduction in oxygen pressure has been so gradual that acclimatization can occur during the reduction. They may occasionally, however, become progressively more serious till life itself is endangered if the reduction has been rapid; and with greater reductions and longer exposures the probability of ultimate danger to life becomes increasingly greater.

It should be noted that the arterial blood still contains far more oxygen than corresponds to what the tissues take from it on an average in its passage through the capillaries. What is deficient is not, or need not be, the total amount of oxygen carried by the blood to the tissues, but the pressure of the *free* oxygen. We can also infer from the symptoms that in man, at least, this deficiency affects most easily the brain. It does so by reducing the partial pressure or diffusion pressure of oxygen in or round nerve-cells or their arborizations; and owing to their consumption of oxygen this partial pressure must be normally lower than in the arterial blood. We can infer, however, that it cannot be greatly lower; otherwise a slight diminution in the total amount of oxygen carried by the arterial blood could hardly have so serious an effect. Similarly, we can infer that the normal hydrogen ion pressure in or around the nerve-cells which are sensitive to the normal stimulus for respiration is normally only a little higher than in the arterial blood. The more or less urgent symptoms produced by failure in the regulation are nervous symptoms, and it is in reality the oxygen pressure and hydrogen ion pressure in or around nerve-cells in the brain that is being directly regulated by respiration. If the oxygen pressure of the arterial blood is much reduced, the effects, which culminate in complete loss of consciousness and paralysis, become more and more serious and dangerous. It has also become more and more evident that during the exposure progressively increasing damage of some kind is produced in the living tissues of the brain, so that after the normal arterial oxygen pressure is restored they only recover slowly or else do not recover at all. Their intimate structure, whatever its nature, has been so altered as to be incapable of acting normally. Gross structural change, visible to the eye, may also be produced.

By variations in the rate of circulation the damaging effects which would otherwise be produced by abnormally low oxygen pressure in the arterial blood are, in the case of many tissues, avoided. This variation is brought about partly by central action of the nervous system, as was shown by Bernard and others, but to a far greater extent also by the local opening up of large numbers of capillaries which were previously closed, as has recently been shown by Krogh. It seems, however, that in the case of the central nervous system the normal oxygen pressure is so high that this means of regulation becomes more or less ineffective when the oxygen pressure of the arterial blood is materially lowered.

It was shown by Paul Bert that an oxygen pressure above normal may be as damaging in its effects on life as an abnormally low oxygen pressure. Here again, however, the tissues seem to be largely protected by variations in the rate of circulation, and from experimental data there is every reason for believing that the central nervous system is actually protected in this way from the effects of a moderate abnormal increase in oxygen pressure. With a great increase, however, fatal effects are produced very rapidly. The tissues of the lungs themselves cannot be protected by varying the rate of circulation, and though they are probably much less sensitive than nerve-cells they become, in time, irreparably damaged, as Lorrain Smith showed, by continued exposure to an arterial oxygen pressure which is quite insufficiently high to cause any sign of damage in the central nervous system.

Of the damage which results from interference with regulation of the blood composition we have also striking evidence in the fatal effects of paralysis by inflammation, or by excision, of the action of the kidneys, with consequent disturbance in the normal balance of the crystalloid constituents of the blood. In one case after another similar damage, and of the most widespread character, has been found to result from serious disease, or excision, of other organs. It has thus become evident that not only the lungs, intestines, and kidneys, but various other organs, such as the liver, pancreas, thyroid gland, sexual organs, suprarenal and pituitary glands, are constantly engaged in regulating the composition of the blood, and that this regulation is essential to the maintenance of normal structure and behaviour of the cells in all parts of the body. On a wider view every part or tissue of the body, including muscular tissue and bone, appears to be engaged in this regulation.

Let us, however, push the physiological analysis still further. The medium in which any individual cell in the body exists must depend, not merely on the composition of the blood-plasma in indirect contact with this medium, but also on the influence of the living cells in its immediate neighbourhood. On this subject much light has in recent times been shed by the cultivation of living cells in artificial media outside the body. Such cells can be kept alive for long periods if the medium is maintained of suitable composition and temperature, and can divide and so multiply. The cells thus grown are, however, of an undifferentiated type unless they contain among them cells derived from another type of tissue normally existing in the original organism side by side with them. Epithelial cells, for instance, cease to present the normal appearances and arrangement of epithelial cells unless cells of connective-tissue origin are present in the culture along with them.

We thus see at once how essential for the normal development and functioning of any kind of cell in the living body is the influence on its medium of neighbouring cells. The medium in every separate part of the body must be normal for that part; and the great outstanding fact is that this normality is maintained, the normality constituting what we call health. We can also see clearly that in embryonic development the two daughter cells of a cell which has divided are no longer in the same medium as the original cell if the daughter cells remain in close contact with one another. In the new environment new growth-stimuli are provided, and the effects of these must lead to structural differentiation, and moreover will be different in different individuals of a collection of cells, since those on or near the surface of such a collection will be in a different medium from those farther from the surface, though the medium surrounding the collection may remain the same throughout.

Let us now consider the bearing of the facts discussed in this lecture on the mechanistic theory of life. In tracing in the last lecture the development of the mechanistic theory we saw that on this theory the peculiar behaviour of living organisms must be regarded as due to the peculiar ultramicroscopic structure of the cell-units composing the organism. Claude Bernard himself still clung to this conception, as he did not realize how far the development of his own reasoning would carry physiology. Now, however, it appears that both the behaviour and the structure of the cell-units depend upon the local medium in which the cells are placed. On the other hand, it is equally evident that the medium, whether it be a general one such as the blood-plasma, neglecting local differences in its composition, may be regarded as being, or whether it be the special local medium, is determined by the activities of the cells. We are therefore reasoning in a circle if we attribute the peculiarities of cell behaviour to their particular structure, since these peculiarities, and the accompanying structure, depend upon the local medium. Thus all that we can really say, in view of the facts which Claude Bernard drew attention to, is that the behaviour of a living organism and its environment is such that the normal life of the organism is maintained. We are forced, however, by the mechanistic theory of life to reason in the circle first alluded to.

That theory is, therefore, bankrupt. It has, in fact, ceased to interest physiologists in recent times, though almost with one accord they refuse to turn back to vitalism, and for very sufficient reasons, as will be shown in the next lecture. The actual development of ordinary physiological investigation has thus carried physiological knowledge to a point where the mechanistic speculations of last century no longer afford any prospect of understanding life; but a little consideration is sufficient to show us that from the beginning there was not the slightest prospect for a complete systematic treatment of biology as a part of physics and chemistry. To explain the fact that organisms, in spite of the extreme lability of their protoplasm, develop and maintain their specific structure and behaviour, it is necessary, on the mechanistic conception, to assume the presence in them of all kinds of specific structure. But that structure is also reproduced from generation to generation, and is apparently being reproduced constantly in ordinary metabolic processes. Of this reproduction the mechanistic theory can give no account whatever. Not by the widest stretch of imagination can we conceive of structural machinery which goes on reproducing itself indefinitely; and the more structure and chemical complication we actually discover or assume in an organism, the more hopeless does the problem of its reproduction and maintenance become from a mechanistic standpoint. Thus from its first beginnings the mechanistic theory of life was embarked on a hopeless task. The more recent developments of physiology, as described in the present lecture, have only brought this home in a new way. It may be that there are still some physiologists who believe that the progress of physiology is bringing us nearer to a physico-chemical conception of life. But if there are, I can only say that their intellectual vision seems to me to be very defective.

In current physiological literature it is still customary, in describing what is known as to different bodily activities, to refer to them as "mechanisms" —for instance, the "mechanisms" of reproduction, respiration, secretion, etc. This is of course a mere matter of custom, handed down from a previous generation. There are perhaps few physiologists who now consider that they have any real conception of these mechanisms. I should like, however, to point out that such a mode of expression is extremely misleading to that miscellaneous body which we call the public.

Looking back at the means through which the progress reviewed in the present lecture has been reached, we can see that it has been reached through the application to physiological phenomena of accurate quantitative methods, and particularly by the measurement, in relation to one another, of differences which may be very small. Much of my own time, and that of most other physiologists, has been taken up in devising sufficiently accurate methods of measurement. It was only, for instance, through the accurate chemical analysis of blood, urine, and alveolar air, and through the application of the principles of physical chemistry and physics, that the co-ordinated activity manifested in excretion, respiration, and circulation became clear. Similarly, it has only been through accurate measurement of intake and output of material and energy that the co-ordinated metabolic activity of the body as a whole has been progressively revealed. Thus the fundamental fact of organic co-ordination has become progressively more evident, while the idea of a physico-chemical mechanism of this co-ordination has faded more and more into the background.

One often meets the statement, repeated, parrot-like, by various persons, that scientific physiology is progressively revealing the mechanism of life. In the light of actual progress this is quite untrue, and can only be described as claptrap. What physiology is progressively revealing is the detail of co-ordinated physiological activity. Knowledge of this detail is of the utmost importance in medicine, both on its therapeutical and preventive sides, in agriculture, and in all the arts which have to deal with the activities of living organisms from yeast and bacteria upwards. Many biologists still hold before themselves as an ideal the discovery of a physico-chemical mechanism of life. But assuredly that ideal seems to them far more distant than it did to Schwann and the other leaders of the mechanistic movement in physiology of last century, though even to the latter, if they had only thought a little more, and not suffered themselves to be carried away by a child-like enthusiasm, the knowledge then existing would have shown that ideal to be unattainable. In view of the facts as to heredity, what, for instance, could have been more futile than Schwann's conception of the formation of living cells by a process of precipitation?

LECTURE IV

VITALISTIC BIOLOGY

THE inherent difficulties in a mechanistic theory of life have been perceived ever since it was formulated, even vaguely. Physiology took its origin in practical medicine, and in connexion with the healing art of the physician or surgeon it became evident in early times, and was clearly realized by Hippocrates, that diseases and injuries tend to be recovered from by an active process apart from either volition or artificial interference, and that artificial interference, where it is efficacious, is either of the nature of an aid to an active natural process or the removal of something which causes abnormal disturbance of natural processes. The mechanistic theory of life gives no coherent account of the natural tendency of the body to maintain actively and reproduce its normal structure and activities and to restore them after disturbance. In mechanisms there is no such tendency, and for this reason the mechanistic theory of life has never appealed to those engaged in the practice of medicine.

On the other hand, it became equally evident as physical science developed that mechanical interpretations of phenomena observed outside living organisms are extremely satisfactory, and can with much success be applied to a good deal of what is observed within the body. In order to give due weight to both points of view it seemed natural, and only common sense, to assume that though the body, as being material, is in itself of the same nature as other kinds of matter, the living body is nevertheless subject to a guiding interference which accounts for its differences from a machine. As we are not directly conscious of this guiding influence, its action was usually not attributed to the soul, but to a " vital principle " or " vital force," or else to the soul acting unconsciously. The word " vitalism " may be regarded as covering every form of this belief, up to the present time.

Before Descartes put forward his mechanistic conception of life, vitalism was hardly a distinctly defined form of belief. Such expressions as " animal spirit " or " vital spirit " were, indeed, in use, but in a sense which was not by any means clear. Descartes, for instance, adopted the conception of " animal spirit "; but for him, as we have seen, this was only an attenuated form of ordinary matter. The formulation by Descartes of a definitely mechanistic theory of life led immediately to the definite formulation of a vitalistic theory by Stahl, who was also the author of the phlogiston theory which dominated chemistry and the physics of heat for so long. Stahl maintained that bodily processes are guided unconsciously, as well as consciously, by the soul, and that it is the presence of this guidance that distinguishes living from non-living bodies. He strongly contested the arguments of Descartes, and maintained that a mechanistic theory of life does not correspond with the facts.

Stahl's criticisms appealed particularly to those engaged in medicine, and we find that for the next two centuries the teaching of physiology in connexion with medicine was more or less vitalistic. The mechanistic theory might appeal to philosophers or theologians, but it certainly did not appeal to the ablest men engaged in the medical profession. Nor did it appeal much to physicists or chemists, since they were well aware of the contrast between life and ordinary physical and chemical processes. It has sometimes been assumed that Wöhler's discovery of the synthesis of urea was fatal to vitalism. All that it was fatal to was the quite artificial distinction which chemists had made between organic and inorganic chemical substances. Wöhler, like Liebig, was and remained a vitalist.

Stahl had assumed that it is the soul, acting unconsciously, which guides the bodily processes; but this hypothesis did not seem necessary, and seemed to involve, for instance, the conclusion that plants have souls. This part of Stahl's theory was therefore soon dropped, a "vital principle," operative in all living organisms, including plants, being substituted for the soul in connexion with all unconscious bodily processes which seemed to present evidence of co-ordinated guidance. The "excitability" of muscular and nervous tissues was also attributed to the vital principle or force, which was thus apparently a source of energy. In the teachings of the Montpellier school of medicine in the eighteenth century, we find a specially detailed development of vitalistic doctrine. In the writings of Hunter in England, Bichat in Paris, and nearly all the most eminent physiologists, medical men, chemists, and biologists up to near the middle of last century, we find vitalism of some kind to be an accepted doctrine, though among philosophers, theologians, and certain popular writers, living organisms were frequently regarded as being, apart from the exercise of conscious control, mere machines. Others went further, and concluded that all the phenomena observed in living organisms, whether conscious or unconscious, are mechanically determined.

Vitalism remained on the whole dominant up to about the middle of last century. Johannes Müller's famous text-book of physiology, and Liebig's numerous writings on physiological chemistry, or as it is now usually called, bio-chemistry, afford a good idea of vitalism as it was then taught. The following are passages from Müller's introductory chapter:

"There is in living organic matter a principle constantly in action, the operations of which are in accordance with a rational plan, so that the individual parts which it creates in the body are adapted to the design of the whole; and this it is which distinguishes organism. Kant says, 'The cause of the particular mode of existence of each part resides in the whole, while in non-living masses each part contains this cause within itself.' . . .

". . . Stahl's contemporaries and followers have partly misunderstood this great man, in believing that, according to his view, the soul, which forms mental conceptions, also conducts with consciousness and designedly, the organization of the body. The soul (anima) spoken of by Stahl is the organizing power or principle which manifests itself in conformity with a rational law. But Stahl went too far in placing the manifestations of soul, combined with consciousness, on a level with the organizing principle, the operations of which, though in accordance with a design, obey a blind necessity. The organizing principle which, according to an eternal law, creates the different essential organs of the body, and animates them, is not itself seated in one particular organ: and it continues up to the date of birth in anencephalous monsters. . . . This principle, thus acting conformably to design, but without consciousness, is also manifested in the phenomena of instinct. There is great beauty and truth in the saying of Cuvier that animals acting from instinct are, as it were, possessed by an innate idea, by a dream. But that which excites the dream can be nothing less than the organizing principle, the 'final cause' of the being.

"The existence of the organic principle in the germ, and its apparent independence of any special organ in the adult, as well as the fact that it is manifested in plants, in which both nervous system and consciousness are wanting, prove that this principle cannot be compared with mental consciousness, which is an after-product of development, and has its seat in one particular organ. Mind can generate no organic products: it can merely form conceptions. Our ideas of the organized being are mere conscious perceptions of the mind. The formative or organizing principle, on the other hand, is a creative power modifying matter blindly and unconsciously, according to the laws of adaptation.

"Organism or the organized state is the result of the union of the organic creative power and organic matter. Whether the two have ever been separate, whether the creative archetypal ideal, the *eternal ideas* of Plato, as he taught in his *Timaeus,* have at some former period been infused into matter, and from that time forward been perpetuated in each animal and plant, is not an object of science, but of the fables and traditions which cannot be proved, and which indicate to us the limitations of our mere consciousness."

Liebig regarded the vital principle or force as an influence which guides molecules into the positions normally occupied by them in the living tissues, and which holds them there or replaces them, in spite of physical and chemical forces tending to scatter or disintegrate them. He also believed that the reason why the consumption of oxygen and formation of carbon dioxide are so much increased during muscular exertion is that the vital force is becoming used up and thus enfeebled, so that it can no longer fully protect the living tissues against oxidation. Increased oxidation is thus a natural consequence. Outside the living tissues in the blood and other liquids, oxidation has free play to go on, and this produces the ordinary resting supply of animal heat.

Since Liebig regarded the vital principle as a source of energy which could be exhausted, but could, apparently, renew itself spontaneously and from no known source, his teaching was inherently very liable to attack. In the previous lecture we have seen how the advances made by Mayer and Helmholtz threw a flood of new light on the sources of muscular energy and the relation of oxidation to muscular contraction and other manifestations of excitability in living tissues. This meant a complete break with the doctrine that the vital principle is a source of the ordinary energy released in vital processes. Liebig's teaching also suffered a further eclipse. He thought, as we have seen, that in muscular work it is previously living tissue that is oxidized; and as living tissue is albuminous, and albuminous material is, when oxidized in the body, converted into urea, carbon dioxide, and water, a greatly increased excretion of urea ought therefore to occur after muscular work. This, however, was not found to occur under ordinary conditions. Thus muscular work must, in the main, be carried out at the expense of oxygen and carbohydrate or fat which has been brought to the muscles by the blood.

We can see how severely shaken were current vitalistic doctrines by the new conceptions of Mayer and Helmholtz. Vitalism could never afterwards be taught in the form which it had assumed in Liebig's writings. If, however, we bear this in mind, we must also bear in mind that what may be called the mechanistic part of Liebig's teaching received also a severe shock when it was gradually shown, as pointed out in the second lecture, that oxidation is not a process occurring in the blood under conditions similar to those in ordinary liquids, but in the living tissues, and in a very definitely co-ordinated manner, as Rubner showed quantitatively.

Vitalism nearly disappeared during the development of the mechanistic movement dating from the middle of last century. It is easy to see, however, that physiologists and other biologists were simply swept off their legs by that movement. The real difficulties in the way of a mechanistic theory of life still remained, though they were for the time partially concealed owing to the rudimentary applications of physical and chemical measurement to physiological phenomena, and equally rudimentary understanding of the principles of physical chemistry. Liebig's conception of the conditions under which physiological oxidation occurs, or Ludwig's of renal secretion, may be taken as typical of mechanistic conceptions which still seemed possible till after the middle of last century. A popular and very readable representation of the mechanistic physiology of last century was contained in Huxley's *Elementary Physiology,* which had a deservedly large circulation. This book contains an admirably clear account of most of what can be interpreted as mere machinery in the bodies of the higher animals and man. Other phenomena indicative of co-ordination everywhere in physiological processes are either passed over very lightly, or not referred to, since they were then unknown. Huxley's attitude in this respect was typical of that of the leading physiologists of his time; and we can see the same ideas reflected in a great mass of the popular literature of present times.

In the previous lecture an endeavour was made to follow the recent development of the mechanistic conception of life, and we must now endeavour to do the same for the vitalistic conception. Vitalism was by no means dead at the end of last century. Such well-known books as Bunge's *Physiological Chemistry* and the papers and books of Driesch and other well-known morphologists are sufficient evidence of this. At the present time vitalism may not be popular, but it is still alive in scientific or philosophical writings. A notable recent example of very emphatic vitalistic interpretation, and in the form adopted by Stahl, is afforded by Professor MacDougall's book on *The Principles of Psychology.* This book is specially noteworthy, since MacDougall himself has studied physiology deeply.

The real strength of vitalism depends now, just as it did in the seventeenth century, on the fact that it gives recognition to the co-ordination which can be traced in the activities of living organisms from the earliest to the latest stages in the life-history of any individual organism. This co-ordination is of such a nature that the organism's normal structure and activities are actively maintained or reproduced. We find in the living body definite mechanical structures so arranged as to conduce to the maintenance of normal vital activities or to protect normal living structure; but on close examination these structures, such as bones, skin, lungs, etc., are found to be themselves alive, either partly or wholly—that is to say, they are constantly being actively maintained by co-ordinated activity; and in individual history they have all been originally formed by co-ordinated activity for which there is no mechanical explanation, and are so formed again and again, indefinitely often, in successive generations.

The fact of the co-ordinated maintenance and reproduction may not be evident to philosophers and theologians, but is forced on the attention of medical men. Co-ordinated activity is thus a fundamental characteristic of living organisms, and is not explicable in terms of special mechanical structure. To account for the co-ordination it therefore seemed necessary to assume the action of a factor wholly different in kind from matter and energy, but capable of guiding them in a co-ordinated manner, just as men guide the unco-ordinated operations of the inorganic world. The energy expended in guidance may be quite inappreciable in ordinary measurements, just as the energy expended in guiding a heat-engine or other powerful machine is inappreciable. Hence vitalism cannot be refuted by measurements of the total intake and output of energy in living organisms. The discovery of chemical sources of the heat and power developed in living organisms was thus no real refutation of vitalism. One might as well try to prove from measurements of the intake and output of energy by a locomotive that the driver does not exist.

Whether the assumed factor is called the " vital principle," " entelechy," or " élan vital " does not seem to matter much, though " vital force " is an objectionable expression, as suggesting that the vital principle is only a special form of physical energy, and is an appreciable source of the energy liberated in physiological activity.

However fully physiologists are now becoming aware of the fundamental significance of co-ordination in the phenomena of life, and however conscious they may be of the defects in the mechanistic physiology of last century, they show but little tendency to return to vitalism, and for very good reasons. The more deeply we probe into the conditions which determine any physiological phenomenon, the more clearly does it appear that it is dependent on what are generally interpreted as physical and chemical conditions. This is so, however strikingly the phenomenon may illustrate the co-ordination which is so characteristic of life, and however obscure may be the actual causal connexion between the phenomenon and the material change or " stimulus " which initiates it. Thus the prick of a needle or other kinds of disturbance may, as Loeb has shown, initiate the process of division and subsequent further normal development in an unfertilized ovum which would not otherwise divide and develop. We know nothing as to any chain of physico-chemical events connecting the prick with the complex and marvellously co-ordinated developmental changes; but the prick is nevertheless what we interpret as in itself only a physical event. A suitable supply of oxygen, or moisture, or of some salt or other substance, or of heat or light, may similarly stimulate various kinds of vital activity; and we can discover no sort of vital activity which cannot be regarded as being not only excited, but also maintained, by what we regard as physical and chemical stimuli.

If there be a vital principle, it is thus impossible to demonstrate its influence apart from that of physical and chemical influences. In any case, it seems more profitable to go on discovering the actual connexions between physical and chemical influences and vital changes than to speculate as to an influence of which the action can never be separated from physical and chemical action. There remains, however, the outstanding fact that, be the physical and chemical influences or stimuli what they may, the characteristic co-ordination of physiological activity is evident unless the influences are such as to bring about what we easily recognize as pathological or abnormal changes, or to cause what we are familiar with under the name of death.

Driesch has brought forward an instance in which he argues that he has practically isolated the action of the vital principle, or "entelechy," as, following Aristotle, he calls it. He discovered that if, in the early stage of development of certain organisms, the cells of the developing organism are separated from one another by mechanical means, each of the separated cells is still capable of initiating the whole development again from the beginning. If we assume that the orderly changes occurring in the development of a fertilized ovum depend on some physico-chemical structure present in the ovum, we are also compelled to think that this structure must divide itself up among the developing cells, so that after division their intimate structure is different, and each individual cell cannot, therefore, again develop in the same way. But as a matter of fact each cell can again develop in the same way if placed in the same medium. Driesch considers this as evidence that cells can develop in a normal manner independently of any mechanism contained within them, or of changes in their environment.

When we examine this argument we find that it contains excellent reasons for concluding that the development from an ovum cannot be regarded as simply guided by some mechanism within the original ovum. In this regard the whole of the facts regarding hereditary transmission of structure and activity have always pointed clearly in the same direction, as has already been remarked. When, however, it is assumed by Driesch that the development must occur independently of stimuli from the environment, his evidence is quite inconclusive. When the cells of the developing organism are separated from one another the immediate environment of each of them is at once altered, since, as was pointed out in the last lecture, that environment is not simply the general medium in which the developing organism is floating, but an environment altered by the presence of the other cells. When the cells are separated their primitive environment is restored, and they naturally return to their primitive physiological state. We can regard their characteristic normal behaviour when cell-division again progresses as the natural response to the same series of changes in environment as occurred in the original development.

The point we are thus brought to is that while we can always discover or indicate conditions in the environment which determine both organic structure and co-ordinated physiological activity, we can never demonstrate the existence of any factor other than what may be regarded as physico-chemical which determines this action. What still remains mysterious is the specific co-ordination of activity, and corresponding organization of structure. These are characteristic of all life, however lowly an organism may be. The idea that in lowly organisms or "simple" protoplasm we are getting beyond these characters has been a veritable *ignis fatuus* to biologists. To realize this we have only to refer back to some of the writings of Huxley.

In a recent book, entitled *The Organization of Life,* Professor Seba Eldridge has discussed this subject very fully. He states clearly the difficulties of a mechanistic theory of life, and also recognizes the difficulty of directly demonstrating the influence of any factor not of a physical or chemical nature. He concludes, however, that it is necessary to assume that such a factor exists, since it seems otherwise impossible to account for the co-ordination which is so characteristic of physiological activity. He is thus driven, like Professor MacDougall, to an acceptance of the vitalistic position. In explanation of the impossibility of directly isolating by experiment the operation of the vital principle he argues that it is only in conjunction with physical and chemical causes that the vital principle can act. It is, in fact, a regulative principle which requires for its manifestation a suitable physical or chemical process which it can regulate.

Now if we admit that processes in which matter and energy are concerned are by themselves purely mechanical in their ultimate nature, it must lead to great scientific confusion if an invisible and intangible something which interferes with these mechanical processes is assumed to exist within the bodies of organisms. With such an assumption we never know "where we are." The assumption will "explain" anything and everything which occurs in a living organism; but in practice it cannot be definitely tested in the investigation of individual phenomena, and is thus practically useless in detail as a working hypothesis.

It is not only, however, this practical uselessness that has prevented physiologists from returning to vitalism, inadequate as mechanistic conceptions have shown themselves to be in the light of accurate measurement and fuller understanding of physical and chemical principles. What appeals to them still more strongly is that however unintelligible physically the phenomena of life may be, yet these phenomena can be shown by experiment to depend on what are admitted by the vitalists to be physical conditions in the environment. It is therefore these physical conditions which determine the phenomena of life, though how they do so is totally obscure for the present. Actual experience also shows that there is no end to the further light which experimental investigation of the physical and chemical environment may throw on any physiological phenomenon.

Vitalism is thus a quite unsatisfactory hypothesis, both ultimately and from the standpoint of scientific advance. The vitalists can, however, retort, and on conclusive grounds, as we have already seen, that the mechanistic theory of life is equally unsatisfactory, since it gives no account of the co-ordination which is characteristic of all vital activity, and leads investigators to ignore the co-ordination. So serious is this defect in the physiological teaching which is at present customary that physiological teaching in connexion with medical education does not occupy the important place which it certainly ought to occupy. The so-called elementary physiology taught to students has lost connexion with the co-ordinated living activity on the existence of which sound medical practice is based, and which old-fashioned language and ideas attributed to a *vis medicatrix*.

The mechanistic conception of life is still reckoned orthodox among physiologists and biologists generally. This is, I think, not because it is regarded as satisfactory, but because the only alternative has seemed to be the very unsatisfactory one of vitalism. The leaders in biology became definitely mechanistic about the middle of last century, and no sufficient reason exists for now going back to vitalism, though their expectations of what the mechanistic theory would accomplish were unjustified, and at any rate have not been fulfilled. Scientific history shows, moreover, that the inertia of scientific beliefs is a very powerful influence. It is hard to realize that what we have learnt from men whom we greatly respected may in reality be far from being true.

In the next lecture I shall endeavour to make clear the necessity for a far more radical treatment of the controversy between mechanists and vitalists than that of adopting one side in the controversy between them.

LECTURE V

BIOLOGY AN INDEPENDENT SCIENCE

THE preceding lectures have shown, not merely the difficulty, but the impossibility, of interpreting life as a physico-chemical process on the general conception of physics and chemistry as formulated on the lines of Galileo and Newton. They have also shown that the attempt to eke out the physico-chemical interpretation by assuming the interference in vital processes of an agency which, since it is neither visible nor tangible, we can properly call a supernatural agency, is equally unsatisfactory in enabling us to comprehend life. To overcome these difficulties it is necessary to deal radically with our hypotheses, and the necessity for this was indicated in general terms in the first lecture.

Hippocrates treated the unconscious activities of life as natural processes. He claimed the right to interpret them in accordance with actual observation, regardless of superstition and of the intrusion of philosophical opinions not based on observation of them. In observing Nature just as she appears in the phenomena of life, and basing his interpretations directly on the observations, he founded scientific medicine, and with it, as it seems to me, scientific biology. The co-ordinated activity manifested in the phenomena of life was regarded by Hippocrates as nothing more than a visible and tangible manifestation of Nature. He found co-ordination and its maintenance in the aspect of Nature which he was studying, and refused to be moved by the philosophical atomism of his time. His influence, through Aristotle and later Greek thinkers and observers, appears to have been a very great one, though Aristotle unfortunately put his teaching into a form essentially similar to that of vitalism.

It seems to me that the attitude of Hippocrates was, and is, the only attitude possible in scientific biology. What we may call the Galilean or Newtonian conception of the visible and tangible universe assumes that the visible and tangible world consists of self-existent bodies, each of which is capable of acting on other self-existent bodies, and being acted on by them, but this mutual action being a mere accident in the self-existence of the bodies. The gradual development of this general conception in the eighteenth and nineteenth centuries seemed to show that the universe must be regarded as consisting of self-existent and eternally-existent atoms, and that the sum of their actions and reactions upon one another when expressed as energy is just as eternally self-existent and constant as the atoms themselves. Until the middle of the nineteenth century, however, the phenomena of heat and temperature were not brought under this conception. Scientific men, including, for instance, Lord Kelvin when he first came as Professor to Glasgow, still believed that heat is a substance. It was another great Scottish physicist, John James Waterston, who, as the late Lord Rayleigh discovered through an unpublished paper in the Archives of the Royal Society, was the first to formulate clearly the modern conception of heat, gases, and temperature. On that conception a perfect gas is an absolutely chaotic assemblage of perfectly elastic molecules in very rapid motion, and clashing with one another in every possible way. Heat is just the chaotic kinetic energy or, as it was then called, *vis viva* of the molecules; and temperature varies with the mean *vis viva* of the molecules, absolute zero of temperature corresponding to a state in which the molecules would be at rest in relation to one another. Heat energy is thus chaotic energy. In liquids and solids the chaotic movements are restrained by blindly acting forces of attraction between the molecules, so that their energy is constantly passing from the kinetic into the potential form and back, in accordance with Mayer's conception; but the energy is still chaotic.

It is easy to see that not only heat energy, but ultimately speaking all visible and tangible activity of every kind, is chaotic on the Newtonian conception, unless this activity is in some way guided. It is also easy to see that since heat is constantly being produced by the mutual action on one another of larger masses, and this process is only incompletely reversible, the energy of the universe must be running down, on the Newtonian conception, towards a dead level of temperature. As actually the universe has not yet done this, we can argue, if we like, that it must have been created in time, just as we can argue, with Paley, that since living organisms are wonderful pieces of machinery which could not have arisen by chance, they must have been created—by an outside God who left the machinery to go to pieces in a chaotic world as all other machinery goes to pieces. Evidently, however, the implications of such an argument are essentially irreligious.

Waterston's writings, published or still unpublished, are so interesting and important that I have collected them together, and they are in course of publication.[1] Among them is an essay on "The Mental Functions." His early studies were mainly in the direction of physiology and psychology, and in this essay he discusses, as Descartes had done two centuries earlier, to what extent a living organism or conscious person can be interpreted on physico-chemical principles. He goes as far as it seems possible to go in this direction; but, unlike Descartes, he realizes the actual nature of his task and sees that the co-ordination which manifests itself in both physiological and psychological phenomena cannot be interpreted physically, unless, indeed, the physical world is something different from what, on the Newtonian interpretation, it appears to be.

In claiming that the mechanical interpretation of visible reality is a "philosophical" interpretation, Newton practically claimed that the mechanical interpretation represents that reality. The real ground for this claim is that with the help of the mechanical interpretation we can predict phenomena with, on the whole, wonderful success in the inorganic world. But we cannot do so in the organic world; and even in the inorganic world the success is only

[1] They are now published under the title, *The Scientific Papers of John James Waterston,* Oliver & Boyd, 1928.

a limited one, as was pointed out in the first lecture.[1]

In the organic world of life we find that structure and activity cannot be separated from one another. The structure is alive, and in destroying life we also destroy the molecular structure in which it manifests itself. Moreover, we cannot separate living structure from its encircling environment or prevent the living structure from reproducing that environment if we partially remove it without destroying life. Between living structure and its environment we can draw no distinct line such as we seem to be able to draw between an inorganic body and its environment. The parts, including environment involved in life, and the activities which manifest themselves in the parts, are evidently so related that for each the others are presupposed. We can only regard them as organized manifestations of a persistent whole; and in particular we cannot, even in thought, separate the structure from the activity or from the environment and its influence, unless we entirely neglect what actual observation shows us to be their real characters. With lifeless structure, or the lifeless body of an organism, it is different. From the hieroglyphics written in the lifeless structure we can, it is true, infer much about the life which was manifested in the living structure; but this is only indirect inference. We cannot possibly

[1] While this book was passing through the press there appeared Professor Eddington's Gifford Lectures at Edinburgh in 1927 on *The Nature of the Physical World.* In these very striking lectures the ultimate limitations inherent in present conceptions of the inorganic world are very clearly pointed out.

examine separately the parts involved in life as we examine separately the parts of a machine. In particular we cannot separate the influence of the environment, since environment belongs to the unity which we perceive as life.

It is thus not sufficient to regard life from the mere abstract standpoint of mass and energy. This abstract standpoint takes no account of the fact that in life mass is maintained in the specific form of structure by corresponding specific activity. It is the recognition of this fact which distinguishes biology from the mechanical sciences of the Newtonian philosophy; and in biology the conceptions of inertial mass and energy are replaced by that of active organic maintenance.

Since living structure and environment cannot be separated, different centres of life must, and do, run into one another, as in the case of the lives of individual cells in different tissues of a higher animal or plant. But the resulting life is no mere sum of individual lives. Each local centre of life is necessarily modified in accordance with the altered environment due to the presence of other centres, and the resulting complex life is no less an organized unity than each centre would be by itself. In communities of separate animals, plants, or unicellular organisms, we see the same thing, though on a less striking scale. The result of the fusion of many lives is still only one life, though in this one life there is full representation of each of its constituent lives.

Within, or surrounded by, living structure we find what we can only interpret as deposits of liquid, solid, or gaseous material, though these deposits are organically determined as regards their composition and amount, and sometimes very exactly, as in the case of supporting material, or the blood, or the alveolar air in the lungs. In so far as they are organically determined, but no further, we can treat them as part of the living structure or its physiological environment.

Outside the living structure and its immediate environment is what we interpret on Newtonian principles as the physical and chemical environment. In so far as this is indifferent to life, it does not concern biology; but in so far as it enters into life, its action upon organisms and their action upon it are organically determined, just like other life-processes. The influence of environment through sense-organs and in other ways is evidently co-ordinated organically. In the case of light, for instance, brightness and colour are evidently under complete organic control; and the physiology of vision deals with this control, which is not intelligible physically, as Locke saw clearly when he discussed "secondary qualities." Whether or not, or how, an organism responds to what, from the physical standpoint, is a physical action upon it, depends on organic control. The action, regarded as mere physical action, may prove to be a positive or negative specific stimulus, or may evoke no response at all; but whatever the result, the physiological reaction is normally under organic co-ordination, and only intelligible as part of an organized activity. It is this organic co-ordination which biology deals with. Quite evidently, biology does not claim to be a general philosophy of Nature, and only deals with life.

Living organized structure and activity are just as visible and tangible to us as mechanical structure and action. In biological observation, and in arts such as medicine, dependent on biological observation, it is visible and tangible organized structure and activity that we are dealing with, and our interpretations must be in terms of that structure and activity. As biologists, and realizing the nature of our observations, and their essential difference from observations which can be described and interpreted in mechanical terms, we must, following Hippocrates, insist firmly on biological interpretation, without which our observations would become a veritable chaos.

Biology, whether on its physiological or morphological side, is nothing but the progressive discovery and elucidation of the maintenance of visible and tangible organized activity in living organisms. We can trace this progressive discovery and elucidation in the history of the two main branches and various subordinate branches of biological science. What we cannot trace, however, is any progress towards a comprehensive physico-chemical interpretation of biological observation. The attempts at this, such as the attempts of Descartes or of Schwann, have been gross and palpable failures. We can, it is true, make great use of physico-chemical interpretations where we are dealing with phenomena artificially isolated from their biological context. The driving of blood through the blood-vessels, of air into and out of the lungs, or the solution of food-material in the alimentary canal, can be, for instance, when they are considered in isolation from the conditions which determine them, interpreted as simply physical and chemical processes; but in such processes the general organic determination is not only evident, but is every year becoming more and more evident as regards detail. In so far as we neglect this organic determination we are neither biologists nor physiologists, but simply physicists or chemists.

It seems to me very important for biologists and for all those engaged in arts which are concerned with life, whether animal or vegetable, to realize that they are dealing with what can only be interpreted generally as the specifically co-ordinated and persistent phenomenon which we call life.

Let me illustrate this from investigations in which I have myself been concerned. Twenty-five years ago the physiology of breathing was in a very confused position. On the one hand, it was known that both deficiency in the oxygen concentration and excess in the carbon dioxide concentration of the air within the lungs lead to an increase of the breathing, and that excessive voluntary or artificially produced breathing leads to the cessation of spontaneous breathing known as apnoea. Thus we could apparently understand why it is that when more oxygen is used up in the body, and more carbon dioxide produced, as in muscular exertion, the breathing is increased.

On the other hand, however, it had been concluded, on apparently good experimental evidence, that breathing is also regulated independently by nervous impulses passing up the vagus nerves which supply the lungs, impulses which stop the breathing being liberated by distension of the lungs with air, and impulses which produce inspiratory effort, or cessation of impulses which stop it, being caused by collapse of the lungs. It was found also that apnoea could be produced, even with air containing a very low oxygen percentage. The apnoea produced in this way, or by simple distension of the lungs, was known as " vagus apnoea." It had also been found in some experiments that during, and for long after, muscular exertion the breathing was increased, though less carbon dioxide and quite as much oxygen were present in the blood and the expired air.

There thus seemed to be at least two sets of influences, essentially independent of one another, affecting the breathing, and apparently tending to conflict with another, since the increased breathing produced by muscular exertion or in other ways would tend, apparently, to produce vagus apnoea, and the influence of the vagus nerves would in general appear to be restricting the depth of breathing. In any case, the influence of the vagus nerves seemed not to be co-ordinated in any way with the supply of oxygen to, and removal of carbon dioxide from, the body.

What struck me was that this is not the way of a living organism, and from my student days I had rejected the mechanistic standpoint in physiology. The experimental evidence seemed not really satisfactory, so I set about, along with scientific friends, to clear it up, and it took many years to do this at all completely. In the first place, we showed that in ordinary breathing the depth and frequency, or either separately, are so regulated as to maintain an extremely constant pressure of carbon dioxide in the air of the lung alveoli, a method for the direct investigation of which I had devised. The arterial blood which leaves the lungs is evidently saturated with carbon dioxide to a diffusion pressure corresponding to the concentration of carbon dioxide in the alveolar air, and this diffusion pressure, acting through the circulating blood on the nervous centres in the brain, determines the nervous respiratory impulses. As already mentioned, we can go further still: it is the " reaction," or hydrogen ion diffusion pressure, as affected by the diffusion pressure of carbon dioxide, which determines the nervous impulses; and this enables us to understand how it is that the breathing is sometimes increased though the pressure of carbon dioxide in the arterial blood is low. The cause of the true apnoea which follows over-ventilation of the lungs is simply the washing-out of too much carbon dioxide from the arterial blood, and there is no other cause. It requires only an extremely slight extra washing-out to produce complete apnoea; and even when the oxygen percentage of the alveolar air is very low the apnoea is easily produced, though not so easily as with a normal oxygen percentage.

