

Physics and the Mind of God: The Templeton Prize Address

Paul Davies

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It is both an honor and a pleasure for me to speak in this world-famous Abbey, just a few metres from the remains of Isaac Newton. Along with Einstein and Darwin, Newton is one of the few scientists known to almost every member of the population. He is one of the great heroes of my own discipline, physics, even if his career as a civil servant left a lot to be desired.

It was Newton, Galileo, and their contemporaries who created science as we know it, three centuries ago. Today we take the scientific method of enquiry so much for granted that few people stop to think how astonishing it is that science works.

I was fascinated to learn that one of the judges for the Templeton Prize was Baroness Thatcher. This is in fact the second time she has been involved in giving me a prize. The first occasion was in 1962, at the Speech Day of Woodhouse Grammar School in North Finchley, when she presented me with a copy of Norton's Star Atlas for doing well in my O level exams. I doubt if her Ladyship recalls the encounter, but I can trace my own decision to become a scientist more or less to that event.

Like all school pupils, I learned science as a set of procedures that would reveal how nature works, but I never questioned why we were able to do this thing called science so successfully. It was only after a long career of research and scholarship that I began to appreciate just how deep scientific knowledge is, and how incredibly privileged we are to be able to unlock the secrets of nature in such a powerful way.

Of course, science did not spring ready-made into the minds of Newton and his colleagues. They were strongly influenced by two longstanding traditions that pervaded European thought. The first was Greek philosophy. Most ancient cultures were aware that the universe is not completely chaotic and capricious: there is a definite order in nature. The Greeks believed that this order could be understood, at least in part, by the application of human reasoning. They maintained that physical existence was not absurd, but rational and logical, and therefore in principle intelligible to us. They discovered that some physical processes had a hidden mathematical basis, and they sought to build a model of reality based on arithmetical and geometrical principles.

The second great tradition was the Judaic worldview, according to which the universe was created by God at some definite moment in the past and ordered according to a fixed set of laws. The Jews taught that the universe unfolds in a unidirectional sequence-what we now call linear time-according to a definite historical process: creation, evolution, and dissolution. This notion of linear time-in which the story of the universe has a beginning, a middle, and an end-stands in marked contrast to the concept of cosmic cyclicity, the pervading mythology of almost all ancient cultures. Cyclic time-the myth of the eternal return-springs from mankind's close association with the cycles and rhythms of nature, and remains a key component in the belief systems of many cultures today. It also lurks just beneath the surface of the Western mind, erupting occasionally to infuse our art, our folklore, and our literature.

A world freely created by God, and ordered in a particular, felicitous way at the origin of a linear time, constitutes a powerful set of beliefs, and was taken up by both Christianity and Islam. An essential element of this belief system is that the universe does not have to be as it is: it could have been otherwise. Einstein once said that the thing that most interested him is whether God had any choice in His creation. According to the Judeo-Islamic-Christian tradition, the answer is a resounding yes.

Although not conventionally religious, Einstein often spoke of God, and expressed a sentiment shared, I believe, by many scientists, including professed atheists. It is a sentiment best described as a reverence for nature and a deep fascination for the natural order of the cosmos. If the universe did not have to be as it is, of necessity-if, to paraphrase Einstein, God did have a choice-then the fact that nature is so fruitful, that the universe is so full of richness, diversity, and novelty, is profoundly significant.

Some scientists have tried to argue that if only we knew enough about the laws of physics, if we were to discover a final theory that united all the fundamental forces and particles of nature into a single mathematical scheme, then we would find that this superlaw, or theory of everything, would describe the only logically consistent world. In other words, the nature of the physical world would be entirely a consequence of logical and mathematical necessity. There would be no choice about it. I think this is demonstrably wrong. There is not a shred of evidence that the universe is logically necessary. Indeed, as a theoretical physicist I find it rather easy to imagine alternative universes that are logically consistent, and therefore equal contenders for reality.

