

Genetic and Cultural Evolution: From Fossils to Proteins, and from Behaviour to Ethics

PETER LACHMANN

Department of Veterinary Medicine, Madingley Road, Cambridge CB3 0ES, UK.
E-mail: pjl1000@cam.ac.uk

At the end of the Darwin bicentenary year it may be thought that there is little more left to say on the subject of evolution, but there are some aspects that still deserve further elaboration. There are several, largely non-overlapping, sets of evolutionary scientists – for example, the palaeontologists who are particularly interested in fossils and in the evolution of structure; the biochemists and molecular biologists who are interested in the molecular aspects of evolution; and the sociobiologists who include cultural evolution in their field of interest. The Darwin celebrations, reflecting his own scientific interests, have been dominated by the palaeontological approach and other approaches may have been somewhat neglected.

Evolution

Evolution describes the processes by which all different life forms have developed from their earliest common ancestor. This definition of evolution can be traced to Erasmus Darwin (1731–1802), Darwin's grandfather, and applies to Jean-Baptiste Lamarck's (1744–1829) theory of evolution as well as to Darwin's. The idea of the 'tree of life' with a single common ancestor certainly goes back to Lamarck, but he was led astray by the belief that evolution had a 'goal' and an inevitable progress leading finally to human beings. Lamarckianism is nowadays frequently associated with the idea that acquired characteristics could be inherited. Whereas Lamarck certainly did believe this, so did Darwin. Pangenesis and gemmules are speculations made by Darwin¹ on how changes in the phenotype, i.e. acquired characteristics, could communicate with genetic inheritance. These speculations never had any experimental basis. The idea now often considered

essential to Darwinism – that the changes on which selection acts are non-purposive in nature and occur in the germline as opposed to the soma – is due to August Weismann² (1834–1914) rather than to Darwin himself.

It is now well established that the most ancient forms of life of whose existence we have a fossil record are the cyanobacteria and the archaea, whose fossils can date from up to 3.5 billion years BP. Their descendents are still abundant. They were responsible for creating the first free oxygen in the atmosphere, without which animals cannot exist. For this reason alone it is impossible that all the living species originated (or were created) at the same time.

The vital component of Darwin's contribution was that evolution occurred by natural selection. This process he defined as favouring the survival of those organisms that leave the most progeny who will themselves successfully reproduce. The latter half of the sentence is important because it means that selective advantage will continue to act for many years after breeding. There is a clear advantage for humans in living long enough to bring up their children to sexual and economic maturity, which can take between a quarter and a third of the normal life span. The naive idea that natural selection ceases to act after active reproductive life is therefore certainly incorrect.

A second important point that needs to be emphasised about natural selection is the pervasive fallacy that competition necessarily involves conflict between competing groups. This fallacy will be discussed further in relation to social Darwinism where it has had a particularly pernicious influence.

A third important point is that natural selection works solely on selective pressures that are present at the time. Evolution does not, and cannot, anticipate future events. Similarly, evolution has no goal. There is no inevitable progress to some final perfect form. That was a Lamarckian, and indeed also Socratic, illusion. The idea of 'inclusive fitness', much beloved by some evolutionary scientists, is probably also to some extent an illusion. It may be worth giving an example. Suppose that HIV were to acquire in some way the infectivity of one of the pathogenic flu viruses and give rise to a lethal epidemic spreading very rapidly. In that case the population that would survive to repopulate the planet would presumably be derived from those people who lack the receptors by which HIV infects cells – CD4 and CCR5. The rare mutants who fail to have these receptors are almost certainly not particularly clever or particularly beautiful, or particularly well adapted in other ways. They survive because they do not have the receptors for a virus that is killing everyone else. That is the way evolution works.

This example also emphasises the major role of parasitism as a driver of natural selection. This was not understood by Darwin. Although he was a contemporary of Pasteur's, he does not seem to have appreciated the enormous importance of Pasteur's work on the microbial origin of infectious disease. It is

only in much more recent times that it has been recognised how powerful a driver of natural selection parasitism really is. W.D. Hamilton published in 1990³ a notable study in which he pointed out that whenever primitive animals have the option of using sexual or asexual reproduction they invariably use sexual reproduction. He analysed a number of possible reasons for this and came to the conclusion that this choice was driven by the advantage that re-assortment of genes important for parasite resistance confers in resisting parasitism. Therefore, the important role of parasitism as a driver of natural selection goes back to very primitive animal life and is not at all recent.

