Convergence to God?*

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Astronomical evidence for the omnipresence of microbial life in the galaxy, and mechanisms by which such microbes survive, become amplified and spread, led us naturally to explore the further question: How did the life come into existence in the first place? Attempts to grapple with this problem led us to dismiss the conventional theory of an origin of life in the primordial oceans as being implausible, and seek ever-widening cosmic horizons for accomplishing the improbable transition from chemistry to biochemistry. Even by extending the setting to encompass the entire universe a superastronomical improbability gap needs to be filled. The role of a "cosmic intelligence" that is somehow involved cannot be excluded on purely logical grounds.

We have thus far presented evidence from astronomy, biology and geology all pointing to life being a truly cosmic phenomenon. At this point, if only in the interest of retaining our credentials as scientists, it might be as well to stop. After all, no biologist has cause for complaint with the present situation. Since for a century or more biologists have believed that the Earth provided an environment sufficient for the origin and evolution of life, they can hardly grouse at the scheme of Figure 1, which on a galactic scale gives of the order of 10^{11} times the evolutionary potential and environmental variety of the Earth, and which on a universal scale gives of the order of 10^{20} times as much.

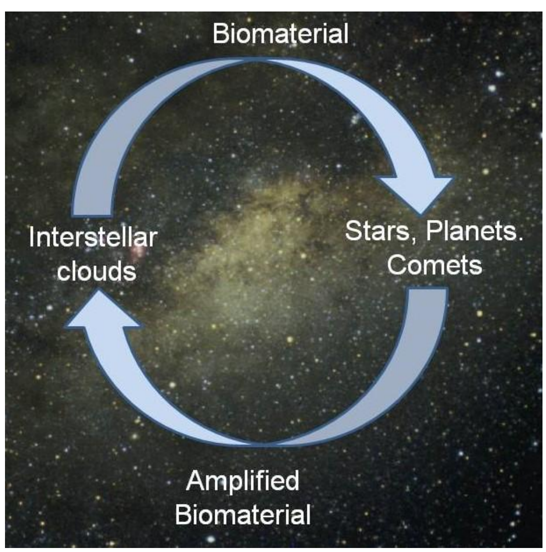

Figure 1 Life cycle in the cosmos

Yet if we are to maintain a proper scientific outlook, the numbers calculated earlier have to be faced at some stage. We showed that a random shuffling of amino acids would have as little chance as one part in $10^{40,000}$ of producing the enzymes. It is usual to attempt to side-step this difficulty by arguing that the first enzymes in the first life were much shorter in their polypeptide lengths, and so were much less improbable to come by. The idea is for the first life to evolve by natural selection, with the enzymes growing in length and becoming more complex, until eventually they reached their present forms. There is nothing in this hand-waving beyond attempting to argue that the 2,000 or so enzymes are built from a much smaller number of basic components, with each component of a simple structure. Whether or not this is so can be decided by reference to the actual amino acid sequences on the enzymes themselves. While there are some repetitions of structure (trypsin and chymotrypsin are examples) we think it safe to say that if so remarkable a suggestion were true it would long since have been discovered. Besides which the same problem applies widely to other complex biosubstances such as the histones.

When one considers the need for a program to control the behaviour of cells, the problem is aggravated. Everyone who has actually set up a sophisticated program for a normal computer (not using provided languages like *Basic* or *Fortran*) will agree, we think, with our experience that the writing of sub-routines is the least part of the job. The hard part lies in the logic of the main program. In the biological case, the enzymes, histones, . . . , are only the sub-routines. The main program remains, and likely enough this is the really awkward part, a part that is probably much less likely to be discovered by random processes than the complex biosubstances on which our probability estimates have been based, *much less* likely than one part in $10^{40.000}$.

Given an atlas showing the amino acid sequences of all the enzymes, human biochemists could construct them with complete accuracy, thereby demonstrating the enormous superiority of intelligence allied to knowledge over blind random processes. Nor would the atlas need to be very large, not more than a single volume of the *Encyclopaedia Britannica*. Indeed, within the compass of that encyclopaedia one could specify all the structural and functional sequences of the DNA within a human cell; and, given sufficient effort, all the complex biochemicals needed by the cell could be constructed. And if the cell program were known, quite likely it too could be given a material representation. In short, it is not grossly beyond human capacity to make a functioning cell, if we had the knowledge of how to do it.

