

The Evidence for Evolution

1. What do we mean by “Evolution”?

Evolution remains controversial to many, and in particular to some who find that the concept of Evolution challenges their deeply held religious beliefs, and particularly the notion that Humans and human consciousness are in some way a special creation of a divine creative force.

Those who seek to challenge Evolution often refer to the subject as “The Theory of Evolution” and, since a “Theory” is by definition “an idea or explanation which has not yet been proved, a conjecture”¹ they seek to suggest that there may be other explanations which have equal validity, and which might involve Intelligent Design or Special Creation.

However, the use of the term “The Theory of Evolution” is disingenuous. There are three separate meanings and contexts for the term, and they have different status and support.

a. The Fact of Evolution

The first meaning is the general idea that organisms have changed over time. If we had a time machine, and could go back 10, 50 or 100 million years, would we find the same species of organisms present on the earth as we do now? The answer is clearly “NO” – all the available evidence points to the fact that the flora and fauna of the earth have changed over time. No-one seriously doubts this, and this meaning of the term Evolution is as well supported as the facts that gravity exists or the world is approximately spherical.

An equally well supported fact is that the world is old – probably around 4.5 billion years old. If the world were really only a few thousand years old, as attested by “Young Earth Creationists”, then clearly there would not be time for Evolution to have produced the diversity of life on the planet. But all the evidence from cosmology to geology supports an old age for the solar system and this planet.

b. The Pattern of Evolution

Given that organisms have changed, there must be true history of which organisms have changed into which, and when. Discovering this true history is the subject of continuing study, and individual histories proposed by scientists are genuinely “theories” in the meaning given above. Over the past 50 years there have been many theories about the correct evolutionary history of humans, for instance, and there is still no single history that everyone would agree to be correct. But to use continuing scientific debate about the correct historical pattern to suggest that therefore organisms, including humans, did not evolve, is ridiculous.

c. The Process of Evolution

For organisms to change through time, genes have to change in frequency. So there was, at some point in the past, a common ancestor to humans and chimpanzees. In each lineage leading to the current populations of humans and chimpanzees, the DNA sequence has changed very little – less than 1% overall. There are two well

¹ Chambers Dictionary, 1998 Edition.

established processes by which genes can change in sequence over time. The first is Natural Selection. If there is genetic variation within a population, and that variation leads to a difference in the survivorship of individuals, or their abilities to find mates and produce offspring, then the genes which increase survivorship or offspring WILL increase in frequency. The second is genetic drift. In finite populations, the offspring in any one generation are a random sample of all the possible offspring that could have been produced, and, like all samples, are subject to sampling error. Sampling error, the difference between what you would expect and what you observe, is a unavoidable by-product of sampling, and the error is greater if samples are smaller. The accumulation of many small changes in gene frequency as each generation is produced can lead to large changes in gene frequency over time. The two processes are well established, both by mathematical, analytical techniques and experiments. Thus these are also as well established as gravity or the chemistry of water. What is not understood necessarily is whether a particular genetic difference observed between, say, humans and chimpanzees was produced by Genetic Drift or Natural Selection. Also, even if we know a gene has changed by selection, we can not necessarily know what were the selective forces leading to the change. These issues are the subject of ongoing research, and there are theories propounded by scientists in any particular case which are challenged and sometimes shown to be false or incomplete. But again, the fact that we cannot explain exactly what the selective process was that lead to a particular difference between, say, humans and chimpanzees, does not mean that we do not understand how evolution takes place, nor that evolution has not taken place at all.

2. The Nature of Science

It is a fundamental tenet of science that for a theory to be truly scientific it must be falsifiable. What this means is that it must be possible to imagine an experiment or set of observations that would refute the theory and show it to be false. All of the work currently engaged in by evolutionary Biologists across the world is within the context of testing theories concerning the pattern or process of Evolution. However, the Fact of Evolution is also scientific. It is possible to conceive of a set of observations which would, if observed, refute Evolution. For instance, if fossils of mammals, dinosaurs and trilobites were all found together in undisturbed sedimentary beds, then this would be a major challenge to our current understanding of Evolution. Despite years of fossil hunting by many thousands of scientists and amateurs no such bed has been discovered.

3. The Evidence for Evolution

The primary evidence that Evolution has occurred – i.e., that organisms have changed through time – has come through the study of fossils. Fossils are the remains of the hard parts of organisms that have died and become deposits in sediments. Over years the sediments become compressed and hardened, and the organic remains become mineralised. Thus a sedimentary rock can preserve within it a record of the sorts of organisms that lived in the environment in which the sediment was deposited. During the 18th and 19th centuries, scientists started the systematic collection and recording of fossils and noted that different rocks tended to have different assemblages of fossils. They were also able to begin the process of identifying the historical order of rock types. This follows from the rather obvious and simple assumption that if a rock, say A, lies underneath another rock, say B, then A must be older than B. Note that before Darwin's seminal work proposing Evolution, the order of rocks, the relative ages and

the major fossil assemblages typical of each age, had been identified. Evolution provided an explanation for these observations which has not been challenged for 150 years.

