3. Did God create the universe?

> 'I want to know how God created this world.'
>
> Einstein

> 'I had no need of this hypothesis.'
>
> Pierre Laplace to Napoleon Bonaparte

A well-known periodical recently proclaimed in banner headlines 'Astronomers discover God!'. The subject of the article was the big bang and recent advances in our understanding of the very early epochs of the universe. In the world of popular journalism, the fact of creation is itself considered sufficient to reveal the existence of God. But what does it really mean to say that God *caused* the creation? Is it possible to conceive of a creation without God? Does modern astronomy inevitably expose the limits of the physical universe and compel us to invoke the supernatural?

The word 'creation' carries with it a variety of meanings, and it is important to keep a clear distinction between them. The creation of the universe can be taken to mean the abrupt organization of matter from a chaotic, structureless primeval form into the currently observed complex order and elaborate activity. It can mean the actual creation of matter in what was previously a featureless void. Or it can mean the abrupt appearance of the entire physical world, including space and time, from nothing at all. There is also the separate issue of the creation of life and man himself, which we shall deal with later.

The biblical version of the creation of the universe 'on the first day' is vague about exactly what was involved. There are actually two accounts of the creation, but neither explicitly mentions that the material from which the stars and planets, the Earth, and our own bodies are made, existed prior to the creation event. The belief that God created this cosmic material out of nothing is a longstanding part of Christian doctrine. Indeed, it seems to be demanded by the assumption of God's omnipotence, for if God did not create matter, it would imply that he was limited in his work by the nature of the raw materials available to him.

Before this century it was assumed by scientists and theologians alike that matter could not be created (or destroyed) by natural means. Of course, the form of matter can change, for example, during chemical reactions, but the total quantity of matter was considered to be, without exception, constant. Scientists, faced with the problem of the origin of matter, were inclined to believe in a universe of infinite age, thereby avoiding the need for a creation altogether. In an eternal universe, matter can have existed for ever, and the problem of its origin is side-stepped.

The belief that matter cannot be created by natural means collapsed dramatically in the 1930s when matter was first made in the laboratory. The events leading up to this discovery provide a classic example of modern physics at its best.

This story, as with so many others, began with Einstein in 1905. His famous $E = mc^2$ equation is the mathematical embodiment of the statement that mass and energy are equivalent: mass has energy and energy has mass. Mass is the quantification of matter: the mass of a body tells you how much matter it contains. Large mass means heavy and ponderous, small mass means light and easy to move. The fact that mass is equivalent to energy means that, in a sense, matter is ‘locked up' energy. If some way can be found to unlock it, matter will disappear amid a burst of energy. Conversely, if enough energy is somehow concentrated, matter will appear.

In its original conception, Einstein's equation, a by-product of his theory of relativity, was concerned with the properties of bodies moving at ultra-high speed, close to the speed of light. According to the theory, the energy of the body's motion ought to result in it appearing to be heavier (to increase in mass). The effect is minute at ordinary speeds because a little mass is worth an awful lot of energy: for example, one gram is the equivalent of a million dollars in energy at current prices. However, modern subatomic particle accelerators can boost the speed of electrons and protons to within a whisker of the speed of light, where their masses are observed to increase dozens of times.

Increase of mass with speed does not, of course, amount to the actual creation of matter. Rather, it involves already existing matter putting on weight. The possibility of completely new particles of matter being produced out of concentrated energy emerged with the epoch-making mathematical investigations of Paul Dirac about 1930. Dirac was attempting to reconcile Einstein's theory of relativity, with its $E = mc^2$, with the other major revolution in twentieth-century physics, the quantum theory, concerned with the behaviour of atomic and subatomic matter. A unified relativistic quantum theory is needed to describe subatomic particles moving at near the speed of light, such as occurs as a result of energetic radioactive emissions.

Following a mathematical analysis, Dirac suggested a new equation to describe high speed atomic matter. It was an immediate success because it explained a hitherto baffling property known to be possessed by electrons, namely, that they are spinning in a fashion totally at odds with either commonsense or elementary geometry. Crudely speaking, an electron has to turn around twice before it presents the same face as before. It provides another good example of how mathematics must replace intuition in the abstract world of fundamental physics.

Dirac's equation did, however, have one puzzling aspect. Its solutions correctly described the behaviour of ordinary electrons, but for every such solution there existed another associated solution which did not appear to correspond to anything in the known universe. With a bit of imagination it was possible to work out what these unknown particles would be like. In mass and spin they would be identical to ordinary electrons, but whereas all electrons carry negative electric charge, the new mystery particles would have positive charge. Other properties, such as their spin, would also be reversed, making the new particles a sort of mirror image of electrons.

