Does Evolution have any Religious Significance?

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ABSTRACT

It has often been thought that the biological theory of evolution has religious implications. This lecture presents the case that the religious significance of evolutionary theory is in fact rather limited, and that as a biological theory it can readily be accommodated within a robust version of Christian theism.

Evolution as a biological theory is distinguished from the various ideologies which historically have been subsumed under the term 'evolution'. Basic concepts in evolution, such as natural selection, mutation and speciation, are explained. Biological evolution is then related to Christian theism, with its twin emphases on the transcendence and immanence of God in the created order.

Six arenas in which evolution may have significance for Christian theism are discussed: the claim that evolutionary theory is intrinsically atheistic; the role of chance; the origin of life; the origin of species; the origin of humankind; and the problem of pain, suffering, death and the Fall. As part of this discussion the views of Richard Dawkins, Michael Behe and Stephen Jay Gould are considered. The anthropological and genetic data pointing to the origin of *Home Sapiens* in Africa is compared with the theological account of human origins given in Genesis, and several models are suggested as ways of relating these perspectives. It is concluded that we do not know the ultimate reasons why God chose to generate biological diversity, including humankind, by a process of evolution. Nevertheless we can state that physical death is intrinsic to carbon-based life, that pain is essential for survival, that the concept of evolution being a wasteful process is ambiguous, and that our own evolutionary origins provide us with no scope for an arrogant humanism, but rather remind us of our dependence upon God's grace.

The notion that the theory of evolution has some religious significance has a long history and is still believed by considerable numbers of both Christians and non-Christians, not to speak of those of other faiths, such as Muslims. A few quotations will quickly illustrate the immense diversity of ways in which evolution has been thought to carry such religious significance.

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For Richard Dawkins, therefore, evolution appears to represent some kind of knock-down argument for atheism. Such sentiments would have been very surprising to the late 19th century Scottish theologian Henry Drummond who wrote in his book "The Ascent of Man" published in 1894 that:....

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Drummond made the theory of evolution a central plank of his Christian apologetic, maintaining that Darwin's 'Origin of Species' was 'perhaps the most important contribution to the literature of [Christian] apologetics' to have appeared during the 19th century.

To switch emphasis again, read the words of one of the founders of the 20th century creationist movement, Henry Morris:

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One can at least not fault Morris for not stating his position clearly.

Now all these authors, whether Christian or atheist, are united in their view that evolution has some kind of religious significance - they would wish to answer a clear 'yes' to the question posed in our lecture title this evening. Indeed as you look at the relationship between evolution and the history of ideas it is remarkable to note that, in its time, evolution has been invoked in support of an enormous array of ideologies, including capitalism, communism, racism, militarism, and so forth, many of these ideologies of course being mutually exclusive. All kinds of ideas can 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.

In the light of those, such as Richard Dawkins, who think that evolution has atheistic implications, it is interesting to note that back in the 19th 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' 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 1870's'.

Ironically, in light of the fact that today about half the American population disbelieves the theory of evolution, in the 19th century it was Christians who did much to popularise the theory in the US. 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.

Further ironies may be derived from the observation that the term 'fundamentalist', often used today in scientific journals to refer somewhat disparagingly to anyone who disbelieves the theory of evolution, stems originally from a mass-produced series of twelve booklets entitled *The Fundamentals* published in the period 1910-15 which were intended to reform and strengthen the basic beliefs of Christianity around the world. But in fact the tone of these booklets towards evolution was ambivalent and generally lacked the strident anti- evolutionary rhetoric which characterised the creationist movement which began in the 1920's. Furthermore, several writers were asked to contribute to the 'Fundamentals' who were well-known for their acceptance of evolutionary theory. For example, the Christian Darwinian George Wright's contribution to volume 7 of *The Fundamentals* commented that the word evolution 'has come into much deserved disrepute by the injection into it of erroneous and harmful theological and philosophical implications'. R.A. Torrey, who edited the last two volumes in the series, once referred to Darwin as 'the greatest scientific thinker of the nineteenth century' and another frequent contributor to *The Fundamentals,* James Orr, reminded his readers that the 'Bible was never given us in order to anticipate or forestall the discoveries of modern twentieth century science'. It is difficult to believe that such sentiments provided much help to the later so-called 'fundamentalists' who began to proclaim that the Bible was a scientific text-book teaching that the world was made in seven days. Clearly the word 'fundamentalist' has been undergoing its own rapid evolution during the course of the twentieth century.

I have no intention of pursuing such historical material further this evening, but I mention it to illustrate the point that more than a century ago Christians were busy baptising Darwinian evolution into a Biblical world-view and many Christian thinkers of that era would, I think, have answered the question "Does Evolution have any Religious Significance?" with the answer "not a lot". That is precisely the answer also which I wish to provide you with this evening, and I suggest that it is an answer which stands in a long and unbroken lineage which stretches back to the convictions of many of Darwin's own Christian

contemporaries. As with virtually all other biologists, for me personally the theory of evolution provides a convincing framework which explains the origins of biological diversity and which links together the various biological disciplines in a satisfying way. My concern this evening is not to assess the scientific evidence for evolution *per se,* which is readily available from books or university courses, but rather to address the basic question as to whether biological evolution has any religious implications.

Discussions about evolution are frequently clouded by the fact that different people come to the conversation with very different understandings of what the word actually means. My own usage of the word tonight, in contrast to those authors with whom we started, is strictly restricted to its contemporary biological meaning. Before we look at theology and philosophy, therefore, a few biological definitions might be useful, and since this is a general lecture I am not assuming that all here this evening have a background in the biological sciences. What, then, *is* biological evolution?

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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 sentences:

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Evolution therefore can 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 e.g. 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.

Alleles are different versions of the same gene. Most animals, including humans, are diploid, that is they contain two alleles for every gene at every locus, one inherited from their mother and one inherited from their father. The locus of a gene refers to its position on a chromosome. Each gene comprises a stretch of DNA and it is the precise order of the nucleotides which make up the DNA which specifies the amino acid sequences of all the proteins in our bodies.