The apparent apnoea produced through the vagus nerves on distension of the lungs is not apnoea at all, but only suspension of inspiratory action, while expiratory action is not only present, but constantly increasing. We do not record this expiratory action if we only record the action of an inspiratory muscle such as the diaphragm; and this led to a mistaken interpretation. There is, in fact, no such thing as vagus apnoea. We found, moreover, that the action of the vagus nerve in arresting or "inhibiting" inspiratory effort is completely under the control of the action of carbon dioxide on the nerve-centres in the brain. The action of the vagus nerves is, in actual fact, such as to regulate the depth and frequency of the breathing in accordance with the strength of the chemical respiratory stimuli, so that the action of the vagus nerves is in complete co-ordination with that of the chemical stimuli; and these bring the breathing into co-ordination with the activities of every part of the body.

We thus seem to have what could be described in the language which is at present customary as a "beautifully co-ordinated mechanism" for keeping the composition of the arterial blood constant as regards its diffusion pressure of carbon dioxide, and consequently also of oxygen. We might call it the "mechanism of breathing." Although, however, it is beautifully co-ordinated, it is not mechanism. The reasons for this conclusion are as follows. In the first place, there is no definite chain of physico-chemical causation between a certain definite hydrogen ion pressure or deficient oxygen pressure and the activity of the nerve-centre in the brain. If we ask why the centre should act more vigorously or become quiescent according as the hydrogen ion pressure rises or falls to an extent so minute that it can hardly be detected by physical or chemical means, there is no physical or chemical answer. In the second place, the reaction, and with it the structure of all the tissues concerned in giving effect to the reaction, and in exciting it in a normal manner, remain constant day after day and year after year, in spite of the extreme lability of the living structures concerned. They are evidently maintained actively, and they have developed actively with the organism itself. It is the old story: we have discovered highly co-ordinated activity; but if we attribute the co-ordination to complexity of structure, then we are at once faced by the question how this complex structure is maintained, and by what mechanism it has been developed from a germ in which it was not present.

The co-ordinated behaviour and co-ordinated structure cannot be expressed in terms of an essentially chaotic physico-chemical world: they are just a part of Nature, as Hippocrates taught. Though inorganic Nature may appear to us through Newtonian spectacles as if she were chaotic, these spectacles blur our vision when we study biological phenomena, so that we do not see what are otherwise evident facts.

Let me take another instance—that of the process of acclimatization—from the physiology of respiration. At a low barometric pressure, such as exists at high altitudes, the concentration of oxygen molecules, and consequently the pressure which they exercise, is diminished. Other things being equal, the partial pressure of oxygen in the lung alveoli, and consequently in the arterial blood, tends to fall to a still greater relative extent. The natural response is excitation of the respiratory nerve-centres and increase of the breathing; but, as was pointed out in the third lecture, anything like a full response in this direction is for some time prevented, owing to the fact that if the breathing, or the rate of circulation, is increased, the pressure of carbon dioxide becomes lowered, which tends to diminish the breathing and circulation by lowering the hydrogen ion concentration of the blood. To this lowering, however, the kidneys respond in the normal manner by gradually excreting alkali, so that, as the man becomes acclimatized, a nearly full respiratory response to the lowered oxygen pressure becomes possible, and the breathing can become considerably increased.

At the same time there is another gradual response, discovered many years ago. The percentage of haemoglobin in the blood is increased, and this tends to diminish the fall in oxygen pressure which would otherwise occur in the systemic capillaries. As has quite recently been shown very clearly by Argyll Campbell,[1] the percentage of haemoglobin in the blood goes up and down in inverse proportion to the oxygen pressure in the arterial blood. Both this reaction, and the change in blood composition owing to excretion of alkali, show how closely the composition of the blood and the formation or elimination of its constituents are co-ordinated with the breathing.

Another and very interesting physiological reaction occurs during acclimatization. Between the air of the lung alveoli and the blood passing through the lungs there is a very delicate layer of living cells; and the question arose whether, in acclimatization to high altitudes, or under other conditions, this delicate layer takes any active part in driving oxygen inwards into

[1] Argyll Campbell, *Journ. of Physiol.*, vol. lxii., p. 211.

the blood, or simply acts mechanically, like a non-living moist membrane, so that the oxygen passes in by simple diffusion. I had discovered a method of investigating this difficult question quantitatively; and one answer which our experiments gave was that during rest under normal conditions at anywhere near normal barometric pressure the mean oxygen pressure is exactly the same in the blood leaving the alveoli as in the alveolar air. There is thus no evidence of active secretion under normal resting conditions, and the intake of oxygen is apparently by simple diffusion. We can thus interpret the process as a mere mechanical one, though of course there is no mechanical explanation of how the amazingly delicate and highly co-ordinated structure of the lungs is maintained and developed.

After acclimatization at very high altitudes, however, as well as during muscular exertion and under conditions where symptoms of want of oxygen are produced, as in carbon monoxide poisoning, we found that the mean oxygen pressure of the blood leaving the alveoli is, during rest, very considerably above that in the alveolar air. Thus in the state of acclimatization the oxygen is pushed or secreted inwards actively, just as occurs in the case of the swim-bladder of deep-sea fishes, where the oxygen pressure inside the swim-bladder may be six hundred times that in the sea-water. Many of our experiments were performed after acclimatization on the summit of Pike's Peak in the Rocky Mountains, at a height of 14,100 feet. Apart from the existence of this active secretion along with the other changes already referred to, it seems quite impossible to explain the phenomena of acclimatization.[1]

The facts relating to acclimatization are very striking, and this has been greatly emphasized by the experiences of the recent Mount Everest expeditions. If a sedentary person living at about sea-level is rapidly transferred in a steel chamber to a barometric pressure corresponding to about 12,000 to 14,000 feet, and left there for a considerable time, nervous symptoms of a most formidable character, known as mountain sickness, show themselves, and may very seriously threaten life. That they are due simply to the diminished oxygen pressure of the air was shown clearly, about fifty years ago, by the French physiologist Paul Bert. But if the transition is gradual, or in not more than moderate steps over a considerable time, no symptoms at all are produced, or any symptoms which show themselves are quickly recovered from. This may hold good, as the Mount Everest experience showed, up to a height of at least 27,000 feet; whereas an unacclimatized person going rapidly to a similarly low barometric pressure in a steel chamber or balloon becomes soon unconscious, and would certainly die if left in the rarefied air.

It is known that during acclimatization the bone-marrow in which the red corpuscles and haemoglobin of the blood are developed becomes hypertrophied. Reasoning from analogy, we may also feel confident

[1] Several physiologists have brought forward evidence which they regarded as contradicting these conclusions. My reasons for disagreeing with them are stated in an article which appeared in *Physiological Reviews*, 1927.

that a corresponding change occurs in the nervous and muscular tissues which are concerned in the increased breathing at high altitudes, and in the cells, probably of the lung capillaries, which are concerned in the secretion of oxygen. Thus not merely activity, but also living structure, is concerned in the acclimatization. This is so because life is maintained as a whole which is realized no less in structure than in activity; life is, in fact, just life.

The phenomena of acclimatization to a low oxygen pressure in the air are typical of endless other phenomena met with in the maintenance of life. The development of what is known as a condition of good physical training is another instance, as also is the development of acclimatization to heat—a subject which has interested me greatly. A very striking instance is the development of immunity. Pasteur, who, it seems to me, was a very great biologist though he was not trained as a biologist, rightly read the biological lesson of Jenner's discovery as to vaccination, and of the familiar fact that immunity from an infectious disease follows on recovery from it. This suggested to him the methods by which he was able to produce immunity, first to anthrax infection, and then to hydrophobia. The production of immunity to infection is on all-fours with the production of immunity to mountain sickness.

It is of the essence of our ordinary conception of life that it is an active manifestation of specific structure and activity. An organism therefore gets "acclimatized" or "accustomed" to what seems to stand in its way, and "heals" or reproduces its structure.

In all normal physiological activities, including even the twitch of a muscle or the passage of a nerve impulse, there is a recuperative process or stage as well as a process or stage of disturbance, however short or long a time these processes or stages may last. The recuperative process tends to limit or resist the disturbance, and to become more powerful the greater or more frequent the disturbance, so that living structure grows and develops with use.

We can contrast the physiological behaviour of a man at a high altitude with the behaviour of an ordinary petrol engine. Whether we take the engine up very slowly or quickly it becomes more feeble as the height increases, since the mass of oxygen taken in at each stroke becomes less and less. The engine never becomes acclimatized. If we wish to make it work normally in the rarefied air we must so arrange that the air is compressed to about normal atmospheric pressure before it enters the carburettor; but the engine does not arrange this for itself. Neither does it repair itself when it is worn or injured: it is a machine and not a living organism.

In endeavouring to interpret living organisms as machines the mechanistic physiology which we have inherited from last century has distorted our ordinary observation and directed attention away from obvious facts. This physiology has thus failed to give to scientific medicine the help which it ought to give, since it has nothing coherent to say about the coordination which is the distinguishing feature of life, or about the natural processes of resistance to disturbance and recovery from it. Consequently it throws no light on the manner in which the resistance and recovery are naturally carried out and can be aided by art. These subjects are necessarily ignored, because they are incapable of being stated in terms of the mechanistic interpretation. The body is treated as if it were simply an extremely complex and delicate piece of molecular machinery—so delicate and complex that it seems hopeless for us to interfere when it has gone out of order. Not this interpretation and attitude, but the interpretation and attitude which Hippocrates indicated, has been justified by the progress of scientific medicine.

It is upon what we can actually observe that we must base our conception of life and our scientific treatment of it; and the co-ordination of the structure and activity which we observe in the life of an organism is evidently of its very essence. The whole is alike in the parts and their influence on one another, including the influence of environment; and this is how we perceive and understand living organisms when we perceive and understand them as alive. It seems to me that once for all we must firmly take up the position that for biology the Newtonian "philosophy" is an impossible scientific basis, since it does not correspond with what is visible and tangible in the organic world.

I have maintained this position as consistently as I could for many years. In a presidential address which I delivered before the physiological section of the British Association in 1908 my conclusion was "that in physiology, and biology generally, we are dealing with phenomena which, so far as our present knowledge goes, not only differ in complexity, but differ in kind, from physical and chemical phenomena; and that the fundamental working hypothesis of physiology must differ correspondingly from those of physics and chemistry. That a meeting-point between biology and the physical sciences may at some time be found, there is no reason to doubt. But we may confidently predict that if that meeting-point is found, and one of the two sciences is swallowed up, that one will not be biology."

When I wrote these words I could see no indication of a meeting-point being actually discovered. The new ideas which have recently been altering the fundamental aspect of the physical world had not yet taken very definite shape. It had not yet become clear that the Newtonian "philosophy" can no longer be regarded from the purely physical standpoint as representing a satisfactory fundamental working hypothesis in its application to inorganic phenomena. The outlook is now very different, as I indicated in the first lecture. The fundamental ideas of physicists seem to be approximating to biological ideas; and at any rate there is no longer any apparent sharp clash between fundamental physical observations and fundamental biological conceptions. The Newtonian conception, enormously useful as it actually is and seems likely to continue, is no longer a "philosophical" conception for physicists.

At the end of his discussion of the physically mysterious co-ordination which shows itself in organic and conscious behaviour, Waterston wrote eighty-five years ago that "we are led to expect that if molecular philosophy is ever destined to advance into the region of organization the phenomena of perceptive consciousness will admit of being applied to illustrate the physical aspect of the elementary powers of matter." [1] There was something prophetic in this remark.

If we ask Nature to reveal the mechanisms of life—for instance the mechanisms of respiration, secretion, circulation, vision, growth, or heredity—we are in reality endeavouring to distort her by the form of the question we are putting. She simply refuses to be distorted, and treats the question as a foolish one, to which there is no answer.

The very nomenclature of biology embodies the conception that life, in whatever form it may occur, occurs as a specific whole, in which the parts and actions are essentially related to one another, and cannot be isolated without destroying their nature. The working hypothesis of biology is that this wholeness exists, and this working hypothesis has carried biology forward just as successfully as the Newtonian conception has carried the physical sciences forward. Biologists are, and always have been, progressively tracing the specific co-ordination which shows itself in the structure, activities, and environment of living organisms. This co-ordination cannot be expressed in terms of ordinary physical and chemical conceptions. For this reason biology must be regarded as a distinct science or group of sciences. A biologist interprets his observations in a different manner from that of a physicist. This, of course, raises a philosophical question, which, however, must be postponed until the second course of lectures is reached.

[1] *Collected Scientific Papers,* 1928, p. 46.

LECTURE VI

PSYCHOLOGY AND BIOLOGY

IN the previous lectures I have treated the phenomena of life just as if they had no relation to consciousness. So far as our direct means of judging go, most of the detailed phenomena occurring in the lives of animals and plants have no direct relation to consciousness, and it would only cause confusion if we tried to read consciousness into them. As, however, I have attempted to show, we can build up a useful, and at least fairly consistent, body of scientific knowledge with regard to life without taking conscious behaviour into account, just as we can build up a useful and at least fairly consistent body of scientific knowledge of what we call Inorganic Nature, without taking either life or conscious behaviour into account. It is now necessary, however, to consider conscious behaviour and what it implies.

As was so strongly emphasized by Johannes Müller, the behaviour of what we regard as an unconscious living organism is "blind." What this means is that the behaviour displays no exercise of foresight or retrospect. To express the same thing otherwise, it displays no evidence of directly "learning" from experience. The organism maintains and reproduces its structure and activity as an organized whole; but assuming this, each step in its behaviour is an immediate response to the conditions existing at the moment. The response, it is true, is organic response, in which organic wholeness and persistence is manifested.

None the less its immediateness or blindness seems to be equally evident. It is because of this immediateness or blindness that we do not attribute consciousness to the behaviour of a plant, or to that of the individual organs or cells in our own bodies. It is also because of the difficulty of distinguishing, in lower organisms, between simple organic behaviour and conscious behaviour that we are so often at a loss in trying to judge whether a lowly animal is conscious.

In the stage of embryonic development, it is true, an organism almost seems as if it were consciously reaching out towards the realization of an ideal. The steps in the development of an oak tree, or of a human being, seem, on the surface, to be somewhat similar to steps in the conscious realization of an ideal. But when we examine embryonic development more closely we find the same immediateness of organic response as in other cases of unconscious organic activity. The steps in development are simply immediate responses to the changes in environment of each part of the developing organism as growth proceeds. Thus the development of an imperfect embryo proceeds as far as possible, regardless of the fact that it cannot survive to maturity. This subject has already been discussed in Lectures II and IV.

What, now, is the essential difference between conscious behaviour and the " blind " immediateness of simple organic behaviour? The more I have thought about this question the more clear has it seemed to me to be that in conscious activity we have the manifestation of organic unity, not merely as regards space-relations, but also, and as an essential feature, as regards time-relations, so that the manifestation is progressive. This conclusion will, in fact, be the key-note of the present and three following lectures; and in the present lecture I shall endeavour to indicate generally the course of the argument, just as, in the first lecture, I tried to indicate generally the course of the argument in the succeeding four lectures.

Conscious behaviour has two aspects, which we can distinguish as receptive and responsive, or as perception and voluntary action. In reality, however, these two aspects are alike active, and they are inseparable. In both what we perceive and what we do, an essential controlling factor is what we call interest. We perceive things in their relation to our interest, narrow or wide; and equally we do things in our interest, narrow or wide. This is only a most ordinary statement of fact, and in particular it has no exclusive bearing on ethics or scientific observation. Even scientific observation is determined by personal interest in some form.

Now, interest implies both a past and a future. When we perceive something of interest to us we perceive it in relation to a past which is still present to us, will be present in the future, and has actively co-ordinated organic form in time as well as in space. Voluntary action is action determined with reference, not to a mere immediate present, but to an enduring organized whole of which both the past and the future are expressed in present action, so that the present is the fulfilment of the past, and the future the fulfilment of the present. Retrospect, foresight, and organization are alike expressed in both perception and voluntary action. This is what we imply when we say that in perception and voluntary action there is always expression of interest.

A conscious person is not a mere living organism the activities of which are accompanied by an impalpable something called consciousness. Perception is not mere physiological stimulation with consciousness of it superadded. Nor is voluntary action mere physiological reaction with consciousness of it superadded. In the mode of occurrence of physiological stimulation or excitation organic wholeness is certainly expressed; but in perception not merely organic wholeness but progressive continuity of interest is directly manifest in the visible and tangible form of the intelligent response. This response may be only in part immediate. The elements in it of both retrospection and anticipation, and so of progressive continuity in organic wholeness, are, however, evident; and it is impossible either to describe perception, or to reason coherently about it and about voluntary action if we neglect these elements. It is equally true, of course, that there is an element, and an essential element, of what is new, and neither anticipated, nor, so far as we can immediately judge, organically determined, in perception, just as in the purely organic phenomena of life there is always an element of what is apparently not organically determined, and is naturally described in merely physical terms of essential chaos.

It is a commonly held belief that whatever may be true of perception, mere sensation is something which exists in itself, independently of retrospect, anticipation, and organic relation to other conscious activity;

also that perception is made up of what may be called agglomerations of sensations and their traces. I hope to discuss in the next lecture the development of this belief, and its relations to the teaching of Kant. Meanwhile, however, I should like to point out, as Kant pointed out, that it is impossible either to imagine or experience sensation of this kind. Sensation has always quality, and quality has no meaning apart from the co-presence of previous sensations in contrast. Sensations are also localized, however vaguely, and this implies the spatial co-presence of other sensations. Any sensation has also within it what we may call an urge to definite action or rest: it is uncomfortable or comfortable, stimulating or restful, so that it holds within itself the future as well as the past.

We only deceive ourselves if we try to imagine separately existent sensations, or a conscious experience which is capable of being analysed into separate and independent sensations. It was the great merit of Kant that he pointed out that separate independent sensations do not exist in our experience, and that it is futile to try to build up psychology on the assumption that they exist. He was nevertheless, as it seems to me, so carried away by the Newtonian "philosophy" that in his *Critique of Pure Reason* he tried to build up psychology on the assumption that what is given in perception, and implicitly given in the simplest of sensations, is only what may be called a Newtonian world of perception, this world of perception corresponding to what Newton had taken to be a self-existent physical world. In his subsequent *Critiques,* illuminating as they are, Kant could not get away from this assumption in the *Critique of Pure Reason.* The preceding lectures imply a definite break-away, not only from the Newtonian "philosophy," but also from the limitations in Kant's account of the perceived world; and in the interpretation of conscious behaviour it seems to me that a still more definite and radical break-away is essential. In this break-away I am only following in the line of Kant's philosophical successors, and particularly Hegel.

Just as we obtain the clearest and most sharply defined biological conceptions through the study of highly developed organisms, so we can obtain the clearest psychological conceptions by the study of conscious behaviour in its most highly developed form in man. It is, therefore, round human conscious behaviour that the discussion in this and the succeeding lectures will be centred.

It is simply a fact of ordinary observation that in our perceptions and voluntary actions interest is always manifested. We set what we call values on the items of our interest, whether this interest be regarded as our mere individual interest or interest which we share with others; and our conscious actions are directed to the maintenance of these values. The values and interest are abiding and progressive, since in both the perception and maintenance of them retrospect and foresight are involved. A present perception thus contains within it perception of both the past and the future; and a present voluntary action is determined directly with reference to both the past and the future. The past and future are bound up in perception and voluntary action with the present, and grow along with it in interest and value. Hence history has constantly to be rewritten, and is constantly blossoming out into growing definition and in new directions. Hence also, our ideals for the future are constantly growing and expanding with present conscious experience, so that we are always defining the future.

It may be said that in the blind maintenance of its structure and activity an organism shows that spatial separation is an unreal thing, since the parts and activities of an organism and its immediate environment express unity and not essential separation. But in the development of interest and values separation in time, as well as in space, becomes unreal. What is past, and what is coming, seem indifferent to the mere living organism, but they are directly present in conscious behaviour, as belonging to the psychological or spiritual unity which embraces them.

The prediction which controls conscious behaviour is based directly on the presence of past experience. This presence is the presupposition of what we call memory. We can compare remembering to the reading of a written record which always opens itself at the place which our interest requires. Memory is more than a mere record which can be read or not at pleasure, and which can, like detailed memory, be blotted out by disease or accident, or through the lapse of time: for our past, whether it is definitely remembered or not, is embodied as such in our present conscious behaviour. The record may be dimmed and obscure; but what is essential in it—its import or interest—remains, and is embodied in present conscious behaviour. It is the same with national behaviour. Written records of the history of a nation may be missing or absent; but if we wish to understand the present behaviour of a nation we must attempt to understand the import of its past—the "tradition" which is embodied in that behaviour, and consequently in the behaviour of each individual born a member of it, whether or not he knows the details of its history. We mean something very real when we say metaphorically that the blood of a nation runs in our veins.

I have tried to emphasize the distinction between psychological and merely biological phenomena. The recognition of this distinction seems to me to be essential to clear thinking and successful investigation in psychology, just as the distinction between life and mechanism is essential to clear thinking and successful investigation in biology.

If we follow psychological phenomena downwards in the animal scale we seem to lose sight of them by degrees, though in all higher animals they are evident at once, and even in what we call lower animals are coming more and more into view as careful study proceeds. It is difficult to imagine how a philosopher like Descartes could have persuaded himself that animals are mere unconscious machines. His beliefs were, however, singularly robust, and often had little regard for actual observation. This was shown, for instance, by the manner in which he disregarded Harvey's observations on the mode of action of the heart, and equally disregarded the mass of patient medical observation which supported the Hippocratic conception of life. No one could now look upon highly organized animals as unconscious; but in plants, even when they are highly organized, consciousness appears to us to be absent, and in the occurrence of different species in plants we seem to find no clear evidence of progressive evolution.

A not unnatural inference is that since consciousness is absent in lower organisms and plants, as well as in the inorganic world, and since higher have been evolved from lower organisms, psychological phenomena cannot really be different in kind from biological phenomena. Nevertheless, I have just pointed out that a very essential difference in kind does, as a matter of fact, exist between the phenomena which we interpret respectively as psychological and biological; also that this difference does not simply consist in the presence or absence of an invisible and impalpable something called consciousness, but implies a difference in actual visible and tangible behaviour—a difference in what we can see and feel. In observing psychological phenomena, what we see before us and feel are not mere inorganic bodies, not mere living organisms, but persons with all around them both spatially and temporally that expresses personality. We see them and what pertains to them just as plainly as we see mere living organisms or inorganic bodies; and it seems to me that the only possible attitude to take up towards those who imagine that they can be resolved into something else is the attitude which Hippocrates took up as regards life towards the philosophical atomists of his time: we must refer back to actual observations. If, moreover, we cannot as yet discover any evidence of conscious behaviour in lower organisms, this does not prove its absence.

In what we interpret as mere life or mere physical existence there seems to us to be no trace of what we interpret as conscious behaviour. We can thus attach no meaning to the idea that conscious behaviour may simply be a development of mere life or physical existence. It has been suggested that life automatically appears when chemical synthesis of albuminous material occurs, and this material attains a certain stage of complexity in its physico-chemical relations to surrounding matter; and that similarly when life has attained a certain stage of organic complexity, conscious behaviour automatically appears. The stage of complexity has been likened to that of a constellation. I must frankly confess that to me it seems that such ideas are not clearly thought out. In fact they convey to me no meaning whatever. It is very different, however, if we conclude that in spite of superficial appearances something of conscious behaviour must in reality be present behind what appears to us as the mere blind organic behaviour of lower organisms or plants, and what appears to be the mere mechanical behaviour of the inorganic world.

To this subject I shall return in the second course of lectures; but meanwhile I wish to refer to another aspect of the psychological interpretation of our experience. In connexion with the biological interpretation I pointed out that not only does organic determination extend out into the environment of an organism, but that when apparently separate centres of life or organisms are in near contact with one another, so that their environments coincide, these lives may manifest in themselves a wider life than that which would appear in connexion with each component organism if it were separate from the rest. In the case of conscious personality we see the same thing on the psychological plane, and exemplified in a very striking manner. The interests of associated persons become a common interest. This does not mean that the common interest is merely the algebraical sum of the more or less conflicting interests of the associated persons, but that there is an extended organized interest, and a corresponding perception and voluntary activity in which this extended interest is manifested.

It is only in fellowship with one another that persons display this extended interest with its corresponding set of perceptions and voluntary actions; but of its reality and extraordinary potency there can be no doubt. Although individual interest is still distinguishable, it may be completely overborne by the common interest. Individual perception and individual conscious activity are then merged in the wider perception and conscious activity, just as in any higher organism the forms and activities of the individual cells present in it display the organic manifestations of the unified life of the whole organism.

Perhaps few things are more striking in the physiology of a higher organism than the manner in which the component cells seem ready to immolate themselves for the maintenance of the common life. Our skins are covered, for instance, by an epidermis which consists of nothing but the adherent dead bodies of millions of cells, constantly in process of dying. To take another instance, the phagocytic dust-collecting cells, whose function it is to collect and carry out up the bronchial tubes the dust-particles which enter the lungs, perish as they deliver their load of dust. Looking at this subject from a still wider standpoint, we see the individual organism constantly perishing, while the species survives, adapting itself, apparently blindly, in this process, to new conditions as they arise.

In the sphere of conscious activity we meet similar phenomena, but on a higher and far wider plane: for it is not the mere blind maintenance of a common organic unity that is concerned, but the conscious development of interest to which neither time nor space sets limitations. We have only to think of the mother who never considers her own safety when her child's life is in danger; of the miner who never thinks of his own danger when he is trying to rescue a comrade; of the soldier to whom his own life is as nothing when he is fighting his country's battles; of the naturalist whom no trouble or risk will prevent from exploring the fauna or flora of some savage country.

To conscious interest there is no limitation of either time or space. Perception reaches outwards into what, from the Newtonian standpoint, are the limitless depths of space, and inwards into what seems the almost equally limitless minuteness of atomic structure. It also reaches backwards into the depths of the Newtonian past, and forwards into the depths of the Newtonian future. When we think of what perception implies we see that in conscious behaviour we are not dealing with something which, like the behaviour of the "bodies" of the Newtonian world, can be regarded as simply existing here and now. The here and the now of conscious behaviour reach out over all other heres and nows.

We can of course treat the conscious behaviour of some particular person as if it were an event occurring at a particular time and place. But in doing so we abstract, or take away, the essence of what we are trying to describe. The perception or conscious action which we are trying to describe extends in every direction in space and in both directions in time. It is not confined to a here and now; and all that we can describe as being here and now is a rather empty abstraction.

When we consider the real nature of perception and conscious action we can easily see that they raise fundamental questions as to the validity of the Newtonian conception of physical reality; and these questions have, in fact, been raised by philosophers in forms which will be discussed in succeeding lectures. The physical world as conceived by Newton is a world which we perceive. This does not mean simply that electro-magnetic waves and other disturbances are conveyed from all parts of it to our bodies, and then produce, directly or indirectly, various sensory disturbances. What it does mean is that the electro-magnetic disturbances, their sources, and our own bodies which react to them, are, together with Newtonian space and time, in a very real sense our own interpretations and so part of ourselves. Perception reaches out over them all, and we do not get away from ourselves when we travel in thought to the farthest-away star which photography can detect in the Newtonian universe, or to the remotest past in Newtonian time.

This is the essence of what Kant pointed out in his *Critique of Pure Reason.*

In the preceding lectures I endeavoured to test the Newtonian interpretation in its application to organic phenomena, with a result which was altogether unsatisfactory. Its application to the phenomena of conscious behaviour has been found to be still more unsatisfactory in the present lecture. In fact it cannot be applied to conscious behaviour at all without first, by abstraction, mentally removing from conscious behaviour all that is really characteristic of it. In claiming that his conception of the visible and tangible universe represented reality itself, Newton, together with those who followed him, failed to realize that though this conception has been, and still is, extraordinarily useful in enabling us to predict inorganic phenomena, it nevertheless represents no more than our own hypothetical interpretation of only one aspect of what is actually present in our experience.

As was pointed out at the end of the first lecture, physicists themselves are no longer satisfied with the Newtonian conception, apart altogether from its failure when applied to the phenomena of life and conscious behaviour. They also realize that space and time cannot be regarded as independent of one another or of their contents. All this appears to be bringing physical conceptions nearer to those which are forced upon us by the consideration of conscious behaviour; but we are still in a stage of transition. Meanwhile the average civilized person of our times, confident in the practical success with which the Newtonian conception has been applied in so many directions, continues to attempt to apply it to what it cannot be applied to, and to suppose that such attempts constitute realism. Whatever else they may be, they certainly are not realism.

The psychological interpretation of our visible and tangible universe of experience is just as indispensable as the physical or biological interpretation, and in actual fact this is always conceded in practice. We do not regard one another as either walking automata or mere irresponsible living organisms; and our real reason for not doing so is simply that conscious behaviour cannot possibly be so interpreted. I have tried in this lecture to point out why this is the case, and why, therefore, those who maintain that conscious behaviour can be so interpreted are nothing but the victims of an impossible form of idealism.

LECTURE VII

ANIMISTIC PSYCHOLOGY

FROM time immemorial it has been quite evident that the behaviour of conscious persons is very different from that of things which are unconscious, or of the dead bodies of persons; and from time immemorial the belief has existed that this difference is due to the presence in the body during life of something different from the body, called by the Greeks ψυχή, or in Latin *anima,* and in English soul. Hence the origin of the modern words "psychology" and "animism," while the modern word "physiology" carries us back to the Hippocratic belief that it is of the nature (φύσις) of life to appear to us as it does. In ancient Egyptian pictorial records the soul is represented as possessing wings, so that it can fly away from or return to the body.

The distinguishing characters of conscious behaviour are thus represented as due to the presence within the body of a soul; and I must now endeavour to follow the development of this interpretation, and to consider the difficulties to which it has led. This development has proceeded side by side with, and is evidently complementary to, the development of what may be called the Newtonian conception of the physical world. We can see the general outlines of that conception in the philosophy of Democritus and other ancient literature; but not till modern times did the Newtonian conception become quite clearly defined. Not till modern times, also, did the difficulties inherent in a conception of the relation between a soul and a body become clearly defined.

From the Newtonian standpoint the reality of a physical universe corresponding to the Newtonian conception seemed unquestionable. Yet conscious behaviour, which clearly affects and is affected by this physical reality, does not seem to correspond with that of physical phenomena, so that some influence of a supernatural or "metaphysical" character must, apparently, be interfering; and to the source of this influence the name of the soul is given. The influence seems to be definitely localized in space and time within the bodies of men and animals; and the localization has seemed to be narrowed down, with the advance of physiology, to the brain. Descartes, as we have seen, thought that the so-called pineal gland, in the centre of the brain, is the seat of the soul; but the grey matter of the cerebral hemispheres has appeared to later physiologists to be its seat, if indeed there be a soul.

What, in general terms, is the evidence for this localization? We can follow what seem to be physical influences, reinforced, it may be, on their paths, from the general surface of the body, or from the internal surfaces of sense-organs such as the eyes, ears, and nose, to the cerebral hemispheres along afferent nerve-fibres. An interruption at any point along these afferent nerve-fibres causes a corresponding interruption to the transmission of the influences in question, but no interference with either transmission along other nervous paths, or intelligent conscious apprehension of or response to these influences. On the other hand, damage to the cerebral hemispheres produces the most serious results as regards conscious apprehension and response—just as if the means by which the soul enters into communication with the body had been damaged. On the efferent side we can trace outwards from the cerebral hemispheres physical influences passing to muscles along definite nervous paths; and, just as in the case of the afferent influences, any particular efferent path can be interrupted at any point without interrupting conscious efferent responses of other kinds. Thus an arm or leg, or the muscles of the eye or face, may be paralysed by interruption on an efferent path, without any paralysis of intelligent apprehension. The white matter of the brain consists of connecting nerve-fibres; only in the grey matter do we find the bodies of the nerve-cells from which the nerve-fibres emanate. Hence it is in the grey matter of the cerebral hemispheres that the seat of the soul would have to be localized, or, to use what at first sight might seem a more non-committal expression, that consciousness would have to be localized.

I should like to point out that if we accept the Newtonian conception of the physical universe there is absolutely no escape from either the assumption of a definite meeting-place and interaction between body and an invisible and impalpable soul, or a denial that there is any such thing as a soul. In the latter case, however, we must assume that a mysterious thing called consciousness is somehow produced in the cerebral hemispheres. To the majority of those who have accepted the Newtonian philosophy it has seemed that since intelligent response, and not mere sensation, is concerned, and since intelligent response seems to be something different from any physical phenomenon, there must be definite interaction between body and soul in the brain. Something, that is to say, which is not physical or chemical in its nature, and which has the character of intelligence, intervenes in the physical and chemical processes occurring in the grey matter of the brain.

Let us now try to follow out the consequences of this conclusion. One thing that clearly follows is that our perceptions of physical things are not mere patterns of the things, but are modified by our sense-organs and nervous system, so that they appear to us distinctly different from the physical objects from which they emanate. Thus things appear to us as coloured, or possessed of odour, or as either hot or cold, dark or bright. They also appear pleasant or unpleasant, beautiful or ugly. But these can only be our subjective impressions of them. We can alter the apparent colours of things by altering the apparent colours of surrounding objects, and similarly we can make things appear bright or dark, warm or cool, by contrast; we can also produce impressions of light by mere pressure on the retina or optic nerve; and in many other ways it is evident that our perceptions can only represent greatly modified pictures of physical reality. Locke gave form to this distinction when he distinguished between the primary and secondary qualities of things, the primary being in physical objects themselves, and the secondary being qualities added in the process of perception and not inherent in the actual objects perceived.

This seems easily enough intelligible on the Newtonian conception of physical reality, and not to involve any serious modification of that conception. But, as Bishop Berkeley in particular pointed out, we cannot stop at the distinction between the primary and secondary qualities of things. All that we can directly perceive consists of the impressions produced on our souls. It can only be by interpreting these impressions that we reach the conception of a physical world around us. In an impression itself there can be nothing that tells us anything about its source in a physical world. All that we can learn from impressions is how they are grouped together; and this we can only learn from actual experience. From that experience we learn that when we experience one impression we may expect to experience also certain others; but we are not justified in inferring the existence of things outside us to correspond with the groups.

Hume carried this reasoning still further, pointing out that, just as we cannot justifiably infer the existence of a physical world, so we cannot justifiably infer the existence of a perceiving soul. All that we can really know about are the impressions or sensations, and the manner in which they are usually associated with one another and thus come to suggest one another as they actually do in the process of perception.

When we consider the reasoning of Berkeley and Hume we can easily see that it is the logical development of the Newtonian conception, when the attempt is made to apply this conception in the interpretation of the phenomena of perception. The Newtonian conception was far too valuable as a practical working hypothesis for anyone with a grain of common sense not to go on using it in practice; and as an actual fact the world so continued to use it, regardless of the sceptical conclusions of Berkeley and Hume, which had not the slightest effect on the development of physical science on Newtonian lines during the succeeding century and a half. The fact remained, however, that it could not be extended to the phenomena of perception and conscious behaviour on the ordinary assumption that it is a soul which, by perceiving the physical world around it, guides conscious behaviour. A new conception was therefore needed of the relation between perception and the physical world. This new conception was furnished by Immanuel Kant near the end of the eighteenth century. The more I have considered this new conception, the more fundamental in importance does the step which Kant took appear to me to have been.

What he saw was that mere unconnected sensations are purely imaginary entities which do not exist. In other words, each distinguishable element in perception has what we call meaning attached to it. Every element in conscious experience contains within itself the reference to other elements, and however much we may try to simplify any element of conscious experience, we find this reference still present, in however imperfectly defined a form. Thus each element refers itself to other elements as qualitatively different from them, and as arranged both after some of them in order of time, and simultaneously with others in order of space. It also refers to others as possessing qualitative identity with itself, but quantitative difference; also refers to them as being causally connected, this connexion implying substances which are acting or being acted on. Kant, in fact, saw that the Newtonian conception of the physical world, including time and space, is in reality implied in the simplest conscious perception, and so cannot be derived from simple sensations, as Berkeley and Hume had supposed. In other words, the association of sensations with one another in the form of a physically ordered experience is part of their very being.

He drew the conclusion that our minds are such that they arrange what would otherwise be formless data into the forms of what is practically the Newtonian interpretation of experience, thus giving these data definite articulation and physical order. These forms are the order of space and time, and the other general conceptions or "categories" which we make use of in interpreting the physical world. The Newtonian world is thus not a world of self-existent things, or self-existent space and time, but a subjectively interpreted world which we project outwards in the process of perception, at the same time giving it the form of the Newtonian world. Thus for Kant time, space, and the matter and energy of the physical world, are not real in themselves, but only projections outwards by our minds. The same is, of course, also true of our own bodies; and the perceived world seems to be the same to all men, or to have objective existence, because the forms are the same for all men, giving the perceived world its logical structure.

Behind this world of perception there was, for Kant, a real world of things in themselves. Apart from this assumption, his philosophy would seem to imply that we made the world of perception by the mere act of perceiving it. This is certainly not consistent with our experience. We cannot predict or deduce in any way the details of the physical universe. All we might be able to say of it would be that its appearance as perceived will be consistent with the Newtonian conception. On Kant's interpretation of perception it *must* be.

Kant's immediate philosophical successors, and particularly Hegel, who was the greatest of them, pointed out that the "things-in-themselves" of Kant's conception are nothing but the ghosts of the Newtonian physical reality. We have no evidence of their existence as "things-in-themselves," any more than of the Newtonian things-in-themselves. Hegel also pointed out that the Kantian general conceptions or categories are incomplete, since we perceive not merely physically interpreted existence, but also existence, such as that of life or of conscious activity, in which the whole is essentially present in each of the parts and actions, so that mere physical interpretation of this existence is impossible. For Hegel the world of Nature seemed to present an embodiment of different categories, from the most empty, abstract, and unarticulated, like mere existence, to the fullest and most articulated, like human behaviour as manifested in history and social life. He also insisted that these categories are essentially related to, or implied in, one another. To the question, however, why the embodiments of these categories should be, as it were, scattered abroad throughout our experience, there is no really satisfactory answer in the Hegelian philosophy; and I do not think that Kant himself would ever have felt satisfied with this philosophy.

To the Hegelian philosophy as a whole I shall return in the second course of the lectures; but meanwhile we must follow out the development of conceptions as to a relation between soul and body. For Kant the experimental investigation of any such relation was impossible, since all that we can actually perceive is necessarily interpreted mechanically as part of a Newtonian world, while the soul belongs to a real world of things-in-themselves, which real world cannot be perceived. Conscious behaviour, as well as organic behaviour, is thus necessarily interpreted by us mechanically, in accordance with Newtonian principles. So far, therefore, as scientific investigation is concerned, the Kantian philosophy is as mechanistic as that of Democritus, and much more mechanistic than that of Newton, since Newton never questioned the intervention of supernatural influences in the physical world, or the possibility of actually observing the results of this intervention, as for instance in voluntary human behaviour, or in the occurrence of miracles. Kant's philosophy is also inconsistent with the scientific attitude of Hippocrates, a development of which is the attitude which I have taken up towards biology in the first five lectures. The Kantian attitude towards the scientific interpretation of all that we can perceive of conscious behaviour seems, therefore, to be the mechanistic attitude; and as such it will be discussed in the next lecture, though Kant had re-established the mechanistic conception in an entirely renovated form.

