

The Blind Watchmaker

Richard Dawkins

Richard Dawkins was born in 1941 in Nairobi, Kenya, where his father worked for the British Colonial Service. In 1949 his family returned to England, where he was educated at boarding schools and then at Oxford University. He chose to study zoology mainly as a way to explore the philosophical implications of evolution and the negative impact of evolution theory on religion. He pursued graduate studies in zoology at Oxford under Nobel Prize-winning ethologist Niko Tinbergen and received his doctorate in 1966. Dawkins then accepted a position at the University of California at Berkeley, where he taught from 1967 to 1969. The following year he returned to Oxford to become a lecturer in zoology and a fellow of New College. He was appointed a reader in zoology at Oxford in 1991, and Charles Simonyi Professor of Public Understanding of Science in 1995. Among his awards are the Royal Society of Literature Award (1987), the Los Angeles Times Literary Prize (1987), the Zoological Society of London Silver Medal (1989), the Royal Society of London's Michael Faraday Award (1990), and appointment to the Royal Society of Literature (1997).

Dawkins's books include *The Selfish Gene* (1976, translated into fifteen languages), *The Extended Phenotype: The Gene as the Unit of Selection* (1982), *The Blind Watchmaker: Why the Evidence of Evolution Reveals a Universe without Design* (1986, translated into thirteen languages); *River out of Eden: A Darwinian View of Life* (1995), *Unweaving the Rainbow: Science, Delusion, and the Appetite for Wonder* (1998), *The Ancestor's Tale: A Pilgrimage to the Dawn of Evolution* (2004), and *The God Delusion* (2006).

Our selection is from *The Blind Watchmaker*. As Dawkins explains, the title alludes to a famous argument advanced by William Paley in his book *Natural Theology* (1802). Paley asks us to imagine walking across a field and finding a watch lying on the ground. The fact that all its parts work together for the purpose of measuring time would lead us to conclude that it was made by an intelligent artisan. Since living organisms are much more complex than any artificial objects, the natural world must be the product of a supremely intelligent designer—namely, God. (Paley's argument appears on pp. 39–46 of this book.) Dawkins agrees with Paley that organisms are entirely too complex to have arisen all at once by some chance occurrence, but he believes that the complexity can be fully explained by the theory of evolution. He argues that although Paley's argument was plausible in his own day, the discoveries of modern biological science have made an appeal to a conscious designer unnecessary.

Dawkins explains that the theory of evolution does not contend that any organism arose through some single chance event; each organism is the end product of a long sequence of minor transformations, each one of which was small enough to have happened by chance. Species of organisms evolve through a gradual process of "natural selection"—if an organism acquires a trait that enables it to adapt to its environment, it will survive and transmit this trait to its offspring. Natural selection is *cumulative* selection; the new traits that randomly occur in organisms are slight variations on traits already possessed by the previous generation. Cumulative selection differs from single-step selection, which does *not* build on previous variations. If natural selection were single-step selection, it admittedly would be unable to account for the complexity of organisms. Dawkins argues that the cumulative nature of natural selection adequately explains the origin of species: The "designer" of species is natural selection, and natural selection is blind.

CHAPTER 1. EXPLAINING THE VERY IMPROBABLE

We animals are the most complicated things in the known universe. The universe that we know, of course, is a tiny fragment of the actual universe. There may be yet more complicated objects than us on other planets, and some of them may already know about us. But this doesn't alter the point that I want to make. Complicated things, everywhere, deserve a very special kind of explanation. We want to know how they came into existence and why they are so complicated. . . .

The process by which an airliner came into existence is not fundamentally mysterious to us, because humans built it. The systematic putting together of parts to a purposeful design is something we know and understand, for we have experienced it at first hand, even if only with our childhood Meccano or Erector set.

What about our own bodies? Each one of us is a machine, like an airliner only much more complicated. Were we designed on a drawing board too, and were our parts assembled by a skilled engineer? The answer is no. It is a surprising answer, and we have known and understood it for only a century or so. When Charles Darwin¹ first explained the matter, many people either wouldn't or couldn't grasp it. I myself flatly refused to believe Darwin's theory when I first heard about it as a child. Almost everybody throughout history, up to the second half of the nineteenth century, has firmly believed in the opposite—the conscious designer theory. Many people still do, perhaps because the true, Darwinian explanation of our own existence is still, remarkably, not a routine part of the curriculum of a general education. It is certainly very widely misunderstood.