More spectacular was Dirac's prediction that if enough energy could be concentrated, one of these ‘antielectrons’ might appear where none had existed before. In order that electric charge be conserved, this event would have to be accompanied by the simultaneous appearance of an electron too. In this way energy might be directly used to create matter in the form of an electron–antielectron pair.

About this time (1930), the physicist C.Y. Chao had been experimenting with the penetrating power of gamma rays (high energy photons of light) in heavy materials such as lead. He noticed that the most energetic gamma rays were being attenuated in a curiously efficient manner. The cause of the additional absorption of the rays was a mystery to Chao, but we now know it was caused by electron-antielectron pair production.

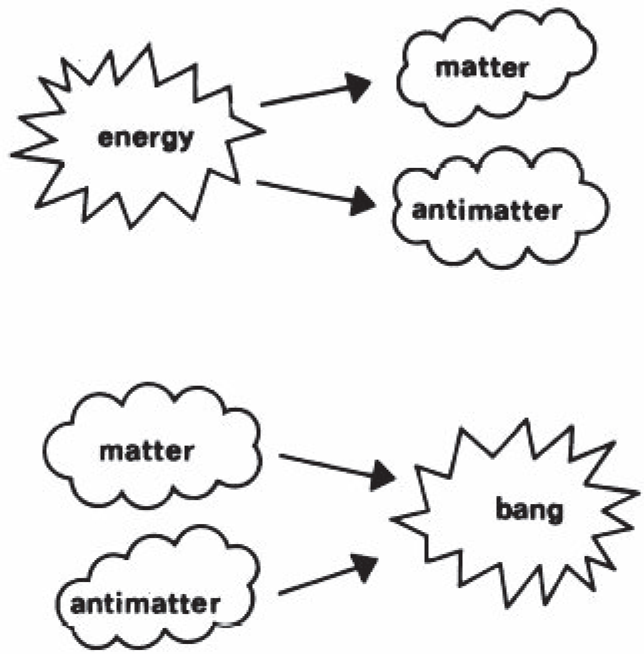
Then, in 1933, Carl Anderson was studying the absorption of cosmic rays — high energy particles from space — by metal sheets, when he spotted, for the first time, the unambiguous appearance of Dirac's antielectron. Matter had been created in the laboratory in a controlled experiment. It was quickly verified that the new particles possessed all the properties expected of it, and Dirac and Anderson shared a Nobel prize for this brilliant prediction and discovery.

In subsequent years, the production of electrons and antielectrons (usually called positrons) became commonplace in a wide range of laboratory processes. After World War II, the development of subatomic particle accelerating machines enabled the controlled production of other types of particles too. Antiprotons and antineutrons were made. Today, positrons and antiprotons can be made in large quantities and stored in magnetic ‘bottles’. Collectively, the mirror or antiparticles are known as antimatter, and it is now made routinely in physics laboratories.

Armed with these facts the way seems open for a natural explanation of the origin of all matter. During the big bang, huge quantities of energy were available to cause the incoherent production of vast amounts of matter and antimatter. Eventually, much cooled, this material would have aggregated into stars and planets. Unfortunately there is a major snag with this simple idea. When antimatter encounters matter, the two annihilate each other with a violent release of energy — the reverse process of matter creation (see Fig. 4).

A universe consisting of a mixture of matter and antimatter is therefore violently unstable. Very stringent limits can be placed on the admixture of antimatter in our galaxy, and it is a trifling amount. So where has all the antimatter gone? In the laboratory, every particle that is created is accompanied by an antiparticle, so we might expect the universe to be a fifty-fifty mix, but the observations rule this out. Some astrophysicists have attempted to explain this enigma by hypothesizing that somehow matter and antimatter managed to separate into large domains consisting predominantly of one type or the other. Perhaps whole galaxies are made of antimatter and others of matter. However, no convincing mechanism for separating matter from antimatter has ever been proposed, and the symmetric-universe theory has fallen into disfavour.

Those scientists who insisted that the big bang was the creation were thereby faced with the apparent necessity of assuming that some



4 In the laboratory, energy can be used to create matter, but it is always accompanied by an equal quantity of antimatter. When matter and antimatter meet, explosive annihilation results, releasing the energy encapsulated in the material. There is a mystery in how all the matter in the universe was created without polluting it with a dangerous mixture of antimatter.

supernatural process had injected matter into the universe without antimatter, in defiance of the laws of physics. Vague excuses about 'all laws break down at the singularity anyway' did little to lessen the feeling of unease.

