HOME

Human Evolution as a Continuous Process

by

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> So then always that knowledge is worthiest …which considereth the simple forms or differences of things, which are few in number, and the degrees and co-ordinations whereof make all this variety.
>
> The Advancement of Learning Book II *Francis Bacon*

> … he that will not apply new remedies must expect new evils. For time is the greatest innovator.
>
> Of Innovations, The Essays *Francis Bacon*

Summary

Human evolution is probably a continuous process rather than the currently accepted model of distinct changes from one species to the next species on the tree. Species can therefore best be described as semi-homogeneous through time. This may be considered to be in effect a new paradigm.

All evolution results from mutations in the genome caused by radiation or faults in the process of cloning, both of which occur stochastically throughout the population. The locus of mutation is in the sperm or the egg of the parent, because these are the link between generations which is necessary for evolution. The genome is so long that it is most unlikely that the same mutation would occur in more than one individual at a time, and certainly not in a whole species. Thus each mutation which survives the body's "quality control" processes occurs in a single individual and diffuses through the rest of the species a generation at a time, subject to natural selection. This is the same sort of process as proposed in my recent paper on Co-evolution.

Morphology does not necessarily develop smoothly, because only a small flaw in the genome is required to produce what seems to us to be a dramatic skeletal change. Periods of apparent stability between marked changes would account for what we see as species. Fossils exaggerate these, because they are widely spaced samples over time. Fundamentally the morphological differences between Neanderthal man and ourselves are not great, given the separation of several hundred thousand years of development.

However, the brain also evolved by the same mechanism of sperm and egg which contained a mutation. The result was a physical part of the brain which acted as a sort of tabula rasa on which knowledge of the processes necessary to survival could be written during life. It was the size and scope of this physical part of the brain and the rate at which information could be copied onto it which distinguished humans from other apes. Such a physical feature could certainly be passed down genetically to offspring. If it increased the chances of survival for the individual which possessed it, it would gradually spread and become enhanced still further in the whole population by the process of natural selection.

Thus as well as skeletal changes, humans spent two million years spreading and developing this unique physical capacity of their brains through natural selection, and turned what was in effect their animal behaviour into human behaviour by lifelong learning. If this is so, this was probably the greatest period of change of the species. They learnt from each other, not necessarily peaceably. It was not a period of stagnation.

As a result of the evolution of the brain, a learning system formed between individuals and between groups, both technological and social. Technological innovation, which was not readily available to other animals, and then language, culture and numbers all increased exponentially from the first human animals up to about 1750. Differentiation of the population occurred as a result of geographical and climatic environments. It may be that Neanderthals became extinct because they arrived too early and in the wrong latitudes, at a time when the climate was unfavourable for mutual learning. Modern man lived in the warmer climates, where interaction was greater and the exponential learning and growth curves were steeper. When he was able to spread out of Africa because of climate change, he arrived in Asia better prepared. The indications are that Neanderthal man started to catch up, but by that time there would be too few individuals to survive in the available space. The whole process was modulated throughout by the Law of Natural Selection, where those most favoured by the environment in which they found themselves would survive.

If this was so, the overall genetic difference between Neanderthals and modern man was not great, although we call them different species, because they were variations on what is in fact a continuum. What difference there was may relate to the ability to absorb and use the ever increasing bulk of “knowledge” of how to survive, especially that gleaned from each other.

The model is difficult to represent in a simple diagram because of the complexities to which time and space gave rise, but the concepts of semi-homogeneity through time and of the mechanism of diffusion of mutations through populations may be of more general application in evolution.

A. Introduction

The record shows that several species of man have existed on Earth over the past two million years. These include Homo heidelbergensis, Homo neanderthalis, Homo sapiens, which is us, and a few others. Different species have different features, as shown by the fossil record, and so it seems clear that step changes have occurred in the transition from one species to another. Every species must have originated from a previous species by definition, because everyone has ancestors. They can be traced back to a common ancestor, yet to be discovered. This raises a number of questions such as: when did the branching into different species occur, what caused the transition and why did all species except Homo sapiens become extinct? What exactly is a species anyway?

This paper proposes a different model. Starting from an ancestral population, different mutations occurring in different places at different times in different climates produced small variations on the basic theme. The implication is that the variations might have been relatively superficial but accumulated over time into something more substantial.

