



Creation and Evolution?

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SECTION II - HOT ISSUES FOR THE TWENTY-FIRST CENTURY - CHAPTER 6

If the twentieth century was the century of physics then it seems likely that the twenty-first century will be the century of biology. One of the main reasons for thinking this is the increasing power of molecular genetics to analyse living organisms at the molecular level. The Human Genome Project has obtained a complete sequence of human DNA and the genome sequences of other organisms are now becoming available at an increasing pace. It is already possible to compare the DNA sequence of every human gene with the equivalent gene found in many other species.

Whereas physics has been going through a rather non-mechanistic phase, particularly following the advent of quantum theory, biology is in the midst of the reverse process, in which the focus is on the interactions between molecules, and the way in which these define the properties of the whole organism ('how genotype determines phenotype in a given environment'). Through the insights of biochemistry and molecular biology, living matter is now amenable to investigation and manipulation in ways which would have been unthinkable even a few decades ago. Advances in biology are certainly likely to raise some hot issues for the twenty-first century.

Creation and Evolution[i]

One topic that has more of a nineteenth than a twenty-first century ring to it is that of creation and evolution. Given that nineteenth century Christian thinkers felt that they had given this topic a good airing, and that they had reached some quite

satisfactory conclusions which did justice to both science and the Bible, it is rather surprising to note how the debate was revived during the course of the twentieth century and still remains active today. There are some particular historical reasons for this which are of interest.

One reason appears to be Christian reaction in the USA to the horrors of the First World War. The Kaiser's philosophy of 'might is right' in Germany drew heavily on the idea of the 'survival of the fittest', a concept which had been introduced into Darwinian theory by Herbert Spencer. Much to Darwin's disgust, Spencer had popularised evolution during the late nineteenth century as if it represented a grand philosophy for the whole of life, history and human progress, rather than in its straightforward Darwinian form of a biological theory to explain the origins of biological diversity. The fact that Darwinian theory had been utilised to support Germany's military ambitions was publicised in the USA by several books which had a great influence on William Bryan, a three-time defeated Democratic candidate for the presidency of the United States, a Presbyterian layman and one of America's greatest populist reformers of that era[ii]. Bryan tapped into a public concern that militaristic ideas would spread from Europe to America, and that evolution would 'sap the morality of the nation's youth'. Armed with such an understanding of the scope of evolution, Bryan proceeded to campaign vigorously against evolution in the name of creationism.

The creationist movement that Bryan supported during the 1920s eventually fizzled out, but was revived again in the USA with great vigour during the 1960s, and once again was linked to a concern that evolution was in some sense immoral. Numerous court cases were fought in an attempt to prevent the teaching of evolution in American schools. Henry Morris, president of the Institute for Creation Research, suggested that the acceptance of the theory of evolution was responsible, amongst other things, for promiscuity, pornography and perversion[iii]. In this brand of creationism it was maintained that the Earth was made some 10,000 years ago over a period of six days of 24 hours each, and that each species was created by God separately, so denying the claim fundamental to evolutionary theory that there is a unity between all living

organisms.

In contrast to the creationists, other Christians such as Teilhard de Chardin and Frank Tipler have tried to use evolution to support grand religious schemes pointing to the evolution of life toward an eventual perfected 'omega point': we have already discussed the shortcomings of such schemes in chapter 2. On the other side of the religious fence, atheists such as Richard Dawkins have tried to use the theory of evolution to prop up their view that our existence on planet earth has no ultimate meaning. Because atheistic writers such as Dawkins try to use evolution to support a materialistic philosophy, in response Christian apologists such as Philip Johnson^[iv] have proposed that Christians should attack evolution because they believe it is intrinsically atheistic.

Besides being used in both religious and anti-religious arguments, at various times evolution has also been used to support capitalism, communism and racism, not to speak of numerous other 'isms'!

From such observations it will immediately be apparent that a key confusion that frequently occurs when 'creation' and 'evolution' are being discussed is that the people in conversation often have quite different definitions in mind as to what these words actually mean. The participants can then spend a lot of time talking at cross-purposes and generating heat rather than light. There is an important difference between the *biological* theory of evolution and the various *philosophies* that people have tried to derive from it ever since the time of Darwin. The fact that many of these philosophies are mutually exclusive should alert us to the possibility that none of them is logically based on the biological theory of evolution, but rather are parasitic upon it. Study of the history of science illustrates many examples of the ways in which scientific theories, particularly the 'grand theories' of science, have been used for ideological purposes. The common strategy is to insinuate, using dubious arguments, or repeated repetition, that a particular ideology is closely associated with a particular scientific theory. All kinds of ideas can then hitch a ride along with the grand theories of science, until they become weighed down by the accretion of associated ideologies. The theory of evolution has often suffered such a fate. To have a sensible discussion about creation and evolution, we must therefore first spend some

time unwrapping the meanings of these terms.

Biological Evolution

The purpose of this section is not to consider the evidence for and against evolution *per se* - this discussion can be surveyed in any good university textbook of biology. The aim rather is to understand what biologists *mean* when they talk about evolution. By the contemporary use of the term 'evolution', biologists are referring to a process that results in heritable changes in a population spread over many generations. Heritable changes occur by means of genes. A gene is a hereditary unit that can be passed on unaltered for many generations. The gene pool is the set of all genes in a species or population. So when biologists say that they have observed evolution, they mean that they have detected a change in the frequency of genes in a population. The process of evolution can be succinctly summarised in three short phrases: genes mutate; individuals are selected; populations evolve [Figure 11].

Evolution can therefore occur without morphological change, that is without any visible changes in the overall structure or appearance of an organism. Equally, morphological change can occur without evolution. For example, humans are larger now than in the recent past, a result of better diet, not a result of genetic changes. Evolution only refers to those changes which are inherited.

In order for evolution to occur, that is, for heritable changes in a population spread over many generations, there must be mechanisms to *increase* or create genetic variation and mechanisms to *decrease* it. When people talk about evolution they often confuse the phenomenon itself with the mechanisms invoked to explain it.

