REITH LECTURES 1959: The Future of Man

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Lecture 6: The Future of Man

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In this last lecture, I shall discuss the origin in human beings of a new, a non-genetical, system of heredity and evolution based upon certain properties and activities of the brain. The existence of this non-genetical system of heredity is something you are perfectly well aware of. It was not biologists who first revealed to an incredulous world that human beings have brains; that having brains makes a lot of difference; and that a man may influence posterity by other than genetic means. Yet much of what I have read in the writings of biologists seems to say no more than this. I feel a biologist should contribute something towards our understanding of the distant origins of human tradition and behaviour, and this is what I shall now attempt. The attempt must be based upon hard thinking, as opposed to soft thinking; I mean, it must be thinking that covers ground and is based upon particulars, as opposed to that which finds its outlet in the mopings or exaltations of poetistic prose.

Jukebox and Gramophone

It will make my argument clearer if I build it upon an analogy. I should like you to consider an important difference between a juke-box and a gramophone—or, if you like, between a barrel- organ and a tape-recorder. A juke-box is an instrument which contains one or more gramophone records, one of which will play whatever is recorded upon it if a particular button is pressed. The act of pressing the button I shall describe as the ‘stimulus’. The stimulus is specific: to each button there corresponds one record, and vice versa, so that there is a one-to-one relationship between stimulus and response. By pressing a button—any button—I am, in a sense, instructing the juke-box to play music; by pressing this button and not that, I am instructing it to play one piece of music and not another. But—I am not gi7ing the juke-box musical instructions. The musical instructions are inscribed upon records that are part of the juke—box, not part of its environment: what a juke-box or barrel-organ can play on any one occasion depends upon structural or inbuilt properties of its own. I shall follow Professor Joshua Lederberg in using the word ‘elective’ to describe the relationship between what the juke-box plays and the stimulus that impinges upon it from the outside world.

Now contrast this with a gramophone or any other reproducing apparatus. I have a gramophone, and one or more records somewhere in the environment outside it. To hear a particular piece of music, I go through certain motions with switches, and put a gramophone record on. As with the juke-box I am, in a sense, instructing the gramophone to play music, and a particular piece of music. But I am doing more than that: I am giving it musical instructions, inscribed in the grooves of the record I made it play. The gramophone itself contains no source of musical information; it is the record that contains the information, but the record reached the gramophone from the outside world. My relationship to the gramophone—again following Lederberg—I shall describe as 'instructive'; for, in a sense, I taught it what to play. With the juice-box, then—and the same goes for a musical-box or barrel-organ—the musical instructions are part of the system that responds to stimuli, and the stimuli are elective: they draw upon the inbuilt capabilities of the instrument. With a gramophone, and still more obviously with a tape recorder, the stimuli are instructive: they endow it with musical capabilities; they import into it musical information from the world outside.

It is we ourselves who have made juke-boxes and gramophones, and who decide what, if anything, they are to play. These facts are irrelevant to the analogy I have in mind, and can be forgotten from now on. Consider only the organism on the one hand—jukebox or gramophone; and, on the other hand, stimuli which impinge upon that organism from the world about it.

During the past ten years, biologists have come to realize that, by and large, organisms are very much more like juke-boxes than gramophones. Most of the reactions of organisms which we were formerly content to regard as instructive are in fact elective. The instructions an organism contains are not musical instructions inscribed in the grooves of a gramophone record, but genetical instructions embodied in chromosomes and nucleic acids. Let me give examples of what I mean.

The Lamarckian Theory

The oldest example, and the most familiar, concerns the change that comes over a population of organisms when it undergoes an evolution. How should we classify the environmental stimuli that cause organisms to evolve? The Lamarckian theory, the theory that acquired characters can be inherited, is, in its most general form, an instructive theory of evolution. It declares that the environment can somehow issue genetical instructions to living organisms—instructions which, duly assimilated, can be passed on from one generation to the next. The blacksmith who is usually called upon to testify on these occasions gets mightily strong arms from forging; somehow this affects the cells that manufacture his spermatozoa, so that his children start life specially well able to develop strong arms. I have no time to explain our tremendous psychological inducement to believe in an instructive or Lamarckian theory of evolution, though in a somewhat more sophisticated form than this. I shall only say that every analysis of what has appeared to be a Lamarckian style of heredity has shown it to be non-Lamarckian. So far as we know, the relationship between organism and environment in the evolutionary process is an elective relationship. The environment does not imprint genetical instructions upon living things.