On the other hand, the attitude of Hegel and Kant's other immediate successors was essentially animistic and vitalistic. I think, however, that it may be truly said that their philosophy had, outside Germany, very little influence in shaping ideas as to either the relation of soul to body or the relation of the "vital principle" to the bodies of animals and plants. In Germany itself the influence of what was called the "Philosophy of Nature" was only a passing one. This philosophy seemed to add nothing substantial to ideas already current, and led to various very empty theories; but at least it helped to support or re-establish animism and vitalism, which the Kantian philosophy seemed to be inconsistent with. Whether the world as perceived is an ideal construction or not, and even if it is the case that in the perception of conscious behaviour there is a different ideal construction from that in the perception of physical and merely organic phenomena, the question as to the relation between psychical and physical phenomena still remained.

With the advance of physiological and medical knowledge it seemed to become more and more evident that all the phenomena of conscious behaviour are dependent on the influence of what was admitted to be, or was interpreted as, the physical environment or mere physiological conditions in the conscious organism. In the early part of last century this was not by any means as evident as it has now become. One discovery after another has revealed what are naturally interpreted as abnormal physical or physiological conditions on which both mental and moral failure depend; and with this revelation has come the corresponding revelation that normal conscious behaviour depends, down to the minutest detail, on what are interpreted as the physical and physiological conditions of hereditary transmission. These are hard facts of observation, and cannot be ignored now, though at a time when few of them were known their full significance was not realized, and it still seemed possible to adhere to the conception of a physical body, with an essentially independent soul to guide it. In the next lecture I shall discuss these facts more fully.

The supposed independent soul has turned out to be something which is dependent in every respect on the supposed physical body and environment. We cannot possibly separate their influences. If we start with the provisional assumption that there is a physical or biological living body, with an independent soul to guide it, the facts lead us inevitably to a correction of this assumption. Body and soul cannot be separated from one another as independent entities. The conception of soul must either include within itself the body and the physical environment, or the conception of body and physical environment must include within itself the phenomena provisionally attributed to interference by the soul.

It is to the former solution that the reasoning sketched out in the previous lecture points; but we must explore the latter solution, which will be done in the next lecture. Meanwhile I wish to leave no doubt or ambiguity about the conclusion reached in this lecture. The conclusion is that we can no longer uphold the animistic conception of a physical body guided—in other words, interfered with—by an independently existing soul. Such a conception would amount to a denial of the full validity of the law of conservation of energy; but this in itself seems to me a trifling matter, since a physical " law " is only a formula in which we summarize our observations. If the observations pointed to an exception to the law, we should just have to accept it as an exception. The objections to the animistic conception go far deeper than our natural reluctance to admit any exception to a well-established law. These objections depend on the fact that the observed phenomena are not consistent with the conception of a soul independent of bodily existence. I am perfectly at one with the most thoroughgoing materialists on this point, though not at all at one with them as to further points.

It seems to me that animism is a counterpart to Newtonian realism and the vaguer representations of it in the days before Galileo and Newton. Conscious behaviour is apparently so different in kind from the behaviour of physical bodies that it seemed necessary to postulate the existence in the body of a soul which interferes with physical processes. Newton was far too good a physicist not to see the need of this counterpart to his physical philosophy; and the common sense of the majority of mankind has been with him and other physicists in this respect. It is only on a wide philosophical view of our experience that it turns out that the Newtonian conception, whether in its original form or in the renovated form given to it by Kant, is inconsistent with the conception of a soul which can be regarded as independent of the body. If we accept the Newtonian conception as part of a philosophical conception of our universe, the observed facts are bound to lead us on to the conclusion that all psychical phenomena are mechanically determined, so that there is no such thing as an independent soul. And if it is nothing but common sense to accept as philosophical the Newtonian conception, then after we have examined the facts revealed by physiological and medical investigation it seems to be nothing but common sense to accept what is commonly called materialism, and to reject entirely the hypothesis of an independent soul.

This is why so many earnestly minded persons have become, and are becoming, materialists. No amount of mere personal authority, whether theological, ecclesiastical, scientific, or State authority, will in the end avail against this trend. It is a trend among persons who are honestly and sincerely striving after the truth, and to whom that striving is part of their religion—part, as I shall endeavour to point out later, of the most powerful influence which determines human behaviour. It may be that, on the whole, materialism makes for personal unhappiness and social disorder; but this also, if it be a fact, will not avail. The only thing that could avail is the result of a perfectly free and open discussion of all the evidence bearing on the subject.

In the present lecture I have discussed the animistic conception of conscious behaviour, and tried to point out its essential defects. The next lecture will include a discussion of the mechanistic, or what is usually called the materialistic conception. Meanwhile, however, I may perhaps again point out that animism—the conception of a soul essentially independent of the body—is only a counterpart to the Newtonian conception of what is visible and tangible. It was not to animism, but to a complete denial of the possibility of interpreting by Newtonian conceptions the visible and tangible phenomena of conscious behaviour, including the whole of our experience in perception, that the discussion in the last lecture pointed.

LECTURE VIII

MECHANISTIC AND BIOLOGICAL PSYCHOLOGY

MECHANISTIC interpretations of conscious behaviour do not seem to have been either so ancient or at any time so widespread as animistic interpretations. Yet we find a mechanistic interpretation outlined clearly in the philosophy of Democritus, side by side with a similar interpretation of the inorganic world. Sometimes, also, the animistic conception of the soul has gone so far in conferring upon it material attributes that it is somewhat hard to distinguish the animistic from a mechanistic interpretation; or conversely the mechanistic has come rather near to an animistic interpretation.

In mediaeval and modern times mechanistic interpretations of conscious behaviour have been to a large extent suppressed or driven below the surface by ecclesiastical or State authority. The mechanistic interpretations were commonly associated with atheism; but this was by no means always the case. Some forms of theology have, at any rate, come very close to mechanistic interpretation in their deterministic conception of human behaviour; and even the very orthodox Dr. Paley, in presenting the conception of God as the great Artificer, came pretty near to a mechanistic interpretation.

When we read the *De Homine* of Descartes we cannot but be struck with how close he had come in this particular book to a mechanistic interpretation of conscious behaviour, though other writings of his were quite inconsistent with such an interpretation. If we assumed that the mechanical processes by which the "animal spirit" was supposed to be separated off in the brain, and the valves to be opened on suitable occasions, were accompanied, but in no way affected, by consciousness, we should have a mechanistic conception of conscious behaviour.

In the eighteenth century we find in France, just before and during the period of the Revolution, a full-blown mechanistic conception in the writings of La Mettrie and others; and since then this conception has become more and more popularized. Among the influences which have contributed to this popularization we may count the waning influence of orthodox theology under the stress of historical and other criticism, the mechanistic movement in biology, the emergence of a belief in evolution, and the great practical successes which have resulted from the applications of physical and chemical science to the uses of mankind. These successes have by themselves produced a popular vogue among credulous persons for mechanistic interpretations.

On the philosophical side mechanistic interpretation could lean for support on the philosophy of Kant. If, owing to the nature of our perceptive faculties, it is impossible for us to perceive anything but phenomena capable of physical and chemical interpretation, it follows at once that all our interpretations of visible and tangible conscious behaviour must be mechanistic. This was in fact the position taken up by Lange in his *History of Materialism.*

If animism is the counterpart to the Newtonian conception of visible and tangible reality, it is equally true that a mechanistic conception of conscious behaviour is a natural revolt from animism. The mechanistic interpretation of conscious behaviour appears at its strongest and best when it is pitted against animism, just as the mechanistic interpretation of life appears at its best when it is pitted against vitalism.

Let us try to see what the mechanistic interpretation, as commonly applied, amounts to. In the first place, it makes no attempt to give any physico-chemical explanation of the fact of consciousness. It simply treats consciousness as a completely mysterious accompaniment of physiological phenomena which occur in the central nervous systems of higher animals. Any physico-chemical explanation of this accompaniment is expressly disclaimed. It is true that one enthusiastic mechanist affirmed, early last century, that the brain secretes consciousness, just as the liver secretes bile. Bile is, however, something visible and tangible, while mere consciousness (treated as an accompaniment of material activity) is not. Hence there is not, so far as we know, any meaning in saying that the brain secretes consciousness, nor is any such assertion needed for the mechanistic interpretation of conscious behaviour.

This point being made clear, it is easy to understand the basis of the mechanistic interpretation. That basis is the now easily demonstrable fact that every element which we can distinguish in conscious behaviour is dependent on what are ordinarily regarded as physiological or physical conditions. In the previous lecture I have already referred to this fact; but perhaps some expansion of the evidence for it may be added at this point. Let us first consider some of the conditions on which consciousness and rational behaviour depend.

Consciousness and the power of voluntary movement are immediately lost in man if the supply of arterial blood to the brain is cut off, as when the heart ceases to beat or a serious wound in the neck or chest allows the arterial blood to escape. Immediate fainting is rapidly followed by death if the blood supply is not restored. An exactly similar result follows if the blood supplied by the heart to the brain is not oxygenated. We have only to take three or four deep breaths of pure nitrogen or hydrogen (so as to wash out nearly all the oxygen in the lungs and in the venous blood normally returning to them) in order to produce complete loss of consciousness and paralysis of voluntary movement. If the oxygen supply to the lungs is now restored again immediately, consciousness and power of voluntary movement are again restored as rapidly as they were lost. The disappearance and reappearance of consciousness are just like the extinction of a piece of flaming and glowing coal when it is placed in pure nitrogen, and its relighting when it is restored to air before it has lost too much of its heat.

If now, instead of completely cutting off the supply of oxygen to the lungs, we gradually reduce the proportion of oxygen in the air breathed to a little less than half, we produce a marked deterioration in mental powers. The senses become dimmed, and what are ordinarily painful stimuli, such as those produced by a burn, may not be noticed at all. Power of memory of anything happening at the time is greatly impaired; behaviour becomes incoherent and irresponsible; and power of co-ordinated muscular movement is markedly diminished. It is thus quite evident that conscious behaviour of a normal kind depends very directly and immediately on a normal supply of oxygen to the brain.

But this is only one of a host of conditions which are now known to determine conscious behaviour. The oxygen supply to the brain is particularly open to exact investigation, thanks largely to the facts that it can so easily be interfered with, and that impairment in the normal saturation of the arterial blood with oxygen is accompanied by a striking change in its colour; but the regulated supply of other components of the blood, and so far as we know of every normal component except gaseous nitrogen, is, in the long run equally important, directly or indirectly, in the maintenance of conscious behaviour. Some of these components are present only in excessively minute proportion, and yet this minute proportion must be maintained. For instance, an increase of about 1 in 20,000 million parts in the proportion by weight of ionized hydrogen present in the brain appears to be sufficient to produce loss of consciousness.

Minute proportions of specific substances produced in other organs than the brain are now known to play an essential part in determining normal behaviour. Perhaps the classical instance of this is the specific iodine-containing substance formed in the thyroid gland and quite recently synthesized artificially outside the body. The absence or insufficient supply of this substance leads to a well-known form of idiocy. We can on general grounds be quite certain that the maintenance of normal cerebral structure and normal conscious behaviour depends on a supply of all sorts of substances brought by the blood to the brain from all other organs of the body, as well as from the external environment.

Equally important for conscious behaviour is the proper maintenance of the energy, potential or kinetic, reaching the brain. Heat is one form of kinetic energy; and if the temperature of the brain becomes too low or too high, conscious behaviour is impaired or annulled: nor can it be maintained without a proper supply of the potential energy contained in the food material and oxygen reaching it. If, moreover, the energy reaching it in the form of afferent stimuli from all parts of the body is not properly regulated, conscious behaviour becomes impaired. Every voluntary movement is guided to a greater or less extent by afferent stimuli from all parts of the body, including organs of the special senses and the semi-circular canals.

If now we consider the origin of the brain itself and of its characteristic behaviour in conscious experience, we find that both structure and behaviour are inherited from previous generations through germinal elements which exhibit no signs of consciousness. We can trace this inheritance backwards towards lower forms of life, and by inference to what we call inorganic material. Thus in every direction there is, it may be argued, the clearest evidence in favour of a physico-chemical determination, and consequent mechanistic interpretation, of conscious behaviour.

In previous lectures I have already, to some extent, discussed and rejected the mechanistic conclusions. The evidence only seems convincing if we make the initial assumption that the Newtonian interpretation of visible and tangible reality represents that reality satisfactorily, so that when, for instance, we speak in the Newtonian sense of matter and energy, time and space, our concepts of them correspond with reality. This correspondence was, we found, assumed by both mechanists and vitalists in the interpretation of mere life, and is assumed by both mechanists and animists in the case of conscious activity. The difficulties into which the assumption leads have already been discussed in the case of life. Let us now consider the difficulties into which the assumption leads in the case of conscious behaviour.

The conception of the soul is a conception, as we have seen, devised to account for the outstanding fact that each element in conscious behaviour expresses itself as belonging to a whole. As has also been pointed out in Lecture VI, the wholeness of conscious behaviour is limited neither in space nor in time. If, in all innocence, we treat its elements as existing separately from one another without a "meaning" which binds them together, we have simply ignored what is characteristic of them. What we interpret as the action of molecules of oxygen on the brain substance is a separate event in space and time, as is the response of what we interpret as the brain substance. No process of addition of such separate events will ever afford us the remotest conception of what we see and experience when we see and experience conscious behaviour. We certainly see something when we see a living body with all the signs of conscious behaviour absent in a person who breathes pure nitrogen for a short time, or when we see a dead body; and we can interpret the perception of the dead body fairly satisfactorily by means of mechanistic conceptions corresponding to the Newtonian "philosophy." But we cannot connect the something which we seem to see with what we seemed to see in the conscious behaviour of the person. We are tempted to join up our broken experience by saying either that there is a soul that has left the body temporarily or permanently or has become paralysed in some way, or else that there is really no such thing as a soul, but only a brain of which the normal activity is accompanied by an impalpable something called consciousness.

It is the latter alternative which I am considering in the present lecture, after rejecting the first alternative in the previous lecture. The second alternative is in every way as unsatisfactory as the first. Let there be no mistake. The difficulty does not concern an invisible and impalpable something called consciousness. If this were all the source of difficulty we could regard consciousness as an imponderable secretion, or as an impalpable accompaniment of all physical action. The difficulty concerns visible and palpable conscious *behaviour*. This behaviour is utterly different in kind from what we interpret as the behaviour of oxygen molecules and brain substance. The molecules, as we interpret their behaviour, do not act as part of a whole which extends over its spatial relations; nor do their actions represent a whole which expresses progressive continuity in its time-relations. Their behaviour as actually interpreted in accordance with physical principles thus throws no light at all on conscious behaviour. To suppose that it does is simply to ignore the character of the phenomena under discussion, and is thus very bad science.

We are, therefore, if we insist in adhering to the Newtonian conception of visible and tangible reality, buffeted backwards and forwards between animism and a mechanistic interpretation. Neither interpretation corresponds with our experience nor is in any way satisfactory as a scientific working hypothesis in the interpretation of conscious behaviour, though either hypothesis may be used so long as we do not attempt to come to close quarters with what we are observing. If, however, we adopt the animistic hypothesis, we seem to leave the field clear for the application of the Newtonian conception to all that is outside the immediate influence of the soul or the vital principle, and to have comfortably shelved the difficulties which arise over mechanistic interpretations of conscious behaviour and life. It was thus very natural for Newton himself, as it has been for most physicists and chemists, to accept animism. At the present time, owing to the completely mistaken impressions which are prevalent as to the practical success of mechanistic interpretations of mere life, the tendency is rather to accept the mechanistic interpretation of conscious behaviour, or at least to suspect that it is probably correct. When, however, we come to close quarters with the mechanistic interpretation, it turns out to be totally unsatisfactory, since it simply ignores the character of what has to be interpreted.

Intermediate between mechanistic and animistic interpretations of conscious experience there is another mode of interpretation, which I shall call the biological interpretation. This is represented to some extent in the writings of Leibnitz, Bergson, and other philosophical and scientific authors; but I think that it has been given by far its most developed and clear-cut form in the remarkable recently published book by General Smuts on *Holism and Evolution.* In this book it is pointed out quite clearly that mechanistic interpretations of life are inconsistent with observation of life, owing to the fact that in the life of an organism the details of structure and activity express the existence of a whole, apart from which these details cannot be either described or understood. Throughout the book the treatment of Reality is made consistent with the fact that the existence of wholes is discernible, not merely in connexion with life, but also, though to a less developed extent, in the inorganic world, and by far most clearly of all in human personality.

It seems to me that the great advance in this book is that for an unintelligible *élan vital* or unconscious mind there is substituted an intelligible conception of a wholeness which is present in various stages of realization throughout the universe, though at first sight it appears on superficial examination to be absent in the inorganic world, with the result that the inorganic world appears to be mechanically determined, in accordance with Newton's conception. The fundamental significance of the newer conceptions in physics is clearly pointed out in this reference.

The book is so much in accord with the conception of life as developed in the first five lectures of this course, and less fully in previous writings of my own, that I am sorry not to be in agreement with part of its conclusions. The point of difference is in General Smuts's treatment of personality. His book is written from the standpoint of organic evolution as a process of separable events, and he treats the evolution of personality as a similar process, continuous with the evolution of less highly developed wholes, as seen in the inorganic and lower organic worlds. This treatment seems to him to be necessary.

" Where," he asks, " was the Spirit when the warm Silurian seas covered the face of the earth, and the lower types of fishes and marine creatures still formed the crest of the evolutionary wave? Or going still further back, where was the Spirit when in the pre-Cambrian system of the globe the first convulsive movements threw up the early mountains which have now entirely disappeared from the face of the earth, and when the living forms, if any, were of so low a type that none have been deciphered yet in the geological record? Where was the Spirit when the Solar System itself was still a diffuse fiery nebula? The evolutionary facts of Science are beyond dispute, and they support the view of the earth as existing millions of years before ever the psychical or spiritual order had arisen; and what is true of the earth may be similarly true of the universe as a whole. The fact that we have to grasp firmly in connexion with creative Evolution is that, while the spiritual or psychical factor is a real element in the universe, it is a comparatively recent arrival in the evolutionary order of things; that the universe existed untold millions of years before its arrival; and that it is just as wrong for Idealism to deny the world before the arrival of Spirit, as it is for Naturalism to deny Spirit when eventually it did appear in the world."

It seems to me that in putting these questions and arguing in this way, General Smuts has forgotten a previous question which was put by Kant, himself the author of a nebular theory of the origin of the solar system. That previous question concerned the nature of time. From an analysis of conscious experience he drew the conclusion that time can only be a form in accordance with which, owing to the nature of Mind, our conscious experience is arranged. In other words, time is part of Mind, so that in the remoteness of Newtonian time Mind or Spirit is still present, and we have not passed outside of its wholeness.

In my sixth lecture I endeavoured to develop Kant's argument still further by pointing out that the wholeness which is expressed in conscious behaviour, whether that behaviour is called perception or voluntary response, is a wholeness which includes order in time as well as order in space, since conscious behaviour expresses both retrospection and anticipation. Temporal as well as spatial order is thus part of the wholeness. The separation implied in mere abstract time in the Newtonian sense has thus no meaning for conscious behaviour, any more than the separation in mere abstract space. The order of time as well as space is thus just a part of the expression of the spiritual whole which is embodied in conscious behaviour. That spiritual whole leaves nothing outside itself, and cannot be identified with what is interpreted as mere individual existence with its here and now.

Like the Copernican discovery, and to a less extent other great scientific discoveries, the Darwinian discovery of organic evolution has to a certain extent disturbed the balance of philosophical reasoning, in addition to acting as a great stimulus to that reasoning. It has thus to some extent tended to throw us back towards pre-Kantian philosophical ideas. One of these ideas is that the spiritual world of conscious behaviour has arisen out of something that is not itself. In actual fact what is taken for a non-spiritual world is only part of the spiritual world of conscious behaviour.

The holism of mere life, or the more dimly apprehended holism of the inorganic world, as it is appearing in the new physics, is different from the spiritual holism of conscious behaviour, since the latter kind of holism includes time-relations as well as space-relations. Just as we cannot coherently conceive life as dependent on, or arising out of, mechanism, so we cannot conceive conscious behaviour as dependent on, or arising out of, mere life. It has become customary in recent times to use such expressions as "unconscious mind" or "the unconscious" in the sense of something which originates conscious behaviour. So, before Pasteur, and to a still greater extent before Redi, men regarded living organisms as arising out of lifeless material, and attributed infection to such things as sewer-gas.

We have only to consider what life implies, and what a simple gas or liquid is ordinarily regarded as being, in order to realize that the immediate generation of life from the gas or liquid does not represent any coherent idea. Similarly, the generation of conscious behaviour out of something which is regarded as not having the specific characters of conscious behaviour is not a coherent conception. It only serves to shelve what is still left as an unsolved problem, just as the mechanistic conception of conscious behaviour shelves the problem of how a Newtonian universe can be related to a mind perceiving and acting on it. The problem left unsolved is a very real and pressing one, as will be pointed out more fully in the last lecture of this series.

For the present I must conclude this discussion by once more emphasizing the distinction between mere life and conscious behaviour. In the second series of lectures I hope to return to the discussion in its wider philosophical relations.

LECTURE IX

PSYCHOLOGY AN INDEPENDENT SCIENCE

IN the two previous lectures I have discussed the attempts which have been made to interpret the characteristic phenomena of perception and the rest of conscious behaviour in terms of either a soul independent of a material body, or of a material body in part of which the physical and chemical phenomena are accompanied by consciousness, or of a higher form of mere life. I endeavoured to show that none of these interpretations is consistent with observation of conscious behaviour.

What we actually observe in conscious behaviour, both in ourselves and others, is the behaviour of persons, with all around them, both in order of space and order of time, that pertains to their personality and is of value to them. We can of course leave the characteristic peculiarities of conscious behaviour out of account, and regard persons from a purely physical and chemical point, as weighing so much, as yielding certain amounts of various proteins and other chemical substances, distributed in a certain way, and as in various ways continuously converting potential into kinetic energy. This mode of regarding persons is of great practical use for engineering and other purposes, but tells us nothing, however far we may extend it, regarding the distinctive characters of conscious behaviour, as was shown in the last lecture.

We can also regard conscious behaviour as that of an individual self-existent, but immaterial soul or subject, in contact with a surrounding physical world. This mode of regarding conscious behaviour is very familiar. It has come down to us along with the Newtonian conception of visible and tangible reality, and is embodied in the old-fashioned psychology; but the facts are inconsistent with it, as was pointed out in the seventh lecture. We cannot distinguish a soul from either a physical environment or the interest which surrounds it both spatially and temporally. Both perception and voluntary action are unintelligible on the animistic interpretation of conscious behaviour.

We may also regard conscious behaviour from a merely biological standpoint as the embodiment of a whole which realizes itself actively, but blindly, or without regard to past and future happenings, in the spatial relations and mutual influence of its parts. Here, again, we have a conception which is of much practical value, and is indispensable in Medicine, but is still incapable of representing the distinctive character of conscious behaviour, which implies wholeness extending over temporal as well as spatial relations, so that past, present, and future happenings express progressive wholeness and not mere aimless maintenance. Conscious behaviour implies looking both forward and backward in time, so that continuity or consistency with the future and past is expressed in the behaviour.

Since, therefore, we cannot separate a psychical element from what is visible and tangible, or since our world is the world which we perceive, we have no alternative but to regard visible reality as expressing, however imperfectly, the spatial and temporal wholeness which is implied in conscious behaviour. This means that the world of our experience is a world which expresses or embodies psychological or spiritual activity. As mere individuals we certainly do not make that world: we find it there with our individual selves belonging to it, a world of what is of interest and value; and we cannot, except by a process of artificial abstraction, separate the objects perceived from their interest and value. Thus the whole of our perceived world, including all that for our immediate practical purposes we interpret abstractly in terms of scientific conceptions, is a world of interest and values, however imperfectly that world seems to be realized.

As I pointed out in Lecture VI, interest and values are not merely the interest and values centred in individual persons. Interest and values are bound up with our association or fellowship with one another and extend over our and their spatial and temporal environment, so that they are common interest and values. Since, moreover, they extend over time they are projected backwards in history and forwards progressively into the future. They thus partake of what is eternal.

From the standpoint of the Newtonian philosophy of Nature, history is a mere description of successive unconnected events occurring in self-existent independent bodies. If the actual world were a world of mechanical chaos, its history would mean no more to us than this description. Since, however, the actual world is a perceived world of interest, the events of its past and future are not outside those of the present. The present summarizes the past, and is a development of it, just as the future is a development of the present. The interest which is embodied in present conscious behaviour is not limited in time, any more than in space. Interest in the past and future is an essential part of interest in the present.

Just as we can by a process of abstraction regard the perceived world as a world of mechanical chaos, we can also regard it abstractly as a world of mere life, asserting itself blindly, so that, although, as in the Newtonian world, the present is indirectly the outcome of the past, there is no immediate oneness of past, present, and future events. The introduction last century of the conception of organic evolution as a blind process in Nature has greatly strengthened the tendency to interpret both history and present conscious behaviour from this standpoint, which is that of biology.

If we adopt this biological standpoint, the interest and values of the present seem to be only temporary passing phases in history, without any evident element of progressive continuity. They have their time and pass away, just as do species. The values and interest embodied in religious, scientific, and philosophical beliefs, ethical standards, artistic ideals, political ideals, appear as if they were constantly changing in the blind course of organic life; and behind what each generation regards as "authority" there appears to be no element of progressive continuity, any more than in the variety of the forms of life thrown up, and afterwards superseded, in what seems to be the blind course of organic history. This conception of history has become very familiar in recent times, particularly in its applications to religious and ethical beliefs. When these beliefs have been represented as " supernatural " revelations, or have been ostensibly based on anything else than direct interpretation of experience, the demonstration that their development can be traced backwards in human history has naturally been interpreted as meaning that they possess no real authority. Similarly, when conscious behaviour has been attributed to the influence of a soul independent of the body, the demonstration that it is impossible to separate the influence of a soul from that of the living body has very naturally led to the idea that conscious behaviour is in no way different from what we interpret as mere blind organic behaviour.

As I have already remarked, there is a fundamental distinction between what we interpret as blind organic behaviour and what we interpret as the conscious behaviour which expresses interest and values. The authority of belief embodying interest and values is based directly on our experience, and this experience refers backwards as well as forwards in time, so that our interpretations of the past are inseparably united with our interpretations of the present. It is only in so far as we treat our ethical, scientific, and religious beliefs as if they were not essentially based on what we can at any time verify from our developed experience that their authority seems to be undermined by historical investigation or by the demonstration that mind and body are inseparable. The knowledge which deals with conscious behaviour cannot be described in terms of anything else than unity which extends progressively in the form of interest or value over time, and so cannot be regarded as having originated in time from what is not itself.

With the help of the scientific abstractions which we make use of for various practical purposes, but which, since our world is a perceived world, represent only partial aspects of its reality, we can project perception indefinitely far as regards both space- and time-relations. The further we do so, however, the more evident does the abstract character of this projection become. To a greater and greater extent we lose contact with detailed interest and value, so that finally nothing of interest remains except the practical value which is ordinarily attached to the mode of scientific abstraction itself.

Psychology must be regarded as a branch of knowledge which deals, not with the relatively abstract aspects of experience dealt with by the mathematical, physical, and biological sciences, but with the more concrete experience which is that of conscious behaviour and the interest and values expressed in it. Since interest and values are expressed in relations of time as well as of space, psychology is distinct from biology, and must be regarded as an independent branch of knowledge or science. Since, moreover, the abstractions which are made use of in the mathematical, physical, and biological sciences are outcomes of human interest, we must regard the latter sciences as being psychological in their origin, and thus fundamentally dependent on psychology, in spite of their abstract character.

The word "psychology" recalls the conception of a soul distinct from the body, and is to this extent unsatisfactory, since we cannot separate body and soul. It has been suggested that in order to avoid this defect some such word as "personology" might with advantage be substituted for the word "psychology." In his recent book General Smuts has given approval to this suggestion. The word "personology" is, however, a hybrid one, and it seems on the whole better to keep to the well-established word "psychology," though on the distinct understanding that its retention does not imply retention of the doctrine that body and soul can be separated, or that consciousness is a mere inert accompaniment of what is abstractly interpreted as physical or biological activity. On the same understanding we can use the word "spiritual" as equivalent to the word "psychological."

When we define psychology as the branch of knowledge which deals with conscious behaviour as such, and when we also take into consideration that conscious behaviour cannot be treated as something pertaining to mere individual and separate persons, and that persons cannot be separated from their environment in space and time, it becomes evident that psychology represents a very widespreading branch of knowledge. It covers, in fact, all that is included in what are often called the humanistic sciences, which deal with the various manifestations of conscious human activity, as we meet them, not merely in individual, but also in social life. Hence it covers the principles embodied in ethics, in social and political science including law, in history, anthropology, literature, and all varieties of art, and in educational science.

Just, however, as biology is divided up into a number of more or less separate branches, so the domain of psychology is divided up into many separate branches, and it is at first sight difficult to recognize their fundamental unity, as dealing directly with various values in which conscious behaviour manifests itself.

This difficulty arises, as it seems to me, from lack of clear recognition that psychological observation is concerned with values which are the expression of conscious behaviour. If we attempt to base psychology on the assumption that conscious behaviour is just a series of physical changes or physiological activities accompanied by consciousness of them, there appears to be no special bond of unity between the humanistic branches of knowledge. The mere fact, for instance, that we are conscious of social or political duties, or of what appeals to us in literature and art, or that history records the conscious strivings of mankind, seems to make no objective difference to the actual facts. In the three preceding lectures I have tried to show that the actual characteristic facts of conscious behaviour cannot be described otherwise than in terms of the maintenance and continuous development of unity of interest which extends over time as well as space. This means that the interest and values with which the humanistic branches of knowledge deal are not only objective interest and values, but represent something different in kind from the objective reality which can be attributed to what we call either physical or biological phenomena.

It is psychology in the sense of science which deals with the characteristic facts of conscious behaviour that seems to me to be the only real kind of psychology. By disregarding these characteristic facts we can of course construct a psychology which is only biology in disguise, or, if the distinctively physiological element is left out, only physics in disguise. Psychology of this variety seems to me irrelevant except in so far as it brings with it some contribution to physiology, or brings physiology or physics to bear in some useful manner. It ignores the characteristic facts of conscious behaviour, as I pointed out in the last lecture. It is, in fact, not psychology at all. Animistic psychology fails in a different direction, which has already been pointed out.

The Newtonian conception of visible and tangible reality has become so impressed upon the modern world that we have great difficulty in realizing that anything visible or tangible can be real or permanent except what we interpret as matter or energy, or an immaterial soul with a self-existence similar to that of matter; but on the view of conscious behaviour which I have put forward the visible and tangible experience which is interpreted in psychological terms has at least the same claim to reality and permanence as the matter and energy of the Newtonian interpretation. Appeal to observation seems to justify both interpretations, and both interpretations appear, so far, to be possible, but in their proper places. In the case of characteristic conscious behaviour, and the values perceived and maintained in that behaviour, it is, however, only the psychological interpretation that can be applied.

The experience realized in every-day conscious behaviour is not merely of the nature of passing whims or blind responses to physiological stimuli. We eat, drink, and keep ourselves warm, not merely in response to the stimuli of the moment, but as part of the behaviour which develops our permanent and organized interest. If this interest, whether it can be regarded as our own individual interest or interest which we share with others, implies that we should at any time not eat or drink, or keep ourselves warm, we act in accordance with it, and not in response to the stimuli of the moment. Our interest is in immediate relation with the society in which we live, with our and its past history and anticipated future, and with the lasting values expressed in our perceptions and conscious actions. We cannot describe conscious behaviour in terms of anything but an active and developing unity of interest, extending over relations of time as well as of space. This is so in the case of the most ordinary perceptions and actions, just as much as in the case of unusual or specially noteworthy ones. An attempt to live a conscious life of mere immediate response to the stimuli of the moment could not be conceived in detail. We are what we are in virtue of the interest which encircles us in time as well as in space.

Our ordinary perceptions and conscious actions thus connect us directly with all the humanistic branches of knowledge, since these are embodied in what we perceive or do. Understanding of our fellow-men, including their history, their ideals and failings as revealed in literature and art, and their ethical principles, together with custom and its embodiment in law, enters directly into our perceptions and actions. Understanding of our spatial environment in its embodiment of interest enters also into these perceptions and actions, since interest is not limited in space. All the tools, devices, and arts which help us to control our environment in our own interest enter likewise into our perceptions and actions, so that when we see things we also see how to mould them in our interest. Prominent among the tools are measures of different kinds; and among the devices comes the application of abstract scientific principles, in the use of which only part of what is perceived is taken into account—for instance, relations of number, extension, bulk, weight, energy, or biological wholeness.

These scientific principles have all originated as devices for realizing or maintaining human interest. Thus they must all be regarded as psychological in their origin. In themselves, however, they treat perceived experience from an abstract standpoint from which no immediate account is taken of interest and values. For this reason they do not belong, except in their origins, to the humanistic or psychological sciences.

In the mathematical sciences the abstraction from actual perceived experience is greatest. The data of experience are treated as simply outside one another in time or space, without regard to any unity which may be manifested in their space- or time-relations, or to qualitative or other differences. Ordinary mathematical interpretations are generally regarded as simple and certain. This is only the case, however, on the tacit assumption that all reference to anything else than relations in time and space has been left out of account. It is just on account of this omission that the practical applicability of mathematical reasoning is so wide.

It has often been claimed for mathematics and physical science that they are exact sciences, while biological and humanistic knowledge are only descriptive. This claim cannot be upheld. It is only in so far as mathematics and physics disregard essential aspects in experience that they appear to be exact. It seems to me that if a comparison is to be made, the biological and humanistic sciences come quite as near to exactitude as do the mathematical and physical sciences. Exactitude in biological interpretation, or exactitude in literary, artistic, or historical interpretation or scholarship, is quite as real as mathematical or physical exactitude, and penetrates deeper into our actual experience.

In the physical sciences the data of experience are ordinarily treated as if they could be referred to a world of things existing separately from one another as regards spatial relations, and continuously in time with regard to their substance and energy only. Since these data all belong to the unified world of perception, they cannot be actually separable; but it is only when we recollect that they are perceived, and endeavour to apply physical conceptions to the actual data of our perceived experience of life and conscious behaviour, that the artificial character of the physical treatment becomes quite clearly evident. Over a great part of our experience the physical treatment seems to correspond well with what we take to be actual observation.

In the biological sciences the data of experience are treated on the assumption that organic unity as regards space-relations is present in them, each item in this unity presupposing the other items, and thus being essentially a part of the unity, but not part of a unity extending also over time-relations. Life continues, just as, on the physical plane, matter and energy continue; but events in life history show no continuity. Here, again, the assumption seems to correspond with a large part of our experience; and its abstract character does not become evident until we compare it with our perceived world as a whole, and realise that perception, as part of conscious behaviour, implies unity extending over time-relations as well as space-relations.

When we take into account the fact that the world of our experience is a perceived world, and that perception is no mere mechanical process in which a perceiving subject is passive or, to use a favourite expression, "plastic," but is a part of conscious behaviour, it becomes evident that psychological or humanistic knowledge, which deals with conscious behaviour and the values in which it is embodied, is the most fundamental knowledge. It is also the proper gateway to the more abstract sciences, since these have their origin and justification in human needs. It follows that the basis of a sound education must be humanistic, and that even the teaching of abstract sciences such as mathematics or physics should, through the history of these sciences or in other ways, be connected with human interest. Dogmatic short cuts may conduce to success in examinations, but hardly to real education, though often that comes later by more natural means.

At first sight it might appear as if this view of the relative positions of the sciences, and of education, were inconsistent with successful practice, as well as with sound theory. The humanistic side is often not very prominent in what is ostensibly taught at good schools or universities; and it may seem to be almost absent. Education, however, starts at home from infancy, and the most lasting humanistic lessons which are received by precept and example are those of childhood. A good school or good university is pervaded by humanistic influences; and in learning to understand one another and their teachers the scholars or students are learning the psychology which is the most indispensable subject to them in future practical life.

The view to which this course of lectures has so far led is that the knowledge represented in the psychological or humanistic group of sciences is not only differentiated clearly from other kinds of scientific knowledge, but is the most fundamental variety of scientific knowledge. To very many persons of the present generation the most fundamental variety of knowledge seems to be that represented in traditional physical science. The reason why I cannot accept this view is that, however useful such knowledge may be, it is based on abstractions which are not consistent with either biological or psychological phenomena; whereas there is not necessarily any similar inconsistency about psychological knowledge, however imperfect such knowledge may be.

I am well aware that at the present time this is neither a usual nor a popular point of view. It is contrary to what takes itself to be common sense to throw doubts on the nature of what is known as physical reality. Moreover, in placing psychological interpretation above physical interpretation are we not making Man the measure of the Universe—Man, a tiny inhabitant of an insignificant planet which would never be missed from the Universe if it disappeared!

Such arguments tacitly take for granted the Newtonian conception of the visible Universe; they belong to the time before Hume and Kant: the time when a soul appeared to be a thing confined within a brain existing in a Newtonian world, or else to be nothing but a succession of flashes of consciousness in such a brain. We cannot go back to these old conceptions. As Kant showed, the whole universe of our experience is the domain of psychological activity, so that it is impossible to localize psychological activity either in space or in time: it pervades them, and if this were not so they would be nothing to us. Our conscious existence is no mere existence here and now. The sooner we cease to be dazzled and confused over psychological questions by the Newtonian philosophy, the better will it be for all of us.

When we realize what is implied in the fact that our universe is a perceived universe it becomes evident that what may be called General Psychology is a very wide-reaching subject, affecting directly or indirectly our conceptions of all the sciences. For this reason it, along with Logic, which deals generally with the forms assumed by knowledge in the various sciences, is commonly taught and studied as a part of Philosophy. If we could separate the influence of a body from that of a soul, or if we could treat the phenomena of conscious behaviour as dependent on physiological processes in the brain, psychology would become a much more limited subject; but, as I have maintained in the previous lectures, such treatment of conscious behaviour is not possible unless we abstract from, or leave out of account, what is specifically characteristic of conscious behaviour.

If there were such a thing as perfect knowledge, there would be no need for the imperfect knowledge which is based on abstractions; but in dealing with human behaviour, as with other phenomena, we must often be content with imperfect or abstract knowledge. Hence we can usefully treat human behaviour from a physiological or even physical standpoint. This treatment is that of "physiological psychology." As a physiologist I am perhaps naturally inclined to claim it as a part, and a very important and interesting part, of physiology. In any case it seems to me to be something different from psychology in the proper sense. This deals generally with the characteristic features of perception and conscious behaviour of every kind, and these features cannot be described in terms of physiological conceptions.

No one can have a firmer belief than I have in the usefulness, and indeed indispensability of physiology; but at the same time I am thoroughly convinced of the limitations attached to physiological interpretation of human behaviour. At present there is what seems to me an exaggerated idea among the general public, not of the importance of psychological knowledge, for its importance can hardly be overestimated, but of the importance of mere physiological or even physical treatment of human behaviour. The scientific knowledge which deals with experience from the psychological standpoint seems to be the most fundamental variety of scientific knowledge; but this knowledge ceases to have the same fundamental character when it is only treated from a physiological or physical standpoint, or from an animistic standpoint.

At the end of this lecture I should like to emphasize the conclusion that psychological knowledge is not only different in kind from other sorts of scientific knowledge, but has an appeal no whit less cogent, and is at the same time more general in its interpretation of our experience.

LECTURE X

DEFECTS IN THE SCIENCES

IN the preceding lectures I have endeavoured to survey and define the general conceptions which are in use in the physical, biological, and psychological branches of knowledge. In this concluding lecture of the first course I wish to draw attention to the very imperfect manner in which it is alone possible to apply these general conceptions.

