

The Lifeless World of Biology

a chapter from the book *The Hollow Universe* by Charles DeKoninck

In animals life is patent and obvious, whereas in plants it is hidden and not clear. . . . Life seems to consist primarily in sensing and thinking. . . . God is the supreme and ever-lasting animal.

ARISTOTLE

THE title of this lecture may seem a contradiction, and perhaps also a piece of impertinence. Yet the judgement which it makes is both true and moderate. Indeed, it should become clear in the course of our discussion that, to the adjective lifeless, must be added the adjectives inorganic and functionless. Modern biology, if some of its distinguished representatives are to be believed, dare not call itself true science unless it avoids and ignores all that naturally comes to the minds of ordinary people when they think of familiar animals and plants. Nor have I been provoked to this general comment by one or two radical works like Mr. N. W. Pirie's *The Meaninglessness of the Terms Life and Living* (1937), or his more recent *The Origin of Life* (1953). Long before I was aware of his opinion, I had pointed out in an *Introduction a l'etude de l'ame* (1947), that neither the courses in biology followed by myself more than a quarter of a century ago, nor anything I have read since, offered any reason why the terms 'life' and 'inanimate' should be used at all except as 'linguistic conveniences'. The reason is that the biology I am talking about is resolved to be sternly empirical, while it can find nowhere any definite, empirically defined property able to separate, once and for all, the animate from the inanimate. Irritability, self-repair, nourishment, growth, and reproduction, as described in typical modern treatises, can be no more than provisional hypotheses, if they amount even to this. It may of course be granted that, as a matter of method, we can and should attempt to explain so-called living phenomena in terms of what we call the inanimate, as far as possible; and that, when we cannot, we should at least keep an open mind on the question. However, even this apparently broad view will lead to difficulties. 'Inanimate', after all, is a negative term: I mean that, linguistically, it is a negation of 'animate', so that it looks none too easy to get rid of the living when, without at least the idea of it, the 'non-living' cannot be named.

On the difficulty of avoiding involvement with the living while pursuing knowledge of the non-living, we shall have more to say later. Meantime Professor W. S. Beck has pointed out, in his *Modern Science and the Nature of Life* (1957), that even Mr. Pirie, having made his attempt at merciless rigor, falls into the trap against which he himself has warned us by going on to use the terms living and non-living as meaningful after all. A similar unconsciously fallacious attitude is sometimes adopted by the physicist. For some unspecified reason, it is assumed that physics is about the inanimate, and that it does not deal with living things, when everyone knows that it seeks to explain things like gravitation, and that the physicist himself is just as much subject to gravitation as a stone or a sack of potatoes. But I am distracting you with incidentals and will serve you better by getting on with my first task, which is to explain, if I can, why biologists come to this curious attitude towards their subject. Here is how they slip into it. Taking for granted our ordinary acceptance of 'living' and 'non-living', these writers, from the start, resolve to explain them in terms of the kind of life we know least about, that is, in terms of the so-called lowest animate forms. Once this method is adopted to the exclusion of any other, there is no escaping Professor Beck's conclusion:

As perceptual objects, plants are plants whether we call them living or not: 'life' is a conceptual object. In other words, Pirie is correct: 'life' is beyond rigorous definition but he, I, we will speak of life because we all know what it means in the large area of nonambiguity. The errors to be avoided are compulsive rigidity and failure to be happy in the company of uncertainty. When asked what viruses are and what they do, we can answer. When asked, what is life, we must reply with no more or no less than an enigmatic smile.

In his very next paragraph, however, Professor Beck, perhaps unwittingly, makes the same criticism of his method which we make:

At the moment, I am having difficulty thinking of any use to which a definition of life could be put -- *other* than to the everyday problem of recognizing death. When a scientist manipulates a living system, it is occasionally useful to him to know if it has died. If the system is a horse, there would seem to be few problems. But we quickly discover that the ambiguity of 'life' affects 'death' in reverse. If it is a bacterium, a seed, or a spore, the problems may be insurmountable, and in practice we usually establish an arbitrary end point at which death, by decision, is recognized to have occurred. Quiescence and death can look very much alike and their distinction brings us straight to the bar of verbal distinctions.

In other words, we can be reasonably sure about the distinction to be made between a live Socrates and a dead one; but we cannot be anything like so sure whether this particular organism is an animal or a plant; nor whether this object, at this moment, is even a plant or something not alive at all. Now, our objection was that the man who hopes to arrive at some definition of life, enabling him to set life apart from non-life, should never begin with the study of what is alive very obscurely, if alive at all. Why not begin with horses? He can see them without a microscope. Or why not start with the kind of thing that asks what horses are? which eventually constructs microscopes and finds itself faced with the obscure forms of life?

A counter-objection to this procedure comes immediately to mind. Is it not a general principle of science that we must try to explain the complex in terms of what is at least less complex? Now a horse, or a philosopher, is more complex than an amoeba, and should not therefore be studied until the simpler organism has been taken care of. But this difficulty is easily met. Though far more complex than the amoeba, the horse, in a sense is far more known to us; and a dead horse far more recognizably dead than a dead amoeba. What is it then, which leads a man to assume that, if the term 'life' is to have any verifiable meaning, it must first be put to test at a level where things are most obscurely alive, if even at that level? I can accept that genes are molecules, as I do that dogs are bodies. But what the latter statement means is much clearer (though we might wrangle over what 'body' means and, in fact, at greater length than some rigorous philosophers suspect). Faced with the question 'What is life?', are not scientists like Mr. Pirie trying to explain what man already knows well in terms of what man knows far less well? Surely the life of plants is more obscure to us *qua* life than that of familiar animals. As we first try to pin down and reflect upon the meaning of the term 'life', why should we be requested to ignore the life already so familiar to us, and to signify which we normally use this term? That what I venture to call the more sensible and natural approach is indeed more sensible and natural seems attested by our usual manner of speaking. Take the kind of question Professor Beck wonders about: how did living organisms 'learn to repair their wounds, to resist stress, to think, feel, and reason?' Some might say that such

language is no more than anthropomorphic convenience, as when we speak of the mouth of a river or the bowels of the earth.

