

## CHAPTER EIGHT

*The limitless power of science*

P. W. ATKINS

I shall explore what I see as the scope of science in explaining the structure and events in the world and ask whether it is limitless. It is therefore inevitable that I speak of religion too, and of its claims that it is an essential component of our understanding of things.

I shall begin with religion's place in the world of explanation. The inclination of the religious seems to be to hope to accommodate the discoveries of science, and in doing so to find a richer comprehension of the world. No religious person, the religious claim, should fear the apparent tensions of science and religion, for their conflict is superficial. In due course it will be seen, it is claimed, that science and religion are partners in a joint activity: the two streams of enquiry and revelation will merge and be seen to be mutually enriching, not mutually annihilating. A well-rounded view of the world will be obtained, the religious claim, only if we listen to science, and its message about its zone of competence, as closely as we listen to the Bible; for science is said to elaborate the Bible. Religion is the antidote to reductionism, for it illuminates the whole rather than the fragments of comprehension.

That, I believe, summarizes in a general way the stance of the scientifically articulate religious believer. It is attractive because it has an air of humility laced with generosity, and it appeals to those who take satisfaction from arguments that conclude in the concord of harmonious compromise. An alternative point of view, however, is that religion has had its day and that science, and the tracing of phenomena to its atomic roots that epitomizes reductionism, should be regarded as supreme. It may be that the religious (and the faint-hearted among agnostic or disinterested and busy scientists) are seeking a final compromise with science. That compromise, which is urged on us when we are encouraged to divide up domains of enquiry, is the last vain attempt to accommodate the conqueror before religion loses all claim to the respect of minds and pretence of truth. I consider that the survival of

religion and the antireductionism that it represents survives merely because it is so deeply ingrained in our cultural attitudes, and its survival is independent of its intrinsic truth. The stifling grip of religion on Man's mind stems partly from its early start, when, as our ancestors dropped from the trees they first sought explanations and solace; it also stems partly from religion's control (for both benevolent and malevolent purposes) of the behaviour of individuals and societies, and it stems partly from its capture of the literature and the arts, which has given it a powerful imagery. Someone with a fresh mind, one not conditioned by upbringing and environment, would doubtless look at science and the powerful reductionism that it inspires as overwhelmingly the better mode of understanding the world, and would doubtless scorn religion as sentimental wishful thinking. Would not that same uncluttered mind also see the attempts to reconcile science and religion by disparaging the reduction of the complex to the simple as attempts guided by muddle-headed sentiment and intellectually dishonest emotion?

But, the antireductionists will cry, we need to listen to the spirit and that science cannot replace. Now, though, you speak of the illumination provided by poets, and although poets may aspire to understanding, their talents are more akin to entertaining self-deception. They may be able to emphasize delights in the world, but they are deluded if they and their audience believe that their identification of the delights and their use of poignant language are enough for comprehension. Philosophers, too, I am afraid, have contributed to the understanding of the Universe little more than poets. They have raised questions, examined the frailties and imprecisions of human languages, and have worried a great deal about what may be a question, but they have not contributed much that is novel until after novelty has been discovered by scientists.

Theologians, incidentally, have contributed nothing. They have invented a world and language of their own, like some mathematicians, but unlike many mathematicians have sought to impose its percepts and precepts on this world. In so doing they have contaminated truth, and wasted the time of those who wish to understand this world. Scientists have had and are continuing to have to scrape away the detritus of religious obfuscation before they can begin their own elucidation.

Scientists, with their implicit trust in reductionism, are privileged to be at the summit of knowledge, and to see further into truth than any of their contemporaries. They are busy in the public domain, where truth can be tested by shared experience, where truth supervenes international boundaries and cultures. Scientists liberate truth from prejudice, and through their work lend wings to society's aspirations. While poetry titillates and theology obfuscates, science liberates.

The grave responsibility of scientists is to use their voices to blow back the fog that shrouds the minds of those who have not yet seen. Scientists are successfully treading the path of reductionism. They are exposing the simple essentials of the world, seeing its mechanism, seeing that they can comprehend its actions, and seeing that they can understand its origin and elucidate the problems that have puzzled people and given priests their power.