There is an enormous amount of genetic variation in natural populations due to different alleles of genes, that is variant forms of the same gene. Levels of genetic variation in animals range from roughly 15% of loci having more than one allele in birds, to over 50% of loci varying in insects. Mammals such as ourselves have more than one allele at about 20% of our loci, so if it turns out that we have as many as 100,000 genes, which will not be clear until the human genome project is complete early in the next millennium, then variant alleles may exist within the total human gene pool for as many as 20,000 of our genetic loci.

In order for evolution to occur, that is, 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. There are 5 mechanisms which are important in evolution, at least as far as evolution within a particular species or biological lineage is concerned, and I have classed these according to whether they decrease or increase genetic variation.

First those that decrease genetic variation.

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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.* Just how conservative may be gauged from the sequence of a particular enzyme which regulates the activation of T cells on which we are currently working in my lab, an enzyme which differs in only three out of its total 601 amino acids between human and mouse, despite the 50 million years of evolutionary time which separate us.

There are plenty of examples of how natural selection operates in contemporary human populations, for example the maintenance of mutant genes in human populations in parts of the world where malaria is endemic, since if one allele is mutated and the other 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.

Now natural selection has a number of other components, such as survival. Clearly if you don't survive its pretty difficult to reproduce. But the phrase 'survival of the fittest' introduced by Herbert Spencer, not by Darwin, into the evolutionary vocabulary, is misleading, since natural selection is about reproductive fitness not merely about survival. Sexual attractiveness is also a very important component of natural selection. Female sticklebacks find males with red colouration on their sides more attractive and it has been shown that the intensity of colour correlates with parasite load - the more red, the fewer parasites, and so the healthier stickleback mate you will end up with.

What about mechanisms that increase genetic variation? There are three:

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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 makes mistakes. These mistakes 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 e.g. 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 - in fact only a small proportion of the DNA of multicellular organisms actually encodes for genes - in our own case it is about 3% - the function of the rest of our DNA is not yet well understood. So most mutations occur in the 97% 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 are 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 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 worldwide 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 us.

One further mechanism should be mentioned which can reduce genetic variation, and this is known as genetic drift. Allele frequencies in a population can change due to chance alone. This is called genetic drift. Alleles that form the next generation's gene pool are a sample of the alleles from the current generation. Whenever you take a sample from a population of anything, slight differences will be present in your sample due to chance. So alleles can increase or decrease in frequency due to drift, especially when they cause no deleterious results to the organism concerned which would then be quickly weeded out by natural selection. Very occasionally new mutant alleles can drift until they become fixed in populations.

Like most biologists, my own research programme does not involve the study of evolution per se, but rather we biologists operate within the overall paradigm of evolutionary theory, since it unites the various disciplines of biology to make a coherent and satisfying story. To briefly illustrate what this means in practice, let me show you a slide.

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This slide relates to a practical question which arose in my own research programme a few weeks ago. We are working on an enzyme which is involved in T cell activation. T cells are a class of white blood cells which protect our bodies against viruses. Upon encountering virally infected cells they become activated. We have recently shown that a protein called SHP-2 is involved in this process. Our research involves introducing mutations into this enzyme by standard genetic engineering techniques, putting it back into T cells, and then seeing what happens to T cell activation. The practical question which arose was, should we use the mouse SHP-2 gene to do these experiments, or the human SHP-2 gene? The answer is, when you line up the sequences as shown in the slide - it doesn't matter. You are not intended to read the detail on this side, it is impressionistic. At the bottom of each line is the sequence of 601 amino acids which is encoded by the SHP-2 gene. The slide shows a comparison of the SHP-2 amino acid sequence between human, rat, mouse, chicken and frog. Wherever you see a red letter indicates a difference in an amino-acid - each hyphen indicates that the amino acid is identical. Although human and mouse are separated by 50 million years of evolution, the amino-acid sequences which the human and mouse genes encode are essentially identical, differing in only three amino-acids out of the total 601 - a 0.5% difference. In contrast the human and frog sequences differ at 32 places, a 5% difference which reflects the roughly 300 million years which separate us from the frogs in evolutionary time. So this tells us immediately that the sequence of this gene is being powerfully preserved by natural selection - change the sequence even a tiny bit by mutation and you're a dead mouse. Probably all the various domains of this enzyme are critical to its present function.

So far we have considered only evolution within a biological lineage, that is, within a single species. What about speciation? A common way of defining a species is to say that

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Some biologists think that special mechanisms, different from those that we have considered so far, may be involved in speciation, whereas others, myself included, believe that in many cases the molecular mechanisms we have described so far are adequate to account for reproductive isolation. 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, they should not be surprised if their accumulation of mutant alleles now means that they can no longer interbreed.

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. 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.

It is sometimes suggested that speciation occurs too rarely or too slowly for any single person to observe a speciation event during their life-time. This is actually not true. There are a number of examples of new species which have emerged naturally during the course of the 20th century, particularly in plants in which speciation often occurs by a doubling of chromosome number. For example:

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It is also 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 are extremely ancient. When we compare ourselves with mice, a species from which we split genetically a mere 50 million years ago, then nearly all our genes are shared with mice in the sense that virtually every human gene studied so far has a comparable gene in the mouse which is normally carrying out the same job as 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 in evolution, 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 very similar bricks and stones.

Now I have spent some time in defining the various terms used in evolutionary theory because this part of the conversation is important. You cannot analyse the relationship between evolution and religious belief sensibly unless it is clear what concepts and ideas are being related. This of course brings us on to religious belief. The belief system which I wish to compare with evolution this evening is that of Christian theism, the kind of robust theism which is portrayed for us in the Biblical understanding of God. What do I mean by robust theism?