It was from the intellectual ferment brought about by the merging of Greek philosophy and Judeo-Islamic-Christian thought that modern science emerged, with its unidirectional linear time, its insistence on nature's rationality, and its emphasis on mathematical principles. All the early scientists, like Newton, were religious in one way or another. They saw their science as a means of uncovering traces of God's handiwork in the universe. What we now call the laws of physics they regarded as God's abstract creation: thoughts, so to speak, in the mind of God. So in doing science, they supposed, one might be able to glimpse the mind of God-an exhilarating and audacious claim.

In the ensuing three hundred years, the theological dimension of science has faded. People take it for granted that the physical world is both ordered and intelligible. The underlying order in nature-the laws of physics-are simply accepted as given, as brute facts. Nobody asks where they come from; at least they do not do so in polite company. However, even the most atheistic scientist accepts as an act of faith that the universe is not absurd, that there is a rational basis to physical existence manifested as a lawlike order in nature that is at least in part comprehensible to us. So science can proceed only if the scientist adopts an essentially theological worldview.

It has become fashionable in some circles to argue that science is ultimately a sham, that we scientists read order into nature, not out of nature, and that the laws of physics are our laws, not nature's. I believe this is arrant nonsense. You would be hard-pressed to convince a physicist that Newton's inverse square law of gravitation is a purely cultural concoction. The laws of physics, I submit, really exist in the world out there, and the job of the scientist is to uncover them, not invent them. True, at any given time, the laws you find in the textbooks are tentative and approximate, but they mirror, albeit imperfectly, a really existing order in the physical world. Of course, many scientists do not recognize that in accepting the reality of an order in nature-the existence of laws "out there"-they are adopting a theological world view. Ironically, one of the staunchest defenders of the reality of the laws of physics is the American physicist Steven Weinberg, a sort of apologetic atheist who, though able to wax lyrical about the mathematical elegance of nature, nevertheless felt compelled to pen the notorious words, "The more the universe seems comprehensible, the more it also seems pointless."

Let us accept, then, that nature really is ordered in a mathematical way-that "the book of nature," as Galileo said, "is written in mathematical language." Even so, it is easy to imagine an ordered universe that nevertheless remains utterly beyond human comprehension, due to its complexity and subtlety. For me, the magic of science is that we can understand at least part of nature-perhaps in principle all of it-using the

scientific method of enquiry. It is utterly astonishing that we human beings can do this-why should the rules on which the universe runs be accessible to humans?

The mystery is all the greater when one takes into account the cryptic character of the laws of nature. When Newton saw the apple fall, he saw a falling apple. He did not see a set of differential equations that link the motion of the apple to the motion of the moon. The mathematical laws that underlie physical phenomena are not apparent to us through direct observation; they have to be painstakingly extracted from nature using arcane procedures of laboratory experiment and mathematical theory. The laws of nature are hidden from us, and are revealed only after much labor. The late Heinz Pagels-another atheistic physicist- described this by saying that the laws of nature are written in a sort of cosmic code, and that the job of the scientist is to crack the code and reveal the message-nature's message, God's message, take your choice, but not our message. The extraordinary thing is that human beings have evolved such a fantastic code-breaking talent. This is the wonder and the magnificence of science: we can use it to decode nature and discover the secret laws the universe follows.

Many people want to find God in the creation of the universe, in the big bang that started it all off. They imagine a Superbeing who deliberates for all eternity, then presses a metaphysical button and produces a huge explosion. I believe this image is entirely misconceived. Einstein showed us that space and time are part of the physical universe, not a pre-existing arena in which the universe happens. Cosmologists are convinced that the big bang was the coming-into-being, not just of matter and energy, but of space and time as well. Time itself began with the big bang. If this sounds baffling, it is by no means new. Already in the fifth century St. Augustine proclaimed that "the world was made with time, not in time." According to James Hartle and Stephen Hawking, this coming-into-being of the universe need not be a supernatural process, but could occur entirely naturally, in accordance with the laws of quantum physics, which permit the occurrence of genuinely spontaneous events.

The origin of the universe, however, is hardly the end of the story. The evidence suggests that in its primordial phase the universe was in a highly simple, almost featureless state: perhaps a uniform soup of subatomic particles, or even just expanding empty space. All the richness and diversity of matter and energy we observe today has emerged since the beginning in a long and complicated sequence of self-organizing physical processes. The laws of physics not only permit a universe to originate spontaneously, but they encourage it to organize and complexify itself to the point where conscious beings emerge who can look back on the great cosmic drama and reflect on what it all means.