Any theory with a probability of being correct that is larger than one part in $10^{40.000}$ must be judged superior to random shuffling. The theory that life was assembled by an intelligence has, we believe, a probability vastly higher than one part in $10^{40,000}$ of being the correct explanation of the many curious facts discussed earlier. Indeed, such a theory is so obvious that one wonders why it is not widely accepted as being self-evident. The reasons are psychological rather than scientific.

Something of this kind was implied by the special creation theory - God created each individual life-form. When biologists began to see clearly that individual life-forms were not entirely separate from each other, as the original form of the special creation theory required, but that evolutionary connections existed between some of them, the impulse was to swing to the opposite extreme. The whole of the special creation theory was thought to be wrong and there was a general revulsion among scientists against it. In effect, because the details were seen to be incorrect, the fundamental idea that life was created by an intelligence was also rejected.

This forced a reliance on the inorganic processes of 'Nature'. Somehow a brew of appropriate chemicals managed to get together, the organic soup, and somehow the chemicals managed to shuffle themselves into an early primitive life-form. From then on, all appeared to be plain-sailing, natural selection operating on randomly generated mutations would do the rest.

Already in the mid-nineteenth century, however, it was seen that the chemical shuffling part of this argument was weak. Thus Charles Darwin wrote: ". . . if (and oh what a big if) we could conceive in some warm little pond with all sorts of ammonia and phosphoric salts present, that a protein compound was chemically formed ready to undergo still more complex changes ..."

Although the difficulty was admitted, just how big an "if" would be needed (one part in $10^{40,000}$) was not understood in the nineteenth century. As the enormity of the supposition was slowly revealed in the present century, there was an attempt to evade this difficulty through the invention of pseudo-science.

The pseudo-science had its origin in the second "law" of thermodynamics. The second "law" of thermodynamics is not a mathematical 1aw of physics in the usual sense, not like Maxwell's equations of electromagnetism or Einstein's of gravitation which relate physical quantities at each individual point of space and time. The second "law" is distributed over a volume of space (a closed box) and it refers to what happens in that volume in an extended interval of time. Thermodynamics is an empirical science, with the "laws" of thermodynamics expressing certain broad features of the way complex material systems are observed to behave. One way of stating the second law is to say that a particular quantity called "entropy" never decreases.

The problem as it seemed to many scientists was to explain in terms of the real laws of physics (like Maxwell's and Einstein's) why entropy never decreased. Perhaps the most penetrating analysis of this question was given in 1909 by the German mathematician, C. Carathéodory[1]. His work did not commend itself generally, however, because it did not arrive at the wanted result. What Carathéodory proved was that either entropy could never decrease or it could never increase, but he couldn't , say which! To agree with the observed situation it was still necessary to make an arbitrary choice.

Nowadays it is understood where the trouble lay. There is no such thing as a closed box isolated from the rest of the universe. If one thinks, for example, of a hot gas within a box, it is impossible to contain the heat energy of the gas as was assumed in 1909, because there is no such thing as perfectly insulating material from which the walls of the box can be constructed. Thus the gas inside will lose heat energy unless there is a compensating inflow from the universe outside. This means that a crucial condition assumed in Carathéodory's argument - the gas neither gains nor loses energy - is only possible if the box is suitably connected to the outside universe.

Of course people were not so innocent in 1909 that they believed in perfectly insulating material.

What they argued was that the walls of the box could be made of sufficiently good insulating material so that the percolation of heat through it was small and could be ignored. This, however, was just where they went wrong. The percolation of heat may be small but it is sufficient to tip the balance between Carathéodory's two possibilities. The situation as it is understood today is that nothing internal to the box can lead to the second law of thermodynamics. lt is the manner of connection of the box to the outside universe which determines the second law. With the advantage of hindsight one feels that perhaps even in 1909 this resolution of the problem should have been perceived. Since the second law does not refer to the individual points of space-time, but to a volume of space-time, it is really an almost obvious guess that the volume in question must be the whole universe. As mathematicians would say, the second law must be a global law.

Without the advantage of this perception, some scientists began to hunt around for what they felt to be a new deep principle applicable to the behaviour of material systems inside closed boxes which would decide the entropy issue from within, some deep principle that imposed itself on all material systems of sufficient complexity. The argument was of the variety which a later generation of physicists came to describe as “pulling oneself up by one's bootstraps”. There had to be an explanation of the facts, therefore there had to be a ‘principle’, so no matter how great the imperfections of one’s theory, it had to turn out to be correct in the long run, much the same bootstrap as is still used for Darwinism.