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A Biblically based robust theism has two critical strands. The first strand is that of the transcendence of God, the belief that God is a personal, all-powerful creator God who is a distinct entity from the universe that He creates. Christians are not pantheists. The second strand is the immanence of God, referring to belief in a personal creator God who is intimately involved in the sustaining and up-holding of every aspect of His creation moment by moment by the utilisation of 'secondary causes'. Christians are not deists, the idea that there are some aspects of the natural order which are in any sense less under God's sustaining control than other aspects. Robust theism therefore views the creation as 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.

In fact 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 (Ps. 104), or the creation of light and darkness which God does every day in the normal passage from day to night (Is.45.7). It is sometimes suggested that the Bible makes a sharp distinction between God's past creative acts in bringing the created order into being, and his present providential sustaining of the created order, as if these two aspects of God's creative activity referred to quite different kinds of processes. But I have to say that I have worked very carefully more than once through all the relevant Biblical passages and I have never noticed such a distinction - indeed the word providence is not once used in the Bible with reference to creation. The Bible seems at pains to point out that the present created order is as much caused by God now as it ever was at the beginning - as Jesus once said "Your father causes his sun to rise on the evil and the good" (Matt. 5.45). The language is not that of providence but of an on-going causality.

What, then, within this robustly theistic world-view, are scientists doing when they carry out their research? Well, they are simply coming up with the best models they can, supported by the best empirical data they can lay their hands on, to describe God's creative activity. They may get their models quite wrong on occasion, and need constantly to improve their descriptions, but what scientists cannot do, within this world-view, is to describe anything in the universe which is not created by God. Their vital task is therefore to tell the truth about God's created order to the best of their ability. Note, therefore, that scientists who are Christians who hold to a robustly theistic world-view will not give any support to the idea that their scientific enterprise, or their scientific methodology, is in any sense tainted with a naturalistic philosophy, as if the very process of science itself promoted the cause of philosophical naturalism. Christian scientists will be quick to point out that naturalistic presuppositions reflect prior metaphysical assumptions which people make before they come to any endeavour, be it artistic, scientific, relational, or whatever, and these assumptions will colour all their endeavours to a more or less comparable degree. Likewise Christian theists have prior beliefs about God and His relation to the world which colour all their endeavours, be they artistic, scientific, or whatever. The competing world-views of naturalism and Christian theism clash not at the point of scientific methodology, a methodology which is shared equally happily by both sets of protagonists, but at the level of prior commitments.

Having briefly clarified some concepts involved in the theory of evolution and in Christian beliefs about creation, we can now focus on those particular areas where, it is thought, evolution may have some religious significance. These can be listed under six headings:

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What I wish to do now is to survey these areas of discussion and in particular to place them within the context of a robust theism.

Let us consider first the claim that evolutionary theory is intrinsically atheistic. We noted earlier that Richard Dawkins claims that his belief in evolution enables him to be an intellectually fulfilled atheist. A few months ago a law professor, Philip Johnson, gave a lecture here in Cambridge in which he suggested that because Dawkins bases his materialistic philosophy on evolution, therefore there must be something intrinsically atheistic about evolution and therefore Christians should be against it. I think this is a weak argument. The history of science is full of examples of both scientists and non-scientists trying to use the prestige of scientific theories to prop up their own personal ideologies. But a moment's thought will usually be sufficient to demonstrate that the scientific theory in question will simply not bear the ideological weight that is being placed upon it. By repeatedly trying to link the theory with the ideology in question, the association may have some propaganda value in the public domain, so that unfortunately even some Christians are hoodwinked, but closer analysis reveals the linkage to be bogus.

Dawkins' own beliefs about the matter appear to be compounded of several different misunderstandings.

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Dawkins probably has some other misunderstandings as well, but lets consider just these three for the moment. Ironically Dawkins shares his first assumption with the creationists. 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 my own preference would be 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 in fact correct to suggest that these are rival theories about the origins of biological diversity - in one 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 creates each species separately. And one can argue that as long as there are creationists around so there will 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 kind of way.

The stance which I am suggesting this evening takes a different tack. 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 to 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. It refers to the belief that the universe has an Author. It should be noted that such a stance undermines the use of scientific theories as arenas for ideological conflict, and instead places the conflict such as that between atheists and Christians, firmly where I think it should be placed, that is on the competing metaphysical assumptions shared by these protagonists. The key question then becomes not "how has God carried out particular aspects of His creative handiwork, but what are the metaphysical assumptions that make best sense of the universe in which we live, including the coherence of its finely tuned physical laws which have in fact rendered the process of evolution possible.

Dawkin's second misunderstanding appears to stem from his mistaken belief that Christians are deists rather than theists. Of course it has to be admitted that there are sufficient Christians around whose deistic stance towards the doctrine of creation quite likely provides Dawkins with a reasonable excuse for such a misunderstanding. Be that as it may, Dawkins seems to be under the impression that if something can be explained in scientific terms then it can no longer be something created by God, whereas if something cannot currently be explained and is rather mysterious, then this is particularly the arena of religion. Similar ideas are commonly propagated through the media. The spooky, the mysterious, the unexplained - these are portrayed as a being a rich hunting ground for religious believers, whereas scientific explanations are thought to bring a secularising influence to bear, rendering God-talk unnecessary. For the Christian whose beliefs are based on the Biblical doctrine of creation, nothing could be further from the truth. When the Bible wishes to draw attention to God's actions in creation, it nearly always does so not by invoking the spooky and the mysterious, but by reminding its readers of God's creative actions in the mundane and ordinary events of everyday life in an agricultural society with which they were familiar - seed-time and harvest, stormy winds fulfilling God's command, the lion seeking its food from God, God making the grass grow for the cattle, and so on - page after page of Job, Psalms, Isaiah, not looking for God at the edges of their known world, least of all in their gaps in understanding, but pointing to His daily actions in familiar events.