One important mechanism which decreases genetic variation is natural selection. Some individuals within a population leave more offspring than others. Over time, the genes from these reproductively more prolific or successful individuals will become over-represented in the population compared with earlier generations. This difference in reproductive capability is called *natural selection*. The most common action of

natural selection is to remove unfit genetic variants as they arise via mutation. Natural selection acts as a stringent sieve to prevent the passing on of genes which are deleterious to the reproductive success of an organism. However, occasionally mutant genes will bestow a reproductive advantage, in which case genetic variation will be maintained. Overall, therefore, natural selection acts to reduce genetic variation, or in some cases to maintain genetic variation in a population, but as a mechanism it is never the *origin* of variation. It is largely a *conservative force* [Figure 12].

There are plenty of examples of how natural selection operates in contemporary human populations. One example is the maintenance of mutant genes in the human gene pool in parts of the world where malaria is endemic. If one form of the gene is mutated, whereas the second copy is normal, then such individuals are more resistant to malaria. A double-dose of the mutant gene, such as that for sickle-cell anaemia, is definitely bad for you, but if you have a single copy of the mutant gene then your reproductive fitness is increased relative to people who have no mutant genes at all.

Three different mechanisms can increase genetic variation within a lineage. Every cell division involves the duplication of its DNA. As millions of our cells divide every second, each individual produces thousands of miles every minute of newly copied DNA. The cellular machinery that copies DNA sometimes (though extremely rarely) makes mistakes, which alter the sequence of a gene. This is called a mutation. Mutations can also increase as a result of chemical contamination or radiation. There are many kinds of mutation. For example a point mutation involves the substitution of one nucleotide base in the DNA sequence by a different nucleotide, and in some cases this leads to a change in a single amino-acid in the encoded protein. In other cases a stop signal can be introduced by the mutation so that only part of the gene is read into a protein sequence, and the protein that results is truncated, rather like a sentence which is chopped in half.

Most mutations are neutral with regard to reproductive fitness. Only a small proportion of the DNA of multicellular organisms actually encodes for genes – in our own case it is about 2%. Other

sections of our DNA are involved in the regulation of gene expression (the actual making of the protein that the gene encodes), while the function of the rest of our DNA is not yet well understood. So most mutations occur in the 98% of our DNA which doesn't encode genes. Even when mutations appear in the DNA which encodes genes, most are lost from the gene pool since they make no difference to reproductive success. Most mutations that have any phenotypic effect, that is, that make any difference to the organism, are deleterious. Only a very small percentage of mutations is beneficial, that is, increase the reproductive fitness of the organism: but of course it is precisely these mutations which are statistically more likely to be passed on. A mutant allele (a variant form of the same gene) that confers a 1% increase in fitness has only a 2% chance of becoming fixed in the population. Yet it is this tiny proportion of beneficial alleles which provides novelty and scope for change as part of the process of generating biological diversity.

One example of a beneficial mutant allele comes from the mosquito. In this organism a mutant gene arose by chance which conferred the ability to break down the type of organophosphates commonly used in insecticides. Not surprisingly this mutant gene rapidly swept through the world-wide mosquito population, thereby providing resistance to such insecticides, a good example of evolution in progress. Clearly this particular mutation has been of greater benefit to mosquitoes than it has to humans.

The other two mechanisms, besides mutation, which increase genetic variation are recombination - the exchange of genes between the mother's and father's chromosomes which occurs during the formation of gametes (sperm and eggs), and gene flow – the introduction of new genes into a population by migration of another population.

So far we have considered only evolution within a biological lineage, that is, within a single species. What about speciation? A species refers to a population of organisms which interbreed with each other but not with other organisms. Speciation is thought to occur either by allopatric mechanisms, which happen when a population is split into two (or more) geographically divided sub-divisions that organisms cannot bridge (such

as the formation of a new ocean separating two landmasses as a result of continental drift) [Figure 13], or by sympatric mechanisms which occur when two sub-populations become reproductively isolated without first becoming geographically isolated.

Some biologists think that special mechanisms, different from those that we have considered so far, may be involved in speciation, whereas others believe that in many cases the molecular mechanisms that have been described so far are adequate to account for reproductive isolation. The issue awaits a clear resolution. Genetically, the reasons for reproductive isolation may in some cases be quite trivial in comparison with the much greater degree of genetic diversity which exists *within* a species. For example, in a sympatric form of speciation a mutation might occur in a key developmental gene which regulates some aspect of reproduction so that successful mating can only occur within the population which shares the mutant allele. Speciation may result from something as trivial as a change in plumage colour, or the inability of a bird to learn the correct mating song from its parents – no song, no sex – or the formation of a new mountain range between a population of snails which used to interbreed. When the two populations finally get back together again after a few millions of years in isolation, it may often happen that their accumulation of mutant alleles now means that they can no longer interbreed.

Until recently it was difficult to identify genes that might be specifically involved in speciation. However, the use of organisms that multiply quickly, like fruit-flies, coupled with rapid sequencing techniques and the power of computer programs to compare gene sequences, is changing the situation. For example if attempts are made to breed the fruitfly *Drosophila simulans* with another species of fruit-fly called *Drosophila melanogaster*, then the male hybrid offspring die. Recently this has been shown to be due to a gene (called Nup96) on chromosome 3 of *Drosophila simulans* which interacts with one or more unknown genes on the *Drosophila melanogaster* male X chromosome to cause the death of the offspring[v]. So it is likely to be this particular gene that contributes to the reproductive barrier between these two species. In fact sequencing of the Nup96 gene from many individuals from

both species has revealed important inter-species differences in the sequence between the two species. Since differences in gene sequence translate into differences in protein structure and properties, this most likely explains the incompatibility of the *simulans* version of the gene when in the presence of the *melanogaster* X chromosome. So in this case it is quite likely that accumulating mutations in a single gene were sufficient to precipitate the branching of two separate lineages.

