Humility and Cosmology

Peter Hodgson

According to the Hebrew cosmology the earth was flat and the sky was like an upturned bowl studded with stars. The earth, and the creatures of the earth, were made to serve man and are under his domination. This view sufficed for many millennia. Careful studies of the regular motions of the stars and the irregular motions of the planets were made by the Babylonians and the Greeks, and Ptolemy devised a complicated system of cycles and epicycles to describe these motions with some accuracy. It was a cosy, man-centred world.

The development of modern science destroyed this picture with a series of shattering blows. Firstly Copernicus showed that it was much simpler to suppose that the sun, and not the earth, is the centre of the world. No longer do we think of the sun serving our needs by circling the earth, night and day. It is we who are ruled by the sun. This view of the sun and the planets was firmly established by the dynamics of Newton, which enabled the orbits of the planets to be calculated from his laws of motion, together with his theory of universal gravitation.

In the following centuries telescopes of increasing power probed further into space, and it became apparent that our resplendent sun is but a rather ordinary star situated in one of the spiral arms of a vast galaxy of some two hundred thousand million stars that we see on clear nights as the Milky Way. Yet more powerful telescopes showed that there is nothing special about our galaxy, which is but one of a hundred thousand million galaxies spread through the vastness of space, like motes in a cathedral.

What remains of the centrality of man, and of the world made for him by God? Compared with the vastness of space, we are totally insignificant. It should make us very humble, or perhaps afraid. We can be filled with awe and reverence, and with the Psalmist we can rejoice that the Heavens show forth the glory of the Lord. Or, with Pascal, we can be terrified by the vastness of space, realising that "man is but a reed, the most feeble thing in nature. The entire universe need not arm itself to crush him; a vapour, a drop of water, suffices to kill him".

It is true that we can reply, again with Pascal, that man "is a thinking reed. If the universe were to crush him, man would still be nobler than that which killed him, because he knows that he dies, and the advantages the universe has over him; of this the universe knows nothing". But how can we be sure even of this? Is it not very likely that around some other stars

https://doi.org/10.1111/j.1741-2005.1993.tb07312.x Published online by Cambridge University Press

in far away galaxies there are sentient beings in civilisations immeasurably superior to our own, who know what we are doing and regard our activities in much the same way as we regard those of ants and bees. There are indeed few grounds for pride when we consider our position in the universe. And if there is no other life in the universe, this raises other questions, posed by Margaret Knight, a well-known humanist: "If life is the purpose of creation, what conceivably can be the point of countless millions of lifeless worlds? Or of the aeons of astronomical time before life existed? The Church has glanced uneasily at these questions but it has never answered them".

It was still possible to regard man as a very special being, created by God as lord of creation. This aspect of the centrality of man was fatally undermined by Darwin's evolutionary ideas. He suggested that all living beings evolved over the ages from more primitive organisms, and ultimately from non-living matter. While it was not possible to provide convincing proof, so much evidence was amassed by him and his successors that it now dominates the way we think about living things. There are outstanding gaps in our knowledge, but it solves so many problems and provides so useful a framework for our thinking that its position seems secure.

Darwin's evolutionary theory had two consequences. Firstly it greatly extended the timescale of the word. A literal reading of Biblical chronology indicated a timescale of about six thousand years, and this was obviously insufficient for organic evolution. Contemporary geological studies required an even longer timescale, and ran into the difficulty that it seemed that the sun could not shine for long enough. Physicists calculated that even if it were made of pure coal, it could shine for only about eighty million years, which was not long enough for the geologists.

The second consequence of Darwin's idea was its implicit threat to the uniqueness of man. If all the varieties of living plants and animals evolved from inanimate matter, is not this also true for man himself ? Are we not just the outcome of the blind interactions of material forces, the result of the chance interactions of atoms in an obscure corner of the universe? Is it not all, in the words of Whitehead, nothing more than "the hurrying of matterial, endlessly, meaninglessly?". Should this not induce a new humility? Or should we reflect that if everything is just the result of impersonal material forces, our consciousness is an illusion and therefore humility itself has lost all meaning?