Very recently, however, a possible route out of this dilemma has appeared. Although under laboratory conditions the creation of matter and antimatter is always symmetric, in the ultra-high temperatures of the big bang it is possible that a very slight excess of matter was permitted. The idea stems from a programme of theoretical work that seeks to provide a unified description of nature's four fundamental forces (a topic to be discussed more fully in Chapter 11). According to the theoretical calculations, at a temperature of a billion billion billion degrees, which could have been attained only during the first billion-billion-billion-billionth of a second, for every billion antiprotons, one-billion-and-one protons were created. Similarly, electrons would have outnumbered positrons by one part in a billion.

Such an excess, while minute, would be crucially significant. In the subsequent carnage, the billion matched pairs of protons and antiprotons would have annihilated each other, but the single unpaired proton would have survived, along with a solitary electron. These left-over particles — almost an afterthought of nature — became the material that eventually formed all the galaxies, all the stars and planets — and us.

According to this theory, our universe is built out of a tiny residue of unbalanced matter that survives as a relic of the first unthinkably brief moment of existence.

Like all good theories, physicists find this explanation for the origin of matter persuasive. But where is the hard evidence?

Two confirmatory results seem possible. The first concerns the wholesale annihilation of the billion matched particle-antiparticle pairs that accompanied each excess particle at the outset. The energy of this slaughter must also survive, presumably in the form of heat. But as mentioned in the previous chapter, the universe is indeed bathed in heat radiation left over from the big bang. It is a simple matter to tot up the heat energy per surviving atom to see if the numbers square up with the one-in-a-billion calculation. They do; or at least agreement can be achieved with very plausible models. So not only is the origin of matter explained by this theory, but also the precise temperature of the universe. It is a remarkable achievement.

Nevertheless, some further confirmation is desirable before one can confidently pronounce that matter no longer requires a divine origin. Some form of direct laboratory evidence of a distinct asymmetry between matter and antimatter would carry the greatest conviction. With luck, we may be on the threshold of obtaining just that sort of evidence.

The theory that predicts the tiny excess of matter production also predicts a minute spontaneous *destruction* of matter by the same mechanism. Over an immense duration of time protons, so the theory goes, will decay into positrons, which will then go on to annihilate electrons. In this way all matter is destined ultimately to disappear. The time scale is, however, so long that the human body, on average, looses only about one of its protons per lifetime. To test this theory, scientists are studying huge accumulations of matter, well below ground to cut out the polluting effect of cosmic rays, to try and catch a disappearing proton in the act. Because the process is statistical in origin (like radioactivity), the occasional freak decay will be observed after a modest wait of several weeks, even though the average lifetime of a proton is at least ten thousand billion billion billion years. The secret is to amass many tons of material (which represents a lot of protons) to spot the occasional random event. Several such experiments are currently in progress, and at least one has produced some possible proton-decay events.

The question of the origin of matter illustrates a fundamental problem that faces any attempt to deduce the existence of God from physical phenomena. What once seemed miraculous — the appearance of matter without antimatter — perhaps requiring a supernatural input at the big bang, now seems explicable on ordinary physical grounds, in the light of improved scientific understanding. However astonishing and inexplicable a particular occurrence may be, we can never be absolutely sure that at some distant time in the future a natural phenomenon will not be discovered to explain it.

Do these scientific advances mean that we can now explain the creation in terms of natural processes? Many theologians would strongly deny this. The processes described here do not represent the creation of matter out of nothing, but the conversion of pre-existing energy into material form. We still have to account for where the energy came from in the first place. This surely requires a supernatural explanation?

Nevertheless, one must be careful about shifting the responsibility from matter to energy this way. Energy is a rather slippery concept, especially in modern physics. What is energy? It can take many different forms. It might simply be motion, for example. In the laboratory, particles can collide at high speed and four appear where previously there were only two. The newcomers are paid for by reducing the speed of the two original particles. The conversion of motion, which is intangible, into stuff, which can be kicked, comes very close to the spirit of creation out of nothing.

There is a still more remarkable possibility, which is the creation of matter from a state of *zero* energy. This possibility arises because energy can be both positive and negative. The energy of motion or the energy of mass is always positive, but the energy of attraction, such as that due to certain types of gravitational or electromagnetic field, is negative. Circumstances can arise in which the positive energy that goes to make up the mass of newly-created particles of matter is exactly offset by the negative energy of gravity or electromagnetism. For example, in the vicinity of an atomic nucleus the electric field is intense. If a nucleus containing 200 protons could be made (possible but difficult), then the system becomes unstable against the spontaneous production of electron–positron pairs, without any energy input at all. The reason is that the negative electric energy generated by the new pair of particles can exactly offset the energy of their masses.