Scientists have a duty to reveal to the public their insight into the world's mechanism. They are the beacons of rationality, lighting the trail for those who wish to use that most powerful and precious of devices, the human brain. They light the beacons for those who wish to escape the prejudice of those who, through irrational belief and faith in the ultimately unknowable, live lives blighted by others.

Theism (and the implicit rejection of reductionism) is a system of knowledge based on ignorance, and that twin of ignorance, fear. It would certainly be too much to expect a theologian (or indeed a scientist) to admit that his lifetime's work had been based on a false foundation. It is even less likely that anyone religious, unless they were exceptionally self-honest and intellectually sinewy, would admit that the whole history of their church was based on a clever, but understandable, self-delusion (and in some cases, I suspect, on a straightforward conscious lie). I consider that religion is a delusion propagated by a combination of ignorance, art, and fear, fanned into longevity and ubiquity by the power it gave to those in command.

Religion emerged from magic, and has never completely discarded its origins. It is a sophistication and institutionalization of magic. It is an elaboration of our bewildered ancestor's belief that there are forces to be cajoled and appeased. Its present power stems from the grip it exerts on minds with its amelioration of the prospect of death, and from its ability to provide sustenance for those exposed to the hardships of life. In its quest for understanding and its intention to help, religion is good. But at root, being founded on ignorance, it is baseless. Religion is utterly unable to digest the paradigm of reductionism, for it rejects the possibility of overall understanding that will come from the reduction of the complexity of the world to its simple substructure and the awesomely difficult tracking of the interrelations of that simplicity back into the complexity of perceived events.

Let me contrast the styles of evidence for theistic and scientific explanations. Suppose you have a blank, unprejudiced mind and are presented with the evidence for religion. You are shown some very beautiful words, and some equally beautiful buildings. Many of the intentions you are shown are highly laudable. At the centre of the evidence you are shown a great and ornate cabinet, a cabinet encrusted with love and time and labelled Faith. You are told

that everything outside the cabinet is not really central, that the most compelling evidence, the irrefutable evidence, the evidence to out-jury any jury lies in that cabinet of Faith. However, you are also told, amid assurances that the evidence is indeed inside, and very, very compelling, that to inspect the interior of the glorious cabinet it is necessary to enter through the door marked Death. What adult, rational intellect would accept such hypocrisy? Only, I claim, the unthinking, the intellectually dishonest, and the people who cannot come to terms with the prospect of their own annihilation.

Science, the system of belief founded securely on publicly shared reproducible knowledge, emerged from religion. As science discarded its chrysalis to become its present butterfly, it took over the heath. There is no reason to suppose that science cannot deal with every aspect of existence. Only the religious—among whom I include not merely the prejudiced but also the underinformed—hope that there is a dark corner of the physical Universe, or of the universe of experience, that science can never hope to illuminate. But science has never encountered a barrier, and the only grounds for supposing that reductionism will fail are pessimism in the minds of scientists and fear in the minds of the religious. The frightened seek to erect false barriers, and vainly hope to preserve their gods from annihilation by defining different domains of competence for science and religion, and by pretending that science is incompetent when it brings its razor to bear on belief.

Religion closes off the central questions of existence by attempting to dissuade us from further enquiry by asserting that we cannot ever hope to comprehend. We are, religion asserts, simply too puny. Through fear of being shown to be vacuous, religion denies the awesome power of human comprehension. It seeks to thwart, by encouraging awe in things unseen, the disclosure of the emptiness of faith. Religion, in contrast to science, deploys the repugnant view that the world is too big for our understanding. Science, in contrast to religion, opens up the great questions of being to rational discussion, to discussion with the prospect of resolution and elucidation. Science, above all, respects the power of the human intellect. Science is the apotheosis of the intellect and the consummation of the Renaissance. Science respects more deeply the potential of humanity than religion ever can.

Simple ideas distinguish science so gloriously from religion, and science's self-sufficiency, its ability to deal with any problem without needing to import some external mysterious cause. Science identifies simple concepts that effloresce brilliantly and publicly into testable conclusions. That is high reductionism. Religion expresses indefinite, obscure ideas that are sometimes a practical (but not always a beneficial) foundation for ethics and morality, but beyond being a guide for human behaviour (for good or for ill) and a salve for the oppressed (and sometimes a weapon of oppression) have no success,

utterly none, in the accounting for, let alone predicting, the phenomena of the world. That is the legacy of no reductionism.