Many other factors, also, may be involved in speciation events, not least the succession of catastrophes which are thought to have wiped out large proportions of species at various times during the Earth's history. The largest mass extinction came at the end of the Permian period about 250 million years ago when as many as 96% of all species are thought to have become extinct, and the most famous one occurred at the end of the Cretaceous period, about 60 million years ago, when the dinosaurs were wiped out. Mass extinctions like these are followed by periods of radiation when new species evolve to fill the empty ecological niches left behind. It has been estimated that there are about 20 million species alive today, but in contrast about 2 billion species have come into being and then gone extinct during the history of our planet.

Speciation is easiest to study in lakes and on islands where the environment is highly restricted[vi]. For example, until very recently there were more than 170 species of cichlid fish in Lake Victoria in Africa and initially it was thought that these all evolved from a single species of fish since the lake's origin about 750,000 years ago in the mid-Pleistocene era. However, more recently genetic and geological studies have revealed a more complex picture[vii]. Geological evidence suggests that the lake dried out completely about 14,700 years ago and that it was then 'seeded' by two distinct lineages of Cichlid fish from the more ancient Lake Kivu. Irrespective of the precise sequence of events, the large number of Cichlid species found until recently in Lake Victoria provides a striking example of rapid speciation in action. The different species show differences in morphology (body structure and appearance) which are linked to their feeding habits. For example, virtually every major food source in the lake is exploited by one species or

another. Some cichlids eat insects, others crustaceans, others eat plants, and yet others mollusks. Each new species has found their particular ecological niche. In fact one species, *H. welcommei*, has the odd habit of feeding on fish scales which it scrapes off the tails of other fish! Just 4000 years ago a small new lake called Lake Nabugabo became isolated from Lake Victoria by a narrow sand-bar and this lake already has 7 different Cichlid species, 5 of which are not found in Lake Victoria and which therefore most likely evolved during these past 4000 years. The Lake Nabugabo species vary most from the Lake Victoria species in male colour. So the cichlid species of these two lakes provides a vivid example of the way in which speciation can be rapid (in terms of geological time) and abundant, given the right environment.

It is sometimes thought that speciation events must involve the evolution of completely new genes. This is also a mistaken idea. We are all living fossils in the sense that our genes have extremely ancient roots. When we compare ourselves with mice, a species from which we split genetically less than 75 million years ago, then we find that 99% of our genes are shared with mice, not in the sense that they are identical, but in the sense that they are so similar that they must encode similar or identical proteins. In most cases those proteins carry out in the mouse the same set of tasks as they perform in humans. In recent evolution, that is evolution which has occurred during the past 600 million years, it is not the generation of completely new genes which has been the key mechanism driving evolutionary change, but the reorganisation and refining of genes already in existence. To use an analogy from architecture, the myriad forms of building which characterise the city of Cambridge come mainly not from the use of different types of stone and brick, but from different configurations of similar bricks and stones.

A lot of the novelty generated during evolution appears to come from gene duplication. Occasionally a gene is duplicated as a cell divides so that two copies of that gene are integrated into the genome of the daughter cells instead of the original one. If this occurs in the germ-line cells (sperm or eggs) then the gene-duplication event will be passed on to the progeny. Sometimes the new gene ends up in a

different part of the genome so that its regulation is different, or it may not even be expressed as a protein at all[viii]. Recent studies have shown that as many as 50% of our own genes have arisen in evolution as a result of gene duplication[ix]. This is almost certainly an underestimate, because many of the duplicated genes are eventually lost from the genome (because they're not really needed), or else end up becoming pseudogenes (genes that are no longer functional). For example, our own chromosome 7 encodes 1,150 genes, but also 941 pseudogenes, which lie there like molecular fossils of our evolutionary past[x].

So gene duplication represents a 'quick-and-easy' mechanism to drive evolution. The second copy of the gene may be under different selection constraints from the original copy. This means that its gene sequence can start drifting faster due to accumulating mutations, endowing the protein with similar but not identical properties to those it had before.

But increases in gene number alone do not account for increases in morphological complexity[xi]. The simple nematode worm possesses nearly 20,000 genes but lacks the full range of cell types seen in the fruit-fly which contains fewer than 14,000 genes. Vertebrates have only about twice as many genes as invertebrates, despite their greater range of tissue-types and increased complexity of structure. The key factor in evolution seems to be the changes that occur in the DNA regulatory sequences that control the panoply of genes that are switched on/off during development[xii]. As many as 10% of our own 30,000 genes are transcription factors – proteins that regulate gene expression. It has also been calculated that perhaps twice as much human non-coding DNA is facing selection pressure during genetic change as compared to the coding regions (those DNA sequences that actually encode proteins). So it seems likely that in many cases speciation will be found to involve changes in a whole panoply of regulatory DNA sequences in addition to genes that encode proteins.

In science theories tend to get discarded unless they continue to fit the data. Most biologists do not work on evolutionary theory *per se*, rather they carry out their research within the evolutionary paradigm. And what they find in practice is that the

theory is like a work-horse which continues to make sense of the data and so they go on believing in it. For example, the sequencing of human DNA, a consequence of the Human Genome project, has provided data which makes perfect sense within evolutionary theory.

Now what you expect if all living organisms have a shared evolutionary history is that many genes will be found in common between organisms, but that the differences in the sequences of genes, and indeed in the actual genes utilised, will increase in proportion to evolutionary time. In other words, the longer it was since one organism shared a common ancestor with another, the more time there will be for genes to change or to be used in novel ways. But if the genes are really essential to life as they are, then there'll be a strong selection pressure to keep them the same way. Remember that natural selection is a very *conservative* force, preventing change.

One of the remarkable findings from a comparison between the genomes of humans, worms, flies and yeast is just how similar we all are, and yet there are some significant differences as well. Kinases are enzyme proteins that regulate almost every aspect of your body's functions. We have about 500 genes for kinases in our bodies, which means that nearly 2% of all our genes belongs to just this one class of enzyme. Now you can divide all the family of kinases up into 209 subfamilies, based on similarities between the gene sequences. There are 93 families that are shared between humans, flies and worms and a further 51 families that are shared between humans, flies, worms and yeast. So we actually contain thousands of genes that are present also in yeast and that haven't changed that much since our evolutionary path split off from yeast about 1 billion years ago. And we share even more genes with the lowly worm and the fly from which we split off in the so-called Cambrian explosion about 600 million years ago. So genes are like molecular fossils, telling us much about our evolutionary histories[xiii].

