Mechanism and Its Alternatives (1925)

C. D. Broad

In this chapter I want to consider some of the characteristic differences which there seem to be among material objects, and to inquire how far these differences are ultimate and irreducible. On the face of it the world of material objects is divided pretty sharply into those which are alive and those which are not. And the latter seem to be of many different kinds, such as Oxygen, Silver, etc. The question which is of the greatest importance for our purpose is the nature of living organisms, since the only minds that we know of are bound up with them. But the famous controversy between Mechanists and Vitalists about living organisms is merely a particular case of the general question: Are the apparently different kinds of material objects irreducibly different?

It is this general question which I want to discuss at present. I do not expect to be able to give a definite answer to it; and I am not certain that the question can ever be settled conclusively. But we can at least try to analyse the various alternatives, to state them clearly, and to see the implications of each. Once this has been done it is at least possible that people with an adequate knowledge of the relevant facts may be able to answer the question with a definite Yes or No; and, until it has been done, all controversy on the subject is very much in the air. I think one feels that the disputes between Mechanists and Vitalists are unsatisfactory for two reasons.

i. One is never quite sure what is meant by "Mechanism" and by "Vitalism"; and one suspects that both names cover a multitude of theories which the protagonists have never distinguished and put clearly before themselves. And
ii. one wonders whether the question ought not to have been raised long before the level of life.

Certainly living beings behave in a very different way from non-living ones; but it is also true that substances which interact chemically behave in a very different way from those which merely hit each other, like two billiard balls. The question: Is chemical behaviour ultimately different from dynamical behaviour? seems just as reasonable as the question: Is vital behaviour ultimately different from non-vital behaviour? And we are much more likely to answer the latter question rightly if we see it in relation to similar questions which might be raised about other apparent differences of kind in the material realm.

The Ideal of Pure Mechanism

Let us first ask ourselves what would be the ideal of a mechanical view of the material realm. I think, in the first place, that it would suppose that there is only one fundamental kind of stuff out of which every material object is made. Next, it would suppose that this stuff has only one intrinsic quality, over and above its purely spatio-temporal and causal characteristics. The property ascribed to it might, e.g., be inertial mass or electric charge. Thirdly, it would suppose that there is only one fundamental kind of change, viz., change in the relative positions of the particles of this stuff. Lastly, it would suppose that there is one fundamental law according to which one particle of this stuff affects the changes of another particle. It would suppose that this law connects particles by pairs, and that the action of any two aggregates of particles as wholes on each other is compounded in a simple and uniform way from the actions which the constituent particles taken by pairs would have on each other. Thus the essence of Pure Mechanism is

a. a single kind of stuff, all of whose parts are exactly alike except for differences of position and motion;

b. a single fundamental kind of change, viz, change of position. Imposed on this there may of course be changes of a higher order, e.g., changes of velocity, of acceleration, and so on;

c. a single elementary causal law, according to which particles influence each other by pairs; and

d. a single and simple principle of composition, according to which the behaviour of any aggregate of particles, or the influence of any one aggregate on any other, follows in a uniform way from the mutual influences of the constituent particles taken by pairs.

A set of gravitating particles, on the classical theory of gravitation, is an almost perfect example of the ideal of Pure Mechanism. The single elementary law is the inverse-square law for any pair of particles. The single and simple principle of composition is the rule that the influence of any set of particles on a single particle is the vector-sum of the influences that each would exert taken by itself. An electronic theory of matter departs to some extent from this ideal. In the first place, it has to assume at present that there are two ultimately different kinds of particle, viz., protons and electrons. Secondly, the laws of electro-magnetics cannot, so far as we know, be reduced to central forces. Thirdly, gravitational phenomena do not at present fall within the scheme; and so it is necessary to ascribe masses as well as charges to the ultimate particles, and to introduce other elementary forces beside those of electro-magnetics.

On a purely mechanical theory all the apparently different kinds of matter would be made of the same stuff. They would differ only in the number, arrangement and movements of their constituent particles. And their apparently different kinds of behaviour would not be ultimately different. For they would all be deducible by a single simple principle of composition from the mutual influences of the particles taken by pairs; and these mutual influences would all obey a single law which is quite independent of the configurations and surroundings in which the particles happen to find themselves. The ideal which we have been describing and illustrating may be called "Pure Mechanism".

When a biologist calls himself a "Mechanist" it may fairly be doubted whether he means to assert anything so rigid as this. Probably all that he wishes to assert is that a living body is composed only of constituents which do or might occur in non-living bodies, and that its characteristic behaviour is wholly deducible from its structure and components and from the chemical, physical and dynamical laws which these materials would obey if they were isolated or were in non-living combinations. Whether the apparently different kinds of chemical substance are really just so many different configurations of a single kind of particles, and whether the chemical and physical laws are just the compounded results of the action of a number of similar particles obeying a single elementary law and a single principle of composition, he is not compelled as a biologist to decide. I shall later on discuss this milder form of "Mechanism," which is all that is presupposed in the controversies between mechanistic and vitalistic biologists. In the meanwhile I want to consider how far the ideal of Pure Mechanism could possibly be an adequate account of the world as we know it.

Limitations of Pure Mechanism. No one of course pretends that a satisfactory account even of purely physical processes in terms of Pure Mechanism *has* ever been given; but the question for us is: How far, and in what sense, *could* such a theory be adequate to all the known facts? On the face of it external objects have plenty of other characteristics beside mass or electric charge, e.g., colour, temperature, etc. And, on the face of it, many changes take place in the external world beside changes of position, velocity, etc. Now of course many different views have been held about the nature and status of such characteristics as colour; but the one thing which no adequate theory of the external world can do is to ignore them altogether. I will state here very roughly the alternative types of theory, and show that none of them is compatible with Pure Mechanism as a complete account of the facts.

(1) There is the naive view that we are in immediate cognitive contact with parts of the surfaces of external objects, and that the colours and temperatures which we perceive quite literally inhere in those surfaces independently of our minds and our bodies. On this view Pure Mechanism breaks down at the first move, for certain parts of the external world would have various properties different from and irreducible to the one fundamental property which Pure Mechanism assumes. This would not mean that what scientists have discovered about the connexion between heat and molecular motion, or light and periodic motion of electrons would be wrong. It might be perfectly true, so far as it went; but it would certainly not be the whole truth about the external world. We should have to begin by distinguishing between "macroscopic" and "microscopic" properties, to use two very convenient terms adopted by Lorentz. Colours, temperatures, etc., would be macroscopic properties, *i.e.,* they would need a certain minimum area or volume (and perhaps, as Dr Whitehead has suggested, a certain minimum duration) to inhere in. Other properties, such as mass or electric charge, might be able to inhere in volumes smaller than these minima and even in volumes and durations of any degree of smallness. Molecular and electronic theories of heat and light would then assert that a certain volume is pervaded by such and such a temperature or such and such a colour if and only if it contains certain arrangements of particles moving in certain ways. What we should have would be laws connecting the macroscopic qualities which inhere in a volume with the number, arrangement, and motion of the microscopic particles which are contained in this volume.

On such a view how much would be left of Pure Mechanism?

i. it would of course not be true of macroscopic properties.
ii. it might still be true of the microscopic particles in their interactions with each other. It might be that there is ultimately only one kind of particle, that it has only one non-spatio-temporal quality, that these particles affect each other by pairs according to a single law, and that their effects are compounded according to a single law.
iii. But, even if this were true of the microscopic particles in their relations *with each other*, it plainly could not be the *whole truth* about them. For there will also be laws connecting the presence of such and such a configuration of particles, moving in such and such ways, in a certain region, with the pervasion of this region by such and such a determinate value of a certain macroscopic quality, e.g., a certain shade of red or a temperature of 57°C. These will be just as much laws of the external world as are the laws which connect the motions of one particle with those of another. And it is perfectly clear that the one kind of law cannot possibly be reduced to the other; since colour and temperature are irreducibly different characteristics from figure and motion, however close may be the causal connexion between the occurrence of the one kind of characteristic and that of the other. Moreover,

there will have to be a number of different and irreducible laws connecting microscopic with macroscopic characteristics; for there are many different and irreducible determinable macroscopic characteristics, e.g., colour, temperature, sound, etc. And each will need its own peculiar law.

(2) A second conceivable view would be that in perception we are in direct cognitive contact with parts of the surfaces of external objects, and that, so long as we are looking at them or feeling them, they do have the colours or temperatures which they then seem to us to have. But that the inherence of colours and temperatures in external bodies is dependent upon the presence of a suitable bodily organism, or a suitable mind, or of both, in a suitable relation to the external object.

On such a view it is plain that Pure Mechanism cannot be an adequate theory of the external world of matter. For colours and temperatures would belong to external objects on this view, though they would characterise an external object only when very special conditions are fulfilled. And evidently the laws according to which, e.g., a certain shade of colour inheres in a certain external region when a suitable organism or mind is in suitable relations to that region cannot be of the mechanical type.

