Disputed territory – the theory of evolution

The conflict

In the beginning, God created heaven and earth… This is possibly the most famous opening line of any book: it seems simple, but it presents problems from both a philosophical and a theological point of view. In every day language, the word "creation" usually means the creation of an object from something else, a pot from clay, or a picture from canvas and oils. But theologically, the universe was created from nothing at all: it comes into being simply by the will of God. People visualise this act of creation as a sort of empty fish tank, into which God puts stars and galaxies and populates them with planets and people, but this picture is quite wrong because it makes God occupy the same space as His creation and puts God on a par with it. God creates space and time which puts Him outside both. This means that when you are talking about God, you are talking about something you cannot possibly know about. Common sense will not apply and the only help philosophy can give is to say, 'whereof we cannot speak, thereof we must be silent' – an injunction not often obeyed.

But with this note of caution, people are usually happy with the idea that God created the fundamental properties of space and time and with that, the laws of physics and the resulting behaviour of the universe. It was not always so. In medieval times and earlier, the bible or the church were authoritative not only for spiritual matters but also for the behaviour of the whole of creation. Looking at what was going on in the world and trying to make sense of it on its own terms, independently of other authorities, seemed to be a threat to true religion, particularly to the authorities themselves. This conflict eventually died down as people thought of science as discovering the laws of nature as created by God: it was a motivation for Newton, for example and is expressed in Addison's beautiful hymn *The spacious firmament on high* which ends with a verse describing the movement of the planets:

> What though in solemn silence all
> move round the dark terrestrial ball;
> what though nor real voice nor sound
> amid their radiant orbs be found;
> in reason's ear they all rejoice,
> and utter forth a glorious voice,
> for ever singing as they shine,
> 'The hand that made us is divine.'

Currently, the laws of physics do not trouble the church: people are quite happy to give control of the heavenly bodies to either Newton or Einstein, but when it comes to life, and ourselves as living things, they feel science must give way to religion. So Darwin's theory of evolution is felt as more of a threat to religion than, say, cosmology.

It is interesting that the major conflict with evolution has occurred with Christianity rather than any other religion, although one might suppose any religion with creation stories would be affected. It certainly gave Darwin pause for thought and although he did not become an atheist, he disengaged from the church, leaving religious observance to his wife. Not buying in to religion, but equally, not buying in to atheism, seems to be a prevalent view today. This lack of commitment suits the

modern ethos, but lack of commitment is a recipe for lack of action in a world where there is much needing to be done, so it is important to explore just how much conflict there is and what this has to say about both science and religion.

In some ways it is strange that the publication of *The Origin of Species* caused such controversy. Geologists were already in the process of demonstrating the tremendous age of the earth and the existence of fossils showed that the biblical story of creation was incomplete, to say the least, so there were already plenty of grounds for conflict with a literal interpretation of the bible. But while geology might throw some doubt on the authority of the bible, Darwin seemed to be saying something about the nature of man, and that was much more personal. Since this time, evolution has been used to advance arguments for the disproof of religion, such as Dawkins's demolition job on the argument from design and the argument that survival of the fittest is hardly compatible with a loving God, so the theory of evolution has been seen as antagonistic to religion, rather than independent of it.

In reacting to the theory, some people have tried to adapt the science to the religion, rather than the other way round. A first point of attack was simply to question the theory, pointing to the many areas where there is uncertainty. To these people, called creationists, evolution is incorrect and everything happened as it says in the bible. This is a position which is impossible to maintain with any rational consistency as it involves believing God created fossils looking millions of years old at the moment of creation and so the attack has matured into something called intelligent design, a theory that accepts evolution, and hence a non-literal interpretation of the bible, but that God has guided the process to result in creatures which would not occur naturally, in particular, man.

This is an approach which is not so patently absurd and it is interesting because fundamentally it is about how God interacts with creation, a religious issue. At one extreme the atheists hold that there is no God and no interaction and everything can be understood by man, and at the other are those who see God upholding the world instant by instant. Where does the truth lie? Is this even a meaningful way of looking at it? These questions are very important. It is not just a question of interpreting one small branch of science or the early chapters of Genesis because the repercussions flow into our lives, dominated as they are by science, technology, and the moral dilemmas they entail. Religious people need to understand the science and to appreciate both its power and its limitations. Unlike relativity, the theory of evolution is not hard to understand, but it is both subtle and fascinating. It has interesting things to say about the nature of man, and religion needs to take them into account. So we shall start with a bird's eye view of the theory of evolution itself.

Isn't Nature wonderful?

People these days are surprisingly unconscious of the natural world around them. I have heard a field of buttercups called a field of dandelions and ash trees confused with willows and with the possible exception of robins, birds are just birds. In cities in particular people are very isolated from nature. When I was little, living in a city, I remember that if the boys caught sight of any bird that wasn't a sparrow, it was a cause for exclamation – "Colour bird!" – but it didn't get much further than that. Nowadays we have television and that helps people to become aware of the diversity of nature, but usually in exotic locations. It is quite hard to capture that intense experience of nature which comes from having the keen eye of the naturalist and just

looking around you. The diversity is all around us. Look at the birds, for example. In a medium sized garden, you will be unlucky not to be able to see a dozen different ones and a keen birdwatcher can find a hundred different bird species in a day. Look in the garden and count the different weeds. It is only a very diligent gardener who has less than thirty different ones.

Once you become aware of all this diversity, it is not long before you start asking, 'Why are there so many? Where have they come from?' These questions must have arisen throughout history. They are the kind of innocent questions children and scientists ask and usually the answer is not very forthcoming. In a Christian world, you often answer, 'Because God made them so.' But this response is not meant to answer the scientific question of how creation came about – we have only known that answer in recent years, and then only partially. Instead, it is another way of saying, 'We don't know.' And how many people, throughout history, would have understood the answer or even wanted to know? The creation stories in the bible are a way of packaging our ignorance with moral instructions on how to act in the light of that ignorance. They are concerned with setting man in creation and with the relations between men and women and this is what is needed as guidance for every day living.