The biblical doctrine of creation

Having spent some time outlining the key elements in biological evolution, we can now consider how it relates to the biblical doctrine of

creation. We have already noted in chapter 5 that Christians are robust theists: they believe that God is intimately involved in creating and sustaining every aspect of the universe in all its details. Creation is a seamless cloth of God's activity. Just as the existence of the TV drama depends upon the continual targeting of electrons on to the TV screen to generate the necessary images, and there would be no drama if the flow of electrons ceased, so there would no scientists and nothing for scientists to describe were God to cease his on-going creative and sustaining activity.

Within this biblical framework the term 'creation' refers not to a particular mechanism for explaining the origins of biological diversity, but to the relationship between God and everything that exists. The Bible uses the word 'create' or 'form' or 'made' with all the various nuances with which these words are used in the English language. The word create is clearly used to refer to *processes* in many biblical texts, such as the creation of the people of Israel, or the creation of the New Jerusalem, or the creation of new animals which takes place during the normal process of animal birth[xiv], or the creation of light and darkness which God does every day in the normal passage from day to night[xv]. The modern tendency to look for God at the boundaries of our present knowledge is quite alien to biblical thought. When God is pictured as answering Job out of the storm whilst Job was struggling with the problem of evil (Job chapter 38), it is to the whole gamut of God's creative activity that he draws attention, not merely to big things like the 'laying of Earth's foundations' (v 4) and organising the stars (v 31–33), but also to its more mundane aspects like watering deserts (v 25–26), frost-formation (v 29) and providing food for lions (v 39).

The concept of 'creation' is not therefore in any sense a *rival* to the biological theory of evolution. Evolution can simply be viewed as the mechanism that God has chosen to bring biological diversity into being. The word 'creation' refers to the origin and source of that process. As with any other scientific theory, evolution is our current best guess as to *how* God has brought about that process. The biblical concept of creation refers not to a description of the particular *mechanisms* that God has chosen to bring biological diversity into being, because creation is

not a concept which refers to mechanisms, but to God's immanent on-going creative relationship with the whole universe, including its biological diversity. 'Creation' is not therefore a scientific term at all and makes no pretence to be so – rather it is a *theological* term expressing a prior belief about God's actions, within which framework all of our scientific observations and descriptions are then interpreted.

The atheist Richard Dawkins appears to be under the impression that when Christians talk about 'creation' they are referring to some rival theory to evolution. It is unfortunate that the word 'creationist' has become attached to a group of people who have a certain view as to *how* biological diversity was created by God, whereas it would be much more accurate to attach the word to *anybody* who believes in God as Creator, irrespective of their beliefs about how God created. Unfortunately, however, words are defined by their usage, and the term 'creationist' has indeed become attached to all those who disbelieve evolution. Therefore insofar as Dawkins is contrasting evolutionary theory with creationist beliefs, he is correct to suggest that these are rival theories about the origins of biological diversity: in the evolutionary theory there is an unbroken lineage between all living organisms from their earliest beginnings to the present day; in the other theory, the creationist view, there are discontinuities in which God supposedly created each species separately. One could argue that as long as there are creationists around, so will there be clones of Richard Dawkins around, because as long as different groups of people invest scientific theories with rival ideologies, then so long will those disputes feed on each other and indeed benefit from each other in a synergistic way.

The adoption of a robust biblically based theism, however, evacuates evolutionary theory of any kind of philosophical pretensions, least of all of any claim to be an argument for a materialistic philosophy. Science is about truth-telling, and if Darwinian evolution is currently the best explanation we have to explain how biological diversity came into being, and biologists certainly think it is, then we should be at the forefront in telling the truth about God's world. Occasionally popular writers, even Christian writers, suggest that evolutionary theory is under

some kind of crisis within the scientific community. This is not true. In recent years the theory has been enormously strengthened by the advent of molecular genetics. The theory is so powerful because it links together disparate data from a wide range of scientific disciplines, including zoology, anatomy, biochemistry, molecular biology, geology, palaeontology, anthropology and ecology. There is no alternative rival theory on offer at the present time. Christians should therefore be truth-tellers when it comes to accurately describing the convictions of the current generation of biological scientists.

Once it is understood that evolution is a description of God's creative activity, then any supposed conflict between creation and evolution simply dissolves. There is nothing 'naturalistic' or 'materialistic' about describing how God's good material world operates. It should be noted that such a stance undermines the use of scientific theories as arenas for ideological conflict. Instead it places the emphasis of the conflict, such as that between atheists and Christians, on the competing metaphysical convictions adopted by these protagonists.

Many Christians from the time of Darwin until the present day have held the view that God has created all living organisms by a long process of evolution. In the light of those today who think that evolution has atheistic implications, it is interesting to note that back in the nineteenth century Darwinian evolution was accepted rather quickly by all the mainstream Christian denominations in America and Britain within a few decades of the publication of *The Origin of Species* in 1859. The idea, so loved by the media, that Darwinism was locked in a bitter battle with the Church from its inception, has long ago been picked apart by revisionist historians, and the picture that has emerged is both more complex and more intriguing. The British historian James Moore writes that 'with but few exceptions the leading Christian thinkers in Great Britain and America came to terms quite readily with Darwinism and evolution'[xvi], and the American sociologist George Marsden reports that '...with the exception of Harvard's Louis Agassiz, virtually every American Protestant zoologist and botanist accepted some form of evolution by the early 1870s'[xvii].

Ironically, in light of the fact that today about half the American population disbelieves the theory of evolution, in the nineteenth century it was Christian academics who did much to popularise the theory in the USA. For example Asa Gray, Professor of Natural History at Harvard, an orthodox Presbyterian in belief, had long been Darwin's confidant, and was one of the privileged few to receive advance complimentary copies of the 'Origin of Species'. Gray reviewed the 'Origins' very favourably in America and arranged for its publication there in 1860.