Another example: bacteriologists have known for years that if bacteria are forced to live upon some new and unfamiliar kind of foodstuff or are exposed to the action of an antibacterial drug, they acquire the ability to make use of that new food, or to make the drug harmless to them by breaking it down. The treatment was at one time referred to as the training of bacteria—with the clear implication that the new food or drug taught the bacteria to manufacture the new ferments upon which their new behaviour depends. But it turns out that the process of training belies its name: it is not instructive. A bacterium can synthesize only those ferments which it is genetically entitled to synthesize. The process of training merely brings out or exploits or develops an innate potentiality of the bacterial population, a potentiality underwritten or subsidized by the particular genetic make-up of one or another of its members.

When Animals Develop

The same argument probably applies to what goes on when animals develop. At one time there was great argument between 'preformationists' and those who believed in epigenesis. The preformationists declared that all development was an unfolding of something already there; the older extremists, whom we now laugh at, believed that a sperm was simply a miniature man. The doctrine of epigenesis, in an equally extreme form, declared that all organisms begin in a homogeneous state, with no apparent or actual structure; and that the embryo is moulded into its adult form solely by stimuli impinging upon it from outside. The truth lies somewhere between these two extreme conceptions. The genetic instructions are preformed, in the sense that they are already there, but their fulfilment is epigenetic—an interpretation that comes close to an elective theory of embryonic development. The environment brings out potentialities present in the embryo in a way which (as with the buttons on a juke-box) is exact and discriminating and specific but it does not instruct the developing embryo in the manufacture of its particular ferments or proteins or whatever else it is made of. Those instructions are already embodied in the embryo: the environment causes them to be carried out.

Until a year or two ago we all felt sure that one kind of behaviour indulged in by higher organisms did indeed depend upon the environment as a teacher or instructor. The entry or injection of a foreign substance into the tissues of an animal brings about an immunological reaction. The organism manufactures a specific protein, an 'antibody', which reacts upon the foreign substance, often in such a way as to prevent its doing harm. The formation of antibodies has a great deal to do with resistance to infectious disease. The relationship between a foreign substance and the particular antibody it evokes is exquisitely discriminating and specific; one human being can manufacture hundreds—conceivably thousands—of distinguishable antibodies, even against substances which have only recently been invented, like some of the synthetic chemicals used in industry or in the home. Is the reaction instructive or elective?—surely, we all felt, instructive. The organism learns from the chemical pattern of the invading substance just how a particular antibody should be assembled in an appropriate and distinctive way. Self-evident though this interpretation seems, many students of the matter are beginning to doubt it. They hold that the process of forming antibodies is probably elective in character. The information which directs the synthesis of particular antibodies is part of the inbuilt genetical information of the cells that make them; the intruding foreign substance exploits that information and brings it out. It is the juke-box over again. I believe this theory is somewhere near the right one, though I do not accept some of the special constructions that have been put upon it.

Genetical Instructions

So in spite of all will to believe otherwise, and for all that it seems to go against common sense, the picture we are forming of the organism is a juke-box picture—a juke-box containing genetical instructions inscribed upon chromosomes and nucleic acids in much the same kind of way as musical instructions are inscribed upon gramophone records. But what a triumph it would be if an organism could accept information from the environment —if the environment could be made to act in an instructive, not merely an elective, way! A few hundred million years ago a knowing visitor from another universe might have said: ‘it’s a splendid idea, and I see the point of it perfectly: it would solve —or could solve—the problems of adaptation, and make it possible for organisms to evolve in a much more efficient way than by natural selection. But it’s far too difficult: it simply can’t be done’.