The watchmaker of my title is borrowed from a famous treatise by the eighteenth-century theologian William Paley. His *Natural Theology; or, Evidences of the Existence and Attributes of the Deity, Collected from the Appearances of Nature*, published in 1802, is the best-known exposition of the "Argument from Design," always the most influential of the arguments for the existence of a God. It is a book that I greatly admire, for in his own time its author succeeded in doing what I am struggling to do now. He had a point to make, he passionately believed in it, and he spared no effort to ram it home clearly. He had a proper reverence for the complexity of the living world, and he saw that it demands a very special kind of explanation. The only thing he got wrong—admittedly quite a big thing!—was the explanation itself. He gave the traditional religious answer to the riddle, but he articulated it more clearly and convincingly than anybody had before. The true explanation is utterly different, and it had to wait for one of the most revolutionary thinkers of all time, Charles Darwin.

Paley begins *Natural Theology* with a famous passage:

In crossing a heath, suppose I pitched my foot against a stone and were asked how the stone came to be there. I might possibly answer, that, for anything I knew to the contrary, it had lain there forever; nor would it perhaps be very easy to show the absurdity of this answer. But suppose I had found a *watch* upon the ground and it should be inquired how the watch happened to be in that place. I should hardly think of the answer which I had given before, that, for anything I knew, the watch might have always been there.²

Paley here appreciates the difference between natural physical objects like stones, and designed and manufactured objects like watches. He goes on to expound the precision with which the cogs and springs of a watch are fashioned, and the intricacy with which they are put together. If we found an object such as a watch upon a heath, even if we didn't know how it had come into existence, its own precision and intricacy of design would force us to conclude:

that the watch must have had a maker that there must have existed, at some time and at some place or other, an artificer or artificers who formed it for the purpose which we find it actually to answer, who comprehended its construction and designed its use.

Nobody could reasonably dissent from this conclusion, Paley insists, yet that is just what the atheist, in effect, does when he contemplates the works of nature, for:

every indication of contrivance, every manifestation of design, which existed in the watch, exists in the works of nature—with the difference, on the side of nature, of being greater and more, and that in a degree which exceeds all computation.

Paley drives his point home with beautiful and reverent descriptions of the dissected machinery of life, beginning with the human eye, a favorite example which Darwin was later to use. . . . Paley compares the eye with a designed instrument such as a telescope, and concludes that “there is precisely the same proof that the eye was made for vision, as there is that the telescope was made for assisting it.” The eye must have had a designer, just as the telescope had.

Paley's argument is made with passionate sincerity and is informed by the best biological scholarship of his day, but it is wrong, gloriously and utterly wrong. The analogy between telescope and eye, between watch and living organism, is false. All appearances to the contrary, the only watchmaker in nature is the blind forces of physics, albeit deployed in a very special way. A true watchmaker has foresight: He designs his cogs and springs, and plans their interconnections, with a future purpose in his mind's eye. Natural selection, the blind, unconscious, automatic process which Darwin discovered, and which we now know is the explanation for the existence and apparently purposeful form of all life, has no purpose in mind. It has no mind and no mind's eye. It does not plan for the future. It has no vision, no foresight, no sight at all. If it can be said to play the role of watchmaker in nature, it is the *blind* watchmaker.

I shall explain all this, and much else besides. But one thing I shall not do is belittle the wonder of the living “watches” that so inspired Paley. On the contrary, I shall try to illustrate my feeling that here Paley could have gone even further. When it comes to feeling awe over living “watches” I yield to nobody. I feel more in common with the Reverend William Paley than I do with the distinguished modern philosopher, a well-known atheist, with whom I once discussed the matter at dinner. I said that I could not imagine being an atheist at any time before 1859, when Darwin's *Origin of Species* was published. “What about Hume?”³ replied the philosopher. “How did Hume explain the organized complexity of the living world?” I asked. “He didn't,” said the philosopher. “Why does it need any special explanation?”