To address all of the issues raised by the theory of evolution is beyond the scope of this book. However, we will briefly consider the question of how God's creative actions are compatible with the rôle of chance in evolution, since this well illustrates how robust theism can provide a framework in which particular objections to evolution lose their potency.

Chance, Evolution and Creation

It is often thought that evolution involves a chance process and therefore must be in some way incompatible with a God of order and design. But a moment's thought will show that such a view is simplistic.

Consider, for example, the course of your life until now. If you are a Christian, then you believe that God in his providential care has been sovereign over all the details of your life, even from the time before you were born. This includes the fact that one particular sperm fertilised one particular egg at a particular moment in time to generate that genetically unique individual that you became. Millions of sperm were involved in that race to get to the egg first – you could so easily have been of the opposite sex to what you are now, and you could easily have looked physically quite different. Fertilisation is truly a chance process. Yet you still believe that God was sovereign in all these contingent events that brought you into existence.

Why stop at biology? If you are a Christian, think about all the myriad events that have been woven together in an immensely complex tapestry to bring about God's will in your life. Some of those events may have been painful – perhaps

things that happened quite out of your control. Other events were quite mundane, yet made a profound difference to the course of your life. The film 'Sliding Doors' was right – seemingly trivial differences in life can have enormous effects. At one level they represent chance events – there is no way that we or anyone else can predict them – but Christians also believe that God is ultimately in control of everything that happens.

The Bible is consistent in its teaching that events that many people would ascribe to chance are within the boundaries of God's sovereignty and plan. When the prophet Micaiah predicted that King Ahab would be killed in battle at Ramoth Gilead[xviii], this indeed came to pass, but it happened by someone who "drew his bow at *random* and hit the king of Israel between the sections of his armour"[xix]. As Proverbs 16:33 so vividly puts the point: "The lot is cast into the lap, but its every decision is from the Lord". The Bible sees God's works occurring equally in all the various manifestations of his activity, whether in the more 'law-like' workings of the natural world (Psalm 33:6–11), in chance events (Proverbs 16:33), or in his control of the weather (Psalm 148:8), which today we describe using chaos theory. There is never a hint in the Bible that certain types of event in the natural world are any more or any less the activity of God than other events.

But what do we mean by chance and how does that understanding relate to evolution? Unfortunately the word chance can be used with at least three quite distinct meanings and people are not always clear in discussion which meaning they have in mind. First, there is the kind of chance events that are predictable in principle but not in practice. For example, if we had enough information about each of the millions of sperm racing to fertilise an egg, then providing we had a complete description also of the environment, we could theoretically predict which one would win the race. But in the second kind of chance, that which typifies events at the quantum level, our ignorance about the future is complete. When a radioactive atom decays we have no way of knowing when the next high-energy particle will be emitted, and this reflects our inability to predict in principle and not just in practice. Some people call that kind of chance 'pure chance'. Then there is a third type of chance, which we can label

'metaphysical chance'. This is something very different from the other two types of chance and refers to the philosophy that in some ultimate sense the universe came into being 'by chance' and has no real rhyme or reason.

Now as it happens it is only the first two types of chance that are relevant to evolution. The reason for this is that mutations can occur in DNA due to failures in the actions of DNA repair enzymes that occasionally miss errors during the 'proof-reading' process. This is an example of the first type of chance – it might be predictable in principle, but not in practice. But mutations in DNA can also happen by exposure to radiation – this is an example of the second type of chance, non-predictable in theory as well as in practice. But so far as evolutionary mechanisms are concerned, it really doesn't matter whether the mutation arose by the first or second kind of chance. Either way a change has come into being in the gene sequence, and if that change occurs in the germ cells (sperm and eggs) so that it is passed on to the next generation, then the change will in any case be tested out by the 'filter' of reproductive success.

So we can picture the evolutionary process taken as a whole as a two-stage process in which random mutations are generated in the genes in step one, but then in step 2 these changes are incredibly tightly controlled by the 'filtering process' of reproductive success. Just how tight is this filtering process can readily be seen by comparing the 99% similarity in the genes between humans and mice, as outlined above. What this means is that even tiny changes in the gene sequence have been lethal, or at least markedly deleterious, not only to any mice that got them, but also to all the intervening mammals that characterise our evolutionary lineage ever since we branched off from mice. So scientists say that such genes are under a very strong 'selection pressure' to stay the same. One little change and you're a dead mouse.

So if you look at the overall process of evolution, it is very far indeed from any notion of 'metaphysical chance'. It is a stringently regulated series of events in which food-chains are built up in precisely defined ecological niches. The process has occurred in particular environments characterised by parameters such as cold

and heat, light and darkness, wetness and dryness, with the constraints of gravity playing a key role in defining animal and plant sizes and shapes. There are good reasons why elephants don't fly. And there are good reasons why the eye has evolved not once but many times during the process of evolution.

Therefore evolutionary mechanisms are nothing like the processes that we normally think of as 'random' in any ultimate sense. When your TV breaks down and you get a horrible meaningless fuzz on your screen you might rightly think of that as 'random noise' without ultimate meaning. But the biological diversity generated by the evolutionary process is as far from that type of random fuzz as you can imagine: it represents a highly organised collection of mechanisms that are only possible in a carbonaceous world with a particular set of elements and physical laws. The physical properties of the universe were defined in the very first few femto-seconds after the Big Bang, and the process of evolution depends utterly on that particular set of properties. Without them we would not be here.

So Christians see the evolutionary process simply as the way that God has chosen to bring biological diversity into being, including us. The process *per se* has no particular theological significance. That's the way things are and our task as scientists is to describe the way things are – what God has done in bringing this vast array of biological diversity into being. Of one thing we can be sure: the evolutionary process provides no grounds for thinking that the universe is a 'chance' process in any ultimate metaphysical sense. In fact, quite the reverse. As biologists we marvel at the complexity and diversity of this planet's life-forms, and at the fact that we as humans are indissolubly linked by our evolutionary history with every life-form on earth.