But, even in such cases of mere metaphor, the words first imply reference to something already known, such as the mouth or internal organs of an animal -- of a horse, say, or a man -- though not without a generous share of vagueness. Of all our normal language it is true that, whether its words be used as metaphors, given new meanings, or meanings long worn out and now revived, they still imply reference to something already known, something that may be quite certain, no matter how fuzzy at the edges.¹ So why let ourselves be confused by questions like: 'Well, where are the mouths of the protozoa?' or 'Has the bacillus a stomach?' Surely it will be wiser to tackle the creatures we can get our hands on, and whose experience we share, before seeing what we can make of elusive animated particles which most of us will never so much as be able to observe.

Suppose we make a start with the most conspicuous and noisy animal here present. When I say that I am alive, how can I verify this statement to my satisfaction and yours? So far as I am concerned, 'being alive' means primarily to have sensations, such as touching, tasting, smelling and so on. If we could agree on the meaning of 'to have a sensation', we might then go on to the ancient definition of what an animal is, viz. a body endowed with power to sense. (Which aims to reveal no more than what the Bourgeois Gentleman already knew.) It is certainly not obvious that trees have sensations, nor that stones do not; on the other hand, there is not a scrap of evidence for sense-power in either.² And though one might easily point to cases where it is not clear whether a

¹ All analogical terms are examples of what is meant. Take, for instance, the Greek 'logos', several of whose meanings are retained in our word 'reason'. Prescinding here from the historical order of its various impositions, logos first stands for the conventionally meaningful sounds or written signs produced by man for the purpose of communication: words, phrases, and speech, as distinguished from the thought they are intended to convey. Then it can mean the thought itself which the sounds are aimed to express. It was further imposed to mean what the thought names, and, again, the definition or 'what it is that the name signifies'. It may also mean proposition, argument, discussion, discourse, or treatise. Finally it has other abstract meanings such as 'notion', e.g. the notion of circle; or the reason or ground for something, as in 'Xanthippe threw a pail of water on Socrates for the reason that he came home too late', or 'the flat triangle has its three angles equal to two right angles for the reason that its exterior angle is equal to the two opposite interior angles'. The same word was again extended to mean the power of reason, the faculty; then, too, the exercise of this power, as in judgement, opinion, justification, explanation. It can also mean proportion, rule, and hypothesis. But the first imposition remains throughout important, inasmuch as the plain, unqualified, unanalysed meaning of 'word' is more known to us, while all the other meanings of 'logos' are somehow related to this first one.

² In *The Foundations of Mathematics*, Frank P. Ramsey remarked that 'Where I seem to differ from some of my friends is in attaching little importance to physical size. I don't feel the least humble before the vastness of the heavens. The stars may be large, but they cannot think or love; and these are qualities which impress me far more than size does. I take no credit for weighing nearly seventeen stone.' When I pointed this out to an enthusiast of rigor I was asked: 'How do you know stars cannot think or love? Meanwhile the statement is meaningless.' Well, I do not know that the stars cannot think or love, nor how I should go about proving that they cannot. But I see no need even to try. None of this offers any reason for calling the statement meaningless. If it is utterly meaningless, how can my rigorist friend know that it is? Though I may remain in ignorance of the truth or falsehood of statements, I can still know what they mean, and would not know myself ignorant of their truth or falsehood unless I did. Thanks to Lord Russell, my friend has since matured. Now he calls the distinction utterly trivial -- which it may well be, since it has always been in use and was thoroughly accounted for by philosophers thousands of years ago.

given object is capable of sensation or not, there is no reason why these cases should disturb our own awareness of being alive as we use our senses.

Besides having sensations, I *know* that I have them; and this is of no small account. I am quite aware, when not seeing red, that I might do so, and that I might not when I do. I know that to see is not the same as to smell, and I distinguish these sensations as I receive them. I also remember having seen red when I no longer see it; and, when now observing something red, I am aware that I have seen such a thing many times before. I can try to recall when and where I last saw a red object and, when I say 'reminisce', I do not mean the same as 'to remember'; just as by 'remembering' I do not mean the same as 'to have something in mind which is not present'. I perceive and distinguish different kinds of sensations, and representations of things no longer, or not yet, present. I know that I possess these various kinds of knowledge, and know that I know this.

To all appearances, elephants have various kinds of knowledge too. I see that they can be annoyed by insects boring into their hides; that they see, hear, and smell. But I am obliged to wonder in what fashion these huge beasts know that they have sensations, and whether they ask themselves what a sensation is; or if, in any sense, they know that they know. The reasons for believing that they never wonder about such matters are more convincing to me than the reasons for believing that they do.

Let us interview our favorite elephant in the zoo in order to establish what we first mean when declaring him to be alive. As he thrusts forth his trunk, I somehow detect that he is wondering whether he is going to get a peanut, for he remembers having been offered pellets of paper instead; and at this moment he is trying to recall whether it was this little fellow who so deceived him. Now that is what *I* mean by a live elephant as opposed to a dead one, though I can hardly imagine what it means to him, or how he could get himself into a state of wonder about what it is to be alive -- or to be an elephant, for the matter of that. He never discusses such things with me, and the reason is likely that he has nothing to say on the subject. He does produce significant sounds, of course, but his vocabulary is rather limited; though I am sure it has nuances which escape any listener but a fellow-elephant. Still, I believe that, unlike Aesop's lion, the elephant has no need to say any more than he does.