There are, to my mind, two great aspects of science in which humanity should take delight. One is the connection science exposes between the disparate. Science, by pursuing the reduction of observation to underlying simplicities, exposes the unity of the world. We see through reductionist science that knowing one thing explains many. As we untangle the composition of Nature we see that it conjures differences by the simple modification of a chemical bond or the deployment of a different atom. It is so important to understand that science identifies extremely simple concepts of exceptional richness and shows how they bind together the apparently disparate into a web. It is the task of science to identify the seeds of explanation, and to plant them like acorns into minds. There they will grow, and people and we among them will come to see that the explanations of the perceived world are as an oak to its acorn.

The second feature of science is that it shows that the world is simple. Even many scientists do not appreciate that they are hewers of simplicity from complexity. They are often more deluded than those they aim to tell. Scientists are often overawed by the complexity of detecting simplicity. They look at the latest fundamental particle experiment, see that it involves a thousand kilograms of apparatus and a discernible percentage of a gross national product, and become thunderstruck. They see the complexity of the apparatus and the intensity of the effort needed to construct and operate it, and confuse that with the simplicity that the experiment, if successful, will expose. Some scientists are so awestruck that they even turn to religion! Others keep a cool head, and marvel not at an implied design but at the richness of simplicity.

Most scientists glance at a mathematical formula and see awesome complexity, and marvel at the brain that first derived it. Like priests, some then seek to retain the mysteries. The awe is well aimed, but nevertheless not quite the correct response. There should be awe reserved for the original discoverer, for few have the power to discover new continents, or even islands, of knowledge. There should be delight, not awe, for the reconfirmation that the human brain is such a brilliant instrument that it can make light of darkness. But most important of all, there should be realization that a connection and a simplicity have been exposed. The connection is the formula, which bundles several knowns together, and shows that they account for another known. The simplicity is the reduction of the concepts that the new relation implies, although this is often interpreted as a complexity.

I can give you an idea of what it is I mean by talking a little about one of the greatest insights of science, the Second Law of thermodynamics. As far as we are concerned, all this law states is that all events are accompanied by an

increase in disorder. The world is slipping into chaos. Some are puzzled by that remark for they cannot see that people can emerge. Those benighted dark-bound over-prejudiced commentators the creationists think that the Second Law is a sign that Man must have been created, for how can ordered Man arise spontaneously from disordered slime? A scientist says 'good question', and then proceeds to answer it by showing that collapse into disorder may be constructive. Events do not occur in isolation, and if an event here creates much disorder, and is connected to a process there that leads to the elimination of less disorder, then the joint process may occur spontaneously because it leads to net disorder. Those who look at the flower opening, or the fish evolving, may see only the constructive process, and be awed. Those others of us who trace the connections and see not only the flower opening but also the decay elsewhere, those of us who see the entire process, see overall collapse, and stand in less awe. Our awe is now directed at the richness of the interconnection and the ramifications of chaos, not at the burgeoning, apparently purposeful, emergence of form.

Dispersal into disorder creates because it need not be uniformly smooth. A flood of chaos there may result in a surge of order here. The purposeless increase in disorder of the world is not a smoothly descending river of energy, but a choppy rapid, that may throw up a structured foam and an elaborate wave as it plunges down. That order may take the form of a protein formed by an enzyme driven ultimately by the energy of the Sun, or the construction of a strip of DNA. It may power the jaws of a cheetah and the emergence on its coat of the stripes of a zebra. Thus the Second Law may erupt into evolution, and stronger cheetahs and better camouflaged zebras may emerge, transitorily, as the universe globally spreads in disorder. Thus the 'Creation'—everything—emerges as chaos spreads.

A gross contamination of the reductionist ethic is the concept of purpose. Science has no need of purpose. All events at the molecular level that lies beneath all our actions, activities, and reflections are purposeless, and are accounted for by the collapse of energy and matter into ever-increasing disorder. The richness of the events of the world stems from the interconnection of the collapse into the network that, here and there, as at you and me, can throw up a local abatement of chaos that we interpret as an action or a deed. Behaviour is also ultimately collapse into disorder, even though that behaviour may on occasion be exquisite.