But you know that it has been done, and that there is just one organ which can accept instruction from the environment: the brain. We know very little about it, but that in itself is evidence of how immensely complicated it is. The evolution of a brain was a feat of fantastic difficulty—the most spectacular enterprise since the origin of life itself. Yet the brain began, I suppose, as a device for responding to elective stimuli. Instinctive behaviour is behaviour in which the environment acts electively. If male sex hormones are deliberately injected into a hen, the hen will start behaving in male-like ways. The potentiality for behaving in a male-like manner must therefore have been present in the female; and by pressing (or, as students of behaviour usually say, releasing) the right button the environment can bring it out. But the higher parts of the brain respond to instructive stimuli: we *learn*.

Now let me take the argument forward. It was a splendid idea to evolve into the possession of an organ that can respond to instructive stimuli, but the idea does not go far enough. If that were the whole story, we human beings might indeed live more successfully than other animals; but when we died, a new generation would have to start again from scratch. Let us go back for a moment to genetical instructions. A child at conception receives certain genetical instructions from its parents about how its growth and development are to proceed. Among these instructions there must be some which provide for the issue of further instructions; I mean, a child grows up in such a way that it, too, can eventually have children, and convey genetical instructions to them in turn. We are dealing here with a very special system of communication: a hereditary system. There are many examples of systems of this kind. A chain letter is perhaps the simplest: we receive a letter from a correspondent who asks us to write to a third party, asking him in turn to write a letter, of the same kind to a fourth, and so on—a hereditary system. The most complicated example is provided by the human brain itself; for it does indeed act as intermediary in a hereditary system of its own. We do more than learn: we teach and hand on; tradition accumulates; we record information and wisdom in books.

Four Stages in the Brain’s Evolution

Just as a hereditary system is a special kind of system of communication-one in which the instructions provide for the issue of further instructions—so there is a specially important kind of hereditary system: one in which the instructions passed on from one individual to another change in some systematic way in the course of time. A hereditary system with this property may be said to be conducting or undergoing an evolution. Genetic systems of heredity often transact evolutionary changes; so also does the hereditary system that is mediated through the brain. I think it is most important to distinguish between four stages in the evolution of a brain. The nervous system began, perhaps, as an organ which responded only to elective stimuli from the environment; the animal that possessed it reacted instinctively or by rote, if at all.

There then arose a brain which could begin to accept instructive stimuli from the outside world; the brain in this sense has dim and hesitant beginnings going far back in geological time. The third stage, entirely distinguishable, was the evolution of a non-genetical system of heredity, founded upon the fact that the most complicated brains can do more than merely receive instructions; in one way or another, they make it possible for the instructions to be handed on. The existence of this system of heredity—of tradition, in its most general sense—is a defining characteristic of human beings, and it has been important for, perhaps, 500,000 years. In the fourth stage, not clearly distinguishable from the third, there came about a systematic change in the nature of the instructions passed on from generation to generation—an evolution, therefore, and one which has been going at a great pace in the past 200 years. I shall borrow two words used for a slightly different purpose by the great demographer Alfred Lotka to distinguish between the two systems of heredity enjoyed by man: endosomatic or internal heredity for the ordinary or genetical heredity we have in common with other animals; and exosomatic or external heredity for the non-genetic heredity that is peculiarly our own—the heredity that is mediated through tradition, by which I mean the transfer of information through non-genetic channels from one generation to the next.

I am, of course, saying something utterly obvious: society changes; we pass on knowledge and skills and understanding from one person to another and from one generation to the next; a man can indeed influence posterity by other than genetic means.. But I wanted to put the matter in a way which shows that we must- not distinguish a strictly biological evolution from a social, cultural, or technological evolution: both are biological evolutions: the distinction between them is that the one is genetical and the other is not.

Almost No Lessons to be Learned

What, then, is to be inferred from all this? What lessons are to be learned from the similarities and correspondences between the two systems of biological heredity possessed by human beings? The answer is important, and I shall now try to justify it: the answer, I believe, is almost none.

