lment, vol. I, Princeton Univ.

gétienne, Bull. de psychologie,

istheorie, Dialectica, fasc. 22,

lie kantische Erkenntnistheorie,

n and Understanding — N. Y.,

logiques et psycholinguistiques aux du Centre de Recherches 172.
Maryland, Lawrence Erlbaum

mation: Kantian themes in the

introduction to Modal Logic,

l'enfant à la logique de l'ado-

éd. — *Epistémologie génétique* , Delachaux et Niestlé, 1977.
cs, Amsterdam, North-Holland

ia and the logic of Fuzzy con- *logic and linguistic semantics.* lel & Co, 1975.
élémentaires: classifications et

gnitives: problème central du

fique (NRF, Pléiade, 1967).
ol. 20, fasc. 1, 1966.
ns, Goals, and Understanding: awrence, Erlbaum, 1977.
nes activités cognitives à l'aide ans *Archives de Psychologie*, 976.
prélogique à partir des fonc- XLV, nº 174, Genève, Méde-

soning: *Synthèse*, vol. 30, 1975.
ing, Memorandum, Electronic , 1977.

ie génétique, publiés sous la 1). (contenant notamment e. a.

Natural Selection and the Emergence of Mind

by Karl POPPER

It is a great honour to have been invited to give the first Darwin Lecture at Darwin College, in Cambridge, which of all Universities is most closely connected with Charles Darwin and the Darwin family.

When I received the invitation, I was worried whether or not I should accept it. I am not a scientist; nor am I a historian. There are Darwin scholars devoted to studying his life and his times; but I have done nothing of the kind. For these reasons, I suppose I ought to have declined the invitation. Yet it was an extremely kind and pressing invitation; and those who invited me were obviously well aware of the fact that I was neither a biologist nor a Darwin scholar, but simply an amateur. In the end I did accept, choosing as my topic a theme which, I believe, is closely linked to two of Darwin's central interests: natural selection; and the evolution of mind.

However, in the first Darwin Lecture a few words should be said about Charles Darwin himself, even by one who has no special qualifications to speak of him. So I may just as well start by saying that Darwin's face and Darwin's name belong to my earliest childhood memories. In my father's study in Vienna there were two striking portraits, the portraits of two old men. They were the portraits of Arthur Schopenhauer and of Charles Darwin. I must have questioned my father about these two men, even before I had learned to read. Schopenhauer's portrait was interesting, though I was not very attracted by it. But Darwin looked most attractive. He had a long white beard, even longer than my father's beard, and he wore a strange dark cloak, a kind of raincoat without sleeves. He looked very friendly and very quiet, but a little sad, and a little lonely. It was the well-known photograph taken in 1881, when he was seventy two, a year before his death. This is how it is that I have known Darwin's face and name for as long as I can remem-

This is the first Darwin Lecture, delivered at Darwin College, Cambridge, on November 8th, 1977.

I now dedicate this contribution to the memory of my dear friend, Paul Bernays.

ber. I knew that he was a great Englishman and traveller, and one of the greatest students of animals who ever lived; and I liked him very much.

Darwin is not only the greatest of biologists — he has often been compared to Newton — but also a most admirable, venerable, and indeed a most lovable person. I know of few books that can be compared to the five volumes of his letters that were edited by his son Francis, and that contain also his Autobiography. From these books there speaks a human being almost perfect in his simplicity, modesty, and devotion to truth.

The topic of my lecture is "Natural Selection and the Emergence of Mind". Natural selection is, obviously, Darwin's most central theme. But I shall not confine myself to this theme alone. I shall also follow Darwin in his approach to the problem of body and mind, both the mind of man and the animal mind. And I shall try to show that the theory of natural selection supports a doctrine which I also support. I mean the unfashionable doctrine of mutual interaction between mind and brain.

My lecture will be divided into four sections.

In the first section, entitled "Darwin's *Natural Selection* versus Paley's *Natural Theology*", I shall briefly comment upon the Darwinian revolution and on today's counter-revolution against science.

The second section is entitled "Natural Selection and its Scientific Status".

The third section is entitled "Huxley's Problem". It contains the central argument of my lecture, an argument based on natural selection. It is an argument for mutual interaction between mind and brain, and against T. H. Huxley's view that the mind is an epiphenomenon. It is also an argument against the so-called identity theory, the now fashionable theory that mind and brain are identical.

The fourth section, entitled "Remarks on the Emergence of Mind", concludes with a few speculative suggestions on what seems to be the greatest marvel of our universe — the emergence of mind and, more especially, of consciousness.

