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Foreword

What Makes Us Human? – An Introduction

Walter Bodmer

There are at least as many answers to this provocative and searching question as there are authors of this compendium. In the various articles you will find suggestions that include the 'spirit of man', referring particularly to religion, speech and not just language, imitation and 'mimetics', cooking, high levels of cognitive ability, causal belief, that humans are symbolic creatures, innate curiosity and the desire to know, mental time travel, and the ability to read other's minds. These all have cognitive ability as a common thread and, deriving from this, high-level development of language and cultural transmission.

Genetic differences

For a biologist, who is a geneticist interested in evolution, the obvious explanation for what makes us human must lie within the genetic differences that distinguish *Homo sapiens* from other species, especially chimpanzees. The data now available on DNA sequences of many species, including the complete DNA sequences of humans, chimpanzees, and several other mammalian species, already are enough to place *Homo sapiens* in the "chimpanzee family", and separated even from the other great apes. Though the human and chimpanzee sequences are very similar, sharing perhaps as much as 99 per cent of their sequence, that still leaves plenty of room for a large number of functionally significant differences. Even if only 1 per cent of protein

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coding genes show such a difference, that still means there are as many as 250 genes whose difference may contribute to the greater cognitive ability of humans. In addition, the new knowledge that there may be at least an equal amount of DNA sequence that codes for functionally active RNA that is not directly involved in protein production, would at least double the number of potential functionally relevant differences between humans and their nearest great ape relatives. Of course, many of these differences may be in genes which are most unlikely to contribute to brain function in a way that could influence cognitive ability such as, for example, those controlling household cellular functions, aspects of immune response to infections, or basic metabolic processes. Nevertheless, I believe that there is plenty of scope within the DNA sequence differences we can now see between humans and chimpanzees, to account for those features that we might consider distinctive to humans as compared to chimpanzees.

Every species has, more or less by definition, a unique DNA sequence signature that distinguishes it from every other species. Our challenge, however, is to discern those human features which make *Homo sapiens* qualitatively distinct from all other species, especially with respect to its cognitive and related abilities.

There is no such thing as 'a gene for' any particular characteristic. What must be sought is the variation in the sequences of those genes, or the versions of the genes, that determine, or contribute to determining the particular characteristic differences we see between humans and their nearest relatives. So the challenge is to find those genetic variations that are unique to humans and which really matter for establishing the key features that make us human and in some way qualitatively different from all other animals.

There is no consensus as to the existence of any anatomically defined area of the brain that is clearly and uniquely associated with human attributes. However, recent work by Pollard and colleagues (Pollard et al., 2006) on the analysis of human, chimpanzee and other mammalian DNA sequences has shown how it may be possible to identify those DNA sequences that may be most relevant to human uniqueness. From a comprehensive analysis of a large amount of DNA sequence data, they identified those sequences which had hardly changed over hundreds of millions of years, until the split between *Homo sapiens* and chimpanzees. This led to the definition of a set of 49 regions of DNA sequence that were very similar in a wide

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range of mammalian species, but which had evolved extraordinarily rapidly in the separation of humans from the great apes, including especially the chimpanzees. One of these was shown to be an RNA determining gene that was highly expressed in the developing neocortex. This, and the other newly defined DNA sequences, are obvious candidates for contributing to the unique cognitive abilities of humans, but the challenge remains of establishing their true functions.

Until we have answers from such biologically oriented studies, we must continue to seek the answers as to what makes us human from more general observations on human and animal behaviour, in the most general sense. Furthermore, we cannot assume that the whole answer lies simply in the genes, though it surely must be the evolved genetic differences that contain the potential for human cognitive uniqueness and other associated distinctive human features. I think it is important to emphasise that, at least in my view, only a subset of genes, perhaps mainly those not involved directly in significant cellular and organismal functions, are really selfish in the Richard Dawkins sense. Natural selection operates on the whole organism, and we therefore see its effects on a particular gene as a 'marginal effect', in the language of experimental design, as introduced by the great statistician and co-founder of the field of population genetics R. A. Fisher, namely averaging over all other genetic differences. We must ultimately seek the explanation for the evolution of the differences that led to an enormously increased cognitive ability in the conventional actions of natural selection. However, there is clearly a huge number of attributes that are a by-product of this increase, such as musical and mathematical ability, which cannot all be the direct result of natural selection.

