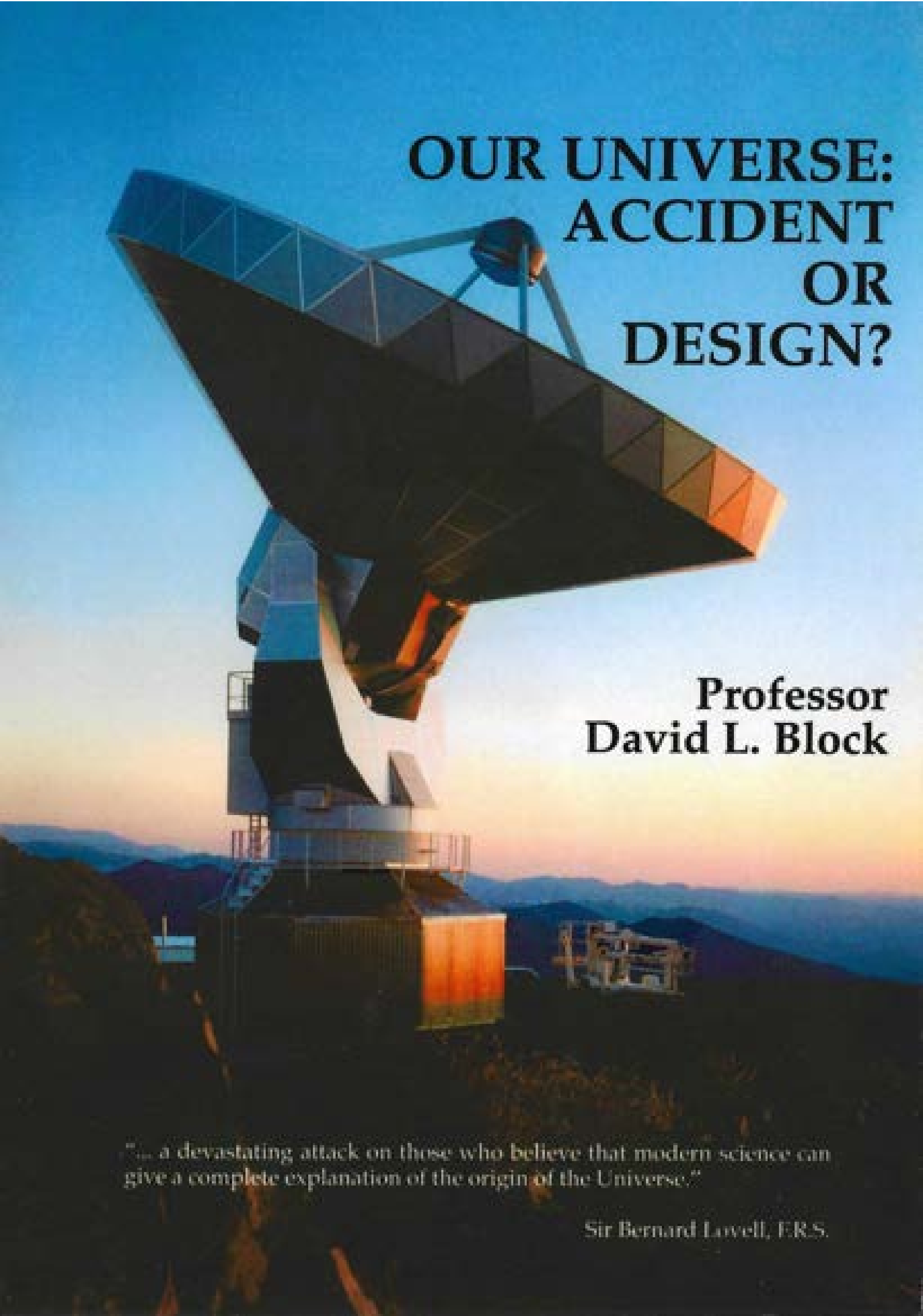

OUR UNIVERSE: ACCIDENT OR DESIGN?

Professor David L. Block

"... a devastating attack on those who believe that modern science can give a complete explanation of the origin of the Universe."

Sir Bernard Lovell, F.R.S.

SUMMARY

"Behold a universe so immense that I am lost in it. I no longer know where I am. I am just nothing at all. Our world is terrifying in its insignificance."

So wrote Bernard de Fontenelle[1] (1657-1757), capturing the mood of his generation as the true extent of the universe became known. The early scientists who had sought to fathom God's ways in creation had discovered a universe so vast that God's greatest creation, humanity itself, seemed like a mere candle flickering in the dark of a medieval cathedral.

In this booklet I want to tackle de Fontenelle's three fears:

- the immensity of the universe
- the irrelevance of mankind
- the insignificance of our human world.

We dig deep into the fields of astronomy and biology, only to awake from de Fontenelle's terror as though from a bad dream.

His fears are not our fears.

We may, you and I, be the focus of creation after all.

PREFACE

From the pen of…

Arno A. Penzias, Nobel Prize Winner in Physics:

"Astronomy leads us to a unique event, a universe which was created out of nothing, and delicately balanced to provide exactly the conditions required to support life. In the absence of an absurdly-improbable accident, the observations of modern science seem to suggest an underlying (one might say "supernatural") plan. In this monograph, Professor Block offers readers a unique opportunity to weigh the evidence for themselves."

The Very Rev. Professor T.F. Torrance, F.R.S.E.:

"This is a quite outstanding essay on the rational nature of the universe of space and time as it expanded from the original dense state – the incredible singularity. Professor Block has assembled in succinct and lucid form the mass of scientific information that has come to light in recent years for the fine tuning of the universe as one in which the presence of the rational human being within the cosmos, far from being the result of irrational chance, belongs to the very essence of its rational nature. The argument is beautifully set out and is thoroughly documented, with support from the greatest scientists of our age. I find particularly impressive the way in which David Block gently lets the nature of the universe speak for itself out of its own rationality, and without any forcing points to the profound link between it and the rationality of the Christian understanding of the created order."

John Polkinghorne, F.R.S., President of Queen's College, Cambridge:

"The fifteen billion years of cosmic history have proved an astonishingly fruitful story. What started as an expanding 'ball' of energy has evolved into a richly varied universe with men and women among its inhabitants. An even more surprising insight of modern science is that this could only have happened in a cosmos whose physical fabric corresponded to very precise and finely – tuned laws of nature. The universe that has given rise to ourselves is not any–old world but a universe in a trillion. This will not surprise those of us who believe it to be God's creation. Professor Block's clear and thoughtful discussion of these issues deserves a wide readership."

Sir William H. McCrea, F.R.S.:

"As an astronomer Professor Block is well known for observational studies of the morphology of galaxies. Here he presents a clear comprehensive summary of the fundamentals of modern cosmology. He does so having special regard to man's place and status in the physical Universe. Herein he sees evidence of design on an awesome scale. For him this culminates in the Christian revelation.