In the gravitational case the situation is still more bizarre, for the gravitational field is only a spacewarp — curved space. The energy locked up in a spacewarp can be converted into particles of matter and antimatter. This occurs, for example, near a black hole, and was probably also the most important source of particles in the big bang. Thus, matter appears spontaneously out of empty space. The question then arises, did the primeval bang possess energy, or is the entire universe a state of zero energy, with the energy of all the material offset by negative energy of gravitational attraction?

It is possible to settle the issue by a simple calculation. Astronomers can measure the masses of galaxies, their average separation, and their speeds of recession. Putting these numbers into a formula yields a quantity which some physicists have interpreted as the total energy of the universe. The answer does indeed come out to be zero within the observational accuracy. The reason for this distinctive result has long been a source of puzzlement to cosmologists. Some have suggested that there is a deep cosmic principle at work which requires the universe to have exactly zero energy. If that is so the cosmos can follow the path of least resistence, coming into existence without requiring any input of matter or energy at all.

Matters are further complicated by the fact that energy is not even properly defined when gravity is present. In some cases it is possible to make sense of the total energy in an isolated system by considering its gravitational influence a great (in fact infinite) distance away. But this strategy fails completely in the case of a universe that is spatially finite, such as the model proposed by Einstein and discussed briefly in the previous chapter. In such a closed universe, the total energy is a meaningless quantity.

Do these examples, such as the natural creation of matter out of empty space, perhaps with no need for even an energy input, amount to the creation *ex nihilo* of theology? It could be argued that science has still not explained the existence of space (and time). Granted that the creation of matter, for so long considered the result of divine action, can now (perhaps) be understood in ordinary scientific terms, is it only by an appeal to God that one can explain why there is a universe at all — why space and time exist in the first place, that matter may emerge from them?

The belief that the universe as a whole must have a cause, that cause being God, was enunciated by Plato and Aristotle, developed by Thomas Aquinas, and reached its most cogent form with Gottfried Wilhelm von Leibniz and Samuel Clarke in the eighteenth century. It is usually known as the cosmological argument for the existence of God. There are two versions of the cosmological argument: the causal argument, to be considered here, and the argument from contingency which will be discussed in the next chapter. The cosmological argument was treated with scepticism by David Hume and Immanuel Kant and has been bitterly attacked by Bertrand Russell.

The goal of the cosmological argument is two-fold. The first is to establish the existence of a 'prime mover' — a being that in turn accounts for the existence of the world. The second is to prove that this being is indeed the God as usually understood in Christian doctrine.

The argument proceeds along the following lines. Every event, it is maintained, requires a cause. There cannot be an infinite chain of causes, so there must be a first cause of everything. This cause is God. Now it must be stated right at the outset that there have been many versions of the cosmological argument, and many subtle interpretations of meaning, so that over the years the debate has become rather esoteric and complex. I make no attempt here to give a balanced appraisal of the pros and cons, save only to say that the argument has engaged the attention of some of the greatest intellects in the history of mankind, which has nevertheless not prevented both proponents and opponents of the thesis from making logical and philosophical blunders. Our concern here is to re-examine the causal chain hypothesis in the light of modern science.

Let us examine the first step in the argument: every event has a cause. As Clarke declared: 'Nothing can be more absurd, than to suppose that anything is; and yet that there be absolutely no reason why it is, rather than not.'[1] One usually assumes, loosely speaking, that everything that happens is caused to happen by something else and every object that has come into existence has been produced by something already existing. It seems reasonable enough, but is it true?

In daily life we rarely doubt that all events are caused in some way. A bridge falls down because it is overloaded, snow melts because the air warms up, a tree grows because a seed has been planted, and so on. But do some things have no cause?

Consider the above assertion 'every object that has come into exis-tence has been produced by something'. What if an object has never come into existence, but has always existed? Such a thing is certainly conceivable: space in the steady-state universe, for example. Does it mean anything to ask whether an eternally existing object — one which at no time did not exist — has a cause? One could still ask ‘Why does it exist?’ The retort ‘It has always done so’ seems rather lame. Since one can well imagine that the object might not exist, it seems legitimate to seek a reason why it exists rather than not, irrespective of its infinite age. So, in the opinion of some, abolishing the creation (as in the steady-state universe) does not remove the necessity of explaining why a universe exists at all.