The importance of the time dimension was further emphasised when Hubble discovered, by examining the spectra of the light from the galaxies, that they are receding at velocities proportional to their distances from us. This immediately suggests that they were once concentrated in a small volume and are flying away as a result of a great explosion. This is the theory of the primeval atom, originally due to the Belgian Abbé Lemaître, and is now known as the Big Bang. Calculations showed that this happened about fifteen billion years ago. What we are seeing now, as we look at the night sky, are just the sparks and ashes remaining from that primeval explosion.

There were other theories about the universe. Hoyle, Bondi and Gold proposed that on a sufficiently large scale, the universe is always the same; this was their steady state theory. To maintain the constancy of density they postulated that matter is continually created at just the rate necessary to make up for the loss of density due to the expansion. It turned out that the required rate of creation is far too small to be observable so in this respect the theory could not be disproved.

Measurements showed, however, that at very large distances the density of the galaxies thins out; this is consistent with the big bang theory but not with the steady state theory. A second line of evidence, that was to prove fatal to the steady state theory, came from the detailed understanding of the processes that took place in the first few instants of the big bang. This came from laboratory studies of nuclear and elementary particle reactions. Already Bethe had identified the nuclear reactions taking place in the sun that produce its heat, and thus incidentally removed the difficulty already mentioned about the age of the sun.

Applying this knowledge to the big bang, it became possible to trace in some detail the successive stages of cosmic expansion. According to Weinberg, at an unimaginably small time after the big bang (10^{-34} seconds) there was just a quark soup at a temperature of 10^{27} degrees. After about one hundredth of a second the temperature had fallen to about a hundred thousand million degrees and there was matter and radiation in very close interaction. It was expanding rapidly, but the interaction was so strong that the matter and radiation remained in a state of thermal equilibrium. The most abundant particles were electrons and neutrons and their anti-particles and also photons. There were also some nucleons in the proportion of one proton or neutron for every thousand photons, electrons or neutrinos. These protons and neutrons were in constant interaction with the electrons and neutrinos so that the numbers of protons and neutrons remained the same. There was no possibility of forming more complex particles as the temperature was so high that they would be broken up as soon as they were formed.

As the expansion continued the temperature fell and soon it became slightly easier for a neutron to interact to form a proton than conversely. By the time a tenth of a second had elapsed there were about twice as many protons as neutrons. The density and temperature continued to fall, and after one second the temperature was about ten thousand million degrees. After about fourteen seconds the temperature had fallen to three thousand million degrees, and now the electrons and their anti-particles the positrons annihilated to produce more photons. This rapidly removed most of the electrons and positrons, and also momentarily slowed down the rate of cooling because of the energy released in the annihilation process. Soon it was cool enough for helium nuclei to form, and as the temperature dropped still further it became possible to build up heavier nuclei as well. This continued until all the nuclei of the familiar chemical elements had been formed.

After about half an hour the temperature had fallen to three hundred million degrees, and all the electrons and positrons had been annihilated apart from the small number of electrons needed to provide one for each proton, so that the universe as a whole was uncharged. The period of intense activity was over, but the universe continued to expand, cooling all the time, and after about a million years the temperature had fallen sufficiently to allow the electrons and the nuclei to combine to form atoms. The disappearance of the free electrons made the universe transparent to radiation, and the decoupling of matter and radiation allowed the atoms to condense to star and the stars into galaxies.

All this is worked out in quite precise detail, using the results of measurements in the laboratory of the rate of nuclear and elementary particle reactions. Some of the details may still be uncertain, but the broad lines seem well established.

How do we know that this story is true? Like all scientific theories, it must be subjected to experimental test, and unfortunately we can neither repeat the experiment, nor observe it directly when it happened. We can however, deduce some of the consequences and compare with what we see now. We can calculate the relative abundance of the chemical elements and compare with the observed abundances, and the correspondence is good.

