The Improbability of God
by Richard Dawkins
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Much of what people do is done in the name of God. Irishmen blow each other up in his name. Arabs blow themselves up in his name. Imams and ayatollahs oppress women in his name. Celibate popes and priests mess up people's sex lives in his name. Jewish shohets cut live animals' throats in his name. The achievements of religion in past history -- bloody crusades, torturing inquisitions, mass-murdering conquistadors, culture-destroying missionaries, legally enforced resistance to each new piece of scientific truth until the last possible moment -- are even more impressive. And what has it all been in aid of? I believe it is becoming increasingly clear that the answer is absolutely nothing at all. There is no reason for believing that any sort of gods exist and quite good reason for believing that they do not exist and never have. It has all been a gigantic waste of time and a waste of life. It would be a joke of cosmic proportions if it weren't so tragic.

Why do people believe in God? For most people the answer is still some version of the ancient Argument from Design. We look about us at the beauty and intricacy of the world -- at the aerodynamic sweep of a swallow's wing, at the delicacy of flowers and of the butterflies that fertilize them, through a microscope at the teeming life in every drop of pond water, through a telescope at the crown of a giant redwood tree. We reflect on the electronic complexity and optical perfection of our own eyes that do the looking. If we have any imagination, these things drive us to a sense of awe and reverence. Moreover, we cannot fail to be struck by the obvious resemblance of living organs to the carefully planned designs of human engineers. The argument was most famously expressed in the watchmaker analogy of the eighteenth-century priest William Paley. Even if you didn't know what a watch was, the obviously designed character of its cogs and springs and of how they mesh together for a purpose would force you 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." If this is true of a comparatively simple watch, how much the more so is it true of the eye, ear, kidney, elbow joint, brain? These beautiful, complex, intricate, and obviously purpose-built structures must have had their own designer, their own watchmaker -- God.

So ran Paley's argument, and it is an argument that nearly all thoughtful and sensitive people discover for themselves at some stage in their childhood. Throughout most of history it must have seemed utterly convincing, self-evidently true. And yet, as the result of one of the most astonishing intellectual revolutions in history, we now know that it is wrong, or at least superfluous. We now know that the order and apparent purposefulness of the living world has come about through an entirely different process, a process that works without the need for any designer and one that is a consequence of basically very simple laws of physics. This is the process of evolution by natural selection, discovered by Charles Darwin and, independently, by Alfred Russel Wallace.

What do all objects that look as if they must have had a designer have in common? The answer is statistical improbability. If we find a transparent pebble washed into the shape of a crude lens by the sea, we do not conclude that it must have been designed by an optician: the unaided laws of
physics are capable of achieving this result; it is not too improbable to have just "happened." But if we find an elaborate compound lens, carefully corrected against spherical and chromatic aberration, coated against glare, and with "Carl Zeiss" engraved on the rim, we know that it could not have just happened by chance. If you take all the atoms of such a compound lens and throw them together at random under the jostling influence of the ordinary laws of physics in nature, it is theoretically possible that, by sheer luck, the atoms would just happen to fall into the pattern of a Zeiss compound lens, and even that the atoms round the rim should happen to fall in such a way that the name Carl Zeiss is etched out. But the number of other ways in which the atoms could, with equal likelihood, have fallen, is so hugely, vastly, immeasurably greater that we can completely discount the chance hypothesis. Chance is out of the question as an explanation.

This is not a circular argument, by the way. It might seem to be circular because, it could be said, any particular arrangement of atoms is, with hindsight, very improbable. As has been said before, when a ball lands on a particular blade of grass on the golf course, it would be foolish to exclaim: "Out of all the billions of blades of grass that it could have fallen on, the ball actually fell on this one. How amazingly, miraculously improbable!" The fallacy here, of course, is that the ball had to land somewhere. We can only stand amazed at the improbability of the actual event if we specify it a priori: for example, if a blindfolded man spins himself round on the tee, hits the ball at random, and achieves a hole in one. That would be truly amazing, because the target destination of the ball is specified in advance.

Of all the trillions of different ways of putting together the atoms of a telescope, only a minority would actually work in some useful way. Only a tiny minority would have Carl Zeiss engraved on them, or, indeed, any recognizable words of any human language. The same goes for the parts of a watch: of all the billions of possible ways of putting them together, only a tiny minority will tell the time or do anything useful. And of course the same goes, a fortiori, for the parts of a living body. Of all the trillions of ways of putting together the parts of a body, only an infinitesimal minority would live, seek food, eat, and reproduce. True, there are many different ways of being alive -- at least ten million different ways if we count the number of distinct species alive today -- but, however many ways there may be of being alive, it is certain that there are vastly more ways of being dead!