The whole discussion stimulates one to ask whether the study of the physics of the cosmos, profound as it certainly is, may perhaps be a prelude to possibly more profound studies of life, consciousness, mind and personality, in the same cosmos, that are still to come."

Sir John Eccles, F.R.S., Nobel Prize Winner in Medicine – Physiology:

"Our quest in life is for love, truth and beauty, all qualities of the Divine transcendence and immanence and of the wonders of Divine creation.

There is firstly the transcendent God in which Einstein believed and that is so wonderfully described by Professor David Block in his story of the universe.

As Christian believers we must worship both the transcendent God and the immanent God, in his creation of us by Divine love.

Professor Block and I both believe that there is a Divine Providence operating over and above the materialist happenings of biological evolution."

CONTENTS

"Behold a universe so immense that I am lost in it. I no longer know where I am. I am just nothing at all. Our world is terrifying in its insignificance." So wrote Bernard de Fontenelle[1] (1657-1757), capturing the mood of his generation as the true extent of the universe became known. The early scientists who had sought to fathom God's ways in creation had discovered a universe so vast that God's greatest creation, humanity itself, seemed like a mere candle flickering in the dark of a medieval cathedral.

Only a few generations earlier, the scholars had offered a far more reassuring view of the heavens. The earth and its people were at the centre; the planets, the sun, and all the stars revolved around this focus of God's creation. Then, in 1543 Copernicus' *De Revolutionibus* was published and we perceived ourselves to be living in a heliocentric world. The sun, not the earth, was the centre. As telescopes were pointed to the heavens, we recognized our sun to be but one of 100 000 million stars in the Milky Way galaxy. Today we know that if we were to count all the stars in the Milky Way at a rate of one every second, the process would take two thousand five hundred years! No wonder that people often believe they are zeroes, non-entities lost in a sea of space and time.

In this essay I want to tackle de Fontenelle's three fears: the immensity of the universe, the irrelevance of mankind, and the insignificance of our human world.

The immensity of the universe

Astronomers find the observable extent of our universe to be very large. The American astronomer Edwin Hubble[2] in 1929 published a famous paper in the *Proceedings of the National Academy of Sciences*. That pioneering paper, together with further observations published in 1931, established beyond any doubt that the universe is in a continual state of expansion[3]. Galaxies recede at speeds dependent on their distances from us. With large telescopes, we can photograph objects moving away from us at speeds of an amazing 274 800 kilometres per second[4], which is over 90 per cent the speed of light! We live in an expanding universe.

An expanding universe

Going backwards in time from today we would see the present outward-moving systems of galaxies contracting, and at all points in the universe the density of matter would become higher and higher. But let us spend a few important moments dispensing with a very popular (but wrong) concept of what the big bang is, and what it is not. For, contrary to popular belief, the big bang is not a point in space from which matter explodes outwards.

The most widely accepted model of our expanding universe is that of a 'big bang'. Unfortunately this phrase suggests that all matter once existed *somewhere* as a superdense ball of matter which suddenly exploded, scattering debris throughout space like an exploding bomb. But this picture is too simple. It presupposes that *space already existed* before the explosion and that the big bang was merely the mechanism that flung the stars and galaxies out into space. It suggests that before the bang there was empty space, like an empty room, with a highly concentrated dot of matter at its centre. It suggests that after the bang the galaxies moved out to fill space, like furniture fills a room.

But the big bang is also concerned with *the formation of space* itself! There was no 'room' within which the explosion could occur. Analogies are inadequate but it is something like representing the early universe as bread dough expanding as it is baked. But note that in this analogy the dough is not 'matter' and the oven in which it is baking 'space', for the dough represents *both* space and matter. Initially the dough is concentrated together, but as the bread rises the dough expands and becomes less dense. If you could run the baking process backwards then every part of the bread would contract. Yet at every stage the bread is bread; it is only the density at all points which varies.

So, in cosmology, the big bang represents an *interval of time* in the early history of the universe when matter everywhere, at all points, was concentrated at immense densities and temperatures. Going backwards in time from today we would see the present outward-moving galaxies contracting, and *at all points* in the universe, the density of matter would become higher. If the universe is infinite now, it *has always been* infinite. If it is finite now, there is and was no 'beyond' in the usual sense of the word.

If the universe is infinite (open) now, it has always been infinite.
If it is finite (closed) now, there is and was no 'beyond' in four dimensions

The creation of time

The big bang models will not permit us to do what Augustine forbade, namely, to ask what God was doing 'before He made heaven and earth'[5]. The big bang epoch marks the beginning of *time* as well as of matter. Augustine argued that, like matter, time was God-created, and that before heaven and earth were made there was no time. The question, 'What was God doing *then*?' is without meaning. If there was not any time, there was not any *then*.

Philo[6], that great first century Jewish scholar in Alexandria, deduced much the same thing. He wrote:

"Time began either simultaneously with the world or after it. For since time is a measured space determined by the world's movement, and since movement could not be prior to the object moving, but must of necessity arise either after it or simultaneously with it, it follows of necessity that time also is either coeval with or later born than the world."

The basic idea in Philo's assertion is that rather than speaking of objects moving in a pre-existing time dimension, time itself is determined by the motion of objects. Before the creation of material objects, Philo asserts there would be no time. Our current understanding is that both time and space have a beginning within the framework of the big bang.

The big bang models therefore have a boundary in time. By convention, they start at time $t = 0$. But our universe may not have a spatial boundary. For if the universe is positively curved or 'closed', it has no boundary in space. The analogy is of a person travelling in a fixed direction on the surface of the earth; he or she never comes up against any impassable barrier or falls over any 'edge'. The person will eventually return to their starting point. However, present astronomical observations suggest[7] that the universe is 'open' and not 'closed'. If so, the expansion will continue forever, the big bang will have occurred only once, and space unfolds along an open boundary. A person equipped with a flashlight in such a universe will encounter a boundary both in space (a lightbeam directed skyward from a flashlight will never return to its starting point) as well as in time (the universe did not exist forever).

What can we know about the early moments of the universe? Can we wind the clock back, right to t=0?

The *cosmic microwave background radiation* (CMBR) is a relic from the time of the big bang epoch when the universe consisted of an exceedingly hot, opaque soup of charged particles and radiation. This faint microwave[8] glow permeates our entire universe. Its discovery by radio astronomers Arno A. Penzias and Robert W. Wilson[9] provided the second major piece of evidence[10] in support of a hot big bang cosmology.

The photons that make up the cosmic background radiation were emitted 300 000 years after the creation event, when the radius of the observable universe was 1/1000th its present value. We cannot look back any farther: no photons can reach us earlier than this since in those first 300 000 years photons were interacting too strongly with matter to move any appreciable distance before scattering. The early universe was opaque. It holds its mysteries intact. But when the universe was 300 000 years old, it had cooled enough for electrons to combine effectively with protons to form transparent, neutral hydrogen. A new epoch in cosmological history had began. The universe changed from being opaque and dominated by radiation to a new state where it was transparent, so that matter such as stars and galaxies could be seen. Cosmologists call this transition the *epoch of decoupling*.