Natural selection, like the interpretation of the Second Law, is one of the most beautiful theories of science, for it is so economical yet powerful. That is, it is simple, yet admits as a consequence complexity. That is the hallmark of high science and the apotheosis of reductionism. From a simple precept (e.g. the unconscious tendency of genes to survive in the face of unconscious

competition) the whole gamut of organisms in the creation can be seen to emerge. It is then entirely gratuitous (but science cannot demonstrate that it is incorrect) to suppose that evolution has been guided teleologically or that matter had some in-built tendency to aggregate complexity. Both speculations are entirely possible, just as other profligate speculations are also possible, such as the unsupported musings that this universe is constantly splitting into others that have no communication with us, or that there is a teapot in orbit around Mars.

Science can perform its elucidation without appealing to the shroud of obscurity of man-made artifice, including that supreme artifice the presumption of purpose. A block of hot metal will cool, not because its purpose is to cool, but because the spontaneous chaotic dispersal of its energy results in its cooling. A shoot emerges from a seed and grows into a plant, not because the seed's purpose is to grow but because the intricate network of reactions in its cells are gearboxes that drive its growth as the rest of the world sinks a little more into chaos. The lily is a flag hoisted by collapse into purposeless chaos. All the extraordinary, wonderful richness of the world can be expressed as growth from the dunghill of purposeless interconnected corruption. People, too, have emerged as the same dunghill has effloresced. One molecule capable of reproducing itself in its own image is all it needs to set the world on the progress that culminates in it being peopled with persons.

Let me speak now a little of the attitudes that science inspires and adopts in order to discover more about the world. Science, as I have said, favours simplicity. Science is the arch-descendant of Ockam. How dare those theologians so obscure truth by their gildings, their hangings, their sentiment, their wishful thinking, their personal fears, and their network of intrusion into personal liberty! They have no right to claim that 'God' is an extreme simplicity, and as cogent and potent an explanation of our origins as is necessary. A 'God' is the embodiment of complexity, the ultimate antisimplicity. Maintaining that God is an explanation (of anything, not merely Creation) is an abnegation of the precious human power of reasoning out comprehension.

When confronted with the analysis of any concept, however complex, the only intellectually honest attitude to adopt is one of exploring the extent to which an absolutely minimal approach will prove sufficient to account for the reliable evidence. There is no justification for a departure from this attitude when the complex concept is that of our own origin or cosmic purpose, however deeply emotive and close to our sensibilities the subject may be and however we may long for a comforting outcome.

In seeking to understand our origin and our purpose science examines whether an absolutely minimal approach is sufficient. Only if a minimal

approach is explicitly demonstrated to be inadequate may there be some justification in indulging in the soft furnishings of additional hypotheses. Science explores, and is having success in showing that our individual existence, persistence, and role in this universe can be explained without the accretion of invented hypothetical additions. Science shows that all our attributes can be explained without the sugar coating of invented attributes that have been proposed by the underinformed or the wily and have been adhered to generally by the religious.

Science is in the midst of showing that the concept of existence can survive the absolute simplicity of stripped-down explanations and their ramifications. Is there any support for the existence of something beyond the absolutely sparse? Is there life beyond bones? Are the fat and tallow of religious and other forms of philosophical or psychological justification necessary and not merely desirable? Science is succeeding without them.

Science treads everywhere, and worms itself under the scabs that religion regards as protecting the special tender patches of human existence. The religious go to intellectual war to maintain that in some areas secularly inspired logic cannot tread. Yet reductionist science is omniscient. Science has never encountered a barrier that it has not surmounted or that we can at least reasonably suppose it has power to surmount and will in due course be equipped to do so. There is no explicitly demonstrated validity in the view that there are aspects of the universe closed to science. I can accept, given the success with which science has encroached on the territory once regarded as traditionally religion's, that many people hope its domain of competence will prove bounded, with things of the spirit on that side of the fence and things of the flesh on this. But until it is proved otherwise, there is no reason to suppose that science is incompetent when it brings its razor to bear on belief. Until the day that science is explicitly shown to be incompetent, we should acknowledge that its not-yet-stopped reductionist razor is slicing through the fabric of the heavens, and is leading us towards an extraordinary deep understanding of the composition, organization, and origin of the world.