And so for the Christian, scientific explanations enrich their understanding of God's world - if those explanations elucidate some molecular mechanism which help us to understand God's creative actions more clearly, so much the better. **Christians have no hidden theological investments in ignorance**.

Dawkin's third point may be readily dealt with once it is understood that Christianity is in a very important and distinctive sense a *materialistic religion*. This is made abundantly clear in Genesis ch. 1 in which God

repeatedly looks at the material world that He made and sees that it is very good. This was no smug self-satisfaction, but an important reminder to the original readers, as it is to us, that there has been a frequent tendency in human thinking, of which neo-platonic philosophy provides the classic example, to down-grade the material in favour of the supposedly greater value of the spirit. The Bible will have none of this and, for example, emphasises the resurrection of the body, not the immortality of the soul. Against platonic thinking Paul reminded Timothy as a leader of the early church that "Everything God created is good, and nothing is to be rejected if it is received with thanksgiving..: (1 Tim. 4.4). Supremely in the Incarnation of Jesus, God declared the material world, the world of biological bodies - cells and genes and organs - to be good. So Christians should be *delighted* in further scientific advances, because they provide insights into the many and varied ways in which matter, God's matter, functions. Much of the suspicion of the material world which runs through creationist writings, for example, seems to me to be quite pagan in origin, and is very far from the Biblical celebration of the material world as the arena of God's daily creative actions.

Intriguingly, Michael Behe, a biochemist who has recently written a defence of the existence of a designer God entitled 'Darwin's Black Box' (The Free Press, 1996), appears to share several of the misunderstandings about the relationship between scientific and religious knowledge which are portrayed in the writings of Dawkins. Behe 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. As it happens, much of Behe's science is quite misleading, particularly in the information which he excludes from his book - for example, we know a lot more about the evolution of the immune system than Behe seems to be aware. But my critique in this context is restricted to Behe's theology of creation and his philosophy of science. So Behe suggests that 'unbridgeable chasms occur even at the tiniest level of life', referring in this context to 'gaps' in biochemical pathways which he thinks cannot be explained in scientific terms. Therefore Behe does think that there is a religious investment in scientific ignorance, since this allows us to plug the gaps in our ignorance with the concept of a designer-God, an idea which is clearly a hostage to fortune, since Behe's designer God will inevitably shrink, in this view, as scientific explanations become ever more complete.

Behe informs us that "If a biological structure can be explained in terms of .....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". So in Behe's scheme the designed bits refer to the biochemical pathways for which we do not yet possess an adequate explanation of evolutionary origins, whereas the undesigned bits are those for which we do have adequate explanations. Biology thereby becomes divided into a more religiously significant sphere, identified by the word design, and a so-called 'natural sphere' where science rules supreme because this is the bit we happen to have scientific explanations for.

My own view is that such a view simply does not fit with the robustly theistic view of creation portrayed in the Bible, in which all of the material world is viewed by God as good. Like Dawkins, Behe appears to think that materialistic descriptions of the world somehow imply an absence of God's actions, but there simply seems to be no good reason for believing this. As far as the concept of 'design' is concerned, the word means so many different things to different people in different contexts that its use, I think, tends to obfuscate conversations rather than bringing clarity. As it happens the Bible never uses the concept of design in talking about God's relationship to His creation, and I suspect that Christians would be better off following the Bible's example and dropping the word, at least in the context of biology.

Now let us briefly consider some of the other aspects of evolution that we have already listed which have been suggested to invest evolution with religious significance. What about Chance?

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'Chance' is a slippery word and in any discussion of 'chance' events it is always worth checking on the particular way in which the word is being used before jumping to conclusions. The word 'chance' may be used in three quite distinct ways, which I will label A, B and C. First, it can refer to events that are

unpredictable because we cannot, for practical reasons, possess the necessary information which would enable us to predict the future outcome (chance A). Coin-tossing exemplifies such an event. Events best described by chaos theory also belong to this category, in which tiny variations in initial conditions make big differences to eventual outcomes. The second major meaning of 'chance' (chance B) refers to events that are physically indeterminate, as in the conventional interpretation of quantum mechanics. Quantum indeterminacy means that when radioactive atoms decay it is impossible to predict when a particular particle will be emitted. The term 'pure chance' is sometimes applied to such quantum events because they are indeterminate in principle and not just in practice. The third major definition of 'chance' is what I have called on the slide 'metaphysical chance' (chance C), a term which embraces several shades of meaning. 'Metaphysical chance' is the idea that in some ultimate sense the universe has no purpose or meaning, that chance ultimately rules over all. One version of metaphysical chance was expressed in the qualities of *Tyche*, the Greek goddess of chance, together with *Fortuna* her Roman counterpart. The personification of chance in this sense is quite incompatible with the two more technical meanings of chance (A and B), since it is clear from *their* definitions that 'chance' is not a causal agency which makes things happen, but rather a description of the way in which we as observers understand the workings of certain events within the world around us. Chance itself *does* nothing. Despite this rather obvious point, it is remarkable how often heroic attempts have been made to extrapolate chance C out of chance A and/or B, most famously by the biologist Jacques Monod back in the 1960's.

Which of these types of chance are most relevant to evolution? Most likely both chance A and chance B. The variation upon which natural selection acts is generated by mutations in DNA. Many of these involve chance A - chance mistakes occur in DNA copying which DNA repair enzymes miss - there are perfectly good reasons for such errors, but we cannot predict them in practice. At the same time Chance B is involved in the quantums of radioactive energy which strike DNA in germ-line cells and contribute to their variation by mutations. But for evolution to occur it really doesn't make any difference whether mutations originate by Chance A or Chance B, because the phenotypes generated by the variant genes are all selected for or against by the process of natural selection. So you can imagine evolution as comprising a variation-generating device pouring its variation into a selection device which carefully selects those combinations of genes which contribute to reproductive success. Just how stringent that selection process is may be seen in the conservation of gene sequences over millions of years of evolution. When we think of something as being 'random' we normally think of things like the fuzz on our TV screens when they go wrong. Evolution in its totality is as far from random in that sense as anything you can imagine. It is a tightly regulated process, restricted by the constraints of food and reproduction and of living in a world of gravity which oscillates between light and darkness. Richard Dawkins has commented that one of the main reasons he wrote his book The Blind WatchMaker was to counteract the popular notion that evolution, taken in its totality, is a chance process.