But in Darwin's time it began to be clearer that a scientific explanation for the origin of species might be possible. It started with Linnaeus, the Swedish naturalist, whose *Systema Naturae* (first drafted 1735) provided a system for classifying living things by generic and specific names, based on common characteristics. In other words, it recognised that living things could be grouped together in families, the genera, with each genus made up of different sets of similar individuals, the species. This classification is extended to group genera into families and families into orders and so on, to make a classification tree based on the extent to which living things shared *structural* characteristics which were similar. So in this classification, you do not put all the big plants into one family and the little ones into another, but you do gather together all the plants in the daisy family, like daisies, dandelions and thistles which have a common structure for the flowers which are held in a composite head and have parachutes to disperse their seeds. Another example is that the trees do not belong to one family, but are scattered about the genera according to their structural characteristics. Cherries are members of the rose family, while oaks form a family of trees with beeches and chestnuts and the conifers belong to an entirely different class altogether. Classification is based on structure.

Seeing living things grouped in this way is very suggestive of inheritance and leads almost inexorably to the idea that species are sets of individuals having a similar structure because they share a common inheritance. This is one of the reasons why sexual structures are so important in classification. If you want to identify a plant, you look first of all at the flowers, the structure which ensures that the characteristics of one generation are passed on to another.

The classification itself raises some questions. Some genera contain only one species, whereas others contain hundreds. Generally, the smaller the creatures are, the larger the number of genera and species needed to describe them. The order of insects is particularly numerous. As J B S Haldane said, in response to a question about what nature could tell us about God, 'The Creator, if He exists, has a special preference for beetles.'

The other highly significant development taking place in Darwin's time was the discovery of fossils and the development of geology. The fact that creatures as

extraordinary as the dinosaurs existed previously and were now extinct was well known. It was also realised that different fossils occurred in different ages, so the fossils which were present in rock strata could be used to date them. If life was the result of special creation it would need to have been repeated several times to account for what could be found in the rocks around us.

Darwin's theory

In its simplest form, the theory can be stated as follows.

> Species change with time, but only slowly. The species observed today are the result of a process which has been going on for hundreds of millions of years. Change occurs as a result of inheritance, that is, the process by which characteristics are passed from one generation to the next. Characteristics which result in more individuals having those characteristics appearing in succeeding generations will tend to dominate groups of individuals which interbreed and hence will define the species.

The theory of evolution is one of those very simple theories which seem perfectly obvious, once they are stated. When Thomas Huxley read *The Origin of Species*, he famously remarked, 'How extremely stupid not to have thought of that.' And other people had been thinking along these lines, most notably Alfred Russell Wallace, whose essay, sent to Darwin, prompted him to publish his own work. As with any scientific theory, the work lies not so much in the stating of the theory – any fool can invent a theory – but in gathering the evidence in support of it. And reading *The Origin of Species* one realises what an immense amount of knowledge Darwin brought to bear on it.

This evidence was necessary to counter the mindset which regarded the species as fixed, a given fact of the world around us. Instead, Darwin proposed that species are not fixed, but change over time – long periods of time – and what we see around us today is a snapshot of a world which changes, but very slowly. So the first thing to grasp about evolution is that it is a theory of a *process*. The theory is about the forces of change which shape living creatures in the world about us.

The next aspect of the theory which needs to be understood is that it is a theory of populations, not individuals. A species is a set of individuals, sharing common characteristics. The theory needs to explain why such sets exist and how long they are likely to remain the same. Why do all blue tits look the same? Why did the dinosaurs become extinct?

And finally, given that evolution is a process, it is clear that inheritance, that is, the way in which characteristics are passed from one generation to another, must be the mechanism of change. No matter what characteristics individuals exhibit during their lifetime, unless they are passed on to succeeding generations they cannot contribute to the definition of the species. Only inherited characteristics can define a species. Inheritance also sets the rate of change because it defines the quantum of change: the time between generations, which is the minimum time for a new or changed characteristic to manifest itself.

Darwin's argument first of all was to establish the extent of potential variation, based on the observation of variation of animals under domestication. Darwin used the example of pigeons, but for modern people domesticated dogs might be more appropriate. Anyone familiar with a Chihuahua and a Great Dane, could be excused

from thinking they are different species. There is no way these two breeds could interbreed and give viable offspring, but they have both been derived by human selection from the one species. All domesticated plants and animals differ widely from their natural state, which shows how much potential for variation exists.

The counterpart of human selection is natural selection. Some individuals will have characteristics which enable them to exploit the environment better. If this characteristic is passed on to succeeding generations, and as a result, these individuals leave more descendants in succeeding generations than individuals without the characteristics, those characteristics will come to dominate and define the species. The key factor is not with whether the *individual* benefits, but with whether more descendants are left in succeeding generations. Survival of the fittest is the term often used for this process of natural selection, but it should be understood that fitness in this sense simply means leaving more descendants. A very effective predator which causes its prey to decline is not fitter than one which is in equilibrium with its prey population and hence leaves food for future generations.

Fitness can be thought of as having two components: fecundity and survival. You can ensure lots of descendants by producing a lot in the first place, and then ensuring their survival. These two factors conflict, particularly in the early stages of the formation of a new individual. Putting more resources into an egg and into protecting and nurturing the young costs the current generation. Too great a cost will affect their own survival, but the species will tend to evolve until these conflicts balance: the losses in the current generation are more than made up by the gains in future generations. For different species, the balance will be different. Many animals, some fish, and frogs for example, produce eggs in huge quantities to make up for the inevitable losses incurred by not guarding the young. Even within a species, male seed is far less costly to produce than female eggs and so is produced in much greater quantities.

Survival is made up of many different factors. It is necessary for individuals to survive to a reproductive age, so they have to gather food within a complex and variable environment. It is necessary to survive predation from other species and competition both from other species and from other individuals in the same species. Now it is important to realise that survival is one of those words like safety and security which are abstract concepts and describe qualities which cannot be measured. They are words which we use to gather together a number of disparate factors simply by their outcomes. For example, the safety of an airliner depends on factors like the ability of the maintenance staff, the design of the aircraft, the attention of air traffic controllers and the weather, to mention only a few. You can measure things like the fatigue resistance of aircraft spars, but there is nothing measurable that corresponds to safety apart from the actual reliability records of practical aircraft operations. It is possible to make assessments based on experience, but these are inherently unreliable as they are combining incomparable quantities, (such as the probability of the failure of a mechanical component with the probability of air traffic control errors). In addition, these concepts are not even stable: a previously inexperienced factor, such as a terrorist attack, can totally invalidate any prediction of safety.