Science is slowly equipping itself to deal with aesthetic and religious experiences, and will be able to account for the perception of oneself as a distinct but responding entity. It will do so, I do not doubt, by showing that these characteristically human capacities, which we lump together for convenience of discourse as 'human spirit' or 'soul', are no more than psychological states of the brain. Likewise, that other component of our existence, the wishful thinking extension of the idea of 'soul' to the expectation of eternal persistence, is already quite plainly explicable in terms of the deep-seated desire to avoid, and the inability to come to terms with, the prospect of one's own annihilation.

There is no reason why consciousness should not be admitted into the kingdom of scientific explanation. Consciousness, like growth and digestion, is open to scientific explanation. There is no evidence that the brain's workings require non-physical impositions. The principal activity of the brain, that of sustaining a sense of consciousness through a lifetime, is open to explanation rooted in its physical structure (as governed by the body's genes being inherited and finding expression through the purposeless workings of the second Law, essentially building on the purposeless collapse of sandwiches into chaos) and its chemical activity (also the manifestation of the Second Law, in the same way). We can never hope to give a formula for the brain (whatever that might mean); but that is not the reductionist programme. Our programme is to comprehend its structure and mechanism to the point where we can build a reasonably accurate simulacrum. Such a brain might well have doubts about its role, an impression of purpose (in which it will be right), and fear that a switch can too lightly be thrown.

Once consciousness is admitted to the kingdom of science, then all our mental attributes are open to comprehension and not merely awe. The brain is subtle and capable it seems of infinite understanding of its self, its origin, its cosmic origin, the origin of the cosmos, and of that cosmos's immediate, intermediate, and long-term featureless future. However, like other complex instruments, the brain can make errors, especially when the opinions it sometimes expresses are pressed on it, and especially when they are widely supported by others. Thus the brain can hallucinate, and it can become perplexed, and armchair brains can avoid unnecessary exercise by adopting easy explanations. Some of these failures lead to poetic expression, others to religious fervour, and some to undisguised madness. All of them, though, are an abnegation of the brain's true power of understanding, which is to be found only in scientific explanation.

My scientific world-view is bleak in terms of its origins, its motivations, and its future. Yet, unless it can be explicitly demonstrated otherwise, it should be the sparse working hypothesis to account for our existence. If everything in the world can be accommodated in this bony view, then there is no justification to impose on our understanding the hypothetical extraneous. I challenge anyone who seeks, hopes, and believes in a seductively richer opinion and a rosier destiny, to travel to the bedrock of existence, and to build their beliefs on it only as their shelter is shown to be essential. I maintain that all softenings of my absolutely barren view of the foundations of this wonderful, extraordinary, and delightful world are sentimental wishful thinking.

Religion is argument by sentiment. Most thinking people would probably agree that the physical laws are best discovered by experiment, not sentiment. However, there will be those who see 'sentiment' as an antenna that responds

to the side of nature left in shadow by science's emotionless glare, and sees what science cannot see. Let me stress again that I do not consider that there is any corner of the real universe or the mental universe that is shielded from this glare, and that there is no aspect of understanding where sentiment is a better source of understanding than science. This is particularly so in our understanding of the origin of ourselves and the Universe, including without exception its matter, energy, opinions, and its morals. Least of all do I favour the special pleading of a sentiment that drives arguments forward in a passionate chase towards the avoidance of annihilation by methods other than scientific and, that subset of science, medicine. I long for immortality, but I know that my only hope of achieving it is through science and medicine, not through sentiment and its subsets, art and theology.