All I have asserted about being alive leaves the reality in deep obscurity, and makes it clear enough that I do not know how far life extends. My certitude of touch as I sit here -- my certitude of the resistance of this chair and of the warmth of my hand on this cool desk -- these do not imply clear knowledge of what this sensation is, though I manage to distinguish it from other kinds. But the point is that my certitude is not diminished by ignorance of the conditions of sensation, while I do see that these are many and in some measure beyond analysis. The tactile world appears quite different when my hands are numb: tepid water, for example, feels warm when my hand is cold; and this page looks blurred when I take off my spectacles. Now, is it reasonable to argue that, because my numb hand cannot feel so well as my normal hand, that my normal hand cannot feel at all? or that my need of spectacles proves my eyes to be untrustworthy?

Yet reasoning of no higher order is now commonly used to convince us that the terms 'living' and 'nonliving' are no longer of any use. It is suggested, for instance, that the word 'living' is meaningless because there are cases to which nobody knows whether it applies, that is, things of which it is not possible to be sure whether they are living or non-living. But, if the denial of the distinction is to have meaning, we must understand the terms whose distinction we deny. So far as I can see, ignorance of where life begins or ends in the world of the microscope has nothing to do with my certitude of being alive, even though I may not know much about my own kind of life.

Professor Beck can bear the company of uncertainty,³ but not, you will notice, as regards the life or non-life of a horse. ‘If the system is a horse,’ he said, ‘there would seem to be few problems’. But, he added, ‘If it is a bacterium, a seed, or a spore [and we might add, a protein molecule], the problems may be insurmountable. . .’. Of course. And since insurmountable they may well remain, it is no wonder that, if the professor is determined that the question shall not be discussed at a more intelligible level, his best answer should remain an enigmatic smile.

Let us get back to our horses. We are agreed that we know more or less what we mean when we say that a horse is alive, and that to all appearances a stone is not. It will be profitable now to make more explicit that difficulty in distinguishing alive from not-alive which was briefly pointed out earlier in our lecture. When compared to a horse, if perhaps not to a creature on the obscure microscopic level, a stone, we confidently assert, is ‘not alive’, or ‘non-living’, or ‘inanimate.’ Now these terms are negations. But a negation is something relative: it is the negation of something. If the negation is to be meaningful, you must know what it is that you are negating. ‘Non-living’ means nothing without some knowledge of what the term ‘living’ stands for. In short, there must have been a definite sense assigned to the term living, before any significance could appear in the negative ‘non-living’. And what can this mean except that we know and name the living before we name the non-living? I certainly know far better what it is to have a sensation than I do what it is to be a stone, even when it is the very stone that causes in me a sensation when I stumble over it.

Of course, the ability to use the word ‘living’ in a significant way of things such as horses and men, does not mean that I know ‘what life is’ in the sense that I can actually define it, not merely interpret the name. It is one thing to know a thing well enough to name it; it is quite another to make fully explicit what it is that I name and to set it apart once and for all from any other kind of thing. But I think we are safe enough in distinguishing horses from stones in terms of life; and if we cannot be so definite about lower forms of life, why should this make us surrender our horses?

It was a typically Cartesian view that science must begin with what is most basic in the things under study. Many of us were raised on the ‘evidence’ that an atom was a much clearer thing than a stone; while in the study of life, we were made to begin by clearing away everything but the amoeba. The assumption was that whatever is less complex ought to be more accessible than the complex. In physics there are no Cartesians left: the world of mathematical physics has turned out to be far more involved than Descartes or even Newton could suspect. It has taken some centuries of experiment and symbolic construction even to approach something basic, such as what are now called atoms and quanta. And every day we learn that these are more complex than was thought yesterday. So the fact must be faced that what we know first and foremost is not what is most basic to things themselves, no matter how much we might like to have it that way.

But in biology, Cartesianism still thrives. Those of us who got their elements of biology some forty years ago will remember the doctrine that protoplasm was the universal stuff of life. Since then, the nature of protoplasm has become happily less clear, and what the stuff of life may

³ Aristotelians bear the company of uncertainty calmly enough, of course: ‘error is a state more natural to the animals than the truth, and in which the mind spends the greater part of its time’ (*De Anima*, III. 3. 427b). Aquinas’s paraphrase reads as follows: ‘For error seems to be more natural to animals, as they actually are, than knowledge. For experience proves that people easily deceive and delude themselves, whilst to come to true knowledge they are in need of being taught. Again, the mind is involved in error for a longer time than it spends in knowing truth, for we barely attain to knowledge of truth even after a long course of study.’

be, is now known to be less known than ever before. Is it credible that some biologists continue to state that their science is working with physical phenomena 'entirely accessible to our understanding', by which they mean that life is explained 'in terms of physics and chemistry?' (I would be grateful if they did no more for me than to explain the distinction assumed here between physics and chemistry.) What are physical phenomena entirely accessible to our understanding? Of the sciences of nature, physics is the most exact; but I have yet to meet a modern physicist who speaks with any such confidence about what he knows. He is in fact growing more and more baffled at the unsuspected complexity of the basal entities of the physical world. Eddington's statement, though made nearly a quarter-century ago, still stands unchallenged: as he digs to the foundations of the physical world, the scientist finds himself 'treating a universe which is the theater of unknowable actions and operations'. How then can biology assert that it is dealing with physical phenomena entirely accessible to our understanding? In the context of an arrested Newtonian physics, in which the basic stuff of the universe and the laws governing it were assumed to be clear *more geometrico*, it would be easy enough to interpret this statement. For the great Newton wrote his *Principia* in the lucid vein of Euclid's *Elements*. But surely there is no excuse for retaining such a conception of the physical world today.