Cognitive abilities

As I have already pointed out, a huge increase in cognitive ability is the most obvious underlying common feature to almost all the attributes that have been suggested to make us human. These include, in particular, language and speech which have enabled a considerable increase in the rate and efficiency of cultural evolution. Paleontological data clearly suggest that increasing brain size has been a major feature of the evolution of the human brain. However, it is clear that while an

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increase in brain size may be a necessary requirement for increase in cognitive abilities, it is not sufficient. There must be many increases in the complexity of brain function, at the level of cellular changes and interconnections, that have made the ultimate increase in cognitive abilities possible.

A persuasive argument, that cooking is unique to humans, is made by Richard Wrangham. I have no doubt, however, that he would not claim that this is the unique feature of humanness. It is just one of the many consequences of increased cognitive ability. The ability to cook follows from the discovery of how to make fire. Darwin argued that "The art of making fire ... is probably the greatest discovery, excepting language, ever made by man" (Darwin 1871). While fire may well have been a unique discovery, language surely must have evolved over a period of time and speech required the evolution of changes in the anatomy of the larynx, probably dependent on the evolution of bi-pedalism. The ability to make fire probably also depended on the evolution of bi-pedalism and subsequently, as a consequence of freeing the hands, on the evolution of the flexible thumb. As Wrangham points out, cooking improves food and reduces the energy expenditure involved in digestion, and allows a broadening of the diet. The evolutionary response to the dietary changes is probably seen, for example, in the smaller stomach of humans. It appears that "even wild chimpanzees take advantage of natural fires to eat foods that have been cooked by chance" (Brewer 1978). The current evidence suggests that Neanderthals had fire and so are likely to have cooked. This is one of many examples where Neanderthals had human attributes not found in chimpanzees. I should have thought that, in addition to benefiting the diet, cooking plays an important role in killing potential pathogens in raw food, especially parasites that are not bacteria or viruses which may have been the most important pathogens in early human societies. Infectious diseases are of comparable importance as components of natural selection, as are diet and predation.

Robin Dunbar suggests that there are different levels of cognitive ability, and that humans, uniquely amongst animals, have achieved a 'fifth order' of cognitive ability. By this he means an ability to follow through a five-fold sequence of causes and effects. He proposes that Neanderthals may have had a fourth order of cognitive ability, and that this would be enough for the evolution of some sort of religion. This, then, would be another remarkable ability common to

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Neanderthals and *Homo sapiens*, but presumably not present in any of the great apes. Lewis Wolpert's claim that "Humans unlike other primates have a belief in physical cause and effect which enables the acquisition of new interactions and led to technology" just seems to me to be another facet of this higher level of cognitive ability in humans as compared to chimpanzees. There can surely be no doubt, even from causal observation of pets at home and in the field, that animals do have the ability, at least to some extent, of assessing physical causes and their effects. The difference between them and humans is a matter of degree.

A matter of degree and combinations

'Innate curiosity' is Charles Pasternak's choice for a unique human attribute. But, as he himself admits, there is innate curiosity in animals, but not to the same extent. He suggests a combination of four inherited attributes that makes humans unique:

1. Bipedalism – freeing the hands for other uses
2. Flexible thumb – a corollary of bi-pedalism
3. Voice box for speech
4. Increased brain size

All of these I have already mentioned, and in each case it is, again, a matter of degree.

For each of these features, and possibly many others, if they are measured on some quantitative scale, humans on average lie at the upper extremes. Thus, if all such variables were plotted in a multi-dimensional space, humans would 'cluster' in a region of the space widely separated from all other animals, even though in individual features there might be some overlap between certain species and humans.

The appeal to an unknown phenomenon: religion and reductionism

The complexity of the human organism and its cognitive ability, reflected in the gap between the understanding of the mind as compared to the brain, leads to a natural tendency to appeal to unknown phenomena as a form of explanation. For some, this is expressed in the form of spiritualism and religious beliefs, and the mind-brain

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distinction is paralleled by that between soul and body. Others may argue that some as yet unknown, but perhaps eventually knowable, phenomenon will provide the nexus between mind and brain, and so explain the nature of consciousness.

As Richard Harries asserts, there can be no scientific proof of the existence or non-existence of God. So long as religious beliefs remain consistent with prevailing scientific understanding, there can be no claim of an inconsistency between religious beliefs and the existence of God on the one hand, and science and its discoveries and methods on the other.