Paley knew that it needed a special explanation; Darwin knew it, and I suspect that in his heart of hearts my philosopher companion knew it too. In any case it will be my business to show it here. As for David Hume himself, it is sometimes said that that great Scottish philosopher disposed of the argument from design a century before Darwin. But what Hume did was criticize the logic of using apparent design in nature as *positive* evidence for the existence of a God. He did not offer any *alternative* explanation for apparent design, but left the question open. An atheist before Darwin could have said, following Hume: "I have no explanation for complex biological design. All I know is that God isn't a good explanation, so we must wait and hope that somebody comes up with a better one." I can't help feeling that such a position, though logically sound, would have left one feeling pretty unsatisfied, and that although atheism might have been *logically* tenable before Darwin, Darwin made it possible to be an intellectually fulfilled atheist. I like to think that Hume would agree, but some of his writings suggest that he underestimated the complexity and beauty of biological design. The boy naturalist Charles Darwin could have shown him a thing or two about that, but Hume had been dead 40 years when Darwin enrolled in Hume's University of Edinburgh. . . .

CHAPTER 3. ACCUMULATING SMALL CHANGE

. . . Living things are too improbable and too beautifully "designed" to have come into existence by chance. How, then, did they come into existence? The answer, Darwin's answer, is by gradual, step-by-step transformations from simple beginnings, from primordial entities sufficiently simple to have come into existence by chance. Each successive change in the gradual evolutionary process was simple enough, *relative to its predecessor*, to have arisen by chance. But the whole sequence of cumulative steps constitutes anything but a chance process, when you consider the complexity of the final end-product relative to the original starting point. The cumulative process is directed by nonrandom survival. The purpose of this chapter is to demonstrate the power of this *cumulative selection* as a fundamentally nonrandom process.

If you walk up and down a pebbly beach, you will notice that the pebbles are not arranged at random. The smaller pebbles typically tend to be found in segregated zones running along the length of the beach, the larger ones in different zones or stripes. The pebbles have been sorted, arranged, selected. A tribe living near the shore might wonder at this evidence of sorting or arrangement in the world, and might develop a myth to account for it, perhaps attributing it to a Great Spirit in the sky with a tidy mind and a sense of order. We might give a superior smile at such a superstitious notion, and explain that the arranging was really done by the blind forces of physics, in this case the action of waves. The waves have no purposes and no intentions, no tidy mind, no mind at all. They just energetically throw the pebbles around, and big pebbles and small pebbles respond differently to this treatment so they end up at different levels of the beach. A small amount of order has come out of disorder, and no mind planned it.

The waves and the pebbles together constitute a simple example of a system that automatically generates nonrandomness. The world is full of such systems. The simplest example I can think of is a hole. Only objects smaller than the hole can pass through it. This means that if you start with a random collection of objects above the hole, and some force shakes and jostles them about at random, after a while the objects above and below the hole will come to be nonrandomly sorted. The space below the hole will tend to contain objects smaller than the hole, and the space above will tend to contain objects larger than the hole. Mankind has, of course, long exploited this simple principle for generating nonrandomness, in the useful device known as the sieve.

The solar system is a stable arrangement of planets, comets, and debris orbiting the sun, and it is presumably one of many such orbiting systems in the universe. The nearer a satellite is to its sun, the faster it has to travel if it is to counter the sun's gravity and remain in stable orbit. For any given orbit, there is only one speed at which a satellite can travel and remain in that orbit. If it were travelling at any other velocity, it would either move out into deep space, or crash into the sun, or move into another orbit. And if we look at the planets of our solar system, lo and behold, every single one of them is travelling at exactly the right velocity to keep it in its stable orbit around the sun. A blessed miracle of provident design? No, just another natural "sieve." Obviously all the planets that we see orbiting the sun must be travelling at exactly the right speed to keep them in their orbits, or we wouldn't see them there because they wouldn't be there! But equally obviously this is not evidence for conscious design. It is just another kind of sieve.