We can safely conclude that living bodies are billions of times too complicated -- too statistically improbable -- to have come into being by sheer chance. How, then, did they come into being? The answer is that chance enters into the story, but not a single, monolithic act of chance. Instead, a whole series of tiny chance steps, each one small enough to be a believable product of its predecessor, occurred one after the other in sequence. These small steps of chance are caused by genetic mutations, random changes -- mistakes really -- in the genetic material. They give rise to changes in the existing bodily structure. Most of these changes are deleterious and lead to death. A minority of them turn out to be slight improvements, leading to increased survival and reproduction. By this process of natural selection, those random changes that turn out to be beneficial eventually spread through the species and become the norm. The stage is now set for the next small change in the evolutionary process. After, say, a thousand of these small changes in series, each change providing the basis for the next, the end result has become, by a process of accumulation, far too complex to have come about in a single act of chance.

For instance, it is theoretically possible for an eye to spring into being, in a single lucky step, from nothing: from bare skin, let's say. It is theoretically possible in the sense that a recipe could be written out in the form of a large number of mutations. If all these mutations happened simultaneously, a complete eye could, indeed, spring from nothing. But although it is theoretically possible, it is in practice inconceivable. The quantity of luck involved is much too large. The "correct" recipe involves changes in a huge number of genes simultaneously. The correct recipe is
one particular combination of changes out of trillions of equally probable combinations of chances. We can certainly rule out such a miraculous coincidence. But it is perfectly plausible that the modern eye could have sprung from something almost the same as the modern eye but not quite: a very slightly less elaborate eye. By the same argument, this slightly less elaborate eye sprang from a slightly less elaborate eye still, and so on. If you assume a sufficiently large number of sufficiently small differences between each evolutionary stage and its predecessor, you are bound to be able to derive a full, complex, working eye from bare skin. How many intermediate stages are we allowed to postulate? That depends on how much time we have to play with. Has there been enough time for eyes to evolve by little steps from nothing?

The fossils tell us that life has been evolving on Earth for more than 3,000 million years. It is almost impossible for the human mind to grasp such an immensity of time. We, naturally and mercifully, tend to see our own expected lifetime as a fairly long time, but we can't expect to live even one century. It is 2,000 years since Jesus lived, a time span long enough to blur the distinction between history and myth. Can you imagine a million such periods laid end to end? Suppose we wanted to write the whole history on a single long scroll. If we crammed all of Common Era history into one metre of scroll, how long would the pre-Common Era part of the scroll, back to the start of evolution, be? The answer is that the pre-Common Era part of the scroll would stretch from Milan to Moscow. Think of the implications of this for the quantity of evolutionary change that can be accommodated. All the domestic breeds of dogs -- Pekingeses, poodles, spaniels, Saint Bernards, and Chihuahuas -- have come from wolves in a time span measured in hundreds or at the most thousands of years: no more than two meters along the road from Milan to Moscow. Think of the quantity of change involved in going from a wolf to a Pekingese; now multiply that quantity of change by a million. When you look at it like that, it becomes easy to believe that an eye could have evolved from no eye by small degrees.

It remains necessary to satisfy ourselves that every one of the intermediates on the evolutionary route, say from bare skin to a modern eye, would have been favored by natural selection; would have been an improvement over its predecessor in the sequence or at least would have survived. It is no good proving to ourselves that there is theoretically a chain of almost perceptibly different intermediates leading to an eye if many of those intermediates would have died. It is sometimes argued that the parts of an eye have to be all there together or the eye won't work at all. Half an eye, the argument runs, is no better than no eye at all. You can't fly with half a wing; you can't hear with half an ear. Therefore there can't have been a series of step-by-step intermediates leading up to a modern eye, wing, or ear.

This type of argument is so naive that one can only wonder at the subconscious motives for wanting to believe it. It is obviously not true that half an eye is useless. Cataract sufferers who have had their lenses surgically removed cannot see very well without glasses, but they are still much better off than people with no eyes at all. Without a lens you can't focus a detailed image, but you can avoid bumping into obstacles and you could detect the looming shadow of a predator.