(3) A third conceivable view is that physical objects can seem to have qualities which do not really belong to any physical objects, e.g., that a pillar-box can seem to have a certain shade of red although really no physical object has any colour at all. This type of theory divides into two forms. (a) It might be held that, when a physical object seems to have a certain shade of red, there really is *something* in the world which has this shade of red, although this something cannot be a physical object or literally a part of one. Some would say that there is a red mental state—a "sensation"—; others that the red colour belongs to something which is neither mental nor physical.[1] On either of these alternatives it would be conceivable that Pure Mechanism was the whole truth about matter considered in its relations with matter. But it would be certain that it is not the whole truth about matter when this limitation is removed. Granted that bits of matter only *seem* to be red or to be hot, we still claim to know a good deal about the conditions under which one bit of matter will seem to be red and another to be blue and about the conditions under which one bit of matter will seem to be hot and another to be cold. This knowledge belongs partly to physics and partly to the physiology and anatomy of the brain and nervous system. We know little or nothing about the mental conditions which have to be fulfilled if an external object is to seem red or hot to a percipient; but we can say that this depends on an unknown mental factor *x* and on certain physical conditions *a, b, c,* etc., partly within and partly outside the percipient's body, about which we know a good deal. It is plain then that, on the present theory, physical events and objects do not merely interact mechanically with each other; they also play their part, along with a mental factor, in causing such and such an external object to seem to such and such an observer to have a certain quality which really no physical object has. In fact, for the present purpose, the difference between theories (2) and (3) is simply the following. On theory (2) certain events in the external object, in the observer's body, and possibly in his mind, cause a certain quality to inhere in the external object so long as they are going on. On theory (3) they cause the same quality to *seem* to inhere in the same object, so long as they are going on, though *actually* it does not inhere in any physical object. Theory (1), for the present purpose, differs from theory (2) only in taking the naive view that the body and mind of the observer are irrelevant to the *occurrence* of the sensible quality in the external object, though of course it would admit that these factors are relevant to the *perception* of this quality by the observer. This last point is presumably common to all three theories.

[1] (*b*) It might be held that *nothing* in the world really has colour, though certain things *seem* to have certain colours. The relation of "seeming to have" is taken as ultimate.

I will now sum up the argument. The plain fact is that the external world, as perceived by us, seems not to have the homogeneity demanded by Pure Mechanism. If it *really* has the various irreducibly different sensible qualities which it *seems* to have, Pure Mechanism cannot be true of the whole of the external world and cannot be the whole truth about any part of it. The best that we can do for Pure Mechanism on this theory is to divide up the external world first on a macroscopic and then on a microscopic scale; to suppose that the macroscopic qualities which pervade any region are causally determined by the microscopic events and objects which exist within it; and to hope that the latter, in their interactions with *each other* at any rate, fulfil the conditions of Pure Mechanism. This result may remind the reader of the carefully qualified compliment which Mr Gibbon pays to the morality of the Negroes in a foot-note which I forbear from quoting. We must remember, moreover, that there is no *a priori* reason why microscopic events and objects should answer the demands of Pure Mechanism even in their interactions with each other; that, so far as science can tell us at present, they do not; and that, in any case, the laws connecting them with the occurrence of macroscopic qualities cannot be mechanical in the sense defined.

If, on the other hand, we deny that physical objects have the various sensible qualities which they seem to us to have, we are still left with the fact that some things *seem* to be red, others to be blue, others to be hot, and so on. And a complete account of the world must include such events as "seeming red to me", "seeming blue to you", etc. We can admit that the ultimate physical objects may all be exactly alike, may all have only one non-spatio-temporal and non-causal property, and may interact with each other in such a way which Pure Mechanism requires. But we must admit that they are also cause-factors in determining the *appearance*, if not the *occurrence*, of the various sensible qualities at such and such places and times. And, in these transactions, the laws which they obey *cannot* be mechanical.

We may put the whole matter in a nutshell by saying that the appearance of a plurality of irreducible sensible qualities forces us, no matter what theory we adopt about their status, to distinguish two different kinds of law. One may be called "intra-physical" and the other "trans-physical". The intra-physical laws may be, though there seems no positive reason to suppose that they are, of the kind required by Pure Mechanism. If so, there is just one ultimate elementary intra-physical law and one ultimate principle of composition for intra-physical transactions. But the trans-physical laws cannot satisfy the demands of Pure Mechanism; and, so far as I can see, there must be at least as many irreducible trans-physical laws as there are irreducible determinable sense-qualities. The nature of the trans-physical laws will of course depend on the view that we take about the status of sensible qualities. It will be somewhat different for each of the three alternative types of theory which I have mentioned, and it will differ according to which form of the third theory we adopt. But it is not necessary for our present purpose to go into further detail on this point.

The Three Possible Ways of accounting for characteristic Differences of Behaviour

So far we have confined our attention to pure qualities, such as red, hot, etc. By calling these "pure qualities" I mean that, when we say "This is red", "This is hot", and so on, it is no part of the meaning of our predicate that "this" stands in such and such a relation to something else. It is *logically* possible that this should be red even though "this" were the only thing in the world; though it is probably not *physically* possible. I have argued so far that the fact that external objects seem to have a number of irreducibly different pure qualities makes it certain that Pure Mechanism cannot be an adequate account of the external world. I want now to consider differences of *behaviour* among external objects. These are not differences of pure quality. When I say "This combines with that", "This eats and digests", and so on, I am making statements which would have no meaning if "this" were the only thing in the world. Now there are apparently extremely different kinds of behaviour to be found among external objects. A bit of gold and a bit of silver behave quite differently when put into nitric acid. A cat and an oyster behave quite differently when put near a mouse. Again, all bodies which would be said to be "alive", behave differently in many ways from all bodies which would be said not to be "alive ". And, among nonliving bodies, what we call their "chemical behaviour" is very different from what we call their "merely physical behaviour". The question that we have now to discuss is this: "Are the differences between merely physical, chemical, and vital behaviour ultimate and irreducible or not? And are the differences in chemical behaviour between Oxygen and Hydrogen, or the differences in vital behaviour between trees and oysters and cats, ultimate and irreducible or not?" I do not expect to be able to give a conclusive answer to this question, as I do claim to have done to the question about differences of pure quality. But I hope at least to state the possible alternatives clearly, so that people with an adequate knowledge of the relevant empirical facts may know exactly what we want them to discuss, and may not beat the air in the regrettable way in which they too often have done.

We must first notice a difference between vital behaviour, on the one hand, and chemical behaviour, on the other. On the macroscopic scale, *i.e.,* within the limits of what we can perceive with our unaided senses or by the help of optical instruments, *all* matter seems to behave chemically from time to time, though there may be long stretches throughout which a given bit of matter has no chance to exhibit any marked chemical behaviour. But only a comparatively few bits of matter *ever* exhibit vital behaviour. These are always very complex chemically; they are always composed of the same comparatively small selection of chemical elements; and they generally have a characteristic external form and internal structure. All of them after a longer or shorter time cease to show vital behaviour, and soon after this they visibly lose their characteristic external form and internal structure. We do not know how to make a living body out of non-living materials; and we do not know how to make a once living body, which has ceased to behave vitally, live again. But we know that plants, so long as they are alive, do take up inorganic materials from their surroundings and build them up into their own substance; that all living bodies maintain themselves for a time through constant chemical change of material; and that they all have the power of restoring themselves when not too severely injured, and of producing new living bodies like themselves.

Let us now consider what general types of view are possible about the fact that certain things behave in characteristically different ways.

(1) Certain characteristically different ways of behaving may be regarded as absolutely unanalysable facts which do not depend *in any way* on differences of structure or components. This would be an absurd view to take about vital behaviour, for we know that all living bodies have a complex structure even on the macroscopic scale, and that their characteristic behaviour depends *in part* at least on their structure and components. It would also be a foolish view to take about the chemical behaviour of non-living substances which are known to be compounds and can be split up and re-synthesised by us from their elements. But it was for many years the orthodox view about the chemical elements. It was held that the characteristic differences between the behaviour of Oxygen and Hydrogen are due in no way to differences of structure or components, but must simply be accepted as ultimate facts. This first alternative can hardly be counted as one way of *explaining* differences of behaviour, since it consists in holding that there are certain differences which cannot be explained, even in part, but must simply be swallowed whole with that philosophic jam which Professor Alexander calls "natural piety". It is worth while to remark that we could never be logically compelled to hold this view, since it is always open to us to suppose that what is macroscopically homogeneous has a complex microscopic structure which wholly or partly determines its characteristic macroscopic behaviour. Nevertheless, it is perfectly possible that this hypothesis is not true in certain cases,

and that there are certain ultimate differences in the material world which must just be accepted as brute facts.