Additional confirmation came from the observation of what is called the cosmic microwave background radiation. At the stage of the formation of the atoms all the electrons were captured by nuclei and thereafter the photons no longer interacted strongly with the rest of the universe. These photons were in statistical equilibrium with each other and their energy distribution is related to their temperature. This is well- known from the early days of the quantum theory, and is given precisely by Planck's formula. As the universe expanded the temperature fell, and with it the average energy of the photons. Since we know the temperature at the time when the matter and the radiation were decoupled, we can calculate the initial energy distribution of these photons and hence their distribution

https://doi.org/10.1111/j.1741-2005.1993.tb07312.x Published online by Cambridge University Press

now.

At the same time as these calculations were being made, this microwave background radiation was actually observed by Penzias and Wilson. They were trying to measure the radio waves from our galaxy, but they found that however they turned their antenna they always detected some radiation, and since its intensity was the same in all directions it could not come from our galaxy. It must come from the universe as a whole, and they realised that it is the radiation left over from the early stages of the big bang. Measurements of the frequency distribution showed that it is very closely what would be expected. Very recently some very slight departures from uniformity have been found in the angular distribution of the radiation. This also supports the big bang theory, because an expansion that is perfectly uniform in all directions would not lead to the differences of densities that eventually lead to stars and to galaxies.

There were several other confirmations of the correctness of the big bang theory, and taken together they now make it the most likely account of the evolution of the universe. The steady state theory is not able to account for these data, and is now discredited.

All this work inevitably suggests the question: what happened before the big bang? It seems to be the ultimate limit of science so perhaps it was the moment of creation. This is not something that can be investigated by scientific methods. It is not possible to observe creation, for the simple reason that before the creation there was nothing and so there can be no observer. Indeed it is possible for the scientist to suggest that before the expansion of the big bang there was a previous contraction leading to a big crunch. While this cannot be observed, it is a theoretical possibility.

This in turn raises the question whether the universe is oscillating, with a whole series of expansions and contractions going on forever. In this we return to the steady state theory, since once more we have a universe that is always doing the same thing, though now on a vastly extended timescale. This whole process can itself be analysed scientifically, and applying the second law of thermodynamics Tolman found that the bounces must steadily get weaker and weaker until they die away altogether. This raises once again the question of the origin.

Another way of testing the idea of an oscillating universe is to see if our present expansion will go on for ever, or whether the expansion will eventually get slower and slower until eventually it stops and turns into a contraction. Whether this happens or not depends on the total mass of the universe. If the mass is great enough, the force of gravitational attraction will slow the expansion down and eventually turn it into an contraction. If the mass is smaller, the expansion will go on forever. To decide this, great efforts have been made to determine the mass of the universe, and at present there seems not to be enough mass to hold the universe together. Several suggestions have been made concerning the possibility of various types of missing mass, and some of these may turn out to be correct. The final answer to this question has not yet been found.

The result of all these scientific studies is a far deeper understanding of the universe and its evolution through time. It is a stupendous story, that should make us deeply humble when we contemplate the vastness of space and time, and all the complicated yet ordered processes that had to take place before we could be born. We can also see the answer to the question of Margaret Knight about the vastness of the universe: all that stupendous evolution was necessary in order that the earth should be made as a habitation for humanity. The processes of nucleosynthesis, by which the elements constituting the human body are built up in the interior of stars, takes billions of years. In this time the galaxies containing these stars will inevitably move vast distances from their point of formation. The universe must be as large and as old as it is so that it can be prepared as a home for humanity.

If we reflect on the process of cosmic evolution in more detail we come to realise that our universe is very remarkable in several respects:

—In the early stages of cosmic evolution, the ratio of the number of nucleons to photons, electrons and neutrinos must have been closely one to a thousand million. If that ratio had been slightly larger or smaller there would have been no nuclei heavier than hydrogen and so no carbon and no possibility of life.