Survival has an advantage over safety inasmuch as the outcome is measurable: for safety or security one can only measure whether a system has failed or not, whereas it is possible in principle to count the number of descendants. But the prediction of survival based on factors which might affect it is made incredibly complicated by the

interdependence of species. This is obvious in the case of predator - prey relationships. The big cats survive by being fast and strong enough to catch herbivores. The herbivores survive by being even faster and by herding together. The interaction of the species gives rise to their characteristics. Similarly, the herbivores are adapted to eat grass which can survive grazing better than broad-leaved plants and this leads to the formation of grasslands which are dominant features in many lands, and which can support large herds. Thus the survival of one species is determined by the survival of another. In many cases these dependencies are cooperative, rather than competitive. Notable examples of this are found in seed dispersal mechanisms in plants. All plants have mechanisms for dispersing seed, to ensure that offspring do not suffer competition from their parents. One mechanism is illustrated by those trees which provide fruit which is eaten by birds who then disperse the seed. The survival of the birds is linked to the abundance of fruit. The survival of the tree is linked to the ability of the birds to disperse the seeds.

This interdependence means that even if it were possible to model all the factors in survival mathematically, the equations which would be produced would be impossible to solve because they would be *non-linear*. This is the term mathematicians use to describe equations they would rather not deal with. Without going into details, these are some of the reasons why.

1 There are no solutions to non-linear equations, but their behaviour can be simulated by what mathematicians call *iteration*. That is, you start with an initial state and use the equations to decide what the next state will be and then repeat the process. But you cannot work out what it would be for ever, and for any initial state.

2 Starting from two different initial states the subsequent development of the simulations can be quite different, even with very small differences in the initial states.

3 There are no stable states, in the sense that once in that state, one iteration delivers the same state again, but the simulations can result in very similar states for many iterations before diverging again.

The non-linear system most people are familiar with is the weather. One day's weather is never the same as another and there are inherent limitations in forecasting it more than a few days ahead. There are general characteristics of the weather, such as the fact that it is hotter in summer than in winter, but that any individual winter's day can be warmer than one in summer. Comparing this non-linear system with evolution, it is easy to see that evolution is far more complicated, but also far, far slower. The weather can change in half an hour, but a thousand generations will only introduce small changes into a species. Observing species over a few centuries is only taking a snapshot of something which changes in unpredictable ways, but only slowly.

The complexities in the notion of fitness, which lies at the heart of the theory, have given rise to much controversy and criticism of the theory. Most of these centre on the inability to quantify the theory with enough precision to make predictions. However, the concept of fitness is qualitatively understandable and seems more than adequate to explain evolutionary outcomes. In some simplified situations it is possible to do mathematical modelling, whose predictions are borne out by observation. And no one doubts the basis of weather forecasting even though it too deals with unpredictable outcomes. Evolution is a sound theory.

How the theory works

With this background, we can see how the theory of evolution explains the species we see around us, and provides convincing answers for the questions which are naturally raised.

Why species can be grouped into families

This is an immediate outcome of the theory, because changes are inherited. This means the classification of species should follow the inheritance tree, although in practice the simple idea of a tree of evolution is complicated by hybridisation and the construction of the tree is made difficult by lack of evidence. The reconstruction of the tree of evolution for a family will necessarily involve fossil evidence, which is very sparse.

Why there are species at all

Given variation from one generation to the next, why do we see species at all? Why aren't all individuals different with a continuous range of characteristics? Why, in a nutshell, do all blue tits look the same? First of all, a species is made up of interbreeding individuals. Consequently, the characteristics of those individuals will be drawn from a pool of characteristics which is constantly being stirred. This pool represents the response of the species to the environment, but the environment averaged over some considerable number of generations. For example, in a region where a sharp frost occurs very infrequently all the perennial plants which are native must be frost resistant, otherwise, when a frost did occur, they would simply be wiped out. Thus although the environment can fluctuate quite rapidly, because of the averaging over many generations, it is much more stable than at first it might appear and consequently the set of characteristics which define the species and allow it to survive is also stable.

Another factor which leads to stability, particularly in appearance, is sexual selection. When individuals choose mates, successful choices, in the evolutionary sense, will result in more offspring in succeeding generations. But individuals can only make choices based on appearance. So the process of choice determines the next generation quite as much as survival. Because of this, desirable characteristics will also tend to show in the appearance. A failure to produce the characteristic appearance of the species is probably a sign of something going wrong, so individuals avoiding the unusual will usually leave more descendants.

This process of sexual selection is so powerful it can operate even with characteristics which adversely affect the individual's survival. For example, the magpie's long tail is actually an impediment: the birds fly better if their tails are shorter. But a short-tailed bird does not attract mates, and so does not leave descendants. This process can go to extremes as illustrated by the peacock's tail, or the bower bird's behaviour. But in these cases the sexes evolve different characteristics, so that the female peahen for example, is inconspicuous and does not have the ungainly tail but rears the young without the assistance of the male who can safely be expended after mating without affecting the number of descendants.

Appearance is not a direct factor in the reproduction of plants, but sexual selection is still important. Pollen transferred from an individual of one species to an individual of another rarely gives rise to fertile offspring, so this leads to a number of

characteristics which prevent this happening and which will tend to affect the appearance. In particular, those species which are pollinated by insects tend to develop characteristics to ensure they are only pollinated by one type of insect, which increases the chance of breeding within the species, but also accounts for the extraordinary variety of flowers, each peculiar to the species.

Why there are so many species

Survival is about exploiting the environment, but the characteristics needed to exploit one environment, such as the sea to take an extreme case, are quite different from those needed on land. Plants exploit sunlight directly, but to do so they have to be immobile and sit in the sun. Animals feed on plants and so can move about. Having leaves with chlorophyll instead of fur would be no advantage to an animal as it would have to sacrifice the benefit of movement to make use of them. There are many different ways of making a living in the world and those individuals which are more efficient at doing so will tend to leave more descendants. Evolution results in specialisation and specialisation results in differentiation. Thus there will be as many species in the world as there are specialised ways of surviving. These are called ecological niches and their number increases as the complexity of the interaction between species also increases.

This is the main factor controlling the increase in the number of species, but the total number of species is still greater than the number of ecological niches. For example, we have great tits and blue tits exploiting the world in very similar ways. Why are there two insect eating birds with very similar behaviour? There are two species of bittercress, the little garden weed which if it seeds will distribute them with a pop of its pods as you disturb it. The wavy bittercress is not *very* wavy and the hairy bittercress is not *very* hairy, but one has six stamens, the other four and the wavy bittercress is longer lived. They are not very different, but both are happy to live in gardens.