(2) We come now to types of theory which profess to explain, wholly or partly, differences of behaviour in terms of structure or components or both. These of course all presuppose that the objects that we are dealing with are at any rate microscopically complex: an hypothesis, as I have said, which can never be conclusively refuted. We may divide up these theories as follows. (*a*) Those which hold that the characteristic behaviour of a certain object or class of objects is in part dependent on the presence of a peculiar *component* which does not occur in anything that does not behave in this way. This is of course the usual view to take about the characteristic chemical behaviour of compounds. We say that Silver Chloride behaves differently from Common Salt because one contains Silver and the other Sodium. It is always held that differences of microscopic *structure* are also relevant to explaining differences of macroscopic chemical behaviour. e.g., the very marked differences between the chemical behaviour of acetone and propion aldehyde which both consist of Carbon, Hydrogen, and Oxygen in exactly the same proportions, are ascribed to the fact that the former has the structure symbolised by

$$\begin{array}{c} \mathbf{CH_3 - C - CH_3} \\ \| \\ \mathbf{O} \end{array}$$

and that the latter has the structure symbolised by

$$\begin{array}{r} \mathbf{O} \\ // \\ \mathbf{CH_3 \cdot CH_2 \cdot C} \\ \backslash \\ \mathbf{H} \end{array}$$

The doctrine which I will call "Substantial Vitalism" is logically a theory of this type about vital behaviour. It assumes that a necessary factor in explaining the characteristic behaviour of living bodies is the presence in them of a peculiar component, often called an "Entelechy", which does not occur in inorganic matter or in bodies which were formerly alive but have now died. I will try to bring out the analogies and differences between this type of theory as applied to vital behaviour and as applied to the behaviour of chemical compounds.

i. It is not supposed that the presence of an entelechy is *sufficient* to explain vital behaviour; as in chemistry, the structure of the complex is admitted to be also an essential factor.

ii. It is admitted that entelechies cannot be isolated, and that perhaps they cannot exist apart from the complex which is a living organism. But there is plenty of analogy to this in chemistry. In the first place, elements have been recognised, and the characteristic behaviour of certain compounds has been ascribed to their presence, long before they were isolated. Secondly, there are certain groups, like CH_3 and C_6H_5 in organic chemistry, which cannot exist in isolation, but which nevertheless play an essential part in determining the characteristic behaviour of certain compounds.

iii. The entelechy is supposed to exert some kind of directive influence over matter which enters the organism from outside. There is a faint analogy to this in certain parts of organic chemistry. The presence of certain groups in certain positions in a Benzene nucleus makes it very easy to put certain other groups and very hard to put others into certain positions in the nucleus. There are well-known empirical rules on this point.

Why then do most of us feel pretty confident of the truth of the chemical explanation and very doubtful of the formally analogous explanation of vital behaviour in terms of entelechies? I think that our main reasons are the following, and that they are fairly sound ones.

i. It is true that some elements were recognised and used for chemical explanations long before they were isolated. But a great many other elements had been isolated, and it was known that the process presented various degrees of difficulty. No entelechy, or anything like one, has ever been isolated; hence an entelechy is a *purely* hypothetical entity in a sense in which an as yet unisolated but suspected chemical element is not. If it be said that an isolated entelechy is from the nature of the case something which could not be perceived, and that this objection is therefore unreasonable, I can only answer (as I should to the similar assertion that the physical phenomena of mediumship can happen only in darkness and in the presence of sympathetic spectators) that it may well be true but is certainly very unfortunate.

ii. It is true that some groups which cannot exist in isolation play a most important part in chemical explanations. But they are *groups* of known composition, not mysterious simple entities; and their inability to exist by themselves is not an isolated fact but is part of the more general, though imperfectly understood, fact of valency. Moreover, we can at least pass these groups from one compound to another, and can note how the chemical properties change as one compound loses such a group and another gains it. There is no known analogy to this with entelechies. You cannot pass an entelechy from a living man into a corpse and note that the former ceases and the latter begins to behave vitally.

iii. Entelechies are supposed to differ in kind from material particles; and it is doubtful whether they are literally in Space at all. It is thus hard to understand what exactly is meant by saying that a living body is a compound of an entelechy and a material structure; and impossible to say anything in detail about the structure of the total complex thus formed.

These objections seem to me to make the doctrine of Substantial Vitalism unsatisfactory, though not impossible. I think that those who have accepted it have done so largely under a misapprehension. They have thought that there was no alternative between Biological Mechanism (which I shall define a little later) and Substantial Vitalism. They found the former unsatisfactory, and so they felt obliged to accept the latter. We shall see in a moment, however, that there is another alternative type of theory, which I will call "Emergent Vitalism ", borrowing the adjective from Professors Alexander and Lloyd Morgan. Of course positive arguments have been put forward in favour of entelechies, notably by Driesch. I do not propose to consider them in detail. I will merely say that Driesch's arguments do not seem to me to be in the least conclusive, even against Biological Mechanism, because they seem to forget that the smallest fragment which we can make of an organised body by cutting it up may contain an enormous number of similar microscopic structures, each of enormous complexity. And, even if it be held that Driesch has conclusively *dis*proved Biological Mechanism, I cannot see that his arguments have the least tendency to prove Substantial Vitalism rather than the Emergent form of Vitalism which does not assume entelechies.

(b) I come now to the second type of theory which professes to explain, wholly or partly, the differences of behaviour between different things. This kind of theory denies that there need be any peculiar *component* which is present in all things that behave in a certain way and is absent from all things which do not behave in this way. It says that the components may be exactly alike in both cases, and it tries to explain the difference of behaviour wholly in terms of difference of structure. Now it is most important to notice that this type of theory can take two radically different forms. They differ according to the view that we take about the laws which connect the properties of the components with the characteristic behaviour of the complex wholes which they make up.

i. On the first form of the theory the characteristic behaviour of the whole *could* not, even in theory, be deduced from the most complete knowledge of the behaviour of its components, taken separately or in other combinations, and of their proportions and arrangements in this whole. This alternative, which I have roughly outlined and shall soon discuss in detail, is what I understand by the "Theory of Emergence". I cannot give a conclusive example of it, since it is a matter of controversy whether it actually applies to anything. But there is no doubt, as I hope to show, that it is a logically possible view with a good deal in its favour. I will merely remark that, so far as we know at present, the characteristic behaviour of Common Salt cannot be deduced from the most complete knowledge of the properties of Sodium in isolation; or of Chlorine in isolation; or of other compounds of Sodium, such as Sodium Sulphate, and of other compounds of Chlorine, such as Silver Chloride.

ii. On the second form of the theory the characteristic behaviour of the whole is not only completely *determined* by the nature and arrangement of its components; in addition to this it is held that the behaviour of the whole could, in theory at least, be *deduced* from a sufficient knowledge of how the components behave in isolation or in other wholes of a simpler kind. I will call this kind of theory "Mechanistic". A theory may be "mechanistic" in this sense without being an instance of Pure Mechanism, in the sense defined earlier in this chapter. e.g., if a biologist held that all the characteristic behaviour of living beings could be deduced from an adequate knowledge of the physical and chemical laws which its components would obey in isolation or in non-living complexes, he would be called a "Biological Mechanist" even though he believed that the different chemical elements are ultimately different kinds of stuff and that the laws of chemical composition are not of the type demanded by Pure Mechanism.

The most obvious examples of wholes to which a mechanistic theory applies are artificial machines. A clock behaves in a characteristic way. But no one supposes that the peculiar behaviour of clocks depends on their containing as a component a peculiar entity which is not present in anything but clocks. Nor does anyone suppose that the peculiar behaviour of clocks is simply an emergent quality of that kind of structure and cannot be learnt by studying anything but clocks. We know perfectly well that the behaviour of a clock can be deduced from the particular arrangement of springs, wheels, pendulum, etc., in it, and from general laws of mechanics and physics which apply just as much to material systems which are not clocks.

To sum up. We have distinguished three possible types of theory to account wholly or partly for the characteristic differences of behaviour between different kinds of material object, viz., the Theory of a Special Component, the Theory of Emergence, and the Mechanism Theory. We have illustrated these, so far as possible, with examples which everyone will accept. In the special problem of the peculiar behaviour of living bodies these three types of theory are represented by Substantial Vitalism, Emergent Vitalism, and Biological Mechanism. I have argued that Substantial Vitalism, though logically possible, is a very unsatisfactory kind of theory, and that probably many people who have accepted it have done so because they did not recognise the alternative of Emergent Vitalism. I propose now to consider in greater detail the emergent and the mechanistic types of theory.

Emergent Theories. Put in abstract terms the emergent theory asserts that there are certain wholes, composed (say) of constituents A, B, and C in a relation R to each other; that all wholes composed of constituents of the same kind as A, B, and C in relations of the same kind as R have certain characteristic properties; that A, B, and C are capable of occurring in other kinds of complex where the relation is not of the same kind as R; and that the characteristic properties of the whole R(A, B, C) cannot, even in theory, be deduced from the most complete knowledge of the properties of A, B, and C in isolation or in other wholes which are not of the form R(A, B, C). The mechanistic theory rejects the last clause of this assertion.

Let us now consider the question in detail. If we want to explain the behaviour of any whole in terms of its structure and components we *always* need two independent kinds of information.

a. We need to know how the parts would behave separately. And
b. we need to know the law or laws according to which the behaviour of the separate parts is compounded when they are acting together in any proportion and arrangement.

Now it is extremely important to notice that these two bits of information are quite independent of each other in every case. Let us consider, e.g., the simplest possible case. We know that a certain tap, when running by itself, will put so many cubic centimeters of water into a tank in a minute. We know that a certain other tap, when running by itself, will put so many cubic centimeters of water into this tank in the same time. It does not follow logically from these two bits of information that, when the two taps are turned on together, the sum of these two numbers of cubic centimeters will be added to the contents of the tank every minute. This might not happen for two reasons. In the first place, it is quite likely that, if the two taps came from the same pipe, less would flow from each when both were turned on together than when each was turned on separately; *i.e.,* the separate factors do not behave together as they would have behaved in isolation. Again, if one tap delivered hot water and the other cold water, the simple assumption about composition would break down although the separate factors continued to obey the same laws as they had followed when acting in isolation. For there would be a change of volume on mixture of the hot and cold water.