—The universe is remarkably homogeneous on a large scale. If the inhomogenieties had been larger the universe would long ago have collapsed into black holes, and yet if they had been any smaller there would have been no galaxies.

—If the force between two protons had been a few percent stronger, nearly all the matter in the universe would have burned to helium before the first galaxies started to condense.

Many more such examples could be given, all pointing to the conclusion that our universe has evolved along a very narrow path, indeed just the path that makes man possible. That is why we can say that it is *our* universe. Freeman Dyson has summed this up in the words: "As we look out into the universe and identify the many accidents of physics and astronomy that have worked together to our benefit, it almost seems as if the universe must in some sense have known that we were coming."

Of course what he calls accidents are really part of a cosmic design that we do not yet understand, a design that prepared the universe for us. Humanity is thus restored to a central place in the universe in a sense far deeper than that discredited by the Copernican revolution. But if we examine the writings of the scientists responsible for these discoveries we find little evidence of humility. Instead there is a casual flippancy that goes beyond the usual familiar talk of scientists. The universe is spoken of by Guth as the last free lunch and it is suggested that it stumbled into being by accident. Spacetime, we are told by Atkins, formed itself out of its own dust. Creation is likened to the decay of a radioactive nucleus; it happened by chance and has no cause. At the end of his book on the big bang, Weinberg concludes that the more we know the more it all seems meaningless.

Yet in spite of this flippancy and sometimes ill-concealed contempt for traditional theology they cannot leave the subject alone. Hawking remarked that the aim of science is to find an equation that explains everything, and then "we will know the mind of God". These last four words have been taken by Davies as the title of his latest book on cosmological questions.

Scientists have the habit of probing things to the limit, so it is natural to ask what happened before the big bang. It is not enough to say that there was a previous contraction because this just pushes the problem back one stage. An infinite regress is intolerable; infinity belongs to mathematics and not to the real world. So there must have been a beginning. So what was the cause of the universe if not an all-powerful being called God? One can try to avoid this question by denying that the universe has a cause, but seeking for causes is so ingrained in the habits of the scientist that this is not really satisfactory.

What is conspicuously lacking in all these accounts is a real understanding of Christian theology. It is apparently not realised that theology and philosophy are disciplines at least as demanding as science, and that it is necessary to study them carefully if one is to speak in an intellectually cogent way. The Christian belief is to be found in the opening words of the Bible: "In the beginning God created heaven and earth". God created freely; He was under no obligation to do so. He created the universe out of nothing, and the universe is entirely distinct from Him. There is no greater difference, at the material level, between being and not-being, or between something and nothing. Only God can create being; only He can cause something to exist where previously there was nothing. The universe is totally dependent on God and is constantly sustained in being by Him. Without this sustaining power it would instantly lapse into nothingness. The universe is in no way an emanation from God or a part of God.

Pantheism is explicitly excluded by the belief that Christ is the only-begotten Son of God. He was begotten, not made. Only Christ is begotten;

the universe was made, not begotten. Also excluded by Christian belief is any form of dualism, any idea that the material world is under the control of different spirits. To make this absolutely clear, all creation takes place through Christ.

These Christian beliefs about creation are not useful simply to clarify the way we talk about the big bang; they lie at the heart of science itself. It was the Christian belief in the creation of the world from nothing by an all-powerful God that made possible the birth and development of modern science, and hence all the knowledge we possess about the universe and its development through time.

The Greeks made an excellent start, and asked many of the right questions. They speculated about the ultimate nature of matter and suggested that it is made up of atoms. But for all its glories, Greek science was still-born, and never developed into a self-sustaining enterprise. This was due in no small measure to Aristotle, a great philosopher and a keen observer of nature. Unfortunately his ideas on the physical world had the effect of putting physics in a straightjacket for two thousand years. Aristotle believed that the celestial and the terrestrial realms were quite distinct. Celestial matter is unchanging and incorruptible; terrestrial matter is changeable. The world has always existed and goes through the same cycle of events again and again. Everything that moves requires the continuing action of the mover.