Intelligent Design and the Panglossian Delusion

Dr Pangloss, the philosopher in Voltaire's *Candide*, is persuaded that he lives in the best of all possible worlds and it takes a lengthy series of calamities to persuade him otherwise. There is a highly analogous view concerning the perfection of the human body, which goes back certainly to the time of the ancient Greeks. Socrates was persuaded of the perfection of (particularly the male) human body and regarded all other forms of life as deriving from this by a process of reverse evolution.⁴ This idea that the human body is perfect was taken up in the Abrahamic religions in the view that man is created in the image of God and, since God was clearly perfect, then man must approach perfection as well. This view has proved extraordinarily durable and was, indeed, taken up by the 19th century evolutionary thinkers who wished to replace the perfect divine creation with the perfect evolutionary adaptation. It can still be found in contemporary literature. For example Richard Lewontin is quoted by Dawkins in *The Extended Phenotype*,⁵ and again in *The God Delusion*⁶ as saying that 'that is the one point which I think all evolutionists are agreed upon, that it is virtually impossible to do a better job than an organism is doing in its own environment'. I and, I imagine, many others would exclude ourselves from this consensus. Evolution is a rather British phenomenon – 'it muddles through'; or as Sydney Brenner once said in a lecture – 'evolution just does the best it can'.

Evolution Muddles Through

Studies of molecular evolution have shown that the process has a restricted range of options for producing new or improved functions. The basic metabolic pathways that underline life are still largely as they were in primitive micro-organisms and, as commonly studied in the bacterium *Escherichia coli*, bear close similarities to those seen in man. The human blood pigment haemoglobin already exists in the earthworm. It is clear that once proteins have acquired vital functions they cannot simply be changed into something different. It was pointed

out in 1970 by Susumu Ohno⁷ in his seminal book *Evolution by Gene Duplication* that in order for evolution to produce novel functions or greater complexities, it requires to have currently unused genetic material. These unused sequences, often called pseudogenes, are frequently produced either by gene duplication or, from time to evolutionary time, by duplication of whole chromosomes or indeed of the whole set of chromosomes. This, then unused, genetic material can subsequently act as a source for new proteins. Pseudogenes may therefore be regarded both as genes that have died and as genes that are waiting to be born. There are other sources of 'junk DNA'⁸ as well. For example around 10% of the genome is made up of retroviral sequences – the traces of bygone infections with these viruses that can integrate into the genome of species they infect.

The other important insight made at about the same time is that evolution of proteins does not operate at the level of the individual amino acid. Proteins are made up of a limited number of self-folding regions known as protein domains,⁹ which are used in many different proteins, not always serving the same function. It is these protein domains that serve as the building blocks of protein evolution. One of the earliest – the 'Rossmann fold' was described in 1974.¹⁰ Many more were soon discovered.¹¹ Protein domains have a long evolutionary history and genome sequencing studies have shown that of all the protein domains identified by 2001, 93% are shared between vertebrates and invertebrates and only 7% are vertebrate specific.¹² The total number of domains is now estimated to be about 1500.¹³

In this way, one can regard evolution as analogous to writing software for computing. One does not start all over again from the beginning but takes modules/domains that are then hitched together and benchmarked by being tested for a useful function. If the new gene has a positive selective function it is kept, otherwise it is discarded. Seen in this way, complexity is quite clearly an inevitable side effect of the way evolution works, and it is certainly not a sign of design, intelligent or otherwise. It is also worth pointing out again that this type of process does not give rise to perfection either in evolution or in computing; it ends up doing just well enough to be selected.