Next let us consider the case of two forces acting on a particle at an angle to each other. We find by experiment that the actual motion of the body is the vector-sum of the motions which it would have had if each had been acting separately. There is not the least possibility of deducing this law of composition from the laws of each force taken separately. There is one other fact worth mentioning here. As Mr Russell pointed out long ago, a vector-sum is not a sum in the ordinary sense of the word. We cannot strictly say that each force is doing what it would have done if it had been alone, and that the result of their joint action is the sum of the results of their separate actions. A velocity of 5 miles an hour in a certain direction does not literally contain as parts a velocity of 3 miles an hour in a certain other direction and a velocity of 4 miles an hour in a direction at right angles to this. All that we can say is that the effect of several forces acting together is a fairly simple mathematical function of the purely hypothetical effects which each would have had if it had acted by itself, and that this function reduces to an algebraical sum in the particular case where all the forces are in the same line.

We will now pass to the case of chemical composition. Oxygen has certain properties and Hydrogen has certain other properties. They combine to form water, and the proportions in which they do this are fixed. Nothing that we know about Oxygen by itself or in its combinations with anything but Hydrogen would give us the least reason to suppose that it would combine with Hydrogen at all. Nothing that we know about Hydrogen by itself or in its combinations with anything but Oxygen would give us the least reason to expect that it would combine with Oxygen at all. And most of the chemical and physical properties of water have no known connexion, either quantitative or qualitative, with those of Oxygen and Hydrogen. Here we have a clear instance of a case where, so far as we can tell, the properties of a whole composed of two constituents could not have been predicted from a knowledge of the properties of these constituents taken separately, or from this combined with a knowledge of the properties of other wholes which contain these constituents.

Let us sum up the conclusions which may be reached from these examples before going further. It is clear that in no case could the behaviour of a whole composed of certain constituents be predicted *merely* from a knowledge of the properties of these constituents, taken separately, and of their proportions and arrangements in the particular complex under consideration. Whenever this *seems* to be possible it is because we are using a suppressed premise which is so familiar that it has escaped our notice. The suppressed premise is the fact that we have examined other complexes in the past and have noted their behaviour; that we have found a general law connecting the behaviour of these wholes with that which their constituents would show in isolation; and that we are assuming that this law of composition will hold also of the particular complex whole at present under consideration. For purely dynamical transactions this assumption is pretty well justified, because we have found a simple law of composition and have verified it very fully for wholes of very different composition, complexity, and internal structure. It is therefore not particularly rash to expect to predict the dynamical behaviour of any material complex under the action of any set of forces, however much it may differ in the details of its structure and parts from those complexes for which the assumed law of composition has actually been verified.

The example of chemical compounds shows us that we have no right to expect that the same simple law of composition will hold for chemical as for dynamical transactions. And it shows us something further. It shows us that, if we want to know the chemical (and many of the physical) properties of a chemical compound, such as silver-chloride, it is absolutely necessary to study samples of *that particular compound*. It would of course (on any view) be useless merely to study silver in isolation and chlorine in isolation; for that would tell us nothing about the law of their conjoint action. This would be equally true even if a mechanistic explanation of the chemical behaviour of compounds were possible. The essential point is that it would also be useless to study chemical compounds in general and to compare their properties with those of their elements in the hope of discovering a *general* law of composition by which the properties of any chemical compound could be foretold when the properties of its separate elements were known. So far as we know, there is no general law of this kind. It is useless even to study the properties of other compounds of silver and of other compounds of chlorine in the hope of discovering one general law by which the properties of silver-compounds could be predicted from those of elementary silver and another general law by which the properties of chlorine-compounds could be predicted from those of elementary chlorine. No doubt the properties of silver-chloride are completely *determined* by those of silver and of chlorine; in the sense that whenever you have a whole composed of these two elements in certain proportions and relations you have something with the characteristic properties of silver-chloride, and that nothing has these properties except a whole composed in this way. But the law connecting the properties of silver-chloride with those of silver and of chlorine and with the structure of the compound is, so far as we know, an *unique* and *ultimate* law. By this I mean (*a*) that it is not a special case which arises through substituting certain determinate values for determinable variables in a general law which connects the properties of *any* chemical compound with those of its separate elements and with its structure. And (b) that it is not a special case which arises by combining two more general laws, one of which connects the properties of *any* silver-compound with those of elementary silver, whilst the other connects the properties of *any* chlorine-compound with those of elementary chlorine. So far as we know there are no such laws. It is (c) a law which could have been discovered only by studying samples of silver-chloride itself, and which can be extended inductively *only* to other samples of the same substance.

We may contrast this state of affairs with that which exists where a mechanistic explanation is possible. In order to predict the behaviour of a clock a man need never have seen a clock in his life. Provided he is told how it is constructed, and that he has learnt from the study of *other* material systems the general rules about motion and about the mechanical properties of springs and of rigid bodies, he ran foretell exactly how a system constructed like a clock must behave.

The situation with which we are faced in chemistry, which seems to offer the most plausible example of emergent behaviour, may be described in two alternative ways. These may be theoretically different, but in practice they are equivalent.

i. The first way of putting the case is the following. What we call the "properties" of the chemical elements are very largely propositions about the compounds which they form with other elements under suitable conditions. e.g., one of the "properties" of silver is that it combines under certain conditions with chlorine to give a compound with the properties of silver-chloride. Likewise one of the "properties" of chlorine is that under certain conditions it combines with silver to give a compound with the properties of silver-chloride. These "properties" cannot be deduced from any selection of the other properties of silver or of chlorine. Thus we may say that we do not know all the properties of chlorine and of silver until they have been put in presence of each other; and that no amount of knowledge about the properties which they manifest in other circumstances will tell us what property, if any, they will manifest in these circumstances. Put in this way the position is that we do not know all the properties of any element, and that there is always the possibility of their manifesting unpredictable properties when put into new situations. This happens whenever a chemical compound is prepared or discovered for the first time.

ii. The other way to put the matter is to confine the name "property" to those characteristics which the elements manifest when they do not act chemically on each other, *i.e.,* the physical characteristics of the isolated elements. In this case we may indeed say, if we like, that we know all the properties of each element; but we shall have to admit that we do not know the laws according to which elements, which have these properties in isolation, together produce compounds having such and such other characteristic properties. The essential point is that the behaviour of an as yet unexamined compound cannot be predicted from a knowledge of the properties of its elements in isolation or from a knowledge of the properties of their other compounds; and it matters little whether we ascribe this to the existence of innumerable "latent" properties in each element, each of which is manifested only in the presence of a certain other element; or to the lack of any general principle of composition, such as the parallelogram law in dynamics, by which the behaviour of any chemical compound could be deduced from its structure and from the behaviour of each of its elements in isolation from the rest.

Let us now apply the conceptions, which I have been explaining and illustrating from chemistry, to the case of vital behaviour. We know that the bits of matter which behave vitally are composed of various chemical compounds arranged in certain characteristic ways. We have prepared and experimented with many of these compounds apart from living bodies, and we see no obvious reason why some day they might not all be synthesised and studied in the chemical laboratory. A living body might be regarded as a compound of the second order, *i.e.,* a compound composed of compounds; just as silver-chloride is a compound of the first order, *i.e.,* one composed of chemical elements. Now it is obviously possible that, just as the characteristic behaviour of a first-order compound could not be predicted from any amount of knowledge of the properties of its elements in isolation or of the properties of other first-order compounds, so the properties of a second-order compound could not be predicted from any amount of knowledge about the properties of its first-order constituents taken separately or in other surroundings. Just as the only way to find out the properties of silver-chloride is to study samples of silver-chloride, and no amount of study of silver and of chlorine taken separately or in other combinations will help us; so the only way to find out the characteristic behaviour of living bodies may be to study living bodies as such. And no amount of knowledge about how the constituents of a living body behave in isolation or in other and non-living wholes might suffice to enable us to predict the characteristic behaviour of a living organism. This possibility is perfectly compatible with the view that the characteristic behaviour of a living body is completely determined by the nature and arrangement of the chemical compounds which compose it, in the sense that any whole which is composed of such compounds in such an arrangement will show vital-behaviour and that nothing else will do so. We should merely have to recognise, as we had to do in considering a first-order compound like silver-chloride, that we are dealing with an *unique* and *irreducible* law; and not with a special case which arises by the substitution of particular values for variables in a more general law, nor with a combination of several more general laws.