However, this requirement for consistency between science and religion is clearly very demanding. Thus Richard Harries argues against what he calls extreme reductionism, interpreted as "we are nothing but our genes" and "the whole is greater than the sum of the parts". I can hardly imagine that any self-respecting biologist or geneticist would ever have such an extreme view of the role of genes, nor would they contradict the view that the whole is more than the sum of the parts. The more we learn about fundamental molecular mechanisms, the clearer it becomes that almost all genetic functions interact with many, many other functions, and hardly any, if any at all, function on their own. In addition, it is clear that the environment, however assessed, has a huge impact on development. The environment involves a large element of chance that is essentially unpredictable, but that can be modelled using stochastic approaches. This element of chance plays a major role not only in an individual's development, but also in evolution, as evidenced, for example, by the enormous influence of major climatic changes and of meteorite impacts with the earth. Thus, reductionism has a much broader potential than appears to be envisaged by Richard Harries. There are many phenomena which we understand today in scientific and reductionist terms, including the whole mechanism of inheritance, which were simply mysteries well into the nineteenth century. There is, therefore, an obvious risk in assuming that the human mysteries of today will not be solved by the scientific method tomorrow.

Were Neanderthals human?

It is clear from archeological evidence that Neanderthals shared many features with *Homo sapiens* that are not found in any other species. They

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may well have had language, they had stone tools, they probably cooked their food at least to some extent, and, following Robin Dunbar, they may well have had a level of cognitive ability that allowed them to develop some form of religion. In our quantitative multidimensional plot, they would surely cluster well away from any extant mammalian species, though it is, I think, impossible to say whether they would be well separated from modern humans. Were they still extant today, would we consider them human? Would that decision be affected if they were distinctly less developed cognitively than modern humans? Would we grant them the same rights and privileges that are granted to all people, whatever their disabilities, in a modern civilised society? Would it be possible to educate Neanderthals to be acceptable members of present-day human societies, or would we need to give them special care and attention, as we do for many of those with severe mental impairment. Such individuals may often have cognitive impairments that take them below the level of Neanderthals, or even perhaps chimpanzees, but we nevertheless, in a modern civilised society, treat them as human. If Neanderthals are considered as human, when in hominid evolution was the threshold to humanity crossed? Perhaps it is fortunate that we do not have to face such decisions, though the issue of how we treat higher primates, the attitude to which has changed enormously even over the last fifty years, comes very close to that problem.

Altruism, group selection and cultural evolution

The late and remarkable naturalist and evolutionist, William Hamilton, expanded on the evolution of altruism, following the initial ideas put forward by R. A. Fisher and J. B. S. Haldane in the 1930s. Hamilton showed how altruism would, in general, work if it operated amongst genetically related individuals. Even casual field observations show remarkable examples of cooperation, for example within a related pack of African wild dogs. Outside humans, it seems that altruism amongst unrelated individuals is rare but not absent, as it is evident in Meerkats. However, it does seem that altruism amongst, at least not closely related individuals, may be quite common in human societies. Cooperation between individuals in small groups is certainly seen in modern hunter-gatherer societies, and may be presumed to have been quite common in early hominids, even before the evolution of *Homo sapiens*.

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It has generally been assumed that group selection is a weak force in evolution, as compared to the effects of natural section on the individual. However, I believe that the wide-spread existence of cooperation and altruism between unrelated individuals in human societies may mean that group selection has played a much larger role in hominid evolution than is generally assumed. Robin Dunbar comments that religion "is a particularly effective way in which one can try to create a sense of belonging, 'groupishness'". That sense may be very important for the survival and success of groups in competition with other groups, and so could naturally be a basis for the evolution of religion. This evolution would be cultural, and not biological, though it is the preceding evolution of cognitive ability that makes this cultural evolution possible. Even in modern historical times, the relative world-wide dominance of a technology and many aspects of culture based on European society, and indeed the widespread use of the English language, could be interpreted as examples of group selection based largely on British colonisation over the last few hundred years.

Cultural transmission is not unique to humans. It was seen, for example, in the remarkably rapid spread in the UK of the practice of certain birds to pierce the aluminium tops of milk bottles (in the days when such things were delivered to the door step) to suck out the cream from the top of the bottle. However, cultural evolution, which depends both on transmission and innovation just as biological evolution depends on Mendelian inheritance and genetic variability, is hugely more developed in humans than in any other animals. It seems doubtful that the brain has evolved significantly, in biological or genetical terms, since the development of the potential for sophisticated language, which must have been a major factor in enabling the possibility of comparatively rapid cultural evolution.