1. Darwin's Natural Selection versus Paley's Natural Theology

The first edition of Darwin's *Origin of Species* was published in 1859. In a reply to a letter from John Lubbock, thanking Darwin for an advance copy of his book, Darwin made a remarkable comment about William Paley's book *Natural Theology*, which had been published half a century before. Darwin wrote: "I do not think I hardly ever admired a book more than

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1 *The Life and Letters*
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2 *L. L.*, volume I, p. 47

Paley's 'Natural Theology'. I could almost formerly have said it by heart." [1] Years later in his Autobiography Darwin wrote of Paley that "The careful study of [his] works . . . was the only part of the academical course [in Cambridge] which . . . was of the least use to me in the education of my mind."[2]

I have started with these quotations because the problem posed by Paley became one of Darwin's most important problems. It was *the problem of design*.

The famous *argument from design* for the existence of God was at the centre of Paley's theism. If you find a watch, Paley argued, you will hardly doubt that it was designed by a watchmaker. So if you consider a higher organism, with its intricate and purposeful organs such as the eyes, then, Paley argued, you are bound to conclude that it must have been designed by an intelligent Creator. This is Paley's argument from design. Prior to Darwin, the theory of special creation — the theory that each species was designed by the Creator — had been widely accepted, not only in the University of Cambridge, but also elsewhere, by many of the best scientists. There were of course alternative theories in existence, such as Lamarck's; and Hume had earlier attacked, somewhat feebly, the argument from design; but Paley's theory was in those days the one most seriously entertained by serious scientists.

It is almost unbelievable how much the atmosphere changed as a consequence of the publication, in 1859, of the *Origin of Species*. The place of an argument that really had no status whatever in science has been taken by an immense number of the most impressive and well tested scientific results. Our whole outlook, our picture of the universe, has changed, as never before.

The Darwinian revolution is still proceeding. But now we are also in the midst of a counter-revolution, a strong reaction against science and against rationality. I feel that it is necessary to take sides in this issue, if only briefly; and also, in a Darwin lecture, to indicate where Darwin himself stood.

My position, very briefly, is this. I am on the side of science and of rationality, but I am against those exaggerated claims for science that have sometimes been, rightly, denounced as "scientism". I am on the side of the *search for truth*, and of intellectual daring in the search for truth; but I am against intellectual arrogance, and especially against the misconceived claim that we have the truth in our pockets, or that we can approach certainty.

[1] *The Life and Letters of Charles Darwin*, edited by his son Francis Darwin, John Murray, London, 1887 (subsequently cited as *L. L.*), volume II, p. 219. The portrait of Darwin described in the lecture forms the frontispiece to volume III.

[2] *L. L.*, volume I, p. 47.

It is important to realize that science does not make assertions about ultimate questions — about the riddles of existence, or about man's task in this world.

This has often been well understood. But some great scientists, and many lesser ones, have misunderstood the situation. The fact that science cannot make any pronouncement about ethical principles has been misinterpreted as indicating that there are no such principles; while in fact the search for truth presupposes ethics. And the success of Darwinian natural selection in showing that the *purpose or end* which an organ like the eye seems to serve may be only apparent has been misinterpreted as the nihilist doctrine that all purpose is only apparent purpose, and that there cannot be any end or purpose or meaning or task in our life.

Although Darwin destroyed Paley's argument from design by showing that what appeared to Paley as purposeful design could well be explained as the result of chance and of natural selection, Darwin was most modest and undogmatic in his claims. He had a correspondence about divine design with Asa Gray of Harvard; and Darwin wrote to Gray, one year after the *Origin of Species*: "... about Design. I am conscious that I am in an utterly hopeless muddle. I cannot think that the world, as we see it, is the result of chance; and yet I cannot look at each separate thing as the result of Design."[3] And a year later Darwin wrote to Gray: "With respect to Design, I feel more inclined to show a white flag than to fire ... [a] shot ... You say that you are in a haze; I am in thick mud; ... yet I cannot keep out of the question."[4]

To me it seems that the question may not be within the reach of science. And yet I do think that science has taught us a lot about the evolving universe that bears in an interesting way on Paley's and Darwin's problem of creative design.

I think that science suggests to us (tentatively of course) a picture of a universe that is inventive[5] or even creative; of a universe in which *new things* emerge, on *new levels*.

There is, on the first level, the theory of the emergence of heavy atomic nuclei in the centre of big stars, and, on a higher level, the evidence for the emergence somewhere in space of organic molecules.