Although an immense over-simplification, the old Newtonian view was nevertheless a fascinating one. The world had the clarity and intelligibility of a machine such as man himself might build. Now there is in fact nothing more known to us, as to what they are, than the things that we ourselves have made by art or craft. True, a good deal of the material that goes into a motor, for example, is known only vaguely. But mere practical knowledge of this material is enough to get the machine to work. We know that a spark will explode gasoline vapor. With very little more knowledge than this it is easy enough to see why gasoline engines operate as they do. The works of our hands, once made -- from hammers and saws, to nuclear bombs and missiles -- are well known to us, as to purpose and function, because we ourselves concoct them. Now, if nature were the same kind of thing, if the whole world and each of its parts were just like a machine, we could then truly speak of physical and biological phenomena as accessible to our understanding. But it so happens that even in physics this model theory, though it worked for centuries, has now quite broken down. Some biologists apparently survive still unaware of these developments, serenely confident that living bodies, as Descartes once thought, are just machines.

Since we are on the subject of over-simplification in biology, let us glance, for a brief moment, at how the same tendency affects the problem of evolution. Having been brought up to accept the fact of evolution, I would not find it easy now to doubt that it has happened, however uncertain I may remain about the value of any particular theory devised to explain how it happened. There seems no reason why nature, 'one mask of many worn by the Great Face behind', could not produce living things from non-living, and higher forms of life from lower, somewhat as we build a table out of a rough piece of timber. If nature cannot accomplish something analogous to this, nature cannot be what an Aristotelian thinks it to be. But though a craftsman may make a chair, he does not thereby make 'what a chair is'. And in the same way, nature may produce this or that living being, without being in the least responsible for 'what it is to be alive', nor for what it is to be this kind of living being'. As Aristotle suggested, to burn down a house is not the same as to abolish 'what a house is.' To produce a man from some ape-like creature no more destroys the *kind* of creature this was than a degenerative evolution of man into an ape-like creature could suppress 'what it is to be a man.' Believe in evolution as much as you like, you are not thereby compelled to believe that the things transformed by evolution are really only the same old thing unchanged and

unchangeable. And yet it is frequently held that the various kinds of living beings are merely incidental variations of the same thing. Some people have lost all true understanding of the problem and take the attitude that it is incidental that two tons should be two tons of elephant rather than of coal. Of course, if all you want is two tons, and you get them in coal rather than in elephants, what more can you ask? It is not always realized that this kind of reduction makes of evolution a superficial phenomenon hardly worthy of the name. To give rise to more complex species now becomes something like producing those 'new' symbolic constructions of ours: 2 is nothing new over and above $1 + 1$. The idea is a venerable one, of course: the very earliest philosophers, using the analogy of human artifacts too superficially, believed that basically all things were of the same nature, as chairs, broomsticks and tables are all wood; and held, further, that these differentiations were wrought by chance, which is without reason, without 'logos.'

Life, we suggested in our opening paragraph, implies the organic, and modern biology -- or so we are told -- is just as ready to dispense with the one as with the other. But before going any further, let us be sure that we know what organic means. A good deal has been said about sensations as a sign of life. Of our own sensations I would like you now to notice how they quite obviously involve certain parts of our body, such as skin, eyes, ears, and other members identifiable perhaps only after some investigation. These parts are commonly called organs, and that is in fact what they are. I do not intend to convey that, with regard to sight, for example, these eye-balls of mine, all by themselves, are the organs of vision; what lies behind them in the brain is no doubt even more important to seeing, and so must also be part of what is meant by the organ.

Now I would like to arrest your attention upon this word 'organ'. In biological writings, no word, you will agree, is more commonly used. How often, though, do we see any attempt to make plain its meaning? Organ, organic, organism, living organism -- the pages of our text-books are littered with such expressions and you may be astonished to hear me maintain that, in the context of these works, their meaning can be exceedingly difficult and complex as anyone can see by reading Professor Ludwig von Bertalanffy's *Problems of Life*. Yet we simply must know what an organ means, and I think the best way to begin is to search out the first and primitive use of the word. Not that we are interested in etymology, of course, but simply that later and more cultivated meanings of a word usually grow from some original meaning.

The name 'organ' is taken from the Greek 'organon', meaning, simply, tool; something used to do something with, like a hammer or a saw. And that is what Aristotle had in mind when he described a living being as 'a natural organized body', that is: a natural body, as opposed to an artificial one, equipped with tools. Now, to verify the meaning of this description, there is no need to hurry off to examine an amoeba for its special type of tools. If it eats and reproduces, doubtless it has the means to do so. But, if it be a good example of organ that is wanted, we had much better begin with a human hand, or an elephant's trunk. After all, it is further knowledge that we are hoping for, not ignorance of what we knew before we began (although this could apply in some cases, since most of us had to unlearn our first knowledge of things like atoms and the basic stuff of life.)

Of any organism, among the well-recognized forms, at least this much may be said: that it has structure, and that it is also an heterogeneous whole; by which I mean that a horse for example is not all legs, nor all eyes, nor all tail. But these generic qualities do not set an organism apart from structures or heterogeneous wholes that are not organisms, unless we have chosen to use organism as a metaphor or to give it wider meaning. In other words, an electron is not an organ of the atom

in the sense in which the trunk is an organ of the elephant. But if it so happens that you want to extend 'organism' to whatever has structure and heterogeneous parts you ought to be aware that you are in fact either using a metaphor, or extending the meaning of the term. If we stick to our elephant, however, and to 'organ' as the word is exemplified by his trunk, then it is as plain as his trunk that by organ we still mean a tool. Now, this is to mean a great deal, because a tool supposes a purpose and, when we speak of organic bodies, if we mean anything, it can only be that these bodies are equipped with the means of pursuing purposes.