We could state this possibility about living organisms in two alternative but practically equivalent ways, just as we stated the similar possibility about chemical compounds.

i. The first way would be this. Most of the properties which we ascribe to chemical compounds are statements about what they do in presence of various chemical reagents under certain conditions of temperature, pressure, etc. These various properties are not deducible from each other; and, until we have tried a compound with every other compound and under every possible condition of temperature, pressure, etc., we cannot possibly know that we have exhausted all its properties. It is therefore perfectly possible that, in the very special situation in which a chemical compound is placed in a living body, it may exhibit properties which remain "latent" under all other conditions.

ii. The other, and practically equivalent, way of putting the case is the following. If we confine the name "property" to the behaviour which a chemical compound shows in isolation, we may perhaps say that we know all the "properties" of the chemical constituents of a living body. But we shall not be able to predict the behaviour of the body unless we also know the laws according to which the behaviour which each of these constituents *would have* shown in isolation is compounded when they are acting together in certain proportions and arrangements. We can discover such laws only by studying complexes containing these constituents in various proportions and arrangements. And we have no right to suppose that the laws which we have discovered by studying non-living complexes can be carried over without modification to the very different case of living complexes. It may be that the only way to discover the laws according to which the behaviour of the separate constituents combines to produce the behaviour of the whole in a living body is to study living bodies as such. For practical purposes it makes little difference whether we say that the chemical compounds which compose a living body have "latent properties" which are manifested only when they are parts of a whole of this peculiar structure; or whether we say that the properties of the constituents of a living body are the same whether they are in it or out of it, but that the law according to which these separate effects are compounded with each other is different in a living whole from what it is in any nonliving whole.

This view about living bodies and vital behaviour is what I call "Emergent Vitalism"; and it is important to notice that it is quite different from what I call "Substantial Vitalism". So far as I can understand them I should say that Driesch is a Substantial Vitalist, and that Dr J. S. Haldane is an Emergent Vitalist. But I may quite well be wrong in classifying these two distinguished men in this way.

Mechanistic Theories. The mechanistic type of theory is much more familiar than the emergent type, and it will therefore be needless to consider it in great detail. I will just consider the mechanistic alternative about chemical and vital behaviour, so as to make the emergent theory still clearer by contrast. Suppose it were certain, as it is very probable, that all the different chemical atoms are composed of positive and negative electrified particles in different numbers and arrangements; and that these differences of number and arrangement are the only ultimate difference between them. Suppose that all these particles obey the same elementary laws, and that their separate actions are compounded with each other according to a single law which is the same no matter how complicated may be the whole of which they are constituents. Then it would be theoretically possible to deduce the characteristic behaviour of any element from an adequate knowledge of the number and arrangement of the particles in its atom, without needing to observe a sample of the substance. We could, *in theory*, deduce what other elements it would combine with and in what proportions; which of these compounds would be stable to heat, etc.; and how the various compounds would react in presence of each other under given conditions of temperature, pressure, etc. And all this should be *theoretically* possible without needing to observe samples of these compounds.

I want now to explain exactly what I mean by the qualification "theoretically". (1) In the first place the mathematical difficulties might be overwhelming in practice, even if we knew the structure and the laws. This is a trivial qualification for our present purpose, which is to bring out the *logical* distinction between mechanism and emergence. Let us replace Sir Ernest Rutherford by a mathematical archangel, and pass on. (2) Secondly, we cannot directly perceive the microscopic structure of atoms, but can only infer it from the macroscopic behaviour of matter in bulk. Thus, in practice, even if the mechanistic hypothesis were true and the mathematical difficulties were overcome, we should have to start by observing enough of the macroscopic behaviour of samples of each element to infer the probable structure of its atom. But, once this was done, it should be possible to deduce its behaviour in macroscopic conditions under which it has never yet been observed. That is, if we could infer its microscopic structure from a selection of its observed macroscopic properties, we could henceforth *deduce* all its other macroscopic properties from its microscopic structure without further appeal to observation. The difference from the emergent theory is thus profound, even when we allow for our mathematical and perceptual limitations. If the emergent theory of chemical compounds be true, a mathematical archangel, gifted with the further power of perceiving the microscopic structure of atoms as easily as we can perceive hay-stacks, could no more predict the behaviour of silver or of chlorine or the properties of silver-chloride without having observed samples of those substances than we can at present. And he could no more deduce the rest of the properties of a chemical element or compound from a selection of its properties than we can.

Would there be any theoretical limit to the deduction of the properties of chemical elements and compounds if a mechanistic theory of chemistry were true? Yes. Take any ordinary statement, such as we find in chemistry books; e.g., "Nitrogen and Hydrogen combine when an electric discharge is passed through a mixture of the two. The resulting compound contains three atoms of Hydrogen to one of Nitrogen; it is a gas readily soluble in water, and possessed of a pungent and characteristic smell." If the mechanistic theory be true the archangel could deduce from his knowledge of the microscopic structure of atoms all these facts but the last. He would know exactly what the microscopic structure of ammonia must be; but he would be totally unable to predict that a substance with this structure must smell as ammonia does when it gets into the human nose. The utmost that he could predict on this subject would be that certain changes would take place in the mucous membrane, the olfactory nerves and so on. But he could not possibly know that these changes would be accompanied by the appearance of a smell in general or of the peculiar smell of ammonia in particular, unless someone told him so or he had smelled it for himself. If the existence of the so-called "secondary qualities," or the fact of their appearance, depends on the microscopic movements and arrangements of material particles which do not have these qualities themselves, then the laws of this dependence are certainly of the emergent type.

The mechanistic theory about vital behaviour should now need little explanation. A man can hold it without being a mechanist about chemistry. The minimum that a Biological Mechanist need believe is that, in theory, everything that is characteristic of the behaviour of a living body could be deduced from an adequate knowledge of its structure, the chemical compounds which make it up, and the properties which these show in isolation or in non-living wholes.

Logical Status of Emergence and Mechanism. I have now stated the two alternatives which alone seem worthy of serious consideration. It is not my business as a philosopher to consider detailed empirical arguments for or against mechanism or emergence in chemistry or in biology. But it is my business to consider the logical status of the two types of theory, and it is relevant to our present purpose to discuss how far the possibility of science is bound up with the acceptance of the mechanistic alternative.

(1) I do not see any *a priori* impossibility in a mechanistic biology or chemistry, so long as it confines itself to that kind of behaviour which can be completely described in terms of changes of position, size, shape, arrangement of parts, etc. I have already argued that this type of theory cannot be the whole truth about all aspects of the material world. For one aspect of it is that bits of matter have or seem to have various colours, temperatures, smells, tastes, etc. If the occurrence or the appearance of these "secondary qualities" depends on microscopic particles and events, the laws connecting the latter with the former are certainly of the emergent type. And no complete account of the external world can ignore these laws.

(2) On the other hand, I cannot see the least trace of self-evidence in theories of the mechanistic type, or in the theory of Pure Mechanism which is the ideal towards which they strive. I know no reason whatever why new and theoretically unpredictable modes of behaviour should not appear at certain levels of complexity, or why they must be explicable in terms of elementary properties and laws of composition which have manifested themselves in less complex wholes.

(3) At the back of the Mechanist's mind there is undoubtedly a notion that there is something radically unscientific and superstitious about non-mechanistic theories. It will be well worth while to consider this vague belief carefully, and to see if there be anything in it.

(*a*) In the first place, I think that the ordinary Biological Mechanist does not clearly distinguish between the Substantial and the Emergent forms of Vitalism; in fact he generally identifies Vitalism with Substantial Vitalism. Now there are grave objections to the first type of theory, which I have already pointed out. But it does not follow that they apply to the second type of Vitalism.

(*b*) How far does the Biological Mechanist's vaguely felt objection to Vitalism remain when we confine ourselves to the emergent form of the theory? I think that the parallel case of chemistry may help us to answer this question. It is perfectly certain that chemistry is a subject about which there is a great deal of scientific knowledge, and that this is constantly increasing. Now of course it may be true as a matter of fact that the atoms of the various elements are wholes composed of various numbers of similar particles with various arrangements and movements And it may be true as a matter of fact that the laws of chemical combination, the properties of compounds and so on, are mere consequences of the laws of electro-magnetics and of the particular number, arrangement and movements of the particles which compose each kind of atom. It may even be true that all chemists now hold this opinion as a matter of scientific faith. But it is perfectly obvious that the progress of chemistry in the past has not depended either on the truth of this proposition, or on the general acceptance of it by chemists. For chemistry had become a science of great extent and certainty long before the electron theory was thought of; and great advances were made in it by workers who utterly scouted the notion that the various elements were all made of a single kind of stuff, and that their differences were due simply to different arrangements of the particles of this stuff. And to this day chemists who accept the electronic theory can make scarcely any use of it in their chemical investigations. If then chemistry can be a scientific subject and can make steady progress without using the assumption that a mechanistic explanation of chemical phenomena is possible, it would presumably have made precisely the same progress if in fact no such explanation had been possible. And, if neither the possibility of mechanistic explanation nor the belief in it is essential to the progress of chemistry, it is hard to see how a parallel belief about vital phenomena can be essential to the progress of physiology.

(*c*) Reflexion on chemistry will teach us another important fact, which applies equally to physiology. I have said that to learn the properties of silver-chloride we must at present study samples of *that substance*; and that we cannot deduce them from a knowledge of the properties of silver and of chlorine by themselves or in other combinations, by help of some general law connecting the properties of any compound with those of its elements and with its structure. It does not follow that there are no general laws connecting *some* of the properties of compounds with those of their constituents and with their structure. There are plenty of such laws, and organic chemists in particular study them. For instance the presence of Carbon, Oxygen, and Hydrogen in the grouping

```
    O
   //
  C
   \
    OH
```

is known to give a compound with acidic properties. Obviously the way to find such laws is to keep the structure and all but one constituent fixed, and then to vary this constituent; or to keep all the constituents fixed, and to vary the structure; and so on. There might, e.g., be certain general properties which are common to all compounds of a certain structure which contain Chlorine, and these might vary in a perfectly characteristic way when the structure is kept fixed and Bromine or Iodine is substituted for the Chlorine. What we have to admit is that such laws have to be discovered independently by an actual study and comparison of the compounds; they cannot be deduced from a mere knowledge of the properties which the constituents would have in isolation or in other wholes; and they cannot be reduced to so many special cases of a single general law.