These different populations in different places were all subject to the law of natural selection, and those individuals least favoured by the environment in which their population existed at the time were eliminated. The environment consisted of not only the climate and geology but also all other living entities which were favoured, both animal and vegetable. Every living thing affected every other. The result of all this was that while other species of man became extinct, Homo sapiens survived. All men on Earth are now are of the species modern man.

Such a model can incorporate smooth, continuous change, even if we cannot see it, and the implications would be profound; we may not be a special as we thought. The simplest way to start evaluating it is by considering a steady state.

B. Steady state

A steady state in this sense means a period during which the balance between all the species which exist at the time does not change. A condition of this is that, while the climate may fluctuate in the normal way, it does not undergo lasting, secular change. That does not mean that the lives of the individuals in species do not change, because by arguments rehearsed elsewhere species must produce a surplus of individual offspring beyond what the environment can sustain (1). If they do not produce enough offspring to replace themselves, the species becomes extinct by definition. If they produce only just enough, the species will still become extinct, because natural hazards will still occur: branches fall off trees, earthquakes happen, rivers become torrents etc. Each reduces the number of individuals until the species disappears.

There must therefore be a surplus of individuals jostling for survival in the space which each species occupies. If the balance between species is to be maintained, some individuals in each species must be eliminated. Those who do not survive tend to be those least favoured by the environment. This is natural selection.

C. Mutation

A mutation is a change which occurs in the DNA of an individual. Many mutations have been found to occur in various people, and each of us contains at least a few. If it is to take part in evolution, a mutation must be a change in the DNA of an individual which it successfully passes on to its offspring. The offspring then passes it on to its own offspring in its turn, and so on down the generations.

Mutation which occurs in the bulk of a body of an individual is an extraneous growth; it damages the body like a cancer. It cannot be passed on to descendants, because there is no link between the DNA of the two individuals after they have been separated by the birth of the offspring.

Mutation which can be passed on to the offspring must therefore affect the two components which form the new DNA of the offspring. These are the sperm of the father and the egg of the mother. The DNA of every offspring will always be different from all others i.e. each individual is unique, unless it is a perfect clone, but mutation is a change or “defect” which cannot be formed by union of two individuals of the species from the DNA which already exists in the species.

There are thought to be only two causes of mutation of DNA. The first is radiation, which covers both high energy subatomic particles and electromagnetic radiation, which is very high frequency light. Electromagnetic radiation also acts as if it were composed of discrete “particles”. Different types of radiation have different effects, but their characteristic is that they damage the structure of DNA by breaking the chains, so that these reform to give a slightly different composition. If radiation affects evolution, it must be because it has changed the DNA of the sperm or the egg of the parents which have combined to produce the new individual.

The more radiation to which a species is subjected, the greater the number of particles which strike the individuals of which it is composed, and so the more mutations the species will suffer. The probability is that radiation has fallen on all individuals at random during the last two million years. Radiation has not in some way selected particular individuals to strike, nor are some individuals who are available for procreation more susceptible than others; the mutations have occurred at random throughout the population. Nor is there reason to believe that any two individuals will suffer exactly the same mutation; DNA is such a long molecule, millions of letters long, that the chances that a random strike by radiation would hit exactly the same spot on the DNA are effectively zero. The more individuals there are in a species, the larger the number of mutations which occur in the species, because there are more individuals to strike. Thus if a mutation is successful in being passed on, the number of mutations which eventually permeate the whole species increases exponentially with the number of individuals of which it is composed.

Radiation falls continuously onto the surface of the Earth; it cannot be turned off. If it has varied in intensity during the period of man’s existence on Earth, it must be because the sources have varied in intensity, which is not likely to have occurred to any great extent. These sources are most likely to be celestial, because it is improbable that local sources or radiation hotspots on the surface of the Earth could give rise to a global phenomenon.

There are two probable celestial sources. The first is radiation from the Sun which travels to Earth along the plane of the ecliptic. In this case the intensity will vary across the surface of the Earth from a maximum at the equator to a minimum at the poles, because the Earth is an oblate spheroid. The other source is cosmic radiation, which is composed of subatomic particles, principally protons, with extremely high velocities and so energy, launched into space by stars. These could certainly do the damage, but they are comparatively rarer and in principle they could come from any direction.

The chance of damage to sperm or eggs in an individual as an origin of evolution is a function of a series of improbable events, because the mutations must be present in the sperm or eggs of the parent at the instant of conception. Virtually all mutations affect either the foetus after its formation or the body of the individuals which grew from them, simply because it is a much larger target. However, none of these could be passed on to offspring.