I began the lectures by discussing the difference between biological and ordinary physical conceptions. The difference between these conceptions is such as to produce a separation between the biological and physical sciences, so that the world as interpreted in the biological sciences seems like a different one from that of the physical sciences, though the two worlds are actually the same. As I endeavoured to show, we cannot possibly describe or interpret biological phenomena in terms of ordinary physical conceptions, but we might conceivably be able to extend the use of biological interpretation so that it applied to what we at present regard as inorganic; and the new developments of physics seem to be to some extent tending in this direction. Apart altogether from this latter possibility, however, I wish now to point out the inherent imperfection of the biological interpretation, and the fact that in biology it is apparently necessary to supplement biological by physical conceptions.

When we consider the co-ordination or wholeness which shows itself in the phenomena of life, it seems as if this can only show itself in contrast to mechanical chaos. As we have seen, it is only through the application of accurate physical and chemical methods of measurement that physiological co-ordination is gradually revealed. But these methods seem to assume the existence of the mechanical chaos which, as we have also seen, is an essential feature of the Newtonian conception of the inorganic world.

Let us take examples in illustration of this statement. We begin to realize the co-ordination manifested in the phenomena of breathing when we determine at different times and under different conditions the pressure of carbon dioxide in the air contained in the lung alveoli, and find that this pressure is maintained nearly constant in spite of variations in the times and conditions. But what is it that we are measuring when we measure the pressure of carbon dioxide? We are simply measuring the pressure produced through mechanical bombardment by free molecules of carbon dioxide moving chaotically. The fact that they are moving chaotically seems to be demonstrated by the fact that as regards the pressure which they produce they follow the gas laws, of which the physical basis is that the molecules are in absolutely chaotic movement, colliding with one another and with the walls of the lung alveoli in every possible way. In spite, however, of the fact that far more molecules of carbon dioxide are being given off from the alveolar walls than are absorbed, the pressure of carbon dioxide in the alveolar air is kept nearly constant by the lung ventilation.

It is only in the maintenance of this constancy that organic co-ordination of respiration manifests itself; but the constancy is maintained by mechanical pumping of air into and out of the lungs. This pumping is under general organic control; nevertheless we regard it as in itself a mere mechanical process. Thus it is only in the general regulation of mechanical processes that the physiological co-ordination or wholeness manifests itself. It seems to be a purely mechanical factor, namely, the bombardment pressure of carbon dioxide molecules, that is regulated; and apart from the fact that we can distinguish and measure this mechanical factor, the existence of the physiological co-ordination would be hidden from us. To discover the co-ordination we have had to apply exact physical and chemical methods and conceptions. We have had, moreover, to assume that mechanical chaos prevails within the air which is concerned in respiration, and but for this assumption the co-ordination would have no definite meaning for us. The co-ordination is a co-ordination of what is in other respects mechanical chaos, so that the existence of this chaos in matters of detail is complementary to the distinctively biological fact of the existence of co-ordination in the phenomena observed. It is only, therefore, in part, or imperfectly, that we can apply the biological conception of co-ordination. We need to assume the presence of a mechanical chaos which is only in part controlled organically.

When we consider other physiological activities in which organic control is manifested, we find the same apparent coincidence between mechanical chaos and organic unity. Thus in the case of excretion of water by the kidneys we have to assume that in the blood-plasma the molecules of water exist in the state of mechanical chaos characteristic of liquids. If they were not controlled in some way, these molecules would pass through the secreting membrane at a rate determined solely by mechanical factors. It is through the fact of their not doing so in spite of the mechanical chaos that we recognize the existence of organic regulation of the blood-plasma. To take still another instance, a reflex nervous response has, by itself, the character of a mere mechanical response to a suitable stimulus; and evidently it tends to act in this way, though on closer study we find that it is inhibited or reinforced in various ways which show that it is also under organic control. Thus chaotic mechanical conditions are here, again, associated with organic unity.

In the maintenance of bodily structure we find the same association between organic control and mechanical chaos. The structure is constantly tending to disintegrate by physical and chemical processes, and it is only in the control of this tendency that organic morphological unity manifests itself.

Apart from the existence of the chaos of physico-chemical conditions, we cannot imagine the existence of active biological co-ordination. Thus the existence of a world of life seems also to imply the existence of physico-chemical conditions. If, by some automatic process, the molecules concerned in the living structure and environment of an organism were kept in a mean normal position without any physico-chemical disintegration tending to occur, there would be no active life, and the very conception of life would have lost its meaning.

We might also imagine that the individual molecules concerned in life-processes, instead of tending to move chaotically, moved as if they were listening to music and taking part in an orderly dance, expressing in its movements the co-ordination of the life-processes. This is, in fact, an approximation to how the molecules more intimately concerned in living structure seem to behave, their movements becoming less and less chaotic as they approach each centre of living activity. With molecules moving in this manner, the gas-laws, and their extensions to liquids and solids, would cease to apply, since organic co-ordination would interfere too much with mechanical chaos; but even in an orderly dance the fundamental physical laws are still distinguishable, and apart from inertia and gravitation the measures of the dance would have no meaning.

It was pointed out in previous lectures that when living organisms come into physiological relation with one another their lives may, together, still form an organic unity, as in the case of the constituent cells of a compound organism. It seems equally true, however, that the life of one organism may be to that of another no more than part of the mechanical chaos in the presence of which the life of either organism is realized. The organic unity of a higher organism is shown clearly in the activities by which it resists and may become practically immune to infection by lower organisms. These activities are on a par with any other physiological activities which seem to resist the mechanical chaos which is everywhere at hand. The invading organism is killed and thrown out, or else succeeds in killing the invaded organism, just as the latter may be killed through failure to resist the mechanical chaos of its environment, as when the stomach, lungs, heart, kidneys, or sense-organs fail to act effectively. Even if we regard atoms as being essentially living organisms, the mechanical chaos remains.

The life of an organism seems thus to be a constant struggle against what, for it, are chaotic conditions, whether the chaos be that of ordinary physico-chemical conditions, or that of organisms struggling blindly with one another. We can see clearly the organic unity of its life, and the study of this kind of unity constitutes the science of biology. But we can see equally clearly the chaotic conditions in which by themselves there seems to be no unity; and the study of the unity is necessarily also the study of the chaotic conditions. If, as in practical medicine, we wish to aid the organism in its struggle, we must not only study in every accessible detail the manner in which the organic unity of the organism's life is maintained, and restored after disturbance, but we must also study the chaotic physico-chemical conditions of the environment, so that by amending them we can aid the organism in its struggle, and aid it in recovery from injury already done. Knowledge of physics and chemistry, and of hostile organisms, is thus an integral part of knowledge of medicine. The chaotic conditions never recede from our view; they seem always evident.

On the plane of psychological experience we find, similarly, that though, in conscious behaviour, psychological or spiritual continuity of this behaviour at different times is evident enough, discontinuity is also always present. The behaviour of no person is consistently rational in the furtherance of what he is interested in. What might have been foreseen is commonly not foreseen, and what might have been remembered is equally commonly not remembered. Apart from this, however, interest and values are not clearly defined in detail, since, like biological unity, they include an element of mechanical chaos, so that perceptions and voluntary actions are correspondingly imperfect. We are always "learning," and it is only in the struggle of learning and acting on new insight that psychological unity shows itself, just as it is only in the struggle with physico-chemical chaos that biological unity shows itself. In so far as a person does not learn, and merely repeats previous imperfect perceptions and so makes correspondingly imperfect responses to them, he becomes psychologically or spiritually inert, since there is to this extent nothing but aimless succession in his actions.

Much of a person's behaviour is, though highly and delicately co-ordinated, mere repetition of previous behaviour, with no improvement in the successive repetitions. The acts of writing, walking, riding a bicycle, or steering a motor-car on an open road, are, for instance, very delicately co-ordinated, and could not be imitated by any machine. But when once they have been learnt they are repeated without mental effort and with no continuous improvement, however imperfect they may be. Thus their details do not any longer enter into conscious behaviour, any more than do the details of respiration, circulation, secretion, and other physiological activities. Nevertheless the imperfection with which bodily activities are carried out is part of the general imperfection of conscious behaviour, and responsibility for that imperfection is part of the responsibility for other imperfections in conscious behaviour. The fact that we are continuously responsible for our own bodily health and efficiency, as well as for those of our neighbours, is being realized more and more as civilization advances.

All around us we see disease and death—facts which, in themselves, we seem unable to interpret from a psychological standpoint. Disease, crime, death, and birth are matters so familiar to us that the deep mystery which surrounds them is scarcely realized; but their existence ought to serve as a constant reminder to us of the merely partial character of either psychological or biological interpretation. We are accustomed to think that since scientific knowledge has cleared up so much that had previously been mysterious, our experience must be much more intelligible to us than it seemed to our forefathers. In so thinking, however, we forget that each scientific advance seems only to throw into clearer relief the mystery which remains. My old philosophical teacher, Professor Campbell Fraser of Edinburgh, used frequently to speak of "our mysterious life in this mysterious universe." The advance of scientific knowledge does not seem to make either our universe or our life in it any less mysterious. It appears to me to be little better than unthinking credulity to believe that the mystery has become less deep through scientific advance. In proportion as we know more and think more, scientific problems still unsolved seem to define themselves progressively.

Interest and values are not those of mere individual persons, but also social interest and values. The imperfection which is inherent in conscious behaviour from the individual standpoint is still more evidently inherent in the conscious realization of social interest and values. It is only very imperfectly that we either perceive or act upon social interest or values which ought to appeal to us. We are confused and diverted by the mechanical chaos which is everywhere around us, and by what are mere immediate sensuous appeals without continuity behind and in front of them, or by appeals in response to which individual interest is in conflict with common interest. Apart from this, it is only very imperfectly that what we ought to regard as common interest is defined. In nothing is the mystery which surrounds us more evident than in this.

Thus all that we can say of psychological interpretation of experience is that though it is certainly necessary, it only applies in conjunction with what seems to be opposed to it, in the interpretation of which we are only able to employ the more abstract conceptions of biology and physics. Similarly, in the case of biological interpretation, we have seen that it applies in conjunction with what we can only interpret as the mechanical chaos of physical interpretation. We might extend the same line of argument to physical interpretation by pointing out that it is only in virtue of the assumption of purely mathematical relations in ideally empty space and time that physical interpretation becomes possible.

In the present course of lectures it has been argued in much detail that in the interpretation of the visible and tangible world of our experience we cannot dispense with biological interpretation by substituting for it physical interpretation, or employ an interpretation in which interference with physical action is confined to parts of the interior of living organisms. It has also been argued that we cannot dispense with psychological interpretation by substituting for it either physical or biological interpretation: nor can we confine psychologically interpreted interference with physically or biologically interpreted activity to some one part of a living organism, such as the grey matter of the brain.

But granted the validity of these arguments, we have not, as has just been pointed out, got rid of the physical world when we pass to biological interpretation, or of the physical and biological worlds when we pass to psychological interpretation. On the one hand, a merely physical or merely biological interpretation of our experience is impossible; but, on the other hand, we can never dispense with the physical or biological interpretations: for their continued existence seems necessary to the existence of the psychological interpretation. The conclusion which at first sight seems to follow in face of this position is that scientific conceptions represent, not reality itself, but only particular aspects of reality. It is one aspect that is dealt with in the physical sciences, another in the biological sciences, and yet another in the psychological or humanistic sciences. The reality of experience must include them all.

This is a practical conclusion often adopted; but when we examine it, we find that the different aspects or interpretations contradict one another. Reality cannot at the same time be a physico-chemical chaos and a world of biological co-ordination in which each part or distinguishable action expresses the existence of a whole. Nor can reality be at the same time a world the events of which express wholeness only in respect to space-relations and a world in which the wholeness of the events extends over time-relations, so that there is progress and therefore wholeness in history, and values exist which partake of what is eternal or outside of the vicissitudes of time.

If we insist on the reality of the physico-chemical aspect of experience, and at the same time recognize the characteristic features of life and conscious behaviour, we are driven into the position of the vitalists and animists. But this position was found to be as impossible as that of ignoring these characteristic features, and attempting to interpret life and conscious behaviour in physico-chemical terms. If, at the other extreme, we insist on the reality of the psychological or spiritual aspect of experience, we must also recognize the apparent chaos and imperfection which are everywhere around us and thus seem to belong to an alien world. We can, however, never separate this alien world from the psychological or spiritual world, since we cannot separate the activities of the soul from those of the body and its environment.

At the end of the survey of the sciences in the present course of lectures we have thus reached no satisfactory position, though I hope that the survey may have placed in a clear light the difficulties and contradictions to which merely scientific interpretations of our experience lead. These difficulties and contradictions concern all that is of most moment and value to us—all that our affections are centred on, whatever philosophical or religious beliefs we may ostensibly hold. We may be materialists, for whom, theoretically speaking, there is nothing but mechanical chaos in the universe—a chaos of conscious experience, as well as of material happenings, so that such things as spiritual values cannot, properly speaking, exist. In actual fact, however, it is only the value which they accord to truth that leads some men to materialism. Materialists are also usually men of what we call exemplary lives, showing in a striking manner the reality to themselves of spiritual values. We may, at the other extreme, be religious mystics, to whom the chaos of the visible universe is theoretically of no account. In this case, too, the lives of religious mystics belie their opinions. The suffering and sin of the visible world around them concern them deeply, and usually far more deeply than in the case of others who have not clearly realized the need for a philosophy of life.

We require something which goes deeper than any of the sciences—something which faces the contradictions to which the different sciences lead when they are applied to actual experience. We need Philosophy, not merely Science. To the great majority of mankind what we call Religion has stood for their Philosophy. It has at least been a practical philosophy. To what extent we can identify Philosophy and Religion will be discussed in my second course of lectures. At this point I only wish to emphasize the need for Philosophy or Religion, as distinguished from Science, but growing out of it, and consequently the distinction between Philosophy or Religion and Science. I have tried to point out the fundamental differences in the interpretations of our experience by different sciences, and the impossibility of basing a satisfactory philosophy on any particular scientific standpoint, such as that of the physical sciences, or biology, or psychology, or on any combination of scientific standpoints. In concluding this first course of lectures I shall endeavour to summarize the reasons for this conclusion.

Although in Greek times, when not only the great practical value of mathematical reasoning, but the unlimited field of its application, began first to be realized, an attempt was made by the Pythagoreans to base a philosophy on mathematical science, it was soon realized that such an attempt could not express our experience, so that I need not refer to it further. It is very different, however, with physical science; and from Democritus onwards to the most recent times we find attempts to base a philosophy on physical science. As I have tried to point out in detail, these attempts have failed to cover the phenomena of life, and still more completely failed to cover the phenomena of perception and conscious behaviour generally. It seems to me that, in spite of efforts under the name of Realism to revive this physical philosophy, it must be regarded as a definite failure, since it has aimed at the impossible, even when, as in Kant's philosophy, its scope was limited to a merely phenomenal world.

In Lecture VIII I endeavoured to show that a philosophy based on the objective reality of biological conceptions, though it now seems to be in all probability capable of partial extension to the inorganic world, does not account for the phenomena of conscious behaviour. It is also open to the criticism that the conception of life seems to imply the inconsistent conception of mechanical determination, as already pointed out in the present lecture.

We can also endeavour to base a philosophy on the objective reality of psychological or spiritual interpretations of experience and the eternal values which that interpretation reveals—values which do not depend on the existence of mere individual persons, and which are embodied in the development and application of scientific conceptions no less than in other events in human history. But such a philosophy fails, by itself, to account for the chaos and imperfection which, in our actual experience, appear side by side with the world of eternal values. In so far as the chaos and imperfection are real, they contradict the psychological or spiritual interpretation, so that we do not reach a philosophy in this way. Along with the element of what is all-pervasive and eternal in us there is a contradictory element of what is only here and now in a world of chaos.

We fare no better as regards a philosophy if we assume that the spiritual world of values exists side by side with a material world of physico-chemical chaos. All the difficulties and contradictions inherent in animism and vitalism confront us. These difficulties and contradictions have been pointed out in Lectures IV and VI.

The only world which the Sciences appear to be capable of representing to us is not consistent with itself. Not merely mathematical, physical, and biological Science, but Science of any kind, fails to furnish us with what we can describe as objective truth. When we examine the body of knowledge presented to us by each science, we find that though it is logically consistent it only corresponds partially or imperfectly with our actual experience. In other words, it does not represent actual reality, but only a subjective picture of reality. If we take it to represent actual reality, and suppose that the representation constitutes realism, we are only mistaking a form of subjective idealism for realism.

Thus Science brings us to a point at which we require more than Science. In the lectures of next year this subject will be pursued further.

PART II

PHILOSOPHY

LECTURE XI

THE NEED FOR PHILOSOPHY

AS this second series of Gifford Lectures is continuous with the first series, I must first remind you of the ground covered last year.

I began the lectures by pointing out that the function of Philosophy is to enable us to frame as consistent as possible a working conception, not merely of part, but of the whole of our experience; and in the lectures of last year I surveyed the interpretations of experience embodied in different main branches of knowledge, or sciences, represented by the physical sciences, the biological sciences, and the psychological or humanistic sciences. I endeavoured to point out the fundamental differences in the general mode of interpretation forced upon us in each of these main branches of science by the nature of our experience itself, and the complete failure of the attempts which have been made to explain away or ignore these differences.

The first five lectures were taken up with the fundamental distinction between biological and purely physical interpretation. The general lines of a purely physical or mechanical interpretation of visible and tangible experience were formulated generally by Newton, and have been developed more and more completely since his time; but biology had no Newton, and it is only by slow degrees, and in face of many misconceptions, that the principles of biological interpretation have been emerging in clear form. Hence a full discussion of the subject was required. I considered at some length the attempts which have been made to treat biology as a part of physics and chemistry, and pointed out the failure of these attempts. I also pointed out the failure of the attempts by the vitalistic school of biologists to interpret biological facts by assuming the existence of spatial demarcation between what is alive and what belongs to a merely physical world, and then endeavouring to study the specific phenomena of life as manifested within the assumed spatial bounds.

The conclusion reached was that there are no spatial boundaries between the living and non-living, and that biology represents an independent group of sciences because the general conception applied, and necessarily applied, in the biological sciences is different from that applied in the physical sciences. The difference consists in the fact that we do not, as in physical interpretation, regard an organism and its environment as consisting of things existing independently of one another in space, but must regard them as forming a co-ordinated whole, of which the observed form, composition, and activity are at all times the expression. In so far as we perceive this co-ordinated whole we are interpreting our observations biologically. In so far as we are unable to do so, we have recourse to mere physical interpretation to the extent which is possible, though this interpretation is evidently of only a provisional character. The old question as to the relation of matter to life is thus in reality a question as to the relation to one another of two different interpretations of the same phenomena, each of which interpretations is in practice not only useful, but even indispensable. It is no individual caprice that necessitates these very different modes of interpretation, but the nature of our experience itself.

In the succeeding lectures I pointed out the further distinction between biologically and psychologically interpreted phenomena. In psychological knowledge something enters into our interpretation, and definitely distinguishes psychological from mere biological interpretation. This additional character is the fact that in psychological interpretation we assume, and must assume, the existence of unity embracing not only the spatial relations of what we are perceiving, but also relations of time, so that the present is the fulfilment of the past and the promise of the future. When we interpret our experience psychologically, each experience is an expression of unity of the past and future with the present. When we are conscious of anything, or when we act voluntarily, retrospect and foresight are of the essence of our experience: present, past, and future are united in the interest or value which the conscious experience or act embodies. We are moving in a psychological or spiritual world of interest and values which are not only embodied in each perception or act, but have no beginning or ending in either space or time.

Psychology which does not take this characteristic into account is nothing but pseudo-psychology. It may be, and sometimes is, good physiology, or sometimes good physics, in so far as physical or biological interpretation can be applied; but it is not psychology.

In so far as it is mere physical interpretation it simply ignores all that is characteristic, not only of psychological, but also of biological phenomena. In so far as it is no more than physiological or biological interpretation, it misses what is distinctively characteristic of psychological phenomena. For biological interpretation life is continuous in time. From generation to generation there is no break in the continuity of life, just as, for ordinary physical interpretation, there is no break in the continuity of mass and energy. But in biological, just as in physical interpretation, the detailed happenings of the present are not regarded as having any direct connexion with the detailed happenings of the past or future. Blind immediacy of response to whatever happens is characteristic of phenomena which are interpreted biologically, though the responses themselves, when taken together, express the maintenance of a spatially co-ordinated whole. On the other hand, retrospect and foresight are embodied in each psychologically interpreted phenomenon, and are of its essence, in addition to mere spatial co-ordination. It is only when we mistakenly apply physical conceptions to psychological phenomena that any question arises as to the relation of body to soul. No such question can arise legitimately, since space and time are not outside psychological unity, but within it. Both animism and materialism are based on the mistake of failing to realize this fact.

The last lecture of the series was devoted to calling attention to the essential defects in scientific interpretation, whether the interpretation be physical, biological, or psychological. The defects in physical interpretation arise from the incompleteness with which what we actually perceive can be interpreted physically, and are evident at once when we endeavour seriously to apply physical conceptions to biological or psychological phenomena. The physical conceptions do not correspond with biological observation, as was pointed out in some detail in the second and third lectures. The want of correspondence has, in the past, been obscured by the fact that during the two centuries since Newton's time physicists had with few exceptions deliberately excluded biological and psychological phenomena from their consideration, accepting, as they usually did, the vitalistic or animistic accounts of these phenomena. It has thus been left mainly to biologists to point out the impossibility alike of vitalistic accounts and of physical accounts of life. In recent years, however, inherent defects of physical interpretation have come to the surface apart altogether from what are ordinarily regarded as biological or psychological phenomena. Recent modifications in the conception of motion or of the atom, for instance, are inconsistent with physical principles on the lines laid down by Newton; and the behaviour of substances with varying temperature furnishes another instance.

On the other hand, if we attempt to apply biological conceptions consistently to the world of our experience we are at once brought up by the impossibility of realizing in detail any such attempt. Biological interpretation is based on the observation of unified co-ordination in the details of form, composition, and activity; but quite evidently this co-ordination cannot be traced in full detail. The nearer we approach to a centre of living activity the more clearly does it appear to us that the molecules, atoms, and electrons present on the physical interpretation are behaving as if they were taking part in a co-ordinated dance, for which there can be no physical interpretation, and which differs entirely from the free chaotic movements of the apparent molecules in a gas, the mutually confined movements in a liquid, or the still more confined movements in a solid. It is none the less true, however, that side by side with the co-ordination there appears to be everywhere the chaotic activity exhibited in the gaseous, liquid, and solid states as interpreted physically.

In so far as it exists, the co-ordination appears to us as if it were in some mysterious way partially and by brute force imposed on the chaos. In other words, it is only partially and imperfectly that the biological conceptions can be applied to our experience; and as we pass outwards from a centre of life to its spatial environment, the applicability seems to become less and less evident in matters of detail. We seem to be surrounded by mere gases, liquids, and solids, and it is only in the quite general mutual relations between organism and environment that biological co-ordination stands out. Life thus appears to us, from the physical standpoint, as a continuous struggle against physical chaos.

Perhaps some of my audience do not clearly realize what is implied in the physical conception of a gas, liquid, or solid, and in the conception of its temperature. The *Collected Scientific Papers* are now on the point of appearing of J. J. Waterston, the great Scottish physicist, who was the first to formulate clearly the dynamical theory of gases and of temperature, and afterwards took essential steps in extending the theory to liquids and solids, though he never, in his lifetime, received the recognition due to him. My own book *Gases and Liquids,* in which I have endeavoured to extend the application of similar reasoning, is also just appearing.[1] It was Waterston who first showed how to extend to the molecular world the general principles formulated by Newton, and whose ideas, to a large extent re-discovered and developed by others, form the foundation of molecular physics or physical chemistry as a wonderfully useful branch of physical and chemical science.

The essential points in the physical conception of a gas are as follows. A perfect gas can be regarded successfully as an absolutely disorderly and chaotic assemblage of perfectly elastic molecules flying about with enormous velocity and striking one another and the walls of any containing vessel at all possible angles and with most variable velocities. The pressure of the gas is due to the bombardment by the molecules, and, if we neglect the volume, almost inappreciable at ordinary pressures and temperatures, of the molecules themselves, necessarily varies with their concentration in accordance with the law discovered empirically by Boyle. The pressure must also vary with the mean energy of impact of the molecules, or as the mean square of the molecular velocity. This corresponds to the temperature of the gas, so that we have a clear

[1] *Gases and Liquids: a Contribution to Molecular Physics.* By J. S. Haldane, Oliver & Boyd, 1928.

conception of what temperature means, and can extend it to liquids and solids. We can then see that if the walls of the confining vessel have the same temperature as the gas, the gas-molecules cannot lose any of their energy. If we regard the absolute temperature of a gas as varying with the mean square of the molecular velocity, we can also at once deduce Charles's empirical law of expansion of gases with temperature. Since, moreover, in a chaotic assemblage of countless molecules the energy will, on an average, be equally distributed among the molecules, whether they are relatively heavy or light, equal volumes of gas at the same pressure and temperature will contain the same number of molecules, in accordance with the empirically discovered generalization known as Avogadro's law. The rate of diffusion of a gas will also vary as the square root of its molecular weight, in accordance with Graham's empirically discovered law.

The behaviour of a gas is thus chaotic behaviour, and its temperature is simply a measure of the chaotic kinetic energy which it possesses. Gases, liquids, and solids are present within and around living organisms. They also have temperatures, so that chaotic energy is everywhere present within them; and however evident may be the co-ordination which shows itself in organic behaviour, the chaos seems also to remain side by side with it, so that a consistent account of the phenomena is impossible.

When we pass from biological to psychological interpretation, the incompleteness of psychological interpretation is even more evident than that of biological interpretation. Although in psychological interpretation we make the most of the unity and co-ordination, both in time-relations and space-relations, which we find in our experience, we seem also to be mere individuals, existing among, and struggling with, other individuals in a more or less chaotic environment, and only here and now. But for this appearance space- and time-relations would be only the manner in which psychological unity expresses itself. As spiritually existing we should not exist as individuals in space and time at all, but space- and time-relations would be an expression of our own nature. Past and future would be an everlasting present, and arrangement in space would be an omnipresent here. Our actual experience, however, seems everywhere to be in conflict with psychological or spiritual unity, though it is equally true that this unity is involved in actual experience. From the psychological standpoint it is a world full of sin and sorrow that seems to present itself: for its defects are our defects.

It is thus evident that not only the sciences taken together, but also the individual sciences, present to us problems which, as mere sciences, they are unable to solve. The task of philosophy is to grasp these problems firmly, and endeavour to reach some sort of solution of them. This is what philosophy has always been striving to do, and what, on the practical side, religions have likewise been striving after.

In the first course of my Gifford Lectures I made a survey and comparison of the sciences. The second course will be devoted to philosophical discussion of the problems which, when considered together, they present, and to the practical bearings of the discussion.

In the rest of this opening lecture of the second course I shall endeavour to indicate the general lines of the discussion and its outcome, to serve as a sort of guide to the second course.

If we compare the biological with the physical interpretation of experience we find that life, though it appears to us as a struggle against physico-chemical mechanism, is something inherent in the apparent mechanism itself. Any other conclusion involves us in the impossible assumption that life is mere physico-chemical mechanism, or the equally impossible vitalistic interpretation. Despite appearances, therefore, the mechanism must be more than mechanism. The apparent independence of one another of different units of matter and energy can thus be no more than a superficial appearance. In other words, physical science deals with reality in only its superficial appearances, however satisfactory may be such a treatment of reality so long as we leave out of consideration the phenomena of life and any other phenomena which are inconsistent with mechanical conceptions.

For endless immediately practical purposes we can treat the visible and tangible world as a mechanical world; but it is not with these immediately practical purposes that we are at present concerned. We may say that in inorganic phenomena we find the " promise and potency " of all life. But in so saying we are either in fact attributing to inorganic phenomena something quite different from mechanical characters, or we are ignoring the essential character of life, as this essential character was ignored by the majority of physiologists during the last half of the nineteenth century, and is still quite commonly ignored in at any rate a great deal of popular literature.

When we study the life of any higher organism we can distinguish in it with the microscope what seem to be innumerable centres of life, in the form of cells, parts of cells, or of the nuclei of cells; and we find that in the process of hereditary transmission the last-mentioned centres take part in various ways. Yet it is one life that manifests itself in these distinguishable activities. If we go beyond the microscopically visible centres of life to molecules and atoms concerned in life we cannot assume that their nature is in ultimate analysis mechanical. We can, it is true, interpret their behaviour mechanically in what we call a gas or liquid; but unless we are prepared to return to the impossible vitalistic position, we must assume that they too are not in reality mere separable units, but would, if we understood them fully, manifest in their behaviour the same organic unity as the microscopically distinguishable centres taken together. In other words, biology cannot accept as more than merely provisional the mechanical interpretation of these ultramicroscopic centres, although in describing the phenomena of life we cannot help making use of physico-chemical description in matters of detail.

When we look, not inwards to what is very small, but outwards to the general environment, and to the mutual relationships of different apparent units of life which may seem at first sight to be merely mechanically affecting one another, biology again cannot accept this appearance as representing reality. Just as the individual cells in a higher organism manifest in their actual behaviour organic unity, so do these higher organisms themselves present evidences of organic unity in their relations to one another. We can see this in the relations between the sexes, between parent and offspring, and between the members of communities of organisms; and biology deals with this unity, and generally with the unity of organism and its environment, whether that environment includes within itself other living organisms or not. The environment is not treated as something foreign to life. There is no limit to either external or internal biological interpretation. For biology the mechanical interpretation of the environment, including the relations between different organisms, is only a provisional practical interpretation, covering what cannot as yet be interpreted biologically. Underlying this provisional interpretation, however, is the postulate that biological interpretation must be ultimately possible.

This involves what may be called an act of scientific faith, but of faith very firmly based on experience. In and about the living body we seem, from the physical standpoint, to find innumerable independent bodies mutually acting on one another. Yet the outcome is the active maintenance of specific and co-ordinated structure. It is this fundamental fact which justifies the act of faith by which we assume an underlying biological interpretation. Those sceptics who object on principle to any such act of faith may be reminded that it is by a precisely similar act of faith that they interpret the behaviour of a gas, or the nature of heat or temperature, or indeed make use at all of the generalized conceptions of mass and energy. Without these latter conceptions we are unable to describe or think definitely about what we regard as a physical world; and without the distinctively biological conception of life we are unable to describe and think definitely about the same world when we take the biological phenomena in it into consideration.

Since the time of Newton and his immediate predecessors the civilized world has become accustomed to treat the visible and tangible world altogether independently of the facts with which biology deals. There is, however, as little justification for this treatment as there would be for ignoring all the facts which we relate to the behaviour of molecules and atoms; and when biological facts are taken into consideration, the Newtonian conception of self-existent bodies and their independent motion is no longer possible except as a merely provisional conception.

The visible and tangible world is, however, not only a world of life, but also of conscious behaviour; and in forming a consistent or philosophical conception of our universe we can no more neglect conscious behaviour than we can neglect biological phenomena. When we neglect conscious behaviour we only reach, by an act of faith, towards a biological conception of our universe. When we take conscious behaviour into consideration we must take another step forwards, and by a similar act of faith, towards a psychological or spiritual interpretation.

As was shown in detail in the first course of lectures, a merely biological interpretation of conscious behaviour is quite insufficient. Yet the phenomena of conscious behaviour enter into our visible and tangible experience—into the phenomena of Nature, when "Nature" is taken in its widest sense as synonymous with Experience. Any consistent or philosophical account of Nature must therefore cover conscious experience. Since we cannot interpret conscious experience in terms of mere life, and far less in terms of physical conceptions, there is no escape from the conclusion that behind the appearances of a physical or biological world we are in presence of a psychological or spiritual world. We cannot, however, see this spiritual world in detail, and have to content ourselves for endless ordinary practical purposes with provisional physical or biological interpretations. It is thus only by an act of faith that all the variegated experiences which appear to us as "Nature" are interpreted as in ultimate analysis spiritual.

Neither space-relations nor time-relations are outside this spiritual interpretation. Just as space-relations express the organic unity of life, so time-relations express in addition the progressive unity of spiritual existence, and time-relations have no reality apart from the space-relations in which interest and values are also expressed. We cannot get outside spiritual unity by going backwards or forwards in time. And just as organic unity pervades the individual cells or other units of a living organism, or different organisms, so does spiritual unity pervade individual personalities, so that our universe appears to us as an objective universe, common to all. In ultimate analysis there can be only one spiritual unity or personality.

It is only in what appears to us as an active struggle against mechanical chaos that life manifests itself; and similarly it is only in active struggle against apparent physical or biological chaos that spiritual unity manifests itself. But from the standpoint reached by faith in an all-embracing spiritual unity the chaos disappears as such, since the apparent vicissitudes of existence in time are no longer outside of the spiritual unity, but must themselves be manifestations of it. The apparent evil and imperfection of the universe are no longer interpreted as evil, but only as imperfect apprehension.

Apprehension is always imperfect, since knowledge or scientific perception of any sort is imperfect. It is only by faith that we can realize spiritual reality. In so far as we regard ourselves as mere individuals we are subject to all the vicissitudes of spatial and temporal existence. We are born and die, like other individuals, though the life that was in us is carried on by other generations. But in our conscious behaviour we partake also of spiritual existence which neither dies nor is born, since time-relations are within and not outside it.

It is only by faith, and certainly not by direct perception, that we realize all-embracing spiritual reality; and we can ultimately define faith as the conviction that our universe is consistent with itself. From the standpoint of philosophy which surveys not merely one aspect, but all aspects, of our experience, no consistency is possible unless spiritual reality is one and all-inclusive.

Spiritual reality leaves neither time nor space outside of it. They are only the order in which it expresses itself. Nor can there be separate spiritual realities. Interest and values are thus no mere individual interest and values, nor are our lives mere individual spiritual lives. Only in so far as we mistakenly regard ourselves and our interests as mere individual selves and individual interests is death an ending.

It is only fitfully and in a more or less confused manner that we realize and act upon what is implied in spiritual unity. In the philosophies and religions of history we find, however, that this all-inclusive unity is represented under one form or another, and very clearly in the Christianity under the influence of which we live. The conclusion to which the argument of this course of lectures will lead up is that our universe, under whatever guise of constituent self-existent things or personalities it may for the moment appear to us, can be nothing else but the manifestation of one Spiritual Reality or one God.

It is thus what may be called spiritual realism that this course of lectures will represent.

LECTURE XII

BIOLOGY AND MORE ABSTRACT SCIENCES

THE first five lectures of the previous course were devoted to showing that Biology must be regarded as a science which is differentiated from the physical sciences owing to its fundamental axioms being different from those of the physical sciences. This matter is so important that a full discussion was required of the attempts which have been made to harmonize biological observation with the axioms of the physical sciences. As, however, was emphasized in the last lecture of the previous course, we cannot, in the perception and description of biological phenomena, dispense with preliminary physical interpretation, the result being that the co-ordination which is characteristic of biological phenomena seems to be only discovered by contrast, as if it were imposed from without on physical phenomena, and as if it were only through the progressive discovery of this imposition that biological interpretation makes progress.

In the history of physiology nothing is more striking than the fact that advance in distinctively biological interpretation depends upon the application of accurate physical and chemical methods and measurements. Apart from such methods and measurements when they are put together, we should know nothing definite of biological co-ordination as contrasted with mechanism. The widespread assertion that the application of accurate physical and chemical investigation to life has been leading towards a physico-chemical conception of life is a ridiculous travesty of scientific history.

What I wish now to discuss is the intimate connexion which exists between biological and physical interpretation. We cannot rest satisfied with the idea that molecules or atoms, though they still continue to be molecules or atoms essentially independent of one another, yet behave within living organisms as if they had there and then lost their independence and become possessed by a foreign influence. Such an idea amounts to the same thing as vitalism, and is thus subject to the fatal objections which were pointed out in the fourth lecture of the previous course.

As a sort of friendly practical compromise with the Newtonian or mechanical ideas under the influence of which they have been brought up, biologists are constantly being driven into vitalistic or animistic modes of expression; while representatives of the physical sciences are perhaps even more willing to accept this compromise in so far as they come into contact with biological phenomena. Yet the great majority of biologists, at any rate, have realized that the attempted compromise is impossible, and on this point I am in full agreement with them.

From a philosophical standpoint it is of the utmost importance to face and thoroughly discuss the difficulty: for similar difficulties appear again in connexion with the psychological branches of knowledge. On the one hand, we seem to have a world of essentially independent Newtonian molecules, atoms, electrons, and other " bodies " acting on one another. On the other hand, in connexion with biological phenomena, we seem to have a world in which the " bodies " do not behave as such, but as the expression of an actively and specifically co-ordinated whole. It seems to me that there is only one solution of the apparent contradiction. This solution is that the appearance of a world of independent bodies is only appearance, while the biologically interpreted world is at any rate something nearer to reality itself.

With our upbringing in the tradition of the Newtonian interpretation of visible and tangible reality it is very hard for us to accept such a solution, or even realize its meaning. The practical utility of the Newtonian interpretation is enormous. In every direction it has opened to us new possibilities of prediction and consequently of controlling our environment; and it is steadily continuing to open further possibilities. We cannot possibly dispense with it. Nevertheless, as will be pointed out more fully in the succeeding lectures, it is constantly threatening to obscure completely our vision of reality as a whole. The time is more than ripe for coming to an understanding with it.

The only understanding which seems to me possible is that the Newtonian interpretation represents only a provisional working hypothesis. This can be no mere spatial or temporal limitation, but must apply everywhere as soon as we examine our visible and tangible world more thoroughly and from a point of wider view than that of ordinary physical investigation. We constantly fail to perceive things correctly because we are only seeing them partially, and this is very strikingly the case when we attempt to apply physical interpretations to biological phenomena. From a point of narrower view the physical interpretation may give promise of being satisfactory, but from a point of wider view the biological interpretation is alone possible.

Let me illustrate this statement by an example from a part of physiology with which I am specially familiar, namely, the physiology of breathing. In the act of breathing, air passes into and out of the lungs, and this is rendered intelligible to us mechanically by the dynamical theory of gases on the one hand, and on the other by the action of the respiratory muscles on the structures forming the lung-walls. To continue the mechanical interpretation, within the lungs a process of gaseous interchange occurs between the air in the alveoli or ultimate air-sacs of the lungs and the blood circulating through the capillaries on the outer surface of these air-sacs. In this exchange oxygen is taken up by the blood and carbon dioxide given off to the air. When we investigate this process more closely, we find that during rest under normal conditions the partial pressures of oxygen and carbon dioxide, or the pressures with which they diffuse out of the gas and out of the blood, come into complete equilibrium as the blood passes through, the blood taking up oxygen and losing carbon dioxide, while the air loses oxygen and takes up carbon dioxide, till, when the blood has become "arterialized," equilibrium is established. This is perfectly intelligible mechanically on the theory of diffusion, considering the enormous capillary surface presented in the lungs. When conditions giving rise to shortage of oxygen exist, as during muscular exertion or life at high altitudes, there is what seems to be quite clear evidence that oxygen is actively driven or secreted through the capillary walls into the blood; but we may leave this out of account for the present.

Now let us consider more closely what is happening in the blood. From the mechanical standpoint it is being pumped round the body and through the lungs by the action of the heart, and on chemical examination of it we find that its corpuscles contain a coloured substance, haemoglobin, which has the property of taking up oxygen to form a loose molecular combination, oxyhaemoglobin. The oxygen diffuses off from this substance when the surrounding diffusion pressure of oxygen is low, as in the capillaries of the systemic circulation, and is taken up again when the oxygen diffusion pressure is relatively high, as in the lungs. It thus acts mechanically as a carrier of oxygen to the tissues. Similarly we find in the blood compounds of carbon dioxide and alkali. Owing to the action upon them of haemoglobin and other proteins which act as acids in an alkaline medium, they are decomposed in the lung capillaries when the diffusion pressure of carbon dioxide is relatively low, the alkali combining with the substances just mentioned, and the carbon dioxide being liberated into the alveolar air. In the systemic capillaries, on the other hand, with the diffusion pressure of carbon dioxide relatively high, the alkali recombines with carbon dioxide, the double process of gaseous exchange which occurs in both the systemic and the lung capillaries being specially favoured by the facts that in proportion as haemoglobin is deprived of its oxygen it acts less strongly as an acid, while in proportion as it absorbs carbon dioxide it holds on less tightly to oxygen.