Now this is not to say that there are not other important chance events which have occurred during evolutionary history. Extinctions belong firmly to Chance A. Without the asteroid hitting the earth which likely caused the extinction of the dinosaurs at the boundary between the Cretaceous and Tertiary periods about 65 million years ago, mammals would not have been able to radiate to fill the ecological niches vacated, and so its unlikely that we would have been here to talk about it. *Asteroid bombardment is coin-tossing on a grand scale*. Plate tectonics has also played a key role in the evolutionary process by moving continents together and then apart again, so separating populations and leading to speciation events.

The evolutionary biologist Stephen Jay Gould is fond of pointing out that evolution could so easily have taken a different track. If we re-ran the evolutionary tape, it is highly unlikely that it would reproduce the same series of speciation events. *Precisely so*. Christians will see God's sovereign actions in all the many and varied events which have contributed to the evolutionary process, from the smallest mutation to the biggest asteroid, and marvel also at God's grace that we are here at all to even discuss the matter. That is also why there is no need to invest a special theological significance in speciation events as if they were a particular focus of God's actions in comparison with God's other actions in the evolutionary process. As we have noted, the genetic differences which account for the cessation of inter-breeding between two populations of plants or animals are in many cases likely to be fairly trivial, trivial that is in comparison with the much greater gene variation which already exists within an inter-breeding population, but which

doesn't happen to disallow the inter-breeding process itself. As we have also noted, there are about 20 million extant species. So, biologically speaking, speciation is not a big deal, and it is therefore difficult to see why Christians would want to invest speciation events with any particular significance, although we *will* come to the question of our own species in just a moment.

What about the origin of life? How did DNA get going in the first place? Strictly speaking this is not an evolutionary question since the theory of evolution refers, as we have noted, to the change in the gene pool of a population over time. For evolution to occur you need genes. But even if its not an evolutionary question, the origin of genes is a pretty important question, because without them evolution would not have been possible. On the geological scale of time, life began remarkably quickly after the start of our planet. If we map the whole history of our planet onto a 24-hour clock, with time zero as 4.5 billion years ago and midnight as the present time, then simple forms of life would already be appearing by 2.40 a.m., that is, about 3.8 billion years ago. It is thought that life evolved in the sea and stayed there for the majority of the history of the earth. Not until 8.45 p.m. in the evening on our 24-hour clock would cyanobacteria and green algae invade the land from the sea and not until 9.33 p.m. do you get the first plants and animals on land, just to put the time-scale into perspective. On the same clock the whole of recorded human history occurs during less than one-fifth of a second before midnight.

It is thought that life began in an anaerobic atmosphere that is without oxygen, and that the first self-replicating molecules were RNA, a nucleic acid similar to DNA. There are many reasons for thinking this, but one is that some RNA sequences have catalytic capabilities. Most importantly, certain RNA sequences can act as polymerases - enzymes that form strands of RNA from its monomers. This is called 'the RNA world hypothesis'. The theory suggests that the common ancestor of all life probably used RNA as its genetic material.

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This putative RNA ancestor gave rise to three major lineages of life: the prokaryotes, archaebacteria and eukaryotes, which include fungi, plants and animals. Eukaryotes and archaebacteria are the two most closely related of the three. The process of translation, that is making protein from the instructions on a messenger RNA template, is similar in these lineages, but the organisation of the genome and transcription, making messenger RNA from the DNA template, is very different in prokaryotes than in eukaryotes and archaebacteria. So this is interpreted to mean that the common ancestor was RNA based - it gave rise to two lineages that independently formed a DNA genome and hence independently evolved mechanisms to transcribe DNA and RNA. In fact rocks as old as 3.5 billion years have yielded prokaryotic fossils.

There is an enormous amount that could be said about the biochemical mechanisms that may have been involved in the origin of life - much of it is speculative, and there is definitely no convincing model as yet which can take us satisfactorily all the way from simple organic molecules to the complexities of the cell, although some of these putative steps can at least be mimicked in today's laboratories. The origin of life is therefore marked by striking scientific ignorance. **Does that matter theologically?** It is remarkable how certain types of religious people like to cluster around arenas of scientific ignorance, like bees round nectar, as if these were in some sense the particular domains of God's activity. We have already criticised such an approach for its theological naivety and for its apologetic weakness. Remove the ignorance and God's arena of activity suddenly declines dramatically in this god-of-the-gaps theology. Of course an all-powerful God can do anything - that is not in question. As Bertrand Russell once famously said, God could have created us all two minutes ago complete with our memories and the holes in our socks! But the question the scientist wishes to answer is 'how did God actually bring life into being?' It is possible that we will never know the answer for sure, and it is not an easy area of research either to carry out or to get funding for, at least in this country. But it is remarkable just how fast and how far ideas, supported by some data, have already advanced in this field. Certainly there seems no reason to think that God used any special processes in the origin of life which were necessarily different from those which chemistry and biochemistry can currently describe.

Whereas few people get very emotional talking about the possible theological implications of DNA and the origin of life, the situation often changes when human origins become the topic of discussion. As a Christian I accept the authority of Scripture in all matters relating to faith and conduct, and I believe that the early chapters of Genesis provide us with a vital theological account of the origins and purposes of humankind, an account which is seminal for our understanding of the rest of the Bible. However I do not personally think that the purpose of the inspired author is to provide us with a *scientific* account of the origins of biological diversity in general, nor of human origins in particular. Rather the author aims to explain the *spiritual* meaning and purpose of human existence, including teaching about the nature of God, human fellowship with God, the Sabbath and the stewardly relationship of humans with the good earth with its wild animals that God had made. These remarkable chapters also expound on the twin themes of sin and redemption which are picked up and amplified throughout the rest of the Bible.