As for the argument that you can't fly with only half a wing, it is disproved by large numbers of very successful gliding animals, including mammals of many different kinds, lizards, frogs, snakes, and squids. Many different kinds of tree-dwelling animals have flaps of skin between their joints that really are fractional wings. If you fall out of a tree, any skin flap or flattening of the body that increases your surface area can save your life. And, however small or large your flaps may be, there must always be a critical height such that, if you fall from a tree of that height, your life would have been saved by just a little bit more surface area. Then, when your descendants have evolved that extra surface area, their lives would be saved by just a bit more still if they fell from trees of a slightly greater height. And so on by insensibly graded steps until, hundreds of generations later, we arrive at full wings.
Eyes and wings cannot spring into existence in a single step. That would be like having the almost infinite luck to hit upon the combination number that opens a large bank vault. But if you spun the dials of the lock at random, and every time you got a little bit closer to the lucky number the vault door creaked open another chink, you would soon have the door open! Essentially, that is the secret of how evolution by natural selection achieves what once seemed impossible. Things that cannot plausibly be derived from very different predecessors can plausibly be derived from only slightly different predecessors. Provided only that there is a sufficiently long series of such slightly different predecessors, you can derive anything from anything else.

Evolution, then, is theoretically capable of doing the job that, once upon a time, seemed to be the prerogative of God. But is there any evidence that evolution actually has happened? The answer is yes; the evidence is overwhelming. Millions of fossils are found in exactly the places and at exactly the depths that we should expect if evolution had happened. Not a single fossil has ever been found in any place where the evolution theory would not have expected it, although this could very easily have happened: a fossil mammal in rocks so old that fishes have not yet arrived, for instance, would be enough to disprove the evolution theory.

The patterns of distribution of living animals and plants on the continents and islands of the world is exactly what would be expected if they had evolved from common ancestors by slow, gradual degrees. The patterns of resemblance among animals and plants is exactly what we should expect if some were close cousins, and others more distant cousins to each other. The fact that the genetic code is the same in all living creatures overwhelmingly suggests that all are descended from one single ancestor. The evidence for evolution is so compelling that the only way to save the creation theory is to assume that God deliberately planted enormous quantities of evidence to make it look as if evolution had happened. In other words, the fossils, the geographical distribution of animals, and so on, are all one gigantic confidence trick. Does anybody want to worship a God capable of such trickery? It is surely far more reverent, as well as more scientifically sensible, to take the evidence at face value. All living creatures are cousins of one another, descended from one remote ancestor that lived more than 3,000 million years ago.

The Argument from Design, then, has been destroyed as a reason for believing in a God. Are there any other arguments? Some people believe in God because of what appears to them to be an inner revelation. Such revelations are not always edifying but they undoubtedly feel real to the individual concerned. Many inhabitants of lunatic asylums have an unshakable inner faith that they are Napoleon or, indeed, God himself. There is no doubting the power of such convictions for those that have them, but this is no reason for the rest of us to believe them. Indeed, since such beliefs are mutually contradictory, we can't believe them all.

There is a little more that needs to be said. Evolution by natural selection explains a lot, but it couldn't start from nothing. It couldn't have started until there was some kind of rudimentary reproduction and heredity. Modern heredity is based on the DNA code, which is itself too complicated to have sprung spontaneously into being by a single act of chance. This seems to mean that there must have been some earlier hereditary system, now disappeared, which was simple enough to have arisen by chance and the laws of chemistry and which provided the medium in which a primitive form of cumulative natural selection could get started. DNA was a later product of this earlier cumulative selection. Before this original kind of natural selection, there was a period when complex chemical compounds were built up from simpler ones and before that a period when the chemical elements were built up from simpler elements, following the well-understood laws of physics. Before that, everything was ultimately built up from pure hydrogen in the immediate aftermath of the big bang, which initiated the universe.

There is a temptation to argue that, although God may not be needed to explain the evolution of
complex order once the universe, with its fundamental laws of physics, had begun, we do need a
God to explain the origin of all things. This idea doesn't leave God with very much to do: just set off
the big bang, then sit back and wait for everything to happen. The physical chemist Peter Atkins, in
his beautifully written book *The Creation*, postulates a lazy God who strove to do as little as
possible in order to initiate everything. Atkins explains how each step in the history of the universe
followed, by simple physical law, from its predecessor. He thus pares down the amount of work that
the lazy creator would need to do and eventually concludes that he would in fact have needed to do
nothing at all!