On the next level, there is the emergence of life. Even if the origin of life should one day become reproducible in the laboratory, life creates something that is utterly new in the universe: the peculiar activity of organisms; espe-

[3] *L. L.*, volume II, p. 353.
[4] *L. L.*, volume II, p. 382.
[5] Cp. K. G. Denbigh, *The Inventive Universe*, Hutchinson, London, 1975.

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On the next level, the great step is the emergence of conscious states. With the distinction between conscious states and unconscious states, again something utterly new and of the greatest importance enters the universe. It is a new world: the world of conscious experience.

On the next level, this is followed by the emergence of the products of the human mind, such as the works of art; and also the works of science; especially scientific theories.

I think that scientists, however sceptical, are bound to admit that the universe, or nature, or whatever we may call it, is creative. For it has produced creative men: it has produced Shakespeare and Michelangelo and Mozart, and thus indirectly their works. It has produced Darwin, and so created the theory of natural selection. Natural selection has destroyed the proof for the miraculous specific intervention of the Creator. But it has left us with the marvel of the creativeness of the universe, of life, and of the human mind. Although science has nothing to say about a personal Creator, the fact of the emergence of novelty, and of creativity, can hardly be denied. I think that Darwin himself, who could not "keep out of the question", would have agreed that, though natural selection was an idea which opened up a new world for science, it did not remove, from the picture of the universe that science paints, the marvel of creativity; nor did it remove the marvel of freedom: the freedom to create; and the freedom of choosing our own ends and our own purposes.

To sum up these brief remarks:

The counter-revolution against science is intellectually unjustifiable; morally it is indefensible. On the other hand, scientists should resist the temptations of scientism. They should always remember, as I think Darwin always did, that science is tentative and fallible. Science does not solve all the riddles of the universe, nor does it promise ever to solve them. Nevertheless it can sometimes throw some unexpected light even on our deepest and probably insoluble riddles.

2. *Natural Selection and its Scientific Status*

When speaking here of Darwinism, I shall speak always of today's theory — that is Darwin's own theory of natural selection supported by the Mendelian theory of heredity, by the theory of the mutation and recombination of genes in a gene pool, and by the decoded genetic code. This is an immensely impressive and powerful theory. The claim that it completely explains evolu-

tion is of course a bold claim, and very far from being established. All scientific theories are conjectures, even those that have successfully passed many severe and varied tests. The Mendelian underpinning of modern Darwinism has been well tested, and so has the theory of evolution which says that all terrestrial life has evolved from a few primitive unicellular organisms, possibly even from one single organism.

However, Darwin's own most important contribution to the theory of evolution, his theory of natural selection, is difficult to test. There are some tests, even some experimental tests; and in some cases, such as the famous phenomenon known as "industrial melanism", we can observe natural selection happening under our very eyes, as it were. Nevertheless, really severe tests of the theory of natural selection are hard to come by, much more so than tests of otherwise comparable theories in physics or chemistry.

The fact that the theory of natural selection is difficult to test has led some people, anti-Darwinists and even some great Darwinists, to claim that it is a tautology. A tautology like "All tables are tables" is not, of course, testable; nor has it any explanatory power. It is therefore most surprising to hear that some of the greatest contemporary Darwinists themselves formulate the theory in such a way that it amounts to the tautology that those organisms that leave most offspring leave most offspring. And C. H. Waddington even says somewhere (and he defends this view in other places) that "Natural selection . . . turns out . . . to be a tautology". [6] However, he attributes at the same place to the theory an "enormous power . . . of explanation". Since the explanatory power of a tautology is obviously zero, something must be wrong here.

Yet similar passages can be found in the works of such great Darwinists as Ronald Fisher, J. B. S. Haldane, and George Gaylord Simpson; and others.

I mention this problem because I too belong among the culprits. Influenced by what these authorities say, I have in the past described the theory as "almost tautological", [7] and I have tried to explain how the theory of natural selection could be untestable (as is a tautology) and yet of great scientific interest. My solution was that the doctrine of natural selection is a most successful metaphysical research programme. It raises detailed problems in many fields, and it tells us what we would expect of an acceptable solution of these problems.

[6] C. H. Waddington, "Evolutionary Adaptation", in S. Tax (ed.) *Evolution After Darwin: volume I — The Evolution of Life*, Chicago University Press, Chicago, 1960, pp. 381-402; see p. 385.

[7] *Objective Knowledge*, Clarendon Press, Oxford, 1972, p. 241.