It is therefore DNA that was mutated at the moment of conception which makes the body of the child, including its own sperm and eggs when it procreates in its own right as an adult. And so on down through the generations. The odds against this happening are overwhelming. First, there are millions of sperm in each ejaculation and so the chance of hitting the one that actually fertilises the egg must be nearly zero. More likely is that it would require a strike on the machinery which actually makes the sperm, resulting in production of “faulty” goods. Eggs are many fewer, and so they could be considered as more likely targets. However, after the two have combined, there are control mechanisms which abort any unusual foetus and the mutation with it. Even if the foetus survives this, and an offspring eventually emerges, the mechanism of natural selection filters out the majority of mutated individuals as inferior or just unlucky. Only those who are left can take part in evolution of the species. Nevertheless, such are the numbers and such is the length of evolutionary timescale that eventually it happens.

The second cause of mutation lies in the process of combining two strands of different DNA, one from the sperm and the other in the egg, to form a new DNA from which the offspring develops. This involves complex interaction of the two strands, scission and recombination, the shuffling of genes from which a new, unique entity emerges. Every part of the process involves a sort of cloning procedure, which from time to time is less than perfect, and a flaw is then incorporated in the combined strands of DNA. This may be complicated by viruses and bacteria which could disrupt the process of combining strands. Even if the DNA which is formed can be reproduced and become the nucleus of a cell, the vast majority of such cells would be aborted by the body’s quality control mechanism. Any which did get through would then be subject to the same conditions as above i.e. it has to pass down to offspring, escape being discarded by natural selection and then remain favoured through the generations.

Thus the rate of mutation from both causes, and so the possibility of human evolution, is proportional to the number of individuals in the species. This results in an exponential function, with result that the process might be very slow in the early stages, but once established, it would accelerate rapidly at an ever increasing rate.

The term “continuity” needs some explanation, because it cannot be continuous in the sense of an abstract mathematical variable, say length, in which a continuous line is defined in terms of infinitely small contiguous points. Rather it is continuous in the practical sense that current electricity is continuous; it obeys all the mathematical equations of continuous variables, even though it consists of discrete charged particles in the form of electrons, which by definition cannot form a continuous stream. The mathematics works because there are so many electrons in an electric current of any interest to us in the normal course of events. The equations break down when the electrons are considered singly.

Mutations are single discrete events separated in time, and so they cannot be contiguous even though the inputs into the process, or sources of mutation, are continuously applied. They are in no sense limited by rationing, because all individuals are bathed in continuous radiation of the same intensity. Therefore the shortest relevant period in evolutionary calculations is the time which elapses between the formation of a sustainable mutation at the conception of an individual and the time at which that individual procreates and passes the mutation on to its own offspring. There may even be a case that evolution does not become established until the mutation is paired with the identical mutation, which would be a form of inbreeding, and only likely to happen after it had been passed around through a number of generations. However, over a period of thousands of years it looks to all intents and purposes like a continuous process.

D. Diffusion of mutations through a population

In the light of this analysis it is possible to show how mutations diffuse through a species, which is in effect a population of individuals. If a mutation occurs in a population which is in a steady state, and it survives all the tests to become part of the evolution of a species, it will diffuse through the population at a rate which is determined by the time which elapses between conception with a sperm or egg of the parent containing the mutation and the appearance of the mutation in the sperm or eggs of its offspring, say about 15 years. The rate can be described in terms of the number of such periods, but of course this is the minimum period, because other factors affect the interaction of males and females, e.g. social constraints. The process of diffusion may be depicted as in Figure 1.

Eventually the mutation will enter every individual in the species, but at any time during this lengthy process the population will be composed of those who have been "infected" by the mutation and those who remain in the condition of the original steady state.

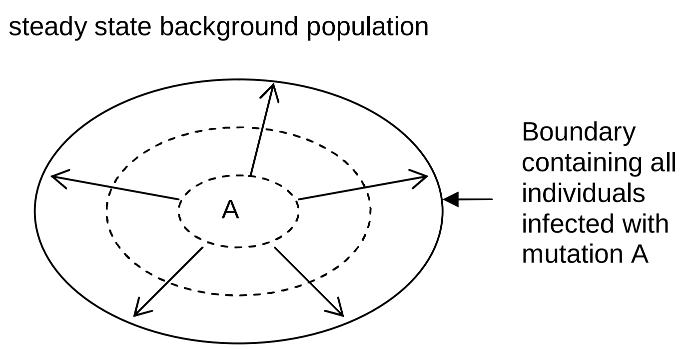

Figure 1. Diffusion of Mutation A through the Steady State Population

There is no reason why the steady state should be infected by only one mutation at a time. Mutation B might occur later, while Mutation A was still making its way through the population, but it would happen to a different individual, probably in a different place. The result would then be as shown in Figure 2.