Now you may think I have written God entirely out of the picture. Who needs a God when the laws of physics can do such a splendid job? But we are bound to return to that burning question: Where do the laws of physics come from? And why those laws rather than some other set? Most especially: Why a set of laws that drives the searing, featureless gases coughed out of the big bang toward life and consciousness and intelligence and cultural activities such as religion, art, mathematics, and science?

If there is a meaning or purpose to existence, as I believe there is, we are wrong to dwell too much on the originating event. The big bang is sometimes referred to as "the creation," but in truth nature has never ceased to be creative. This ongoing creativity, which manifests itself in the spontaneous emergence of novelty and complexity, and organization of physical systems, is permitted through, or guided by, the underlying mathematical laws that scientists are so busy discovering.

Now the laws of which I speak have the status of timeless eternal truths, in contrast to the physical states of the universe that change with time and bring forth the genuinely new. So we here confront in physics a reemergence of the oldest of all philosophical and theological debates: the paradoxical conjunction of the eternal and the temporal. Early Christian thinkers wrestled with the problem of time. Is God within the stream of time, or outside of it? How can a truly timeless God relate in any way to temporal beings such as ourselves? But how can a God who relates to a changing universe be considered eternal and unchangingly perfect?

Physics has its own variations on this theme. In our century, Einstein showed us that time is not simply "there" as a universal and absolute backdrop to existence-it is intimately interwoven with space and matter. As I have mentioned, time is revealed to be an integral part of the physical universe; indeed, it can be warped by motion and gravitation. Clearly something that can be changed in this manner is not absolute, but a contingent part of the physical world.

In my own field of research-called quantum gravity-a lot of attention has been devoted to understanding how time itself could have come into existence in the big bang. We know that matter can be created by quantum processes. There is now a general acceptance among physicists and cosmologists that space-time can also originate in a quantum process. According to the latest thinking, time might not be a primitive concept at all, but something that has "congealed" from the fuzzy quantum ferment of the big bang, a relic, so to speak, of a particular state that froze out of the fiery cosmic birth.

If it is the case that time is a contingent property of the physical world rather than a necessary consequence of existence, then any attempt to trace the ultimate purpose or design of nature to a temporal Being or Principle seems doomed to failure. While I do not wish to claim that physics has solved the riddle of time-far from it-I do believe that our advancing scientific understanding of time has illuminated the ancient theological debate in important ways. I cite this topic as just one example of the lively dialogue that is continuing between science and theology.

A lot of people are hostile to science because it demystifies nature. They prefer the mystery. They would rather live in ignorance of the way the world works and our place within it. For me, the beauty of science is precisely the demystification, because it reveals just how truly wonderful the physical universe really is. It is impossible to be a scientist working at the frontier without being awed by the elegance, ingenuity, and harmony of the lawlike order in nature. In my attempts to popularize science, I am driven by the desire to share my own sense of excitement and awe with the wider community; I want to tell people the good news. The fact that we are able to do science, that we can comprehend the hidden laws of nature, I regard as a gift of immense significance. Science, properly conducted, is a wonderfully enriching and humanizing enterprise. I cannot believe that using this gift called science-using it wisely, of course-is wrong. It is good that we should know.

So where is God in this story? Not especially in the big bang that starts the universe off, nor meddling fitfully in the physical processes that generate life and consciousness. I would rather that nature can take care of itself. The idea of a God who is just another force or agency at work in nature, moving atoms here and there in competition with physical forces, is profoundly uninspiring. To me, the true miracle of nature is to be found in the ingenious and unswerving lawfulness of the cosmos, a lawfulness that permits complex order to emerge from chaos, life to emerge from inanimate matter, and consciousness to emerge from life, without the need for the occasional supernatural prod; a lawfulness that produces beings who not only ask great questions of existence, but who, through science and other methods of enquiry, are even beginning to find answers.