So far the process of respiration can be interpreted as a purely mechanical one, assuming that the required structures and chemical compounds are present, and that the respiratory muscles and heart play their mechanical part in the process. When, however, we put all the observations together, we find that the whole process is regulated in the most delicate manner at every point, and the whole of the structures concerned are being constantly maintained with corresponding delicacy.

In the first place, the pumping action of the respiratory muscles is so regulated as to keep the partial pressure of carbon dioxide in the alveolar air very exactly constant from minute to minute under ordinary conditions. This has the effect of keeping the reaction or hydrogen ion pressure of the arterial blood extremely constant, since the arterial blood becomes more alkaline, or less, according as the partial pressure of carbon dioxide falls or rises in the alveolar air. In fact, the breathing is regulating in the most delicate manner the reaction of the blood—so delicately in fact that no existing method of determining the reaction is sufficiently delicate to follow the slighter variations which are sufficient to produce a marked effect on the breathing. Were it not that the kidneys also are engaged in regulating the balance of alkalies and acids in the blood, so that when the pressure of carbon dioxide in the alveolar air is kept constant the reaction of the arterial blood is also normally almost exactly constant, the pressure of carbon dioxide in the alveolar air would never be steady; and since in man much more acid than alkali is constantly being formed in the body, the blood would soon become acid.

When the reaction of the arterial blood tends to become less alkaline, it excites a nerve-centre or centres in the brain in such a manner as to evoke increase in the respiratory movements, or corresponding diminution or complete cessation if the blood becomes more alkaline, provided that the altered alkalinity of the blood is communicated through cell-walls to the nerve-centres. We can see at once that in this way the respiratory movements are made to harmonize with the varying production of carbon dioxide by the body. This production, for instance, is often ten times as great during muscular exertion as during rest; but the respiratory movements are correspondingly increased, so that the reaction of the arterial blood, or at any rate the liquid in contact with the protoplasm of nerve-centres, is kept almost steady. As, moreover, the production of carbon dioxide runs parallel with consumption of oxygen, an adequate oxygenation of the arterial blood is at the same time automatically secured except under exceptional conditions which are dealt with in the manner described in the discussion of acclimatization in Lecture V of the previous course.

We have every reason to believe that just as respiration is delicately regulated to keep the reaction and oxygen pressure of the arterial blood steady, so the circulation through every part of the body is regulated with similar delicacy to keep the local composition of the blood as steady as possible. Our knowledge on this subject is still, however, very defective, and it is only in man that we can even measure satisfactorily the rate of the general circulation under varying conditions of work, etc., and the gas-pressures of the mixed venous blood returning to the lungs. The ideas, formerly current, of the breathing and circulation going on in a blind mechanical manner are now obsolete, and it was, I think, the exact quantitative study in man of the regulation of respiration that gave them their death-blow. Apart from quantitative study of this kind, in which I have myself been engaged for most of my scientific life, biological co-ordination is entirely obscured.

We can form no mechanical conception of why it is that the respiratory centre responds, and continues to respond, with such amazing delicacy to minute changes in a certain definite hydrogen ion pressure, or why the kidneys show a similar delicacy in response, so that with the very slightest diminution or increase in hydrogen ion pressure of the blood they secrete urine containing either far less or far more acid, thus exerting a most powerful influence in steadying the reaction of the blood. Calculation from our actual experiments on man shows that a deficiency in ionized hydrogen of one part by weight in about one million million parts of arterial blood is sufficient to suspend completely the activity of the respiratory centre, although, owing to cell-walls being only partially permeable to certain substances the reaction of the blood sometimes does not communicate itself fully to the respiratory centre and other parts.

All that we can say from a mechanical or physico-chemical standpoint as to this and other responses of equal delicacy, is that various parts of the body respond, and often with the most amazing delicacy and constancy, to slight changes in their "normal" environment. The kidneys, for instance, respond by immensely increased or diminished excretion of water to a scarcely measurable increase or diminution in the diffusion pressure of water in the blood. This, as I have shown in my book on *Gases and Liquids,*[1] has hitherto been wrongly called a diminution or increase in the osmotic pressure of the blood.

When the chemical nature of substances which evoke responses is unknown, they are now usually called "hormones" if they are produced within the body, or "vitamins" if they come from outside sources; and there is a curious popular idea abroad that the discovery of hormones and vitamins is a great step towards a physico-chemical explanation of life. In actual fact, however, the more we discover as to the physiological necessity for the presence in the blood of various substances in specific amounts, often extremely small, the further are we from any physico-chemical understanding of life, since there is just so much more for the specific maintenance of which we have no physico-chemical explanation. We also must not mistake the invention of a convenient word for the discovery of something new in principle. Practically every substance present in the body,

[1] *Gases and Liquids,* Oliver & Boyd, 1928.

beginning with water, which is the most abundant substance, acts when in solution in the same physically and chemically unintelligible manner as a " hormone " in the narrower sense.

Not only is the influence of hydrogen ion pressure (and oxygen pressure) on respiratory activity physically unintelligible, but the maintenance and development of all the structures and chemical substances essentially concerned in respiration are equally unintelligible physically. Almost as a matter of course we assume that these structures and substances are maintained in their normal state of delicate adjustment; but when we ask how this is brought about there is absolutely no answer from the physico-chemical side. How, for instance, is the living structure so maintained that liquid is prevented from leaking out of the blood into the alveoli? As death approaches, wholesale leakage often begins to occur with dramatic suddenness. The " death-rattle " of pulmonary oedema has been familiar since antiquity. We can investigate one by one the various conditions on which the maintenance or development of normal structure and composition depends, and there seems to be no limit to the complexity of these conditions from the physico-chemical standpoint. But of their specific coordination in maintaining and originating normal structure we can find no trace of a physico-chemical explanation, so that each discovery makes the attainment of such explanation seem more remote.

What we do discover, however, and in ever-increasing detail, is that when we look at the phenomena of the life of any organism in their relation to one another, they are the expression of actively maintained specific and co-ordinated unity. The structure is an expression of specific co-ordinated activity; and the activity is specifically co-ordinated in such a manner that the structure is maintained. It is true that when we isolate from one another the phenomena of life we see nothing more than the essential chaos of self-existent units of matter and energy acting on one another in a manner which though here intelligible is there quite unintelligible. But this appearance of chaos and unintelligibility vanishes when we regard the phenomena as a whole and interpret them biologically. We then see clearly the active maintenance and reproduction of specific structure which we call life. We also realize that the assumption of this maintenance furnishes us with a working hypothesis which gives us a clue through the apparent unintelligibility, and enables us to predict what will happen and see backwards into what has happened. This working hypothesis is the working hypothesis of biology, and differentiates biology completely from the physical sciences. In so far as we do not yet see how to apply this hypothesis we have to content ourselves with provisional physical interpretation, so far as it goes; but it is mere futility to shut our eyes to the co-ordination in so far as it is already known and embodied in the very nomenclature of biology, or to cease to search for it where we have not yet traced it. Such is the futility of attempted mechanistic interpretation.

Let us imagine the physical picture of what is occurring in a lung alveolus. The alveolus seems to contain a swarm of myriads of perfectly elastic molecules moving with enormous velocity and colliding at all angles with one another and with the alveolar walls. The scene is apparently one of absolutely chaotic interaction of minute " bodies." Molecules of oxygen are also constantly shooting into and through the molecular interstices of the alveolar and capillary walls and so disappearing, but are replaced by means of an intermittent stream of pure air passing up and down the bronchial tubes. In a similar manner molecules of carbon dioxide are appearing and being carried away. It is because the walls are sufficiently leaky and of sufficient surface, and since the partial pressure of oxygen (though not of nitrogen) molecules is greater on the inner than on the outer surface of the walls, that, by the law of probability, on the whole more oxygen molecules pass inwards than outwards, and similarly for the passage of carbon dioxide outwards. It is also because when the alveolus alternately expands and becomes smaller there is alternately a less and greater concentration of molecules within it that, by the law of probability, air passes out of and into it, more oxygen and less carbon dioxide being present in the incoming than in the outgoing air, so that, on the whole, oxygen passes into the alveolus from the outside air, and carbon dioxide passes out.

If we confine our attention to the gas in the alveolus, this mechanical picture seems to represent what is occurring within it, and according to the Newtonian " philosophy " represents reality. But the activity which ultimately maintains the flow of gas molecules, the structure of the alveolar walls, and all the other structures involved in breathing, determines all the phenomena, and we perceive the specific character of this determination in perceiving the life as a specifically co-ordinated whole, just as it is as a whole, in which self-existent letters, or daubs of paint, or notes, disappear, that we perceive a word, or a sentence, or a picture, or a piece of music. As participating in the life of the organism, the activity in the lung alveoli and other responding structures has taken on an interpretation quite different from the physical interpretation. It is not mere mechanical chaos, but organic co-ordination that we perceive; and to a biologist the organic co-ordination is the essential feature.

If we insist that the organic co-ordination which we find in the activities of a living organism is only something imposed from without on the physical reality, we are involved in all the difficulties of vitalism or animism. The only possible course, therefore, is to conclude that, in spite of appearances, when we regard part of the phenomena in isolation, the organic co-ordination is part of their very nature, so that the biological interpretation of the phenomena is the truer interpretation. In other words, the phenomenon we are dealing with is no mere chaos of self-existent bodies acting on one another, but is the expression of life.

This involves a radical change in our interpretation of the phenomena, since it is now only in superficial appearance that the mechanical interpretation holds good. We can hardly help glossing over the change in interpretation by means of the assumption that the co-ordination is only a form of artificial restraint by an outside influence in the form of a " vital force " or by whatever other name we designate this influence.

This course is not open to us, however, as has already been pointed out. We cannot escape the conclusion that the physical interpretation must in ultimate analysis give place to a biological interpretation.

It still remains the case, nevertheless, that it is only ultimately that the biological interpretation holds good. The transition to biological interpretation has the character of an act of faith. There is far more in the phenomena than we can see how to interpret biologically, just as there is far more in an actual picture than we can see how to interpret artistically. Though the apparent mechanical chaos is not really a chaos, yet it is only imperfectly and by contrast that we can interpret it as being actually organic co-ordination and unity. The process of normal respiration may, for instance, be interfered with by some apparent mechanical cause, and from the biological standpoint this failure of organic control is unintelligible. Thus in order to fill in to the best of our ability the gaps in biological interpretation, we must have recourse to physico-chemical interpretation, and this interpretation, in its proper subsidiary place, is indispensable. Without clear mechanical theories of gases and liquids, of solution and diffusion, of partially permeable membranes and osmosis, and of chemical combination and dissociation, we could not piece together a coherent account of physiology, however true it is that the mere application to physiology of mechanical conceptions leads to only a confused medley of isolated observations, which are of little use for practical purposes.

Apart from the biological conception of active organic co-ordination, the physiology of respiration, or of excretion or circulation, is not only quite unsatisfactory, but is also apt to be very misleading. It tends to become, in fact, a futile travesty of scientific knowledge. On the other hand, unless we have clear conceptions as to what can be interpreted in physical and chemical terms within and around living organisms, we can form no clear ideas as to organic co-ordination. Looking back at the attempted mechanistic physiology of the latter part of last century, what is very striking is the absence of clearly applied physical and chemical conceptions from the minds of the leaders of the movement, although they were constantly speaking of physico-chemical explanations. Their attempted physico-chemical explanations of physiological activities were woolly to an extreme extent.

For purposes of illustration I have considered the case of alveolar air. A similar process of reasoning would apply to the contents of the alimentary canal or to the composition of the blood at any part of the body. Within what we are accustomed to regard as the substance of the body itself, organic co-ordination seems, however, to manifest itself in a much more directly effective and striking manner. Specific composition and activity are evident at once, without our having to seek for it by careful and accurate analysis and measurement. The more, also, we succeed in applying analysis and measurement to the substance, form, and activities of living protoplasm, the more clearly does organic co-ordination manifest itself. The days are long past when "protoplasm" was regarded as merely a solution and suspension of simple though somewhat indefinite composition. Not only the structure, but also the composition, of any variety of cell is specific and complex, while the activities of the cell are such that this specific structure and composition are being constantly maintained and reproduced. Each individual cell, moreover, plays its specific part in maintaining the specific structure and composition characteristic of the life of a specific organism.

This part is never a mere mechanical part. We must regard each cell as behaving in a specific manner in presence of neighbouring cells, so that their nutrition and growth are " normal." At the same time the nutrition and development of cells at a distance are organically co-ordinated. The behaviour at a distance in this way of so-called ductless glands and other organs is now well known. Perhaps, however, it is apt to be forgotten that the mere fact that the body develops and maintains itself as an organic whole shows quite clearly the co-ordinated mutual behaviour of all the different parts in the promoting or restraining of development. This influence is exerted in part direct from cell to cell, but largely through the blood-stream.

Owing to the artificial separation of anatomy from physiology it was for long imagined that different parts of the body develop and grow independently of their influence on one another, and that, for example, developing germ-cells develop independently of the influence on them of the rest of the parent organism. These ideas are devoid of any real foundation, and are inconsistent with the conception of organic co-ordination and unity. There can be no real separation between anatomy and physiology, although, under the baneful influence of attempted mechanistic or vitalistic conceptions of life, anatomy almost abdicated its position as an experimental science.

The alveolar air, or the contents of the alimentary canal, or the blood, may be regarded as the more or less immediate environment of the body-cells. The relation of the external environment to the conception of organic unity will be discussed in the next lecture.

LECTURE XIII

BIOLOGICAL AND PHYSICAL ENVIRONMENT

THE organic unity displayed in the immediate environment of a living organism is evident enough, and becomes more and more evident as biological investigation is extended. This is not only the case as regards the blood, which may be designated, after Claude Bernard, as the internal environment of higher animals, but also as regards the immediate environment in a wider sense, including the alveolar air, intestinal contents, and usually also the temperature, moisture, and movement of the air in immediate contact with the skin. When, however, we consider the environment in a wider sense, we are apt to think that the conception of organic unity cannot be extended to it.

An organism is physiologically connected with the wider environment through its skin, organs of sense, or in the case of lower organisms and plants through receptive structures of various kinds. In the case of plants, for instance, the combined influence of light and the surrounding atmosphere is largely through chlorophyll-containing cells beneath the epidermis, which itself, with the aid of stomata, controls the influence of the surrounding atmosphere.

Let us consider the connexion between a higher organism and its wider environment through its skin and sense-organs. We can endeavour to regard this connexion from a mere physical standpoint, just as we can consider respiration, circulation, or digestion from this standpoint. From the physical standpoint impressions are constantly being produced on the skin and sense-organs, and may be transmitted in a reinforced state along afferent nerves or through the blood to the central nervous system. Here they may spread, with further reinforcement, until they reach nerve-cells connected by efferent nerve-fibres with muscles and other organs of which the activity is aroused or inhibited by them, this being the final response of the body to afferent impressions.

It is of considerable practical service to be able to interpret the connexions in this way, and to follow out all the details of the connexion. There is, however, no direct biological interest in such interpretation, and its inadequacy is evident at once. As soon as we enquire further into the connexion it becomes evident that not only the impressions on the sense-organs, but also the whole train of further consequences, are coordinated in a manner of which the physical interpretation has given no account. In the case of conscious responses there are, in addition, all the characteristic features of perception and conscious response, to which the physical interpretation gives us not the smallest clue. Consciousness may, however, be entirely absent, so far as can be ascertained, and it is only the purely biological aspect of what is happening that will be considered in this lecture.

The biological connexion between organism and environment through the sense-organs and skin can be studied quite easily in man by observing sensory activities of which we are conscious, and at the same time deliberately leaving out of account their psychological aspects as perceptions of a surrounding world. In other words, we can study them simply as physiological activities, or as physiology of the senses, just as we study unconscious activities of respiration, nutrition, excretion, or circulation.

The first point to be made in connexion with sensory activities is the constancy of their influence. At first sight it might seem that when the surface of the body, or the fields of vision, hearing, smell, or taste, are not specially excited by some external disturbance, there is no sensory or afferent influence in the corresponding fields. That this view is a mistaken one becomes evident when we reflect that the particular character of efferent activity depends at all times not merely on special isolated afferent stimuli, but also on many other simultaneous afferent influences. The particular sort of movement evoked in a limb by an external disturbance or " stimulus " depends on innumerable afferent exciting or inhibitory influences corresponding to the position of the limb at the moment and that of the whole body, together with all the chemical or so-called metabolic influences which determine the strengths of afferent impulses. A living organism does not behave like a machine which when some particular stop is pressed or handle turned responds always in some particular manner. The manner depends on an indefinite number of other stops, constantly in variable operation and reacting on one another in an indefinite number of different ways. From a physical standpoint, therefore, the response of the living organism to external disturbance depends upon endless circumstances. The simple general conception, which Descartes illustrated in his *De Homine,* of reflex responses does not at all correspond with observation.

Throughout all this endless complexity the one thing which appears as a net outcome is that the life of the organism is maintained or fulfilled in a characteristic manner. This is an elementary fact of observation, just as from the physical standpoint the existences of mass and energy seem to us to be elementary facts. In other words, we perceive that the connexion between an organism and its external environment is a living connexion in virtue of which specific living structure is maintained through specific activity, so that we can designate the connexion as the life characteristic of a species, and investigate its details from this point of view, which is that of biology.

From a physical standpoint the maintenance of the specific structure of a living organism in presence of a constantly and chaotically changing external environment would appear as a continuous miracle demonstrating the presence of some sort of supernatural intervention. From the biological standpoint life is just a manifestation of Nature, and it is no mere miracle or inconceivably improbable coincidence of physical events that an organism nourishes itself, reproduces itself, and maintains its specific structure and activities. The environment is thus not something foreign to it, but enters into its own life. What influences its receptive organs and structures influences them as participating in the unity of its own life, so that this life extends indefinitely beyond the confines of the body. To a biologist the external environment of an organism enters just as much into its life as the parts of its own body or the internal environment. Through the organs of sense and other receptive organs the surrounding external environment participates in its whole life, and biology interprets this participation.

From a physical standpoint material and energy are constantly or at intervals entering the body of a living organism, and afterwards leaving it; and we can balance the intake of both material and energy against the output if nothing is left in or taken from the body. The balance is always true, leaving no demonstrable margin corresponding to any other appearance or disappearance of either material or energy. On the other hand, however, the intake and output of both material and energy are subject to constant physiological co-ordination. This means no less than that the influence of the environment on the organism, and of the organism on the environment, expresses the maintenance of specific normal structure and activity. Of this there is not only no physico-chemical explanation any more than there is for the maintenance of structure and activity within the body, but, just as between the parts of the body, the relation also between the body and its environment expresses the maintenance of what is normal.

Wherever physiology is concerned, as in the general physiology of nutrition, with the relations between organism and environment, it is the maintenance of normal conditions and the manner in which that maintenance is brought about that are of interest. Our knowledge of what these normal conditions are, and how they are maintained, is constantly growing; but the conception of normal conditions and their maintenance is fundamental, whether we are considering the phenomena of life within the body or its relations to environment. In biology we never get away from the specific conception of life, and the attempt at a mere physico-chemical account of the relations between organism and environment misses the relevant facts and leaves us in a chaotic maze of quite unintelligible causal connexions. If we take the fashionable word " bio-chemistry " in its literal sense, and set out to give a purely chemical account of the phenomena of nutrition, we lose ourselves inevitably in this maze. My work as a physiologist has been almost entirely on the chemical side, and I am speaking from wide experience, though no one realizes better than I do how useful the word " bio-chemistry " has been in obtaining much-needed endowments.

Let us now consider the general characters of the physiology of vision. Through vision a living organism is kept in active connexion with its environment in all directions up to indefinite distances. The field of vision, however rudimentary may be the organs of vision, brings the body into an oriented relationship with the whole of a biologically co-ordinated environment simultaneously, just as the tactile field does. This relationship is preserved in higher organisms through the mobility of the eyes and head and the presence of the crystalline lens, which projects on the retina an image of the environment. For the individual organism space-arrangement is its own individual space-arrangement, centred in, or relative to, itself, and thus essentially relative.

Visual orientation is closely co-ordinated with tactile, heat-sense, auditory, gustatory, and olfactory orientation; and though visual, auditory, and olfactory activity may not coincide with tactile activity, the combined field of co-ordinated sense-activity is solid. When we consider the nature of the oriented connexion through sense-activity, the biological connexion shows itself to be different from mechanical connexion, for we cannot separately distinguish influences of one sort from other influences. The influences of different parts of the visual field do not appear and disappear in the same manner as in mechanical action, though varying in action from moment to moment. They also persist as a whole, and in specific interconnexions with one another, just as the specifically co-ordinated activities within the bodies of living organisms persist actively. We find that the activity of one part of the field of vision is bound up with the activity of other parts, and thus depends on what we call contrast. As activity increases in one part of the field it automatically diminishes in other parts; but in the field as a whole it tends to remain constant. Weber's law of sensation, according to which the degree of excitation in any part of the field depends, not on the exciting influences as measured physically, but on their relation to simultaneous other excitations in the field, is of fundamental biological significance.

If, as in photometry, we wish to measure physical differences in strength of light-excitation, we can do so accurately if we keep the surrounding field even in its influence, as when, in comparing two illuminations, the whole of the rest of the field of vision is either darkened or evenly illuminated round the two illuminated surfaces which are being compared. If the surrounding illumination is uneven, the comparative measurement is more or less falsified; and this is particularly evident in comparing tints of colour, as we find at once on transposing the tinted surfaces. A painter represents depths and tints of illumination as they appear physiologically, and not as a physicist might measure them. In this respect the painter, like the physiologist, neglects completely the "physical reality" of intensity and predominant wave-length of radiation. To painter and physiologist alike, what is bright or coloured in a definite manner depends on the surrounding depths and tints of illumination. It is only through confusion of mind that we identify brightness and colour with intensity and wave-lengths of physical illumination.

As regards the delicacy of visual excitation, it is well known, for instance, that within enormously wide variations of general illumination in the physical sense, the apparent brightness and the visibility of objects remain about the same. The physical illumination may be a thousand times greater with bright daylight than by the light of a candle at a distance of one or two feet; but objects seem to us about equally bright and visible with either illumination. It is only when we go to extraordinarily low illuminations in the physical sense, particularly when, as in a coal-mine, very little light is reflected by the illuminated surfaces, that objects become indistinguishable. Even when they are at first almost indistinguishable, as when a coal-miner, with only the illumination given by one of the very inadequate flame or electric safety hand-lamps still ordinarily used in this country, goes from daylight to the pit-bottom, the eye soon adapts itself so far to the dim illumination that surrounding objects become fairly visible.

When surrounding objects become invisible, this is not because visual excitation is absent, but because excitation produced in another way than by what we regard as external causes becomes so strong as to obscure the latter excitation, if a source for it is still present. In a room which is perfectly dark, the field of vision is not black but on the whole grey, though variegated and full of movement. It is not nothing that we see, but only nothing " objective."

It is the same with the fields of our other senses. They are never empty in a physiological sense; and this is shown by the fact that the condition at any time of one field influences in a definite manner the responses to stimuli in other fields. In the dark we automatically proceed warily; and the absence of some particular set of afferent stimuli, such as those accompanying contact of the foot with the ground, may automatically stop or completely alter muscular movement.

It is quite impossible to interpret the actual relations between a living organism and its spatial environment as a mere relation between the self-existent " bodies " of Newtonian physics. The influences of the physical bodies cannot be distinguished separately. A living organism does not respond to objective reality as interpreted physically. The physical or physicochemical influence appears to be distorted or altered to an indefinite extent. The assumed "primary" physical characters of the environment are overwhelmed by "secondary" characters which seem, from the physical standpoint, to be conferred on the environment by the organism. The physiology of the senses investigates these "secondary" qualities scientifically. This and other parts of the physiology of the nervous system are often confused with psychology.

When we examine these secondary characters, we find that to a constantly increasing extent we can interpret them biologically as corresponding to the physiological requirements for maintenance of life when the life of the organism is regarded as an actively and specifically maintained whole, including within itself the active relations between organism and environment. What seem from a physical or chemical standpoint to be mysterious variations in excitability, "tropisms," etc., become intelligible biologically. The more we study them, the more and more intelligible do they become biologically, and the less and less intelligible physically. In this respect they are on exactly the same footing as the phenomena of respiration, circulation, absorption, excretion, etc., as discussed in the previous lecture.

The mechanistic school of physiologists assumed, and still assume, that it is not legitimate to interpret phenomena biologically in the sense which I have just indicated. For them visible and tangible reality is physical reality in the sense to which Newton gave clear definition, and there is no other visible or tangible reality unless it be something supernatural or else, perhaps, occurring in conjunction with consciousness within the body of an organism. To speak of distinctively biological interpretation of the environment thus implies " teleology " worthy of only the scholastics or of persons who do not make use of the common sense which is constantly confirming the Newtonian conception. Since the days of Francis Bacon, Galileo, and Newton, " teleological " interpretations of our external environment have been out of fashion, and the vitalists were in complete agreement with the mechanistic physiologists on this point.

On the mechanistic interpretation the apparent " teleological " relations between organism and environment are only apparent. Though organisms live through their reactions with their environment, this is only because their structure has peculiar characters which bring this about. According to theologians, this structure was given them in the remote past by a supernatural Creator. According to mechanistic biologists, the structure was acquired in the course of long ages, and became a dominant feature, specifically characterized for each species, through the influence of natural selection. The assumption of existing specific physico-chemical structure in the bodies of each species of living organism is thus an essential part of the mechanistic theory. Considering the amazing definiteness and complexity in the reactions of known living organisms, with their environment, and between different parts of their own bodies, the structure must be almost inconceivably complex. Nevertheless the mechanistic conception, whether theological or materialistic, seems a possible one so far. Let us follow it out farther, however.

Quite clearly, the mechanistic interpretation assumes the fact of hereditary transmission, and apart from hereditary transmission the theory of natural selection or of supernatural creation in the remote past would be meaningless. But what do we assume when we assume hereditary transmission? On the mechanistic interpretation, hereditary transmission means the reproduction in offspring of an enormously complicated physico-chemical structure. We must sweep away the crude idea that what happens is simply the increase and division of an albuminous substance without definite structure, called protoplasm. The substance must, on the mechanistic interpretation, be enormously complex and yet perfectly definite in molecular structure. But if it is so complex, how can we imagine its dividing into two parts, one at least of which must have the capacity of repeating the process indefinitely often?

A mechanist of robust faith would reply that though we do not understand the process, there *must* be some molecular mechanism by which the reproduction is brought about. In accordance with his robust faith he will also speak of the "mechanism" of reproduction. But the more we ponder over this question the more clearly does it appear that the idea of a complex mechanism which can also reproduce itself or mend itself is not a coherent idea at all. In fact no scholastic absurdity was ever more of an absurdity than a mechanism of heredity. Those who may still have a lingering affection for a mechanistic conception of life, or who imagine that life must be something which had a beginning in time, would do well to ponder further over the nature of hereditary transmission. A mechanism of hereditary transmission is simply a contradiction in terms.

The reason why organism and environment are complementary to one another in such a way that life maintains itself cannot, therefore, be simply that the physico-chemical structure of any living organism is such as to promote this maintenance. It is quite true that what appears to us as mechanical structure and arrangement in the bodies of living organisms is always admirably fitted to promote their particular mode of life, whether they may be amoebae, elephants, oak trees, or human beings. Their structure and biological environment suit one another. But if, as I have argued, the life which manifests itself in a living organism is an actively maintained whole without spatial boundaries, both the structure and the life-activities of the organism must be manifestations of this organic unity, so that they fit one another in the manner found to be actually the case.

Heredity, the way in which a living organism is constantly renewing or replacing its structure, and the fact that structure is suitable to environment, are alike manifestations of life. They are not matters which either require or are susceptible of explanation in physical terms. In other words, they are just Nature—what is. We can observe and investigate their details as manifestations of life; and this is what biology actually does, with signal scientific success and practical advantage. To ask for a physical explanation of them is only blind foolishness.

Thus the conception of life as a specific co-ordinated unity of structure and activity applies indefinitely beyond the immediate environment of any living organism, and can be confined neither to anything within its body that might be distinguished as being specifically alive, nor to within the more immediate environment. The biological interpretation is, in fact, different from the physical interpretation, but applies over the same phenomena; and by no possibility can we reduce biological to physical interpretation on the lines laid down by Galileo and Newton. However far we pass outwards from a centre of life, the biological interpretation is still there.

Just as within the bodies of living organisms we find scope for the application of both a biological and physical interpretation, so do we in their environment. We cannot consistently express in physical terms the observations which we interpret biologically. Nor do we see any way clear to expressing biologically the details which we interpret physically. But in view of the irreducibility of biological to physical interpretation, the only possibility of reaching consistency as regards interpretation of the two sets of observations would be by extending the biological interpretation to the observations interpreted physically. It is only, however, by an act of faith that we can do so. We cannot actually perceive life in the details of what we at the same time interpret as an inorganic world.

This faith is no mere groundless belief, but is based on the postulate, which is that of all knowledge or science, that our experience is ultimately consistent with itself. The mechanical interpretation of our experience is certainly inconsistent with biological observation; but in the growth of biological knowledge we see the continuous extension of biological interpretation to what we at first could only refer to in physical terms. There is no limit to the possibility of further extension in this direction in the future. On the other hand, there is no possibility of interpreting biological observations physically. We can, it is true, very often apply new physical interpretations to phenomena within and around living organisms; but just in proportion as we do so we find that we are also in presence of extended biological interpretation, so that biological interpretation has increased in the manner so strikingly exemplified, as already pointed out, in the history of physiology.

To put the same conclusions in a different manner, physical interpretation is of a more abstract character than biological interpretation. In physical interpretation, that is to say, we are leaving out of account essential features which must be present, though we cannot perceive them, and which are actually taken into account in biological interpretation. Just as physical interpretation takes into account features in our experience which are not taken into account by purely mathematical science, so does biological interpretation take into account features which are not taken into account in merely physical interpretation. For this reason we get nearer to reality in biological interpretation, and we are dealing to a less extent with mere abstractions, however useful in certain practical applications these abstractions may be, just as are the still greater abstractions of mathematical science.

I have dealt in this lecture with the external environment of living organisms because even when it is clearly seen that within the living bodies of organisms merely physical and chemical conceptions are inadequate scientifically, it is often supposed that in the external environment nothing but physical and chemical interpretation is required, and that we are surrounded by an environment in which mechanical chaos reigns supreme. This is even regarded as nothing but common sense.

I wish to emphasize as strongly as I can that the belief in a merely physical world surrounding us has no basis. Our environment is not something indifferent to our lives, but belongs to them. Surrounding Nature is not an influence outside our lives, but within them. From the standpoint of biology, Nature is not merely a healing and beneficent influence within the living body, as Hippocrates first clearly pointed out and every educated doctor takes as axiomatic, but is a healing and beneficent influence in the whole of our environment to the farthest depths of space. The supposed common-sense view to the contrary is only the common ignorance characteristic of the particular times in which we live. The facts of biology were left out of account in the scientific reasoning from which that view originated.

Had they been taken into account effectively, it would have been impossible to represent visible reality, as Newton did, as corresponding simply to the physical representation of it. But in Newton's time life was regarded from either the vitalistic or mechanistic standpoint, and this state of matters has continued up to the present time. In my book *Mechanism, Life,* *and Personality,* published first in 1913, I pointed out the impossibility of either the mechanistic or vitalistic conception of life. But nothing is more difficult than to persuade people to think, and to judge from various recent references to my opinions, I am commonly set down as a vitalist, or perhaps as a "neo-vitalist."

The world has been familiar for long with mechanistic and vitalistic conceptions of life. As neither of these conceptions is satisfactory, it is surely time to do a little thinking on the subject of life. In this connexion I was particularly pleased to see, in the Presidential Address given by Professor Lovatt Evans to the Physiological Section at the recent (1928) meeting of the British Association in Glasgow, that he has reached conclusions essentially similar to my own.

At the same meeting the mechanistic view of life was presented in a popular lecture by Professor Donnan. Needless to say I regard this view as now entirely obsolete, since it ignores the observed facts; and this is far more evident now than it was a few years ago, before physiology had become to so large an extent a quantitative science. The fact that Professor Donnan, though his work in physical chemistry commands universal respect among those who know it, is not a physiologist, may partly account for his opinions.

LECTURE XIV

PSYCHOLOGY AND MORE ABSTRACT SCIENCES

IN the two previous lectures I have discussed the relations towards one another of physical and biological interpretation, but in this discussion no account whatever has been taken of conscious behaviour, including perception and voluntary action. We must now take conscious behaviour into account.

In the first course of lectures it was pointed out that conscious behaviour differs from what we interpret as mere biological behaviour owing to the fact that conscious behaviour is no mere immediate response to momentary happenings, but involves both retrospect and foresight. A conscious organism is responding, not to chaotic impulses of a physically interpreted world, nor simply to the spatially co-ordinated stimuli of a biologically interpreted world, but to perceptions of a world which is co-ordinated not merely as regards space-relations, but also as regards time-relations. Past and future happenings are definitely co-ordinated as progressive interest with the spatially co-ordinated present, so that past and future are bound up with the present. Thus the perceived world is a world of co-ordinated duration or progress.

When co-ordination expresses itself not merely in momentary behaviour, but in relations to past and future behaviour, it expresses what we call interest and constituent values. A conscious organism or centre of life is thus a centre of values or interest. Its behaviour expresses far more than that of what we regard as a mere living organism, since it is " responsible " behaviour, co-ordinated in such a way as to bring past and future happenings into the sphere of co-ordination. The responsibility is no less in respect of perception than of voluntary action: for perception is no less an active response than voluntary movement. If, through want of care, we have failed to perceive the proper occasion for action, we are just as responsible as if, seeing the occasion, we had not taken proper action. To what we interpret as a mere living organism, responsibility is meaningless.

In discussing the relation of the psychologically interpreted world of interest and values to the physically or biologically interpreted worlds we must dismiss from our minds the idea that the psychologically interpreted world has no real existence of its own, so that we could regard it as merely a physically or biologically interpreted world accompanied by a mysterious something called consciousness. This idea is just as groundless and inconsistent with experience as the idea that we can reduce biological to physical interpretation. We can neglect or strip away the psychological aspects of experience, just as we can neglect the biological aspects; but all that is left is a travesty of actual experience. We cannot reconstruct actual experience out of this travesty. The facts embodied in psychological interpretation are not only clear and undeniable, but they do not admit of statement in terms of either physical or biological interpretation.

This is because of their very nature. A perception, or conscious response to it, cannot be described as a mere physical impression or result of it, nor as a merely spatially co-ordinated response to a spatially co-ordinated stimulus. Such an impression or stimulus would carry with it no reference to past or future impressions or stimuli—not even a bare qualitative difference. It was Kant who, in his criticism of Hume and the eighteenth-century English school of psychology and philosophy, pointed this out clearly, and his criticism was fundamental. Perception is no mere occurrence in time, for time-relations are included in perception. Kant expressed this conclusion by saying that time-relations constitute a form imposed on objects in their perception. Thus for Kant, though as a former professor of physics he was greatly interested in astronomy and had put forward the nebular theory of the origin of planetary systems, time was not something within which mind exists, but only an expression of mind itself.

Kant did not infer that mind makes the universe, but only that mind gives to it the form which it takes in our perception of it. Behind the visible and tangible world of our perceptual experience there was for Kant a world of "things-in-themselves," while the visible and tangible Newtonian world of bodies existing in time and space and acting on one another was the form given in perception to the world of things-in-themselves.

This was Kant's mode of reconciling the facts relating to perception with the Newtonian interpretation of the visible world. But we have already seen that there is a visible world of life coinciding with the visible Newtonian world and not reducible to it. Had there been a biological Newton, Kant would certainly have hesitated about his postulate of a real world of things-in-themselves, since for biological interpretation things-in-themselves do not exist. We can even speculate as to how Kant's view might have been altered if Goethe, with his deep poetic insight into the phenomena of life, had written before or alongside of him. Actually, however, biological conceptions were for Kant only "heuristic principles," incapable of systematic scientific application to the visible world of perception.

Not only is there a visible world of life, but also a visible psychological or spiritual world of interest and values. What is interpreted as belonging to this spiritual world does not manifest itself as separate events succeeding one another in time, but as events inseparable from one another in both space and time, just as the parts and environment which participate in life are inseparable in space. The world regarded as a perceived world is thus a world of interest and values. It is only through interest that our perceived world is unified in perception and conscious action. Physical and biological interpretation are incapable by themselves of unifying it as we find in our actual experience that it is unified. But it is unified in our interest, which extends, as perceived, throughout both space- and time-relations.

The interest and values which give unity to our experience are not in reality separable from one another, though by artificial distinction we may regard them separately. We become hungry and thirsty no less if we are poets or men of science than if we are manual workers, and satisfaction of hunger or thirst is an element unified in the interest of the poet or man of science no less than in that of the manual worker. The smell of food or the sight of drink appeals to them all, and so, probably, do poetry, science, and craftsmanship, though the degrees of interest they take in these may be different.

Interest and values are not mere interest and values of individuals. This is evident at once when we consider actual conscious behaviour, whether in men or animals. Perceptions and conscious actions include perceptions and actions of far more than individual interest, and what has this wider interest has a value which cannot be regarded as a sum of individual values. Unselfish actions are not such as we count on an ultimate personal return for. The really unselfish person likes doing them, but only because he is inspired by an interest which is far more than his mere individual interest, and which is also an interest only showing itself in his relations with other persons. This subject will be discussed more fully in the succeeding lecture, but meanwhile I only wish to point out that interest and values and the corresponding perceptions and actions are not merely centred round individual persons as such.

We seem to find ourselves in presence of a physically interpreted, a biologically interpreted, and a psychologically or spiritually interpreted world, the latter being a world of interest, values, and responsibilities. Each of these interpretations bases itself on our actual experience, and thus lays claim to objective significance.

But as regards the experience appealed to we must remember, with Kant, that this is perceived experience. There is nothing else that we can appeal to. We cannot jump out of our own skins. Since, however, it is only perceived experience that we can appeal to, the character of perception must in reality enter into even our physically interpreted world, and perception implies that whatever is perceived is so in virtue of co-ordinated relation, both spatial and temporal, to the rest of experience.

In view of this conclusion, a physical universe of self-existent bodies, such as we ordinarily, following Newton, imagine to exist, can have no real self-existence in its parts. The assumed self-existence can represent no more than a working hypothesis which is convenient in our interest in so far as it works, but is not ultimately correct.

Recent developments of experimental physical investigation, apart altogether from biological, psychological, or philosophical considerations, have been tending more and more to undermine completely the foundations of the Newtonian conception of physical reality, although in other directions the application of this conception is being extended very fruitfully. I am neither sufficient of a physicist nor sufficient of a mathematician to follow in detail all the developments which are inconsistent with the Newtonian conception; but I must at least attempt to discuss these developments in a general manner, and it will be convenient to do so in this lecture.

On the Newtonian conception, as fully developed during the two centuries following the publication of the *Principia,* the visible world consists of indestructible " bodies " or collections of " substance," acting on one another in different ways, according to their properties, but all possessing " inertia," which is a measure of their substance or mass. They can act, either on what we picture to ourselves as actual contact, or at a distance in various ways; but all bodies attract one another in proportion to their masses and inversely as the squares of their distances apart in accordance with the law of gravitation, so that inertial mass and gravitational mass are identical. In acting on one another the bodies communicate " energy " or the power of action to one another, and this energy is just as indestructible as the substance of the bodies.