These slight differences can also be explained by evolution. A species is a set of interbreeding individuals, but if one set of individuals is isolated from another so that they do not interbreed, they will evolve in slightly different ways because of the non-linearity of the process. From slightly different starting points, evolution will lead to different solutions to exploiting the same ecological niche. Isolation can happen as a result of geographical separation which is the reason why island flora and fauna tend to be different from those on the nearest continent. It is also the reason why there are so many more insect species than other animals, because they are smaller and consequently isolation is more likely to happen to them. But isolation can also happen as a result of incompatibilities in breeding, which may simply be a question of behaviour. For example, if a species of plant splits into two populations flowering at different times, they will tend to diverge into two different species.

Evolution works!

The theory of evolution gives a convincing explanation of the problem it was intended to solve, which, in a nutshell, is, if species are not immutable, then how do they change? In a way, the answer is perfectly obvious, they change to adapt to their environment, including other creatures, but Darwin's contribution was in answering the objections to the theory and in presenting the evidence for the theory which would be hard to explain otherwise. In addition to this, it gives insight into why creatures

are the way they are, in particular, how they work within the environment. Like all good theories it gives a fruitful way of looking at things.

But it has its drawbacks, the most prominent of which is that it has almost no predictive power. This is largely because it is not possible to construct mathematical models of how evolution works which are at all realistic and even if it were it would be impossible to solve the equations. It is only possible to give explanations of how existing species are adapted to the environment, and even in this case there can be no hard and fast solution. For any given characteristic, there are usually two or three explanations possible as to how the characteristic is adaptive and it must be said that in the hands of some people, evolutionary explanations have about as much credibility as a *Just so* story. As with all scientific theories, it is important not to go beyond what the theory actually says.

The problems with intelligent design

The fundamental problem with Intelligent Design is that it seems unnecessary: the theory of evolution is perfectly adequate for explaining the state of affairs in the world around us, so why complicate issues? From a scientific point of view, there has to be some fact which the theory of evolution cannot explain and it is difficult to think how intelligent design might actually manifest itself. The usual argument is what is called irreducible complexity: some organism must be shown to exist with characteristics impossible to explain on the theory of evolution, for example, two organs which only confer a benefit when they work together. This is essentially William Paley's argument from design, described in a book, *View of the Evidences of Christianity*, published in 1794. This work was extremely popular, and went through several editions, but it is mainly remembered now for its argument for the existence of God, based on the complexity of living things. The particular example chosen was the eye. This marvellous organ, with its focussing lens, iris diaphragm and photo-sensitive retina is a perfect analogy of a modern camera. How could this complexity arrive, without it being designed? And if designed, there must be a designer. Richard Dawkins, in his book, *The Blind Watchmaker*, used the theory of evolution to provide a counter to this, essentially arguing that the theory provided a perfectly capable mechanism for creating the marvellous complexity of living things, without the need to invoke God at all. For the eye in particular, it is possible to exhibit creatures with all stages in the development of an eye, from light sensitive spots to a fully functional focussing lens. And there is no other example of a characteristic for which a scientific explanation using the theory of evolution cannot be given.

Another problem with Intelligent Design comes from the science of cladistics, concerned with the classification of species according to their characteristics. Applied to living creatures this generates the tree of inheritance. It can also be applied to man-made things, which actually are designed and the trees which emerge are quite different. Think of the development of the motor car: some early cars had tiller steering and three wheels; the arrangement of the controls varied and each car had its own peculiar engine. Modern cars have a range of engines for the same bodywork and a standardised layout of the major controls. These features arrived in a haphazard fashion as designers borrowed ideas from one another and the resulting cladistics tree is full of missing links and looks entirely unlike those produced for living creatures.

A further problem for Intelligent Design is the existence of non-functional organs. Some cave dwelling animals, adapting to the lack of light, nevertheless have eyes

which never open. Man has an appendix, which serves no function and is a cause of illness, but has been acquired from an ancestor. And even those organs which do work are often not perfectly adapted to their function. Adaptations in nature are wonderful and the human eye is a fine example, but there is a high probability you are reading this with the aid of spectacles, a lower probability that your back is aching and ask your mother about childbirth. My female friends tell me that is one point they intend to take up with God when they get to heaven. Nature is wonderful, but it is far from perfect.

And why did God design the tapeworm and the malaria parasite and all the other things that trouble the pinnacle of creation. Did God think, 'This will be good to smite them with'? And why *did* God design so many beetles? And why was God content with the dinosaurs for so many years and create man at the last instant?

Intelligent Design raises far more questions than it answers and indeed it does not seem to answer any at all. It is not a theory but a hypothesis without supporting evidence. But if it is bad science, it is also bad theology. The problem with Intelligent Design is that it has presuppositions about how God has created the world, but will not adjust these presuppositions in the light of reality. We all have theories about the world, scientists more than most, but the reason science makes progress is that the theories are tested against reality. Not doing this is equivalent to breaking the second commandment. And it is so misleading, as our ideas of God are so much less than reality. On the roof of the Sistine chapel Michelangelo depicted the creation, including that most iconic image of the creation of man and that image of God as an old man on a cloud has bedevilled Christianity ever since. Far better to be like the Muslims and allow no depiction of the deity. It is terribly misleading: take a look at one of the other panels in the chapel roof and you will see God creating the plants, with a fetching view of his rear as he bends down with a screwdriver to fix up the daisies. This is not what religion is about.

The hostility that scientists feel towards Intelligent Design arises because it strikes at the foundations of science. Scientific theories are based on experiment: the only authority is what you can test against reality, not some preconception. This is important from a theological point of view too. It is so easy to import into our thinking our own ideas of God, rather than the reality of what God does and has done. If you want to see the work of creation accurately, you need to empty your mind of what preconceptions you have about what you will find there. Reality always contains surprises and it is the surprises that tell us about God.

If Intelligent Design is a case of religion straying into science, what can we do about science straying into religion? Does science disprove religion? What does the theory of evolution say about the nature of man? What do we mean when we say God created the world? How is natural selection compatible with a loving God? What part does chance play in our nature? These questions naturally raise themselves and they need to be understood, if not answered. These issues will be discussed in turn, but starting with the most important, what does evolution say about the nature of man.

What does it mean to be human?

The theory of evolution tells us why species differ from each other. Consequently it tells us why humans differ from the other great apes. Consequently it tells us why we are what we are. We are no more than a hairless ape with a gene for language.