How then are we to understand the account of Adam and Eve and the doctrine of the Fall within this framework? The Hebrew word *adam* as a common noun can mean either 'humankind' or 'man as distinct from woman'. The first time the word is used in Genesis is in chapter 1.26-28 and there it is clearly used in the first sense of 'humankind' - 'So God created *adam* in his own image, in the image of God he created him; male and female He created them'. Then in Genesis 2 and 3 *adam* often occurs with the second meaning of 'man'. We know this because the definite article regularly appears before the word and in Hebrew personal names do not occur with the definite article. Genesis also makes clear that the choice of the term, *adam*, to describe man is not accidental, but is in fact a wordplay with the similar sounding word, *adama*, which means ground. There is a perfectly good word for man, *ish*, which is used in the rest of the OT for man, but in Genesis the alternative word *adam* is used to emphasise that the man is from the ground and to the ground he will return. Genesis certainly has an earthy realism about matter! But there is more to it than that, for the use of a word for 'man' was common in the Near East of the second millennium B.C. as a means to describe the rulership of a town or area. For example the Ish-Tob mentioned in 2 Samuel 10.6-8 was the 'ruler of the land of Tob'. So the use of *adam* in Genesis in relation to *adama* may also be underlining Adam's role as God's ruler of His earth, the Garden of Eden. Adam is God's earth-keeper.

Adam is also used as a proper name in texts from the ancient Near East but in the Genesis account is not used unambiguously as a proper name until ch 4.25 where Adam is used without the definite article. Remember that in Hebrew personal names do not occur with the definite article.

The other point to note about the Genesis narrative of Adam and Eve and their family is that they are portrayed as living in the Near East, as farmers with fields and herds of animals, with other people living around them, many of them in cities. The use of bronze and iron is also specifically mentioned (4.22). The culture portrayed would perhaps be that typical of Neolithic farmers of the Near East, sometime after 8,000 B.C.

What about the evolutionary account of human origins? Biologically speaking a human is any member of the species *Homo sapiens*, the only living representative of the family Hominidae, or hominids, a group of up-right walking primates with relatively large brains. Anatomically modern humans, of the kind that you would not mind meeting if you met them in a pub in Cambridge, are known as *homo sapiens sapiens*. There is overwhelming evidence, I think, that we are descended from the apes, not of course that anatomically modern humans actually evolved from the apes, but that we evolved from hominid intermediates who stand in an evolutionary lineage between us and the apes, our actual split from the apes being about 5 million years ago. Those other hominids are now extinct. We share with the apes the same genetic code, virtually the same number of genes and a similar anatomy. Roughly 99% of the DNA sequences of our genes are identical with DNA from chimpanzees. However, humans possess 46 chromosomes compared with an ape's 48, our version of the extra chromosome having been lumped together on Chromosome 2.

Recent findings, many of them genetic, support the idea that we evolved in Africa. Anatomically modern humans first appear in E.Africa after about 200,000 years ago. A single population of modern humans is then thought to have emigrated from Africa to populate the world around 100,000 years ago.

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There have been a large number of descriptions of hominid fossil remains discovered in Africa and elsewhere over the past few decades, and this has allowed a rough series of lineages leading towards modern humans to be constructed, although the details certainly remain controversial. What we have then in this Phylogenetic Tree is a series of Hominid species, classified as species on anatomical grounds, who overlapped in time over a period of several million years, before going extinct, but in many cases it is as yet impossible to say which Hominid species emerged from which - as indicated by the numerous question marks scattered over the Tree. But what we do know is that new fossil specimens are being regularly discovered, and it is likely that the Phylogenetic Tree will considerably improve with the passage of time. Note that *Homo Erectus* spread out of Africa from about two million years ago onwards, and this global spread is represented in Indonesia by Java Man (about 1.8 million years BC), in China by Peking Man and in Europe by Heidelberg Man. The Multiregional Hypothesis has suggested that human evolution then proceeded more or less independently in these various regions of the world, starting with *Homo erectus*, with enough genetic mingling to ensure that *Homo Sapiens* remained a single species. Modern genetics has, however,cast serious doubt on such a hypothesis, and it is currently thought that the contemporary world's anatomically modern human populations all originate with the single migrant population which emerged from Africa, the descendants of *Homo Erectus* having gone extinct at some stage.

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Putting both genetic and fossil data together, a rough map of the progress of this early human migration out of Africa across the world can be constructed - so modern humans reached Australia and W. Asia before they made it into Europe, and then migrated down into the Americas across the Alaska bridge from 35,000 B.C. onwards. In Europe and W.Asia modern humans overlapped with the Neanderthals, but these went extinct about 35,000 years ago. An important paper published in Cell last summer described a comparison between human and Neanderthal DNA, confirming what was already known on anatomical grounds, that Neanderthals evolved in parallel with humans but that humans did not evolve from Neanderthals, and neither is there any evidence for genetic mingling between them. Neanderthals were our first cousins, though rather scary ones.

The analysis of mitochondrial DNA (mit. DNA) as well as nuclear DNA has greatly contributed to our understanding of human evolution. Most DNA inside each cell is found in the nucleus. But out in the cytoplasm are little organelles which act as the power factories for the cell, called mitochondria, and these have their own separate DNA consisting of a mere 16,500 nucleotides. There are two reasons why mitochondrial DNA is so useful for genetic studies. The first is that our mitochondrial DNA is, like Jewishness, inherited from our mothers, since our mitochondria all derive from the cytoplasm of the ovum, and the sperm do not contribute their mitochondria to the fertilised egg. Second, the mutation rate is 10x faster in mitochondrial DNA than in nuclear DNA. so changes in mitochondrial DNA sequences can act as a useful molecular clock to give an estimate of the time which separates different samples.