We live in a *lumpy* universe, filled with galaxies, clusters of galaxies and even superclusters. The lumpiness we observe in our universe now must have been present in the universe *then* (the early universe). What we now observe as galaxies must have once been 'gravitational seeds' or energy density fluctuations which acted as 'wells' from which galaxies and other large scale structures grew gravitationally. In other words, the mass distribution in the universe at the era of decoupling cannot have been perfectly smooth, but rather must have exhibited small fluctuations which would later grow in amplitude to become galaxies and clusters of galaxies.

The *Cosmic Background Explorer* (COBE) satellite was launched by NASA in November 1989 specifically to map variations in the brightness temperature of the microwave sky. Microwave maps are 'snapshots' of the universe showing radiation which has been travelling for more than 14 billion years. These maps provide unique opportunities to view the gravitational seeds predicted by a big bang model.

The COBE maps show that the cosmic background radiation is extremely uniform wherever we look. It varies by only 0.25 per cent; by a mere 25 parts in 10 000. But in April 1992 a major discovery took the astronomical community by storm. Stephen Hawking, Lucasian Professor of Mathematics at the University of Cambridge (the same chair once held by Sir Isaac Newton) hailed it as "the discovery of the century, if not all time[11]". For the first time, astronomers saw the birth of the universe: they detected *minute structure* in the microwave background radiation. The ripples reported by the Differential Microwave Radiometer[12] on board COBE were the very fluctuations imprinted on our cosmos that led billions of years ago to the formation of galaxies. Without these minute fluctuations there would have been no stars, no sun, no human observers 14 billion years later. COBE team leader George Smoot remarked: "What we have found is evidence for the birth of the universe. It's like looking at God."[13]

That the universe has not always existed - that it had a beginning - has not always been popular. It has immediate philosophical and theological implications. Sir Arthur Eddington[14] once wrote, "Philosophically, the notion of a beginning to the present order of Nature is repugnant to me". But in general relativity theory, points where all known laws of physics break down cannot be avoided[15,16]. These points are called 'singularities' and it has been proved that, under very general conditions, solutions to Einstein's equations will always contain a singularity.

Strenuous efforts have been made to try and avoid the concept of a start to the universe. The most recent attempt, by Stephen Hawking[17], invokes the effects of quantum gravity at very early times and proposes that the universe has *no boundary in time* and space. An analogy may be helpful. Hawking speculates with models of four dimensional, no-boundary spheres. These would be like the surface of the earth (but in four dimensions), and would have no boundaries or edges. There is, then, no beginning in time. However, there is a very subtle problem. A quantum universe, such as Hawking proposes, necessarily consists of not just one 4-dimensional sphere, but rather *the infinity of spheres* of all possible radii. Since it is meaningless for the radius of a sphere to be less than or equal to zero, a four dimensional sphere of zero radius forms a boundary to Hawking's universe. Frank Tipler[18] concludes, "Hawking has eliminated the classical singularity - the beginning of time - only to have it reappear as the 'beginning' to the space of all possible four-spheres."

In attempting to overcome the singularity in general relativity, Hawking has seemingly unawares substituted one kind of singularity (the beginning of time) for another (a quantum singularity). Hawking's case remains unproved[19], and the majority of astronomers continue to use a model of a big bang universe with a fixed beginning.

Two further questions remain: when was this 'beginning'? And if the universe has been constantly expanding, how large is it now?

The age of the universe

Galaxies, such as our Milky Way, are not isolated: they generally lie in small groups, or in larger clusters which sometimes contain thousands of member galaxies. (Our Milky Way does not lie in a large cluster, but rather in a small group of about thirty members, known as the 'Local Group', some 10 million light years across). Light from the Virgo cluster of galaxies has taken 60 million years to reach our eyes; light from the Fornax cluster has travelled for 100 million years. Light from the most distant objects ever observed has taken some 15 000 million years to reach our telescopes, so that the universe we find ourselves in is at least 15 000 million light years across.

The universe is very old. We need only study globular clusters, which contain the oldest known stars in the universe. According to all known criteria their ages are of the order of billions of years[20,21]. The age of the globular cluster NGC 288 is at least 14 billion years[22]. The universe cannot be younger than one of its constituent objects and so, allowing some time after the big bang for galaxies and stars to form, the universe must be about fifteen to twenty billion years old.

We can say that fifteen to twenty billion years ago the density at any one point was immensely high. This is what cosmologists mean when they refer to the 'age of the universe'.

The irrelevance of mankind?

Bernard de Fontenelle knew only a little of what we know today. Yet he felt lost as he pondered the distances between planet and planet, star and star. Today we know the universe is up to twenty billion years old, and fifteen to twenty billion light years across. So is mankind an irrelevance? Are we a chance event in one minute part of an ever expanding cosmos? Is life, as Bertrand Russell once defined it, 'an accidental co-location of atoms'?

The fact that you and I are here requires the universe to have certain properties: we require gravitationally bound systems (galaxies). This is not a trivial point[23]. The recently released COBE maps confirm that our universe is specifically structured so as to contain superclusters and clusters of galaxies.

In the initial formation of the universe, an extremely delicate balance had to be established between the densities of the 'blobs' of matter destined to form galaxies, and the expansion rate of the universe. If the early universe expanded too slowly, regions of higher density (which could have formed galaxies) would have had time to collapse in on themselves. Instead of galaxies they would have formed black holes. Today there would be no constellations, no stars, no suns to support any life.

On the other hand, if the early universe expanded too quickly, the same regions of matter of higher density would have continued to expand outwards indefinitely. The star systems could not have been held together by gravity to form galaxies. Again, no stars, no suns.

The balance is critical. In the early big bang scenario, a reduction in the rate of expansion by only one millionth, millionth when the temperature was 10 000 million degrees would have caused the universe to recollapse when its radius was only 1/3 000th of its present value[24]. In the most modern version of the big bang (the inflationary big bang models) the balance at early times is even more critical[25]: a change of one part in 10^{55} (a decimal point followed by 54 zeroes and a 1) would have meant we would not have had an opportunity to come into existence. Put simply, the early universe expanded at just the critical rate to produce galaxies ... and hence life.

We live in a finely tuned universe. By very reason of our existence, the universe must have special, and not arbitrary, properties.

Such an amazing balance may, of course, be a sheer accident. And what if this present universe is but one of many over countless aeons of time? Some argue that if the universe is constantly collapsing back on to itself, only to 'bounce' out again in a new state, the critical factors to support life may have occurred by chance. If so, we are the lucky ones. We just happen to be riding a universe which bounced in a favourable way!

Does the universe bounce?