When we examine the bodies we find that they consist of atoms with certain quite definite properties and amounts of substance. Moreover, the different atoms have relative masses which led Prout, more than a century ago, to suggest that they are in some way additive compounds of an elementary unit of mass. This idea has been definitely verified recently through Aston's discovery that elementary substances which seem to contradict the hypothesis are in reality mixtures of " isotope " elements, each of which accords with the theory. Thus we might say that not merely does mass occur in the form of atoms, but that atoms are multiples of a single more fundamental " quantum " of mass.

So far there is nothing inconsistent with the Newtonian conception; and the general theory which was reached about the middle of last century as to the nature of the gaseous, liquid, and solid states of matter, and as to the nature of heat and temperature, were also consistent with the Newtonian conception, and constituted extremely important extensions of its application. But the Newtonian conception tells us nothing as to why atoms have masses which are multiples of a definite unit, and further investigation of both the atom itself and the manner in which it communicates energy to its surroundings has progressively revealed additional difficulties for the Newtonian conception.

To take one example, the discovery of radio-active elements by the Curies, and of the disintegration of atoms in the process of radio-activity, has shown that an atom itself contains enormous stores of internal energy, part of which is liberated when an atom disintegrates. But why, when atoms come into contact with one another, does this energy not share itself with the environment under ordinary conditions? In other words, why does an atom ordinarily maintain its internal energy indefinitely? In a gas, solid, or liquid, the energy of translation and rotation is regarded as sharing itself mutually and between the molecules, as we should expect on Newtonian principles; but if the internal atomic energy of which radio-activity gives us a glimpse were suddenly to share itself similarly, our world would be dispersed into the depths of surrounding space.

Faraday's investigations of the process of electrolysis showed that each atom or other component part of a dissolved substance deposited at either pole deposits also a definite electrical charge. From independent evidence we know that dissolved molecules in the solution have been split up so as to form " ions," which we can regard as each having gained or lost one or more " electrons " by exchange with a corresponding ion or ions. Atoms can thus lose or gain electrons; and the conclusion has been gradually built up through the investigations of J. J. Thomson, Rutherford, Niels Bohr, and others that the atom is a system consisting of a relatively very minute but extremely massive central core or " proton " charged positively, with minute negatively charged electrons of very little mass revolving round it in definite orbits, the distances of these bodies from one another, as compared with their sizes, being comparable to the distances from one another, as compared with their sizes, of the sun and planets of our planetary system. Electrons, or even protons, can easily be made to shoot through very large numbers of atoms without encountering anything.

It is not the mere existence of this marvellous intra-atomic system, but the fact that its energy does not spread chaotically to the atomic environment that is unintelligible from the Newtonian standpoint. Energy is, however, exchanged between the inside of the atom and its environment by what we know as radiation, and the study of radiation has brought still further insight into the nature of intra-atomic activity. The investigations of Young and Fresnel more than a century ago had shown that rays of light and heat could be interpreted as due to wave-motion at right angles to the ray in an all-pervasive and perfectly elastic medium, the luminiferous ether. The phenomena of interference made it possible to estimate the wave-lengths of light corresponding to different parts of the spectrum. With the introduction of good spectroscopes it was found, first, that there were a large number of black lines (Fraunhofer lines) in the otherwise continuous spectrum of sunlight, and then that these black lines corresponded to definite bright lines coming from definite chemical elements when they are strongly heated or exposed to the kathode discharge in a vacuum tube. Thus atoms, when they do take up or give off internal energy, only give it off and take it up as radiant energy of certain definite wave-lengths. These critical wave-lengths form, moreover, a characteristic interconnected series.

In order to explain the general relations between the temperature of radiating bodies and the prevalent wave-lengths of the emitted or absorbed radiant energy, Planck was led to the conclusion that radiant energy is emitted, not with continuously graduated wave-lengths, but with emissions each of which is a multiple of a fundamental unit or quantum, so that if radiation from an atom is occurring at all, it is only by increasing the frequency of emission, or diminishing the wave-length, that the rate of emission of energy can be increased. This must be the reason why, as the temperature of a radiating body rises, the prevailing wave-length diminishes. At low temperatures all the radiation is heat of low, infra-red frequency, while as the temperature rises the radiation passes more and more towards the high, ultra-violet frequency.

The discontinuity in the atomic spectrum is satisfactorily explained by Bohr's conclusion that the orbits of electrons in an atom are not just any orbits corresponding to the amount of heat-energy which may chance to be communicated to the inside of the atom, but only certain specific orbits, so that if the atom gives off or takes up internal energy at all, this will occur in definite amounts, to each of which, in accordance with Planck's conclusion, a certain wave-length will correspond. The application of this hypothesis in detail, particularly in connexion with the relatively simple hydrogen atom, has proved very fertile.

It is not merely as regards the internal energy and mass of atoms, but also as regards their external energy, that selective distribution shows itself. It was discovered early last century by Dulong and Petit that the specific heat of a number of solid elements, when divided by the atomic weight, gives a constant figure. The atomic heat of all these solid elements is thus the same. This was not mechanically intelligible at the time, but became intelligible in the light of the dynamical theory of gases. On that theory the kinetic energy per particle in an extremely numerous collection must, on an average, be evenly distributed and vary with the temperature. This gives us Dulong and Petit's principle at once, though the actual specific heat of a solid must depend also on the heat-energy absorbed in the work of either separating the atoms or compressing them as the temperature rises. It was found by Kopp that the specific heats of many solid compounds are also related similarly to the atomic weights of the atoms present.

For various of the lighter elements, such as carbon or boron, and their solid compounds, the law did not hold. Thus the atomic specific heat of carbon is only a fraction of what the law requires, but, as the temperature is raised, diverges less and less from the law. In the investigation of the specific heats of the solid compounds of other lighter atoms, such as those of oxygen, nitrogen, and hydrogen, Kopp found similar divergences in the atomic specific heats. These lighter atoms seemed to afford anomalous and unintelligible exceptions to the law; but when the atomic specific heats of various elements were determined by Dewar at the very low temperatures obtainable by the evaporation of liquid air, various atomic specific heats were found to diminish; and further, more exact experiments by Nernst and others showed that at very low temperatures the specific heat of solid carbon became inappreciable, while with all other substances the atomic specific heat became very low.

To explain these facts it had to be assumed that a certain amount of " push " is required to produce any effect at all on the movements of the atoms, so that at sufficiently low temperatures, when the pushes become feeble, fewer and fewer of the pushes are effective, and finally a substance like carbon pays no attention to temperature as indicated by the behaviour of a perfect gas. Thus selective distribution of energy and quantum relations again show themselves here in a manner which is inconsistent with the Newtonian conception.

Since the energy of rotation (with its three theoretical degrees of freedom) of an atom is internal energy, a monatomic gas does not take up energy of rotation in proportion to rise of temperature, and thus has only about half the molecular specific heat of a triatomic gas, which can spin freely in all three degrees of freedom, besides being able to move freely in all three degrees of freedom of translational movement. This is only intelligible in view of the selective distribution of energy within atoms.

In studying quantum phenomena of atomic radiation we are in presence of an extended and more comprehensive study of exchange of energy between the inside of an atom or group of atoms and the environment. It is only, however, statistical knowledge of this exchange that we obtain by such study. If we could study an individual atom, the phenomena might seem less anomalous, since they might disclose analogies with the exchange of energy between a living organism and its environment. The form and internal activity of a living organism tend to maintain a normal level in spite of what we interpret physically as actual continuous exchange of energy with the environment. Variation in the characters of living organism tend also, as shown by the investigations initiated by Mendel, to occur in what we might call quanta. The body of a living organism has also what might be described as a quantum structure, perhaps analogous to that of a complex atom. The quantum units are cells and much smaller units of the existence of which the phenomena of heredity have in recent times disclosed particularly clear evidence.

In the study of biology we are studying life as such from within, while in physics we can only study statistically enormous numbers of molecules from without, and therefore from a physical and not biological standpoint. Nevertheless the disclosure of quantum relations in both structure and communication of energy seems to have partially brought physical investigation within sight of distinctively biological investigation, though not within sight of psychological investigation. The point of connexion is that among what we regard as purely inorganic phenomena mechanically unintelligible co-ordination has been found in the distribution of mass and energy, so that mass and energy seem to be manifestations of a deeper reality, as in the case of life.

In a further and still more fundamental respect the Newtonian conception has been undermined by recent developments in experimental physics. In order to explain the propagation of radiant energy it was necessary on Newtonian principles to assume that in addition to the ordinary matter which is always moving about there exists a " luminiferous ether " which is not moving, so that, as the observations of astronomers demanded, light is propagated in it at the same rate in all directions, this rate being dependent on the properties of the ether. But if this ether is stationary and an observer is moving with the earth, it must, on Newtonian principles, be possible to measure the absolute velocity of the earth's motion.

The surface of the earth is moving with great and variable velocity relatively to the sun; and the whole planetary system may be moving at an unknown further velocity. But neglecting this further velocity, the velocity of the earth's surface relatively to the sun is an appreciable fraction of that of light. Since we could easily detect a difference of the order of this fraction in the apparent velocity of light, and since light in travelling from a given point to a mirror and back ought to take longer when the ray is sent out in a direction against that of motion of the earth's surface than when sent out with it, we also ought, by measuring the difference in apparent velocity with the ray sent out in different directions, to be able to deduce the absolute velocity of motion of the earth's surface. When, however, the experiment was made by Michelson in 1887, he found no difference in the apparent velocities, and accurate repetition of the experiment gives always the same result. The measurements thus seemed to point to the impossible conclusion that the earth's surface is at absolute rest—a conclusion which would flatly contradict our other experience as interpreted on Newtonian principles.

This result gave rise to much speculation, which culminated in the inference drawn by Einstein in 1905 that there is no such thing as absolute velocity, since velocity is only relative. This, however, carried with it the conclusion that there is also no such thing as absolute time or simultaneity. To persons travelling at widely varying relative velocities the lapse of absolute time would be different and there can be no such thing as real or absolute simultaneity at different places. Thus time does not exist apart from space and our own movement; nor space apart from time and our own movement. We must therefore think of physical events as occurring, not in space and time separately, but in a four-dimensional space-time.

Einstein pointed out a few years later that since velocity of rotation must also be merely relative, this affects our conception of attractive forces, including gravitation. On the Newtonian interpretation gravitation is an attractive force universally present between any two bodies, and varying directly as the product of their masses and inversely as the square of their distance apart. But the observed attractive force is interpreted as dependent also on centrifugal force due to absolute rotational movement. We allow for this in estimating the true value of purely gravitational attraction. If, for instance, the earth were rotating sufficiently much faster, bodies at the equator would have no apparent weight at all, or a negative apparent weight, in spite of gravitation, though we should still regard it as existing. When we reject the conception of absolute velocity of rotation we must therefore also alter our conception of gravitation.

We cannot by any direct means distinguish between an effect due to gravitational attraction and one due to acceleration. If, for instance, one is in a colliery cage starting rapidly from the pit-bottom, the effects are the same as if the force of gravity had been much increased; and when the cage is near the surface and slowing down rapidly, the effects are of an opposite character, and are, in fact, so like those of a positive acceleration downwards that persons unaccustomed to pits often imagine that the winding-rope has snapped and they are falling rapidly. If, now, gravitation is in reality due to nothing else than acceleration, this acceleration can be no mere acceleration in space, as bodies are subject to gravitation when they are at rest relatively to one another in space. Einstein concluded that it is acceleration in space-time, and due to curvatures or distortions corresponding in space-time to the masses of bodies. Thus bodies moving, as they are always moving, in space-time are deflected towards one another, just as if they were undergoing an acceleration by a force acting on them in the Newtonian sense. It is, however, the distortion of space-time, and not a so-called " force " acting between them, that produces the acceleration.

At first sight this conception may seem to be a rather far-fetched attempt at an explanation of the disconcerting result of Michelson's experiment. By working out mathematically the implications of the conception Einstein showed, however, that it furnishes, in addition, an explanation of what had hitherto proved inexplicable on the Newtonian theory—namely, the variation in the perihelion of Mercury. What was still more striking, however, was that the theory implied a certain definite deflection in rays of light passing close to the sun, and that this deflection, which had never before been suspected, was actually verified in eclipse observations carefully carried out for the purpose of testing the prediction.

On the new physical conception initiated by Einstein space and time do not exist independently of one another. Only a space-time medium is real. Nor do bodies act on one another at a distance. For the conception of action at a distance we have to substitute the conception of distortion in the space-time medium; and owing to the distortions in this medium the shortest path may not be a straight path. A light-impulse sent out by an observer in one direction, and travelling by the shortest path, might even ultimately return to him from the opposite direction. The old conception of a stationary luminiferous ether is also no longer needed.

Physical conceptions of the universe have, as already pointed out, been framed without taking into account the fact that the world of our experience is a perceived world of interest and values. Not only space-relations, but time-relations also, enter into perception and interest. At the outset of this lecture I pointed out that when we take conscious behaviour into account the only ultimate conclusion we can come to as regards the physical universe as pictured on the Newtonian conception is that, though very useful for practical purposes, it does not represent reality. The universe as we perceive it is at any rate perceived not merely as co-ordinated and so unified according to space-relations, but also according to time-relations. We cannot, and do not, separate space-relations from time-relations in perception. In so far as Einstein's conception insists on the unreality of the separation, it seems to represent a great step forward in bringing the physically conceived universe nearer to reality as it appears when the fact that our experience is conscious experience is taken into account. It still remains the case, however, that even this amended conception of a physical universe does not take into consideration the fact that reality is for us perceived reality, and therefore embodies co-ordination of the phenomena which constitute it. On the amended conception, perception of the world would still be impossible; and the universe would still be a meaningless physical, and not the actual spiritual, universe.

A different criticism of a more practical character may perhaps be made on Einstein's conception. The old Newtonian conception is so very simple and useful practically that we can hardly get on without it. It is at least a great mental effort to translate Newtonian into Einsteinian conceptions, and for the limited practical purposes of physical science it is nearly always unnecessary to do so. Further experience alone will show whether the deeper and less untrue conceptions of Einstein will come into extensive practical use. When we regard neither the Newtonian nor Einsteinian interpretation of reality as more than a useful working hypothesis which must in any case be discarded when we take life and conscious experience into consideration, it may prove more generally useful to retain the Newtonian conception for the practical purposes which it meets so well on the whole, though it fails to meet some of them.

Many physicists and other writers are still under the impression that it is the duty of physical science to reveal a complete representation of visible reality or Nature. Newton thought that he had done so; but, as I have pointed out already, he failed because he left out life and conscious behaviour, which his representation of reality was incapable of interpreting. Einstein's representation is an improvement, but still fails, for just the same reason as Newton's representation failed. Nature just mocks at us, as she mocked at Michelson, when we attempt to divorce her from conscious perception; and she still mocks at Einstein. There is no such thing as a physical world existing apart from consciousness; no such thing as absolute space or time or space-time, or absolute mass, motion, or energy. When we realize that perception is no mere event in a physical universe, and no mere individual perception, we begin to realize that physical science does not really set out to interpret reality, but only to discover and make use of such a provisional conception as can be used for certain limited practical purposes.

LECTURE XV

INTEREST AND VALUES

As has already been pointed out repeatedly in these lectures, conscious behaviour implies that the world of our conscious experience is inseparably co-ordinated, not only in respect to space-relations, but also in respect to time-relations. This means that our world is not a mere biological world, but a world of developing interest manifesting itself in separately distinguishable values. In the present lecture I propose to consider generally the nature and extent of interest and values.

In a universe conceived merely physically or merely biologically, no account is taken of interest and values. Thus though for a physical universe regarded in the light of Einstein's conception, space-relations cannot be separated from time-relations, no account is taken of any essential connexion or co-ordination existing among events in the space-time medium, or the "distortions" in it. The matter and events in it are mere separate bodies and events. From the psychological standpoint of interest and values the criticism on such a world is that it fails to represent the world as it is perceived. If, in other words, there is a universe of mere separate bodies, events, and distortions in a space-time medium which isolates them, it is not our universe, and has no relation to the universe as perceived. Nor does a world which is only biologically interpreted represent the universe as perceived. Neither the physically interpreted nor the biologically interpreted universe is more than an abstraction from the universe we perceive.

The interest and values revealed in perception and conscious action are, in appearance, very complex and different in kind. Let us first consider what may at first sight appear to be merely individual interest, unconnected with what are interests not centred in ourselves alone. The conception of what is called "physical well-being" may perhaps seem to express individual interest. We are interested in the maintenance through the future of conditions which from past experience we know to be essential to the maintenance of "physical well-being," and our interest is of such a nature that the relationship which is consciously maintained between our bodies and their environment coincides with "physical well-being." The expression "physical well-being" is, however, an imperfect and indeed self-contradictory one. From a purely physical standpoint any condition is of the same general character as any other condition. We might, perhaps, endeavour to define comfort as a physical state of dynamical balance or equilibrium with the environment. But if so, where do organism end and environment begin? There is, and can be, no answer to this question. We can only describe "physical comfort" in biological terms as a condition in which the relations between the organs of the body, and between the body and its biological environment, are of an ideally "normal" character, so that biological unity is completely manifested in the life of the individual. The conception of "normality" or "health" is, in fact, a purely biological conception which cannot be expressed in physical terms, so that "physical" is not a descriptive adjective in this connexion, and is only used owing to the confusion arising from the neglect of biological facts in the prevailing Newtonian interpretation of visible reality.

Individual interest could not, of course, be identified with the presence for the moment of ideal health or normality. Both the anticipated future and the remembered past are essentially involved in interest. Individual interest is not being maintained except in so far as future normality is being promoted, together with present, as an outcome of past, normality. Interest can only be defined in terms of past normality and its future realization.

From the standpoint of life, individual existence is centred round, but not confined to, a "here," but has a "now" which is continuously changing, and in which life is alone permanent. From the standpoint of Newtonian physics there is also no particular "here," and the "now" is continuously changing in a flux of events, in which mass and energy are alone permanent. From the standpoint of relativity physics there is not only no particular "here," but also no particular "now"; and the universe is a flux of events, apparently occurring discontinuously. From the standpoint of individual interest the universe is centred round, but not confined to, a particular "here," just as from the biological standpoint; but the "now" is no longer fleeting: reality reaches forward into the future, and back into the past, so that it extends over time-relations as well as space-relations. Hence there is no longer a fleeting now, but a reality which manifests itself progressively in past, present, and future together.

Let us now examine this apparent individual interest more closely. Even from the purely biological standpoint a merely individual centre of life is unreal. The behaviour of the individual centres of life in a living cell, or of the individual cells in any higher organism, is unintelligible biologically from the standpoint of their individual lives. Their life is centred in their common life as a whole, with only an unreal centre in their individual lives. The same fact is shown to a greater or less extent in the relations of one higher organism to others. Individual interests are similarly unreal in the sense that our conception of them is incapable of interpreting actual conscious experience. In presence of others a wider interest manifests itself. It may be that this wider interest is consistent with the furtherance of what could be regarded as purely individual interest; but equally this may not be so, since the wider interest may imply the complete suppression of the apparent individual interest.

In order to see this we have only to consider the conscious behaviour of members of a family, or tribe, or of fellow-countrymen. Both their perceptions and their conscious actions express no mere individual interest, but a wider interest which may entirely overbear what would be interpreted as individual interest. The latter thus shows itself to be unreal in itself, and only real in so far as it expresses the wider interest.

When we examine what appears to be merely individual, self-regarding interest, we find that its scope is very wide. It extends in all directions, and in many different ways, to environment. In other words, the normal relations which express individual interest, and thus have value, are very wide in their scope, so that harmony of environment covers a great deal. The individual as such is by no means indifferent to the maintenance of what we call harmony or beauty, through whichever of the senses it appears to him. He avoids what would be ugly or inharmonious, and maintains what is beautiful and harmonious, whether revealed in sight, sound, touch, taste, or smell.

If we attempt to define, in terms of anything else than our direct perception of it, what is "normal" in the life of an organism, we always fail. Life appears to us as a unique whole, revealed in the perception of its maintenance. Further insight into it is only given by the addition of further detail to this unique perception, whether the further detail is added through special experiment or not. We may, for instance, employ only the naked eye, or else the microscope, or we may observe the manner in which the wholeness of life is maintained under what we interpret as altered conditions of physical or chemical environment. Or as a consequence of further physical or chemical investigation of the environment we may discover new details of normality. In every case the normal is a unique unity, revealed in the perception of its maintenance.

It is the same with harmony or beauty of environment as expressing maintenance of individual interest.

We can reach no artificial definition of what is harmonious. We can only point to its maintenance as of value in even individual experience. It defines itself in its maintenance, just as life defines itself in its maintenance. Thus it is empirically revealed and can therefore only be studied empirically, just as the apparent physical universe or apparent biological universe can only be studied empirically.

The wider interest which shows itself in presence of other individuals, or in which apparent individual interest is superseded, is only an extension of what seemed to be individual interest. We are not merely interested in the health or physiological normality in a narrow sense of those near to us, as belonging to the societies to which they, together with ourselves, belong, but are also interested, in a wider sense, in harmonious relations between them and their environment. Individual interest in beauty or harmony of environment thus takes a wider form. What is beautiful or harmonious is perceived as a value developed in, and to be further developed in, the social unity we belong to. It is thus perceived as of social and not merely individual value. Our conscious actions in presence of it express its social development, just as do our perceptions.

The social values which we perceive and act upon are not merely centred in family or country. They are not even limited to human society, for lower animals share in the fellowship of human beings. What, from the physical standpoint, we interpret as a mere inorganic world surrounding us, becomes also a world of beauty and value in relation to social interest. The land of our fathers and children is not capable of description in mere physical terms; nor are the stars which have lighted and guided them, and will light and guide them.

We make, in practice, a sharp distinction between what we regard as of value from a mere individual standpoint and what has a wider social value. From the individual standpoint what is of value can be exchanged between different individuals, and has thus what is called a market value. This is often also called a material or money value. From the wider social standpoint, however, there is no such thing as market value, and values in the wider sense are distinguished as spiritual values. He who, in his conduct, puts a market value on a spiritual value is *ipso facto* separating himself from human fellowship. The person, for instance, who lets his "material" advantage interfere with social duty is thus contradicting himself or acting against his real interest.

If we ask why we should act honestly when if we acted dishonestly in our own individual interest it would almost certainly never be found out, or why we should go out of our way to act courteously to persons who do not know us and whom we shall never see again, the answer is that it is in our own wider and more real interest to act honestly or courteously. This wider interest is just a fact, and a fact which obliterates the mere individual interest which, owing to ill-breeding or defective education, we may have mistaken for a fact and assigned a market value to.

Reality is not to be found in the ideal world of economics, dealing with market values, any more than in the ideal worlds of physical or biological science. A mere economically constituted society is only an ideal construction, like a society assumed to be held together by brute force. Those who keep nothing but their own self-interest before them are very properly treated with contempt in good society. A real State depends on the honesty, loyalty, courage, and mutual charity of its citizens; and true citizenship bears no relationship to the possession of wealth or specialized knowledge. We depend at every turn on the reality of this citizenship, and the general extension of the franchise in civilized States is only an acknowledgment of it. It is in the real world which is present with us everywhere and at all times that we find spiritual values when we open our eyes to see them. Actual realism is their representation, and is not the sham which is at present often taken for realism.

We are accustomed to the thought that at any rate inanimate things around us have in reality only a physical existence, and that though we attribute inherent value to their presence, this is only a matter of sentiment, and does not enter into their real existence. But what right have we to this thought? The basis of all our inferences as to our universe is our experience of it in perception. If we leave out of account its biological relations, together with the fact that it is perceived and that perception is an expression of interest, we can treat the inorganic environment as a physical environment, existing, if not in media of space and time, in a space-time medium. But we have no right to leave perception out of account, any more than we have any right to leave out of account, in the interpretation of physical environment, the Michelson experiment or the bending of light-rays passing near the sun. When we leave the fact of perception out of account we are dealing only with an artificial or ideal world of our own subjective invention. However useful such an artefact is for certain limited practical purposes, it certainly does not represent reality.

What is called realism consists commonly in the ascription of reality to the world as interpreted physically, or else biologically. It is at present customary either to endeavour to make such interpretations the basis of art, or else to banish art to a palpably unreal world of what is supernatural. In reality these interpretations are destructive of all art, since art deals with values which have no meaning in a universe which is only physically or biologically interpreted. Values only stand out the more clearly the more their presence is, through artistic insight, rendered manifest in what, apart from that insight, might appear as mere individual calamity. Thus true tragedy is never sordid. A deeper reality shines through the apparent calamity, or if it does not there is no art. It is not away from, but towards reality that true art points. I can think of no simpler example of true literary art, without any trace of unreality, than Dr. John Brown's story of *Rab and his Friends*.

The interest and values of the psychological or spiritual world show themselves, not only in direct social relations, and the relations of individuals and societies to their environment, but also in the artifices and tools which are employed in the maintenance of social and individual interest. Of these artifices or tools perhaps the most important is language. Language may be regarded as a very complex and at the same time very adjustable tool for the maintenance of social interest and values. The use of this tool is guided by the interest and values, and is capable of revealing and expressing them with either exquisite delicacy or immense power. The proper use of spoken language, with the proper gestures, intonations, and facial expressions accompanying it, aided, it may be, by rhythm, rhyme, and musical intonation, thus becomes an art by itself, based, however, on an appreciation of the values expressed, apart from which language and intonation become mere verbiage and noise. Written or printed language cannot be aided by gesture, facial expression, or intonation, and for this reason requires even greater care than spoken language, though rhythm, rhyme, and alliteration can be equally well used as an adjunct in written and spoken language.

The use of tools and apparatus of every kind expresses the values in the development of which the tools are employed; and we naturally regard the tools themselves as partaking in the values. Hence a tool is often not merely designed and maintained always fit for service, but ornamented or beautified in various ways, so that it has a further value apart from its proper function; and this applies very evidently to language as a tool, or to buildings or clothes.

In the use of language we apply the same word to designate what we recognize as common in different values and their maintenance. Thus words represent abstractions from concrete reality, so that from them we can build up systems of abstractions. We can, for instance, regard time- or space-relations abstractly, as if they existed independently of the interest which they express in all its concrete reality, as a manifestation of values. Within such a system of abstractions various relations hold good and form the basis of a science which can be used with immense simplification of action in cases where the abstraction does not matter so far as certain practical actions or interests are concerned. Thus though the conception of a gallon of beer is a highly abstract conception, and the beer may be in vessels of any description, or lying in the gutter, the ideas that it may be regarded as amounting to just a gallon, and that it is a substance called beer, of a certain origin, and therefore does not need to be tasted and drunk to prove its value, are of the utmost practical service. Scientific measurement of the abstraction called volume is therefore of corresponding importance.

If, however, we confuse the very practical abstractions of spoken or written language with reality itself, and thence proceed to build up sciences under the presumption that they express actual reality, we are only deceiving ourselves, and it becomes the business of philosophy to lay bare the difference between reality and its representation in these sciences. It is, for instance, extremely convenient for practical purposes to assume that there is one reality called time, another separate one called space, and other separate ones called matter, energy, living organisms, and persons. Sooner or later it appears, however, that these abstractions are not consistent with one another. Space and time, for instance, turn out to be inseparable from one another, so that it seems to become necessary in mathematics and physics to substitute a four-dimensional medium, space-time. The conception of a living organism as a special sort of entity in space and time or space-time is similarly inconsistent with the physical conception, so that we have to choose between shutting our eyes to facts and clinging to the physical conception, or else adopting a new conception to cover the actual facts. The conception of personality as something existing in space and time associated with life is, finally, inconsistent with either personality or the physical or biological conception. It is for philosophy to point out the inconsistencies between different kinds of scientific interpretation, and at the same time to discover as far as possible how these inconsistencies may be reconciled.

In spite of their inconsistencies, the abstractions of different sciences or branches of what we are familiar with as knowledge are so useful for practical purposes that we cannot dispense with them as tools in the perception and development of interest. If, therefore, we bear in mind that the abstractions of language, and the sciences based on them, are in reality only practical tools for the perception and development of interest, we can assign to these abstractions their proper and indispensable place in our experience. But if we regard them as more than tools for special purposes, we are encountered by fatal philosophical criticism which points out that they do not represent our experience as it actually exists.

It is always to the actualities of experience that philosophy, just like any experimental science, points us. This implies that any universe which is not the universe of our actual experience has no meaning for us. Before no tool of theory set up by either scientific, ecclesiastical, State, or any other kind of authority, will philosophy bow her head. She bows her head only to actual experience, and not to what for her are only tools.

The interest and values which we experience are those which present themselves to us in the society we belong to, and they extend backwards into the remote past, and forwards into the unlimited future. We belong in the most intimate sense to our environment, or the environment belongs to us. The idea that individual persons represent units which exist apart from their environment is not consistent with experience. The man or woman who emigrates to a new country carries also his or her traditions and interests. In a physical sense the environment is new, but in a deeper and truer sense it may be the same. Scotland, for instance, seems to go with the Scottish settler, so that other Scots may even find themselves more at home in a remote colony than in Scotland itself. The interests and values associated with Scottish character may appear more plainly than where they are obscured by the vulgarities so often associated with a more complex civilization. It is not possible to distinguish personality from the concrete environing interests and values associated with it.

In the sphere of biological interpretation we are familiar with analogous facts. As a reproductive cell casts loose from the environment of the parent organism it reproduces that environment. In the earliest stage of reproduction the ovum and its immediate progeny provide within their own substance the nutrient environment, and during further development the complete environment of the parent organism is reproduced more and more perfectly. We can never at any stage separate the organism from its environment; and this applies no less to the chromosomes within a cell than to cells themselves. Organism and environment are inseparably united where life is present; but where conscious behaviour is present, the social environment extends also over time-relations in the form of tradition and aspiration.

The social environment is a complex psychological or spiritual world of interests and values. This is the world which literature and other arts portray or reveal; but they can reveal nothing to those for whom the values and interests do not already exist to a greater or less extent. Interests and values are part of ourselves: they cannot be pieced on from outside of us. We of Scottish origin are specially near to the art of Scott or Burns, or Raeburn or Dr. John Brown; but this is because the real world which they light up and so render clearer is also our own world.

Since philosophy is our ultimate interpretation of reality, every philosophy must claim to be realistic. The philosophical conclusion which I have so far placed before you is that reality is not to be found in mathematical, physical, or biological interpretations of reality, since these interpretations deal only with abstractions from the psychologically interpreted world of interest and values, which is thus prior to them, or more elementary. So-called materialism, or philosophy which bases itself on the physical interpretation of experience, is thus out of account, though it still survives in popular literature among those who have never given any serious study to philosophy. I should like, however, to refer at this point to a very different form of realism, of which a systematic presentation was made by my distinguished predecessor in the Gifford Lectureship, Professor S. Alexander.

I think we can regard Alexander's writings as a protest against any system of so-called idealism which seeks to find the basis of reality in mere ideas. Up to this point I can fully agree with him. Ideas or universals may be immortal things, but at the same time they are only abstractions from reality, however useful they may be for certain limited practical purposes. Out of mere ideas we can never construct reality, and if we regard the post-Kantian philosophy of Hegel as an attempt to show that reality does, as it were, construct itself through the dialectic activity of the most general ideas, such as that of pure being, we must admit his philosophy to be a failure in this respect.

Alexander starts from the assumption that space and time are real, and not mere ideal, things, and he seeks to show that what he regards as the concrete reality of the physical, biological, and psychological worlds arises from space and time. It seems to me that he has set himself just as impossible a task as Hegel did if he set out to deduce a concrete world from the implications of " Pure Being " and " Nothing." If the latter were abstract ideas, so also are Space and Time, or Space-Time.

On attempting to follow Alexander's deduction, I find first an unintelligible jump from space and time to the Newtonian physical world. The " bodies " of that world are not pieces of space or extension, but pieces of something very different, namely, matter or mass. Descartes and Spinoza endeavoured to interpret them as pieces of extension, but Newton showed clearly that they must be regarded as masses. The space occupied by a body is no criterion of its mass. In other words, there is no fundamental connexion between the space occupied by even an atom and its massiveness, so that there is no transition from the mere conceptions of spaces and their movements to those of matter and its exchanges of energy.

The transition from physical existence to life in Alexander's deduction seems to me equally abrupt and unintelligible. He assumes that with a certain complexity of physical structure, or " constellation," life " emerges " as something new. He avoids the common futile attempt to reduce life to mechanism, but under the cover of the word " emergence " he in reality supposes that a miracle—something supernatural—occurs, so that organic co-ordination appears where it was absent before.

It is the same with the further transition from mere life to conscious behaviour. When physical structure attains sufficient further complexity, as he supposes that it does in a central nervous system, another miracle occurs, and mind "emerges." He is well aware of the difference between perception and physical action, and that perception passes backwards over time. The latter fact he gives metaphorical expression to by saying that time is the mind of space. But time which does not pass away irreversibly is no longer the time of physical science, so that the hiatus between mere life and conscious behaviour remains.

It seems to me that Alexander produces the real world very much as a conjurer produces rabbits from a hat. The rabbits are real enough, and not shams; but in reality they were there from the beginning. Newtonian matter was there from the beginning if it is there now. Life was also there from the beginning if it is there now; and I have already pointed out that organic evolution presupposes life, since it presupposes heredity. Equally without beginning are the interest and values of conscious behaviour.

It does not seem to me that Alexander's ostensible realism avoids the difficulties of ostensible idealism. Time which disappears as it passes, and space of which the parts are simply outside one another, are both of them only abstract ideas like pure being and pure nothing: they are nothing real, and out of them nothing real can come. Reality is there all the time, and we cannot deduce it. Our perception of it is, however, more adequate or less adequate according as our interpretation of it is more adequate or less adequate. The mathematical interpretation as space- and time-relations is extremely inadequate; the physical interpretation less inadequate; the biological interpretation still less inadequate; and the psychological interpretation as a world of interest and values least inadequate of all these interpretations.

LECTURE XVI

THE UNITY OF EXPERIENCE

WHEN we speak of conscious experience we are accustomed to think of it as the conscious experience of many individuals, existing in different parts of space and time. We never doubt, however, that it is experience of the same universe, which we regard as an objective universe, existing independently of our own special or subjective experience of it. Apart from this assumption, the language in which we describe it and communicate with one another about it would have no meaning.

We commonly regard it as an objective world of bodies and events, occurring in objective space and time. Or we may regard it as an objective world of life; or else of values of various sorts. To a physicist, chemist, or geologist it appears under one aspect; to a farmer or doctor under another aspect; to a teacher, artist, or clergyman under other aspects. But it appears to be the same world for all, and in this sense an objective world, however we may regard it.

We do not ordinarily regard the different aspects of this world as mutually contradicting one another, for we smooth over the latent contradictions in various ways. We may, for instance, regard its beauty or ugliness as merely ideal or subjective, or matters of convention. Or we may regard the whole of it as a mere passing show, the apparent contradictions in which are ultimately unreal, though for us, with our limited understanding, at present insoluble. But even so, the question remains why it at least appears to us as an objective show, or an objective physical world.

The foregoing analysis has suggested the answer to this question. As we have seen, the physical interpretation as formulated by Newton and his successors does not express reality itself, but only a conception of it which is extremely useful in the perception and furtherance of our interest or the corresponding values. When we compare closely this conception with our experience of even what we call the inorganic world, but far more clearly if we endeavour to apply the same conception to our experience of life or conscious behaviour, it becomes evident that it fails to correspond with this experience. The conception of bodies existing separately in space has to be abandoned when we endeavour to form a coherent conception of living form and activity or conscious behaviour.

This involves the corollary that even in those parts of our experience where the Newtonian conception seems to correspond with the actual experience this correspondence is only superficial. Behind the apparent Newtonian world there must be a world which only reveals itself clearly in our experience as a whole. The Newtonian conception, however useful it is for certain practical purposes, is only a make-shift conception. It cannot represent reality. It somehow appears to us, nevertheless, as an objective makeshift, in the sense that all men can make use of it in so far as it can be used to further their interests. It can also be applied, though its inadequacy is glaringly apparent, to our experience of life and conscious behaviour. Thus we can regard a man or animal as a mass of material localized in space and time, and acting on or being acted on by other similar material. For various sorts of practical purposes, such as those with which an engineer deals, we need not ask too closely where or how the man ends and his spatial environment begins, or where or how his now is separated from his past and future. For many practical purposes these questions are unnecessary, and it suffices to regard him from the Newtonian standpoint.

Thus the Newtonian interpretation is in some way objective in the sense that it is the same for all men. But on the other hand it is merely subjective, in the sense that it is only an artefact or tool which we have invented for the furtherance of our interests. It is not the actual world of experience, but a grossly inadequate representation of it, that the Newtonian conception presents to us. Nevertheless this representation has been of such extraordinary service to mankind that in modern times it has been taken for a true representation of what we meet with in actual experience, and therefore as representing objective truth which would be the same to all observers if they observed carefully enough. The name Realism has also been claimed for philosophy which starts by acknowledging this supposed objective truth.

It is perfectly certain that such philosophy is not only not realism but is nothing but a form of idealism which takes abstract ideas, which are only practical devices represented by words, as corresponding with reality. The reality revealed in experience includes the fact that it is conscious experience of interest and values; and the ideal Newtonian world of things existing independently of one another in space and time does not correspond with this reality.

As we cannot reduce life to mechanism, and yet biological observation is part of our visible and tangible experience, so that we must include its data in a consistent interpretation of experience, biological interpretation comes nearer to reality than physical interpretation. The essential spatial co-ordination which we meet with in biological phenomena does not express the co-ordination in both time and space which we find in all conscious experience; but at least it expresses spatial co-ordination. Biological interpretation seems also just as objective as physical interpretation, in the sense that we naturally make the assumption that it would be the same to all men. It is true that the world of biological interpretation seems on superficial examination to be a world of many different lives struggling against one another and against a physical world in a spatial environment. But this is only because we have become confused by the Newtonian conception in our endeavour to apply biological interpretation. There is no spatial limitation to life; nor is life merely centred in separate organisms or parts of organisms. As already pointed out, one cannot see in detail how the conception of life applies, any more than we can see in detail how the Newtonian conception applies. But the conception of life is just as much an apparently objective conception appealing to all men, and extremely useful for practical purposes, as is the Newtonian conception.

It remains true, nevertheless, that biological conceptions are incapable of describing our actual experience, and only describe an abstract aspect of it. In biological observation we interpret phenomena as essentially related to other simultaneously existing phenomena. When we perceive a man or animal panting, or sweating, or taking food, or responding to sensory stimuli, we perceive this, in so far as we are applying biological interpretation, in relation to many other associated phenomena, which together express the maintenance of the normal unity which we call life; and similarly when we perceive bodily structure or the biological environment of the organism. But the relationship is a " blind " one, since neither past nor future events are regarded as entering directly into the phenomena observed. In actual experience not only is a present phenomenon essentially related to other simultaneous phenomena, but also to past and future phenomena, so that interest and corresponding values are maintained and developed.

The doctor, or farmer, or hunter, perceives biologically; but he at the same time perceives as part of the interest he is pursuing, and the biological element in his perception takes no account of this. Thus biology, like physics, deals only with abstractions from actual experience, however useful these abstractions may be. They are only artefacts, and the fact that they can be embodied in words makes no difference in this respect.

Since actual experience embodies interest and values which are without either spatial or temporal limitation, it partakes of the infinite and eternal. If we describe it as made up of elements each of which is here and now, the description is unmeaning and could only apply to the happenings in the existence of a body belonging to the ideal Newtonian world. The conception of such ideal happenings is often very useful practically, but has no application when we are considering the nature of experience itself. In actual experience, past, present, and future are alike involved, and knit into one by the interest and values embodied in the experience.