It is true that a number of amusing (but in one respect highly dangerous) parallels can be drawn between our two forms of heredity and evolution. Just as biologists speak in a kind of shorthand about the 'evolution' of hearts or ears or legs—it is too clumsy and long-winded to say every time that these organs participate in evolution or are outward expressions of the course of evolution—so we can speak of the evolution of bicycles or wireless sets or aircraft with the same qualification in mind: they do not really evolve, but they are appendages, exosomatic organs if you like, that evolve with us. And there are many correspondences between the two kinds of evolution. Both are gradual if we take the long view; but on closer inspection we shall find that novelties arise, not everywhere simultaneously..—pneumatic tyres did not suddenly appear in the whole population of bicycles—but in a few members of the population; and if these novelties confer economic fitness, or fitness in some more ordinary and obvious sense, then the objects that possess them will spread through the population as a whole and become the prevailing types. In both styles of evolution we can witness an adaptive diversification, a deployment into different environments: there are wireless sets not only for the home, but for use in motor-cars or for carrying about. Some great dynasties die out—airships, for example, in common with the dinosaurs they were so often likened to; others become fixed and stable: toothbrushes retained the same design and constitution for more than a hundred years. And, no matter what the cause of it, we can see in our exosomatic appendages something equivalent to vestigial organs; how else should we describe those functionless buttons on the cuffs of men's coats?

All this sounds harmless enough: why should I have called it dangerous? The danger is that by calling attention to the similarities, which are not profound, we may forget the differences between our two styles of heredity and evolution; and the differences between then-i are indeed profound. In their hunger for synthesis and systematization, the evolutionary philosophers of the nineteenth century and some of their modern counterparts have missed the point: they thought that great lessons were to be learnt from similarities between Darwinian and social evolution; but surely it is from the differences that all the great lessons are to be learnt. For one thing, our newer style of evolution is Lamarckian in nature. The environment cannot imprint genetical information upon us, but it can and does imprint non-genetical information which we can and do pass on. Acquired characters are indeed inherited. The blacksmith was under an illusion if he supposed that his habits of life could impress themselves upon the genetic make-up of his children; but there is no doubting his ability to teach his children his trade, so that they can grow up to be as stalwart and skilful as himself. It is because this newer evolution is so obviously Lamarckian in character that we are under psychological pressure to believe that genetical evolution must be so too. But although one or two biologists are still feebly trying to graft a Lamarckian or instructive interpretation upon ordinary genetical evolution, they are not nearly so foolish or dangerous as those who have attempted to graft a Darwinian or purely elective interpretation upon the newer, non-genetical, evolution of mankind.

A Liberating Conception

The conception I have just outlined is, I think, a liberating conception. It means that we can jettison all reasoning based upon the idea that changes in society happen in the style and under the pressures of ordinary genetic evolution; abandon any idea that the direction of social change is governed by laws other than laws which have at some time been the subject of human decisions or acts of mind. That competition between one man and another is a necessary part of the texture of society; that societies are organisms which grow and must inevitably die; that division of labour within a society is akin to what we can see in colonies of insects; that the laws of genetics have an overriding authority; that social evolution has a direction forcibly imposed upon it by agencies beyond man's control—all these are biological judgments; but, I do assure you, bad judgments based upon a bad biology. In these lectures you will have noticed that I advocate a 'humane' solution of the problems of eugenics, particularly of the problems of those who have been handicapped by one or another manifestation of the ineptitude of nature. I have not claimed, and do not now claim, that humaneness is an attitude of mind enforced or authorized by some deep inner law of exosomatic heredity: there are technical reasons for supposing that no such laws can exist. I am not warning you against quack biology in order to set myself up as a rival pedlar of patent medicines. What I do say is that our policies and intentions are not to be based upon the supposition that nature knows best; that we are at the mercy of natural laws, and flout them at our peril.

It is a profound truth—realized in the nineteenth century by only a handful of astute biologists and by philosophers hardly at all (indeed, most of those who held any views on the matter held a contrary opinion)—a profound truth that nature does *not* know best; that genetical evolution, if we choose to look at it liverishly instead of with fatuous good humour, is a story of waste, makeshift, compromise, and blunder.