The composition of the new population resulting from this would be as follows:

- Individuals in the original steady state, and
- Individuals with the mutation A, and
- Individuals with the mutation B, and
- Individuals with both mutations A and B.

The point here is that all these individuals would be contemporaries, not successors. If the two mutations produced what we now call different species, this mechanism shows how the species could be contemporaneous, at least for a time, both of each other and of a third species which combined both mutations. These might be embedded in the original population from which they all mutated, because there had been insufficient time for all individuals in the population to become infected with all the mutations, and reach the steady state.

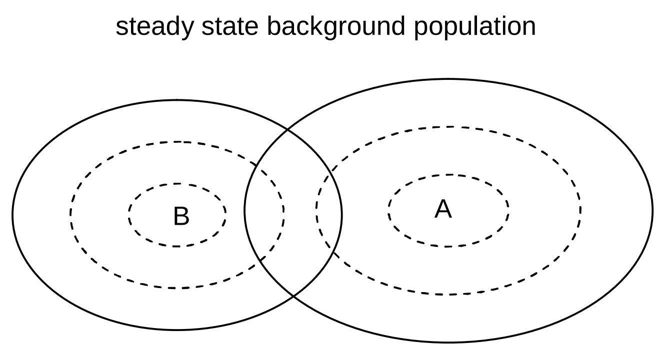

Figure 2. Diffusion of Mutations A and B through the Steady State Population

This process of diffusion says nothing about the nature of the results of genetic mutation on the individuals and eventually on the whole species. It is simply a chemical change resulting from exogenous inputs or imperfect combination. The results may be changes of morphology or of brain and nervous system. It is most likely to be both, that is evolution of the entire human entity. These results are the output of the processing of the inputs by the physical machinery of the individual.

E. Capability of the human brain

Recent observations of an adult chimpanzee in the wild showed it cracking a nut encased in a thick shell. The entire process which the chimpanzee carried out was finding the nut at the right time for eating, carrying it off to its stone anvil and smashing the shell with a stone hammer. The comment was made that this was a process which a juvenile would need years of copying and practice before it was successful. Humans by contrast could master the process in a much shorter time.

There are two parts to this. First, in neither case could the process of cracking the nut have been passed on in the DNA formed at conception. It must be a skill learnt during life, or else this DNA would have to include a process for doing everything which might occur during the individual’s lifetime, expected or unexpected. However, what can certainly be passed down by the combination of sperm and egg is the physical capacity of the brain which enables the individual to learn how to carry out the process. This is not the volume of the brain but the facility which allows what is detected by senses during life to be registered in the memory and recalled for use. It is this which is physically part of the brain and therefore the product of evolution. The chimpanzee must have it to some extent, but it is the size and scope of the facility in man which accounts for the wide gulf between the two, quite apart from any of the gross skeletal differences.

A second example concerns London black cab drivers. These are obliged to undergo an intense course of study lasting several years to memorise the entire road network in London, what they call the “knowledge”. A surprising finding is that their brains actually make new neurons relating to the acquisition of this “knowledge” i.e. the brain develops after birth in the direction which facilitates the gathering and use of the “knowledge”. Now knowledge of London road maps can scarcely be passed down through DNA, but the facility to develop in the direction of what the individual finds to be very important must be inherited in the DNA. This is one of several research findings which show that there is a genetic basis, common to all humans, which enables their brains to grow in response to senses in order to meet the particular demands of their environment. It cannot be growth of the entire brain, because the total physical capacity is restricted by the skull. Such growth must be a bias towards neurons in areas of the brain which are favoured by the individual’s senses at the expense of others which do not receive the same attention.

It is not simply the acquisition of facts but the ordering of them which enables processes to be carried out. It is processes rather than data which really matter for practical living, which leads to a further aspect of this facility. It is one thing to use it in processes in which the individual is directly involved, such as the nut and the chimpanzee, because one can imagine senses printing data on something in the brain by some kind of wiring mechanism. However, it is quite another to use it in relation to processes which are merely contemplated at one remove. It is even more extraordinary if events are just imagined, because this does not involve the senses, and so there is nothing to print. This is the basis of abstract thought.