Sieving of this order of simplicity is not, on its own, enough to account for the massive amounts of nonrandom order that we see in living things. Nowhere near enough. . . . The kind of nonrandomness that can be generated by simple sieving is roughly equivalent to opening a combination lock with only one dial: It is easy to open it by sheer luck. The kind of nonrandomness that we see in living systems, on the other hand, is equivalent to a gigantic combination lock with an almost uncountable number of dials. To generate a biological molecule like hemoglobin, the red pigment in blood, by simple sieving would be equivalent to taking all the amino-acid building blocks of hemoglobin, jumbling them up at random, and hoping that the hemoglobin molecule would reconstitute itself by sheer luck. The amount of luck that would be required for this feat is unthinkable, and has been used as a telling mind-boggler by Isaac Asimov⁴ and others.

A hemoglobin molecule consists of four chains of amino acids twisted together. Let us think about just one of these four chains. It consists of 146 amino acids. There are 20 different kinds of amino acids commonly found in living things. The number of possible ways of arranging 20 kinds of thing in chains 146 links long is an inconceivably large number, which Asimov calls the "hemoglobin number." It is easy to calculate, but impossible to visualize the answer. The first link in the 146-long chain could be any one of the 20, so the number of possible 2-link chains is 20×20 , or 400. The number of possible 3-link chains is $20 \times 20 \times 20$, or 8000. The number of possible 146-link chains is 20 times itself 146 times. This is a staggeringly large number. A million is a 1 with 6 naughts after it. A billion (1000 million) is a 1 with 9 naughts after it. The number we seek,

the “hemoglobin number,” is (near enough) a 1 with 190 naughts after it! This is the chance against happening to hit upon hemoglobin by luck. And a hemoglobin molecule has only a minute fraction of the complexity of a living body. Simple sieving, on its own, is obviously nowhere near capable of generating the amount of order in a living thing. Sieving is an essential ingredient in the generation of living order, but it is very far from being the whole story. Something else is needed. To explain the point, I shall need to make a distinction between “single-step” selection and “cumulative” selection. The simple sieves we have been considering so far in this chapter are all examples of single-step selection. Living organization is the product of cumulative selection.

The essential difference between single-step selection and cumulative selection is this. In single-step selection the entities selected or sorted, pebbles or whatever they are, are sorted once and for all. In cumulative selection, on the other hand, they “reproduce”; or in some other way the results of one sieving process are fed into a subsequent sieving, which is fed into . . . , and so on. The entities are subjected to selection or sorting over many “generations” in succession. The end-product of one generation of selection is the starting point for the next generation of selection, and so on for many generations. It is natural to borrow such words as “reproduce” and “generation,” which have associations with living things, because living things are the main examples we know of things that participate in cumulative selection. They may in practice be the only things that do. But for the moment I don’t want to beg that question by saying so outright.

Sometimes clouds, through the random kneading and carving of the winds, come to look like familiar objects. There is a much published photograph, taken by the pilot of a small airplane, of what looks a bit like the face of Jesus, staring out of the sky. We have all seen clouds that reminded us of something—a sea horse, say, or a smiling face. These resemblances come about by single-step selection, that is to say by a single coincidence. They are, consequently, not very impressive. The resemblance of the signs of the zodiac to the animals after which they are named, Scorpio, Leo, and so on, is as unimpressive as the predictions of astrologers. We don’t feel overwhelmed by the resemblance, as we are by biological adaptations—the products of cumulative selection. We describe as weird, uncanny or spectacular, the resemblance of, say, a leaf insect to a leaf or a praying mantis to a cluster of pink flowers. The resemblance of a cloud to a weasel is only mildly diverting, barely worth calling to the attention of our companion. Moreover, we are quite likely to change our mind about exactly what the cloud most resembles.

Hamlet. Do you see yonder cloud that’s almost in shape of a camel?
Polonius. By the mass, and ’tis like a camel, indeed.
Hamlet. Methinks it is like a weasel.
Polonius. It is backed like a weasel.
Hamlet. Or like a whale?
Polonius. Very like a whale.⁵

I don’t know who it was first pointed out that, given enough time, a monkey bashing away at random on a typewriter could produce all the works of

Photo: ©— iStockphoto.com/stevegriffith. Used here to illustrate single-step selection. The early stages of cumulative selection are also shown.