But let us play devil's advocate for a moment. Let's argue for a cyclic series of closed universes, even though astronomical observations do not support it[7]. We imagine that each expansion phase to a maximum radius is followed by recollapse and a bounce to a new expansion phase, ad infinitum. Are we then not the product of one 'perfect' bounce in which the early expansion rate just happens to be the appropriate one to support our existence? Such studies have been undertaken by Barrow[26], Barrow and Matzner[27] and Guth and Sher[28], amongst others. Barrow and Matzner find in their work on certain closed universe models that the probability of a bounce is related to the ratio of the minimum to maximum sizes of the universe. Inflationary models imply a large maximum value. We have already estimated that our observable universe is 15 billion light years across. Minimum values are of the order of the Planck length, that is approximately 10^{-33} cm. These realistic values show that it is *most unlikely* for a universe ever to bounce. The probability of only one bounce is infinitesimally small. It is less than 10^{-60} (a decimal point followed by 59 zeroes and a 1)! And we need the universe to oscillate or bounce almost ad infinitum before the early expansion rate is found, on a random basis, to be finely tuned to one part in 10^{55}.

> "In the range of models discussed, it is overwhelmingly improbable that a bounce could occur when the scale exceeded the Planck length — 10^{-33} cm."
>
> *John Barrow and Richard Matzner*[27]

Physicist Bludman argues[29], on account of irreversible thermodynamic processes, that 'a closed universe lives only once.' Guth and Sher[28] entitle their paper 'The impossibility of a bouncing universe' and comment: "If a contracting universe is dominated by radiation, then a bounce is impossible."

Carbon is required to make physicists

We only have one universe to work with.

The critical rate of expansion at early times in our one universe is but one of many parameters which have to be satisfied to give rise to intelligent life. Could we still be reading this booklet if the fundamental forces in this one universe were significantly altered?

There are four basic forces which cement the universe together:

- Electrical or electromagnetic force - controls the structure and interactions of atoms and molecules,
- Gravitational force - responsible for the structure and dynamics of planets, stars and galaxies,
- Weak Nuclear Force - operates on atomic particles over very short ranges,
- Strong Nuclear Force - holds protons together in the atomic nucleus. Protons are positively charged and if unrestrained would repel each other.

The need for electromagnetism to be finely tuned can be rephrased as a need for the fine tuning of gravitation, because it is the ratio between the electromagnetic and gravitational forces which is crucial. Were electromagnetic forces stronger as the universe expanded, the galaxies would consist almost entirely of low-luminosity, red stars which are too cool to promote and sustain life. Furthermore, low-mass stars do not explode as supernovae. Elements such as carbon are created deep within the interiors of stars[30,31], and can only be released in to space by supernovae explosions. The presence of such elements is essential when any potential life-supporting planet is formed. And as Robert Dicke of Princeton University has quipped[32], "It is well known that carbon is required to make physicists."

Were the electromagnetic force slightly weaker, there would only be hot blue stars. The life-times of such stars are far too short and the temperatures far too high to support the emergence of human beings.

Alternatively, if the gravitational constant was to have been increased, nuclear reactions in the cores of stars would have been so rapid that the lifetimes of such stars would have been very short - too short for the appearance of carbon-based life[33]. Conversely, if the gravitational constant was weaker than at present, stars would not have become hot enough for nuclear reactions to start, and we would have no suns!

And so it is with the weak and strong nuclear forces, and other critical fine tunings. For carbon to be created in quantity inside stars the strong nuclear force must be within *ninety-nine* per cent of its present value[34].

The exact balance needed between the four basic forces points to the improbability of life. But, many argue, the sheer size of the universe, with its countless stars and planets, must mean that there are forms of life scattered throughout the universe. Given that the improbable *did* happen, that the critical balance of forces did occur, then life forms must be common. There must be an abundance of extra-terrestrial life on account of the immensity of the universe. But, could our universe harbour us as observers if it were not as old, and as big, as astronomers find it to be?

The key point here is that the observable extent of a universe expanding from a highly dense big bang state is inextricably bound up with its age. A big bang universe one year old would be one light year in radius. A big bang universe one million years old would be one million light years in extent. Each year our observable horizon increases by one light year, so that the universe we find ourselves in must be at least 15 000 million light years in size because it is at least 15 000 million years old. Cosmologists John Barrow and Frank Tipler[35] explain:

"The requirement that enough time pass for cosmic expansion to cool off sufficiently after the Big Bang to allow the existence of carbon ensures that the observable universe must be relatively old and so, because the boundary of the observable universe expands at the speed of light, very large." We can therefore say that no one should be surprised that the universe is so large. We could not exist in one that was any smaller!

"A naive person looking at the cosmos has the impression that the whole thing is extravagantly, even irrelevantly, large. This extravagant size is our primary protection against a variety of catastrophes."

Princeton Physicist Freeman Dyson[36]

If it does take 15 000 million years after a hot big bang state for temperatures to be conducive to life, then the observable universe *must* be 15 000 million light years in extent, for its boundary has been expanding for 15 000 million years at the speed of light. The argument that the universe must be teeming with life, simply because it is so immense, loses much of its persuasiveness. The universe has to be as large as it is just to support life on earth!

In considering the probability of life emerging, we must also count the odds stacked against the formation of even just one gene.

The miracle of life

So far we have only considered astrophysical fine tunings, but there are remarkable blueprints for design in the biochemical world as well. In particular,

- The odds against spontaneously assembling one single gene are enormous.

- The odds against assembling the human genome spontaneously are even more enormous.

DeLey[37] estimates that approximately 10 to 20 per cent of the amino acids comprising an enzyme do not change under enzyme activity. The other amino acids can be changed by random mutations without changing the biological effect of the enzyme. The same ratios (1 in 10 or 1 in 5) may be applied to related biological structures: while most of the structure can change with no alternation in biological function, a change in the remaining 10 or 20 per cent *is* significant. This means that if we suppose the average gene to have 1800 nucleotide bases[38], then 180 to 360 nucleotides are significant (immutable) for each gene. Now each nucleotide in a DNA chain represents one of four 'letters' A, C, G and T (adenine, cytosine, guanine and thymine). The 'words' obtained when the four letters A, C, G and T are arranged in their proper order are the genes. The number of different kinds of chain in a gene is therefore equal to the number 4 raised to the appropriate number of available significant nucleotides. To create a *single* gene with the required properties necessitates a coding of between

$$4^{180} = 2.3 \text{ X } 10^{108} \text{ and}$$

$$4^{360} = 5.5 \text{ X } 10^{216}$$

of the 'letters' A C G T in the sequential arrangement of its nucleotides.