So it came about that the concept of a scientific unicorn which would one day turn out to be a real animal was born. The trouble with unicorns is that once you have one of them, pretty soon you have a whole herd. If a unicorn could decide the second law of thermodynamics, why not have another unicorn that could shuffle the amino acids into the enzymes? Not an intelligent unicorn like a human biochemist, mark you, but a unicorn of deep principle. Somehow matter of its own accord would shuffle itself into the enzymes, because of a deep over-riding principle in the nature of things. Except that *Nature* was the word used instead of *God*, the idea was really the same as the older religious concept it was supposed to replace.

Trotting immediately on the heels of the unicorn of deep principle was the unicorn of Darwinism. As we have seen in earlier, there are so many flaws in Darwinism that one can wonder why it swept so completely through the scientific world, and why it is still endemic today. The reasons were several.

Natural selection as proposed by Edward Blyth[2] in 1835 was a sound and solid idea. Only those who suffered from extreme religious prejudice could fail to accept its validity. Yet it was precisely those sufferers who chose to argue the case against Darwinism and to do so in the full glare of public controversy. Their defeat on the natural selection issue was inevitable, and when the public saw them in disordered flight it seemed only a matter of commonsense to accept the validity of the whole Darwinian story. There was no general perception that the real issue of controversy, as it had existed decades earlier between Blyth and Darwin, had still to be resolved.

The difficulty for the few who wished to come to grips with the real question of whether random mutations and natural selection had been sufficient to explain the origin of species, and by implication the origin of life, which Darwin maintained but which Blyth did not, was that in the nineteenth century the theory was impossible to quantify. Before modern microbiology, the evolutionist simply pointed to the long time-scales of geology and there was then no way to demonstrate that it would need a time-scale $10^{40,000}$ times as long to produce the effects that were being claimed.

Undoubtedly, however, the biggest thing going for Darwinism was that it finally broke the tyranny in which Christianity had held the minds of men for many centuries. Christianity as it is practised today is a rather mild social philosophy, but in medieval times it bestrode in the most dreadful way the whole range of intellectual thought. It did this by imposing on the brain a set of concepts that were false and by then insisting (on pain of extreme punishment) that all subsequent thinking be made consistent with those false concepts. A similar but less extreme situation pervades Marxist nations today. Today, a dissident can attempt to escape by crossing the 'Iron curtain'. In medieval times there was no iron curtain, because there was then nowhere to escape to.

By the nineteenth century the tyranny had gone, otherwise *The Origin of Species* would have met a similar reception to that given to Copernicus' *De revolutionibus orbium caelestium libri VI*. But although Christianity had lost its thumbscrews and other instruments of torture, it still retained respectability. You could hardly be considered a gentleman unless you were a Christian, and if you wished to attend the University of Cambridge in order to study mathematics you had to pass an examination in Paley's "*Evidences*" and to attend compulsory chapel. It was this less extreme position that was broken by Darwinism. It gradually became moderately respectable not to be a Christian, and it gave to those who were earnest in their thinking the confidence to rid themselves of the false concepts which had formerly been so stultifying and so mentally painful.

William of Ockham (c.1285 to c.l349) is often referred to nowadays as a prophet of scientific method, mostly, we suspect, by scientists who have not read anything of what he actually wrote. Ockham was a good example of how the brain of an intelligent man could be tormented into absurdities by the need to conform with Christian concepts. Typical of the issues on which his mind was occupied, in 1330- 1331 Ockham preached a number of sermons in which he proposed that the souls of the saved did not enjoy the vision of God immediately after death but only after they were rejoined with the body at the Last Judgement.[3]

Needless to say, this was hardly an appropriate frame of mind in which to approach the delicate problems of scientific method.

We mention William of Ockham because doubtless there will be some who will be thinking of using his razor to slash the arguments presented here. "Ockham's razor" would seem nowadays to mean just what you want it to mean, in the style of Humpty Dumpty. We give two examples that have been used against us in the past, and then we give our own interpretation, after which we leave it to medieval historians to decide which, if any, of the three is right.

1. 'If there is already a theory which has not been disproved to the satisfaction of the scientific community, don't advance a new theory'. If this was what Ockham meant, then so far as science is concerned, his opinion was worthless. If Einstein had adopted such a

position he would not have advanced his theory of gravitation, because Newton's theory was not considered by scientists in general to be disproved. Newton's theory was in excellent agreement with many thousands of facts. There was only one small detail which might have been considered a discrepancy, and this small detail did not seem important to most astronomers and physicists until well *after* Einstein published his theory.