It may be that intense learning based on this facility accounts for the success of humans; the mutation which first sparked it off would then be responsible for a major difference between man and the great apes. This would not necessarily be reflected in the rapid development of new technology as expressed by the artefacts which have come down to us, though considerable advances were achieved in the course of two million years. It is much more likely to be demonstrated through its use, both by individuals and in co-operation with others, and the evidence of this would be continued success in surviving, which would result in an increase in numbers of individuals against all the odds.

What has been described here is certainly known to those who study brain functions as “plasticity” etc, but its link to evolution and speciation of humans extends the concepts deep into the past and our very origins.

F. Learning systems

Evolution is not likely to be something that the individuals concerned can recognise, because it happens over timescales which are very long compared with the life of a human being. Even what in retrospect is apparently abrupt physical change may have taken place in smaller steps that do not strike anyone as particularly abnormal at the time. Individuals are not consciously involved in changing their human genetic identity.

However, what they can do is to respond to the environment in which they happen to find themselves at the time. There are new ways of organising for survival, which is interaction between individuals, and the technology which facilitates it. There is even an element of natural selection in this; those whose new ways give them an advantage tend to thrive, those who do not change tend to be at a disadvantage and fail.

No individual of the human species could survive for long by himself. Man does not have the strength or the speed to live as a lone predator or avoid becoming a lone prey, and the idea of individuals who live alone just meeting up to procreate, as some animals, do is absurd. The period of gestation and child rearing among humans is so long and the vulnerability so great that the imperatives of survival obliged them to live in groups or roving bands, say of the order of a hundred individuals.

This would give a very small gene pool, and limited scope for organisation and the development of tools. Everyone would be engaged in some aspect of the fight for survival. Nevertheless such a band would serve as the basis for a behavioural learning system.

The term “learning system” is described in my book on systems A Degree of Freedom (2). A system is a process for transforming inputs into outputs. The two important assets of a behavioural system are learning and creativity. Learning takes place in a system, when it adds to its store for later use the information gained about success of attempts to achieve the optimum result in a particular situation. The system detects that it needs to change in relation to its environment i.e. change its outputs, which is to say, make some alteration to what it does next time the same situation arises. It processes this information and feeds it back to its inputs, and these are then adjusted to give more relevant outputs as determined by the goal, which in this case is survival. Thus a learning system observes how well its attempts at optimisation worked in practice, and adds this information to its store, so that if the situation arises again, it can do better next time. Learning is better processing of inputs of information to produce better responses.

Creativity is quite different. The system looks at its environment, its inputs and its outputs, and then decides spontaneously that quite a different transformation would be more successful still. Creativity is inventing completely new responses, an unexpected way of processing inputs into outputs.

Analysing systems in this way is a general mathematical methodology for evaluating processes. But to give a more specific example, suppose hunter/gatherers observed that throwing stones only just repelled a predator, say a lion. The learning system response would be that they needed to throw bigger stones and aim better next time. They conclude that they have to train and practise. This would be how they would behave almost all the time. One might add as an aside that one has to survive to learn.

However, occasionally and much more rarely they might show a spark of creativity and do something completely different to achieve the same goal; they might have the idea of using long pointed sticks to repel the animal, what we now recognise as spears. If they were effective, spears would be added to their armoury for future use.

All this might seem a very slow process, but it leads to a gradual accumulation of know-how in the band which could turn out to be crucial for survival in the long run.

However, the products of learning and creativity are spread very much faster by the interaction of bands with each other, either peacefully or aggressively. For instance, there might be exchange of brides for gifts between two bands of hunter/gatherers. This would not only spread the genes but it would also transfer the technology embodied in the goods. In addition the brides might take their way of doing things with them, and if this is better than that already used in the band, it might be adopted by the whole band. Eventually best practice would spread to all bands which interact in this way. The more bands there were, the faster and wider it would have spread.

The other way of interacting is by aggression. If one band overcame another in battle, the likely outcome for the defeated would be that all males of or near fighting age would be killed, either during fighting or after capture, in case they seized the weapons and turned the tables on the victors. The women would be kept as concubines and their children would grow up in slavery. The victors would undoubtedly keep all the weapons, and adopt any useful practices which the captives brought with them. The result would be to spread genes, social organisation and technology in the same way as above.