Shakespeare. The operative phrase is, of course, given enough time. Let us limit the task facing our monkey somewhat. Suppose that he has to produce, not the complete works of Shakespeare but just the short sentence “Methinks it is like a weasel,” and we shall make it relatively easy by giving him a typewriter with a restricted keyboard, one with just the 26 (capital) letters and a space bar. How long will he take to write this one little sentence?

The sentence has 28 characters in it, so let us assume that the monkey has a series of discrete “tries,” each consisting of 28 bashes at the keyboard. If he types the phrase correctly, that is the end of the experiment. If not, we allow him another “try” of 28 characters. I don’t know any monkeys, but fortunately my 11-month-old daughter is an experienced randomizing device, and she proved only too eager to step into the role of monkey typist. Here is what she typed on the computer:

```
UMMK JK CDZZ F ZD DSDSKSM
S SS FMCV PU I DDRGLKDXRRDO
RDTE QDWFDVIOY UDSKZWDCCVYT
H CHVY NMGNBAYTDFCCVD D
RCDFYYRM N DFSKD LD K WDWK
JJKAUIZMZI UXDKIDISFUMDKUDXI
```

She has other important calls on her time, so I was obliged to program the computer to simulate a randomly typing baby or monkey:

```
WDLDMNLT DTJBKWIRZREZIMQCO P
Y YVMQKZPGJXWVHGLAWFVCHQYOPY
MWR SWTNUXMLCDLEUBXTQHNZVJQF
FU OVAODVYKDGXDEKYVMOGGS VT
HZQZDSFZIHIVPHZPETPWVOVPMZGF
GEWRGZRPBCTPCQMCKHFDBGW ZCCF
```

And so on and on. It isn’t difficult to calculate how long we should reasonably expect to wait for the random computer (or baby or monkey) to type METHINKS IT IS LIKE A WEASEL. Think about the total number of *possible* phrases of the right length that the monkey or baby or random computer *could* type. It is the same kind of calculation as we did for hemoglobin, and it produces a similarly large result. There are 27 possible letters (counting “space” as one letter) in the first position. The chance of the monkey happening to get the first letter—M—right is therefore 1 in 27. The chance of it getting the first two letters—ME—right is the chance of it getting the second letter—E—right (1 in 27) *given that* it has also got the first letter—M—right, therefore $1/27 \times 1/27$, which equals $1/729$. The chance of it getting the first word—METHINKS—right is $1/27$ for each of the 8 letters, therefore $(1/27) \times (1/27) \times (1/27) \times (1/27) \dots$, and so on, 8 times, or $(1/27)$ to the power 8. The chance of it getting the entire phrase of 28 characters right is $(1/27)$ to the power 28—that is, $(1/27)$ multiplied by itself 28 times. These are very small odds, about 1 in 10,000 million million million million million million. To put it mildly, the phrase we seek would be a long time coming, to say nothing of the complete works of Shakespeare.

So much for single-step selection of random variation. What about cumulative selection; how much more effective should this be? Very very much more effective, perhaps more so than we at first realize, although it is almost obvious

when we reflect further. We again use our computer monkey, but with a crucial difference in its program. It again begins by choosing a random sequence of 28 letters, just as before:

WDLMNLT DTJBKWIRZREZLMQCO P

It now "breeds from" this random phrase. It duplicates it repeatedly, but with a certain chance of random error—"mutation"—in the copying. The computer examines the mutant nonsense phrases, the "progeny" of the original phrase, and chooses the one which, *however slightly*, most resembles the target phrase, METHINKS IT IS LIKE A WEASEL. In this instance the winning phrase of the next "generation" happened to be:

WDLTMNLT DTJBSWIRZREZLMQCO P

Not an obvious improvement! But the procedure is repeated, again mutant "progeny" are "bred from" the phrase, and a new "winner" is chosen. This goes on, generation after generation. After 10 generations, the phrase chosen for "breeding" was:

MDLDMNLS ITJISWHRZREZ MECS P

After 20 generations it was:

MELDINLS IT ISWPRKE Z WECSEL

By now, the eye of faith fancies that it can see a resemblance to the target phrase. By 30 generations there can be no doubt:

METHINGS IT ISWLIKE B WECSEL

Generation 40 takes us to within one letter of the target:

METHINKS IT IS LIKE I WEASEL

And the target was finally reached in generation 43. A second run of the computer began with the phrase:

Y YVMQKZPFJXWVHGLAWFVCHQXYOPY,

passed through (again reporting only every tenth generation):

Y YVMQKSPFTXWSHLIKEFV HQYSPY
 YETHINKSPITXISHLIKEFA WQYSEY
 METHINKS IT ISSLIKE A WEFSEY
 METHINKS IT ISBLIKE A WEASES
 METHINKS IT ISJLIKE A WEASEO
 METHINKS IT IS LIKE A WEASEP

and reached the target phrase in generation 64. In a third run the computer started with:

GEWRGZRPBCTPGQMCKHFDBGW ZCCF

and reached METHINKS IT IS LIKE A WEASEL in 41 generations of selective "breeding."

The exact time taken by the computer to reach the target doesn't matter. If you want to know, it completed the whole exercise for me, the first time, while I was out to lunch. It took about half an hour. (Computer enthusiasts may think this unduly slow. The reason is that the program was written in BASIC, a sort of computer baby-talk. When I rewrote it in Pascal, it took 11 seconds.) Computers are a bit faster at this kind of thing than monkeys, but the difference really isn't significant. What matters is the difference between the time taken by *cumulative selection*, and the time which the same computer, working flat out at the same rate, would take to reach the target phrase if it were forced to use the other procedure of *single-step selection*: about a million million million million million years. This is more than a million million million times as long as the universe has so far existed. Actually it would be fairer just to say that, in comparison with the time it would take either a monkey or a randomly programmed computer to type our target phrase, the total age of the universe so far is a negligibly small quantity, so small as to be well within the margin of error for this sort of back-of-an-envelope calculation. Whereas the time taken for a computer working randomly but with the constraint of *cumulative selection* to perform the same task is of the same order as humans ordinarily can understand, between 11 seconds and the time it takes to have lunch.

There is a big difference, then, between cumulative selection (in which each improvement, however slight, is used as a basis for future building) and single-step selection (in which each new "try" is a fresh one). If evolutionary progress had had to rely on single-step selection, it would never have got anywhere. If, however, there was any way in which the necessary conditions for *cumulative selection* could have been set up by the blind forces of nature, strange and wonderful might have been the consequences. As a matter of fact that is exactly what happened on this planet, and we ourselves are among the most recent, if not the strangest and most wonderful, of those consequences.

It is amazing that you can still read calculations like my hemoglobin calculation, used as though they constituted arguments *against* Darwin's theory. The people who do this, often expert in their own field, astronomy or whatever it may be, seem sincerely to believe that Darwinism explains living organization in terms of chance—"single-step selection"—alone. This belief, that Darwinian evolution is "random," is not merely false. It is the exact opposite of the truth. Chance is a minor ingredient in the Darwinian recipe, but the most important ingredient is cumulative selection which is quintessentially *nonrandom*. . . .

CHAPTER 11. DOOMED RIVALS

. . . We have dealt with all the alleged alternatives to the theory of natural selection except the oldest one. This is the theory that life was created, or its evolution master-minded, by a conscious designer. It would obviously be unfairly easy to demolish some particular version of this theory such as the one (or it may be two) spelled out in Genesis. Nearly all peoples have developed their own creation myth, and the Genesis story is just the one that happened to have been adopted by one particular tribe of Middle Eastern herders. It has no more

special status than the belief of a particular West African tribe that the world was created from the excrement of ants. All these myths have in common that they depend upon the deliberate intentions of some kind of supernatural being.

At first sight there is an important distinction to be made between what might be called "instantaneous creation" and "guided evolution." Modern theologians of any sophistication have given up believing in instantaneous creation. The evidence for some sort of evolution has become too overwhelming. But many theologians who call themselves evolutionists . . . smuggle God in by the back door: They allow him some sort of supervisory role over the course that evolution has taken, either influencing key moments in evolutionary history (especially, of course, *human* evolutionary history), or even meddling more comprehensively in the day-to-day events that add up to evolutionary change.