2. 'If there are two theories, one simpler than the other, the simpler one is to be preferred'. At first sight this does not seem quite so bad, but a little thought shows that our tendency to prefer the simpler possibility is psychological rather than scientific. lt is less trouble to think that way. Experience invariably shows that the more correct a theory becomes, the more complex does it seem. Quantum electrodynamics is the only theory we have that is probably completely correct, and quantum electrodynamics is highly complex. So this second interpretation of the elusive "razor" is also worthless.

Our own interpretation is:

3. 'Be suspicious of a theory if more and more hypotheses are needed to support it as new facts become available, or as new considerations are brought to bear.'

This interpretation leaves Darwinism in a poor way, for this is exactly what has happened to Darwin's theory over the 120 years (now 150 years) since it was announced in *The Origin of Species*. The disposition is to argue: "Darwinism is correct. Therefore any hypothesis essential to its support must also be correct". This, in our view, is what Ockham's razor enjoins one not to do.

While on this small historical diversion, it is worth adding a few remarks concerning the evolutionary theory of J.B. de M. Lamarck[4] (1744-1829) which preceded Edward Blyth by about a quarter of a century. Lamarck argued that characteristics acquired by the parents tended to be passed to their offspring. If you spent your life in a gymnasium your children were more likely to be athletic, or if you spent your life in intellectual studies your children were more likely to be born geniuses. lt would easily be possible to produce impressive statistics in support of this idea, and in an age innocent of the lies which can be told by statistics, people could just as easily be deceived into believing it to be true. The point of course is that individuals who are inherently weak physically do not choose to spend their lives in a gymnasium. Nor do the less intelligent wish to spend their lives in intellectual studies. In a complex society with many diverse occupations available, most people select the work they can do best. In effect, the social environment itself acts as a mechanism of choice. It is no wonder, then, that the abilities of the offspring turn out to be generally correlated with the activities of their parents.

The statistical trap in Larmarck's idea was not too difficult to spot, a trap that was avoided by Darwinism. It is likely therefore that, following the publication of Darwin's *The Origin of Species* (ref.5), little more would have been heard of Lamarck if an ironical social development had not occurred in the latter half of the nineteenth century. Just as Nature is said to abhor a vacuum so it seems that societies abhor fluid intellectual situations. People seem more contented in their lives if there are simple broad issues to which they can devote themselves with great passion. With the breaking of the intellectual bonds imposed by Christianity there was a mighty casting around among those with a lot of time on their hands for some new form of intellectual bondage. Quite a lot of solutions were tried. Some tried throwing aside the trappings of civilization, returning to the simple life along with the animals in the field, but the attempt to crop grass failed because we do not possess the right kind of bacteria in our digestive system. The winner proved to be Marxism in some societies, and its more pallid relative, socialism, in others.

The early Marxist idealism was very different from its later rigid reality, just as early Christianity had been very different from the later rigid reality of the medieval world. To begin with, all the talk was about the dignity and fulfilment of man. To anyone imbued with such ideas, the teachings of biology must have seemed appalling. Yet Darwinism could not be denigrated, since it was Darwinism that had destroyed the hated rival, Christianity. In this dilemma a loophole was perceived, Lamarckism.

It was eminently in keeping with the socialistic ideal for the earnest efforts of the parents to be rewarded by the improved abilities of their offspring. How much better that Beethoven should have been born to parents who had worked as earnest and humble musicians (especially the humble part) than that he should be born to a tubercular mother and a drunken father. (That the genetics of biology permit a great genius to arrive out of an unfavourable social situation is actually a superb inspiration, comparable to the inspiration of the late quartets of Beethoven himself.)

The idea was really the same as the Christianity it replaced, of course, except that instead of being rewarded in “heaven” for one’s efforts in life, it was now to be one's children that were to be rewarded. Indeed, there was little that was different in the new socialism from the old Christianity, except the removal of the concept of God, which ironically was the sole concept of any importance in the old religion.

The loophole was to combine Darwin and Lamarck. Natural selection was seen to be fine, provided it operated on acquired characteristics in the sense of Lamarck. Many attempts were made to prove that acquired characteristics could be inherited. Experiments to this end continued well into the second half of the twentieth century.

Although the issues were sometimes subtle, the claimed proofs of Lamarckism have always been shown false, to a point where not even the leaders of the Soviet Union dare attempt any longer to maintain a Lamarckian position, although doubtless they will return to it should they succeed eventually in dominating thought throughout the world.