John Barrow and Frank Tipler affirm that: "There simply has not been sufficient time since the formation of the earth to try a number of nucleotide base combinations even remotely comparable to these numbers."[35]

They illustrate this by noting that the total number of nucleotide base

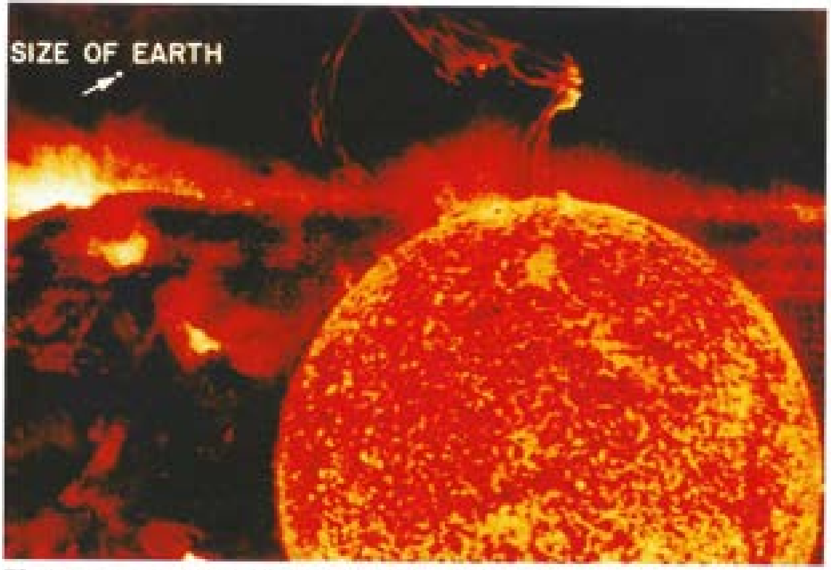

Plate 1 – A size comparison of our earth and our closest star, the sun.
What colour would stars be if the force of gravity in our cosmos were increased?

Plate 2 – A stellar incubator, against a backdrop of myriads of stars in our Milky Way Galaxy.
If every star sported a planet on which life might form, would there be enough stars to make intelligent life a likely outcome?

Plate 3 – This spiral galaxy recedes from us at 800 kilometres per second. We are looking back 52 million years in time. The young, hot stars are blue, and are born in the spiral arms of the galaxy.

Would galaxies exist today if the rate of expansion of our early universe were 'monkeyed with' fifteen billion years ago?

Plate 4 – The Coma cluster of galaxies. Each 'fuzz' is a galaxy, containing 100 000 million stars. We are looking back over 400 million years in time.

Should we be surprised to find the universe so large? Could we exist in one that was any smaller?

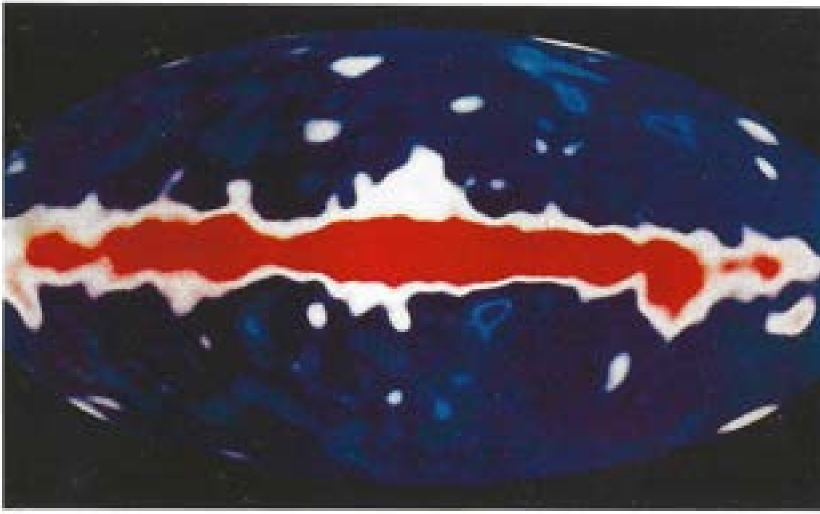

Plate 5 – Ripples from the big bang, seen here on either side of the plane of the Milky Way, which is the bright horizontal band along centre. This microwave map is a 'snapshot' of the creation event, showing radiation which has been travelling for more than fourteen billion years.

Does our existence depend on a crucial one proton excess fifteen billion years ago?

Plate 6 – A man, a child, the moon, a tree.

Is it our signature on the picture that gives it value? Was the entire cosmic canvas so framed that it might display our name?

Plate 7 – A child is conceived. A fertilized ovum, four days old, glides into the uterus of a mother.

"Each Soul is a new Divine creation which is implanted into the growing foetus at some time between conception and birth... I submit that no other explanation is tenable; neither the genetic uniqueness with its fantastically impossible lottery, nor the environmental differentiations which do not determine one's uniqueness, but merely modify it." – Nobel laureate Sir John Eccles[39].

Plate 8 – The birth of my son, Aaron. One hundred and ten thousand different genes.

Is each key gene likely to have appeared more than once in fifteen billion years?

combinations over the entire past history of the earth (4.5 billion years = 10^{13} hours) is only 10^{47}, and this is 61 orders of magnitude too few, for $10^{108-47} = 10^{61}$.

> *"If life really depends on each gene being as unique as it appears to be, then it is too unique to come into being by chance mutations."*
>
> **Frank B. Salisbury**[39]

One of the most primitive bacteria *Mycoplasma Gallisepticum* contains 170 different genes. *Escherichia Coli* contains 2 500. There are 7 250 genes in the fruit fly. The human genome is estimated to contain 110 000 different genes[38], of which *each* key gene is unlikely to have appeared more than once in 15 000 million years. The probability of spontaneously assembling Homo Sapiens is even more staggering. It lies between

$$4^{-180\,(110\,000)} = 10^{-12 \times 10^6} \text{ and}$$

$$4^{-360\,(110\,000)} = 10^{-24 \times 10^6}$$

Such figures show the enormous improbability of Homo Sapiens appearing by spontaneous assembly.

Now, no sane biochemist would argue that a single gene, let alone the human genome, was spontaneously formed. We have to consider the mechanism of construction. Taking full recognition of this, what do leading biologists say?

"There has developed a general consensus among evolutionists that the evolution of intelligent life, comparable in information processing ability to that of Homo Sapiens, is so improbable that it is unlikely to have occurred on any other planet in the entire visible universe. The consensus has been defended by many of the leading evolutionists such as Dobzhansky[40,41], Simpson[42], Francois[43], Ayala et. al.[38] and Mayr[44]."

The key issue here is the *unpredictability* of evolution. It is not deterministic. There is no 'straight line' from the origin of life to observers studying the cosmos.

Recalling conversations with astronomer Donald Menzel, zoologist Ernst Mayr at Harvard University writes[45]: "I was forever astonished how certain he (Menzel) was that if life had ever originated on Mars (or been transported to Mars), this would inevitably lead to intelligent humanoids. The production of man was for him like the end product of a chemical reaction chain where the end product can be predicted once you know with what chemicals you had started. He took it virtually for granted that if there was life on a planet it would in due time give rise to intelligent life."

> *"The question of the probability of extraterrestrial intelligence is a difficult one. Biologists almost unanimously consider it almost totally improbable; almost all those who disagree are physicists."*
>
> *– Harvard Evolutionist Ernst Mayr*[46]

Even though natural selection may ultimately impose certain kinds of mutation on a species as a whole, the appearance of new taxa is not deterministic. Even if the universe expands at the right rate; even if the basic physical forces are finely balanced in favour of the formation of galaxies, suns and planets; even then there is no guarantee, a priori, that a large and old universe will necessarily give rise to human beings. Life, the miracle of life, itself hangs on an impossibly fine thread.