You see what bad tactics it is to begin with creatures like the amoeba. With no better idea of an organ than this obscure little creature can give us, we should never know quite what we meant by the word. Later on, of course, we must investigate the world of microscopic life, but the acquisition of this new and different knowledge should not cause us to cease to know what we knew.

That many modern biologists cannot endure the thought of nature as attracted by purpose, as acting 'for the sake of something', is evident from much of the literature on the subject. Ever since Darwin, the opinion remains prevalent that the notion of purpose in nature is unscientific and unnecessary. 'At first sight, the biological sector seems full of purpose', admits Julian Huxley. 'Organisms are built as if purposely designed, and work as if in purposeful pursuit of a conscious aim.'⁴ But the truth lies in those two words "as if." As the genius of Darwin showed, the purpose is only an apparent one.' Now, what I am attempting to establish is merely that, if an organism has no purpose, it is no organism at all: it is not a body equipped with tools making possible the fulfilment of needs, but simply a mass in which appear a number of functionless appendages. Whether this last description makes sense need not concern us for the moment; the point is that there is no avoiding it when purpose is denied.

Sometimes, of course, a scientist is entirely right in excluding all thought and mention of purpose from his work. This is the case whenever his methods are formally mathematical. Thousands of years ago, it was recognized that, when applying mathematics to the study of the physical world, we prescind from the good and from purposeful activity in nature, no less than we do in pure mathematics. It is not because it is good for the triangle that this figure of parabolic geometry has its three angles equal to two right angles; nor is Galileo's quadratic law a plausible equation because it is better for it to be so. So if by the scientific outlook is meant the mathematical vision of things, it will be necessary to agree with Bertrand Russell when he says that ' "purpose" is a concept which is scientifically useless': and that 'in science it is the past that determines the future, not the future the past. "Final causes", therefore, do not occur in the scientific account of the world'.

But good was pursued and evil avoided in this world long before there was any scientific account of it, nor does the scientific account in this respect seem to have made any great change in things. The natural world is so mysterious, so stupendously complex, that a science has every right to prefer the simplest possible methods, and so is entitled to shun many problems that cannot yield to these tactics. But we do not have to accept what is left as the world in which we have got to live. Whatever the nature of cancer, for example, we continue to call the subjects of it 'victims' and,

⁴ Of course there is no need to suppose, as the phrase seems to do, that, in order to be genuine, purpose requires that nature be conscious of it. All the same, Sir Julian seems to have understood that 'si natura operetur propter finem, necesse est quod ab aliquo intelligente ordinetur' (Aquinas, *In II Physics.*, lect. 12).

leaving aside worse evils, we may truly declare that it is simply good not to have this one. We shall also agree that it is good for a man to have both his legs, both his eyes, and water when he is thirsty. Nor should it appear any less reasonable nowadays to state that it is good for him to be endowed with the proper electrical charges, molecules, cells and tissues. Certain chemical combinations make obviously living beings possible; and why should these not be called good, at least with respect to the beings which need them? Purpose is of course clearer to us in what we are wont to call the higher animals, not to mention man himself: it is plainly good for an elephant to have his trunk, and a whale his tongue. The good is obscure to us in the case of plants and, when, if at all, we penetrate to still lower regions of being, final causality fades out of sight. Where we can no longer relate things to recognizable living creatures, we can no longer be sure of what is good or bad. All this is the plainest common-sense, and we shall be silly indeed if we abandon any of it for no better reason than the impossibility of translating it into formal equations.

Aristotle had his troubles with that account of the world which Russell calls scientific, whereby the past determines the future; a doctrine which aims to explain in terms only of causes that exist *before* whatever it is that comes to be. One of these causes is the stuff (a conveniently vague term) of which that which comes to be is composed, another is the agency giving rise to that which comes to be. Instances of these two causes would be the stone and the sculptor, both of which exist *before* the statue does. Causes that come to be *after* these first two,⁵ would be, for example, the shape of the statue, by which it differs from the unhewn stone, as well as what the sculptor had in mind while selecting the stone and hewing it, namely the statue. Now, although the completed statue is what comes about last of all, it was what the sculptor intended before it actually came to be. This finished shape, and that which he intended while hewing this stone, are in fact one and the same thing, though considered in different respects: the shape now in existence makes and reveals the statue as different from the unhewn stone, and it is also what the sculptor intended.⁶

Now, according to the doctrine which Aristotle had to refute, the analogy between art and nature would hold with regard to the stuff that things are made of, and in some small measure for the agency as well. But the analogy already begins to break down in the latter respect, inasmuch as agency is reduced to aimless process determined only by the material, in the way a landslide occurs. There is no agent intending a good so that, if some good does in fact come about, such as the erect posture of man and the attendant size and quality of his brain, this happened for no other reasons than the kind of stuff of which he is composed and the process which left him composed of it: there

⁵ As Russell has repeatedly observed, 'The "efficient" cause is what we should call simply "the cause..."'. While it is the one which was first named 'cause' it is, in fact, as Hume's critique has shown, quite difficult to defend outside the domain of human making and acting. But once we have defined cause as 'that upon which something depends in being or becoming', the notion of material cause is the most obvious and certain, such as the wood of a wooden table; then that of form, e.g. the shape of the table; and any critical discussion of causality should begin with these.