The details of the early phase of the universe belong to the realm of physics, whereas I am a
biologist, more concerned with the later phases of the evolution of complexity. For me, the
important point is that, even if the physicist needs to postulate an irreducible minimum that had to
be present in the beginning, in order for the universe to get started, that irreducible minimum is
certainly extremely simple. By definition, explanations that build on simple premises are more
plausible and more satisfying than explanations that have to postulate complex and statistically
improbable beginnings. And you can't get much more complex than an Almighty God!

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The Improbability of You

To Live at All
Is Miracle Enough

by Richard Dawkins

excerpt from Chapter I, "The Anaesthetic of Familiarity,"
of his 1998 book *Unweaving the Rainbow*

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To live at all is miracle enough.
-- Mervyn Peake,
The Glassblower (1950)

We are going to die, and that makes us the lucky ones. Most people are never going to die
because they are never going to be born. The potential people who could have been here in my
place but who will in fact never see the light of day outnumber the sand grains of Arabia. Certainly
those unborn ghosts include greater poets than Keats, scientists greater than Newton. We know
this because the set of possible people allowed by our DNA so massively exceeds the set of actual
people. In the teeth of these stupefying odds it is you and I, in our ordinariness, that are here.

Moralists and theologians place great weight upon the moment of conception, seeing it as the
instant at which the soul comes into existence. If, like me, you are unmoved by such talk, you still
must regard a particular instant, nine months before your birth, as the most decisive event in your
personal fortunes. It is the moment at which your consciousness suddenly became trillions of times
more foreseeable than it was a split second before. To be sure, the embryonic you that came into
existence still had plenty of hurdles to leap. Most conceptuses end in early abortion before their mother even knew they were there, and we are all lucky not to have done so. Also, there is more to personal identity than genes, as identical twins (who separate after the moment of fertilization) show us. Nevertheless, the instant at which a particular spermatozoon penetrated a particular egg was, in your private hindsight, a moment of dizzying singularity. It was then that the odds against your becoming a person dropped from astronomical to single figures.

The lottery starts before we are conceived. Your parents had to meet, and the conception of each was as improbable as your own. And so on back, through your four grandparents and eight great grandparents, back to where it doesn't bear thinking about. Desmond Morris opens his autobiography, *Animal Days* (1979), in characteristically arresting vein:

> Napoleon started it all. If it weren't for him, I might not be sitting here now writing these words ... for it was one of his cannonballs, fired in the Peninsular War, that shot off the arm of my great-great-grandfather, James Morris, and altered the whole course of my family history.

Morris tells how his ancestor's enforced change of career had various knock-on effects culminating in his own interest in natural history. But he really needn't have bothered. There's no 'might' about it. *Of course* he owes his very existence to Napoleon. So do I and so do you. Napoleon didn't have to shoot off James Morris's arm in order to seal young Desmond's fate, and yours and mine, too. Not just Napoleon but the humblest medieval peasant had only to sneeze in order to affect something which changed something else which, after a long chain reaction, led to the consequence that one of your would-be ancestors failed to be your ancestor and became somebody else's instead. I'm not talking about 'chaos theory', or the equally trendy 'complexity theory', but just about the ordinary statistics of causation. The thread of historical events by which our existence hangs is wincingly tenuous.

> When compared with the stretch of time unknown to us, O king, the present life of men on earth is like the flight of a single sparrow through the hall where, in winter, you sit with your captains and ministers. Entering at one door and leaving by another, while it is inside it is untouched by the wintry storm; but this brief interval of calm is over in a moment, and it returns to the winter whence it came, vanishing from your sight. Man's life is similar, and of what follows it, or what went before, we are utterly ignorant.

> -- The Venerable Bede, *A History of the English Church and People* (731)