So slender is this thread that even if every star in the heavens sported a planet on which life might form, still there would not be enough stars to make intelligent life a likely outcome. A realistic estimate of the number of galaxies in our visible universe is conservatively 10^9; let us assume 10^{11}. Let us furthermore suppose that each galaxy contains the same number of stars as does the Milky Way (10^{11}). That makes a total of 10^{22} stars within the present day observable horizon. Even if the probability for intelligent life to develop on a planet were as high as one in 10^{30} (is actually less), there are only 10^{22} candidate stars!

Only three minutes to go

To demonstrate the unpredictability of evolution, Mayr uses a simple table[45]. The table gives the date of the origins of different organisms if the age of the earth (4.5 billion years) is made equivalent to one calendar year:

Origin of	*Equivalent day*
Earth	1 January
Life (Prokaryotes)	27 February
Eukaryotes	28 October
Chordates	17 November
Vertebrates	21 November
Mammals	12 December
Primates	26 December
Anthropoids	30 December, at 01:00 a.m.
Hominid line	31 December 10:00 a.m.
Homo sapiens	31 December 11.56¾ p.m.
	(= 3¼ minutes before year's end).

Mayr writes: "What is most remarkable is that for 3 000 million years nothing very spectacular happened as far as life on earth was concerned. From the origin of life to the origin of the eukaryotes about two-thirds of the age of the earth had passed by without any noticeable events except for diversification within the prokaryotes ... If evolutionists have learned anything from a detailed analysis of evolution, it is the lesson that the origin of new taxa is largely a chance event."

Given that conditions on our planet are suitable for the emergence of intelligence, there is no a priori guarantee that intelligent life will actually emerge – or that it will emerge within a time frame when the earth can still support a biosphere. We have suddenly appeared 3¼ minutes before the year's end! The timing for the appearance of intelligence, given the unpredictability of evolution, has been exceedingly precise.

The earth's atmosphere is only marginally stable[47]. As the earth orbits the sun in its habitable zone[48], there is a very fine tuning between runaway glaciation and runaway heating due to the greenhouse effect[49]. Barrow and Tipler[35] estimate that the length of time that the earth will still contain a biosphere, and thus remain suitable as a habitable planet, may only be another 3½ minutes in a timescale where the remaining lifetime of our sun, approximately 4.5 billion years, equals 365 days. One minute on this timescale corresponds to 8562 years; 3½ minutes is equivalent to 30 000 years.

They comment[35]: "This is an incredibly short period by astronomical, biological and geological standards; it is about the length of time anatomically modern man has existed... We must take seriously the timescale estimates given to us from purely biological data, even if the logical implications of these data may appear incredible."

The presence of vanishingly small probabilities in the microcosm of the gene and the macrocosm of the universe suggests a unifying theme that would make biology and cosmology each intelligible to the other and to anyone else addressing the question. If the end result (the original establishment of the genetic code, or a human being) is specified by a Creator *in advance*, the probabilities of their assembly discussed above are so dramatically increased that the actuality of the genetic code, a man, a woman, with only three minutes to go, is realised.

But there is more. Each human being is *self-aware*. Nobel Prize winner Sir John Eccles, one of the world's most eminent brain scientists, explains[50]: "The amazing success of the theory of evolution has protected it from significant critical evaluation in recent times. However it fails in a most important respect. It cannot account for the existence of each one of us as unique self-conscious beings."

The unifying theme between cosmology and the marvel of the human mind-brain is, I believe, teleology linked to the immanence of the Creator. The Creator permanently pervading the universe with his presence. Genes model the future purposefully because purpose underlines their existence and draws them forward to their goal. Teleology relates to the end (or purpose) beyond the scope of any internal modelling process. The genetic modelling mechanisms are subject to the specified goals. Actuality unfolds, moment by moment, in a continuous dialogue with the end result, or potential. Sir Eccles continues[50]: "I believe that there is a Divine Providence operating over and above the materialist happenings of biological evolution."

James Trefil[51] expresses our uniqueness and our self-awareness succinctly:

"...But we are living on an insignificant speck of rock going round an undistinguished star in a low-rent section of the galaxy. We are not the centre of the universe.
Maybe so, but we are special.
But we share our biochemistry with millions of life forms, from flatworms up. We are one member of a large family of animals using one particular variant of carbon chemistry known as DNA.
Maybe so, but we are special.
Why?
Because only on this insignificant speck of rock have beings evolved who can look at the universe and ask the question, 'Why?' "

An insignificant world?

Cosmologist Bernard Carr sets the scene. He writes: "Until recently, the progress of science seemed to involve a continual denigration of Man – we are insignificant as judged by scale and duration and life itself appears to be no more than an accident, a result of random chance processes. However, recent developments in cosmology suggest that the existence of life is very sensitive to the initial conditions of the Universe and to the values of the physical constants. This has led to the Anthropic Principle, the proposal that the existence of life imposes a selection effect on where and when we observe the Universe – and even on the nature of the Universe itself."

The question has been asked:
"What room, then, for a Creator?"
God created the room.

– Elizabeth Block

Science has now begun to recognize that the miracle of our existence must influence the way we understand the universe. We *are* special.

Instead of a common line of reasoning that mankind is an inevitable and incidental entity in the cosmos, the *Anthropic Principle* (after the Greek word *Anthropos*, for man), formulated by cosmologist Brandon

Carter[52], argues the reverse. In the light of the immensely small astrophysical probabilities for our one and only universe to contain life, followed by the preposterously large biochemical timescales needed to make even one gene, the fact that mankind exists is indeed remarkable. It should be taken as a *starting point* when attempting to understand the prior history of our universe.

> *"The knowledge that our presence in the universe represents a fundamental rather than an incidental feature of existence offers, I believe, a deep and satisfying basis for human dignity."*
>
> ***Paul Davies[53]***

Rather than stating that "certain conditions such as temperature were favourable to the emergence of life", the Anthropic Principle turns it around. It asserts that *we are here* – therefore, constraints are placed on the diversity of ways the universe could have begun and on the physical laws that could have governed its development.

The Anthropic Principle may be stated in strong and weak forms. In its strong form asserts what *must* have happened. The universe must have those properties which allow life to develop. The weaker form of the Principle is content merely to observe that, from a range of possible values, the forces from the beginning took on those values which allowed life to develop.

The Anthropic Principle

In full, the "Weak Anthropic Principle" (WAP) states that:

"The observed values of all physical and cosmological quantities are not equally probable[35] but they take on values restricted by the requirement that there exist sites where carbon-based life can evolve, and by the requirement that the Universe be old enough for it to have already done so." Arbitrary initial conditions at the big bang do not necessarily develop to produce a life supporting universe after more than 15 billion years of expansion.

We essentially have three possibilities for the initial conditions of the universe. Either the very early universe was smooth, or we come from a chaotic and random early universe, or the initial conditions were exactly tuned for life.