This is a model of a species lifting itself up by its own bootstraps. The rate at which it rose would be proportional to the number of interactions between bands, and so the number of individuals in the species. The more successful it was, the faster the rate at which it would rise; their numbers would increase exponentially with time, and organisation and technology would similarly improve. Of course if they were not successful and not favoured by the environment, to use Darwin’s terminology, then they and the species to which they belonged would eventually disappear, which is natural selection.

This was the sort of thing that might have been going on for the most recent two million years of man’s existence on Earth, until the rules changed a few hundred years ago. Far from being a fallow period, it would have been a period of the greatest change in man’s existence. It would have been the time during which his transition from an animal-with-potential to a human being who was the ancestor of us all gradually took place.

G. The evolution of a species

Several things come together here. Irradiation continues to bathe all individuals, and so mutations in the species as well as numbers, social and technological improvements all grow exponentially with time. Bands would have had to spread out in the search for their own space in which they could live by hunting and gathering. The distance between them would depend on the concentration of the natural resources. The closer they were able to co-exist, the more the interactions, and the steeper the exponential curves not only for numbers but also for learning and creativity. The discovery of fire must have increased the available space, as did the Neolithic farming revolution much later.

Thus mutations must have continued to build up during the two million years of man's existence on Earth. They would have accumulated and diffused through the population, affecting both morphology and brain capability together as part of the same process. Nor is there reason to think that any single mutation or cluster of mutations would affect either the one or the other exclusively. They must have interacted, each promoting the other and evolving together. However, while we can observe the resulting morphology in fossils, we cannot converse with them to discover how mutations in the brain were helping them in their battle to survive. This would be evident only from their numbers.

It is known that many features are produced by several genes acting together. The analysis suggests that the mutations which produced these genes would have had to occur over a period of time, because the chances that random mutations would happen simultaneously are vanishingly small. The different genes would have appeared in different individuals in different places at different times and eventually made their way through the whole species.

Exponential accumulation of mutations may mean that any new ones have less and less effect. This is suggested by the fact that many physical characteristics can be traced to more than one gene or cluster of genes acting independently i.e. each appears to duplicate the actions of others, though of course that may happen only when they interact with the main body of the DNA molecule in which they are located. The system may be becoming increasingly resistant to change, or alternatively less and less able to adapt.

If so, this may be interpreted in two ways. Either man has developed to the point where he is stable and immune to further mutation. Or alternatively, he has reached a point at which he can no longer adapt to changes which are yet to come. He may need his unique ingenuity even more.

The current view is that species appear, endure for a time and then become extinct. During the period of their existence they are considered to be unchanging, which can be described as homogeneous through time. However, the new paradigm of this paper suggests that changes continue to happen during the existence of a species, even if they are not apparent to us, either now or in retrospect. This has been classified as semi-homogeneous through time (op. cit.). Semi-homogeneous through time means homogeneous or unchanging enough over one human being's timescales for the purpose of analysis.

H. Differentiation by climate

The analysis started from the hypothesis of a steady state with a balance of species and homogeneous populations. Disturbances were then introduced in the form of mutations to evaluate their spread. There was constant change driven by the sources of mutations, but the generation of mutations which could be passed down the generations was a most improbable process. Nevertheless, over the vast periods of time which evolution has at its disposal, it was bound to happen from time to time, however infrequently.

However, the reality of life on Earth is anything but steady state. The climate and the conditions on the surface of the Earth are constantly changing, not just the daily or seasonal changes, but secular changes long enough to affect evolution. For instance in this small country alone, man has been confronted at different stages of his evolution with subtropical forest and with frozen wastes and glaciers a mile high. Land bridges to the continent of Europe over which man, flora and fauna travelled were the normal condition, which made this a mere promontory of Europe rather than an island. Remains have been found of Mesolithic settlements under what is now the North Sea.

Much greater and vastly more important during the life of man on Earth have been the advances and retreats of the Sahara desert, flourishing with abundant flora and fauna for brief periods, but for most of the time a vast, hot, dry, impassable barrier to movement between Africa and Asia. Fortunately even brief geological periods are long compared with man's lifespan, which gave him a chance to spread across into the other continent. The barriers by contrast lasted almost an eternity.