⁶ An infinity of different purposes may be prior or concomitant to his purpose as a sculptor, such as his commission, obedience to his patron, and so on. But these are incidental to the statue as such -- which faces us again with that distinction between *per se* and *per accidens*. If this distinction is ignored, we can say just as readily that the sculptor's purpose was to escape his mother-in-law's bad temper, and so vindicate that extreme form of sophistry which exploits the kind of non-being found in the infinite *per accidens*.

was nothing prior to these that had anything to do with what came about. Here is how Aristotle describes the theory:

Why should not nature work, not for the sake of something, nor because it is better so, but just as the sky rains, not in order to make the corn grow, but of necessity? What is drawn up must cool, and what has been cooled must become water and descend, the result of this being that the corn grows. Similarly if a man's crop is spoiled on the threshing floor, the rain did not fall for the sake of this -- in order that the crop might be spoiled -- but that result just followed. Why then should it not be the same with the parts in nature, e.g. that our teeth should come up *of necessity* -- the front teeth sharp, fitted for tearing, the molars broad and useful for grinding down the food -- since they did not arise for this end, but it was merely a coincident result; and so with all the other parts in which we suppose that there is purpose? Wherever then all the parts came about just what they would have been had they come to be for an end, such things survived, being organized at random in a fitting way; whereas those which grew otherwise perished and continue to perish, as Empedocles says his 'man-faced ox-progeny' did.⁷

If the notion that there is purpose in nature can be made to look so outlandish, as in the instance of rainfall and the growth or destruction of grain, the reason may be an undue haste in relating an effect to a cause out of all proportion to it, as in the case of 'his house burned down because he was on time for dinner'; which seems easy enough since, even when convinced that there ought to be such a cause, we can in fact rarely put our finger on it. But whatever this cause may be, the grain is good and nourishing, and its destruction will be regretted when there is need for food. The point is that so long as we do not care whether a product of nature is good or bad, the question whether -- even in the frightful contrarities upon which the so-called balance of nature depends -- there is action for a purpose or not, is irrelevant. If we allowed all the same that nature does in fact produce good results -- such as the proper kind of teeth; and regrettable deviations too, such as blindness and cancer -- but without purpose, so that even failures have no proportionate cause, such results would have a reason to account for them, but not in respect of their goodness or badness. Nonetheless, we could hardly put down all effects of this to chance, since chance events can scarcely be held to occur without supposition of action for a purpose -- unless of course we impose a new meaning on the word, as in 'laws of chance', which in their mathematical form are wholly determined. Nor can we escape the conclusion that a distinction between what is by nature and what is by chance will be irrelevant if there is no distinction between *per se* and *per accidens*.⁸

⁷ *Physics*, II. 8. 198b16. Trans. Hardie and Gaye

⁸ That chance events occur in action for a purpose is plain in the case of human actions. If a man, digging for water, strikes oil, this event, so far as his explicit intention is concerned, is a piece of good fortune. But if in digging a well for water, a man frequently strikes oil, then, provided he knew this, the discovery of oil would not be attributed to chance. A pregnant woman took the bus to go to market, caught the German measles, and eventually gave birth to a crippled child. So far as she was concerned, there was no connection between what she intended and what happened as an unforeseen side-effect. In nature, chance can be recognized in the case of the lioness which, having lost her cubs during an elephant raid, finally gives up the search when she loses their scent at the stream they had fled across; then there appears an antelope which she pursues for the sake of food; the prey leaps across the stream, and the lioness in pursuit is suddenly faced with her cubs. If this discovery can be called a good, it is a chance event in nature.

If in science it is the past alone that determines the future, by reason of what the past was and of the consequent necessity of what shall be; if that which, though last to exist, but first intended, is not a true cause; as if the house as actually built is in no sense responsible for the builder's choice and arrangement of materials, or the spider's web as actually finished does not suppose something analogous to intellect producing something like the purposeful structure of our machines,⁹ then the scientific outlook on nature will be

as if one were to suppose that the wall of a house necessarily comes to be because what is heavy is naturally carried downwards and what is light to the top, wherefore the stones and foundations take the lowest place, with earth above because it is lighter, and wood at the top of all as being the lightest. Whereas, though the wall does not come to be *without* these it is not *due* to these, except as its material cause; it comes to be for the sake of sheltering and guarding certain things. Similarly in all other things which involve production for an end; the product cannot come to be without things that have a necessary nature, but it is not due to these (except as its material); it comes to be for an end. For instance, why is a saw such as it is? To effect so-and-so and for the sake of so-and-so. This end, however, cannot be realized unless the saw is made of iron. It is therefore necessary for it to be of iron, *if* we are to have a saw and perform the operation of sawing. What is necessary then, is necessary *on a hypothesis*; it is not a result necessarily determined by antecedents. Necessity is in the nature of matter, while 'that for the sake of which' is in the definition [of what a saw or what a house is].¹⁰

But to hold that nature acts for an end does not imply that we can in every instance tell what that end is: just as it is one thing to say that there is such a thing as a living being, and quite another to be able to distinguish the living at all levels of life. There are large areas of science, as we have seen (indeed all of mathematical physics), where no object or activity is to be recognized as good and where search for purpose would be wholly vain. In biology proper, however, while one can deny purpose, it is not easy to do it and remain consistent.¹¹ For instance Professor Beck himself banishes all purposeful production in and by nature, but then goes on to write:

It is by connecting coat color with the idea of visibility and the concept of protection from predatory animals that permits us to say the polar bear is white because white fur enhances his chances of survival. By going behind what is observable, we have explained his color.