Discussing the first option is easy. The early universe could not have been perfectly smooth or we would not be here to write about it! The COBE satellite microwave maps support an early universe with minute structure in the distribution of mass.

If we say that a primordial chaos prevailed at the big bang, why did order ever arise out of such chaos? This is a very subtle but profound point. For, according to the second law of thermodynamics, *disorder* (entropy[54]) has an overwhelmingly large probability to increase. This natural tendency toward disintegration and chaos is evident all around us: stars burn out, cars rust, mountains erode and people grow old. Where order apparently increases it is always at the expense of greater disorder elsewhere. The complex design of the simplest leaf is at the expense of vast explosions within our sun. We observe on earth localised order; overall the universe is running down.

We are presented with a curious question: if information and order have a natural tendency to disappear, where did all the precise information that makes the universe such a special place come from originally? Chaos initially should systematically lead to even greater chaos.

Now, movement from disorder towards order *can* happen. But it is exceedingly unlikely. Paul Davies notes that[55]: "It is curious that no less a person than Boltzmann once suggested that the orderly world is indeed a stupendously rare fluctuation from an overwhelmingly more prevalent chaotic state... a fluctuation of the kind Boltzmann envisaged would take at least $10^{10^{80}}$ (one followed by 10^{80} zeroes!) years to occur."

There are other problems with *random* or *chaotic* initial conditions. If this is a true picture of the early universe, the universe now should be very lumpy with only *small* uniform patches. Why are we located in a patch in which life has developed? And what is more, if the initial conditions are random, why is our patch *just the correct size* to contain observers? In addition, not all random initial conditions would give rise to a universe ballooning outwards at early times[56].

One proton too many

The initial conditions are not random. Neither are they chaotic. They are finely tuned to support life. There must have been, in that early universe, the seeds of matter which later became our galaxies. But this, too, is subject to critical balance: the amount of matter had to exceed the amount of anti-matter, or we would not be here. In fact our existence depends on a crucial one proton excess 15 000 million years ago!

All matter comes in particle-antiparticle pairs. Particles and their antiparticles have the same mass and lifetimes. The initial conditions for us to be here today is that for every 100 million antiprotons in the early universe, there was only *one* more proton. In other words, there were 100 million + 1 protons. The 100 million antiprotons annihilate with the 100 million protons at very early times, and the *one remaining* proton becomes part of the matter- dominated universe we live in today!

The tiny asymmetry between matter and antimatter built in to the initial conditions was crucial for our existence, because all matter (including ourselves) derives from it. If the ratio of protons had exactly equalled the ratio of antiprotons, all matter and antimatter would have annihilated within 1/100 000th of a second to produce a universe of pure light. And we would not exist.

The Anthropic Principle recognizes that we live in a very finely tuned universe, where the values of cosmological quantities and fundamental forces are not equally probable but are *designed to support life*[57,58].

Bernard de Fontenelle saw the human world as terrifyingly insignificant. The Anthropic Principle completely reverses this: the very fact of our existence defines the necessary structure of the universe. It is our signature on the picture that gives it value. Indeed, the whole canvas of the universe was so framed that it might display our name.

Freeman Dyson[59] puts it this way:

"As we look out into the universe and identify the many accidents of physics and astronomy that have worked together for our benefit, it almost seems as if the universe must in some sense have known that we were coming."

Many have taken the Anthropic Principle further, seeing in the development of the universe, divine design.

Divine design

A deductive theory[57] begins by specifying the initial conditions of a physical system and the laws of nature that apply to it; the theory then predicts the subsequent state of the system. The Anthropic Principle has been invoked in cosmology precisely because the deductive method cannot be employed here. For example, the initial conditions of the universe are not known; neither are the physical laws which were operative at very early times (those laws may even depend on the initial conditions). Therefore, perhaps the only realistic constraint that can be imposed on a theory reconstructing the initial conditions of the universe and the corresponding laws of nature is the requirement that those conditions and laws give rise to an *inhabited* universe. The initial recipe in creating our one universe has to be *very* precise.

The Strong Anthropic Principle (SAP) postulates that, "the universe *must* have those properties which allow life to develop within it at some stage in its history." Expressing the Principle in these terms hints at 'design' and a version of the SAP can be formulated as: "There exists one possible universe designed with the goal of generating and sustaining observers."

American astronomer Allan Sandage was asked the question, "If you could design the universe any way that you wanted to, how would you do it?" In reply[60], he said:

"If I were present at the creation, would I give the Creator better advice? And you are asking for that better advice. I wouldn't want to destroy all the mystery, as we do in reductionist science. The greatest mystery is why there is something instead of nothing, and the greatest something is this thing we call life. I am entirely baffled by you and me... . Perhaps the universe is the only way it can be for us to exist. If that's true, to ask to create a different universe is to ask to enter into genocide. Now that's the anthropic principle, but the more I think about how everything is so finely tuned, the more that principle makes sense."

The British astrophysicist Sir Fred Hoyle[61] writes:

"I do not believe that any scientist who examined the evidence would fail to draw the inference that the laws of nuclear physics have been deliberately designed with the consequences they produce inside the stars. If this is so, then my apparently random quirks have become part of a deep-laid scheme."

Were it not for remarkable fine tunings within the atoms of carbon and oxygen, we would not be here[61,62]. The laws of nuclear physics are specifically such as to produce man. To reiterate the words of Paul Davies, our presence in the universe is *fundamental*, not *incidental*.

Astronomer George Greenstein[63] expresses his thoughts:

"As we survey all the evidence, the thought insistently arises that some supernatural agency - or rather, Agency - must be involved. Is it possible that suddenly, without intending to, we have stumbled upon scientific proof of the existence of a Supreme Being? Was it God who stepped in and so providentially crafted the cosmos for our benefit?"

Science and Rationality

All science is based on the tenet of rationality. This is evident as soon as we confront rationality with its opposite, irrationality. Scientific rationality stems from the very fact that human beings are equipped with the faculty of thinking and of choosing to accept only that which has sufficient proof or argument. It would be irrational to believe that the earth is flat, for we have bountiful evidence that it is not. If rationality is a value, as indeed it is, then the decision to be rational is a moral choice. Sir Karl Popper expresses it simply: "The choice before us is not simply an intellectual affair, or a matter of taste. It is a moral decision."

There are many who would rather place their faith in the roulette of chance. For them the Anthropic Principle is an aggravation; it challenges their fervently held beliefs about the meaningless of the universe. Atheists exhibit an extraordinary degree of faith, albeit be it in the negative form of faith called doubt. They choose to believe – yes, *believe* – that the fine tunings in the universe on both microscopic and macroscopic scales are accidental, despite unmistakable blueprints for design. The barrier to theism is more often than not a *moral* rather than an *intellectual* one.

Cosmologist Chris Isham[64] affirms: "Perhaps the best argument in favour of the thesis that the Big Bang supports theism is the obvious unease with which it is greeted by some atheist physicists. At times this has led to scientific ideas, such as continuous creation[65] or an oscillating universe, being advanced with a tenacity which so exceeds their intrinsic worth that one can only suspect the operation of psychological forces lying very much deeper than the usual academic desire of a theorist to support his or her theory."