If we admit this, it might seem that we have reached no objective world, the same to all men; for the interests of different persons are different, and the values which they perceive and act upon are correspondingly different. This is undeniably true. What, for instance, has all the value and interest of home to one person has no such interest and value to another, or may be only an eyesore, better done away with as being insanitary or ugly. Or where one man sees endless beauty in a landscape, another man may see only an uninteresting waste.

But let us look more closely. We have become accustomed to the assumption that the physical world has an existence which is objective and the same to all men when they properly understand it, and that there is a corresponding objective space and objective time. This assumption has been discussed in previous lectures, and the reasons set out which prove it to be untrue. Yet apart from these reasons, which ordinarily do not occur to us, we think of the physical world as being objective, in spite of the fact that it appears very differently to different persons. When, for instance, we see a rainbow, or the colours produced by a thin film of oil, we may imagine that we see coloured objects, though to a physicist the coloration is only subjective and dependent on the relation of our eyes to surfaces at which rays of light are refracted and reflected.

It is only, therefore, with correct and complete physical interpretation that the physical world could appear to us as objective if such interpretation were capable of affording an objective interpretation. Without the correct interpretation the physical world appears quite differently to different observers, and it is only by what we regard as well-grounded faith that we interpret this world as an objective world. It is the same with our experiences of interest and values; for where they are not at first perceived and acted on, further examination can reveal them, just as further examination reveals what we suppose to be an objective physical world. What we call sympathy is realization of the interest and values of another person, and perception at the same time that the interest and values are common.

It has already been pointed out that interest and values are not merely centred in individuals, any more than life is merely centred in individual organisms. In other words, individual interest does not exist as something apart from social interest, with corresponding social values. This makes real sympathy or comradeship or fellowship possible; and there is no limit to the extension of this fellowship. We experience it at once, not only in connexion with other human beings, but also in connexion with animals, in so far as we understand their conscious behaviour. We extend it also to surrounding Nature, and we all understand the language of poets such as Wordsworth who have specially expressed this extension. It is this that makes a world which appears the same to all men possible, and that makes language possible.

Fellowship in interest shows itself most markedly between parent and child, between husband and wife, or between members of a family; and those who do not remember this are often rudely reminded of it. The same fellowship extends to the interests of others, and specially of fellow-countrymen. The bond is a subtle and far-reaching one, covering every variety of value, including the value of the country itself and all that pertains to it. He who travels into a foreign country without any sympathetic respect for and understanding of it and its people, must expect the hostile treatment which he will probably receive. The bond of fellowship extends, however, far beyond country, and far beyond the human species. It is there as a fact in our actual experience, and a fact of overwhelming significance. The abstract ideas which we use as tools in the realization of this fellowship, embody in spoken and written language, and make the basis of what we know as sciences, are mere derivatives of this fellowship, which is the source of their apparent objectivity. The attempt to describe it or analyse it in terms of abstract ideas is thus entirely meaningless. But since it appeals to all men, the tools which we use in its realization, including language and all the sciences, appeal also to all men, and are thus objective in this limited sense.

I belong to the old Oxford College of which the motto is "Manners makyth Man." We are proud of that motto, because it expresses a supreme truth. It is by our manners that we express, whether in word or deed, our fellowship with others and with all that surrounds us. This is true whether the manners are those of a king or of the lowliest of his subjects. Manners may be something unconnected with the abstractions which we designate as our bodies, but they express an inner reality of our actual being, and in this sense they "make" us. No better motto could have been chosen for a place of education and learning; for education and learning which do not make manners towards present, past, and future are just no education or learning. This is true whatever be the special subject studied. It must be studied and taught as a subject of living human interest which brings student or learner into relations of sympathetic understanding.

What we call bad manners or vulgarity signifies a defective perception of values, more especially a defective perception of the highest values; and if this is associated with display of wealth or its equivalents, the vulgarity is specially evident, owing to the contrast between a lower or mere individual interest, represented by the possession of wealth, and the higher and wider social interest represented by human understanding and sympathy. It is only education of the widest kind, including very particularly early education at home, that can save the world from vulgarity. Too much specialism in education is a common source of vulgarity; and mere appeals to lower interests bring vulgarity into political life—a vulgarity which is sooner or later found out.

The reason why physical realism has made such a wide appeal to the modern world is that it seems to furnish us with an objective reality, the same to all men, and corresponding to our conception of what an objective world should be. It is true that Berkeley and Hume showed by reasoning which has never been shaken that if the physical world were real in the sense assumed by Newton, we could never come to know of its existence. That world, however, seemed so imposing that little heed was paid to the scepticism of Berkeley, and still more thorough scepticism of Hume. It required a deeper analysis of experience, in which the first great step was taken by Kant, and further very important steps by Hegel, to meet Hume's scepticism. Any form of so-called idealism, however, failed to meet the criticism that it does not furnish an objective world. I have tried to meet this criticism by carrying the analysis of experience still further, so as to reach a form of realism which is proof against the objection to any form of physical realism, and yet accounts for the fact that physical, biological, artistic, and ethical interpretations appeal to all men, just as if each of these interpretations represented an objective world.

Neither are interest and values centred in ourselves as individuals, nor are there any spatial or temporal limits to them. Time- and space-relations express them instead of limiting them. But in what sense can we regard them as existing objectively and the same for all? However important they may be, they seem to clash with one another and to lead to competition, quarrels, and war. They undoubtedly do so, but the contests and disagreements are only the process of realization of interest, and when a stable decision is reached there is a wider or more detailed expression of interest and values. It is only through effort and struggle that values are maintained and developed.

Owing to the confusion produced in our minds by the assumption, presented to us in modern times as being nothing but "common sense," that the world as described in terms of physical sciences is a real world, we seem forced to the conclusion that however important may be the interest and values which we perceive immediately around us, they are limited in their existence by a vast outside physical universe, surrounding us both in space and time, or in space-time. I have already pointed out the reasons for the conclusion that this physical conception of a universe is by itself a mere make-believe. In other words, the conception, though of the greatest use for certain limited practical purposes, is not in itself consistent with our actual experience. Here I touch on the very kernel of what I am maintaining in this course of lectures. There is no mistaking the issue. The conclusion forced upon me in the course of a life devoted to natural science is that the universe as it is assumed to be in physical science is only an idealized world, while the real universe is the spiritual universe in which spiritual values count for everything.

The apparent individual interests and values in this spiritual world turn out, when we examine them, to be not separable interests, but one interest, with its values organically united with one another in time-relations as well as space-relations; and the perception of this is never far off. This perception guides us towards honest, diligent, unselfish, and charitable conduct, and is the motive impulse of all that we regard as being best in our actions. It gives us width of intellectual vision, courage to act, courage to endure, inspiration to carry forward what we have inherited from those before us, and charity. We live, if we will only realize it, in the presence of, and through the power of, this spiritual reality. It is the inspiration of all the splendid and painstaking effort which has built up our language, our literature and art, our science, our institutions, our machinery of all sorts, our loyalty to one another, and all that we call civilization.

If we look far enough backwards in the ideal time-relation of physics or outwards in the corresponding ideal space-relation, we may lose its detail, but it is still there; for the stars are to us like old friends whose presence around us is an expression of spiritual reality. We also do and can see it all around us in our daily lives, and apart from its existence our conscious experience or behaviour is entirely unintelligible or inconsistent with itself.

It is equally true that within the world of our daily observation we cannot trace the spiritual world of values in detail. What we see in detail is frequently what we can only attempt to describe in the abstract terms of physical science. In other words, we can only see the spiritual world partially and in outline, so that it seems to us to be only imperfectly real. Yet if we conclude that there is a real material world

—a physical world of mechanical chaos—which limits the spiritual world of values, this cannot be correct: for the supposed physical world is part of the perceived world, and this is inconsistent with its being a real world. The faith that in spite of our blurred vision of it the real world is one spiritual world cannot be shaken.

It is thus only an imperfectly revealed spiritual world that we had taken for a material world; and so the world of our experience is a progressive realization of the spiritual world. This gives us a new conception of time, not as a mathematical entity, but as the progressive realization of one spiritual reality, involving space-relations as well as all other relations which make up an ordered world of values. However useful the ordinary Newtonian conception of time may be, it is no longer, even for physicists, more than an ideal creation, as was pointed out in the fourteenth lecture. For the historian of conscious behaviour, Newtonian time or Einsteinian space-time is only an ideal abstraction. For a true historian or scholar or man of science the past of his subject is not something done with, but revealing itself in the present and future, which in their turn only reveal themselves as the outcome of the past. The physical conception of time or space-time is only a tool to be used for certain practical purposes. Let us use it efficiently for these purposes, but not regard it as anything more than a tool.

It is of its very nature that the universe of our experience—the universe of perception and conscious behaviour—must be a spiritual world of interest and values, and that the interest and values are not merely subjective, or those of a particular individual, but objective, since all can enter into them, and there is nothing outside them in our experience. In them the whole of our experience is unified as the active manifestation of one spiritual universe.

All around us we seem to see physical chaos, death, disease, decay, selfishness, and war between interest and interest, between man and man, or beast and beast. We certainly cannot see in detail how the picture which they present can be reconciled with the conception of a spiritual universe. It is only by faith that the reconciliation appears to us—the faith that our universe is consistent with itself. This faith is of the same nature as that which guides and inspires the work of pure science in its fight with ignorance and unintelligibility. Science is a continuous human struggle with what is as yet unintelligible, and this struggle is its very life. The petrified science of an inferior text-book is not science at all. In a far wider sense the whole of our experience, when we rightly comprehend it, is an active struggle in which we are continuously realizing the living and active spiritual unity which is without and within us everywhere in space and time, though it is only through the inference which we call faith that we know that it is being realized. The reality of this active spiritual unity sums up for us the message of philosophy.

We are to be pitied if we have lost our faith, lost sight of our spiritual continuity with the past and future as well as with what is around us, so that we only seem to be engaged in a hopeless or selfish struggle which will end with our deaths. Philosophy bids us to look again, and shows us how to look. She does not bid us to shut our eyes to the apparent evil within and around us, but tells us that in the effort of facing and dealing with it according to our abilities we become one with Supreme Active Reality.

LECTURE XVII

PHILOSOPHY, RELIGION, AND THEOLOGY

IT has often been imagined that mankind could get on very well without either Religion or Philosophy. In actual fact we do get on without any study of what is recognized as philosophy; but all civilizations have had their religions with associated theologies. We can trace forms of religious belief back to dim antiquity.

The attitude of philosophical and scientific investigation towards recognized religious beliefs has varied at different times. From its very nature, however, philosophy must come into conflict with religious beliefs unless these satisfy the test of consistency with experience. Between various of the sciences and religious beliefs there is much less of direct contact. The simple and sincere orthodoxy of such men as Newton or Faraday exemplifies this, though historical investigation has now undermined what were regarded as very essential parts of Christian religious beliefs, while geology and biology have come into open conflict with other parts.

Religious beliefs have always had a practical outcome in conduct, and it is on the practical side that they make their appeal to mankind. They have not only furnished a working hypothesis for conscious action, but they have possessed the peculiar character of bringing with them courage to act and courage to endure. It is easy to treat religious beliefs in a wholly superficial manner, emphasizing points in them which are unessential, and leaving out of account what is essential. Those who have not been brought up in a religious environment, or those who have violently broken free from such an environment, are specially prone to this error. Avoiding this error as far as possible, let us endeavour to see what is characteristic of religious belief as we actually find it around us in this country, and without regard to its special theological form.

The essential elements in religious belief are, I think, that God is the Creator and Sustainer of us and our universe, and the Source of all that we recognize as good: that He is revealed to us; and that in accepting and acting on this revelation we become one with Him and are thus beyond all apparent ill.

Of course, current religious beliefs go either not so far or farther than this. Thus it is generally held in Christian countries that though God originally created the visible world, He then left it to itself, with only the laws which we discover by scientific investigation for its further guidance. He is thus not the direct Sustainer of the universe. It is also commonly held that the revelation of Him to men has only been through certain persons and at certain times, or through His Son, who appeared in human form on our earth for this purpose, or through a special hierarchy. God, though all-powerful, is therefore outside us. Another general belief, which will be discussed in the next lecture, is that of the individual immortality of human beings. In the present lecture I shall endeavour to compare what seems to me to be the substance of religious belief with the conclusions already reached by direct analysis of conscious experience.

It is evident at once that these conclusions are identical with what I have just indicated as being essentially embodied in religious belief, or religion, but diverge very considerably from further beliefs which are associated with religion in both Christian and other religious communities. The Spiritual Unity which we have found by philosophical analysis to be the Reality manifesting itself in all our experience corresponds to the Reality called, in the language of religion, God. This Reality both creates and sustains our universe of experience, leaving nothing outside in either space or time, since spatial and temporal relations themselves are nothing but its manifestations. The same Reality creates in us the abstract conceptions which make language and the sciences possible; sustains also all that we recognize as being of value, and is the source not only of the courage and energy to maintain and develop what is of the highest value, but also of all that we call charity in its widest sense. Hence in so far as we are realizing our true selves we are realizing, not a mere individual self, which is only an abstraction, but the Spiritual Unity which gives us being. In that Spiritual Unity we live, move, and have our being. If we call this Spiritual Reality God we can no longer distinguish the philosophical conclusion from the essential religious belief.

When, however, we come to what may be called the theological admixtures with religious beliefs, the agreement ceases. The idea of a physical world, created in time, and then left by God to work out its destiny on mechanical principles, except for what is due to individual human interference and perhaps occasional divine interference, is directly contrary to the philosophical conclusion. It is, in fact, nothing but a bowing down of theology to the idol of a materialism which neither philosophy nor true religion can ever bow down to. For physical or biological science this idea is also completely unsatisfactory. If the universe is regarded from the physical standpoint, no meaning can be attached to any beginning of it in time. The same is also true if we regard it from a biological standpoint. It is true that many biologists have expressed belief in an origin of life from purely physical conditions; but, as was pointed out in a previous lecture, such an idea is due to mere confusion in thought, and is on a par with the idea of a creation of life in time.

The further theological idea that the revelation of God comes to us, not directly, but indirectly, through inspired or divine messengers and messages, or writings, is also contrary to the philosophical conclusion. It is an outcome of the materialism of those who have lost their vision of the omnipresence of Spiritual Reality. The Spiritual Reality of philosophy is within us as well as all around us, so that nothing can come between us and it. Except in so far, therefore, as revelations to others are also direct revelations to us, they are meaningless for us. The most they, or any philosophy, can do is to make an already present revelation more clear to us. The words of philosophy, or the words of religion, are meaningless unless philosophy or religion is already implicit in our experience. Those who regard religious beliefs or ministrations as a means for averting trouble in a future life, or those who treat philosophy as only a means for sharpening their wits, are not in sight of either religion or philosophy. This is no hard saying, unless it is an equally hard saying that a living tree must grow and cannot be made.

There are innumerable persons who put to themselves the question whether various beliefs to which they have been brought up in connexion with religion are worthy of credence. They often stifle their doubts with the reflexion that their Church, and perhaps most of their neighbours or fellow-countrymen, assent to these beliefs. But this is no real reason. We should still be what are called heathens if our ancestors had similarly stifled their doubts. It was really the good and sincere lives associated with Christian belief that strengthened their doubts and converted them, and which still appeal to mankind. But when we ask further whether certain of those beliefs are essentially connected with a good and sincere life, the only honest answer is in the negative. We can value the goodness and sincerity, and show in our lives that we value it, though we have discarded beliefs hitherto associated with religion, and even profess to be either atheists or agnostics in matters of religious belief. And when we see selfish lives associated with theological orthodoxy, we rightly regard the theological orthodoxy with contempt.

The further question arises whether, by discarding what we believe to be either untrue or doubtful, we have not weakened our religion. The answer to this question depends on how much we have discarded and how much we have purified and strengthened what is left. If, in discarding religious beliefs, we have dimmed our vision of the highest values, and correspondingly lost practical hold of them, our religion is weakened. If, on the other hand, we have only, by getting rid of what had become a source of obscurity, clarified our perception of the highest values, then our religion is strengthened.

It seems to me that just in proportion as we clarify religious beliefs from materialism, without at the same time dimming our perceptions of ultimate spiritual reality, we are strengthening religion. As soon as we see that the universe as interpreted physically or biologically is only an ideal construction, we can rid religious belief from its materialism, so that the spiritual reality with which religion is concerned stands out far more clearly. If, however, we only clear away the bad science in religious beliefs, without at the same time realizing the reality of what is spiritual and its practical significance, there is apparently no religion left, and spiritual values become dim.

Without the aid of philosophy, we are more or less overborne by the apparent physical world. We seem compelled to make with it compromises which never in actual fact hold. If once we admit what at the present time is presented to us as mere common sense, namely, that the world as interpreted physically is real, there is no stopping until we have apparently stripped our world of everything to which we can attach objective value. It is only philosophy which looks the apparent material world fully in the face and points out its real nature, that can at the same time rid religious belief of these fatal compromises and point clearly to the spiritual reality which lies behind the apparent physical universe.

If we merely lop away the apparent inconsistencies between religious beliefs and the physical or biological interpretations of reality, leaving these interpretations as if they represented reality, no basis at all is left for real religious belief, and religion becomes a mere subjective make-believe. We could still perhaps regard religious belief as something which will help to uphold social stability so long as persons remain who are willing to pay attention to such beliefs and inculcate them in children. The mere hope of heaven and fear of hell, or even of social disapproval, might be powerful influences in support of an ordered society, failing external compulsion through the collective power of that society. But when the illusion of religious belief finally died out, we should apparently be faced by a state of society in which honesty, diligence, charity, and patriotism would have to be enforced by the feeble weapons of compulsion or individual self-interest. Such a society would be wholly unstable, and would go down at the first encounter with an intelligent society inspired by religious beliefs.

Some of my hearers may have read a recently published book on Religion by Dr. Sigmund Freud, the originator of what is known as psycho-analysis. The book is well written, short, and closely reasoned from his own standpoint; and the title is *The Future of an Illusion.* For Freud the physical interpretation of the world around us is the final interpretation, and human personality is the playground of various blind instincts, restrained only by external repressive influences arising partly from individual self-interest organized as compulsion, and partly from the illusions of religious belief. It goes without saying that from Freud's standpoint religious belief can be nothing but an illusion; and he discusses the probable effect of the inevitable disappearance of this illusion as scientific knowledge advances. Culture or civilization he defines as the increasing power of gratifying human instincts, with the minimum of accompanying necessity for repressing these instincts where partial repression is needed in order to secure the maximum of gratification. It is from the applications of science that the increasing power of gratification is derived, and he regards civilization as primarily based on the increasing applications of natural science.

Whether or not we dislike such a picture of human nature or of science, the picture is there, painted with unmistakable clearness. Freud looks forward hopefully to a civilization from which the illusion of religion will have disappeared, as he believes that it will do whether we wish or not, with the advance of scientific knowledge. He points, in particular, to the hopelessness of preventing the so-called working classes from discovering that religion is an illusion.

The discussion of conscious behaviour in the preceding lectures has shown that it is a very different thing from what Freud imagines, and that Science also is a very different thing. It is Freud's conception of human nature, of science, and of religion, that is the real illusion. We shrink instinctively from such a conception as his; but to many persons who are ignorant of both the history of philosophy and that of science it has a certain fascination. The morbid curiosity excited among ignorant and unstable persons by Freud's ideas as to matters of sex is also well known. Many other persons who see that psychological knowledge is of extreme practical importance are led to take seriously the psychological ideas of Freud and those with a somewhat similar view of human nature. The moral of this, to my mind, is that psychology as a branch of science is still on about the same level as chemistry was in the days of the alchemists. It has still no generally-acknowledged guiding principles, so that the chaotic literature which is at present poured forth in the name of psychology has come to be regarded by educated persons with the very utmost suspicion, though it appeals to an ill-educated multitude, especially among the well-to-do.

When, in the first series of these lectures, I referred to the psychological interpretation of experience I was unable to point to any scientific statement embodying this interpretation at all satisfactorily, and could only say that this interpretation is in actual fact embodied in all the "humanistic" branches of knowledge and activity, including literature and art. Freud's conception of psychology would imply that here, too, and not merely in religion, we are dealing with mere illusions which will pass. Even in this country there are some foolish people who imagine that instruction in so-called psychology on lines not very different from those of Freud can take the place of a humanistic upbringing and education, or be substituted for it in the training of teachers. Instruction on such lines could only be described comprehensively as instruction in nastiness.

As regards the supposed ignorant working classes to whom "culture" in the Freudian sense has not yet come, I think that experience will show that it will never come to them. Spiritual values are not merely real things, but are real things to them just as much as to other persons, though perhaps they will express their contempt for the "culture" in question by rougher means. My scientific work has brought me much into contact with the so-called working classes in this country; and this has produced in me a feeling of deep respect on account of their keen appreciation, shown not in mere words but in deeds, which count for much more, of the higher values referred to in the last lecture. Even if we regarded these values as mere illusions, produced by "father complexes" *et hoc genus omne,* we should be compelled to admit that there is no prospect of their disappearing.

It is possible to consider this matter in a wider manner. The kind of psychological interpretation represented in Freud's book is presumably based on science, and on the attempted physical interpretation of life. From this standpoint the nervous reactions of men and animals are the outcome of an endless concatenation of exciting and inhibiting stimuli, and the inhibiting stimuli are quite as real and significant as the exciting ones. Freud treats the inhibitions as if they were only an external outcome of civilization, whereas they are deep down in the very centre of nervous reaction. The sort of organism which he imagines is thus a mere product of his imagination, even if we neglect the fundamental biological fact that the nature of life lies in the maintenance of normal structure, environment, and activities. Of the characteristic features of conscious activity his conception gives no account at all, as follows from the discussion in Lecture VII of the previous course.

Thus the whole structure of any such psychology rests on bad physics and bad physiology, besides being hopelessly inadequate from the special standpoint of psychology. It misrepresents our actions, because it misrepresents both our perceptions and our passions. The love between man and woman, between parent and child, between man and his fellow-men and country, or between man and God, are matters which any such psychology is incapable of describing or expressing. If I speak strongly on this subject I mean every word of what I say; and perhaps these words, coming as they do from a physiologist, may be more heeded than if they came from a philosophical teacher by profession, or from one tied by the creed of a Church.

When we look below the surface we can see that it is only a misunderstanding on our part when we imagine that philosophy and science began with the Greeks. Religious belief had always been to articulate mankind its philosophy, and at the same time its science, before religion, philosophy, and science had begun to be distinguished from one another. Religion has, moreover, always been practical, in the sense that it influences conscious behaviour directly. It might seem that neither philosophy nor science is practical in the same sense. In fact we commonly picture to ourselves a philosopher or man of science as a very unpractical person, devoting himself to curious and doubtless excellent, but not very useful pursuits. Of the man of science we are beginning now to take a juster view: for we know that behind every advance in science there come a host of directly practical persons. The conclusion put forward in these lectures has been that science is simply the practical outcome of our needs, and that in reality no one is more essentially practical than a man of science.

Philosophy, too, which, like religion, takes into account, not merely a part, but the whole of our experience, including all our scientific working hypotheses, is just as practical as either science or religion. It aims, like religion, at furnishing a working hypothesis on which we may base our interpretations of what we perceive, and the corresponding conscious behaviour.

The separation of science, philosophy, and religion from one another is thus an artificial one. Let us consider how this situation has arisen. Turning to religion first, the truths, in so far as they are practically valuable truths, embodied in religious beliefs, have from time immemorial been treated as if they were mere external revelations carried to us either by traditions of very indefinite origin, or by what were believed to have originally been definite and fixed revelations made at certain times and places. The result has been that we seemed to be in the position of either having to accept these beliefs in their entirety or to be left in complete doubt as to the authority of religion. Instead of a living and developing religion, we were thus presented with a rigid system of beliefs. Science and philosophy, as they grew and developed, were thus bound to come into conflict with this rigid system. The trouble was added to by the vested interests of religious institutions, and the need for legal preservation of these interests.

If we turn next to science, we find that she has become equally shackled by traditional hard-and-fast belief. The scientific working hypothesis to which definite shape was first given by Galileo and Newton, and which has been applied to a further and further extent since their time, was originally applied by them to what we call inorganic phenomena, but came to be regarded, even by Newton himself, as if it were a definite and fixed revelation as to the nature of visible reality. Scientific men will perhaps not be ready to acknowledge this picture as applying to themselves, and not merely to theologians. But the picture certainly does apply, and the nemesis of this rigid tradition has come with the attempt to apply the physical hypothesis to life and conscious behaviour, as I have already pointed out. The naïve belief that in observing "phenomena" we are simply observing reality as represented on physical principles has precisely the same defects as the traditional externally revealed theology. The inability of so many men of science to see this is completely similar to the inability of theologians to see the difficulties of their position; though both the men of science and the theologians see clearly that their concern is with working hypotheses of immense practical value.

Philosophy has questioned the assumptions of scientific men as well as of theologians, and such questionings have been of the utmost value. But the questionings have usually stopped short, so that we have had, for instance, either a more or less materialistic system of philosophy or a system which seemed to attribute reality to what are only abstract ideas.

Nevertheless we can trace continuous, if somewhat erratic, progress in the conceptions of reality formed by philosophers, men of science, and theologians. It has, however, become increasingly clear that freedom from certain traditional conceptions is necessary if the three classes are to live at peace with one another, through recognition of the ultimate identity in their aims. It seems to me that they must all rid themselves of what may be described comprehensively as materialism.

The materialism of science, and of much of what has passed for philosophy, has arisen through the mistake of endeavouring to extend to life and conscious behaviour a working hypothesis which has, on the whole, been extremely useful when life and conscious behaviour are left out of account. When the limitations of this working hypothesis are recognized, the materialism of science disappears, and the mathematical, physical, biological, and psychological sciences can pursue their own special paths without interfering with one another, or with philosophy or religion.

The materialism of theology has arisen from what is essentially the same mistake. Theologians have assumed that the ordinary visible world is simply the physically interpreted world, even though this world is also assumed to have been originally created. As a consequence it can only be through what is supernatural that God, as the source of spiritual values, is revealed to us, since spiritual values are without meaning in a physically determined world. Thus a supernatural element seems to be essential for religion. Revelation becomes also a supernatural process, but for which we should be in presence of only a natural world of mere mechanism. When the true nature of the materialism in ordinary theology is recognized, there is no need for a supernatural element in religion. To insist on the need for it becomes equivalent to insistence on doubting the omnipotence and omnipresence of God. No supernatural revelation is needed, because conscious behaviour contains within itself the revelation of God's existence and nature.

In current theology our knowledge of the existence of God is treated as a revelation made only at certain times and places. We must accept it in this sense or leave it. An attempt is also made to support the supposed revelation by arguments based on supposed design in the apparent physical world, or supposed existence of supernatural events in this apparent world. These arguments are simply a buttressing of bad theology by bad science. The real evidence for God's existence and love is within and around us everywhere and at all times when we take from our eyes the scales of bad philosophy or theology which obscure our vision.

LECTURE XVIII

THE BELIEF IN IMMORTALITY

BELIEF in the immortality of individual persons is usually associated, sometimes dimly, and sometimes very definitely, with religious belief. In Christianity, for instance, this belief is very prominent, though it is absent or far from prominent in the Old Testament writings. In some religions it takes the form of belief in transmigration of souls to other human beings or animals. A future resurrection of the body, along with the soul, has been a prominent feature in Christian belief.

In Lecture VII of the first series I discussed animism, or the theory that the body is inhabited or animated by a soul distinct from it and therefore separable from it in space. I pointed out that this theory is similar to, and subject to the same fatal objections as vitalism, which is the theory that life is due to the fact that the material body is, during life, the site of operation of a "vital principle," "entelechy," or by whatever other name we may call it. I also pointed out that these fatal objections are no less applicable to the philosophical conception of a living organism, as this conception is expressed in the writings of Hegel, and of what may be called the British Hegelian school of philosophy.

Animism, no less than vitalism, concedes what philosophy can never concede, namely, the reality, or at least the reality for our perception, of a mechanical material world. Animism and vitalism are simply vain attempts to evade the consequences of this assumption. It is easy to show that if the visible and tangible world is simply a material world, or what we are compelled to interpret as such, all that we attribute to the influence of either a vital principle or soul must be dependent on material conditions. The fact that all psychical activity is dependent on environment is clear to all who have studied the evidence closely; and if that environment is mechanical in nature it follows that psychical activity of all kinds is mechanically determined.

The evidence has already been discussed which shows that the material mechanical world is only an ideal interpretation of reality, useful for certain purposes, but limited in application by the limited scope of these purposes, so that not even life, and still less conscious behaviour, can be described in terms of this ideal interpretation. Thus neither vitalism nor animism is a possible theory. A universe interpreted biologically is at any rate nearer to reality and less of an ideal abstraction than a universe interpreted physically; but a universe interpreted psychologically, as a spiritual universe, is still nearer to reality. We have seen, moreover, in the last lectures, that a spiritual universe consisting of mere individual spiritual realities is not consistent with itself. The spiritual universe is one, and leaves nothing outside. In other words, the only ultimate reality is, in the language of religion, God. This seems to me to be the result of analysis of what our Experience means, or what Nature means, if we prefer the word Nature to the word Experience.

The question as to immortality appears now very differently from what it did from the animistic standpoint. In the first place, mere individual personality is unreal. It is only in so far as God is manifested in us that we partake of reality. Just as death of the individual cell or individual compound organism, or even the last of a species, must be regarded as a normal event in a wider life, so death of the individual person must be regarded as only an event in God's manifestation in time-relations. Through faith in God as the only ultimate Reality we must regard death of the individual from this standpoint, and our faith in this regard is just our faith in the self-consistency of our experience. It is God manifested within us, and not the abstraction which we call our individual self, that is immortal and the Creator and Sustainer of time-relations themselves. From this standpoint the immortality of individual persons is only a meaningless conception.

In the present times we live under the shadow cast by the physical conception of visible and tangible reality. This conception looms up before us and seems to menace the whole spiritual world of values which we are also more fully conscious of than ever before. On the physical conception we and our interests seem to be mere helpless specks in an essentially chaotic universe of overpowering immensity in space and time, or in space-time. In reality, however, the immensities of time and space represent, as Kant, himself a physicist as well as philosopher, pointed out, only the unlimited scope of the ideas through which we have ourselves ordered our experience. These ideas are, moreover, abstractions—useful tools, but only for certain limited practical purposes. Owing to the very nature of our perceived world, the abstractions cannot describe it. For philosophy the immensities of space and time are not outside us, but within us as our own useful, but in reality abstract, and therefore to this extent unreal, creations. We have become, however, so accustomed to take for granted that the physical interpretation of our experience represents reality itself that we can hardly help accepting this assumption and idolatrously bowing down before it.

Since we see at the same time that a merely physical interpretation of life and conscious behaviour is impossible, we are driven into the acceptance of vitalism and animism. Conscious behaviour thus appears to us as a struggle of a soul with a vast surrounding physical universe. The supposed soul itself appears also to have originated in time and to disappear from the scene at death, leaving nothing visible but a lifeless body subject wholly to mechanical interpretation.

If we simply assumed that the soul passes out of existence at death, this would, from the animistic standpoint, be an admission that what it had acquired in its struggle through life would be thrown away; also that the merit or demerit acquired during life would go unrewarded or unpunished. Such an admission seems inconsistent with the deep-seated religious belief that God is both omnipotent and the source of all that we call good. Hence a belief in personal immortality has come to be associated with religious belief, and to appear as an essential part of it.

We live in the presence of death all around us. Those nearest and dearest to us may be stricken by it at any time. Both young and old have often to pass through the valley of its shadow. We can face and deal with the ordinary ills of life as they come, and gain strength in overcoming them; but in presence of the death of one near to us our efforts seem to have been vain, and we may have had to watch helplessly while the end approached. Without a belief in personal immortality religion may easily appear to us as little better than a mockery.

In actual fact religion must sooner or later appear to us as nothing but an illusion and mockery if once we take the initial step, which is part of the animistic conception, that the visible world around us is in reality a physical world. It makes, moreover, no actual difference if we assume in addition that this physical world was originally created by God, and at the same time given its mechanical constitution. The scientific evidence has become overwhelming that our life, conscious behaviour, and religious or philosophical beliefs depend upon our environment. We are entangled in the meshes of what is known as materialism; and not only belief in immortality, but belief in the objective reality of all that we regard as of value, disappears. Even the belief in an original Creator of this mechanically-determined universe must disappear, since physical science reveals to us no such Creator, however far back in time we may go.

The argument of these lectures is that the physical world is not the real world, but only an ideal and quite insufficient representation of it. The real world is the spiritual world of values, and these values are in ultimate analysis nothing but the manifestation of the Supreme Spiritual Reality called, in the language of religion, God. What we interpret as physically determined is only what is imperfectly seen. Our faith that this is so is firmly grounded, so that we can walk through the valley of the shadow of death without fear. Death of the individual is no extinction of values, and no injustice. If he had a real and practical faith in God he needs no compensation in a future life; and if he had not faith in God, but had been snatching at the illusion of his own individual interests, he has already during his life paid the penalty. We are accustomed to lament over the grave of a good man, but we might with better reason rejoice over the manifestation of God in his life: for our lamentations are a bowing down before materialism. In showing, however, our practical sympathy with those who have been left alone, we can best help them to realize God's continued presence to them, so that they can face their loss bravely.

Belief in a soul existing in a material universe, but separable from it, brings us very soon into conflict with physical science, since we have accepted physical science, not as what it really is, a useful system of abstractions from reality, but as a full representation of reality itself. From its very nature physical science can attach no meaning to the existence of a soul or to its immortality, and if we seek for physical evidence of the soul's existence we can never find it. The history of so-called spiritualism is, and can be, nothing but the record of illusion, and I shall not waste time by discussing it. Not even during life can physical science present any evidence of the existence of a soul. Consciousness is for it a quite mysterious accompaniment of certain extremely complex and remarkable physical processes occurring within the brain, and it has to leave the matter at this. It has no language in which it could possibly describe the actual phenomena of perception and conscious action, and in reality it is dumb before these phenomena, though the dumbness is concealed by what is only senseless mumbling. We cannot imagine a material world and a spiritual world to exist side by side, as on the animistic theory. When once we have admitted the reality of the physical world, the spiritual world must sooner or later disappear from any clear view.

The animistic conception of a soul separable from a material body seems to me to be essentially irreligious, since it assumes that outside the spiritual world within which God manifests Himself there is a material world of mechanical chaos in which there is no direct manifestation of God. If we say that God created this chaotic world we are attributing to Him something which seems inconsistent with His attribute of goodness. We are also setting up souls as existences separable from God's other manifestations.

The belief in individual immortality is evidently bound up closely with animism, or the theory that an immaterial soul is present in a material body. In the previous course of lectures, as well as in the present course, I have stated what seem to me the conclusive objections to animism. The same objections seem to me to apply to the idea of individual immortality, and I wish to leave no doubt as to my own conclusion on this subject. I do not think that one to whom religion is the guiding influence in life, and for whom the reality of God is the only reality, could seek for individual immortality. If his vision of God is a true and whole vision, it has effaced the vision of mere individual self, as well as the vision of a real physical universe. We are accustomed, through the New Testament Scriptures and other writings, to the idea that it is only through losing our individual selves, and through faith in the love and omnipotence of God, that we attain to union with Him. It is surely in this union, and not in our continued individual existence, that we attain true immortality, and with it freedom.

Philosophical writers are apt to be somewhat timid and vague on the subject of individual immortality, and still more timid and vague on the subject of physical science. In view of the immense practical success of the latter it tends to escape searching criticism except in so far as physicists themselves criticize it; and, even in the case of Kant, their criticisms have been essentially from the narrow Newtonian standpoint which accepts the very useful physical interpretation of the visible world as representing our actual experience of it. This remark applies just as much to the more recent developments of physical science as to the more literal Newtonian physics of last century.

Immensely valuable as were the post-Kantian developments of philosophy, particularly as represented by Hegel, it seems to me that they failed as effective philosophy through concentration on the ideas which shape our interpretations of experience rather than on the fundamental nature of experience itself. For Hegel the different sciences or departments of knowledge seemed to represent different spheres of application of different fundamental ideas, and he greatly extended Kant's conception of these ideas. But he also concluded that these ideas have in themselves the tendency to become transformed into ideas of a truer or higher sort, so that ideas really make our world, instead of being mere tools used in a partial and limited interpretation of it. As a consequence, his philosophy got out of touch with the fundamental nature of experience itself.

In that experience Hegel's highest categories or general ideas are there from the beginning. The conceptions of God, or of time, space, and matter, for instance, have never been new, though with the advance of civilization they have progressively become clarified, and the stages in this clarification are associated with the names of great men. But the ideas are themselves given in or implied in our experience. If they were not so given, their clarifications would constitute no revelation to us. The ideas embodied in the sciences are only tools devised for the limited practical ends which present themselves in our experience as a part of more comprehensive ends; and God is no mere finally-developed idea, but the presupposition of all ideas and all experience.

From the mere ideas of physics, or of biology, we can never pass directly to what we regard as higher ideas. It is only by reference back to wider experience that we pass to these higher ideas. Ideas are in themselves rigid and immutable, and are only susceptible of clarification where they are not sharply defined. Hegel really attempted to show how the concrete world produces itself from developing ideas, each stage in the process representing a richer and more concrete idea. But the inner dialectic through which he thought that ideas develop into new and higher forms was, it seems to me, just as artificial as in Alexander's realistic philosophy; and he was dealing with ideas abstracted from their concrete application, and therefore unreal, whereas the world of our experience, even if we interpret it wrongly, is a real world not constituted by mere ideas.

Thus the Hegelian philosophy, though it contains a collection of fundamental ideas or categories, does not help us as regards the manner of their application. It tells us nothing as to limitations in the scope of application of physical science or biology, and throws no definite light on the question of personal immortality. Unreality clings to it, in spite of the acuteness of its criticisms and the great influence which it has exerted.

In considering the subject of immortality we are apt to think of unrecognized merit and undeveloped promise, even more than of the recognized merit and experience which seem to end in death. But faithful and gentle conduct, whether it is recognized or not by men, and whether it is prolonged or cut short, is what unites us with God. Even in the lives of criminals, but particularly in those of children, we can recognize this, as Christ did and as our greatest literature does. It is only through halting faith in the reality of God that death of the individual seems to be an actual or potential disappearance of what is to us of the highest value.

The subject of Immortality, including a very illuminating historical account and discussion of the beliefs which have been and are held on this subject, was treated in the Gifford Lectures of 1922 by Professor Pringle 'Pattison. He is in agreement with what I have said as to a belief in individual immortality forming no essential part of religion, and that it is union with God which means eternal life, beyond the vicissitudes of time. Nevertheless he argues for individual immortality, differing in this respect from the late Professor Bosanquet, another great thinker who recently discussed the same question.

The difference between my own standpoint and that of Pringle Pattison and other idealists can be traced back to our different conceptions of life. Life, as I have pointed out, is not something confined to the body of a living organism as its entelechy, but is a unity in which the whole environment is included. Similarly, personality is not something confined and complete in itself separately from an environment in space and time, but extends over that environment; and for either philosophy or religion individual personalities are unreal, the only real personality being that of God. Thus Nature or Experience is nothing but the manifestation of God, though certainly not Nature as merely interpreted by the Sciences. It is therefore a personal God that philosophy and religion point us to, but no mere individual person distinguishable from other persons. It seems to me that belief in individual immortality, just like belief in the existence of individual souls, implies a questioning of the omnipresence and omnipotence of God.

In these lectures I have laid very great stress on a correct scientific conception of what mere life implies; for if we go wrong on this point we go wrong also in the interpretation of personality. It seems to me that neither Aristotle nor Kant nor Hegel reached an adequate conception of what life is. They all regarded a living organism as a self-contained individual, and were thus led to a similar conception of a soul or subject of knowledge.