Turning aside from the issue of eternal objects for the moment, suppose we restrict ourselves to the coming-into-being of objects. Can something be created out of nothing? We saw how particles can be created out of empty space, but in that case the spacewarp was the cause. We still have to explain where space came from (if it hasn't always existed). Some people might question whether space is a *thing*. Certainly it is hard to imagine Thomas Aquinas or Leibniz regarding it as part of the causal chain. Still, let us press on. What caused space to suddenly appear in the big bang? The singularity? But a singularity is most certainly not a thing. It is the boundary of a thing (spacetime). Impasse.

Does every *event* have a cause? Can something happen without any prior action, or any rational reason? Newspapers often proclaim ‘Object in sky unexplained’. This does not mean, however, that aerial phenomena occur that have *no* explanation, only that there is no *known* explanation. Unfortunately it is hard to see how the assertion ‘every event has a cause’ could ever be definitively falsified, for to do so one would not only have to find an event for which no cause is apparent, but go on to demonstrate that however much information one had about the universe and however deep one's understanding of nature, no cause would ever be found. That seems to be impossible. How can one be sure that the event in question is not caused by some totally obscure, exceedingly rare, never-before-encountered, unobtrusive, freak process?

The nearest science has come to falsifying the claim that every event has a cause is quantum mechanics. As we shall see in Chapter 8, in the subatomic world the behaviour of particles is generally unpredictable. From one moment to the next you cannot be sure what a particle is going to do. If for an event one were to choose the arrival of a subatomic particle at a particular place then, according to the quantum theory, that event has no cause, in the sense that it is inherently unpredictable. No matter how much information is available about the forces and influences acting on the particle, there is no way that its arrival at the designated place can be regarded as ‘fixed’ by anything else. The outcome is intrinsically random. The particle just pops up in that place with no rhyme nor reason.

Some (a minority) of physicists have not taken kindly to this idea. Einstein dismissed it in a famous retort: ‘God does not play dice.’ These physicists desire that every event should be caused by something or other, even at the subatomic level. Amazingly enough, it is possible to perform an experiment to demonstrate that, unless influences can travel faster than light, atomic systems are indeed inherently unpredictable — ‘God' *does* play dice. Subject to the proviso that some extraordinary conspiracy of nature has not confounded the experimental results, this claim seems to be on a fairly firm foundation.

If, therefore, one accepts that quantum events have, individually, no direct cause, then can the creation of matter, which is a classic example of a quantum process, be said to be without physical cause? In a sense, yes. An *individual* particle will come into existence abruptly and unpredictably, at no specially designated place or moment. However, its behaviour, while maverick, is still subject to the laws of probability. Given a spacewarp of a particular strength, it can be very probable that a particle will appear in a given volume of space in a certain interval of time. But never definite. Conversely, though the probability is exceedingly small, there is still a finite chance of such a particle popping out of nowhere in your living room right now. In the quantum world, such things happen without warning. The fact that the *probability* of particle creation depends on the strength of the spacewarp implies a sort of loose causation. The spacewarp makes the appearance of a particle *more likely*. Whether that is to be regarded as strictly the *cause* of the particle's appearance is largely a matter of semantics.

Now it might be objected that the central discussion concerns whether or not the entire universe has a cause, not whether an electron's creation or arrival at a place has a cause. Some physicists would doubtless reply that the whole universe is also subject to quantum principles, but this is to take us into the vexed topic of quantum cosmology that is fraught with its own problems of self-consistency. (Further discussion will be deferred until Chapter 16, where I shall suggest a quantum scenario which may solve the problem of the origin of the universe.) Accepting for now that, quantum theory notwithstanding, the total universe can be said to have a cause, what is that cause? God?

At this point we proceed to examine the second step of the cosmological argument: there cannot be an infinite chain of causes. The buck must stop somewhere. The galaxies form from swirling nebulae, the nebulae form from primeval hydrogen gas, the hydrogen forms from the protons created in the first brief bang, the protons were created out of spacewarps. The assumption has always been that this sequence must have a first member. Aquinas wrote:

> In the observable world causes are found to be ordered in series; we never observe, nor ever could, something causing itself, for this would mean it preceded itself, and this is not possible. Such a series of causes must however stop somewhere; for in it an earlier member causes an intermediate and the intermediate a last (whether the intermediate be one or many). Now if you eliminate a cause you also eliminate its effects, so that you cannot have a last cause, nor an intermediate one, unless you have a first. Given therefore no stop in the series of causes, and hence no first cause, there would be no intermediate causes either, and no last effect, and this would be an open mistake. One is therefore forced to suppose some first cause, to which everyone gives the name 'God'.[2]