In the light of Christian theology, we should unravel the structure of the universe through rational attempts to decipher God's creative and redemptive plan. For the entire universe is a rational plan of the Creator, who has designed the cosmos, fifteen billion light years across, as a home for spiritual mankind.

We must be objective. We must be brave. We must be rational.

The Anthropic Principle achieves a new dimension in the coming to be of each of us as unique, self-aware human beings. In this essay, we *have* asked questions; questions about ourselves. Questions about the universe outside of ourselves, and of our place in it. To paraphrase a statement made by Karl Popper, the emergence of self-reflection is indeed one of the greatest of miracles[66].

The Mind of God

Ironically we return to the sixteenth and seventeenth centuries. Then great scientists such as Kepler believed that the universe reflected the mind of God, and mankind was the pinnacle of creation. Kepler wrote: "There is nothing I want to find out and long to know with greater urgency than this. Can I find God, whom I can almost grasp with my own hands in looking at the universe, also in myself?"[67]

The Anthropic Principle in its strong form views our presence as the product of a great, supernatural design which has been operative since *creatio ex nihilo* began.

And what of Kepler's question? Can we discover God not only by his footprints in the universe, but by his divine love in our hearts?

Christians have always drawn on the majestic words at the beginning of the Gospel according to St. John. Here John reveals that the divine Word – God's order and rationality – lay behind creation.

"In the beginning was the Word (Logos), and the Word was with God, and the Word was God.
The same was in the beginning with God.
All things were made by him; and without him was not any thing made that was made."

John, Chapter 1, vv1-3.

But St. John does not stop there.

"And the Word was made flesh, and dwelt among us..."

John, Chapter 1, verse 14.

In the course of human history, the Logos assumed the flesh of scientific rationality. In Christ, God identified himself with our confines of time and of space. Our thought processes, confined to a one dimensional time line. That perfect balance between God's transcendence (existing outside of his created cosmos) and his immanence (permanently pervading the universe with his presence) is found in Jesus, the luminous figure of the Nazarene[68].

As human beings we are significant on two counts. First, we are significant here and now because we are the focus of creation. This lecture has attempted to substantiate that claim. But, second, we can be eternally significant because Jesus – that Word of God – became part of creation. Why? So that for all time those who accept his love may be called his children.

God's immanence in our world makes the human world rational.

We awake from de Fontenelle's terror as though from a bad dream.

We may, you and I, be 'the focus' after all[69].

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Notes & References

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53. P.C.W. Davies, *The Cosmic Blueprint - New Discoveries in Nature's Creative Ability to Order the Universe* (Simon and Schuster, NY, 1988).

54. Information is negative *entropy*. A *highly structured* system needs a lot of information to describe it and is said to be in a state of *low* entropy. Conversely, systems of *high* entropy are highly disordered and have a *low* information content.

55. P.C.W. Davies, *New Scientist*, vol **80**, No. 1129 (16 November, 1978).

56. Neither can *all* global pre-existing gradients be removed by a ballooning (inflationary) epoch.

57. G. Gale, *Scientific American*, vol **245**, No. 6, p154 (December, 1981).

58. H. Ross, *The Fingerprint of God* (Promise Publishing, California, 1989), chapter 6.

59. F.J. Dyson, *Disturbing the Universe* (Harper and Row, NY, 1979).

60. A. Sandage in *Origins – The Lives and Worlds of Modern Cosmologists* ed. A. Lightman and R. Brawer (Harvard Univ. Press, Massachusetts, 1990), p83.

61. F. Hoyle in *Religion and the Scientists* (SCM, London, 1959). Also, F. Hoyle in *The Universe: Past and Present Reflections, Annual Review of Astronomy and Astrophysics*, vol **20**, p16 (1982). The experimental confirmations of Hoyle's predictions for carbon-12 appear in F. Hoyle, D.N.F. Dunbar, W.A. Wensel & W. Whaling, *Physics Review*, vol **92**, p649 (1953).

62. From an extensive study of stellar nucleosynthesis, Hoyle predicted that the only way to make enough carbon inside stars would be from atomic reactions involving beryllium and helium – provided there was a previously undetected (resonant) energy level in the carbon-12 nucleus. He made a precise calculation of what that *specific* energy level must be, and came up with an answer of about 7.7 million electron volts, abbreviated 7.7 MeV. (Physicists measure mass –strictly speaking, 'rest energy' – in terms of a unit known as an electron volt, or eV. In these units, the mass of an electron is a little over 500 000 eV). Hoyle enthused some rather sceptical nuclear physicists at the time to perform experiments to test his prediction. To the astonishment of everyone, except Hoyle, an energy level at 7.65 MeV was discovered! Hoyle had said, in effect: "Since we are here, carbon must have an energy level at 7.7 million electron volts." *Only then* were the experiments performed and the hitherto undetected energy level found. This example highlights the *predictive power* of the Anthropic Principle, even in its weak form.

    Now this is not the end of that story. Carbon could be destroyed in a subsequent nuclear reaction by combining with helium to give oxygen. Were it not for another remarkable fine tuning within the oxygen atom, all carbon would be rapidly destroyed. But the oxygen nucleus has an energy level of 7.1187 MeV – *just below* the 7.1616 MeV energy of carbon + helium – so that the presence of carbon is secured. If these 'coincidences' did not exist in nature, neither would we.

63. G. Greenstein, *The Symbiotic Universe: Life and Mind in the Cosmos* (William Morrow, New York, 1988), pp26-27.

64. C.J. Isham in *Physics, Philosophy and Theology*, ed. R.J. Russell, W.R. Stoeger and G.V. Coyne, (Vatican Observatory, 1988), p378.

65. With continuous creation, matter is always coming into being uniformly throughout infinite time and infinite space. Hydrogen atoms in such a steady-

state model would appear *de novo* at a constant rate. The preponderance of scientific evidence rules out *ex nihilo nihil fit* (nothing is created out of nothing) and affirms *creatio ex nihilo*, a universe with a definite beginning of time and of space.

66. K. Popper, quoted by J.C. Eccles and D.N. Robinson, *The Wonder of Being Human* (New Science Library, Boston, 1985), p26.
67. Kepler to an unidentified nobleman, 23 October 1623. *Johannes Kepler Gesammelte Werke*, vol 17, p80; translation from *Johannes Kepler: Life and Letters*, pp114-15.
68. In an interview by George Viereck, Albert Einstein was once asked to what extent he was influenced by Christianity. "As a child I received instruction both in the Bible and in the Talmud. I am a Jew, but I am enthralled by the luminous figure of the Nazarene." George Sylvester Viereck, 'What Life Means to Einstein', *The Saturday Evening Post*, 26 October 1929.
69. Psalm 8 and John, chapter 3, verse 16, *The Holy Bible*.

A video recording of "*Our Universe: Accident or Design?*" by the author is available through the Publishers, at address on inside of front cover.

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