Is this chain of reasoning true? To the Victorians, the fact that there might be some continuity between man and other animals was shocking. But the bible is quite clear that man is part of creation. There are two creation stories in Genesis: the first one describes the creation of man as follows:

> Then God said, 'Let us make man in our image and likeness to rule the fish in the sea, the birds of heaven, the cattle, all wild animals on earth, and all reptiles that crawl upon the earth.' So God created man in his own image; male and female he created them. *Genesis 1.26f*

The second story is like this:

> The Lord God formed a man from the dust of the ground and breathed into his nostrils the breath of life. Thus the man became a living creature
>
> *Genesis 2.7f*

This second story makes no bones about the earthy nature of man, echoed in the funeral sentences we use today: 'Earth to earth, ashes to ashes, dust to dust.' This is surely not incompatible with evolution from animals. The first story is about the dominion of man, which some deplore, but is no more than a fact of life, the consequences of which we should surely take on board.

But there is no doubt that the bible does teach that man is special in all creation. Another famous bible quote comes from the Psalms:

> When I look up at thy heavens, the work of thy fingers
> the moon and the stars set in their place by thee,
> what is man that thou shouldst remember him,
> mortal man that thou shouldst care for him?
> Yet thou hast made him little less than a god,
> crowning him with glory and honour.
>
> *Psalm 8.3ff*

Man is different from other creatures: there are not many apes who have done things like proving Gödel's incompleteness theorem, or developing a theory of evolution or doing any of the myriad other things which make man special. But the question is, what does evolution have to say about human characteristics; and what is the importance of what it says.

Most people would be quite happy with whatever evolution has to say about our physical characteristics. After all, chemists can show that we have a lot in common with a barrel of Mulligatawny soup, but this fact is not particularly disturbing. What then, is the significance of the fact that geneticists tell us we share 97% of the chimpanzee's genes? Perhaps this only goes to show how unimportant genes are?

The fact that our bodies have a lot in common with those of chimpanzees is important for medicine, but physical characteristics generally do not impinge on everyday life. However, behaviour does and it is the modern focus on evolutionary aspects of behaviour which has sharpened the conflict in recent years. Now it may be surprising to some that behaviour has adaptive aspects which bring it within the scope of the theory of evolution. But in social animals like man, co-operation is essential for survival and the rearing of offspring obviously has behavioural aspects. The definition of a species invokes behaviour as well as physical structure.

An interesting example of human behaviour being susceptible to evolutionary explanations is that men and women behave differently. *Vive la difference!* But

why? To take an example, men take more risks than women. In Spain, there is a tradition of bull running, when bulls are let loose in the streets (the pavements are fenced off) and young men run in front of the bulls, escaping over the barriers when the bulls get too close. Why do they do it? Here is an evolutionary explanation. Young women choose mates. A young man who demonstrates he can take risks and survive is likely to be a better bet in a risky world than weeds like me who wouldn't dream of doing such a thing. After all, males are more expendable than females, so it is natural that they should do the riskier things.

Now this explanation may be convincing, but it should be realised that it is completely untestable. You cannot run controlled experiments in human behaviour. Looking at the statistics for descendants of people who did bull running is not likely to be informative. How do you choose a control group to compare? How do you measure the amount of bull running and how do you control for other risky activities. So this explanation is as likely to be right as it is to be wrong, and it does not seem that any significance should be placed on it at all.

Other aspects of human behaviour are very strongly influenced by culture. It is true that it is possible to think of culture along evolutionary lines. By definition culture deals with groups and populations, and culture is imbibed by a variety of methods which have some resemblance to inheritance. But cultural groups and cultural mechanisms of transfer are very, very imprecisely defined and vary from characteristic to characteristic. People pick up different traits from different social groups and by means which vary from family contact to television. If it is hard to make testable statements about the physical characteristics of species, it is much harder to make testable statements about human behaviour.

People use the theory of evolution to give an air of scientific respectability to their opinions and wishful thinking. If you cannot test something, you are not doing science and you should cross out statements like 'the theory of evolution shows us …' and replace them with 'I think that …'

Another fact that people lose sight of, is that the theory of evolution is about populations, not individuals. No one makes life-choices based on the number of their descendants. You cannot say of any individual behaviour whether it is adaptive or not, except as it affects others and descendant populations. And when you have made such an analysis, have you said any more than that good ideas tend to spread? No one makes choices based on the number of their descendants. Religion, on the other hand, is about individuals and in particular is concerned with questions about what way of life to lead. Evolution may have something to say about the consequences of large numbers of individuals following a given way of life but it would be wrong to say that evolution had caused these choices as there are far too many other factors at work. Evolution can say why big fierce animals are rare, or why very virulent viruses change to less virulent forms, but as far as this argument about human nature is concerned, it usually has very little of significance to say. There are three possibilities.

1. There are behaviours for which evolution provides an explanation, but the behaviour has no religious significance. An example is sleep, for which we have limited functional and evolutionary explanations, but when complete explanations become generally accepted, they are unlikely to conflict with any religious point of view.

2. There are aspects of behaviour which are adaptive, but which also need to be looked at from a religious point of view: examples are altruistic and racist behaviours. In the Christian religion, altruism is good, but racism is bad, but one can give evolutionary explanations for both. The *critical* issue is not so much whether the explanation is correct or not, but what you deduce from it. If you have a behaviour which is adaptive that does not, from a religious point of view, provide a compelling reason for either rejecting or following it. The theory of evolution does not compel behaviour, which instead is determined by individual choices. The theory of evolution is only concerned with the consequences of those choices when pursued over many generations.

3. And finally, there are qualities for which adaptive explanations are irrelevant.

From the point of view of the conflict between science and religion, case 2 is the most interesting, but it is worth pointing out that case 3 includes qualities like art, literature, science, politics and religion, which, adaptive or not, gain little or nothing from an evolutionary understanding. Andrew Marr, in a recent BBC television programme on who was the greatest Briton, made the case for Darwin on the basis that Darwin told us what it meant to be human. For myself, I would not have thought that being human was mainly concerned with the number of my descendants.

Chance and necessity

There is a well known fallacy which regards evolution as progressing to a goal. There is a picture of a sequence of ape-men, initially on all fours but progressively becoming more erect and culminating in modern man, busily buying consumer goods. The picture is absolutely iconic and crops up in all sorts of contexts. I think this is because it gives the comforting message that man is the culmination of evolution and that is what it is all about. In fact, the theory of evolution says nothing of the sort. For one thing, modern man has only been in existence for the merest wink of an eye compared with the length of time life has existed on earth. The age of the dinosaurs lasted hundreds of millions of years: modern man has existed for a few hundred thousand years. It is thought that the dinosaurs became extinct as a result of an asteroid impact and that this chance event allowed the development of mammals, including man. Did God get fed up with the dinosaurs and toss an asteroid at the earth to liven things up? Or are we the product of chance rather than the creation of God?