You might be tempted to suppose that any old rag-bag of laws would produce a complex universe of some sort, with attendant inhabitants convinced of their own specialness. Not so. It turns out that randomly selected laws lead almost inevitably either to unrelieved chaos or boring and uneventful simplicity. Our own universe is poised exquisitely between these unpalatable alternatives, offering a potent mix of freedom and discipline, a sort of restrained creativity. The laws do not tie down physical systems so rigidly that they can accomplish little, but neither are they a recipe for cosmic anarchy. Instead, they encourage matter and energy to develop along pathways of evolution that lead to novel variety-what Freeman Dyson has called the principle of maximum diversity: that in some sense we live in the most interesting possible universe.

Scientists have recently identified a regime dubbed "the edge of chaos," a description that certainly characterizes living organisms, where innovation and novelty combine with coherence and cooperation. The edge of chaos seems to imply the sort of lawful freedom I have just described. Mathematical studies suggest that to engineer such a state of affairs requires laws of a very special form. If we could twiddle a knob and change the existing laws, even very slightly, the chances are that the universe as we know it

would fall apart, descending into chaos. Certainly the existence of life as we know it, and even of less elaborate systems such as stable stars, would be threatened by just the tiniest change in the strengths of the fundamental forces. The laws that characterize our actual universe, as opposed to an infinite number of alternative possible universes, seem almost contrived-fine-tuned, some commentators have claimed-so that life and consciousness may emerge. To quote Dyson again: it is almost as if "the universe knew we were coming." I cannot prove to you that this is design, but whatever it is it is certainly very clever.

Now some of my colleagues embrace the same scientific facts as I, but deny any deeper significance. They shrug aside the breathtaking ingenuity of the laws of physics, the extraordinary felicity of nature, and the surprising intelligibility of the physical world, accepting these things as a package of marvels that just happens to be. But I cannot do this. To me, the contrived nature of physical existence is just too fantastic for me to take on board as simply "given." It points forcefully to a deeper underlying meaning to existence. Some call it purpose, some design. These loaded words, which derive from human categories, capture only imperfectly what it is that the universe is about. But that it is about something, I have absolutely no doubt.

Where do we human beings fit into this great cosmic scheme? Can we gaze out into the cosmos, as did our remote ancestors, and declare: "God made all this for us"? I think not. Are we then but an accident of nature, the freakish outcome of blind and purposeless forces, incidental by-product of a mindless, mechanistic universe? I reject that, too. The emergence of life and consciousness, I maintain, are written into the laws of the universe in a very basic way. True, the actual physical form and general mental make-up of *Homo sapiens* contain many accidental features of no particular significance. If the universe were rerun a second time, there would be no solar system, no Earth, and no people. But the emergence of life and consciousness somewhere and somewhen in the cosmos is, I believe, assured by the underlying laws of nature. The origin of life and consciousness were not interventionist miracles, but nor were they stupendously improbable accidents. They were, I believe, part of the natural outworking of the laws of nature, and as such our existence as conscious enquiring beings springs ultimately from the bedrock of physical existence-those ingenious, felicitous laws. That is the sense in which I wrote in *The Mind of God*: "We are truly meant to be here." I mean "we" in the sense of conscious beings, not *Homo sapiens* specifically. Thus although we are not at the center of the universe, human existence does have a powerful wider significance. Whatever the universe as a whole may be about, the scientific evidence suggests that we, in some limited yet ultimately still profound way, are an integral part of its purpose.

How can we test these ideas scientifically? One of the great challenges to science is to understand the nature of consciousness in general and human consciousness in particular. We still have no clue how mind and matter are related, or what process led to the emergence of mind from matter in the first place. This is an area of research that is attracting considerable attention at present, and for my part I intend to pursue my own research in this field. I expect that when we do come to understand how consciousness fits into the physical universe, my contention that mind is an emergent and in principle predictable product of the laws of the universe will be borne out.