In arguing against an infinite chain of cause and effect neither Aquinas nor Clarke object on the grounds that the chain is infinite as such. Indeed, both these thinkers developed their arguments in the context of an eternal, infinitely old universe, content to let the evidence for a creation rest on 'divine revelation' rather than rational argument. Rather, the objection seems to be that an infinite chain of cause and effect which encompasses the entire universe is allegedly impossible:

> If we consider such an infinite progression… 'tis plain this whole series of beings can have no cause from without, of its existence; because in it are supposed to be included all things that are or ever were in the universe; And 'tis plain it can have no reason within itself, of its existence; because no one being in this infinite succession is supposed to be self-existent or necessary… but every one dependent on the foregoing… An infinite succession therefore of merely dependent beings, without any original independent cause; is a series of beings that has neither necessity, nor cause… either within itself or from without: That is, 'tis an express contradiction and impossibility.[3]

The belief that an infinite succession of 'dependent beings' — loosely, an infinite chain of cause and effect — needs an explanation for its existence (which cannot be found when that chain includes all of existing things) has been sharply attacked by philosophers, especially Hume and Russell. In a famous B.B.C. debate with Father Copleston, Russell illustrated his point as follows: 'Every man who exists has a mother… but obviously the human race hasn't a mother.' In short, so long as each individual member of the succession is explained then, *ipso facto*, the succession is explained. And as every member of the chain owes its existence to some preceding member or members, each member of the infinite chain is explained. Asking for a cause of the whole universe has a different logical status from asking for a cause of an individual object or event within the universe.

In fact, the topic of 'sets of sets' is notoriously slippery. If a set is defined innocuously as any collection of things (concrete or abstract) then, as Russell showed by his famous paradox, a set of sets may not even be a set! Thus, we can envisage as a set a catalogue of all the books in a library. But is the catalogue itself to be included in this list? Sometimes it is. Call such catalogues 'Type I', and the others, that do not include themselves, 'Type II'. Now envisage as a set of sets a master catalogue at the central library. Its function is to list all Type II catalogues; it is a set of catalogues. Reasonable enough? Unfortunately not. The set of all Type II catalogues is paradoxical, as we discover as soon as we ask the question, is the master catalogue itself Type I or Type II? If Type II, then it does not include itself. But the master catalogue is defined as listing all self-excluding (Type II) catalogues. So it does list itself; it is Type I. But this cannot be so, for the master only lists Type II catalogues, so it cannot list itself if it is Type I. So it doesn't list itself; it is Type II. Result: self-contradictory nonsense.

The upshot of all this is that the concept of the entire universe of existing things is a subtle one indeed. It is not clear that the universe is a *thing*, and if it is defined as a set of things it runs the risk of paradox. Such issues lie in wait to ensnare all those who attempt to argue logically for the existence of God as a cause of all things.

Even granted the cosmological argument so far — that the universe must have a cause

— there is a logical difficulty in attributing that cause to God, for it could then be asked 'What caused God?' The response is usually 'God does not need a cause. He is a *necessary* being, whose cause is to be found within himself.' But the cosmological argument is founded on the assumption that everything requires a cause, yet ends in the conclusion that at least one thing (God) does not require a cause. The argument seems to be self-contradictory. Moreover, if one is prepared to concede that something — God — can exist without an external cause, why go that far along the chain? Why can't the universe exist without an external cause? Does it require any greater suspension of disbelief to suppose that the universe causes itself than to suppose that God causes himself?

> If we stop, and go no farther (than God), why go so far? Why not stop at the material world?… By supposing it to contain the principle of its order within itself, we really assert it to be God.[4]

This quote of Hume is reminiscent of the vague belief of many scientists that 'God is nature' or 'God is the universe'.

Perhaps the most serious objection, however, to the causal version of the cosmological argument is the fact that cause and effect are concepts that are firmly embedded in the notion of time. Yet, as we have seen, modern cosmology suggests that the appearance of the universe involved the appearance of time itself. It is usually accepted that cause always precedes effect in time: the target shatters after the gun is fired, for example. In that case it is clearly meaningless to talk about God creating the universe in the usual causal sense, if that act of creation involves the creation of time itself. If there was no 'before' there can be no cause (in the usual sense) of the big bang, either natural or supernatural.

This point seems to have been well appreciated by St. Augustine (354–430) who ridiculed the idea of God waiting for an infinite time and then deciding at some propitious moment to create a universe. 'The world and time had both one beginning,' he wrote. 'The world was made, not in time, but simultaneously with time.'[5] This is a remarkable anticipation of modern scientific cosmology considering the completely erroneous ideas of space and time that were current in Augustine's day.