Now this oddity could arise from the mere fact that Professor Beck is using words such as 'because', 'enhance', and 'survival'. When taken together these terms would normally convey that it is a good

⁹ When we speak of the purpose of machines, we do not mean that the machines themselves act for an end, but that we, the principal agents as distinguished from these tools, built them for a purpose.

¹⁰ *Physics*, 9200a.

¹¹ I must not convey the impression that Professor Beck's negation of purpose in nature is the common view amongst biologists today. Quite the opposite was held by Guyenot and Cuenot, who, in their later years, could reconcile random mutations with finality; and by C. H. Waddington, a scientist who is fully aware of the limitations of mathematics in biology, as may be seen from a reading of his *The Strategy of Genes*.

thing for the polar bear to have a white fur, the reason being that it enhances his chances of survival, which, for the polar bear at least, is apparently a good. All the same, 'because', or 'the reason for', are ambiguous terms, as can be readily seen in 'The landslide occurred because of abundant rains', 'Mr. Smith built a house because he had the means to do so', or 'he built it because he wanted shelter'. It is the meaning of the term in the last example which is crucial. Does there exist in nature a 'because' which offers an intended good as explanation? The modern theory of random mutations, anticipated by Empedocles, proposes a final account of the origin of all types of organisms which dispenses with ends or goals as causes. But can such a theory stand? How does it differ from the assertion that the duck was brought down because this particular pellet of shot happened to strike a vital spot? that the bird was therefore downed by a random missile, since any other pellet might have done as well? Will this do as an ultimate explanation? Why does the hunter cultivate a random distribution of bird-shot? What would happen to mushrooms if they did not produce their enormous superfluity of spores? Or to humanity if there were but one sperm for each ovum? The duck-hunter uses shot instead of a bullet because it enhances the probability of hitting his target. In fact, his hope is that most of the pellets will miss the duck. But the 'scientific account' of a successful shot would suggest that the bird fell because one of the pellets happened to strike it in a vital organ. This is true; but is this all there is to it, when the plain purpose of a charge of many pellets was to ensure that one should strike?

A certain reluctance upon the part of biologists to introduce final causes into their explanations is sometimes quite understandable. This type of cause if first and foremost, is also the most obscure. To see how it works, even in the most vivid examples, is not easy and, as we have seen, in large domains of research it cannot so much as be identified. Yet, if it be final cause which establishes an intelligible connection between the other causes in nature, as it does between causes in art, it remains true that to banish finality completely will be to imply that nature is basically unintelligible. The scientific account of things would consequently be obliged to shut out all reference to reason as explanatory of anything. Now many things can in fact be accounted for without reference to intelligence, but the crux of the matter is that final cause is not one of them. Are we to conclude that the scientific account of the world cannot be a reasonable one? that science is hostile to intelligence?

Now, it is a curious fact that the writers most ready to make this suicidal rejection can accuse those who disagree of falling victim to anthropomorphism. Not only a belief in purpose, but even the conviction that nature is more than a machine, or that certain creatures, like mammal and tree, are radically different, or that general laws governing the whole universe can never explain everything in it, are all scornfully dismissed as 'organismic concepts', beliefs on a level with pan-animism. But might not the opposite be nearer the truth?

It will be agreed by all, except those perhaps who are determined that nature shall behave as they think best, that mental constructions, though submitted to experience and converging towards nature, may never be equated with what they are thought to approach. To so equate them would be anthropomorphism of the most preposterous kind. It would be like saying that nature is just what we happen to know of it; or that what a thing is in itself exists after the manner in which we come to know something about it; that our symbolic constructions are after all neither symbolic nor constructions; or perhaps that nature, which we reach out to in our constructions and idealizations -- such as inertia, true spheres, stars taken as points, and ideal gasses -- is itself no more than symbolic construction or idealization. Such a claim would indeed be far more

anthropomorphic, or organismic, in the pejorative sense usually intended, than the belief that everything in nature is alive in the way a man is, that thunder and lightning are signs of nature in a rage, or that the moon truly smiles upon the waters. But it is just as easy to be anthropomorphic by rash denials as by rash assertions. The assumption that, to be valid, the word 'good' must have a single meaning, or that 'purpose' must be confined to human affairs, may well be another instance of anthropomorphism, though of a more sophisticated kind. This word 'good', like any other analogical term, such as 'life', 'power', 'cause', has many, distinct meanings, as in 'a good steak', 'a good man', 'a good saw', 'a good house', 'a good mind', and so on. What the single word 'good' stands for is not a single concept, but a whole group of more or less interrelated concepts, all of which refer to different kinds of things or properties.

The idea of final causality in nature is based, of course, on the assumption of an analogy between art and nature; it being understood that analogy means proportion, not identity. Now, if the analogy holds good: if what comes about by nature is *that for the sake of which* the process resulting in the structure of an elephant or a man occurs, in a way somehow comparable to human purpose in making or in acting, then, to ignore that nature acts for an end would place us in the position of a man who is ready to explain a house without any reference to that for the sake of which houses are built. The difficulty of the question 'What is a house?' would be side-stepped by the narrower questions, 'What is a house made of?' or 'How was it made?' Only the latter type of question would now belong to the scientific outlook. And, of course, if it were indeed impossible to learn what a house is for, there would remain plenty to occupy us in finding out what it is made of, and in understanding what would happen if its materials were arranged otherwise -- if the foundations were of wood, the roof of stone, or the walls too high.