Moreover, if I am right that the universe is fundamentally creative in a pervasive and continuing manner, and that the laws of nature encourage matter and energy to self-organize and self-complexify to the point that life and consciousness emerge naturally, then there will be a universal trend or directionality towards the emergence of great complexity and diversity. We might then expect life and consciousness to exist throughout the universe. That is why I attach such importance to the search for extraterrestrial organisms, be they bacteria on Mars or advanced technological communities on the other side of the galaxy. The search may prove hopeless-the distances and numbers are certainly daunting-but it is a glorious quest. If we are alone in the universe, if the Earth is the only life-bearing planet among countless trillions, then the choice is stark. Either we are the product of a unique supernatural event in a universe of profligate over-provision, or else an accident of mind-numbing improbability and irrelevance. On the other hand, if life and mind are universal phenomena, if they are written into nature at its deepest level, then the case for an ultimate purpose to existence would be compelling.

It is often pointed out that people are increasingly turning away from the established religions. However, it remains as true as ever that ordinary men and women yearn for some sort of deeper meaning to their lives,

what is sometimes loosely referred to as a "spiritual" aspect. Our secular age has led many people to feel demoralized and disillusioned, alienated from nature, regarding their existence as a pointless charade in an indifferent, even hostile, universe, a meaningless three-score years and ten on a remote planet wandering amid the vastness of an uncaring cosmos. Many of our social ills can be traced to the bleak worldview that three hundred years of mechanistic thought have imposed on us—a worldview in which human beings are presented as irrelevant observers of nature rather than an integral part of the natural order. Some may indeed recoil from this philosophy and find comfort in ancient wisdom and revered texts that place mankind at the pinnacle of creation and the center of the universe. Others choose to put their faith in so-called New Age mysticism, or resort to bizarre religious cults.

I would like to suggest an alternative. We have to find a framework of ideas that provides ordinary people with some broader context to their lives than just the daily round, a framework that links them to each other, to nature, and to the wider universe in a meaningful way, that yields a common set of principles around which peoples of all cultures can make ethical decisions yet remains honest in the face of scientific knowledge; indeed, that celebrates that knowledge alongside other human insights and inspirations. The scientific enterprise as I have presented it may not return human beings to the center of the universe, it may reject the notion of miracles other than the miracle of nature itself, but it does not make human beings irrelevant either. A universe in which the emergence of life and consciousness is seen, not as a freak set of events, but fundamental to its lawlike workings, is a universe that can truly be called our home.

I believe that mainstream science, if we are brave enough to embrace it, offers the most reliable path to knowledge about the physical world. I am certainly not saying that scientists are infallible, and neither am I suggesting that science should be turned into a latter-day religion. But I do think that if religion is to make real progress it cannot ignore the scientific culture; nor should it be afraid to do so, for as I have argued, science reveals just what a marvel the universe is.

If religion is to progress it must confront modern scientific thought. Over the years I have enjoyed fruitful discussions on science and religion with theologians of varying persuasions—behind closed doors. What has most impressed me about my encounters with these theologians has been their open-mindedness and willingness to accept the conclusions of modern science. While the interpretation of the scientific account of the world may be contentious, there is considerable consensus on the scientific facts themselves. Basic notions like the big bang theory, the origin of life and consciousness by natural physical processes, and Darwinian evolution seem to cause these theologians little difficulty.

Yet among the general population there is a widespread belief that science and theology are forever at loggerheads, that every scientific discovery pushes God further and further out of the picture. It is clear that many religious people still cling to an image of a God-of-the-gaps, a cosmic magician invoked to explain all those mysteries about nature that currently have the scientists stumped. It is a dangerous position, for as science advances, so the God-of-the-gaps retreats, perhaps to be pushed off the edge of space and time altogether, and into redundancy.

The position I have presented to you today is radically different. It is one that regards the universe, not as the plaything of a capricious Deity, but as a coherent, rational, elegant, and harmonious expression of a deep and purposeful meaning. I believe the time has now come for those theologians who share this vision to join me and my scientific colleagues to take the message to the people.

Paul Davies is Professor of Mathematical Physics at the University of Adelaide in Australia and the twenty-fifth recipient of the Templeton Prize for Progress in Religion, which hereceived on May 3, 1995 at Westminster Abbey. His books include *The Mind of God*, *God and New Physics*, *The Cosmic Blueprint*, *Superforce*, and *Other Worlds*.