Curiously though, this profound interpretation of Genesis was later challenged when the Church came under the influence of the Ancient Greek tradition in the thirteenth century. In the ensuing controversy, the Fourth Lateran Council (1215), refuting Aristotle's philosophy of a universe of infinite age, insisted that, as an article of Christian faith, the universe *did* have a beginning in time, but even today theologians are still divided over the interpretation of the book of Genesis.

The problem about postulating a God who transcends time is that, though it may bring him into the 'here and now', many of the qualities which most people attribute to God only make sense within the context of time. Surely God can plan, answer prayers, express pleasure or anxiety about the course of human progress, and sit in judgement afterwards? Is he not continually active in the world, doing work, 'oiling the cogs of the cosmic machine' and so on? All of these activities are meaningless except in a temporal context. How can God *plan* and *act* except *in time*? Why, if God transcends time and so knows the future, is he concerned about human progress or the fight against evil? The outcome is already perceived by God. (We shall return to this topic in chapter 9.)

In fact, the very idea of God creating the universe is, as we have already seen, an act that takes place *in* time. When giving lectures on cosmology, I am often asked what happened before the big bang. The answer, that there was no 'before', because the big bang represented the appearance of time itself, is regarded with suspicion — 'Something must have caused it'. But cause and effect are temporal concepts, and cannot be applied to a state in which time does not exist; the question is meaningless.

If time really did have a beginning, any attempt to explain it in terms of causes must appeal to a wider conception of cause than that familiar to us in daily life. One possibility is to relax the requirement that cause always precedes effect. Is it possible for causes to act backwards in time, to produce prior effects? Of course, the idea of changing the past is replete with paradox. Suppose you could influence nineteenth-century events in such a way as to prevent your own birth, for example? Nevertheless there are a number of theories in modern physics that involve retro-active causation. Hypothetical faster-than-light particles (called tachyons) could accomplish this. To avoid paradox, one might suppose that the link between cause and effect is very loose and uncontrollable, or else it is of a more subtle variety. As we shall see, the quantum theory requires a sort of reversed time causality, inasmuch as an observation performed today can contribute to the construction of reality in the remote past. This point has been emphasized by the physicist John Wheeler: 'The quantum principle shows that there is a sense in which what the observer will do in the future defines what happens in the past — even in a past so remote that life did not then exist.'[6]

Wheeler here introduces mind ('the observer') in a fundamental way, as indeed one is obliged to do in the quantum theory, and involves the existence of mind at a later stage of cosmic evolution with the very creation of the universe:

> Is the very mechanism for the universe to come into being meaningless or unworkable or both unless the universe is guaranteed to produce life, consciousness and observership somewhere and for some little time in its history-to-be?[7]

Wheeler hopes that we can discover, within the context of physics, a principle that will enable the universe to come into existence 'of its own accord'. In his search for such a theory, he remarks: 'No guiding principle would seem more powerful than the requirement that it should provide the universe with a way to come into being.'[8] Wheeler has likened this 'self-causing' universe to a self-excited circuit in electronics.

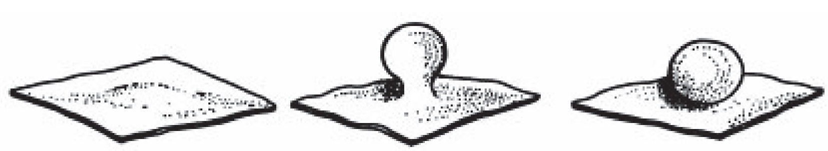
Now even if it were possible to find a cause of the creation of spacetime from some later natural activity (be it mind or matter), it is hard to see how creation out of nothing could occur naturally. There would still have to be the 'raw materials' for mind or whatever to go to work on, retroactively. Wheeler suggests that space and time are indeed synthetic structures — they are made out of component 'bits' which he calls pregeometry. Many other physicists have suggested that space and time are not fundamental concepts, but approximations. Just as apparently continuous matter is in fact built out of atoms, so might spacetime be built out of more primitive, more abstract, entities. This might be one outcome of the attempt to find a quantum theory of gravity (gravity being merely spacetime geometry). Under extreme physical conditions, such as at the beginning of the big bang, spacetime might 'come apart' and the internal components be exposed. Expressing this in forward-time language, the big bang could have been the event when the 'cogwheels' engaged coherently and organized themselves into an apparently continuous spacetime. According to this view, the big bang was the beginning of space, time and matter, but not the limits of physics. Beyond the big bang (not 'before' for there was no before) lay the disorganized 'cogwheels' — physical things, but not *in* space or time.