The idea that the human body is perfectly designed or engineered does not stand up to even the most superficial examination. The basic skeletal structure seen in man is common to all mammals and evolved for animals that move on all four limbs, rather than for humans who have in fairly recent times adopted an erect posture and walk on only two. Humans are left with a musculo-skeletal system that more often than not wears out within the normal human lifespan. An engineer who, starting *ab initio*, designed a creature walking upright on two legs that functions as badly as man, would not deserve to be worshipped nor would he pass his degree in engineering.

Social Darwinism and ‘the Survival of the Fittest’

The term ‘the survival of the fittest’ was coined by Herbert Spencer (1830–1903), a contemporary of Darwin and a philosopher who also wrote about evolution. He introduced this phrase in 1864 in his *Principles of Biology*¹⁴ writing ‘this survival of the fittest which I here sought to express in mechanical terms is that which Mr. Darwin has called natural selection, or the preservation of favoured races in discoverable life’. Spencer was a sociologist as well as a philosopher and applied his evolutionary views to human sociology. It is probably for this reason that the term ‘the survival of the fittest’ acquired unfortunate connotations with the belief that natural selection always involves conflict between competing groups and that it can be regarded as a duty of the fitter groups to eradicate those less fit. This is not inherent in the theory of natural selection and is probably less common than is often believed in animal evolution. To give a recent example – the introduction of the American grey squirrel into the UK has caused a great decline in numbers of the native red squirrel, which is a different species. It had long been believed that the loss of red squirrels in areas where grey squirrels had settled was due either to conflict or to direct competition for food. However, neither turns out to be the truth. It is the squirrel pox virus that seems to be the basis of the loss of red squirrels.¹⁵ This virus infects both species of squirrel but whereas grey squirrels recover, red squirrels tend to die from this infection. Grey squirrels probably leave the virus in their drays and in the environment in which they feed and this allows it to pass to the red squirrels who then succumb to it.

The whole idea of survival of the fittest and of conflict between competing groups probably lies at the core of the deep misunderstanding of Darwin and natural selection by politicians from Marx to Hitler who acted on the view that competition between different human groups, be they classes or races, would be accomplished by the destruction of the groups who were competing with them. Although Marx and Hitler may be the most prominent advocates of this form of social Darwinism, it can still be seen in contemporary political conflicts.

Cultural Evolution

Cultural evolution can be defined as ‘the transmission of information between individuals and generations by any means other than through the genome’. In humans, cultural evolution is responsible for bringing about behavioural changes that differentiate different groups of human.¹⁶ However, cultural evolution is not entirely peculiar to humans. It has been described in other animals¹⁷ among which the transmission of the information occurs entirely by observed example. David Attenborough¹⁸ described a population of monkeys who had learnt to separate grain from sand by putting the mixture in water where the sand sinks and the grain floats. This learned behaviour was maintained by that troupe

of monkeys. However, in a highly developed form, cultural evolution is seen only in humans and is intimately associated with the development of language. Oral transmission was supplemented by writing about 200 generations ago and by electronic means about two generations ago.

Cultural evolution certainly operates by way of natural selection, as does genetic evolution, but there are major differences. There are, for example, no cultural species. All forms of culture can interbreed, both physically and intellectually in the human species. There is also no 'non-blending' inheritance', i.e. traits are not dominant or recessive in the sense that they are in genetic evolution. For these reasons, the postulated cultural homologues of genes, the culturgenes of EO Wilson,¹⁹ or the memes of Richard Dawkins,^{5,20} should not be taken too seriously. Genes have a physical identity in sequences of DNA; they can be sequenced, they can be modified, and they can be 'knocked out'. None of these things can be done for their cultural equivalents and it remains to be shown that pursuing this analogy very far is particularly useful. Furthermore, cultural evolution quite clearly operates at the level of the group, which E.O. Wilson and Dawkins found difficult to accept, although Wilson has more recently changed his mind on this point.²¹ For human group behaviour to evolve culturally, behavioural prescriptions of any kind need to be kept constant over a sufficient number of individuals and over a sufficient period of time that natural selection can occur. I have argued elsewhere¹⁷ that these prescriptions have been expressed largely in religious form and that is what gives religions an evolutionary function.