The failure of Lamarckism to prove itself has been taken, not just as a disproof of Lamarckism, but as a proof of Darwinism. If the two had been shown to exhaust the possibilities, the logic of this inversion would be justified. Of course no such mutual exclusivity has been shown. We are not faced by an either/or situation, and so the inversion is just as false as were the claimed proofs of Lamarckism. Nevertheless the downfall of Lamarckism certainly played an historical role in convincing biologists that Darwinism must be correct.

To what has been said in our attempt to understand why Darwinism has achieved such a strong grip on scientific thinking we must add the great force of educational continuity. lt is hard in later life to doubt those basic tenets of intellectual thought which all one's teachers have accepted without question. We have had quite a number of encounters with biologists who have remarked much as follows: "I will admit that your views are consistent with the facts, and that they even have a certain driving logical quality which normal theory lacks, but I just cannot bring myself to face the upheaval in my thinking that would follow if l agreed with anything you say."

Once the whole of humanity becomes committed to a particular set of concepts, educational continuity makes it exceedingly hard to change the pattern. You either believe the concepts or you will inevitably be branded as a heretic. The Protestant reformers of northern Europe broke free from control by the Catholic Church of Rome after a long and bitter struggle, but they did not do so by breaking free from Christianity itself. The issues of great controversy were trivial, such as how many angels can cluster on the head of a pin, or like the inconsequential issue raised in the sermon of William of Ockham. Real escape for the individual was impossible.

Escape is comparatively easy, however, when humanity is divided over a controversial issue, because if you are thinking of changing your mind on it there is always someone in the opposite camp with whom you can talk about your problems. This is why controversial situations are healthy, why a non-controversial society is unhealthy, and why the leaders of the Soviet Union are so concerned that "dissidence" be suppressed throughout the territories controlled by the KGB and the Red Army. This is the reality towards which Marxism has led. Past history and educational continuity are undoubtedly two reasons for the hold which Darwinism maintains on the scientific world, but we would be doing our biological colleagues serious injustice if we maintained they were the only reasons. Undoubtedly there is also a clear appreciation of what the alternative to remaining within the safe smokescreen of Darwinism would mean.

It is as if one were sitting in the mist on a little pile of snow. The mist clears and instead of finding ourselves on some friendly eminence as we had hoped, we are suddenly on the North Wall of the Eiger. Once we say that only through intelligence can the enzymes and other biochemicals be assembled, we find ourselves with a long and desperate climb ahead, a climb to safety which it may take many generations to achieve.

The first few steps are not so bad, however, just as the first few steps on the Wall of the Eiger might not be so bad. We happened to mention Copernicus' book *De revolutionibus* in the above discussion. In his book Copernicus abandoned unequivocally for the first time the notion that the Earth is the geometrical centre of the universe. The usual biological theory, a terrestrial organic soup plus a miraculous assembly of complex biochemicals leading to the origin of life, is an attempt to maintain an essentially pre-Copernican position, with the Earth as the biological centre of the universe. It will be no bad thing to abandon this position. The avidity with which some people seek to maintain it is clearly analogous to the passionate attempts of the sixteenth century to retain the Ptolemaic theory of the pre-Copernican era. If thereby man's horizons turn out to widen as much as they have done over the three centuries which separated *De revolutionibus* from Hubble's discovery of the expansion of the universe, nobody should be unduly surprised.

The next step is to face up to a chicken-and-egg problem. If life existed already, it would not be hard to imagine an intelligence somewhere in our galaxy (or elsewhere in the universe) deciding to assemble the enzymes. But what would be the point of it if the enzymes existed already in the functioning of the life-form itself. Even if we could show that the assembly was for some purpose, we would be no further forward in a logical sense, we would still have to explain how the enzymes came to be assembled in the first place in order to permit our postulated life-form to function.

Here we might seek to play a naive trick. We could say that the assembly of the enzymes had then become a problem for the other life-form, not for ourselves. Stated this way, the trick seems absurd, but it is really just this same trick that is played in all religions, namely to displace all problems to *God* and then refuse to discuss them any further.

To be consistent logically, we have to say that the intelligence which assembled the enzymes did not itself contain them. This is tantamount to arguing that carbonaceous life was invented by a non-carbonaceous intelligence, which by no means need be God, however.

Silicon is an atom similar to carbon, and there has often been speculation on whether a form of life based on silicon instead of carbon might exist. Yet if one attempts to follow a similar chemical system for silicon - silicon sugars, silicon nucleic acids, silicon proteins and so forth-the idea soon grinds to a halt, because it is easy to show that, although generally similar, silicon is less versatile chemically than carbon. lt is therefore hardly conceivable that a siliceous form of life could have preceded the carbonaceous form, at any rate if the two are thought of in terms of similar chemistries.