We cannot disprove beliefs like these, especially if it is assumed that God took care that his interventions always closely mimicked what would be expected from evolution by natural selection. All that we can say about such beliefs is, firstly, that they are superfluous and, secondly, that they *assume* the existence of the main thing we want to *explain*, namely organized complexity. The one thing that makes evolution such a neat theory is that it explains how organized complexity can arise out of primeval simplicity.

If we want to postulate a deity capable of engineering all the organized complexity in the world, either instantaneously or by guiding evolution, that deity must already have been vastly complex in the first place. The creationist, whether a naive Bible-thumper or an educated bishop, simply *postulates* an already existing being of prodigious intelligence and complexity. If we are going to allow ourselves the luxury of postulating organized complexity without offering an explanation, we might as well make a job of it and simply postulate the existence of life as we know it! . . . The theory of evolution by cumulative natural selection is the only theory we know of that is in principle *capable* of explaining the existence of organized complexity. Even if the evidence did not favor it, it would *still* be the best theory available! In fact the evidence does favor it. But that is another story.

Let us hear the conclusion of the whole matter. The essence of life is statistical improbability on a colossal scale. Whatever is the explanation for life, therefore, it cannot be chance. The true explanation for the existence of life must embody the very antithesis of chance. The antithesis of chance is nonrandom survival, properly understood. Nonrandom survival, improperly understood, is not the antithesis of chance, it is chance itself. There is a continuum connecting these two extremes, and it is the continuum from single-step selection to cumulative selection. Single-step selection is just another way of saying pure chance. This is what I mean by nonrandom survival improperly understood. *Cumulative selection*, by slow and gradual degrees, is the explanation, the only workable explanation that has ever been proposed, for the existence of life's complex design.

The whole book has been dominated by the idea of chance, by the astronomically long odds against the spontaneous arising of order, complexity and apparent design. We have sought a way of taming chance, of drawing its fangs. "Untamed chance," pure, naked chance, means ordered design springing into

existence from nothing, in a single leap. It would be untamed chance if once there was no eye, and then, suddenly, in the twinkling of a generation, an eye appeared, fully fashioned, perfect and whole. This is possible, but the odds against it will keep us busy writing naughts till the end of time. The same applies to the odds against the spontaneous existence of any fully fashioned, perfect and whole beings, including—I see no way of avoiding the conclusion—deities.

To “tame” chance means to break down the very improbable into less improbable small components arranged in series. No matter how improbable it is that an X could have arisen from a Y in a single step, it is always possible to conceive of a series of infinitesimally graded intermediates between them. However improbable a large-scale change may be, smaller changes are less improbable. And provided we postulate a sufficiently large series of sufficiently finely graded intermediates, we shall be able to derive anything from anything else, without invoking astronomical improbabilities. We are allowed to do this only if there has been sufficient time to fit all the intermediates in. And also only if there is a mechanism for guiding each step in some particular direction—otherwise the sequence of steps will career off in an endless random walk.

It is the contention of the Darwinian world-view that both these provisos are met, and that slow, gradual, cumulative natural selection is the ultimate explanation for our existence. If there are versions of the evolution theory that deny slow gradualism, and deny the central role of natural selection, they may be true in particular cases. But they cannot be the whole truth, for they deny the very heart of the evolution theory, which gives it the power to dissolve astronomical improbabilities and explain prodigies of apparent miracle.

NOTES

1. Darwin (1809–1892) was an English naturalist. He formulated the theory of natural selection, which states that if an organism develops traits that enable it to adapt to its environment, it will survive and transmit these traits to its offspring, and that if the organism *fails* to develop adaptive traits, it will perish. [D. C. ABEL]
2. This passage appears on pp. 39–40 of this book; a biography of Paley appears on p. 39. [D. C. ABEL]
3. David Hume (1711–1776) was a Scottish philosopher and historian; for a biography, see p. 47. [D. C. ABEL]
4. Asimov (1920–1992) was an American biochemist and author, known mainly for his science fiction novels. [D. C. ABEL]
5. William Shakespeare, *Hamlet*, act III, scene ii, lines 384–390. [D. C. ABEL]

FIFTY READINGS IN PHILOSOPHY

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Donald C. Abel

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