Science is exceptionally honest, and succeeds because it bares its breast to constant attack. Take the goal it has for its description of the creation. If reductionist science is to be proved omniscient it must achieve a complete description, one devoid of precursor and intervention. That is, it must account for everything in the world, not only atoms, aardvarks, electrons, and lecturers, but also the sense of human spirit, goodwill, religious enthusiasm, and beliefs in Gods and the powers of potions and prayers. Moreover, if it is to be honest, it must achieve all this by starting from something without a precursor; that is, it must start from nothing at all. The scientific account of cosmogenesis cannot stop when it has accounted for the universe springing from a seed the size of a Sun, nor when it has arrived at a seed the size of a pea. Nor can it stop at any smaller seed. A seed the size of a proton implies that that seed had to be manufactured, placed there by some cosmic pre-existing gardener. Science will be forced to admit defeat if it has to stop at a seed of any size. That is the severity of the criterion that science sets for itself. If we are to be honest, then we have to accept that science will be able to claim complete success only if it achieves what many might think impossible: accounting for the emergence of everything from absolutely nothing. Not almost nothing, not a subatomic dust-like speck, but absolutely nothing. Nothing at all. Not even empty space.

How different this is from the soft flabbiness of a nonscientific argument, which typically lacks any external criterion of success except popular acclaim or the resignation of unthinking acceptance. One typical adipose arch-antireductionist argument may be that the world and its creatures were created (by something called a God), and that was that. Now, that may be true, and I cannot prove that it is not. However, it is no more than a paraphrase of the statement that 'the universe exists'. Moreover, if you read into it an active role for the God, it is an exceptionally complex explanation, even though it sounds simple, for it implies that everything (or almost everything,

even if the God supplied no more than electrons and quarks) had to be provided initially.

My personal belief for the future of cosmology is that we shall shortly have to start thinking about what happened on the other side of zero. I suspect that the only route to knowledge about the structure and properties of the Universe and the processes that accompanied its inception is to speculate about the events that preceded the Creation. I see that we shall need to build a model of what was before there was time in a place not in space, and to explore whether its consequence was creation. We shall, in a sense, need to model nothing, and to see if its consequences are this world. I don't regard that as impossible or ludicrous; I regard it as the next logical step for the development of the paradigms of science.

The attitude that I advocate is that the omniscience of science, and in particular the simplicity its reductionist insight reveals, should be accepted as a working hypothesis until, if ever, it is proved inadequate. I began by wondering whether science and religion could be reconciled and if they were complementary explorations of the cosmos. I have to conclude that they cannot be reconciled. A scientist's explanation is in terms of a purposeless, knowable, and understandable fully reduced simplicity. Religion, on the other hand, seeks to explain in terms of a purposeful, unknowable, and incomprehensible irreducible complexity. Science and religion cannot be reconciled, and humanity should begin to appreciate the power of its child, and to beat off all attempts at compromise. Religion has failed, and its failures should stand exposed. Science, with its currently successful pursuit of universal competence through the identification of the minimal, the supreme delight of the intellect, should be acknowledged king.

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## CHAPTER NINE

# *Reductive megalomania*

MARY MIDGLEY

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### THE REDUCTIVE TEMPER

I want to examine the reductive approach as a general attitude, rather than looking at the forms of actual reductions. These forms vary. There can be reduction of wholes to parts, of mind to body, or of different conceptual schemes to one unifying one. But the use of the special word 'reductive' points to something they are believed to have in common. This element does not seem to be only a formal one. The point is not just that these are all ways of simplifying the conceptual scene. It concerns intentions, and examining those intentions is not an irrelevant, psychoanalysing exercise, because formal reductions don't spring up on their own, like weeds in a garden. They are not value-free. They are always parts of some larger enterprise, some project for reshaping the whole intellectual landscape, and often our general attitude to life as well. Whenever we get seriously involved in the business of reduction, either as supporters or resisters, we are usually responding to these wider projects.

My first point is that we need to be aware of these projects and to discuss them explicitly, even when they lead us far outside our specialities. We cannot settle the vast, looming, vulgar background questions indirectly by fixing the small logical issues. You can't shift a muck-heap with a teaspoon. My second point—about reductivism in particular—is that the large background projects involved are never just destructive but always aim at something positive as well. In our time, reduction overwhelmingly presents itself as purely negative, a mere exercise in logical hygiene, something as obviously necessary as throwing out the rubbish. But this presupposes that we have already made sure what we want to throw away and what we want to make room for.

Parsimony is a respectable ideal, but it is not one that makes sense on its own. In thought as in life, false economy is possible. We cannot tell what we