Essential Reactions

I could give a dozen illustrations of this judgment, but shall content myself with one. You will remember my referring to the immunological defences of the body, the reactions that are set in train by the invasion of the tissues by foreign substances. Reactions of this kind are more than important: they are essential. We can be sure of this because some unfortunate children almost completely lack the biochemical aptitude for making antibodies, the defensive substances upon which so much of resistance to infectious disease depends. Until a few years ago these children died, because only antibiotics like penicillin can keep them alive; for that reason, and because the chemical methods of identifying it have only recently been discovered, the disease I am referring to was only recognized in 1952. The existence of this disease confirms us in our belief that the immunological defences are vitally important; but this does not mean that they are wonders of adaptation, as they are so often supposed to be. Our immunological defences are also an important source of injury, even of mortal injury.

For example: vertebrate animals evolved into the possession of immunological defences long before the coming of mammals. Mammals are viviparous: the young are nourished for some time within the body of the mother: and this (in some ways) admirable device raised for the first time in evolution the possibility that a mother might react immunologically upon her unborn children— might treat them as foreign bodies or as foreign grafts. The haemolytic disease that occurs in about one newborn child in 150 is an error of judgment of just this kind: it is, in effect, an immunological repudiation by the mother of her unborn child. Thus the existence of immunological reactions has not been fully reconciled with viviparity; and this is a blunder—the kind of blunder which, in human affairs, calls forth a question in the House or even a strongly worded letter to *The Times*.

But this is only a fraction of the tale of woe. Anaphylactic shock, allergy, and hypersensitivity are all aberrations or miscarriages of the immunological process. Some infectious diseases are dangerous to us not because the body fails to defend itself against them but—paradoxically—because it does defend itself: in a sense, the remedy is the disease. And within the past few years a new class of diseases has been identified, diseases which have it in common that the body can sometimes react upon its own constituents as if they were foreign to itself. Some diseases of the thyroid gland and some inflammatory diseases of nervous tissue belong to this category; rheumatoid arthritis, lupus erythematosus, and scleroderma may conceivably d so too. I say nothing about the accidents that used to occur in blood transfusions, immunological accidents; nor about the barriers, immunological barriers, that prevent our grafting skin from one person to another, useful though it would so often be; for transfusion and grafting are artificial processes, and, as I said in an earlier lecture, natural evolution cannot be reproached for failing to foresee what human beings might get up to. All I am concerned to show is that natural devices and dispositions are highly fallible. The immunological defences are dedicated to the proposition that anything foreign must be harmful; and this formula is ground out in-a totally undiscriminating fashion with results that are sometimes irritating, sometimes harmful, and sometimes mortally harmful. It is far better to have immunological defences than not to have them; but this does not mean that we are to marvel at them as evidences of a high and wise design.

Improving upon Nature

We can, then, improve upon nature; but the possibility of our doing so depends, very obviously, upon our continuing to explore into nature and to enlarge our knowledge and understanding of what is going on. If I were to argue the scientists' case, the case that exploration is a wise and sensible thing to do, I should try to convince you of it by particular reasoning and particular examples, each one of which could be discussed and weighed up; some, perhaps, to be found faulty. I should not say: Man is driven onwards by an exploratory instinct, and can only fulfil himself and his destiny by the ceaseless quest for Truth. As a matter of fact, animals do have what might be loosely called an inquisitiveness, an exploratory instinct; but even if it were highly developed and extremely powerful, it would still not be binding upon us. We should not be driven to explore.

Contrariwise, if someone were to plead the virtues of an intellectually pastoral existence, not merely quiet but acquiescent, and with no more than a pensive regret for not understanding what could hate been understood; then I believe I could listen to his arguments and, if they were good ones, might even be convinced. But if he were to say that this course of action or inaction was the life that was authorized by Nature; that this was the life Nature provided for and intended us to lead; then I should tell him that he had no proper conception of Nature. People who brandish naturalistic principles at us are usually up to mischief. Think only of what we have suffered from a belief in the existence and overriding authority of a fighting instinct; from the doctrines of racial superiority and the metaphysics of blood and soil; from the belief that warfare between men or classes of men or nations represents a fulfilment of historical laws. These are all excuses of one kind or another, and pretty thin excuses. The inference we can draw from an analytical study of the differences between ourselves and other animals is surely this: that the bells which toll for mankind are —most of them, anyway—like the bells on alpine cattle; they are attached to our own necks, and it must be our fault if they do not make a cheerful and harmonious sound.