Now laws like this could exist and could be discovered in Physiology on the emergent form of Vitalism, just as they can exist and be discovered in Chemistry. But they will have to be discovered by studying living beings, as such, and varying their constituents so far as possible one at a time while keeping the structure as constant as may be. If emergence be true they *could* not have been deduced from any amount of reflexion on the properties of these constituents taken separately or in non-living wholes; nor, when they have been discovered, can they be reduced to so many special cases of a single general law which applies equally to the living and the non-living. I do not see that such a view conflicts with the actual procedure of any physiologist. No physiologist in practice professes to deduce the laws of living matter simply from what he knows of the properties which the constituents of living bodies, or substances more or less like them, exhibit in non-living wholes; any more than a chemist in practice professes to deduce the properties of a compound wholly from the properties of its elements when free or in other combinations and from the supposed structure of its molecules. Thus, whatever the ultimate truth of the matter may be, both the chemist and the physiologist are forced in practice to behave as if the complexes with which they deal had emergent properties

(*d*) Let us now sum up the theoretical differences which the alternatives of Mechanism and Emergence would make to our view of the external world and of the relations between the various sciences. The advantage of Mechanism would be that it introduces a unity and tidiness into the world which appeals very strongly to our aesthetic interests. On that view, when pushed to its extreme limits, there is one and only one kind of material. Each particle of this obeys one elementary law of behaviour, and continues to do so no matter how complex may be the collection of particles of which it is a constituent. There is one uniform law of composition, connecting the behaviour of groups of these particles as wholes with the behaviour which each would show in isolation and with the structure of the group. All the apparently different kinds of stuff are just differently arranged groups of different numbers of the one kind of elementary particle; and all the apparently peculiar laws of behaviour are simply special cases which could be deduced in theory from the structure of the whole under consideration, the one elementary law of behaviour for isolated particles, and the one universal law of composition. On such a view the external world has the greatest amount of unity which is conceivable. There is really only one science, and the various "special sciences" are just particular cases of it. This is a magnificent ideal; it is certainly much more nearly true than anyone could possibly have suspected at first sight; and investigations pursued under its guidance have certainly enabled us to discover many connexions within the external world which would otherwise have escaped our notice. But it has no trace of self-evidence; it cannot be the *whole* truth about the external world, since it cannot deal with the existence or the appearance of "secondary qualities" until it is supplemented by laws of the emergent type which assert that under such and such conditions such and such groups of elementary particles moving in certain ways have, or seem to human beings to have, such and such secondary qualities; and it is certain that considerable scientific progress can be made without assuming it to be true. As a practical postulate it has its good and its bad side. On the one hand, it makes us try our hardest to explain the characteristic behaviour of the more complex in terms of the laws which we have already recognised in the less complex. If our efforts succeed, this is sheer gain. And, even if they fail, we shall probably have learned a great deal about the minute details of the facts under investigation which we might not have troubled to look for otherwise. On the other hand, it tends to over-simplification. If in fact there are new types of law at certain levels, it is very desirable that we should honestly recognise the fact. And, if we take the mechanistic ideal too seriously, we shall be in danger of ignoring or perverting awkward facts of this kind. This sort of over-simplification has certainly happened in the past in biology and physiology under the guidance of the mechanistic ideal; and it of course reaches its wildest absurdities in the attempts which have been made from time to time to treat mental phenomena mechanistically.

On the emergent theory we have to reconcile ourselves to much less unity in the external world and a much less intimate connexion between the various sciences. At best the external world and the various sciences that deal with it will form a kind of hierarchy. We might, if we liked, keep the view that there is only one fundamental kind of stuff. But we should have to recognise aggregates of various orders. And there would be two fundamentally different types of law, which might be called "intra-ordinal" and "trans-ordinal" respectively. A trans-ordinal law would be one which connects the properties of aggregates of adjacent orders. A and B would be adjacent, and in ascending order, if every aggregate of order B is composed of aggregates of order A, and if it has certain properties which no aggregate of order A possesses and which cannot be deduced from the A-properties and the structure of the B-complex by any law of composition which has manifested itself at lower levels. An intra-ordinal law would be one which connects the properties of aggregates of the same order. A trans-ordinal law would be a statement of the irreducible fact that an aggregate composed of aggregates of the next lower order in such and such proportions and arrangements has such and such characteristic and non-deducible properties. If we consider the properties of a given aggregate of high order we could then divide them into three classes.

i. Those which are characteristic of this order, in the sense that all aggregates of the order possess them, that no aggregate of lower order does so, and that they cannot be deduced from the structure of the aggregate and the properties of its constituents by any law of composition which has manifested itself in lower orders. These might be called the "ultimate characteristics" of the order.
ii. Those which are characteristic of this order; but which could in theory be deduced from the structure of the aggregate, the properties of its constituents, and certain laws of composition which have manifested themselves in lower orders. These might be called "reducible characteristics" of the order.
iii. Properties which aggregates of this order share with those of lower orders. These might be called "ordinally neutral properties".

I will now illustrate these conceptions.

Suppose, e.g., that living bodies form an order of aggregates in the sense defined. Then the power of reproduction might be an example of an Ultimate Characteristic of this order. The law which asserts that all aggregates composed of such and such chemical substances in such and such proportions and relations have the power of reproduction would be an instance of a Trans-ordinal Law. The laws connecting the reproduction of living bodies with other ultimate characteristics of living bodies would be instances of Intra-ordinal Laws. A great many, though not perhaps all, of the facts about the beating of the heart might be Reducible Characteristics of this order. i.e., although they are characteristic of living beings, they might in theory be deduced from what we know of the chemical, physical, and mechanical properties of nonliving aggregates, and from the special structure of the living body. Lastly, the conservation of energy, the property of inertial and gravitational mass, etc., would be examples of Ordinally Neutral Properties, since they appear unchanged in living bodies, chemical compounds, elements, etc.

There is nothing, so far as I can see, mysterious or unscientific about a trans-ordinal law or about the notion of ultimate characteristics of a given order. A trans-ordinal law is as good a law as any other; and, once it has been discovered, it can be used like any other to suggest experiments, to make predictions, and to give us practical control over external objects. The only peculiarity of it is that we must wait till we meet with an actual instance of an object of the higher order before we can discover such a law; and that we cannot possibly deduce it beforehand from any combination of laws which we have discovered by observing aggregates of a lower order. There is an obvious analogy between the trans-ordinal laws which I am now discussing and the trans-physical laws which I mentioned in considering Pure Mechanism and said must be recognised in any complete account of the external world. The difference is this. Trans-physical laws, in the sense in which we are using the term, are *necessarily* of the emergent type. For they connect the configurations and internal motions of groups of microscopic particles, on the one hand, with the fact that the volume which contains the group is, or appears to be, pervaded by such and such a secondary quality. Since there are many irreducibly different *kinds* of secondary quality, e.g. colour, smell, temperature, etc., there must be many irreducible laws of this sort. Again, suppose we confine our attention to one *kind* of secondary quality, say colour. The concepts of the various colours—red, blue, green, etc.—are not contained in the general concept of Colour in the sense in which we might quite fairly say that the concepts of all possible motions are contained in the general concepts of Space and of Motion. We have no difficulty in conceiving and adequately describing determinate possible motions which we have never witnessed and which we never shall witness. We have merely to assign a determinate direction and a determinate velocity. But we could not possibly have formed the concept of such a colour as blue or such a shade as sky-blue unless we had perceived instances of it, no matter how much we had reflected on the concept of Colour in general or on the instances of other colours and shades which we *had* seen. It follows that, even when we know that a certain kind of secondary quality (e.g., colour) pervades or seems to pervade a region when and only when such and such a kind of microscopic event (e.g., vibrations) is going on within the region, we still could not possibly predict that such and such a determinate event of the kind (e.g., a circular movement of a certain period) would be connected with such and such a determinate shade of colour (e.g., sky-blue). The trans-physical laws are then necessarily of the emergent type.

On the other hand, emergent laws are not necessarily trans-physical, and it cannot be positively proved that any intra-physical law is emergent.

i. The process of breathing is a particular kind of movement which goes on in living bodies. And it can be described without any essential reference to secondary qualities. Yet in its details it may be such that it could not be deduced from any amount of knowledge about non-living wholes and the movements that take place in them. If so it is an "ultimate characteristic" of the vital order, and it is determined by a trans-ordinal law. But this law is not trans-physical, in the sense defined.
ii. On the other hand, since it is a movement and since the characteristic movements of some complex wholes (e.g., clocks) can be predicted from a knowledge of their structure and of other complex wholes which are not clocks, it cannot be positively *proved* that breathing is an "ultimate characteristic" or that its causation is emergent and not mechanistic.