It should also be obvious from these reflections that chance *does nothing*. Chance is simply a handy description that we humans use for our beliefs about the properties of matter. There is no such agent as 'metaphysical chance', but there *is* the human belief held by some people that the universe has no ultimate meaning. However, those who try propping up that particular belief-system using the prestige of scientific theories will find not a shred of comfort in evolutionary theory.

So there is really no need for evolution to be a hot issue for Christians, or for anyone else for that matter, in the twenty-first century. Darwin's Christian contemporaries in the nineteenth century had it just right when they decided to baptise Darwinian theory into the Christian doctrine of creation. There is no reason why we should not continue to do the same in the twenty-first century.

Darwin's Black Box?

A 1996 book by Michael Behe entitled 'Darwin's Black Box'[xx] illustrates rather well the way in which the attempt to revive a contemporary form of natural theology can unfortunately end up leading down the pathway to semi-deistic thinking. Michael Behe is an Associate Professor of Biochemistry at Lehigh University in the USA who believes that biological diversity derives from common descent, but who is sceptical that the Darwinian processes of natural selection are sufficient to generate such complexity. Behe does not hold to young earth creationism, but instead believes that there are 'irreducibly complex systems' in cellular biochemistry which can only be explained by invoking a God of design. These systems, such as the clotting of blood and the molecular mechanisms involved in the immune system, only function correctly as complete systems, and so Behe thinks that they could not have evolved gradually by Darwinian mechanisms.

Behe is a champion of what has come to be called the 'Intelligent Design' (ID) movement, a way of thinking which purports to find direct evidence for God's actions based on scientific evidence. The theoretical underpinnings of the movement have been provided by a mathematician called William Dembski[xxi]. Dembski suggests that it is possible to infer that some systems, for example in biology, display what he calls 'specified complexity'. Such a designation can only be justified, Dembski claims, by first excluding the possibility that the system has been generated by what he calls 'natural processes'. Natural processes are presumed by Dembski to fall into one of three categories: chance, necessity or the joint action of chance and necessity. If it can be shown that the system or object in question could not possibly have been brought about by one of

these three types of explanation, then they display 'specified complexity' and must therefore be the products of 'intelligent design'.

A thorough critique of Dembski's thesis is outside the scope of this book[xxii]. Instead we shall briefly survey Behe's biologically based claims for ID within the scope of the 'creation/evolution' debate and see if they stand up to closer scrutiny. There are at least two specific arenas in which, we think, Behe's arguments are weak: the scientific and the theological.

In the context of science Behe maintains that Darwinian mechanisms of natural selection are inadequate to explain the evolution of complex systems. He suggests that 'irreducibly complex systems' such as blood-clotting mechanisms could not have come into being by such 'chance' processes. Behe likens such systems, which require the cooperation of multiple proteins to have the desired end-effect, to a mouse-trap which only functions properly if all the components are put together simultaneously. How could such a system evolve gradually when each of the components taken separately would be of no particular use to the organism? Just as each separate component of the mouse-trap would be of no use in catching mice, so each separate protein used in the blood-clotting process would be of no use without its interactions with all the others.

The problem for Behe's argument comes when you start looking more carefully at the genes that encode the proteins that are involved in blood-clotting and also at simpler blood-clotting systems that are present in other animals. Blood clotting in most vertebrates like us is quite similar. It requires the presence of a fibrous, soluble protein called fibrinogen to circulate in our blood. Fibrinogen has a sticky centre, but this region is normally kept well covered by the rest of the molecule. To form a clot a protease enzyme called thrombin cuts off the outside of the fibrinogen so that the sticky bits, now called fibrins, can stick together to start clot-formation. Proteases are enzymes (proteins that act as catalysts) that clip bits off other proteins.

So why does thrombin suddenly start clipping bits off fibrinogen? The answer is that thrombin itself is activated by another protease called Factor X. And then in turn Factor X requires two more

proteases, Factor VII and Factor IX, to switch it on, and they in turn need other factors. One of the essential factors is called Factor VIII which is defective in haemophiliacs, and who therefore suffer from faulty blood clotting. When Queen Victoria gave birth to her eighth child in 1853, assisted by the new gas chloroform, little Prince Leopold turned out to be a 'bleeder', and eventually died from a fall at the age of 31. This was the first indication that Queen Victoria was a carrier of haemophilia, and with time this mutant gene was spread through her descendants to many royal houses in Europe.

Altogether there are more than 20 components in the 'reaction cascade' that results in clot-formation. Why so many? The answer is that the cascade of steps whereby one protease activates another provides an amplification system in which an initial trigger can produce a very rapid response at the bottom of the cascade. So if a single active Factor (= protease) can activate 20 molecules of the next Factor in the chain, and then that one activates 20 more, then a million-fold amplification of the initial signal can readily be achieved by such a system. And the trigger that makes the 'clotting gun' fire is pulled by various factors released by damaged tissues that activate the first Factor in the chain. Clotting would still occur without the amplification system, but it would just happen a lot more slowly.

Could a Darwinian mechanism explain how this system came into being? As it happens, quite easily. For a start it turns out that genes encoding proteases comprise as much as 3% of the whole human genome. Since we have about 30,000 genes, that means we have about 900 proteases. It is clear that many of these proteases have arisen by gene duplication. The proteases that comprise the cascade of Factors involved in blood-clotting are all related to each other – they are all members of the same protein 'family'.

The next part of the Darwinian explanation for the evolution of blood-clotting requires that we should be able to find a gene encoding for fibrinogen in a simpler organism than vertebrates where it does a different job. We should also be able to find simpler blood clotting systems in the animals from which vertebrates evolved. Both of these requirements have been fulfilled. In 1990 a gene encoding a protein similar to fibrinogen was

found in the sea cucumber, an echinoderm^[xxiii]. As far as simpler blood-clotting systems are concerned, it is intriguing to look at the systems that invertebrates use to prevent blood loss. Invertebrates such as star fish and worms don't bleed to death when they get a cut for two reasons. First, unlike us their circulatory systems are under relatively low pressure. Second, and of more relevance to the present argument, they have various forms of sticky white blood cells that are good at plugging leaks. So if a blood vessel is broken then white blood cells are swept into the hole where they become sticky, bind to other proteins like collagen, and block any further escape of blood. As a system it's not nearly as good as ours, but it is quite adequate for animals that don't have hearts pumping their blood around at high pressures.