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I still believe that natural selection works in this way as a research programme. Nevertheless, I have changed my mind about the testability and the logical status of the theory of natural selection; and I am glad to have an opportunity to make a recantation. My recantation may, I hope, contribute a little to the understanding of the status of natural selection.

What is important is to realize the explanatory task of natural selection; and especially to realize *what* can be explained *without* the theory of natural selection.

We may start from the remark that, for sufficiently small and reproductively isolated populations, the Mendelian theory of genes and the theory of mutation and recombination together suffice to predict, *without natural selection,* what has been called "genetic drift". If you isolate a small number of individuals from the main population and prevent them from interbreeding with the main population, then, after a time, the distribution of genes in the gene pool of the new population will differ somewhat from that of the original population. This will happen even if selection pressures are completely absent.

Moritz Wagner, a contemporary of Darwin, and of course a pre-Mendelian, was aware of this situation. He therefore introduced a theory of *evolution by genetic drift,* made possible by reproductive isolation through geographical separation.

In order to understand the task of natural selection, it is good to remember Darwin's reply to Moritz Wagner.[8] Darwin's main reply to Wagner was: if you have no natural selection, you cannot explain the evolution of the apparently designed organs, like the eye. Or in other words, without natural selection, you cannot solve Paley's problem.

In its most daring and sweeping form, the theory of natural selection would assert that *all* organisms, and especially *all* those highly complex organs whose existence might be interpreted as evidence of design and, in addition, *all* forms of animal behaviour, have evolved as the result of natural selection; that is, as the result of chance-like inheritable variations, of which the useless ones are weeded out, so that only the useful ones remain. If formulated in this sweeping way, the theory is not only refutable, but actually refuted. For *not all* organs serve a *useful* purpose: as Darwin himself points out, there are organs like the tail of the peacock, and behavioural programmes like the peacock's display of his tail, which cannot be explained by

[8] See *L. L.*, volume III, p. 158f.

their *utility*, and therefore not by natural selection. Darwin explained them by the preference of the other sex, that is, by sexual selection. Of course one can get round this refutation by some verbal manoeuvre: one can get round any refutation of any theory. But then one gets near to rendering the theory tautological. It seems far preferable to admit that *not* everything that evolves is *useful*, though it is astonishing how many things are; and that in conjecturing what is the *use* of an organ or a behavioural programme, we conjecture a possible explanation by natural selection: of *why* it evolved in the way it has, and perhaps even of *how* it evolved. In other words, it seems to me that like so many theories in biology, evolution by natural selection is not strictly universal, though it seems to hold for a vast number of important cases.

According to Darwin's theory, sufficiently invariant selection pressures may turn the otherwise random genetic drift into a drift that has the appearance of being purposefully directed. In this way, the selection pressures, if there are any, will leave their imprint upon the genetic material. (It may be mentioned, however, that there are selection pressures that can operate successfully over very short periods: one severe epidemic may leave alive only those who are genetically immune.)

I may now briefly sum up what I have said so far about Darwin's theory of natural selection.

The theory of natural selection may be so formulated that it is far from tautological. In this case it is not only testable, but it turns out to be not strictly universally true. There seem to be exceptions, as with so many biological theories; and considering the random character of the variations on which natural selection operates, the occurrence of exceptions is not surprising. Thus not all phenomena of evolution are explained by natural selection alone. Yet in every particular case it is a challenging research programme to show how far natural selection can possibly be held responsible for the evolution of a particular organ or behavioural programme.

It is of considerable interest that the idea of natural selection can be generalized. In this connection it is helpful to discuss the relation between selection and instruction. While Darwin's theory is selectionist, the theistic theory of Paley is instructionist. It is the Creator who, by His design, moulds matter, and instructs it which shape to take. Thus Darwin's selectionist theory can be regarded as a theory that explains by selection something that looks like instruction. Certain invariant features of the environment leave their imprint on the genetic material as if they had moulded it; while in fact, they selected it.

Many years ago I visited Bertrand Russell in his rooms at Trinity College and he showed me a manuscript of his in which there was not a single correction for many pages. With the help of his pen, he had instructed the paper. This is very different indeed from what I do. My own manuscripts are full of corrections — so full that it is easy to see that I am working by something like trial and error; by more or less random fluctuations from which I select what appears to me fitting. We may pose the question whether Russell did not do something similar, though only in his mind, and perhaps not even consciously, and at any rate very rapidly. For indeed, what seems to be instruction is frequently based upon a roundabout mechanism of selection, as illustrated by Darwin's answer to the problem posed by Paley.