This is another respect in which we are lucky. The universe is older than a hundred million centuries. Within a comparable time the sun will swell to a red giant and engulf the earth. Every century of hundreds of millions has been in its time, or will be when its time comes, 'the present century'. Interestingly, some physicists don't like the idea of a 'moving present', regarding it as a subjective phenomenon for which they find no house room in their equations. But it is a subjective argument I am making. How it feels to me, and I guess to you as well, is that the present moves from the past to the future, like a tiny spotlight, inching its way along a gigantic ruler of time. Everything behind the spotlight is in darkness, the darkness of the dead past. Everything ahead of the spotlight is in the darkness of the unknown future. The odds of your century being the one in the spotlight are the same as the odds that a penny, tossed down at random, will land on a particular ant crawling somewhere along the road from New York to San Francisco. In other words, it is overwhelmingly probable that you are dead.
In spite of these odds, you will notice that you are, as a matter of fact, alive. People whom the spotlight has already passed over, and people whom the spotlight has not reached, are in no position to read a book. I am equally lucky to be in a position to write one, although I may not be when you read these words. Indeed, I rather hope that I shall be dead when you do. Don't misunderstand me. I love life and hope to go on for a long time yet, but any author wants his works to reach the largest possible readership. Since the total future population is likely to outnumber my contemporaries by a large margin, I cannot but aspire to be dead when you see these words. Facetiously seen, it turns out to be no more than a hope that my book will not soon go out of print. But what I see as I write is that I am lucky to be alive and so are you. We live on a planet that is all but perfect for our kind of life: not too warm and not too cold, basking in kindly sunshine, softly watered; a gently spinning, green and gold harvest festival of a planet. Yes, and alas, there are deserts and slums; there is starvation and racking misery to be found. But take a look at the competition. Compared with most planets this is paradise, and parts of earth are still paradise by any standards. What are the odds that a planet picked at random would have these complaisant properties? Even the most optimistic calculation would put it at less than one in a million.

Imagine a spaceship full of sleeping explorers, deep-frozen would-be colonists of some distant world. Perhaps the ship is on a forlorn mission to save the species before an unstoppable comet, like the one that killed the dinosaurs, hits the home planet. The voyagers go into the deep-freeze soberly reckoning the odds against their spaceship's ever chancing upon a planet friendly to life. If one in a million planets is suitable at best, and it takes centuries to travel from each star to the next, the spaceship is pathetically unlikely to find a tolerable, let alone safe, haven for its sleeping cargo. But imagine that the ship's robot pilot turns out to be unthinkably lucky. After millions of years the ship does find a planet capable of sustaining life: a planet of equable temperature, bathed in warm starshine, refreshed by oxygen and water. The passengers, Rip van Winkles, wake stumbling into the light. After a million years of sleep, here is a whole new fertile globe, a lush planet of warm pastures, sparkling streams and waterfalls, a world bountiful with creatures, darting through alien green felicity. Our travellers walk entranced, stupefied, unable to believe their unaccustomed senses or their luck.

As I said, the story asks for too much luck; it would never happen. And yet, isn't that what has happened to each one of us? We have woken after hundreds of millions of years asleep, defying astronomical odds. Admittedly we didn't arrive by spaceship, we arrived by being born, and we didn't burst conscious into the world but accumulated awareness gradually through babyhood. The fact that we slowly apprehend our world, rather than suddenly discover it, should not subtract from its wonder.

Of course I am playing tricks with the idea of luck, putting the cart before the horse. It is no accident that our kind of life finds itself on a planet whose temperature, rainfall and everything else are exactly right. If the planet were suitable for another kind of life, it is that other kind of life that would have evolved here. But we as individuals are still hugely blessed. Privileged, and not just privileged to enjoy our planet. More, we are granted the opportunity to understand why our eyes are open, and why they see what they do, in the short time before they close for ever.

Here, it seems to me, lies the best answer to those petty-minded scrooges who are always asking what is the use of science. In one of those mythic remarks of uncertain authorship, Michael Faraday is alleged to have been asked what was the use of science. 'Sir,' Faraday replied. 'Of what use is a new-born child?' The obvious thing for Faraday (or Benjamin Franklin, or whoever it was) to have meant was that a baby might be no use for anything at present, but it has great potential for
the future. I now like to think that he meant something else, too: What is the use of bringing a baby into the world if the only thing it does with its life is just work to go on living? If everything is judged by how 'useful' it is -- useful for staying alive, that is -- we are left facing a futile circularity. There must be some added value. At least a part of life should be devoted to living that life, not just working to stop it ending. This is how we rightly justify spending taxpayers' money on species and beautiful buildings. It is how we answer those barbarians who think that wild elephants and historic houses should be preserved only if they 'pay their way'. And science is the same. Of course science pays its way; of course it is useful. But that is not all it is.

After sleeping through a hundred million centuries we have finally opened our eyes on a sumptuous planet, sparkling with colour, bountiful with life. Within decades we must close our eyes again. Isn't it a noble, an sssssenlightened way of spending our brief time in the sun, to work at understanding the universe and how we have come to wake up in it? This is how I answer when I am asked -- as I am surprisingly often -- why I bother to get up in the mornings. To put