Cultural evolution has a number of advantages over genetic evolution. First, it is much faster than genetic change since it does not depend on reproduction but occurs continuously – another major difference from genetic evolution.

Second, cultural change can be disseminated more efficiently. Oral transmission served for long periods as the mechanism to disseminate cultural advances. However, with the development of writing it became possible to produce long lasting records of behavioural prescriptions and they could then be disseminated over much larger distances and much more rapidly than had been possible before. In the last generation or two, the coming of electronic communication and above all of the World Wide Web, has given rise to a further revolution in the speed and the range of communication. How this will affect human behavioural evolution in the future is a fascinating question.

Thirdly, cultural evolution allows a much greater range of behaviour and innovation than is likely to be possible for genetic evolution. There are activities that it is difficult to envisage being encoded genetically. These include technological behaviour, such as flying an aeroplane or performing surgical procedures; or indeed bureaucratic activities, such as filling in tax returns and similar activities, which are long established in human history. The oldest written records that were recovered in Knossos turned out to be palace inventories, censuses, or

taxation accounts.²² The earliest writings of all, around 5000 BP in Southern Mesopotamia, were a form of accounting technology.²³ Bureaucracy rather than prostitution seems to be the oldest human profession.

There are, inevitably, also disadvantages to cultural evolution. The principal disadvantage is that the gains of cultural evolution are much less secure than those of genetic evolution, where the gains, being shared by all members of the group, are not readily lost. In cultural evolution this is not the case, and in the past, at least, these were often confined to the literate elite, who were frequently the priesthood, and so cultural genes could be lost in response to various forms of disaster. A good example is the Mayas who had a sophisticated civilisation and a very advanced calendar, but after the Spanish conquest, when the ruling elite were destroyed, the remaining (illiterate) Maya returned to the forests in Guatemala and Mexico and reverted to an entirely Stone Age form of existence.

What is it that makes Humans so Different from other Animals?

Structurally, the peculiarly human facet of the brain is the development of the neocortex, the large areas of the frontal lobes that are associated with the characteristics which we consider peculiarly human: abstract thought, planning and decision making, purposive communication and the development of language. Purposive speech describes the phenomenon where humans can choose what it is they wish to communicate. Most animals communicate but their communications are automated responses to the proximity of predators, to the availability of food, to the desire to find a mate etc. It is only humans who can decide that they have had an idea which they wish to transmit to other humans. Purposive speech, which can be assessed experimentally, can be looked upon as a good candidate to be a surrogate marker for self-consciousness, as has also been proposed by John Harris.²⁴

A second major characteristic of humans is the awareness of individual mortality, which undoubtedly shapes many human attitudes. It is not clear that other animals are aware that they will die, at least until death is imminent.

A third characteristic, albeit not unique to humans, is the long generation time. Humans have a generation time of between three and four per century, and therefore there are only about 4000 generations in total since the evolution of *Homo sapiens sapiens* in East Africa about 120,000 years ago. Mean human generation times are quite difficult to calculate and are different in the female and male line. However, one that can readily be measured is the succession line of the British Royal Family over the last 1000 years. This is slanted towards first children and one would expect it, therefore, to be shorter than the average but here too it is somewhere in the region of 30 years. A lot of this apparently long generation time is the result of the high infant mortality that has characterised humans, at any rate since the agricultural revolution around 10,000 years BP.

Cairns²⁵ has estimated that in urban societies, from classical Rome to mid 19th century Liverpool, between 50 and 60% of all children born were dead by the age of five.

The final property that is quite exceptional in humans is the extremely long period before the young become reproductively mature and ‘economically’ independent. Even today, this may still be more than 25% of the normal life span and this gives humans a very special range of social structures, where prolonged childcare is extremely important. This has clearly had a strong influence on human cultural evolution.

Ethics and Evolution

TH Huxley (1822–1895), ‘Darwin’s bulldog’, wrote a book on the topic of ethics and evolution.²⁶ He took the view that virtue was incompatible with evolution by natural selection, which he refers to as ‘the cosmic struggle for existence’. His views are worth quoting at some length because they have persisted, quite literally, to the present day²⁷ and because the question Huxley raises is a central issue for cultural evolution.