Amazingly, if you take mitochondrial DNA from two different gorillas sharing the same forest in Africa and compare their sequences, the chances are that the two sequences will be more different than the differences that you would find between mitochondrial DNA sequences between all the human individuals in the world. What does that mean? It means that whereas gorillas have been around in a relatively small geographical area for millions of years, so that their mit. DNA has diverged considerably over this time, human mit. DNA sequences are remarkably homogeneous, and that points to a relatively recent origin in a single human mother of the mitochondrial DNA that is now contained in all the cells of all the humans in the world. It is estimated on genetic grounds that this common female ancestor of modern mit. DNA lived in Africa during the period 120,000-150,000 years ago, the so-called African Eve hypothesis. Note, however, that this model does not imply that this African Eve is the mother of us all, only that she is the originator of our mit. DNA, nor that the date of the origin of our species is the same date as the origin of of our mit. DNA. Our mitochondrial Eve ancestor need not have been the ancestor of any other sequences in our genomes. Nor would she have been the only female human alive at that time - it is just that the descendants of the other females alive then eventually died out, so their mitochondrial DNA is not represented in contemporary human populations.

Similar work has now been carried out on DNA sequences in the Y chromosome, transmitted only via males, and therefore the male equivalent of mit.DNA. All modern Y chromosomes have a single paternal ancestor, although it cannot be predicted a *priori* whether the ancestor was a recent human or an ancient prehuman. Recently a group at Stanford described an ancient mutation in the Y chromosome called M42. In its most ancient form, shared by other primates, this piece of Y chromosome DNA sequence contains an adenine, but today the adenine in M42 is found only in a small percentage of a few African populations. But in the rest of Africa and all the rest of the world's populations this sequence contains a thymine, the result of a mutation. Such data support the idea of the original male source of all the Y chromosomes in the world as having been in Africa. Studies on the Y chromosome are in their infancy compared with the much simpler work of studying mit.DNA, but several Y chromosome studies suggest a common male ancestor for our Y chromosome in the period 188,000-270,000 years ago. Note, however, that it is genetically very unlikely that mitochondrial Eve overlapped in time with the male who gave all today's males their Y chromosomes.

Now how are we to relate such an evolutionary story with the Adam and Eve narrative found in the first few chapters of Genesis? Some Christians maintain that the field of anthropology is changing so rapidly, and that its grand hypotheses, such as the 'Out of Africa' Hypothesis, are so speculative, that we should not even bother to relate the two accounts, but just wait until the dust settles. I have a small amount of sympathy with this view. It is true that the field is moving quite fast at the moment, and the Out of Africa Hypothesis, for example, has only got a grip on the field during the last 10 years. Nevertheless, there is an enormous amount of evidence to support the view that we have evolved from the apes via a succession of hominid species, now extinct, and I think therefore it is important that we generate tentative models to relate the Anthropological Adam of evolutionary biology with the Theological Adam of Genesis. I would like to suggest three models which are consistent to a greater or lesser degree with both the scientific and Biblical accounts. Note that there are many variants on these models, but we only have time to consider them with broad brush-strokes.

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Taking these models in turn - the Retelling Model suggests that the Adam and Eve account refers to the original progenitors of anatomically modern humans in Africa, but the account has been retold within a Near East context to make it accessible and understandable to readers of the time. A scientific problem with this model is that its highly unlikely that the species Homo Sapiens started with a single couple as it is thought that speciation events generally require a small interbreeding population which either suddenly or gradually becomes isolated from its parent population. Biblically also, this Model requires a very loose reading of the text, to put it mildly. The Federal Humanity Model suggests that the Adam and Eve account is a theological essay in which Adam and Eve are portrayed as the representative humans through whose experiences we learn of the Fall from God's grace of the whole human race since its origin. This theological essay is then fused on to the early roots of the Jewish people. It envisages that the Fall was a process rather than a single historical event. I think the Model has a number of attractions, but it will not please those who wish to root Genesis 1-4 more in a specific history and culture. The third Model, which I have nicknamed the Bipartite Model, goes much more in a historical direction, and suggests that the Adam and Eve account is in two parts. The first part (including Gen. ch 1) is a theological essay/saga which places humankind in their overall context within God's plan of creation. The second part recounts the calling of God of a particular couple in the ancient Near East, who disobeyed God (the Fall) but spiritually were the progenitors of all who eventually came into God's Kingdom. The Model, which I myself rather favour, can be illustrated by a further illustration:

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At the left is the theological essay or saga literature of Genesis 1 -2.3 - this tight literary structure which paints the big picture of God's filling of an empty and formless planet with order and beauty by His word of command - at the same time acting as an early Private Eye-like scathing comment on the other creation stories that were circulating at the time. Then on the right you have the more specifically historical material from Genesis 5 onwards, starting with the introductory Toledoth "This is the written account of Adam's

line", whereas at the beginning of Ch. 2 you have the Toledoth "This is the account of the heavens and the earth" - something rather different.. And so in the middle you have these intervening chapters 2-4 which I have pictured as over-lapping fingers, as its here you get the theological essay/saga side linked up with the more historical later account, and there seem to be elements of both mingling. So you've got serpents talking, and God walking in gardens, and flaming swords guarding the Garden, but you've also got farmers and cities and rivers with names and human genealogies and talk of forging of tools out of bronze and iron. And so if you want to root Adam and Eve in the history and culture which the Bible describes then, as I have already mentioned, you would want to describe them as Neolithic farmers in the Near East some time during the millennia from around 8000 BC onwards. Genesis speaks of cities, and of a Cain who was afraid that whoever found him would kill him as he wandered the earth - clearly there were plenty of other people around. And so it may be that God called a specific couple in to fellowship with Himself, already fully Homo Sapiens, but who were not yet spiritually alive. Being Homo Sapiens was necessary but not sufficient for full humanity in the theological sense. This was only made possible by God's gift of spiritual life to Adam and Eve, but they disobeyed Him, with bitter fruits in their lives and ours. Yet this couple did become according to God's plan the spiritual progenitors of the new spiritual family which He had always purposed to bring about, and which culminated in Christ's death for us on the cross, whose genealogy Luke in his Gospel is careful to root in the line leading to Seth, the son of Adam, the son of God.