But what if we forget about chemistry and think of electronics? Then it is silicon that wins handsomely over carbon. Everybody has heard nowadays of the silicon chip, but nobody considers the possibility of a carbon chip, for the thing would be an electronic absurdity. So what if our progenitor were an extremely complex silicon chip?

One thing looks right about this idea. lt would not be possible for an intelligence, however great, to generate carbonaceous life without performing an immense amount of calculation. While the blueprints for all the enzymes, and quite a number of other crucial biochemicals, too, could be specified within the compass of a single volume of the *Encyclopaedia Britannica*, distinguishing that particular volume by calculation from all the $10^{40.000}$ volumes with incorrect specifications would be a task far beyond human capability. The best way we know to perform the necessary calculations would be through the silicon chip. For doing, for getting about, for being active, carbonaceous life is the best, but for swift calculation, and perhaps for thinking too, a siliceous form of life could be greatly our superior.

If we could estimate the amount of calculation in a quantitative way, the idea would be testable in principle, because then we could arrive at a specification of the computational power that would be needed. Unfortunately, however, not enough is yet known of the mathematical detail of complex chemical structures to decide whether or not the calculations would be feasible, even for the silicon chip. We can only speculate that they might be.

The crucial point of the argument is that intelligence and swift calculation could face up to an analysis of the potentialities of a wide range of possibilities, whereas mere random trials with actual chemicals could never do so. Much the same is true even on the level of the human chemical industry, which would soon descend to chaos if it elected to depend only on a random throwing together of chemical substances.

From the point of view of the thinking silicon chip, what would be the point of it? Tools. Tools for the control of large-scale astronomical processes, as has been suggested elsewhere[6]. And a very powerful tool, in the sense that we humans have now given rise in our turn to the silicon chip itself. So one would have the sequence (in which the arrows mean 'leading to':

silicon chip → carbonaceous life → silicon chip

by which the silicon chip would succeed in spreading itself.

So much is conceivable within our present knowledge. Yet if this were all, there would be a lack of grandeur about the idea that would surely come as an anticlimax to the story we have been attempting to develop. To proceed further we can either write:

? → silicon chip → carbonaceous life → silicon chip

where ? is an unspecified intellect, or we could take ? as our immediate progenitor:

? → carbonaceous life → silicon chip

losing some definition of the problem but adding to our sense of dignity.

The interest now focuses on ?, so that it becomes somewhat irrelevant which of the above sequences we choose. Remarkably enough, we have evidence of the existence of ?. Life depends on oxygen and carbon being roughly equal in their cosmic abundances. If either one dominated markedly over the other, life would not be possible. The requirement is for oxygen to be rather more abundant than carbon, which is exactly how things actually stand.

Both of these elements are produced from helium by nuclear reactions that occur inside stars, the details of which are quite well understood. So far from the abundances coming out correctly in an unavoidable way, it turns out that getting conditions right depends on a couple of curious properties, one a property of the carbon nucleus, the other of the oxygen nucleus. (Both the 7.65 Mev level of the carbon nucleus, and the 7.12 Mev level of the oxygen nucleus, must be tuned very closely indeed to these particular energy values.) lf we did not know from laboratory experience that everything is the way it should be, if in ignorance we had to set a chance of things coming out appropriately, the chance might be estimated at about l part in 1000.

In the past the favourable nuclear properties had been thought of as curiosities, lucky accidents of physics, without which life could not exist. It was as if a child had twiddled the tuning knob of a radio receiver, and then when you yourself switched on the receiver the tuning just happened by accident to be on exactly the station you were seeking - except that the accident was there twice, once for the carbon nucleus and once for the oxygen nucleus.

Over the quarter of a century since these properties of oxygen and carbon were discovered, the disposition of astronomers has been to shy away from the thought that the situation might be deliberate. There is a mental trick one can easily play, both here and in respect of several other favourable provisions of physics. The trick begins with a correct statement, namely that if things had been otherwise there would have been no life, in which case we ourselves would not have been around to think about the problem. So far so good. Then comes an inversion of the logic. Because we are here, the argument continues, the favourable provisions of physics must hold, and therefore no problem exists. Our existence fixes the physics. The argument is really not much better than the logic of the following question and answer:

Q. Why is A taller than B?
A. Because A is 6 ft l in. tall whereas B is only 5 ft 9 in.

If a random inorganic origin of life could have been maintained, then one could not have made too much out of this situation. Everything would be the result of chance. Once we see, however, that the probability of life originating at random is so utterly minuscule as to make the random concept absurd, it becomes sensible to think that the favourable properties of physics on which life depends are in every respect deliberate.