I suggest that we might try out the conjecture that something like this happens in many cases. We may indeed conjecture that Bertrand Russell produced almost as many trial formulations as I do, but that his mind worked more quickly than mine in trying them out and rejecting the non-fitting verbal candidates. Einstein somewhere says that he produced and rejected an immense number of hypotheses before hitting on (and first rejecting) the equations of general relativity. Clearly, the method of production and selection is one that operates with negative feedback.

More than forty years ago I proposed the conjecture that this is also the method by which we acquire our knowledge of the external world: we produce conjectures, or hypotheses, try them out, and reject those that do not fit. This is a method of critical selection, if we look at it closely. From a distance, it looks like instruction or, as it is usually called, induction.

What a painter does is often strikingly similar. He puts on his canvas a spot of colour and steps back to judge the effect, in order either to accept it, or to reject it and to go over the spot again. It does not matter for my discussion whether he compares the effect with an object painted, or with an inward image, or whether he merely approves or disapproves of the effect. What is important here has been described by Ernst Gombrich by the excellent phrase "making comes before matching".[9] This phrase can be applied with profit to every case of selection, in particular to the method of producing and testing hypotheses, which includes perception, and especially *Gestalt* perception. Of course, the phrase "making comes before matching" can be applied also to Darwinian selection. The making of many new genetic variants precedes their selection by the environment, and thus their matching with the environment. The action of the environment is roundabout because

[9] See under "making comes before matching" in the index of E. Gombrich *Art and Illusion*, Phaedon, London, 1960 and later editions.

it must be preceded by a partly random process that produces, or makes, the material on which selection, or matching, can operate.

One of the important points about this roundabout method of selection is that it throws light on the problem of downward causation to which Donald Campbell and Roger Sperry have called attention. [10]

We may speak of downward causation whenever a higher structure operates causally upon its substructure. The difficulty of understanding downward causation is this. We think we can understand how the substructures of a system cooperate to affect the whole system; that is to say, we think that we understand upward causation. But the opposite is very difficult to envisage. For the set of substructures, it seems, interacts causally in any case, and there is no room, no opening, for an action from above to interfere. It is this that leads to the heuristic demand that we explain everything in terms of molecular or other elementary particles (a demand that is sometimes called "reductionism").

I suggest that downward causation can sometimes at least be explained as *selection* operating on the randomly fluctuating elementary particles. The randomness of the movements of the elementary particles — often called "molecular chaos" — provides, as it were, the opening for the higher-level structure to interfere. A random movement is accepted when it fits into the higher level structure; otherwise it is rejected.

I think that these considerations tell us a lot about natural selection. While Darwin still worried that he could not explain variation, and while he felt uneasy about being forced to look at it as chancelike, we can now see that the chancelike character of mutations, which may go back to quantum indeterminacy, explains how the abstract invariances of the environment, the somewhat abstract selection pressures, can, by selection, have a downward effect on the concrete living organism — an effect that may be amplified by a long sequence of generations linked by heredity.

The selection of a kind of behaviour out of a randomly offered repertoire may be an act of choice, even an act of free will. I am an indeterminist; and in discussing indeterminism I have often regretfully pointed out that quantum indeterminacy does not seem to help us; [11] for the amplification of

[10] See D. T. Cambell, " 'Downward Causation' in Hierarchically Organized Biological Systems", in F. J. Ayala and T. Dobzhansky (eds), *Studies in The Philosophy of Biology*, Macmillan, London, 1974, pp. 179-86; R. W. Sperry, "A Modified Concept of Consciousness", *Psychological Review, 76*, 1969, pp. 532-6; and "Lateral spezialization in the surgically separated hemispheres", in F. O. Schmitt and F. G. Worden (eds), *The Neurosciences: Third Study Programme*, M. I. T. Press, Cambridge, Mass., 1973, pp. 5-19.

[11] Cp. my *Objective Knowledge*, chapter 6, pp. 226-9.

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something like, say, radioactive disintegration processes would not lead to human action or even animal action, but only to random movements. I have changed my mind on this issue.[12] A choice process may be a selection process, and the *selection* may be *from* some repertoire of random events, *without being random in its turn*. This seems to me to offer a promising solution to one of our most vexing problems, and one by downward causation.

3. *Huxley's Problem*

The denial of the existence of mind is a view that has become very fashionable in our own time: mind is replaced by what is called "verbal behaviour". Darwin lived to see the revival of this view in the nineteenth century. His close friend, Thomas Henry Huxley, proposed the thesis that animals, including men, are automata. Huxley did not deny the existence of conscious or subjective experiences, as do now some of his successors; but he denied that they can have any effect whatever on the machinery of the human or animal body, including the brain.