So it is quite easy to envisage how the vertebrate clotting system may have evolved. Since fibrinogen-like molecules were already present, most likely in the blood plasma initially for other functions such as maintaining the correct osmotic pressure, all that was then necessary was for a protease such as thrombin to be mis-targeted to the blood as a result of a mutation, a not unlikely scenario. Together with thrombin activation by a further protease this would then give a simple 3-component system that would be sufficient to cause blood-clotting. This simple mechanism alone would have given the first vertebrates using it an immense selective advantage and the system would have therefore been passed on to many progeny. Other steps in the cascade may have been added later as incremental components, most likely due to gene duplication as discussed above, gradually building up to the multi-component speedy system that is used in our bodies today.

So, far from being a 'black box', blood-clotting mechanisms actually provide rather striking illustrations of the way in which multi-component systems can assemble by Darwinian mechanisms. The key point to remember is that such systems do not assemble all at once in a single organism (which really would be remarkable), but rather that each component is already present in order to carry out a different task altogether. There are many examples in biology of 'moonlighting proteins' –

proteins that carry out quite different tasks depending on whether they are inside the cell or outside, on the particular tissue in which they are located, or even which specific location they occupy inside a cell^[xxiv]. For example, there is one enzyme called phosphoglucose isomerase which is a key enzyme in energy metabolism, but it also has at least four other quite different additional roles. This enzyme has probably been around in evolution for more than a billion years, because it's present in all the three major branches of life – the eukaryotes (like us), eubacteria (bugs) and archaea. So it's had plenty of time to be used for other functions. By bringing two or three proteins together that already exist for other functions, then a simple system can be formed to do a specific job like blood-clotting that gives the individual organism expressing that particular set of genes a big selective advantage. Later on in evolution further components can be added to the system incrementally to make it more sophisticated. Once a really efficient system is established in evolution, then organisms are naturally loathe to let it go. The vertebrate blood-clotting system has remained pretty stable now for the last 400 million years of evolution that separate us from the puffer fish^[xxv]. If you have a good system on board, why change it?

We have examined Behe's blood-clotting example in some detail because if one of his examples in 'Darwin's Black Box' fails to convince, then this tends to make the other examples proffered least plausible. And although we do not have space here to look at each example in detail, this is in fact the case. There are convincing Darwinian explanations for each of the supposedly 'irreducibly complex' systems that Behe presents to us, not least the cilia that cells use to generate force and movement^[xxvi]. The immune system represents a further beautiful physiological system which only operates properly when all its various components are in place (involving hundreds of components, not 20 or so as with blood-clotting). Yet our understanding of the evolution of the immune system has increased greatly over the past decade and we now know that many of the genes involved in our innate immune system are extremely old and may be found in organisms such as fruit-flies (about 40% of our genes are shared with fruit-flies and worms – enough to keep us humble!).

So the moral in science when it comes to present gaps in our knowledge is: 'never say never'. The history of science is littered with examples of people who thought that something would never be explained, or that something would never happen – and then it did happen, sometimes only a short while later. As Lord Kelvin pontificated in a speech to the British Association for the Advancement of Science around 1900, a few years before Einstein made his great discoveries: "There is nothing new to be discovered in physics now. All that remains is more and more precise measurement".

And it is this point that brings us to the key philosophical and theological weaknesses of Behe's thesis. For it is difficult to avoid the conclusion that Behe's argument is a somewhat up-dated version of the classic 'god-of-the-gaps' argument for the existence of God. Behe points us to systems in biology for which he thinks science cannot provide adequate explanations, even in principle, and then suggests that those particular systems must be 'designed', suggesting the existence of a supernatural designer.

But there are three fatal weaknesses in this line of thinking. First, if 'design' can only refer to systems about which science is currently ignorant, then inevitably the design concept will shrink – and the designer as well – as the scientific explanations become more comprehensive. This is the god-of-the-gaps argument: 'god' or the 'designer' is used as an 'explanation' to plug the current gap in our knowledge, but as our knowledge base grows, so the 'god' shrinks.

Second, one invariably ends up in a muddle if metaphysical language and scientific descriptions are mingled together. More technically in philosophy this is called a 'category error'. 'Design' is a word referring to purpose and intentionality. In human discourse it is common to refer to the 'design' of a car engine, even though we have available to us a complete specification of how all the components of the engine operate to make the car move. We do not normally refer to things as being 'designed' on the grounds that we do not have any explanation for how they came into being. Yet that that is the use of the word 'design' that Behe wishes us to make. And in the process he tries to invoke 'design' as if it represents an explanation for something, when in

reality it is just a rather unsatisfactory way of flagging up some gaps in our current scientific knowledge. As already noted, those gaps have a habit in any case of being filled rather rapidly.

Third, the situation becomes even more problematic as Behe suggests that 'If a biological structure can be explained in terms of those natural laws, then we cannot conclude that it was designed... It turns out that the cell contains systems that span the range from obviously designed to no apparent design'. As an example of biochemical structures which have not been designed Behe discusses cell membranes and haemoglobin. So Behe envisages the created order (although he does not call it that) as being divided into a non-designed aspect which works by natural laws and which science can currently describe, and a designed aspect which does not involve natural laws and which science cannot currently understand. It is in dissecting this argument that the semi-deism of Behe's position may be perceived most clearly. The key give-away phrase is where Behe states that 'Some features of the cell appear to be the result of simple natural processes, others probably so.' Behe envisages a quasi-autonomous domain called 'nature' in which there are 'naturalistic processes' which science can explain, and a quite different domain in which the designer acts supernaturally to bring about designed processes which science is unable to explain.