Its intriguing that the passage in Gen. 1 recounting how 'God created Adam in his own image, in the image of God he created him, male and female he created them', is placed in the context of God's command to humankind to rule over the earth and its wild animals and to take care of it. God empowered humankind with authority to carry out kingly work in being God's earth-keeper. In other ancient Mesopotamian texts only a very rare king or outstanding person is created in the divine image, whereas Genesis recognises the inherent value of every person because of their divine responsibilities. God's image, in this view, is less about the *intrinsic qualities* of humans, than it is about *divinely delegated* responsibilities.

Now I do not for one moment think that <u>any</u> of these models that I have suggested is free of question-marks, and I can think of plenty of problems and questions with all of them myself. I would never hold any one of them more than tentatively, which is a familiar situation for the scientist who knows that new data may be just round the corner which will bring his favourite model crashing to the ground. It is also clearly vital that that Christians attempting to integrate their Biblical understanding of creation with contemporary science do not lose the key elements of humankind in fellowship with God, a fall from grace, and then the great Biblical theme of redemption. But equally we must respond with integrity to scientific data which, after all, come from God's world. Christians have, I think, sometimes over-interpreted Scripture in an attempt to generate convincing apologetic systems in which everything is neat and tidy, but often I wonder whether such systems owe more to works like Milton's Paradise Lost than they do to what Scripture actually says. In the real world things are not always neat and tidy and there are many questions to which we do not have answers.

This brings me, then, to my final question this evening. For Christians who believe in an all-powerful loving God, why on earth would He choose to bring us, and all the rest of biological diversity, into being by such a long and messy process as evolution, during which process an estimated two billion species have become extinct? Obviously I don't have any final answer to that question - we are in the final analysis in the same position as Job - at the end of the day he had to admit that God was God and that he was on the earth as a created being, not the creator, and that he actually didn't know all the answers. That is not a position that modern humans naturally like adopting. But having said that I'd like to close with a few reflections:

First, the kind of carbon-based life that God has brought into being on planet earth depends entirely for its existence on the kind of universe that God has created. Our bodies are made from elements generated in the dying moments of exploding stars. In the standard cosmology it was not until about 10 billion years after the Big Bang that stars began to run out of their nuclear fuels and start exploding - and it was during those explosions that the elements were made, such as carbon, nitrogen, phosphorus and oxygen, which were then scattered into space and of which our own bodies are now composed. Carbon-based life is only possible because the universe is as old as it is. And death is intrinsic to carbon-based life. All biological organisms belong to massive interlocking food-chains in which the chemical energy put into making

complex carbon-based compounds is then passed on to the next organism in the chain. In fact every cell in every individual animal has a biochemical programme which can be switched on to cause the suicide of that cell by the process known as apoptosis. Biologically, life is impossible unless there is also physical death.

Second, biologically speaking life would be impossible without pain. All biological organisms have complex warning signals which communicate both external and internal dangers. Our survival depends on our possession of pain receptors - otherwise they wouldn't be there. Without pain receptors we would be eating with decayed teeth, walking on broken ankles, getting extremely sunburnt and ignoring heart attacks. We may wish that our pain receptors didn't work quite so efficiently, but they do.

Third, for people who think that the process of evolution has been a wasteful process, I'm not really quite sure what they mean. Waste as measured by what? The concept of waste only makes sense when there are limited resources, but the earth's history has been characterised by extraordinary abundance. We deal with the God who scatters stars into space and generates two billion species. God is perhaps much less like the divine designer watch-maker, a picture so loved by the natural theologians of earlier centuries, and much more like the divine artist in his studio generating canvas after canvas of amazing beauty and complexity, scattering lots of paint around as he does so - or like the divine musician creating symphony after symphony, all of them different.

Does evolution have any religious significance? Viewed within the framework of robust theism, then once again let me say that I think the answer must be 'not a lot' - scientifically it provides an explanation, a good explanation I think, for biological diversity - and theologically may simply be viewed as God's way of bringing that biological diversity into being. Ultimately why did God choose to bring us into existence *this particular* way? I don't know - I can only describe what I see and then relate it to what I know from the Bible about the doctrine of creation. Indeed I am as suspicious of natural theologians when they become over-zealous in their attempts to extract theological mileage out of the natural order as I am of the Dawkins of this world who represent their opposing mirror image. But, it is worth noting that evolution provides us with a useful reminder of our own unity with the rest of the created order, of our own frailty and dependence upon God, and of the fact that from dust we have come and to dust we *will* return. It certainly provides us with no scope for an arrogant humanism. Resistance to the acceptance of an evolutionary origin for humanity often comes, I think, from pride. When God created humankind, he did not make super-humans, nor angels, but people made to live in fellowship with Him in a world full of responsibilities, dangers, pain and challenges - in a word, a world in which moral and spiritual growth is possible - a world, in fact, which is a preparation for the new heavens and the new earth which God is preparing. The sting of death, according to the Apostle Paul in 1 Corinthians 15, is not death itself, but sin. But sin has been dealt with by the death of Christ on the cross for us. The gateway to life is not by going back to the first Adam, but by trusting in the person Paul calls the second Adam, Jesus Himself, and then looking forward to God's new creation in which, I would like to think, there will be plenty more research projects to do, but probably not on evolution. And on that note I will close and take questions.

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[N.B. This list is eclectic and makes no claim to be comprehensive]

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