As I have already urged, the practice of that which is ethically best – what we call goodness or virtue – involves a course of conduct which, in all respects, is opposed to that which leads to success in the cosmic struggle for existence. In place of ruthless self-assertion it demands self-restraint; in place of thrusting aside, or treading down, all competitors, it requires that the individual shall not merely respect, but shall help his fellows; its influence is directed, not so much to the survival of the fittest, as to the fitting of as many as possible to survive. It repudiates the gladiatorial theory of existence. It demands that each man who enters into the enjoyment of the advantages of a polity shall be mindful of his debt to those who have laboriously constructed it; and shall take heed that no act of his weakens the fabric in which he has been permitted to live. Laws and moral precepts are directed to the end of curbing the cosmic process and reminding the individual of his duty to the community, to the protection and influence of which he owes, if not existence itself, at least the life of something better than a brutal savage.

It is from neglect of these plain considerations that the fanatical individualism of our time attempts to apply the analogy of cosmic nature to society. Once more we have a misapplication of the stoical injunction to follow nature; the duties of the individual to the state are forgotten, and his tendencies to self-assertion are dignified by the name of rights. It is seriously debated whether the members of a community are justified in using their combined strength to constrain one of their number to contribute his share to the maintenance of it; or even to prevent him from doing his best to destroy it. The struggle for existence which has done such admirable work in cosmic nature, must, it appears, be equally beneficent in the ethical sphere. Yet if that which I have insisted upon is true; if the cosmic process has no sort of relation to moral ends; if the imitation

of it by man is inconsistent with the first principles of ethics; what becomes of this surprising theory?

Let us understand, once for all, that the ethical progress of society depends, not on imitating the cosmic process, still less in running away from it, but in combating it. It may seem an audacious proposal thus to pit the microcosm against the macrocosm and to set man to subdue nature to his higher ends; but I venture to think that the great intellectual difference between the ancient times with which we have been occupied and our day, lies in the solid foundation we have acquired for the hope that such an enterprise may meet with a certain measure of success.

Huxley is here subscribing to the dogmas of ‘Social Darwinism’, the inadequacies of which have already been discussed. He even uses Spencer’s phrase ‘survival of the fittest’ and assumes that competition inevitably involves conflict. He comes to a conclusion that I regard as perverse. He believes the ethics serve to combat evolution rather than that ethical prescriptions are the building blocks of natural selection for cultural evolution.

Huxley’s point of view presupposes that there is some absolute and permanent standard of ethics that does not, and has not, evolved. This supposition I would entirely reject. Over evolutionary spans of time, ethics have certainly evolved. The idea that there is a single absolute Virtue enshrined in ‘natural law’ that is eternal and (usually) derives from God(s) does not bear much scrutiny. Even within the historical period (i.e. where there are written records) many cultures had no moral qualms about slavery, about human sacrifice or about cannibalism. Some contemporary cultures (e.g. the Japanese) appear to have no ethical objections to suicide. Views on human rights – and their corresponding duties – have also changed greatly during historical times, with the modern view perhaps best encapsulated by Kant’s injunction that ‘humanity is an end in itself’, and by the rights to ‘life, liberty and the pursuit of happiness’ enshrined in the American Constitution. Since the European Enlightenment (secular) moral philosophy has been transformed and new ethical fields such as Bioethics have come into prominence.²⁸

Those ethical prescriptions that have the longest and the widest distribution are those that have been selected for in many very different environments and therefore can be seen as the most important for the existence of human societies. Altruism, respect for human life and dignity, truthfulness and honesty may be numbered among them.