Eolution is not entirely random and one can argue for a certain amount of determination in its outcomes. One of the things which puzzles scientists these days is that the universe is peculiarly fitted to life. The fundamental properties of carbon, hydrogen, oxygen and nitrogen, seem peculiarly fitted to make them the building blocks of life. The fundamental constants governing the nature of matter are just such as to make it possible to build life. There are so many of these peculiarities in the physical laws governing the universe that some scientists are taking the view that the universe is adapted to life, and not the other way round.

Many scientists find this an unpleasant conclusion. So much so, that they have proposed the 'many worlds hypothesis,' simply to avoid the conclusion that our present universe is in any way special. This overcomes the problem by supposing there are many universes with all possible values for the parameters which control the structure of each one. Inevitably, we only live in the one which supports life. This avoids the possibility of believing in God at the expense of believing in these many

universes, which have no possible effect on our own. This seems to be a rather greater step of faith than believing in God.

Whether one accepts this or not, it remains the case that the random process of evolution is operating within the constraints of the nature of matter. Without carbon, there would be no life at all. Its properties, and the endless chemistry of carbon compounds which result, are necessary to the complexity of life. Given these properties, then evolution will deliver the goods. Dawkins quotes the physical chemist Peter Atkins, in his book, *The Creation*, as follows:

> A great deal of the universe does not need any explanation. Elephants, for example. Once molecules have learnt to compete and create other molecules in their own image, elephants, and things resembling elephants, will in due course be found roaming through the countryside.

It is rather engaging to hear scientists, no doubt tongue in cheek, cheerfully belittling each other's specialities. One could equally add that Chemistry needs no explanation either: once you know the laws of atomic physics you have all you need to know. But the point is being made, nevertheless: evolution works within constraints which governs what it produces.

Evolution is often described as a random process, but because it is a theory of populations, not individuals, it is less random than might appear. The fact that one animal falls over a stone and breaks a leg can be regarded as a chance event: but if this happens to a large proportion of the population, then there is a basic fault which will get eliminated. Is evolution like quantum mechanics, where the behaviour of particles is random, but the behaviour of ensembles of particles is perfectly predictable?

There seem to be two views on this. Randomness and unpredictability are emphasised in Stephen Jay Gould's book, *Wonderful Life*, which describes the re-interpretation of the fossils of the Burgess shale as the radiation of life forms which emerged in the Cambrian era. Out of this remarkable diversity, a relatively small number of forms survived to give the species we see today. In other words, we might have had five eyes and tentacles and the fact that we only have two eyes and legs was determined by the chance survival of our ancestors.

Convergence on the other hand can be seen all around us. Fish from widely differing genera have similar shapes; many plant families give rise to trees; the response to dry and arid conditions leads to very similar plants like the cacti and the succulent euphorbias. Biologically, it is possible, and even necessary, to take up both positions: sometimes environmental factors will dominate, at others it is a simple question of chance. However, people have used these two extremes to question the existence of God. 'Evolution is determined, therefore God can't have a hand in it.' 'Evolution is random, therefore God can't have a hand in it.'

The deterministic argument against religious belief is an example of the "we are nothing but our genes / chemistry / environment" fallacy. Just because we have two descriptions of reality does not mean that one must be wrong any more than we think that physics disproves chemistry. The possibility that conscious human beings are an almost inevitable outcome of evolution does not mean that God did not make it so. But it does make an obligation on those who do invoke God in this way to say precisely what is being added by that statement. For this it is important to re-emphasise that the theory of evolution states nothing more than individuals having an

adaptive characteristic will tend to leave more descendants than those lacking it. What do we do with that knowledge? Altruism is adaptive, but what do I care about my descendants if altruism is costly for me? Should we intervene to allow infertile couples to have children when this means some non-adaptive characteristics will persist? The theory of evolution does not answer these questions, but religion does. Different religions answer the question in different ways but evolution can only give tentative explanations of the impact of such decisions on future generations, which may, or may not, help the individuals making these decisions today.

Let us now refine the random argument: religious belief is all about giving a point to life and, by extension, a point to humanity. But if our present state is a matter of chance, or at any rate of unrelated events without any apparent plan to them, how can there be any point?

But the chance events in evolution do not seem to have theological significance. The fact that many body plans were eliminated after the Cambrian explosion may not be significant: would our religious beliefs be affected if we had five eyes and tentacles? It seems possible that complex organisms, requiring consciousness as a characteristic, are an inevitable consequence of evolution. Dinosaurs did not attain that level. They do not talk about God, any more than they talk about science. Without consciousness, there is no need for God, any more than there is for science. But it seems likely that sooner or later conscious beings would arise for whom questions of value and purpose would be important, which would lead to the need for religion and some idea of God. Chance events do not nullify eternal purposes.

So where are we? First of all, it is worth re-iterating that regardless of the degree to which chance enters into the outcome, the theory of evolution is a perfectly adequate explanation for the characteristics of living creatures, given the basic laws of nature. Consequently, the argument from design constitutes no *proof* for the existence of God. Basically, Dawkins is right and Paley is wrong. However, the fact that this argument for the existence of God is not valid does not mean that this is a proof of the non-existence of God either.

If you wish to invoke God in a way which is compatible with the science you must either say that God acts imperceptibly through what appear to be random events or that God created the laws of nature and then left the universe to run itself. Both of these present theological problems. The idea that God occasionally takes out a screwdriver to change things is unacceptable. (For if he can do that, why did he allow the holocaust to happen, etc, etc.) And do we really want to confine the action of God to chance events? Do we really want to say that God sent the asteroid to kill off the dinosaurs? On the other hand, a God whose sole interaction with the world is at creation does not square with religious experience.

It seems to me that the problem with these positions arises from our attempts to understand the nature of God, something which is beyond our capabilities. Whether we are determined by the process of evolution, or are merely the product of chance, I would regard as irrelevant speculation. The tree of evolution could take many forms, but we are here, at the end of one twig of it. The path from the base of the tree to any of its leaves is a progression, and if that progression results in a conscious organism capable of asking the question, why, which is the basis of all religion, that question will be asked. Without conscious organisms, God might exist, but religion would not. I would say that the rise of such conscious organisms is a purpose of God. But that is

a statement which, if meaningful, is likely to be incomprehensible. How can the creature comprehend the purpose of creation?