"It may be assumed", Huxley writes,[13] "... that molecular changes in the brain are the causes of all the states of consciousness ... [But is] there any evidence that these states of consciousness may, conversely, cause ... molecular changes [in the brain] which give rise to muscular motion?" This is Huxley's problem. He answers it as follows: "I see no such evidence ... [Consciousness appears] to be related to the mechanism of ... [the] body simply as a collateral product of its working ... [Consciousness appears] to be ... completely without any power of modifying [the] working [of the body, just] as the steam-whistle ... of a locomotive engine is without influence upon its machinery."

Huxley puts his question sharply and clearly. He also answers it sharply and clearly. He says that the action of the body upon the mind is one-sided;

[12] See also p. 540 of J. C. Eccles and K. R. Popper, *The Self and Its Brain*, Springer-Verlag, Berlin, Heidelberg, London, New York, 1977.

[13] See T. H. Huxley, "On the hypothesis that animals are automata, and its history" (1874), chapter 5 of his *Method and Results*, Macmillan, London, 1893, pp. 239-40. While the passage quoted in the text refers to animals, Huxley follows it up, a few pages later, by saying "... to the best of my judgment, the argumentation which applies to brutes holds equally good of men; and, therefore, ... all states of consciousness in us, as in them, are immediately caused by molecular changes of the brain-substance. It seems to me that in men, as in brutes, there is no proof that any state of consciousness is the cause of change in the motion of the matter of the organism ... We are conscious automata ..." (*ibid.*, pp. 243-4). I have discussed these views of Huxley's in my paper "Some Remarks on Panpsychism and Epiphenomenalism", in volume 31, Nos 1-2, 1977, pp. 177-86, of *this journal*, and in my contribution to *The Self and Its Brain* (see note 12 above).

there is no mutual interaction. He was a mechanist and a physical determinist; and this position necessitates his answer. The world of physics, of physical mechanisms, is causally closed. Thus a body cannot be influenced by states of consciousness. Animals, including men, must be automata, even if conscious ones.

Darwin's view of the matter was very different. In his book on *The Expression of the Emotions in Man and Animals* he had shown in great detail how the emotions of men and of animals can and do express themselves in muscular movements.

One direct reply of Darwin's to his friend Huxley, whom he greatly admired and loved, is most characteristic. A charming letter to Huxley written three weeks before Darwin's death, closes with a characteristic mixture of tenderness, irony and wit: [14] "... my dear old friend. I wish to God there were more automata in the world like you."

In fact, no Darwinist should accept Huxley's one-sided action of body upon mind as the solution of what is called the mind-body problem. In his *Essay* of 1844, in his *Origin of Species*, and even more so in his much larger manuscript on *Natural Selection*, Darwin discussed the mental powers of animals and men; and he argued that these are a product of natural selection.

Now if that is so, then mental powers must help animals and men in the struggle for life, for physical survival. It follows from this that mental powers must be able to exert in their turn an important influence on the physical actions of animals and men. Animals and men could not, therefore, be automata in Huxley's sense. If subjective experiences, conscious states, exist — and Huxley admitted their existence — we should, according to Darwinism, look out for their use, for their adaptive function. As they are useful for living, they must have consequences in the physical world.

Thus the theory of natural selection constitutes a strong argument against Huxley's theory of the one-sided action of body on mind and for the mutual interaction of mind and body. Not only does the body act on the mind — for example, in perception, or in sickness — but our thoughts, our expectations, and our feelings may lead to useful actions in the physical world. If Huxley had been right, mind would be useless. But then, it could not have evolved, no doubt over long periods of time, by natural selection.

My central thesis here is that the theory of natural selection provides a strong argument for the doctrine of *mutual interaction* between mind and body or, perhaps better, between mental states and physical states.

[14] *L. L.*, volume III, p. 358.

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Of course, I am very much aware of the fact that the doctrine of *mutual interaction* is utterly old-fashioned. Still, I propose to defend interaction, and old-fashioned dualism (except that I reject the existence of so-called "substances"); I even defend *pluralism*, since I hold that there are three (or perhaps more) interacting levels or regions or worlds: the world 1 of *physical* things, or events, or states, or processes, including animal bodies and brains; the world 2 of *mental* states; and the world 3 that consists of the *products of the human mind*, especially of works of art and of scientific theories.