The measure of intelligence needed to control the properties of the oxygen and carbon nuclei would be exceedingly high. The so-called coupling constants of physics are numbers which appear in science empirically. That is to say, they are numbers that we determine by reference to observation rather than from logical argument. The basic unit of electrical charge (the charge of the electron) is one such number. So far as the consistency of physics is concerned the unit of electrical charge could apparently have an infinity of values other than the value we assign to it from observation.

It is the coupling constants which determine the favourable aspects of physics, like the favourable properties of the carbon and oxygen nuclei. It would be through exercising control over the coupling constants that an intelligence might determine a wide range of features of the universe. The remarkable chemical behaviour of the carbon atom and the remarkable electronic properties of the silicon chip are other
crucial examples of properties which might be controlled in this way.

It will be apparent that we have moved on now to an altogether higher level of intelligence than the silicon chip. Calculating the properties of the enzymes would surely be an amazing achievement, judged from the human level, but likely enough it would seem rather a simple matter to an intelligence that could control the coupling constants of physics. In astronomical terms, control over the origin of life is probably equivalent to controlling processes on the scale of stars, whereas control of the coupling constants is probably equivalent to controlling processes on the scale of galaxies.

We can now suggest the equivalence:

Control over the coupling constants of physics a ≡ ?

The disposition next is to add ? ≡ *God*, and so to be done with it. But such a slapdash conclusion leads to difficulties. It leaves the relation of *God* to the universe still quite unclear. As we contemplate the resulting situation, ? would still be only a part of the universe, *within* the universe as one might say, and so *God* would only be a part of the universe, surely an unsatisfactory conclusion.

We must also guard against an emotional difficulty of the human mind. Most people are happy with a situation in which there is just one intellectual level higher than the human, leading to the satisfactory relationship *God* → man. This relationship, analogous to parent and child, is emotionally pleasing but hard to defend logically. From the point of view of the dog there would be a three-tiered structure, *God* → man → dog, and from the point of view of the meanest sparrow that falls there would be a considerable many-tiered structure.

People in the past did not think in quite this biological sense, but they could see at a glance that society was many-tiered in its relationships. Instead of just king → subject, there was king → nobles → knights → squires → yeomen → folk.

The conflict between the emotional requirement for a two-tiered structure and the logical requirement for a many-tiered structure led to wild confusions in the religious systems of the past. The Greeks were never able to get their religion under control. The system (in which the arrows indicate progression from higher beings to lesser beings, here and in the following sequences)

> shadow figures → Zeus → main gods and goddesses eg. Chronos
> → subsidiary gods and goddesses →kings → people

caused them a lot of trouble, but not remotely to be compared with the problems of the catholic Christian, who is required to master a sequence that runs approximately as follows:

> *God* → Christ → archangels → angels → saints → the beatified → Pope → cardinals
> → priests → people.

Although these particular sequences are plainly unacceptable, the sequence idea is far better logically than the over-simple two-tier *God* → man concept. To avoid the ludicrous, we must write:

> … → ????? → ???? → ??? → ?? → ? → man → . . . .

The dilemma of religion is that the sequence is meaningless unless we attach explicit significance to at least one of its members (to the left of man) yet attempts to do so have always led in the past to absurdities.

The position of most scientists can, we think, be said to accord with one or other of the following three points of view:

(1) there is no such sequence;
(2) the correct sequence is the simplistic one, *God* → man;
(3) there is such a sequence, but since we know nothing about it there is no point in discussing it.

Our opinion is that all of these are wrong. The correct position we think is: there is such a sequence, and among the question marks to the left of man there is a term in the sequence, an intelligence, which designed the biochemicals and gave rise to the origin of carbonaceous life. Still further to the left there is another still higher level of intelligence that controlled the coupling constants of physics.

This may seem a grey form of religion, not at all suited to the wearing of gaudy clothes or to parades in the streets on saints' days, but it is far better to be in with a chance of being modestly right, instead of being faced by the absolute certainty of being overwhelmingly wrong.

Where does the sequence going to the left stop? It doesn't. It goes on and on and on, with ever-rising levels denoted by more and more question marks. But like a convergent mathematical sequence of functions it has an idealised limit, with the property that by going far enough to the left the terms differ by as little as one pleases from the idealised limit. It is this idealised limit that is *God*, and *God* is the universe:

God ≡ universe

The logical system is now closed, leaving no inherently baffling questions, except one. The remaining conundrum is: Why is there anything at all?