If one were to hold that this statement is meaningless, that there is no purpose in the universe, there is an immediate consequence that there are no values. If my existence is simply a chance matter with no purpose or meaning what guide for life can there be but what makes me happy? One of course will be aware of others because cooperation could be in my immediate interests, but one could not condemn Hitler, Stalin or the Mafia because there are no meaningful values by which to do so.

As I understand the humanist position, it is that the values themselves are in some way transcendent and that we should follow them even at some cost to themselves. This makes the values themselves into a god, a position not too far removed from religions which look at God as a source of all values. We can both be agreed on the need to get rid of the old man on a cloud, even if it means demolishing the Sistine Chapel to do so. But one needs to go beyond this to say something about God beyond a set of values. Otherwise, humanism simply degenerates into, 'Do this because I say so.'

As a guide for life then, religion in this particular area should say something about our attitude to creation. We invoke the idea of God to say that the universe has a meaning although we may not know what it is. Rather than thinking about how God acts in creation we should think about our response to it and for this the scientific description is essential. We would not know half the wonder of nature if our attitude was simply that creation was like that because God made it so. The creation stories tell us our response to creation should be an attitude of respect and wonder and a realisation of our duty of care, but without elevating nature itself into some form of deity. Anything outside this is venturing not into the unknown, but the unknowable.

Nature red in tooth and claw

David Attenborough's very popular wild life programmes used to be broadcast on BBC TV at around dinner time, but I think they were eventually moved from this slot because people got put off their television suppers by watching animals eating each other. Unfortunately, when animals are not mating or eating each other, they tend to be asleep, which does not make good television. Particularly repellent are those parasitic wasps which paralyse caterpillars, lay eggs in them and then leave the grubs to eat the caterpillar alive. How can this be an aspect of a God-given creation?

The problem was stated most eloquently in William Blake's poem, *The tiger:*

> Tiger! Tiger! burning bright
> In the forests of the night
> What immortal hand or eye
> Could frame thy fearful symmetry.
> . . .
> Did he who made the Lamb make thee?

Have a good look at a picture of a tiger. This is an animal which has nothing to do with A A Milne's Tigger: it is a highly refined killing machine.

Let us note first of all, that this is a problem for Christianity with a particular idea of a God of love, rather than those religions which do reflect the violence in nature. So we are interested in justifying a particular theological position, rather than religions in

general. The first step is to take a lesson from science. It is very easy to wish on to animals the feelings and sensations we experience as humans and one of the first lessons you learn in biology is not to endow the living world with human emotions. Moral considerations which apply to humans are inapplicable to other living things. We do not blame the tiger for eating the deer.

Generally, it seems that people are quite happy with the idea of animals eating plants. So why then should it be a problem if wasps eat caterpillars? Most people would say that it depends on whether the caterpillar is conscious or not, so the problem only seems to be a problem insofar as one endows living things with consciousness, and with consciousness of the same degree and nature as we experience. This is obviously a difficult question, but one would be unlikely to endow anything but a small proportion of living things with anything like human consciousness.

Another qualifying factor is the extent of this harmful competition. After all, cooperation between species, as opposed to competition, is common too and competition is often moderated by characteristics such as the defence of territories. So the problem is not as great as it is sometimes made out to be, but nevertheless it remains a problem: male robins incur a 10% mortality in defending their territories and that naturally leads to the question, what is the point of it?

The point is of course, natural selection, which in the theory of evolution is the engine of change. To make the point, consider primitive man. We often use the expression, man the hunter as though that were a natural description. In fact, an animal not fleet of foot, not particularly agile and not provided with armour or natural weapons is more likely to be hunted than to hunt. One can make a strong case that man's superior intelligence developed as a response to being hunted and as a by-product enabled him to become a predator too. Competition is what has given rise to higher organisms. Without it, the earth would be covered in a green slime happily exploiting the sun's rays. This is the way species are made, and it is a very effective mechanism.

Could creation be done in any other way? What an impossible question to answer! The religious point of view is to accept it as the work of God and to act in that light, based on faith in the nature of God. The Christian view is actually quite interesting. In Christian religious language, creation, like man, is fallen and needs redemption. This idea of redemption is the central feature of the Christian view of the nature of God. God is not an arbitrary and capricious deity, but is involved in creation and acts to change things for the better. Creation needs change, and our role in this is to act as an agent of change, but completing the work of creation, as a work of God. This is not a prescriptive programme so much as a set of attitudes which should inform our actions as agents of the change.

And with this in mind, we can ask how we would like creation to be, given that we can refashion it. If you are not happy with the way God has made creation, how would you change it? And there are not many people who would say the tiger should be driven to extinction. This issue is extraordinarily important at this time when human activities are driving untold numbers of species to extinction. From an evolutionary point of view, a species so dominant as man is bound to increase until it hits some environmental limit. This has happened several times in the past, but the adaptability of man has always provided ways to transcend the limits. It seems unlikely that this will always be the case and likely that we are at the limit now. It will surely not be the case that the world in a thousand years will be very like the present.

There are at least four different reactions to this state of affairs, corresponding to what I would say are different religious attitudes.

1. Evolution is our god: there is nothing you can do to stop evolution, so why worry about the future? A belief in doing nothing is always attractive, so this is quite popular.
2. Humanity is our god: we should only preserve species which are useful, or potentially useful to us. The problem with this approach is that it is difficult to see what is useful in the long term. In practice decisions are made by people in power on the basis of what is useful to them, so we end up serving not humanity, but the great god, profit.
3. In complete contrast are those who make nature their god: nothing is to be changed without propitiation of some deity and we must revert to our "natural" state. I think this attitude is only attractive as a reaction to the previous two. People are concerned for the future, but would like to do something about it, not motivated by self interest.
4. The Christian point of view is that creation is clay, given us by God, from which to form the future. We are part of this clay and it is not to be used for base vessels, but because it is God given, must be used to shape a thing of beauty.

To answer the implicit question from the heading of this section, if you have a problem with creation, God has given you the power to do something about it.

Is religion a disease?

Which came first, the chicken or the egg? Evolution answers this old conundrum by saying that what came first was a replication mechanism, eventually becoming the system of genes and DNA which lies at the heart of the theory. This very complex system of genes is expressed in individuals whose interaction with each other and the environment can be looked at from many different points of view. Geneticists focus on the genes: for them, the chicken is the way the egg makes another egg. Biochemists focus on the expression of the genes while ecologists look at the interaction of the species. From the geneticists point of view, individuals are out of focus: it is the gene complexes which spread in the pool of genes represented by the species. But from an individual's point of view there is a clear difference between those genes which are inherited from parents and those which are caught by infection, the viruses. The genes inherited from our parents are not unmixed blessings, but virus genes are hardly beneficial and we try and eliminate them. Now religions are caught: we are not born Anglicans or Buddhists. Should we regard them as viruses and try and eliminate them too?