Within the physical realm it always remains logically possible that the appearance of emergent laws is due to our imperfect knowledge of microscopic structure or to our mathematical incompetence. But this method of avoiding emergent laws is not logically possible for trans-physical processes, as I have tried to show.

Teleology, Mechanism, and Design

I have so far discussed Mechanism and its alternatives in a perfectly general way; and have said nothing in detail concerning those peculiar facts about living organisms which make it plausible to distinguish a "Vital Order" with "ultimate characteristics" of its own. Now the peculiarities of living organisms are often summed up in the phrase that organisms are "Teleological Systems". And there is thought to be some special connexion between Teleology and Design, and some special opposition between Teleology and Mechanism. I shall end this chapter by trying to clear up these points.

Teleology is an observable characteristic which certainly belongs to some things in the world. Design is a particular cause which certainly produces teleology in some cases. I want to begin by defining "teleology" in such a way that there shall be no doubt of its existence and that the admission of this fact shall not presuppose the acceptance of any special theory. Suppose that a system is composed of such parts arranged in such ways as might have been expected *if* it had been constructed by an intelligent being to fulfil a certain purpose which he had in mind. And suppose that, when we investigate the system more carefully under the guidance of this hypothesis, we discover hitherto unnoticed parts or hitherto unnoticed relations between the parts, and that these are still found to accord with the hypothesis. Then I should call this system "teleological ". It will be noticed that there are two clauses in the definition. The first is that our more or less superficial knowledge of the system suggests that it was designed for a special purpose which a rational mind might be likely to entertain. The second is that, if we use this hypothesis as a clue to more minute investigation, we continue to find that the system is constructed as if the hypothesis were true. I think that probably both factors are necessary. Of any system whatever we might suppose that it was designed to do what we actually find it doing. But in general we should not find that this gave us any clue to investigating its more minute structure or predicting its unobserved behaviour.

Now it seems to me perfectly certain that the world contains systems which are teleological, in this sense. The most obvious examples of such systems are machines, like watches, motor-cars, etc. In this case of course we start by knowing that they have in fact been designed by intelligent beings for a certain purpose, such as telling the time or conveying people quickly along roads. Knowing this we can explain, as we say, "what each part is for." Suppose now we were to meet with a certain machine for the first time and to know nothing about the purpose of its constructor. As we have met with plenty of other machines (though none exactly like this); as we know that all of these have been made by some human being for some purpose; and as we know of no machines which have arisen in any other way; we may legitimately infer that this one also was constructed by a human being for some purpose. By studying the action of the machine we may then be able to guess what the purpose probably was. We can then predict how it will probably be constructed in detail, and how it will probably work under various circumstances. And, if our predictions are found to be true, it is likely that we have hit on the true purpose of the machine. I will call the kind of teleology which is shown by watches, motor-cars, and other artificial machines, "external teleology". By this I mean that the purpose for which such systems were constructed, and by which their minute structure can be anticipated, is not wholly or mainly to keep themselves going or to produce other machines like themselves. Their main function is to do something, such as telling the time, which is of interest not to themselves but to their makers or other men.

Now it seems to me equally clear that living organisms are teleological systems in the sense defined. The most superficial knowledge of organisms does make it look as if they were very complex systems designed to preserve themselves in face of varying and threatening external conditions and to reproduce their kind. And, on the whole, the more fully we investigate a living organism in detail the more fully does what we discover fit in with this hypothesis. One might mention, e.g., the various small and apparently unimportant glands in the human body whose secretions are found to exercise a profound influence over its growth and well-being. Or again we might mention the production in the blood of antitoxins when the body is attacked by organisms likely to injure it. I will call this kind of teleology "internal teleology". Whatever be the right explanation of it, it is plainly a fact.

We have now to consider the relation between Teleology and Design.

i. The definition of "teleology" involves a hypothetical reference to design. The system is teleological provided it acts *as if* it were designed for a purpose. But it does not involve anything more than this. It remains a question of fact whether the system was actually the result of a design in someone's mind.
ii. So far as we know, the teleology of non-living machines is always due to design. They behave in the characteristic way in which they do behave simply because their parts are constructed and fitted together in certain special ways, and we have no reason to suppose that this special arrangement could arise spontaneously without the intervention of a mind which deliberately chose it.
iii. The real paradox about organisms is that they are teleological systems which seem nevertheless to arise without design. It is this last fact which we must now discuss.

Many organisms have minds connected with them. But we know that if they were designed at all, the mind which designed them was certainly not the mind which animates them, unless this be extraordinarily different from what it appears to be both to itself and to others. The highest type of mind which we are acquainted with is that which animates a human body. If we designed our own organisms we are quite unaware of the fact. And the enterprise seems altogether beyond our powers. The most skilled physiologist does not know how to make a living body; but, if we say that his mind designed his own organism, we must suppose that it performed as an embryo a feat which it is totally incapable of performing in its developed state. We must say then that, if organisms are designed by minds, either

a. the designing mind is altogether different from and enormously wiser and more skilful than the animating mind; or
b. that the animating mind, as known to itself by introspection and to others by communication, is the merest fragment of the total animating mind, and that the part of it which does not appear to itself or to others is of superhuman wisdom and ingenuity.

Of course it might be held that the designing mind, or the designing part of the animating mind, though extraordinarily clever at its own particular job, takes no interest in anything else; or that it works in a wholly different way from the minds which are known to us. But this will not help us. If the conception of design is to provide any explanation of the peculiarities of organisms we must mean by "design" something of the same nature as the only designs that we know anything about, viz., our own. Otherwise we are merely playing with words. Now we have designs only when we imagine a possible state of affairs, apply our knowledge of the properties and laws of matter to discover how it might be brought about, and then use our technical skill to shape the material and to arrange it in those ways which we have seen to be necessary for our purpose. If the minds which design organisms act in this way they must have a superhuman knowledge of the laws and properties of matter, superhuman mathematical ability to work out the consequences of various possible combinations, and superhuman technical skill; and all analogy makes it most unlikely that a mind which took no interest in anything but the one job of manufacturing organisms would have these powers. If, on the other hand, the minds which design organisms act in some quite different and to us unknown way, then we have no right to call them "minds" or to call their mode of operation "design". We are merely assuming a wholly mysterious cause for the teleology of organisms, and tricking ourselves into the belief that it is an explanation by using the familiar words "mind" and "design". I conclude then that, if organisms be the result of design in any intelligible sense, their designers may fairly be called "gods"; and either we are gods in disguise or there are superhuman beings who make organisms.

These considerations remove one positive argument in favour of the theory of entelechies. I am sure that many people who look with a friendly eye on entelechies do so because of the teleological nature of organisms. They think of entelechies as little minds which design organisms and direct and control their growth and reactions. But they modestly regard entelechies as very inferior minds or as the inferior parts of the minds which animate organisms. Now, if I am right, this modesty is wholly out of place. If the hypothesis of an entelechy is to explain anything, we must suppose that an entelechy is a very superior mind or the very superior part of the mind which animates an organism. The theory insinuates itself into our confidence by pretending that the entelechy is so lowly a mind as scarcely to deserve the name; but it can explain the facts only if it supposes the entelechy to be so exalted a mind as to deserve the name of a "god".

I pass now to the relations between Teleology and Design, on the one hand, and Biological Mechanism, on the other. It is evident that, up to a point, there is no opposition between teleology and mechanism. Nothing can be more thoroughly teleological than a watch or a motor-car; yet these are machines, and their characteristic behaviour is wholly deducible from the special arrangement of their parts and from the general laws which these parts would equally obey in isolation or in other and non-teleological complexes. We may say then that, so long as we take a material system as a going concern and do not raise questions about its origin, there is no reason whatever why its characteristic behaviour should not be at once teleological and capable of complete mechanistic explanation. Now the mechanistic biologist regards organisms as very complex machines; and indeed if we were not very familiar with artificial self-acting and self-regulating machinery it would never have entered our heads to suggest a mechanistic theory of vital behaviour. So long as he confines his attention to a developed organism there is nothing preposterous in this theory. It is only when we consider the *origin* of teleological systems that a legitimate doubt arises whether teleology and mechanistic explanation are *ultimately* consistent with each other.

(i) Every system which is *certainly known* to be at once teleological and mechanistic is an artificial machine; and, if we follow its history far enough backwards, we always come to one or more *organisms*, which are teleological but not *certainly* mechanistic systems. It is true that many machines are themselves made by machines; but sooner or later in this chain we come to human bodies which made these machines and were not themselves made by machinery. Thus, apart altogether from any question of minds and their designs, there is something dangerously like a vicious circle in professing to explain the teleology of organisms by analogy with artificial machines. For, the moment we begin to consider the *origin* of organisms in general or of any particular organism, we have to admit that *all* artificial machines were ultimately made by organisms whilst *no* organism is ever made by an artificial machine.