The evolution of the use of clothing, after nakedness had evolved to help avoid parasite infections (an idea put forward by Pagel and Bodmer, 2003), is another example of significant cultural evolution. This development must have been essential for survival in the colder, mainly northern, climates to which *Homo sapiens* migrated after the end of the last ice age.

Pivotal changes, whether in biological or cultural evolution, such as the enlargement of the brain or the discovery of fire, allow subsequent rapid evolutionary changes to take place. That seems to me to be the reason why the pace of both biological and cultural evolution is

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not uniform. Pivotal changes will be uncommon and their occurrence largely determined by chance.

The key feature of cultural evolution is horizontal transmission within generations, rather than just vertical transmission from generation to generation. The horizontal cultural transmission process in humans, which is largely dependent on their superior cognitive abilities, is enormously more rapid than conventional biological evolution. This undoubtedly is the major determinant of the extraordinarily rapid development of human society over the last few thousand years, which are hardly a tick in the usual time frame of the clock of biological evolution. It is especially during this process that I believe that group selection has played a much more important role than is usually assumed.

Much of the extreme development of human culture, such as music, science, mathematics, and literature, may simply be a by-product of our superior cognitive abilities, which were selected, not to make music or solve complex mathematical problems, but for our better survival and adaptation to rapidly changing environmental conditions. Culture is nowadays largely passed on from generation to generation through education, and language, in one form or another, remains the main vehicle for cultural transmission.

Let us consider as an interesting example of cultural divergence, extant so-called primitive or hunter-gathering tribes, such as are still found in the Amazon basin. They must be presumed to have the same potential for cognitive ability that an educated person, say, in Europe or America has. Yet they will have a totally different culture and associated way of thinking. Nevertheless, it seems almost certain that if a newborn baby from such a tribe were brought up in, say, a typical British family, they would have ways of thinking that were just like other people brought up in that same culture. That surely emphasises the overriding importance of culture in determining our ways of thinking. Widely different human cultures have been superimposed upon the presumed unique cognitive features of humans.

Conclusion

The various chapters of this book contain many suggested attributes that contribute to human uniqueness which raise intriguing questions

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about the comparisons between human and animal behaviour. Do only humans have humour? Is the parrot that seems to be making fun of you not just doing it for the fun of it? And what about its extraordinary ability to imitate the human voice?

Is the capacity to show remorse specifically human? Is it only humans that can create an imagined world for themselves? How do we know that other species cannot explore imagined worlds? We have no means of adequate communication, even with chimpanzees, to be able to assess that. Small movements that, for example, dogs make when they are asleep, certainly suggest, as does the existence of REM sleep, that animals can dream. Does this not imply a certain level of imagined world? It is all a matter of degree, as already emphasised.

Sound transmission is the key to a spoken language, and Gentilucci and Corballis suggest that this followed visual communication and is peculiar to humans. But many, if not most animals communicate by sounds. Surely it is more likely that the transition was from sound to visual communication. That is what is suggested in the origin of flexible written languages from pictorial symbols, and, as already emphasised, it is the written language that has been key to the rapidity and fidelity of human cultural transmission.

Is language essential for symbolic thought? Is a chimpanzee really like a 4–5 year old child? How can this be reconciled with the fact that many children at that age have a much more sophisticated development of linguistic ability than any chimpanzee has ever had?

Is the ultimate function of the brain to control movement? While that is clearly a major function of the brain, what about the senses of seeing and hearing and, indeed, quite generally thought processes, even in animals?

And what about Susan Blackmore's memes, which she maintains are now driving evolution? Perhaps that is just another way of emphasising the importance of cultural evolution. Do memes have a selfish life of their own? Is that how the English language has spread throughout the world? It is, however, easy to see how the European-based technology has been advantageous, at least economically, and so ultimately even in terms of survival and perceived quality of life, if not reproductive performance. English, having become the lingua franca of science and technology is bound, therefore, to have had a selective advantage over other languages and has itself evolved to a simpler form for non-native English speakers. These sorts of arguments

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parallel closely the types of analyses that population geneticists have classically applied to the evolution of genetics differences.

It has been an interesting challenge for me to have had the opportunity to write this introduction and to try and organise my thoughts on human uniqueness, stimulated by the various contributions that follow. There can be no doubt that this book will make you think about the basic question of what makes us human in a new light. You will also, no doubt, make your own choices of what it takes.

Walter Bodmer
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