I am afraid that I do not have time to say more about world 3 tonight. I must confine myself to formulating the conjecture that the world 1 of physical objects, and the world 2 of mental states, interact, and that the world 3 of scientific theories, for example of medical theories, also strongly interacts with the world of physical objects, *via* the psychological world 2.

The present fashion is either to deny that anything like mental experience exists, or to assert that mental experiences are somehow or other *identical* with physical states of the central nervous system.

I do not think the first of these fashions — the suggestion that we don't have experiences — is very interesting. For we have good intersubjective tests of the hypothesis that we do have such experiences. And all that ever seems to have been said against our hypothesis is that the universe would be a simpler place by far if we did not have experiences — or since we do have them, if only we could keep mum about them.

However, there is what seems to be a more serious position than the bare denial of mind. It is the currently most fashionable theory that mental states are in some sense identical with physical states: the so-called identity theory of body and mind.

Against the identity theory I think that I can use the same argument from natural selection that I used against Huxley: the identity theory seems to me to be incompatible with the theory of natural selection. For according to the identity theory, the world of physical objects or states is closed. All causation is physical causation. Thus even the identity theorist who admits consciousness cannot attribute to it any independent causal function in the physical world. [15] It cannot have evolved by natural selection. The situation of the identity theorists is the same as that of T. H. Huxley.

[15] If, as Spinoza says, the order and connection of things is the same as the order and connection of ideas, then the order and connection of ideas is, from an evolutionary or Darwinian point of view, clearly redundant for the identity theorist.

4. Remarks on the Emergence of Mind

I conjecture that life, and later also mind, have evolved or emerged in a universe that was, up to a certain time, lifeless and mindless. Life, or living matter, somehow emerged from non-living matter; and it does not seem completely impossible that we shall one day know how this happened.

Things look far more difficult with the emergence of mind. While we think that we know some of the preconditions of life, and some of the substructures of primitive organisms, we do not have the slightest idea on which evolutionary level mind emerges. H. S. Jennings said in 1906, in his great book on *The Behaviour of the Lower Organisms*, that, in observing the behaviour of the amoeba, he could hardly help attributing to it consciousness. On the other hand, some students of biology and some students of human language do not wish to attribute mind or consciousness to any animal except man. And, as I have mentioned before, there are philosophers who deny the existence of mind altogether; who regard talk of mind or of conscious states as sheer babble: as a verbal habit that is bound to disappear, like talk about witches, with the progress of science, especially of brain research.

In constrast to these philosophers, I regard the emergence of mind as a tremendous event in the evolution of life. Mind illuminates the universe; and I regard the work of a great scientist like Darwin as important just because it contributes so much to this illumination. Herbert Feigl reports that Einstein said to him: [16] "But for this internal illumination, the universe would be just a rubbish heap."

As I said earlier, I think we have to admit that the universe is creative, or inventive. At any rate, it is creative in the sense in which great poets, great artists, and great scientists are creative. Once there was no poetry in the universe; once there was no music. But then, later, it was there. Obviously, it would be no sort of explanation to attribute to atoms, or to molecules, or even to the lower animals, the ability to create (or perhaps to proto-create) a forerunner of poetry, called proto-poetry. I think it is no better explanation if we attribute to atoms or molecules a proto-psyche, as do the panpsychists. No, the case of great poetry shows clearly that the universe has the power of creating something new. As Ernst Mayr once said, the emergence of real novelty in the course of evolution should be regarded as a fact.

In view of the difficulty, if not the impossibility, of testing the conjectural ascription of mental powers to animals, speculation about the origin of mind in animals will probably never grow into a testable scientific theory. Never-

[16] See Herbert Feigl, *The 'Mental' and the 'Physical'*, University of Minnesota Press, Minneapolis, 1967, p. 138. I have made a small change to the wording.

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[17] See Ernst Mayr,
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theless, I will briefly offer some speculative conjectures. At any rate, these conjectures are open to criticism, if not to tests.

I will start from the idea, stressed by ethologists such as Thorpe, that the behaviour of animals, like that of computers, is programmed; but that unlike computers, animals are *self-programmed*. The fundamental genetic self-programme is, we may assume, laid down in the coded DNA tape. There are also acquired programmes, programmes due to nurture; but what can be acquired and what cannot — the repertoire of possible acquisitions — is itself laid down in the form of the fundamental genetic self-programme, which may even determine the probability or propensity of making an acquisition.