Overborne as our present age is by the Newtonian interpretation of reality, we are accustomed to think of old age as simply the wearing out of a bodily machine, and death from ordinary diseases and accidents as an unavoidable result of the mechanical conditions which surround us. From a mere physical standpoint, however, there is as little explanation for old age as for the fact that during life the body is constantly renewing and replacing its substance in ordinary nutrition. If the processes of nutrition go on at all, there seems to be no inherent physical reason why they should not go on indefinitely; and in the line of reproductive cells they do as a matter of fact go on indefinitely.

It is clear that the metaphor of a machine wearing out does not apply. From the biological standpoint old age with resulting death is just as much a normal event as is reproduction; and apparently the succession of new individuals makes for the maintenance of adaptation, or organic unity in the relations between organism and environment. From the biological standpoint mere individual life is unreal, though we see this more easily in the cells and other apparent units of life in a higher organism than in the lives of what we commonly regard as whole organisms. The immediate cause of death is asphyxia from want of oxygen, and death is not the mere stoppage of a machine, as a heat-engine stops when its oxygen supply is stopped, but disintegration of living structure, for which there is no physical explanation any more than there is for the maintenance of living structure during life.

I have already pointed out that from the higher and more real philosophical or religious standpoint our individual lives as such are unreal, and that it is only in so far as we lose our individual lives that we become one with Spiritual Reality or God. In the death of an old man the accumulated experience and insight of a lifetime may seem to be lost; but that experience and insight belong to past conditions. Mankind must always be building up its experience and insight anew, and the old experience will only mislead when the conditions are new. Thus old age and death seem to be just a part of losing our individual lives in becoming one with Spiritual Reality or God.

Not only soldiers, but men and women in every walk of life, deliberately risk their lives when the duty of the moment calls on them to do so. If they are true to their race, and not lost in the selfishness and materialism which breed cowardice, they never hesitate about it, and their example lights up the spiritual reality which is within and around us. In losing their individual lives for the sake of others they show that individual life in itself is unreal. Even when death comes by disease or accident it is not something merely useless: for it serves as a warning of danger to those who are left, or removes one who can no longer serve. The knowledge which has accumulated in consequence of deaths from disease and accident is of the utmost practical value in the avoidance of danger. We can therefore regard such deaths as in the same category as death for others on the field of battle or as a direct consequence of the performance of whatever duty may have presented itself. In civilized countries the circumstances of every death are enquired into and recorded as far as possible, and the information thus collected guides future conduct.

In the present lecture I have dealt very openly and directly with the belief in personal immortality, and in doing so it seems to me that I have been guided by the light of religion itself, and that in reality religion, when purified from the materialism mingled with religious beliefs, is the same as philosophy when similarly purified. No one realizes more fully than I do how sensitive a point in religious belief I have been touching on. When we are in presence of the unresponding features and deaf ears of one we have loved we can hardly help seeking for some more direct comfort than the mere faith that individual life and individual death are only a manifestation of God still everywhere around and within us. Our faith is weak, and clouded by the abstractions which seem to us to be realities. We therefore seek for a countervailing abstraction which we call a soul.

It is not to the conception of a soul, but to the reality of God, that we must turn for strength, courage, and comfort. It seems to me that as the shadow of the physical conception of reality passes away from the civilized world, so also will the fear of death pass, and the feeling that there is any real parting in death, since all that was real in those who have died is immortal and ever-present. It is through the presence of God within us all that we attain to eternal life, and that the loved ones whom we seem to have lost are still with us, since God is with us.

LECTURE XIX

THE SCIENCES AND RELIGION

IT is often supposed that the sciences, and particularly the so-called natural sciences, are essentially incompatible with religion. At present this is a widespread popular belief for which there seems at first sight to be a substantial basis; and certainly this belief is common among scientific men themselves, although they may say little about it, out of respect for those who do hold sincere religious beliefs and whose lives they admire.

There are, of course, many examples of men who have been eminent in natural science, and who have nevertheless remained quite orthodox members of various religious bodies; but I think that their number is rapidly becoming smaller. One cannot help feeling that they are abnormal persons who keep their science in one part of their minds and their orthodoxy in another. There are, however, a great many others who, while refusing to accept what are at present called orthodox religious beliefs, yet think that religion embodies, or probably embodies, truth of the utmost importance. The number of scientific men who think in this way seems to be growing, and their attitude towards religious belief is far from unfriendly.

In this lecture I wish to discuss, not only the real and apparent clashes between the sciences and religious beliefs, but how far religion enters into science itself. This last part of the discussion is to my mind the more important part, though it is hardly ever referred to.

The clashes between primitive science and primitive religious beliefs are probably as old as human history, and would formerly have been regarded as heretical or reform movements in religion; but in comparatively modern times the first great clash between recognized science and recognized religious beliefs arose through the discovery of Copernicus, and its promulgation by Galileo, that the earth revolves round the sun, instead of the sun revolving round the earth, as the theologians and the Bible taught. This discovery disturbed profoundly the orthodox theology of the time, though it is perhaps difficult for us now to realize why it should have done so. In any case, the theologians got the worst of the encounter, in spite of the fact that they endeavoured, with the futile weapon of personal restraint, to suppress Galileo's teaching.

With the revival of knowledge the sciences, both natural and humanistic, began to outgrow more and more the tutelage of the Church or Churches, and also to affect their teaching very materially, particularly in the Protestant Churches. In the nineteenth century geology came into open conflict with the biblical accounts of creation, and historical criticism cast the gravest doubt on the authenticity of the biblical records and on the belief that religious teaching originated in a supernatural revelation. The evidence was then brought forward by Darwin that species arise, not by any supernatural act of creation, but by a natural process of selection. Belief in supernatural interference of any kind declined very rapidly as scientific investigation proved more and more clearly that such intervention is not found to occur. To those who believed that religion is dependent on a belief in supernatural intervention it seemed to be dying the death of other superstitions. Yet as a matter of fact religion continued to appeal to men as strongly as before, or perhaps more strongly, as shown in particular by the widespread evangelical movements in the Churches.

The discussions in previous lectures will, I think, have made clear the underlying explanation of this. If my reasoning has been correct, there is no real connexion between religion and belief in supernatural events of any sort or kind. It is only a narrow view of what is "natural" that prevents our recognizing the presence of God everywhere within and around us. The spiritual world of values which we ordinarily recognize is something far less abstract and unreal than what we call the physical world. But the spiritual world is also the world of Nature unless we confine the connotation of the word "Nature" to a mere idealized conception of reality. When, moreover, we look at this spiritual world as a whole, it appears as one Spiritual Reality in which individual interests and individual values disappear as such. It is this which we recognize when we speak, in the language of religion, of God. Nothing else is real except God, and relations of time and space are only the order of His manifestation. Nature is just the manifestation of God, and evolution is no mere biological or physical phenomenon, but the order in time-relations of His manifestation.

In the official creeds and other formularies of existing Churches supernatural events are still a prominent feature. There are even influential sections within, at any rate, the English Church who wish to see, not less, but more of supernatural belief definitely countenanced. On the other hand, a very large and increasing body of persons who have studied or been influenced by one branch or another of science find themselves unable to belong to any recognized Church, because they cannot accept any form of belief in what is supernatural. It is to this body that I myself belong, and, as you must have already seen, I am not here to support what seems to me unsatisfactory theology, but to carry out to the best of my ability the intention of the founder of the Gifford Lectureships. I can put my heart into this attempt because no one can feel more strongly than I do that religion is the greatest thing in life, and that behind the recognized Churches there is an unrecognized Church to which all may belong, though supernatural events play no part in its creed.

Belief in supernatural events is just the complement of the materialism associated with theology, though not with religion itself. If once we admit, as theologians have done, that the visible world is actually a material world, then supernatural events of various sorts have to be called in to justify religious belief. Supernatural creation, supernatural revelation, supernatural raising from the dead, and even supernatural action of the soul on the body, all become necessary. My own wish to see belief in the supernatural dissociated entirely from religion is only part of a wish to see materialism dissociated from it. The materialism with which orthodox theology is at present shot through and through is the whole source of the weakness of religious belief in presence of the sciences, and of the alienation between religious belief and the sciences. It ought to be added, however, that men of science themselves are equally to blame in this respect. They have, on the whole, disregarded philosophy completely. It is probable, for instance, that hardly any scientific writers during the nineteenth century had a real appreciation of the work of Hume and Kant; and even now we find scientific writers taking an actual pride in their ignorance of philosophy. They are in a similar position to that of the Schoolmen who despised experimental science.

In a previous lecture I traced the sciences to their origin in the device of abstract ideas and language to express them in. For the purpose of communicating needs from person to person, language embodying abstract ideas is indispensable. The words themselves represent only abstract aspects of what they refer to; but for practical purposes these abstract aspects are often sufficient. Words referring to extension and number are, to take one example, of a different class from words referring to beauty; and out of the different internally consistent systems of words applying to different abstract aspects of experience the different sciences or branches of knowledge have gradually arisen.

It was a natural enough further step to imagine that the different systems of abstract ideas correspond to separate realities. But the assumed separate realities are inconsistent with one another, and hence arose the clash between different sciences, and between science and religion. Hence also arose the need for a philosophy to mediate between the different sciences.

Each of the sciences or consistent systems of abstract ideas is of the greatest practical use in its proper place; but that place is defined and limited by the practical needs which the science was originally devised to meet. If we extend it further it comes into conflict with other branches of knowledge. It goes also without saying that no science ever represents reality itself, since it deals only with abstractions from reality.

There is a common belief that at any rate in physical science we simply draw conclusions from observation in which we play only a passive part, so that Nature, as it were, simply forces herself upon us, and we are thus in presence of absolute truth, of which physical science is the generalized representation. To those who have read and absorbed the philosophical writings of Hume, Kant, and their successors this is simply a childish belief. In actual fact, where one man observes the "bodies" of the Newtonian world in Newtonian space and time, another man may observe what pertains to life, for which space-relations are not relations of externality. Still another man may observe artistic or ethical values for which neither space- nor time-relations are relations of externality. Yet another may simply realize that he is in the presence of God.

In physical observation we deliberately disregard or abstract from other aspects of what we are observing; and to this extent physical observation is only dealing with abstractions. But we are also doing a great deal more. From the biological or artistic standpoint it is only on what may be called a low-power or general view that we observe life or beauty. The details of this view are dim and undefined, just as the details of a picture—the daubs of paint in it—are undefined in the artistic view. Yet the artist must know, sufficiently for his practical purpose, how to obtain and manage the paint which he employs; and this knowledge is physical knowledge, obtained from observation, not by any mere process of abstraction, but as something new, which he learns from Nature. From the physical standpoint the picture is, moreover, nothing but a collection on the canvas of daubs of paint, arranged relatively to one another in a certain way. But in this apparent mere collection the daubs of paint have, in the logical judgment which embodies artistic perception, lost their individuality as "bodies." The picture is no mere collection of bodies: it is something which is meaningless to the physicist as such, because his perception of it abstracts from its artistic reality; but he may see far more deeply into the abstraction called "paint" than even the artist did.

However true it may be that the world of our actual experience is a spiritual world, it is also true that this spiritual world only appears to us in the process of interpretation of a world of what by themselves are mere abstractions. In actual experience these abstractions are constantly welling up before us, and it is only in the constant overcoming or logical transformation of them that spiritual reality manifests itself. Their appearance is thus essential to spiritual reality, which is the reality of their transformation in perception and conscious response. The artist must always be overcoming the abstractions of his paint, and the good man must always be overcoming the abstractions of the evil surrounding him. On a lower plane, life only manifests itself in the fuller interpretation of an abstract physical world. Mind does not merely arrange formed perceptions, but creatively transforms them and their corresponding responses. The old traditional account of logic is very inadequate.

The definite shaping of an abstract world is thus necessary for the manifestation of a more concrete world. In this sense the world of mathematical abstractions is necessary to the less abstract physical world, the world of physical abstractions to the less abstract biological world, and the world of biological abstractions—the world of "the flesh"—to the less abstract spiritual world. It is not the mere contrast between the more abstract and less abstract worlds that is necessary: the connexion is far more intimate. The logical building-stones for the more concrete knowledge are, as it were, supplied by the less concrete knowledge, but become completely transformed in the process of building. The daubs of paint make a picture, but only if the paint is suitable. A series of physical and chemical measurements become a manifestation of the life of an organism, but only when the measurements are definite and correct. With sloppy measurements the manifestation is obscured or obliterated. It was the absence of definite and relevant physical and chemical measurements that, as already pointed out, led, during the latter half of last century, to the idea that life could be interpreted as a physico-chemical process.

It thus appears that the more abstract branches of knowledge, mathematical, physical, and biological, are essential for the spiritual interpretation of our experience and corresponding conscious behaviour. The practical applications of the more abstract sciences are evident in connexion with all branches of conscious activity; as regards, for instance, the phenomena connected with our own bodies and environment, we are constantly making use of biological conceptions. Thus when we attempt to apply merely physico-chemical conceptions to life, a scientific practice of medicine is impossible, as Hippocrates clearly saw. It might seem, however, that we can apply ourselves to pure science without any thought of its practical application. Many scientific men have refused to turn aside from their work in order to apply it to practical ends, and so far as their scientific work is concerned they are often regarded as somewhat inhuman persons. In reality they are at the very opposite extreme from being inhuman. They have devoted themselves to their specialized work under the conviction that they saw how it could be of the utmost use to others. They therefore take great pains to put their results into shape for publication in a form which will be intelligible and useful to others; and if they refuse to be turned aside by immediately practical applications of their knowledge, this is only because they consider that the work they have set out to do is more important. Again and again scientific men have turned out to be right as to this; but sometimes they have faltered in their judgment, as in the case of Pasteur, who at an early stage in his career imagined that he could do more important work as a Senator, and was only stopped through the electors fortunately rejecting him. Other instances occur to me where born scientific leaders have actually turned away to politics or business work, with results which were certainly not in the public interest.

In actual fact the work done by men of science is determined, not by the mere nature of the scientific abstraction which they are following up in its direct applications to experience, but by the human needs which the employment of the abstraction meets. Work in pure science is just as essentially unselfish as any other kind of work can be, and ought to be. Even if it is regarded as work for the purpose of ascertaining truth, this means such truth as will be of service to fellow-men in saving them from the consequences of ignorance and superstition.

It often happens that scientific men are hostile to religious belief and disclaim any connexion with it. In their actual scientific work, however, they behave just as if they were actuated by faith in the reality and unity of the highest spiritual values. Belief in the reality and self-consistency of truth, combined with the conviction that truth will help in the realization of everything that is called good, differs only in name from religious faith. At any rate I am unable to distinguish them after religious faith has been purified from the dross of the theological materialism to which reference has already been made.

It is true that scientific men commonly mistake scientific abstractions for representations of reality. But so do those who hold ordinary orthodox religious beliefs, and particularly those who in the name of religion attack others who cannot hold orthodox religious beliefs, and act conscientiously and unselfishly according to what they believe to be true. If it is in the name of supposed religion that the attack is made, it will be repelled with the power and conviction of real religion.

I think there can be no doubt that scientific men as a body will continue to oppose religious beliefs in so far as these beliefs are associated with any element of what is known as the supernatural; and it may be long before the supernatural element is eliminated from religion as represented by the Churches. I can, however, see no final obstacle to this elimination. The Churches, purged from materialistic theology, will then stand united for belief in God, communion with God, and all the strength, steadfastness, and Christian charity which true religion carries with it. Scientific materialism has been due to a misunderstanding as to the scope and limitations of physical interpretation. As soon as it is realized that such interpretation is limited in scope, since it cannot be applied to life, and still less to conscious behaviour, scientific materialism will disappear, though physical science and biology will continue in their necessary and extremely useful careers. Religion and philosophy will also be one.

Religion has always been, in practice, a general philosophy of conscious behaviour, and it has stood for the reality of the spiritual interpretation of reality, without neglecting the sin and suffering which appear to be around us on every side. Religious belief freed from the confusions which have arisen out of mere one-sided use of scientific abstractions becomes indistinguishable from a philosophy which is similarly freed. The mathematical and physical sciences stand already for what appeals to all men in every country; but the same cannot be said for religious belief in its present form. Christian theology hardly appeals to those holding sincere religious beliefs of different historical origins from ours, or even to more than a section, though still a large one, of our own countrymen, or of other persons of European stock. Nevertheless the Founder of Christianity intended it to appeal to all men, and it seems to me that it would be only in the spirit of that Founder to purge Christian theology of everything that prevents it from making a universal appeal, to which men of science and those belonging to other civilizations can respond just as well as those to whom the present form of Christian theology or some other theology appeals. Christianity represents, not the mere letter transmitted to us, but a message capable of growing in clearness and in the universality of its appeal.

The abstractions with which the sciences deal are no less useful and necessary when we recognize that they are abstractions. In the case of the mathematical sciences this is generally understood; but the physical sciences are commonly supposed to deal with reality itself. In the allegorical figure representing Justice she holds in her hands a balance, which is a physical apparatus for measuring the abstraction called mass by means of mathematical observations as to the position of the pointer. Justice cannot be expressed in either physical or mathematical terms; but physical and chemical measurements and mathematical calculations are essential to fair dealing. When they are associated in a certain way they embody justice. It is justice which determines the nature and association of the measurements and calculations, but without them there would be no justice, so that they are essential.

They enter similarly into the perception of interest and values of every sort, and the conscious behaviour which corresponds to interest and values. A scientific worker immersed in the problems of what is called pure science, or teaching pure science, may seem to the world, though not to himself, to be somewhere far away from human interests; but the engineers, technical chemists, doctors, agriculturists, and others who are engaged in utilizing scientific knowledge in ordinary life are in constant direct touch with these interests, which grow in concrete richness or definiteness with their work. Their knowledge is directly to them the power of helping their fellow-men, and in the right use of that power they reach, just as in the cases of other men who are following out the duties which are constantly being presented to them, oneness with the Spiritual Reality which is within and around them. The difference between them and those engaged in pure science is simply that the work of the latter is commonly of wider application.

Thus it is the case that although the mathematical, physical, and biological sciences do not, at first sight, seem to deal with spiritual values, they are in reality inspired by them, and just in proportion to the sincerity with which they are pursued they bring science into contact with Supreme Spiritual Reality, or God. He who attacks scientific work as such is thus attacking religion itself. Science, it is true, is constantly attacking theological accompaniments of religion; but these attacks, when rightly understood, are not on religion itself, but on what only obscures religion and prevents its appeal to mankind from being effective. We must not confuse religion with all that is taught in churches or embodied in creeds and religious ceremonies. What the sciences can rightfully ask for from the Church is that its creed should be so amended as not to exclude those who, while accepting the great truths of religion, are unable to accept supernatural beliefs.

Humanistic knowledge and occupations, including Art, seem at first sight to be more directly in contact with spiritual values than the "natural" sciences and their applications, or than so-called mechanical occupations. A little reflection shows, however, that this is not, or need not be, the case. The person who is doing in all sincerity the duties which present themselves to him in whatever station he occupies is in direct contact with Spiritual Reality. Religion raises us all to the same level through the presence of God within us; and however powerful its influence is for social stability, it is an equally powerful influence for social freedom and underlying equality.

The conclusion which has been reached as to the relation between the Sciences and Religion may be summed up by saying that there is no contest between them at all. This appears as true, however, only in the light of the inferences, firstly that beliefs in supernatural events form no part of religion itself, and secondly that Science deals, not with ultimate reality, but only with abstractions of limited practical application.

With those who imagine that Science can or will present anything but the firmest opposition to beliefs in supernatural events I cannot for a moment agree. To ask Science to desist from this opposition would be equivalent to asking her to abjure her religion; and anything stronger it is impossible for me to say as a representative of Science. On the other hand, when Science pays no heed to the wider analysis of Experience, or of Nature, by Philosophy, and sets up her own working hypotheses as representing Reality itself, she will meet with just as firm opposition from Religion as she presents to belief in supernatural events.

The present widespread belief that Religion will die out as Science advances is nothing but evidence of intellectual blindness. Existing Churches will decay if they do not amend their creeds; but Religion will no more die out than Science will, or Philosophy will. Religion and Philosophy are in reality one thing, which is just as indispensable as Science is.

LECTURE XX

RETROSPECT

IN this concluding lecture I shall endeavour to sum up the reasoning which I have laid before you, which, needless to say, is simply an attempt to bring consistency into the inheritance which has come to me individually in science, philosophy, and religion. That inheritance has been received from sources which can be traced backwards through the history of many nations to dim antiquity; and it is much the same inheritance as, in Scotland particularly, very many have received. Perhaps, however, it has come to me in such a manner as to bring the apparent inconsistencies in it into specially sharp outline, for it came very directly through those who were nearest to me.

In the first course of lectures I reviewed the various kinds of knowledge, or sciences, which seem to be forced upon us in our actual experience. We can divide these sorts of knowledge into mathematical, physical, biological, and psychological or humanistic knowledge. These kinds of knowledge are just different kinds of interpretation of our experience, and on them are based different kinds of occupation or behaviour; but they seem to contradict one another, and we seem to be constantly passing inconsistently from one kind of interpretation and behaviour to another.

The mathematical sciences deal merely with time-relations (arithmetic and algebra) and space-relations (geometry). We can count events regardless of their inter-connexion, their importance, or the intervals between them. We can also reason about shapes without regard to what the shapes are of, or how far or in what sense actual shapes correspond to them. Thus the mathematical sciences deal quite evidently with ideal abstractions which we at once recognize as such. I therefore passed lightly over the mathematical sciences, as in recent times since Newton we have not been much perplexed by them.

It is very different, however, with the physical sciences, since the physical interpretation of our experience, as given definite form to by Galileo, Newton, and their successors, has claimed to represent visible reality itself; and round this particular claim the main problems of modern philosophy have centred. I pointed out that on this claim visible reality consists of " bodies " existing independently of one another in space and permanently in time, each body possessing definite fundamental properties of its own, and acting at different times on other bodies in such a manner that their actions and reactions can be summed up as energy, which is just as indestructible as the bodies themselves, and is constantly passing from body to body.

Without waiting to discuss the direct philosophical objections to this interpretation, I then proceeded to consider the biological interpretation of visible reality; and this occupied several lectures, as biology has suffered severely from the failure of its representatives to put their science into coherent form, though they have evolved a large and characteristic body of knowledge and a distinctive nomenclature. The science is there, but the form in which it is commonly summed up is very deficient, owing to their having been overborne by the physical interpretation.

Up till about the middle of last century most biologists had attempted to interpret the experience they were dealing with on the "vitalistic" theory that within living organisms, but not outside them, physical influences are interfered with and guided in a specific manner by what was known as a "vital principle" or "vital force," or, in recent times, as an "entelechy." This theory, as was pointed out in Lecture IV, was almost universally abandoned, on the very sufficient ground that it can easily be shown experimentally that whatever influence had been attributed to the vital principle depends on the influence of the admittedly physical environment. It seemed, therefore, that biology must in reality belong to the physical sciences; and this became the orthodox conclusion of biologists in the latter part of last century.

In Lectures II and III this conclusion was examined and shown to be completely unsatisfactory and inconsistent with biological observation. It is, moreover, quite impossible to return to vitalism. What the observations necessitate is nothing less than abandonment of the physical interpretation of visible reality, substituting for it the conclusion that in the phenomena of life we have the manifestation of a unity within which physical bodies as such, with their corresponding spatial externality, do not exist, and which includes the environment as well as the bodies of organisms. This unity persists just as do the "bodies" of the physical interpretation; but its persistence is active, since it is only through activity that it manifests itself. The structure which it displays is the expression of activity, and the activity is an expression of the structure.

This is the unity which we call life; and the branch of knowledge which deals with life is biology. It is distinguished from the physical sciences because its fundamental conceptions are different from those of physical science. It is thus an independent science or group of sciences. Both the vitalistic and the mechanistic school in biology had, as it were, sold its birthright for a mess of very unsatisfactory pottage. Looking back on the history of biology we can see how its progress has been retarded or deflected by the misleading mechanistic and vitalistic theories, which led, for instance, to an artificial separation of anatomy from physiology, and to futile theories of heredity and of an origin of life in time.

We cannot express biological phenomena in terms of physical conceptions. Yet biological phenomena are part of our visible world. It follows at once that physical conceptions are by themselves incapable of representing visible reality, however useful they may be. They are thus in the same position as merely mathematical conceptions: they do not express reality. This is a conclusion of great philosophical importance, for we can no longer describe as realism a philosophy which accepts the physically-interpreted world as a representation of reality. The distinction between physics and biology stands, therefore, for something fundamental in philosophy. It cannot be neglected, as it has so often been in the past.

Life has many forms. But for one organism the life of another is simply part of its biological environment, and is thus included in the unity of its life. When, however, we examine the unity of life more closely, we find that it is not, as may at first sight suggest itself, something merely centred in individual organisms or individual cells, or in units of life in a cell, but expresses the life of communities of organisms or cells. The life of the individual organism or cell is thus actually the wider life; and the death of the individual cell, or organism, or even group or species of organisms, becomes only a normal incident in a continuous wider life. With the occurrence of death we do not pass outside of biological interpretation, any more than we pass outside physical interpretation when a solid substance is gasified. From the biological standpoint life is continuous in time, and represents something inherent in the very existence of Nature, just as do matter and energy from the ordinary physical standpoint.

In the sixth to the ninth lectures of the first course I discussed the branches of knowledge concerned with conscious behaviour, this knowledge being comprehensively designated as psychology, though we might also designate it as humanistic knowledge. The fundamental fact was pointed out that both perception and conscious action embody interest, and that this implies, not merely, like life, unity in spatial relations, but also unity in time-relations, so that events in their time-relations, and not merely in their space-relations, enter into the unity. This implies the existence of progress or evolution. What is perceived is perceived in relation to both past and future, as a whole, as well as to present as a whole, since it is of interest; and similarly retrospect and foresight enter into conscious action. The world of psychological knowledge is a world of interest and the values embodying it. For neither physical nor biological knowledge have interest or values any significance, since events in the physical and biological worlds are simply regarded as what may chance to occur, though they must occur in accordance with physical or biological conceptions. In psychologically interpreted knowledge, on the other hand, events are no longer regarded as matters of indefinite "chance," but as the progressive manifestation of interest and values, which unify the events.

For psychological interpretation present events are inseparable from past and future events, since these events embody interests and values which manifest themselves in time-relations as well as space-relations. We cannot separate their manifestation in time-relations from that in space-relations. History, whether of individuals or countries, is no mere chronicle of isolated events, but the present is the fulfilment of the past and the promise of the future. If we endeavour to regard perceptions and conscious actions as mere isolated events, like physically interpreted events, we are just missing what is characteristic of them, and are thus lost in meaningless abstractions. If, for instance, we endeavour to regard them as being either the interaction between a soul or subject and a material world, or the manifestation of mere life, we are simply endeavouring to do what is impossible. It is meaningless to speak, either of the relation of the soul to the body, or of conscious behaviour as a mere blind manifestation of life.

Just as in the biologically-interpreted world what at first sight may seem to be individual lives turn out to be the manifestations of a wider life, so in the psychologically-interpreted world what appear at first sight to be individual centres of interest and values turn out, as shown by social relations, to belong to social centres. Hence individual interest and personality are swallowed up in the wider interest and personality. We can, moreover, classify apparent values in correspondence with the less real and fundamental, or more real interest which they represent. The former we roughly classify as material, and the latter as ethical or spiritual values.

The survey of different kinds of science or knowledge in the first course of lectures thus led up to the result that the different sciences or groups of sciences represent fundamentally different interpretations of reality, and we may regard these interpretations as the bases of Logic for each science. There are thus no grounds whatever for concluding that the physical representation, however useful it may be for certain practical purposes, is a true representation. It is nothing but an ideal representation which breaks down completely when we endeavour to apply it to the facts of biological and psychological experience; while biological interpretation breaks down in presence of the psychological facts of conscious behaviour. The facts of conscious behaviour belong just as much to our visible and tangible experience as other facts, and we cannot neglect conscious experience in framing our conception of what is real.

In the last lecture of the first course I pointed out that it is only in a general manner, and imperfectly, that we can apply the psychological interpretation. In matters of detail we have to fill up the gaps by applying physical or biological interpretation. Thus we seem compelled to regard ourselves as if, in spite of psychological interpretation, the events in our lives exist also only here and now, subject to all the mere chances of a physical or biological universe. It seems also to be the case that even in so far as we interpret our experience and actions in the light of interest and values, the interest and values are to a large extent of a lower kind. Although, therefore, we have got rid of the meaningless questions as to the relation of life to matter, or soul to body, we are still confronted by the question why it is that reality appears to us under the more abstract physical or biological interpretations, as well as under the less abstract psychological interpretation. This is the real question which the sciences propound to philosophy, and which was the subject of the present second course of lectures.

The question confronts us at once when we consider the relation between physical and biological interpretation; and this relation was discussed in the first three lectures of the present course. What is before us is not the meaningless question as to the relation of life to matter, but the question as to the relation to one another of two different interpretations of our experience. I pointed out that it is only on the basis of an accurate preliminary application of physical interpretation in matters of detail that biological interpretation advances. Defective physical and chemical investigation produces only defective biology, just as defective mathematical data produce defective physics and chemistry. It was defective physical and chemical investigation which led to the idea, still widely prevalent, that biology can be regarded as nothing but a branch of physics and chemistry.

When, in placing physical and chemical data in conjunction with one another, we take the phenomena of life into consideration, it becomes evident that these data can only be interpreted consistently on the theory that visible reality implies co-ordinated persistence of activity expressing itself in a correspondingly co-ordinated persistence of structure or arrangement of parts. The fact of the co-ordination, as clearly shown in the phenomena of life, is inconsistent with the fundamental physical assumption that bodies and actions exist in space independently of one another. Hence we cannot form a consistent physico-chemical conception of visible reality, and must regard it, in spite of superficial appearances, as life, making the conception of life not only the basis of the science of biology, but also an ideal for a deeper understanding of the whole of visible reality. It is only, however, through scientific faith, based on a conviction of the consistency of our experience that we make this inference. We certainly cannot see in anything like full detail how this inference applies, and must content ourselves with a physical interpretation of detail where biological interpretation is not discoverable, as it is in what we recognize as the phenomena of life. This means that though the physical interpretation of reality is of great practical service as giving us a limited insight into reality, it never represents reality itself.

When we turn to the facts embodied in the psychological or humanistic interpretation of experience we find that our experience embodies interest and values which extend indefinitely over both space-relations and time-relations. This is just a fact of experience, of which there is no " explanation " any more than there is of the existence, on the physical interpretation, of matter and energy, or, on the biological interpretation, of life. For psychological interpretation the spatial and temporal arrangement of things and events are not relations of externality or separation, but expressions of their own nature, which extends throughout all space and time relations.

It is when what might otherwise appear as isolated events in mere blind organic life are considered together that the necessity for psychological interpretation appears. Thus psychological interpretation, though it is an inherent aspect of experience, can grow in definition only through preliminary biological interpretation, just as biological interpretation can grow in definition only through preliminary physical interpretation. In this sense psychological interpretation is based on biological, and biological on physical interpretation. Thus we can regard both biological and physical interpretation as nothing but the first stages in psychological interpretation, and therefore parts of it.

Interest and values are no mere individual interest and values, but, in so far as they are what we call spiritual interest and values, are common to all men and extend indefinitely beyond mere human society. Hence they appeal to us as being objective or the same to all. But since biological and physical interpretation are the first stages in this objective interpretation, they also appeal to all men as being to this extent objective. They are not objective by themselves, since they are by themselves quite incapable of interpreting our experience, but as the first stages in objective psychological interpretation they become objective in the sense that they appeal to all men. In this sense the mathematical, physical, and biological sciences belong to the world of spiritual values, and imply no opposition to, or separation from that world.

The universe of spiritual interest and values would be inconsistent with itself if it were not one spiritual universe, corresponding to what, in the language of religion, we call God. God is thus the only final reality, and individual interest or personality has its only reality in God. From this standpoint existence in time is just the progressive manifestation of God. The existence of God and His love is a primary and fundamental fact, the presupposition of all experience or of what we call Nature; and it is solely in our perception of spiritual values and faith in their unity that the existence of God is revealed to us. Through this faith we identify our own wills with God's will when we strive for what presents itself to each of us as his or her own particular duty.

In the light of this conclusion we must reject without any hesitation the theory that reality is represented by the mere physical interpretation of what we perceive. The physical interpretation is only objective as a stage in spiritual interpretation. Hence we must reject materialism in every shape and form, and without the smallest compromise. In doing so we at the same time vindicate the place of the mathematical, physical, and biological sciences in the world of spiritual values. The sciences are in no way hostile to, or outside of, the world of spiritual values, but an essential part of it. As a representative of one of the sciences I must insist on this claim.

We must also reject a great deal of what, as theology, is at present usually associated with religious belief. Current theology is full of what seem to me to be materialistic beliefs which obscure religion and deprive the Churches of co-operation, just as the work of a scientific organization would be injured if its investigations were only carried on in the light of obsolete scientific conceptions. The theory that God is a person distinct from His creations, and created the Universe in time as a mechanical universe, seems to me to be a mere compromise with the materialism for which visible reality is physical reality. There is no physical reality outside God: the assumption that there is such reality is only materialism which must be firmly and decidedly dissociated from religion.

Another theological belief which must be rejected is that religion has only come to us by a "supernatural" revelation. This is also part of the materialism which assumes that our universe is not a spiritual universe in which God is revealed to us everywhere and at all times if we will only open our eyes. That God and His love are everywhere present amid our apparent world of sin and sorrow was the real message of the Founder of Christianity, and this message was only put then into a much truer and deeper form than that in which it had previously existed. It is for the representatives of religion and philosophy to make that message stand out still clearer and more cogent, as representing a faith which is the inspiration of everything that has true value, and that represents real progress.

Ever since physical interpretation was definitely formulated and applied, the idea of a real physical universe has seemed to menace more and more all that we include under the description of spiritual values. The apparent menace has come to a head in our times. I have tried in these lectures to face it without the slightest flinching. It has turned out that physical interpretation is only a preliminary ideal interpretation, and is therefore no menace at all. The time is not far distant when our successors will look back with wonder at the materialistic superstition of the times we are living in: for materialism is nothing better than a superstition, on the same level as a belief in witches or devils. There are earnest, conscientious, and unselfish materialists, just as there are, or have been, earnest, conscientious, and unselfish believers in witches, devils, and hell. But all these beliefs will go the way of other superstitions; and the world will be well rid of what has tended only to obscure religion.

A further unfounded theological belief is that there is a soul existing in space and time independently of a merely material body from which it parts at death.

This belief is also part of the materialism of current theology. A material world as such does not exist, nor have mere individuals as such any real existence. The only reality is in God, and we are one with God in so far as we are realizing the spiritual values in the progressive realization of which His existence is expressed. These values are not individual values, and death of the individual does not imply a partial extinction of them.

It is only through want of faith, and corresponding failure in surrender of our individual interests to God's interest, that we fear death and look for personal immortality, or regard our interest as a merely personal interest commencing with birth in a surrounding material world. Death or personal calamity or advancement should be regarded as only an incident in the fulfilment of God's will. So it is that a brave sailor or soldier meets death in battle, or meets either neglect or the conferment of personal honours. We can all die like brave sailors or soldiers, trusting in God as they do, though to them trust in God may take the form that their comrades and their country will carry on in the duty which stands above any mere individual interest.

Belief of any kind in what is supernatural seems to me to imply a faltering in religious faith. For religion, Nature is nothing but a manifestation of God, so that the very idea of anything supernatural is contrary to religion. It is only in so far as we have accepted a materialistic and thus totally irreligious interpretation of visible reality that belief in supernatural interference has to be brought in as a feeble make-weight. It seems to me that the sooner religious belief is dissociated entirely from belief in supernatural interference, the better will it be for humanity. Apart from other considerations, men of science, in so far as they are true to the high ideals which inspire their work, will never accept any belief in supernatural interference. Belief in the self-consistency of the universe is for them equivalent, in ultimate analysis, to belief in the existence of God, and is thus something sacred and not to be tampered with for any consideration whatsoever.

In the course of these lectures I have brought you into contact with the deepest and most far-reaching questions which we all have to grapple with in some sort, and I have given you the results which have been forced on me in the course of a life now drawing to its close, but during which these questions have been constantly present. I am glad that the lectures have been given before a Scottish audience; for I think that it is by an audience of my own countrymen in the narrower sense that the arguments which I have presented, and the manner of their presentation, will be most readily understood, since philosophy, pure science, and theology have come to flow to an unusual extent together in the blood of Scotsmen. These lectures have not been in the form of practical sermons. Nevertheless they seem to me to have practical applications in various directions; and in concluding this last lecture I wish to glance very shortly at some of these applications.

In the first place, I think that the interpretation which was given of the true aims of biology and its consequent place as an independent science has bearings of the most direct kind on the teaching and practical applications of the biological sciences and on the direction of future investigation and progress in these sciences. Both biological teaching and biological investigation seem to me to have been held back owing to the inadequacy with which the aims of biology and its true place among the sciences have been understood. As a science it is in reality one, and the disastrous theoretical separation of physiology from anatomy ought to disappear, together with corresponding misconceptions in Medicine and Agriculture.

As regards psychology also, the practical applications seem very clear. For if the conclusions placed before you are correct, psychology is an independent science distinct from biology or physics, with fundamental axioms of its own. Under the guise of psychology the world is being flooded with literature which consists partly of very imperfect physics, partly of equally imperfect physiology, and partly of a gross and often extremely nasty misrepresentation of human nature. All this upsets old beliefs, but puts nothing but a far worse muddle in their place; and since psychology is a subject of the utmost importance, the importance of placing it on a sound theoretical basis as an independent science is very great. In actual fact it is represented, though not specifically as a science, in all the humanistic branches of knowledge.

The practical importance of philosophy in bringing consistency into the relations between different kinds of knowledge was taken for granted at the outset of the lectures, and must have become more and more evident as the discussion advanced. Of all the very foolish ideas current at the present time none is, I think, more foolish than the idea that philosophy is useless and has made no progress since antiquity. I am bound, however, to admit that I have only as yet myself encountered this idea as originating south of the Tweed. Those who, in modern times, think that they can do without philosophy, and at the same time without religious belief, are invariably the victims of bad and obsolete philosophy; and unfortunately these victims have been very numerous in the ranks of men of science, owing to their defective education in philosophy. Philosophy, to be effective, must, however, be in constant living contact with the sciences, from which her questions come. She becomes impotent if she is not fully aware of the sharply defined questions which are constantly being presented to her by the sciences.

The practical applications as regards theological teaching and its embodiments in the creeds of Churches are very direct. I have not avoided or touched only lightly on this subject, since I feel that it is of vital importance. These lectures will have been in vain if they have not produced the conviction that religion, which is, in reality, only philosophy under another name, is a matter of supreme practical importance. The acknowledged representatives of religious teaching are the Churches, and if they are hampered by obsolete creeds they cannot perform their duty effectively. I pointed out that existing creeds are obscured by materialism in one form or another, and that belief in supernatural events is simply the outcome of this materialism. The clear practical deduction is that such belief should, since it is inconsistent with full faith in God, be eliminated from the teaching of the Churches. I have not the slightest fear for the future of religion, but it seems to me that the influence of the Churches is certain to dwindle more and more unless supernatural belief is banished from their teaching.

When that day comes the Churches will be able to fight practical materialism, and everything in modern life that drags us downward, with weapons which will not fail. Religion will also go hand in hand with the sciences, as it once did, and, like them, will appeal to all men, irrespective of their nationality or scientific conceptions.

When we understand the real evidence that this universe is nothing but a spiritual universe and the manifestation of God present within and all around us, the Churches can again teach, in a manner which will carry general conviction, these old words which have brought strength to go forwards, peace of mind, and charity, to so many: "For I am persuaded that neither death, nor life, nor angels, nor principalities, nor powers, nor things present, nor things to come, nor height, nor depth, nor any other creature, can separate us from the love of God."

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