Of course one can play the usual anthropic trick of saying that if there was nothing, there would be nobody to ask the question. But this is an evasion, not an answer. Nor would it be an answer for a physicist to argue that the universe is created by particle pairs emerging from the vacuum, because the physical properties of the vacuum would still be needed, and this would be something.

The old religions were at their best when they kept to generalities such as "man was created in the image of *God*" (to give this particular idea its Judaic form, although it probably dated from much earlier times). The sequence displayed above would not make sense unless each level of intelligence was contained in all those levels to the left of it in the sequence. It is therefore almost inevitable that our own measure of intelligence must reflect in a valid way the higher intelligences to our left, even to the extreme idealised limit of *God*. Our defects lie in a restriction of the intellect, not in a failure to reason correctly within our own lights. Otherwise our situation would be hopeless, and indeed so would be the situation of every member of the sequence.

The calculation of the properties of the enzymes is an example of a restriction of the intellect. We ourselves could not cope with the enormity of detail involved in this particular problem, but we can easily conceive of the calculation being done, and we can even understand the general way in which it would go, and the physical principles on which it would be based. Modern developments in physics may not be too far from the day when we can understand how the coupling constant problem might be fixed. The situation therefore appears to be that, while we cannot actually emulate what the intelligences far to the left in the sequence are doing, we can understand in a non-detailed way what kinds of monkey business they are up to. And this is really what science, properly understood, is all about.

There are those who think that the way to establish a connection with a higher intelligence is to go riding around the galaxy in spaceships, or to listen for coded radio signals emanating from other planetary systems in the galaxy. In the past we have had some sympathy with the second of these notions, but have always rejected the first as woefully slow, crude and profitless. Now we are inclined to think the second is also unnecessarily cumbersome. If our ideas are correct, there must surely be a multiplicity of clues around us here on the Earth's surface, clues to the identities of the intelligences immediately to the left of us in the sequence, probably as far as the intellect which calculated the properties of the enzymes. It would be more sensible, for example, to broadcast clues on the unexpressed DNA of yeast cells than to go through the ponderous technology of radio transmissions (discussed in our former book *Lifecloud*[7]). In a search for such clues it would of course be necessary to acquire the DNA before it became garbled by too many copying errors.

If we invert the religious dictum that man was created in the image of *God*, to the extent of attributing to all higher intelligences the chief characteristics of the mentality of man, then it seems possible that higher intelligences have a pronounced sense of humour. The clues might then have been distributed in the fashion of the child's game of "hunt the thimble". Attempting to cast ourselves in the role of a higher intelligence, it would surely suit our sense of humour to lock up clues in the genome of the California redwood. Or if one were more inclined to farce than wit, one might lock up clues in the social behaviour of insects. Either possibility would be much simpler than travelling around the galaxy.

There is in many people a strong emotional conviction that some higher intelligence must be around us all the time. The idea is far better than its attempted realisation as the occupants of unidentified flying objects, for example. Such vague gropings will not do, of course, but the idea may still be true in the sense that a multiplicity of clues are lying around, waiting for us in the hunt-the-thimble game. A still better idea, again in essence an old religious idea, is that the important connections along the sequence

. . . → ????? → ???? → ??? → ?? → ? → man →. . . .

occur in thought. Not by any means all thoughts, although the whole process of consciousness probably has a profound cosmic significance. The connections of the sequence are more likely to be restricted to those sudden flashes of perception that have made so much difference to all the main trends of human thought, the conversion of Paul on the road to Damascus.

References

1. Carathéodory, C., 1909. Investigations on the foundations of thermodynamics (trans), *Math. Ann*, **67**, 355-386
2. Blythe, E., 1835. *The Magazine of Natural History*, **8**, 40-53
3. The non-political works of William of Ockham are in the course of publication by the Franciscan Institute, St. Bonaventure, New York. The first volume in a projected 25 volume series appeared in 1956.
4. Lamark, J.B.de M., 1801-1809 www.lamark,cnrs.fr
5. Darwin, C., 1857. *The Origin of Species* (John Murray, Lond.)
6. Hoyle, F., 1980. *The relation of biology to astronomy*, (University College, Cardiff Press)
7. Hoyle, F. and Wickramasinghe, N.C., 1978. *Lifecloud* (J.M. Dent, Lond.)