The Rejection of the Enlightenment – Fideism versus Scepticism

There is a quite clear division in attitude between those who regard belief as central to their existence and those who are entirely sceptical of anything that does not have evidence to support it. At the two ends these attitudes may be called Fideism and Scepticism. Fideists take as their motto the statement by

Tertullian ‘credo quia absurdum’ – ‘I believe because it is absurd’. Tertullian was an early church father and there seems to be some difference of opinion whether this remark concerned the Resurrection or the nature of the Trinity, or whether indeed he made it at all. However, whether he did or didn’t, what he says nevertheless enshrines a very widespread attitude. For fideists there is no challenge in believing things that are reasonable, but they are enthusiastic about believing what is clearly absurd. At the other extreme are the sceptics, whose motto is that of the Royal Society ‘nullius in verba’ a dog Latin tag which translates (roughly) as ‘do not believe anything just because somebody told you so’. For substantial periods of historical time the conflict between fideism and scepticism was predominantly focused on religion. The coming of biblical scholarship on the one hand, and the development of natural science on the other, was responsible for the sceptics rejecting the more literal accounts given in the holy books. The sceptical movement came to its apogee with the European Enlightenment and the recognition that experimental evidence was essential for understanding both the physical and the biological world. It is hard to put this better than Adam Smith:²⁹ ‘Science is the great antidote to the poison of enthusiasm and superstition’

In recent years, the conflict between fideism and scepticism has moved into quite different areas. Now it is by no means restricted to religion but includes such matters as genetically modified foods, alternative medicine, vaccination, stem cell research and reproductive technologies. There is a powerful and well-financed movement in the UK (where it has the outspoken backing of the Prince of Wales³⁰), in Europe and also in the United States, which rejects the Enlightenment entirely – and generally evolution by natural selection as well. The stance often taken by this movement is to reject activities that they do not regard as ‘natural’. This is, however, not a satisfactory stance in the absence of a definition of what is and what is not to be regarded as ‘natural’. At the most fundamental end, they would probably regard as natural only those activities that are entirely without human agency. Since this would involve not wearing clothes and not eating cooked food, it is unlikely that even the most fundamentalist of the anti-enlightenment group would be prepared go that far. It is possible, I suppose, to look for a definition from patent law, which distinguishes between discoveries, which are not patentable, and inventions, which are. Inventions need to include some original and novel human contribution. It is again difficult to imagine that many people would be prepared to avoid everything that has ever been granted a patent. This would deprive them of nearly all the conveniences of modern life and most medical care. No objective definition of what is natural or unnatural seems to exist and what is commonly used is the ‘declamatory’ definition: ‘this is unnatural because I say it is unnatural’. That is essentially unhelpful as the views expressed will vary widely. The proposition that natural is good and unnatural is bad makes little sense.

Those who reject the Enlightenment look back to an imagined, golden, pre-industrial, pre-scientific past where life was not accompanied by worries about nuclear bombs, climate change or “Frankenstein foods”; but they fail to acknowledge that life then had ‘No arts; no letters; no society; and which is worst of all, continual fear and danger of violent death; and the life of man, solitary, poor, nasty, brutish and short’.³¹

Conclusions

In the 21st century it is absurd to talk about ‘evolution by natural selection’ as a theory. It is an entirely established fact that has withstood all attempts made to falsify it. Its modes of action at the molecular level and the limitations that these impose on the process are well understood for genetic evolution and further new information from modern genomic and epigenetic studies will clarify the details further.

Cultural evolution by natural selection is also very much more than a theory even though there are no molecular studies to underpin it. Patterns of human behaviour (between groups of humans) have been culturally evolved, as have ethics. The significant role that religious prescription has played in the process of cultural evolution is discussed elsewhere.¹⁷

There persists, even in Europe, a vocal movement that rejects the European Enlightenment from which views on evolution ultimately stem. It must surely be prominent among the aims of the Academy of Europe to stand up to this movement and to defend the Enlightenment against its foes.

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About the Author

Peter Lachmann is emeritus professor of immunology in the University of Cambridge and a fellow of Christ's College – where Darwin was a student and remains a living presence. He has been founder President of the UK Academy of Medical Sciences (1998–2002); Biological secretary of the Royal Society (1993–1998) and President of the Royal College of Pathologists (1990–1993). His principal research interest has been the complement system including its genetics and its evolution. This led to a broader interest in molecular evolution. He has kept bees as a hobby for many years; and comparing bees with humans sparked an interest in cultural and behavioural evolution.