The medieval philosophers received the writings of the Greeks through the Arabs, and realised their usefulness for Christian theology. They explained and developed the Greek ideas, but did not hesitate to oppose them if they were not in accord with Christian Revelation. Thus it seemed that celestial and terrestrial matter must be the same, as they were both created by God. The universe is not eternal; it was created by God in time. This in turn suggested to Buridan, a Parisian philosopher, that when He created the world God gave all the particles the impetus they need for their subsequent motions; thus is was not necessary to suppose the continuing action of the mover. In this way he introduced the concept that we now know as momentum, and adumbrated Newton's first law of motion.

In this way the Christian doctrine of creation broke the stranglehold of Aristotelian philosophy and made possible the development of modern science. The belief in the absolute rationality of the world that is the result of belief in creation by God is the mainspring of research. In the words of Whitehead, "the greatest contribution of medievalism to the formation of the scientific movement" was "the inexpugnable belief that every detailed occurrence can be correlated with its antecedents in a perfectly definite manner, exemplifying general principles." This is an instinctive principle that underlies all research; that there is a secret that can be found. Without it the heroic efforts of scientists to understand the smallest detail would be senseless. Thus Kepler toiled for years to understand the orbit of the planet Mars. Following Aristotle he believed that the orbit was circular, as this is the most perfect form of motion, as befits celestial matter. He tried to make the circular orbit fit the very precise measurements of Tycho Brahe. They could be fitted to about ten minutes of arc, but not to two, which was the accuracy of the data. So he toiled on, year after year, until he found that it could not be a circle. He tried an ellipse, and it fitted. This led to the work of Newton, who showed that elliptical orbits follow from his laws of motion together with the law of gravitational attraction, and thus founded celestial dynamics.

The Christian belief in Creation is not only responsible for the origin of modern science, but continues to influence it in hidden and not so hidden ways. It is probably no accident that the big bang theory was proposed by the Abbé Lemaître, and that the theory of continuous creation was due to scientists prominent for their secularist views. Atkins is a fervent atheist, and Hawking makes no secret of his agnosticism.

The belief in an oscillating universe, the idea that all events are repeated endlessly, is found in all ancient cultures and played no small part in preventing the rise of genuine science. This belief was decisively broken by the belief in the unique Incarnation of Christ. Writing about this belief, the French physicist Pierre Duhem declared: "To the construction of that system all disciples of Hellenistic philosophy—Peripatetics, Stoics, Neo-Platonists—contributed; to that system Abu Masar offered the homage of the Arabs; the most illustrious rabbis, from Philo of Alexandria to Maimonides, have accepted it. To condemn it and to throw it overboard as a monstrous superstition, Christianity had to come". As Jaki has remarked, religions fall into two categories, "in one there is the Judaeo-Christian religion with its belief in a linear cosmic story running from "in the beginning " to "a new heaven and earth". In the other are all pagan religions, primitive and sophisticated, old and modern, which invariably posit the cyclic and eternal recurrence of all, or rather the confining of all into an eternal treadmill, the most effective generator of the feeling of unhappiness and haplessness." Concerning that treadmill, Chesterton has remarked, "I am exceedingly proud to observe that it was before the coming of Christianity that it flourished and after the neglect of Christianity that it returned".

Now that the oscillating universe is discredited, the main secularist line of attack is to say that the universe is the result of a chance process and has no cause. The idea that the universe is a random process has been strengthened by recent research on chaotic motion. We are familiar with the idea that if we know the initial conditions, then application of the laws of physics enables us to calculate the subsequent behaviour. Recent work has however shown that in many systems the motion is exceedingly sensitive to the initial conditions. A very slight change soon leads to completely different behaviour. For example, if we try to calculate the motion of the molecules of a gas that are continually colliding with each other, then the motion after a collision depends sensitively on the initial trajectory, and so a very small change may easily determine whether a subsequent collision take place or not.