There are many other sources of evidence which are also often cited as evidence for Evolution, but should more accurately be said to be consistent with Evolution, rather than positive evidence in favour. This is because many of these observations might also be consistent with theories which invoked an active designer. However, if any of these were absent, it could be held as evidence against Evolution: i.e. these are further tests of the falsifiability of this Science.

The process of evolution proceeds by the progressive changing of pre-existing organisms effectively one gene at a time. This results in a number of consequences. First, that the pattern of life will be more or less “tree-like”, and that most of the genes in an organism will show rather similar trees. This is the burgeoning science of molecular phylogenetics, and all the evidence from the past twenty years of gene sequencing has shown that this pattern is generally found. So for instance, if we compare the haemoglobin molecules of humans, chimpanzees, gibbons and cats, we find that the human sequence most resembles that of chimpanzees; and both resemble gibbons more than cats. This shows the same tree from physical resemblance, and from other molecules such as insulin or cytochrome C. Note that this is not a necessary feature of life: if all organisms were independently created, and thus all equally related, why should different structures show parallel patterns of resemblance?

Second, since evolution proceeds by modifying pre-existing structures, it is likely that related organisms will show rather similar patterns of early development, with the differences appearing later in development. This is what is observed: the early stages of development of birds, whales and monkeys share remarkable similarities, even though the final structure of the organisms is very different.

Thirdly, we would not expect evolution to always find the “best” solution to a problem. Since evolution has to modify what already exists, the previous evolutionary path may have closed off the most “obvious” solution to the problem. This results in many examples of clearly mal-adaptive solutions which are explicable when you know the evolutionary history of the organisms, but not if you tried to design the “best” organism. For instance, humans can choke because the food and air ways share the same tube for a part of the way down the body. This is not an inevitable design: invertebrates do not do this. But not all mammals choke as easily as humans. Chimpanzees have a more effective epiglottis that shuts off the larynx (airway) during eating than humans. But humans, during their evolution from their common ancestor with chimpanzees, have developed a much lower larynx that is not so effectively closed during eating: this is associated with the evolution of the structures which allow us to speak. Thus the evolution of the neck and head which make us human has resulted in a mal-adaptive system for separating food and air. This is easily understandable in the context of evolution from a common ancestor, but does not fit so easily with a concept of an active designer.

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4. Evolution in action

We can observe Evolution occurring at present, and indeed it is responsible for many of the problems that face the pharmaceutical and pesticide industries. When new antibiotics and pesticides were introduced in the middle part of the 20th Century, they worked. Penicillin and DDT, for instance, between them saved millions of lives by killing pathogenic bacteria, or the insects that spread disease or destroyed crops. Very soon after their introduction, however, bacteria and insects began to evolve resistance to them, and industry had to produce ever more chemicals, many of them much more toxic and environmentally damaging than the early ones, in order to keep pace with the bacteria and pests in this evolutionary arms race. We are losing that race, in the sense that evolution has outstripped our ability to develop new drugs and pesticides.

The story of the peppered moth in the latter part of the 19th century is well known: between 1848 and 1900 a melanic form of the peppered moth largely replaced the ancestral mottled grey form over much of the industrialised parts of Britain. The melanic remained common until the 1960s, and much research was conducted on the reasons for this evolutionary event. Since the introduction of the Clean Air Act in 1956 there has been a dramatic reduction in air pollution in Britain, and the frequency of the melanic has recently seen a corresponding reduction. Note that there is controversy over the exact reasons for the increase and subsequent decline in melanic frequencies (ie the role of selection, and what selective forces were actually responsible) but that evolution took place is not in doubt. In the Galapagos Islands, careful studies by Peter and Rosemary Grant over many years have documented changes in the bill shapes of the native finches in response to changes in climate caused by El Nino.

Many other examples of rapid change in the form or function of plants, animals or microbes could be given. Examples of the evolution of new species have also been seen, particularly in plants, but also in insects (e.g the Apple Maggot, *Rhagoletis pomonella*). There is even a suggestion that the introduction of an Australian Wallaby, adapted to a temperate climate, into tropical Hawaii at the beginning of the 20th Century resulted in the rapid evolution of a novel form that could be classified as a new species of Mammal.

5. Conclusion

All the evidence available indicates that Evolution has taken place. As Dobzhansky once said “Nothing in Biology makes sense, except in the light of Evolution”. It is evolution which means that we can study bacteria or fruit flies and learn things about biochemistry or physiology that can be applied to other organisms, including humans. Evolution is not in doubt; what makes the continuing study of the subject so interesting and exciting is that we still do not know the exact pattern of evolution, nor the precise roles of selection and drift in fashioning any particular behaviour, structure or biochemical pathway.

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