We may distinguish two kinds of behavioural programmes, *closed behavioural programmes* and *open behavioural programmes*, as Mayr calls them. [17] A closed behavioural programme is one that lays down the behaviour of the animal in great detail. An open behavioural programme is one that does not prescribe all the steps in the behaviour but leaves open certain alternatives, certain choices; even though it may perhaps determine the probability or propensity of choosing one way or another. The open programmes evolve, we must assume, by natural selection, due to the selection pressure of complex and irregularly changing environmental situations.

I can now state my conjecture as follows:

Ecological conditions like those that favour the evolution of *open behavioural programmes* sometimes also favour the evolution of the beginnings of consciousness, by favouring conscious choices. Or in other words, consciousness originates with the choices that are left open by open behavioural programmes.

Let us look at various possible stages in the emergence of consciousness.

As a possible first stage there may evolve something that acts like a centralized warning, that is, like irritation or discomfort or pain, inducing the organism to stop an inadequate movement and to adopt some alternative behaviour in its stead before it is too late, before too much damage has been done. The absence of a warning like pain will lead in many cases to destruction. Thus natural selection will favour those individuals that shrink back when they receive a signal indicating an inadequate movement; which means, anticipating the inherent danger of the movement. I suggest that pain may evolve as such a signal; and perhaps also fear.

[17] See Ernst Mayr, *Evolution and the Diversity of Life*, The Belknap Press, Harvard University Press, Cambridge, Mass., 1976, p. 23.

As a second stage, we may consider that natural selection will favour those organisms that try out, by some method or other, the possible movements that might be adopted *before they are executed*. In this way, *real* trial and error behaviour may be replaced, or preceded, by *imagined* or vicarious trial and error behaviour. The imagining may perhaps initially consist of incipient efferent nervous signals, serving as a kind of model, or symbolic representation of the actual behaviour, and of its possible results.

Richard Dawkins has brilliantly developed some such speculations about the beginnings of mind in considerable detail. [18] The main points about them are two. One is that these beginnings of mind or consciousness should be favoured by natural selection, simply because they mean the substitution of imagined or symbolic or vicarious behaviour for real trials which, if erroneous, may have fatal consequences. The other is that we can here apply the ideas of *selection* and of *downward causation* to what is clearly a choice situation: the open programme allows for possibilities to be played through tentatively — on a screen, as it were — in order that a *selection* can be made from among these possibilities.

As a third stage, we may perhaps consider the evolution of more or less conscious aims, or ends: of purposeful animal actions, such as hunting. Unconscious instinctive action may have been purpose-directed before, but once vicarious or imagined trial and error behaviour has started, it becomes necessary, in situations of choice, to evaluate the end state of the imagined behaviour. This may lead to feelings of avoidance or rejection — to *anticipations* of pain — or to feelings of eager acceptance of the end state; and the latter feelings may come to characterize a consciousness of aim or end or purpose. In connection with open choices, a feeling may evolve of preference for one possibility rather than another; preference for one kind of food, and thus for one kind of ecological niche, rather than another.

The evolution of language and, with it, of the world 3 of the products of the human mind allows a further step: the human step. It allows us to *dissociate ourselves* from our own hypotheses, and to look upon them critically. While an uncritical animal may be eliminated together with its dogmatically held hypotheses, we may *formulate* our hypotheses, and criticize them. Let our conjectures, our theories die in our stead! We may still learn to kill our theories instead of killing each other. If natural selection has favoured the evolution of mind for the reason indicated, then it is perhaps more than a utopian dream that one day may see the victory of the attitude (it is the

[18] See R. Dawkins, *The Selfish Gene*, Oxford University Press, Oxford, 1976, pp. 62f.

rational or the scientific attitude) of eliminating our theories, our opinions, by rational criticism, instead of eliminating each other.

My conjecture concerning the origin of mind and the relation of the mind to the body, that is the relation of consciousness to the preceding level of unconscious behaviour, is that its usefulness — its survival value — is similar to that of the preceding levels. On every level, making comes before matching; that is, before selecting. The creation of an expectation, of an anticipation, of a perception (which is a hypothesis) *precedes* its being put to the test.

If there is anything in this interpretation, then the process of variation followed by selection which Darwin discovered does not merely offer an explanation of biological evolution in mechanical terms, or in what has been slightingly and mistakenly described as mechanical terms, but it actually throws light on downward causation; on the creation of works of art and of science; and on the evolution of the freedom to create them. It is thus the entire range of phenomena connected with the evolution of life and of mind, and also of the products of the human mind, that are illuminated by the great and inspiring idea that we owe to Darwin.