To this objection I think that the following answer might be made. It might be said: "Admittedly we must distinguish two kinds of machines, viz., natural and artificial. We can quite well admit the general principle that *all* machines are made by other machines. Natural machines (i.e., organisms) are always made by other natural machines; artificial machines may be made proximately by other artificial machines, but in the long run in the history of any artificial machine we come to a natural machine. We admit then that natural machines are *causally* prior to artificial machines; but this involves no logical circle. We first derive the general notion of machinery and of a mechanistic explanation of teleological behaviour from the specially simple and obvious case of artificial machines, at a time when we do not suspect that our bodies are themselves natural machines. Eventually we *apply* the notion thus derived to our bodies, and find that it fits them perfectly. There is no inconsistency between the facts

a. that the recognition of artificial machines is psychologically prior to the recognition of natural machines, and
b. that the existence of natural machines is causally prior to the existence of artificial machines".

I think that this is a valid answer to the particular logical objection raised above. But it does not exhaust the difficulties of Biological Mechanism; and this brings us to our next point.

(ii) It is true, but it is not the whole truth, to say that the history of every system which is positively known to be both teleological and mechanistic (*i.e.,* of every artificial machine) we come at length to an organism. We also come to the mind which animates this organism; to a design in this mind; and to the deliberate arrangement of matter in view of an end. And this seems to be essential for the production of a teleological system out of non-teleological materials. On a mechanistic theory the teleological behaviour of a system must be due wholly to the initial configuration of its parts; and, if matter has only the properties which physicists and chemists ascribe to it, it has no tendency by itself to fall into those extraordinarily special arrangements which alone can give rise to teleological behaviour. Now, if the analogy of organisms to artificial machines is to be used at all, it must be used fairly; we must not ignore one essential part of the facts about the origin of artificial machines. Let us then apply the whole analogy to organisms. It is certain that, when one organism produces another by ordinary processes of generation, the mind of the first does not design and construct the second, as it would if it were producing an artificial machine like a watch or a type-writer. This in itself need cause no trouble to the Mechanist. When one artificial machine produces another the mind of the first does not design the second, for artificial machines have no minds. The Biological Mechanist will therefore simply say that the generation of one organism by another is analogous to the production of one artificial machine by another. But, as we have seen, the latter series eventually brings us back to a mind with designs. Hence, if the Biological Mechanist is to apply his analogy fairly, there arc only two courses open to him. The first is to say that there always have been organisms, and that organisms have never arisen from inorganic matter. On this alternative he has a series of natural machines going back to infinity. In that case of course every artificial machine will also have an infinite ancestry of other machines, since the production of an artificial machine eventually brings one back to a natural machine. Such a theory would be self-consistent; though it would still leave the awkward difference that design enters into the history of *every* artificial machine and of no natural machine. It is of course an alternative that most mechanists would be very loath to take; for one of the advantages claimed for Biological Mechanism over Substantial Vitalism is that the former does and the latter does not render the development of living from non-living matter conceivable.

The other possible alternative is to admit that organisms arose in the remote past out of non-living matter. This means, on the mechanistic view, that natural machines arose from matter which was not arranged in the form of a machine. And this can be consistently held only if the Biological Mechanist will postulate at that point the intervention of a mind which deliberately designed and arranged non-living matter in the form of a natural machine. For, as we have seen, the only systems which we positively *know* to be machines have all arisen in this way; and, if matter has no properties except those which chemists and physicists assign to it, there is not the least reason to suppose that it can spontaneously fall into the extremely special configuration which is needed if the resulting system is to behave teleologically. Thus the proper complement to a completely mechanistic theory about organisms is some form of the doctrine of Deism; a result which accords very well with that simple piety which is so characteristic of Biological Mechanists.

But, even if we are willing to go thus far with the Biological Mechanist, we cannot allow him to leave the matter there. Every system which is positively known to be a machine has been ultimately made, not by a pure spirit, but by a mind which animates an organism which it did not design or construct. This mind formed a design; in consequence of this the organism which it animates has moved in various ways; and it is thus and thus only that the design has been realised in foreign matter. Once more, if we are to use the analogy of machines at all, we must use it fairly and not ignore these parts of it which, so far as we can see, are essential but which are not convenient. The Biological Mechanist, having been brought willingly or unwillingly to Deism, must now take a further step and ascribe to God an organism which God's mind animates. And by all analogy we must suppose that God did not design or construct his own organism; since, so far as our experience goes no mind designs or constructs the organism which it animates. Thus, in the end, we shall be brought to one organism at least, viz, God's, which presumably has not arisen out of non-living matter either spontaneously or by design. This seems to be the final result of seriously and fairly applying the analogy between organisms and machines, when we cease to confine our attention to the organism as a going concern and try to account also for the origin of organisms, as Biological Mechanism would wish to do.

Tentative Decision between the Three Theories of Organisms

When we consider the teleological characteristics of organisms the three possible theories of Substantial Vitalism, Emergent Vitalism, and Biological Mechanism cease to be on a level. In the first place, there seems to be nothing to be said for Substantial Vitalism, and a great deal to be said against it. We may therefore provisionally reject it, and confine our attention to Emergent Vitalism and Biological Mechanism. It seems to me that, so long as we merely consider the behaviour of the organism as a going concern, there is no strong argument for deciding between the two types of theory. For it is quite certain that a material system, once it is in being, can be teleological and at the same time mechanistic in its behaviour. Hence, even if we did not see our way to explain certain teleological characteristics of developed organisms mechanistically, the Biological Mechanist could always answer that this is merely because we do not yet know enough about the minute structure of the machine or about the more obscure physico-chemical properties of non-living matter. And this is what he is continually occupied in saying. But, when we come to consider the origin of organisms as well as their behaviour, the case is altered. We find that Biological Mechanism about the developed organism cannot consistently be held without an elaborate Deistic theory about the origin of organisms. This is because Biological Mechanism is admittedly a theory of the organism based on its analogy to self-acting and self-regulating machines. These, so far as we can see, neither do arise nor could have arisen without design and deliberate interference by someone with matter. And, in applying our analogy, we have no right whatever to ignore this side of it. I do not of course assert that this is a conclusive objection to Biological Mechanism. Deism has always seemed to me a much more sensible theory than most of its more pretentious successors. But I do wish to make it quite clear that Biological Mechanism is committed logically to a great deal more than is commonly supposed. It Emergent Vitalism could dispense with the need for all this Deistic supplementation it would *pro tanto* score over Biological Mechanism. But can it?

It might well be thought that in this matter Emergent Vitalism is no better off than Biological Mechanism. On both theories the peculiar behaviour of an organism is completely determined by its structure and its components and by nothing else. The only difference is that on the Emergent View the peculiar behaviour of such systems must be "seen to be believed", whilst on the Mechanistic View it could in theory have been foretold from the structure and the behaviour of the components in isolation or in non-living wholes. If you make it an objection to the Mechanistic Theory that the characteristic behaviour of the organism depends on the arrangement of its parts, and that this arrangement could only have happened by design, does not the objection apply equally strongly to the Emergent Theory? This argument is plausible, but I do not think that it is sound. The Biological Mechanist points to the analogy between organisms and artificial machines, and asks us to believe on this ground that organisms are machines. To this we answered that matter has no natural tendency to arrange itself in the form of *machines* (*i.e.,* of teleological systems whose characteristic behaviour is *mechanistically* explicable); and that therefore, if organisms be of the nature of machines, there is no reason to suppose that they could have arisen spontaneously and without design. But it is perfectly consistent for a man to hold that matter has *no* tendency to fall spontaneously into the form of *machines* and that it *has* a natural tendency to fall into the form of *organisms*; provided he holds, as the Emergent Vitalist does, that organisms are not machines but are systems whose characteristic behaviour is emergent and not mechanistically explicable. Thus the real difference is that a possibility is open to the Emergent Vitalist, who recognises two fundamentally different kinds of teleological system, and that this possibility is closed to the Biological Mechanist, who recognises only one kind.

Of course this possibility, which is open to the Emergent Vitalist and not to the Biological Mechanist, is very vague and needs to be worked out in much greater detail. This would be the task of the empirical scientist rather than the critical philosopher. I will content myself with saying that the Emergent Vitalist should not rest with nothing better than the vague statement that matter has a natural tendency to fall into that kind of structure which has vital behaviour as its emergent characteristic. If Emergence be true at all there are probably many Orders below the Vital Order. What must be assumed is not a special tendency of matter to fall into the kind of arrangement which has vital characteristics, but a general tendency for complexes of one order to combine with each other under suitable conditions to form complexes of the next order. At each stage in this process we shall get things with new and irreducibly characteristic properties and new intra-ordinal laws, whilst there will probably remain certain complexes of all the lower orders. The universe would thus grow continually more varied, so long as the special conditions necessary for this combination of complexes of lower order to give complexes of higher order continued; and at every new stage new possibilities of further development would begin. It would be the business of the believer in Emergence to determine the precise condition under which the passage from one order to the next can take place; to state definitely what are the irreducibly characteristic features of each order; and to deduce those characteristic features which can be deduced.

It seems to me then that on the whole Emergent Vitalism is distinctly to be preferred to Biological Mechanism. It does not necessitate a complicated Deistic supplement, as Biological Mechanism does; and this seems to me to be an advantage. At the same time it is perfectly *consistent with* the view that there is a God who created and controls the material world; so that, if there should be any good reason to believe in such a Being, the Emergent Vitalist could meet the situation with a quiet mind.

C. D. Broad, "Chapter II: Mechanism and Its Alternatives," *Mind and Its Place in Nature* (1925)

http://www.ditext.com/broad/mpn2.html