The stance of robust theism towards the created order is very different from that proposed by the ID movement. Nature is "what God does". Therefore all scientific descriptions without exception represent descriptions of the creative and sustaining activities of God in the world around us. The properties of matter reflect God's creative power irrespective of whether or not we are currently in a position to understand them. Current gaps in our scientific knowledge should act as a spur and motivation for further research until we can make our scientific explanations more complete to the glory of God. Every component of cells, indeed every single entity described by biology, all equally represent the out-workings of God's activities in the created order.

In Christian theology there is no 'two-tier' universe that one can split into the 'designed' portion and the 'undesigned' portion. As the psalmist wrote, the

whole created order is such as to arouse our awe, wonder and worship^[xxvii], but this is because every aspect of it, without exception, has God as its Author. We have dealt at some length with Behe's 'intelligent design' approach because it illustrates rather well the way in which semi-deism can permeate even works that claim to be defending the Christian faith. One motivation appears to be the desire to underline the 'miraculous' aspect of God's creative actions. If science cannot (currently) explain something very well, then this seems to provide scope for the miraculous. The problem with such an emphasis is that the Bible does not view God's creative actions as being miraculous. Instead the Bible repeatedly draws attention to the *consistency* of God's actions in creation. It is only because of this consistency that science is possible. Only if the material world behaves reproducibly is there the opportunity to carry out experiments and to formulate generalised laws describing the behaviour of matter and energy.

The Bible sees the whole of creation as flowing out of God's word of command, and God goes on commanding his creation to continue until the present day, but the Bible does not describe this as 'miraculous'. Miracles are those special actions of God which play a key rôle in fulfilling God's salvation plan for humankind, but nearly always in the Bible they refer to signs of God's grace in particular human situations. Since the whole of creation derives from God's actions there is no notion that the created order *per se* is miraculous, in its origins any more than in its continued existence. This point was well understood by the writers of the Old Testament. For example, in Nehemiah Chapter 9 as the people of Israel are praying they give thanks to God for his creation (verse 6), but with no mention of miracles, and then a few moments later in the same prayer give thanks to God for his 'miraculous signs and wonders' in delivering them out of Egypt.

The Mediaeval Church had a habit of proliferating miracles, no doubt in an attempt to impress the irreligious and to draw attention to the power of the Church. But one of the missions of the biblical reformers such as Calvin and Luther was to counteract this tendency, reminding their listeners of God's common grace which was available to all. We should be careful that we do not repeat the error of the Mediaeval Church in calling some

aspects of his creation miracles, which God himself has chosen not to call miracles in his biblical revelation to us.

has several chapters on evolution.

[ii] The details are in D. C. Lindberg & R. L. Numbers (editors) (1986) *God and Nature: Historical Essays on the Encounter Between Christianity and Science*, University of California Press, pp. 407–415; R. L. Numbers (1992) *The Creationists*, University of California Press.

[iii] Quoted by Philip Kitcher (1983) in *Abusing Science*, Open University Press, p. 187.

[iv] Philip E. Johnson (1997) *Testing Darwinism*, Inter Varsity Press.

[v] M.A.F. Noor (2003) Genes to make new species, *Nature* **423**, 699–700.

[vi] P. Skelton (editor) (1993) *Evolution*, Addison-Wesley Publishing, pp 402–408. See also the example of speciation in the Hawaii Drosophilids in this chapter.

[vii] E. Verheyen et al. (2003) Origin of the superflock of Cichlid fishes from Lake Victoria, East Africa, *Science*, **300**, 325–329.

[viii] J. Zhang (2003) Evolution by gene duplication: an update, *Trends in Ecology and Evolution* **18**, 292–298.

[ix] W.H. Li (2001) Evolutionary analyses of the human genome, *Nature* **409**, 847–849.

[x] L.W. Hiller et al. (2003) The DNA sequence of human chromosome 7, *Nature* **424**, 157–164.

[xi] M. Levine & R. Tjian (2003) Transcription regulation and animal diversity, *Nature* **424**, 147–151.

[xii] S.B. Carroll (2003) Genetics and the making of *Homo Sapiens*, *Nature* **422**, 849–857.

[xiii] Those interested in human evolution will enjoy: G. Finlay (2003) *Homo Divinus: the Ape that Bears God's Image*, *Science & Christian Belief* **15**, 17–40.

[xiv] Psalm 104:30.

[xv] Isaiah 45:7

[xvi] J.R. Moore (1979) *The Post-Darwinian Controversies*, Cambridge University Press, p. 92.

[xvii] G.M. Marsden (1984) in *Science and Creationism* (ed. A. Montagu), Oxford University Press, p. 101.

[xviii] 1 Kings 22: 15–28

[xix] I Kings 22: 34

[xx] Michael J. Behe (1996) *Darwin's Black Box – The Biochemical Challenge to Evolution*, New York: Free Press.

[xxi] William A. Dembski (1998) *The Design*

Inference: Eliminating Chance Through Small Probabilities, Cambridge: Cambridge University Press.

[xxii] See also William A. Dembski (2002) *No Free Lunch: Why Specified Complexity Cannot Be Purchased Without Intelligence*, Lanham, MD: Rowman & Littlefield Publishers. Also see a more detailed critique of Dembski's ideas in H. Van Till (2003) Are bacterial flagella intelligently designed? Reflections on the rhetoric of the modern ID movement, *Science & Christian Belief* **15**, 117–140.

[xxiii] X. Xu & R.F. Doolittle (1990) Presence of a vertebrate fibrinogen-like sequence in an echinoderm, *Proceedings of the National Academy of Science, USA* **87**, 2097–2101.

[xxiv] Constance J. Jeffery (1999) Moonlighting Proteins, *Trends in Biochemical Sciences* **24**, 8–11.

[xxv] Y. Jiang & R.F. Doolittle (2003) The evolution of vertebrate blood coagulation as viewed from a comparison of puffer fish and sea squirt genomes, *Proceedings of the National Academy of Science, USA*, **100**, 7527–7532.

[xxvi] For a critique of Behe's claims about cilia, see Kenneth R. Miller op cit. Pages 140–143.

[xxvii] Psalm 19:1–6.