Justification of the analogy is not an easy task, and I do not intend to attempt it here. The point I wish to make is that, if the analogy is true, if there is such a proportion between nature and art, it follows -- as a tautology, if you wish -- that the unqualified negation of nature's action for an end implies that nature, as compared to art, is finally unintelligible, that the bird building her nest functions as we might if we produced a house with no purpose in view, or made something that just happened to be a house. I venture to say that this seems to be the way some people want it nowadays: a methodology which takes us back to the beginnings of science, to the *antiquissimi philosophi*,¹² to whom it appeared that things must be accounted for entirely in terms of whatever they are made of: which is what these earliest philosophers meant by nature, substance, essence, or matter. And this was far from being a bad start, for, as a matter of principle, we must account for as much as possible with as little as possible.

Nevertheless, it is not so easy to hold nature and intelligence apart. In some of his pursuits, man finds himself almost watching and listening for some sign of nature's intentions, because it can be so much to his advantage to learn them. What is our agriculture, for example, but an attempt to make nature improve upon herself? to achieve more efficiently and rapidly what our investigations have convinced us she must be trying to achieve? We have discovered short-cuts to objectives which nature could attain only imperfectly, if at all. Medicine and surgery supply familiar instances. The fruit, vegetables and live-stock we feed on are largely the products of nature enhanced by art -- *ars cooperativa naturae*. Indeed we may be at last on the verge of rousing life itself in a test-tube. But when we do bring to life some inanimate brew (a trifling achievement, notice, if there is really

¹² Thomas Aquinas, *Quaestiones Disputatae de Veritate*, q.5, a.2.

no difference between them), surely the least we may hope for is that we shall do so knowingly, with full appreciation of what we are about. And should this come to pass, dare we then maintain that this is the first time that something natural was brought about by reason and not by chance? Or will the fact that reason at long last has managed to do what Nature does, prove rather that Nature is very like us? that Nature, though not possessed of the kind of reason that we have, does nevertheless share in some kind of Reason, and in one the power of which we may well envy since, if we commanded it, we could make wood *grow* into a ship?

The trouble, it seems to me, is that the attempts to account for the living entirely in terms of the general laws of mathematical physics are the result of the artificial barriers which have been set up between the sciences of nature, so that there is nothing left for the isolated worker but to explain everything in terms of his own department (although in this he at least bears witness to the scientist's instinctive desire to attain the whole, and thus to philosophize). But such a procedure is defensible only when adopted as a mere working hypothesis. Nature is a heterogeneous whole, in the exploring of which various methods must be used. Dissect it as we may, the subject under investigation somehow persists in remaining one. Take, for example, Democritus's 'small world' that is a man: he can be cooked down to his molecules, and even to less, to sheer radiation. But what is the effect of this rendering process? Does it enable us to pronounce that now at last we have got hold of what a man is? It is familiar knowledge that a house is composed of brick, cement, boards, plaster, nails, wire and pipe. But does this knowledge ever impel us to think or state that a house simply is brick, cement, boards, plaster, and so forth? The difference between a heap of building materials and a house is plain enough. Surely there is an even greater difference between a heap of molecules or atoms and a man.

The truth is that, by the sciences of nature, we should not mean physics and biology (including psychology) only, as these are now understood. Professor Pascual Jordan seems aware of this when (in *Physics of the 20th Century*) he regrets that 'The increasing independence of natural scientific branches from philosophy from Aristotle's time to the present has simultaneously also emptied philosophy of its original content and problems.' For whatever may be the tactics of this or that science of nature, it remains true that all should converge upon the single, though infinitely varied, whole which is their subject. Now, to hold this general objective steadily in view, and in its light, to pass judgement on the conclusions of specialized branches of research, is the business of natural philosophy -- which should be the concern of each and every scientist. The fatal consequences of abandoning all thought of the subject as a whole, to become absorbed and lost in independent investigation of single aspects of it, is illustrated everywhere. The absence of co-ordination between the sciences, the failure of each to reflect constantly upon the scope and significance of the others, have brought all to a state of hollowness and shapelessness, like the grin without the cat or the cat without an outline. In earlier sections of this lecture, I had occasion to emphasize relatively clear cases of what we mean by being alive, and to suggest that it is a strange sort of science which cannot bring itself to allow them. But I do not contend for a moment that knowledge of nature has accomplished much by identifying such cases, or by offering a general definition of what they represent. To recognize something as an animal may be just a little better than nothing; to recognize it as a horse or a rabbit, is to make a real step, though only the first, towards our true goal. Knowledge of nature that would rest in something so vague and general as what is conveyed by 'animal' would be as empty in a way as the kind which I am criticizing. My

purpose in all such examples was simply to show that, to recognize the horse or the cat at least as living things, is far less fictitious than to dismiss them as machines.

The problems of philosophy, when distinguished from those which Bertrand Russell calls scientific, will remain forever in debate. Should the day ever come when Leibniz has his way: when, to settle their problems, philosophers will merely have 'to take their pens in their hands, to sit down to their desks and to say to each other (with a friend as witness, if they liked), "Let us calculate" ', there will be no more problems, for there will be no one to raise them. Meantime, the calculators have their use, while philosophers are forever in need of being debunked, a thing no one knew better than Socrates. Nevertheless, as Aristotle suggested, no one can deny philosophy without at least implying a philosophy of his own, and his own may prove to be a very foolish one.

What did we know of man before we found out that he is a throng of electric charges? and that he is composed of multitudinous cells? and that the circulation of his blood is an exquisite piece of chemistry and mechanics? Is it possible that, having learned all this, we may remain far more ignorant of him than Sophocles, or Shakespeare? or the people who believe they know what these writers meant? Over the dead body of his faithful Cordelia, the aged Lear had no more need of what is now offered to mankind as science than you and I will feel, if it ever becomes our lot to know such grief.

She's gone for ever.
I know when one is dead, and when one lives;
She's as dead as earth.