Before leaving the topic of the creation and whether or not it is meaningful to ask if it was caused by something, we must consider the possibility that the answer may be yes, but that the something may not be God. As already remarked, the second part of the cosmological argument seeks to establish that a cosmic creator must indeed be God, but the discoveries of modern physics have opened up new possibilities of which the proponents of the cosmological argument could never have dreamed.

In the previous chapter it was explained how the creation of matter is adequately defined in terms of expanding space (spacewarp). Moreover, there seems to be no limit to the elasticity of space. The tiniest region can be expanded ad infinitum. At one billionth of a second after the creation the currently observed universe (all billion billion billion cubic light years of it) was shrunk to a volume about the size of the solar system. At earlier moments it was smaller than that. Hence space may grow out of nothing, and matter may come out of space. Nevertheless something, one feels, must start an infinitesimal blob of space on the path of explosive expansion, and this is where we get back to singularities, causation, and so on.

There is, however, an alternative explanation for our universe of space and matter. This can be dubbed, crudely speaking, the 'reproducing universe'. It is best described by analogy. As space is elastic, imagine it to be represented by a rubber sheet. (The sheet is only two-dimensional whereas space is three-dimensional. This is a conceptual shortcoming, but not a logical one. What is about to be described will also work in three dimensions, but is impossible to visualize in that case.)

Figure 5 shows a sequence of steps. First a bump is made in the rubber. Then the bump is inflated, all the while keeping the 'neck' very narrow where it connects to the sheet. The bump takes on the features of a balloon. Now allow the neck to shrink until the rubber touches and closes off the balloon completely. Finally cut the neck, releasing the balloon and allowing the neck to heal into a continuous sheet once more. The sheet has effectively given birth to a totally disconnected, independent sheet (balloon), which may then be inflated ad infinitum. If desired this new balloon could itself be used to generate other balloons.



5 The elasticity of space suggested by Einstein's general theory of relativity permits the growth and separation of a 'daughter universe' (bubble) from the 'parent universe' (sheet). Such topology changes have been proposed in some recent theories, but are not at all well understood.

If we envisage our universe — all of the space to which we can possibly have physical access — as the 'new balloon' then it is certainly the case that this universe has not always existed: it was created. However, its creator can still be found within the scope of natural physical processes, namely a creation mechanism with its origin in the 'mother sheet'. That sheet is now totally inaccessible to us, it is beyond our spacetime, so we can find no cause within our universe for its existence, and yet God is not involved.

The central feature which emerges from this idea is that what is usually regarded as 'the universe' might in fact be only a disconnected fragment of spacetime. There could be many, even an infinite number of other universes, but all physically inaccessible to the others. With this definition of 'universe' the explanation for our cosmos does not lie within itself — it lies beyond. It does not involve God, only spacetime and some rather exotic physical mechanism.

Such a mechanism has been proposed recently in a number of theoretical studies.[9] Under extreme heat it is conceivable that space could become unstable to 'breeding' other 'balloons' in this way. One could even envisage a sufficiently advanced technological community deliberating engineering the creation of new universes. Nevertheless, purists will no doubt object that this hypothesis of the creation constitutes only a pseudo-explanation, for it still does not account for the totality of 'sheets and bubbles'. That is true, but the example does serve to illustrate that everything that we can, in principle, perceive in our universe may still have been created by *natural* causes a finite time ago, and that what (if anything) lies outside all our spacetime may not be entirely supernatural.

What, then, has this analysis contributed to our search for God the creator? The argument that there must exist a first cause of everything is open to serious doubt so long as we adhere to any simple notion of cause, irrespective of whether the universe is infinitely old, or had a definite beginning in time. Exotic causal mechanisms, such as reversed-time causality or quantum mental processes might conceivably remove the need for a prior cause of the creation. Nevertheless one is still left with a feeling of unease. The theologian Richard Swinburne writes:

> It would be an error to suppose that if the universe is infinitely old, and each state of the universe at each instant of time has a complete explanation in terms of a previous state of the universe and natural laws (and so God is not invoked), that the existence of the universe throughout infinite time has a complete explanation, or even a full explanation. It has not. It has neither. It is totally inexplicable.[10]

To illustrate the point, suppose that horses had always existed. The existence of each horse would be causally explained by the existence of its parents. But we have not explained yet why there are horses at all — why there are horses rather than no horses, or rather than unicorns, for example. Although we may be able to find a cause for every event (unlikely in view of quantum effects), still we would be left with the mystery of why the universe has the nature it does, or why there is any universe at all.