The first thing to say is that religions are not genes like viruses, but aspects of culture. If one is thinking of applying evolutionary ideas to the process of cultural change one ought to be precise about the units and mechanism of inheritance and the selection principle corresponding to survival of the fittest. And one can only do this in an excessively woolly way. Equating religion with an infection is not science, but opinionated waffle.

Nevertheless, it has to be said that the evolutionary ideas are suggestive and perhaps it is worth looking at religions from the point of view of whether they benefit their

adherents or whether the beliefs of the religion are there simply to propagate the religion. On the understanding that what I am about to say is indeed opinionated waffle, one can argue for several aspects of religion being adaptive.

The first is that religions provide a focus of identity. Tribal gods are there to reinforce the notion of a tribe, which is certainly adaptive as humans can only survive by cooperation. Tribes lead to warfare and this too can be adaptive in the same way that the maintenance of territories is adaptive: aggressive species are successful. Religion also acts as a store of information. Medicine men must surely sometimes do good and if the medicinal properties of plants are remembered in terms of spirits, that can be adaptive too. Religion can also reinforce the rule of law, which is almost always beneficial.

It is in the nature of evolutionary theory that it is very easy to find arguments for the adaptive nature of a characteristic, but rather hard to verify them. Equally, it is possible to point out the non-adaptive features. It is certainly arguable that some religions are like viruses. It is difficult to believe that the violent Aztec religion, involving frequent human sacrifice maintained by a reign of terror, could be in the interests of the population at large, although like all persistent viruses it was not so virulent as to drive the host population to extinction. The ancient Egyptian religious beliefs, requiring the construction of the pyramids and temples, must have placed enormous burdens on the population at large. The situation is complicated and it is hard to know whether the benefits of maintaining a productive society were greater than the burdens placed on the people, but one cannot help but feel that these burdens must have been excessive.

From an evolutionary point of view therefore, one can ask if a religion is more concerned with propagating itself than with the good of the people. To be adaptive, a religion must have some mechanism of propagating itself, often a priesthood. The key issue seems to be whether the priesthood has power over people or not. If the priesthood has power, the religion will tend to evolve to maintain itself. If not, it can only survive by benefiting the people. This gives a very good argument for separating church and state. Once a religion has power over individuals it will tend to evolve as a virus, rather than a cooperative gene.

So some religions, or more likely, some aspects of some religions, could simply be there to propagate the religion. They are not adaptive except insofar as the religion itself confers benefits. For example, church buildings are not adaptive in themselves – quite the reverse, they are a burden to support. But they are adaptive if they support the propagation of a religion which is adaptive.

Practically, this look at the transmission of religion from an evolutionary point of view does not seem to be very illuminating because evolutionary explanations are so difficult to verify and make predictions, in this case, of no great significance. We can all recognise when someone has an axe to grind, and evolution does not tell us much more than this.

Darwinism and the significance of evolution

Darwinism is word which is in the vogue these days and I must say, it is a word which, as a scientist, I find distasteful. An '-ism' is not attached to any other scientist's name, unless you count Marx as a scientist. *The Oxford Dictionary of Philosophy* defines it as a belief in the theory of evolution, but usage seems to make it

mean more than this. We do not have Einsteinism for believers in relativity or Heisenbergism for believers in uncertainty. We do have Freudian for followers of that pseudo-science, but the theory of evolution is good science, not speculation. In practice, the '-ism' seems to mean taking the idea of evolution and using it outside its domain of applicability, and as such is bad science. The theory of evolution does not allow you to say anything apart from the fact that the characteristics of a *species* are probably adaptive. That is, individuals having these characteristics will, on average, probably leave more descendants than those not having the characteristics to the same degree. Anything else is outside the bounds of the theory.

Somehow, the theory of evolution is very prone to being hijacked. Even in the 19th century, the philosopher Herbert Spencer attempted to build a philosophy on it as a basis, including an evolutionary ethics. Systems of this nature tend to view evolution as a progression, with some cherished notion such as Western Democracy, or the free market economy as its culmination. Progression, in some sense, is a characteristic of evolution: it is not reversible. Polar Bears are not going to evolve into amoebas, so there are always characteristics which progress. But evolutionary progression could result in the *loss* of facilities, just as much as the gain: think of blind moles, or the slow worm, a legless lizard. The mistake is in attributing a value to a particular progression. And it is a mistake because the theory of evolution is value free: it is outside its scope.

If you do want to draw conclusions from evolution in the domain of human behaviour, then one of the things you should deduce is the variety of different ways a species can fit into an evolutionary niche. Just a slight acquaintance with the different societies in the world should be enough to convince anyone that there are any number of ways of being human. They are not inevitable and one can make choices which are not the inevitable outcome of evolutionary theory.

The theory of evolution lends itself to metaphor. One sees ideas and behaviours spreading: they are sometimes taught and sometimes just imitated and it is tempting to make an analogy of the dynamics of this process with evolution. But the mechanism of inheritance in human behaviour is not stable: it varies from individual to individual quite as much as from generation to generation. It is hard to draw any valid conclusions in such a case and the analogy is simply not helpful. To take an example: does evolution have anything to say about the desirability or the truth of science, a set of ideas which is certainly spreading? If not, why should we think it has something to say about religion?

This is not to say that the analogy is never helpful. An example is in Jared Diamond's book, *Guns, Germs and Steel* which looks at historical development from a biological and evolutionary perspective. Development, and the spread of conquest, can be looked at from the point of view of the spread of technology, the resistance of populations to infectious diseases and the quality of the resources available to them. This pattern of thinking is illuminating, but it does not negate other more traditional approaches to history in terms of politics, economics and sociology. It is just a different take on a very complicated subject.

One can summarise on the significance of evolution by noting that the applications people make of the theory, particularly in the field of human behaviour, are frequently unquantifiable, frequently subjective and frequently not testable. Applications are frequently outside the domain of application of the theory and contain statements of value, such as whether a behaviour is good or bad, not with whether it is adaptive or

not. If you remove these misuses, evolution can be helpful and illuminating – particularly to biologists. But it remains the case that religion is about attitudes and values. The theory of evolution is about the dynamics of animal and plant populations. They should not be confused.