The effect of this is that it is impossible to predict the future behaviour of such systems. All measurements are limited in precision, and the imprecision of our measurements is always such that our calculations of the future behaviour of some systems soon becomes quite unreliable. There is however a clear difference between our ability to predict, and whether the motions are strictly determined. Because we cannot predict the behaviour of a system it does not mean that it is undetermined or random in itself.

This enables us to assess the attempts that have been made to account for creation as a chance process. Thus Atkins suggest that "the fleeting emergence of our incipient universe can be visualised as an aimless, purposeless, stumbling of points into a pattern.There was no need for intervention. Before time and space formed there were unrelated points. Then by chance a clustering of the points stumbled into a pattern of such complexity that it corresponds to four dimensions..we have a universe which is a collection of viable relationships." This is vague, speculative and irrational, ignoring the absolute distinction between being and not-being. It looks like a desperate effort by a professed atheist to find a scientific way of disposing of the Creator. Chance is referred to as a causative agent, not as indicating unknown causes. There is a more general difficulty: all a scientific theory can do, and this is exceedingly important, is to say that if there exists matter with such and such properties that obeys certain equations, then if it is started off in a particular configuration it will behave subsequently in a way calculable from these equations. What it cannot say is whether there exists matter with these properties, and how it is put into a particular configuration and no other. As Hawking asked, in a rare flash of metaphysical realism, "what is it that breathes fire into the equations and makes a universe for them to describe?" And who sets the initial conditions? A scientific theory is only reliable in regions where it has been thoroughly tested, and what more unpredictable or more singular than the moment of creation?

Very often creation is associated with simple structures, as if this makes it easier. Thus to quote Atkins again: "The creation can generate only the most primitive structures, of such simplicity that they can drop out of absolutely nothing". But it must be repeated that, simple or complicated, small or large, the passage from non-existence to existence is the most radical of all steps. No one with any sense of ontological reality could accept this for an instant. The passage from non-being to being is the greatest possible transition; this concerns creation itself, and this belongs to God alone.

The story of man's attempts to understand the world shows a complex interaction of theological beliefs, scientific observations and theoretical speculations. It is notable that it was Christian theology that made science possible in the first place, and with it all the vast development that had led to our modern understanding of the universe. The influence of theology has remained strong, and it is notable that theories developed in opposition to the Christian doctrine of creation, like that of continuous creation, have tended in the end to be sterile, whereas those consistent with the doctrine have proved fruitful.

There have been many scientists who have written with great confidence about the creation in such a way as to dispense with the need for a Creator. One can imagine them being interrogated with gentle irony when at last they come before the judgement seat:

> Where were you when I laid the earth's foundations?
> Tell me, since you are so well-informed!
> Who decided the dimensions of it, do you know?
> Or stretched the measuring line across it?
> Have you grasped the celestial laws?
> Could you make their writ run on the earth?
> Can your voice carry as far as the clouds
> And make the pent-up waters do your bidding?
> Will lightning flashes come at your command
> And answer."Here we are?"
> Tell me, since you are so well-informed!

P. W. Atkins, *The Creation* (Freeman, 1981).
J .D. Barrow and J. Silk, *The Left Hand of Creation* (Heinemann, 1984).
P .Davies, *The Mind of God* (Simon and Schuster, 1992)
F. Dyson, Scientific American 225. 25. 1971.
S. W. Hawking, *A Brief History of Time* (Bantam Press,1988).
S. L. Jaki, *Science and Creation* (Scottish Academic Press, 1974).
S. L. Jaki, *Cosmos and Creator* (Scottish Academic Press, 1974).
S. L. Jaki, *God and the Cosmologists* (Scottish Academic Press,1989).
S. L. Jaki, *The Only Chaos and Other Essays* (University Press of America, 1990).
S. Weinberg, The First Three Minutes (Basic Books, 1977).
A. N. Whitehead, *Science and the Modern World* (Macmillan, 1925)