These are just examples of the changes which regularly occurred all over the Earth during the comparatively short period of the last two million years, which are the most relevant to the evolution of modern man. The result was to create great areas in which the bands of humans, which are at the core of the preceding analysis, were in effect isolated, even if they were continent-sized islands. It became impossible for the genetic changes i.e. mutations to travel between these "islands". Since mutations happen at random, different islands got different mutations, which diffused through the "island" populations, as described above, and superficial differentiation took place in what was inherently the same ancestral species of mankind.

It was global climate change which led to the advance and retreat of glaciers and ice-caps, and opened up briefly the passages between Africa and Asia. But, of course, the different islands had different, varying climates, and this would result in different criteria for natural selection. This caused even more differentiation.

The intensity of radiation is greater at the equator than at the poles, and so the number of mutations is likely to be greater in equatorial regions. The rate at which mutations spread depended on the distance between bands of hunter/gatherers, which in turn was a function of the abundance of food sources, game, plants etc. Thus those near the North Pole, where all these are more difficult to acquire, are less likely to interact with each other. This is equivalent to saying: the sparser the population, the fewer the opportunities to interact, and the slower the transmission of genes through the population of the "island". Those caught in polar regions were likely to change less than those trapped in Sub-Saharan Africa.

Available surface area must affect these processes. In the context of this analysis the continent of Asia forms an enormous "island", of which Europe is merely a promontory, and it contains a wide range of climates in itself. Africa, even the part which is south of the Saharan barrier, is a gigantic "island" with the greatest variety of species on Earth. These "islands" are so large and varied that they contain "islands" within them caused by mountain ranges and deserts, so that movement of bands would be along restricted routes. Australia and the Americas have been separated from both Africa and Asia for far longer than man has existed, indeed since Gondwanaland. They would have been more difficult to reach, and so their involvement in human evolution is likely to have been limited by the rate at which man could reach them across the oceans.

The success of man's survival in these islands varied. All were subject to natural selection according to the climate of the time, because this was always changing, depending on geological factors. Thus the outcome of the process of evolution depended on when they evolved.

Those caught early in unfavourable climates would tend to disappear, even if they reached the same evolutionary level as survivors elsewhere. It is possible that this is what may have happened to the Neanderthals. It may be that they were caught for long periods in conditions of frozen landscapes and ice which made survival almost impossible. Meanwhile modern man thrived in much more crowded and congenial conditions in Africa, becoming slightly more sophisticated and resilient because of the interactions which this made possible. When by chance the Sahara happened to be passable, modern man spread out into Asia driven as always by drought and hunger. When they reached the more northerly latitudes, they proceeded to crowd out the less fortunate Neanderthals with their more sophisticated ways and greater, supporting numbers. From this fortunate starting position, they went on to occupy the whole world. The opportunity arrived too late for their competitors to seize it when the ice receded.

If this model is correct, the difference between them and us is largely a matter of lucky timing, at least initially.

According to the preceding analysis, these processes would lead to differentiation of technology and organisation around the globe, which would account for the spectacular but mostly cultural and social differences we see between human beings today.

I. Conclusions

The evidence which is currently available seems perfectly compatible with the proposition of this paper that human evolution is a continuous process. The corollary is that human morphology and mental ability should show gradual changes over the period of two million years, if we could see them directly. However, just a very small proportion of the remains of individuals would have survived, and then only as skeletal remains. Fossils are a sample of these from different places and periods, because we cannot recover all of them, and they seem to be revealing an increasingly complicated process of global development. It is likely to become even more complex as the work of finding and classifying fossils grows apace. The model of this paper provides a different backdrop against which to evaluate them.

Complementary to the human remains are the artefacts which they left behind, which are valuable as indicators of the state of the capability of the brains of the humans who made them, especially if they are found together with fossilised remains e.g. in burials. However, they are an incomplete record, because no wood, which is the natural and abundant source of tools and weapons, survives this length of time. Nor does the animal tissue which would have been available after every kill for use in wooden constructions. Tribes who follow deer herds today still have sophisticated uses for sinews, and even the Romans used animal intestines as elastic in their war machines. By contrast rocks and stones survive, and they show that they were progressively refined into cleverly manufactured weapons, tools and ceremonial artefacts, and perhaps even because someone liked them (what we might call art).

Species are a difficult concept in a continuous process because apparent stability seems incompatible with perpetual change. Species cannot be homogeneous through time, when all life is bathed in a continuous flood of radiation and suffers the trials of erratic reproduction. The steady-state hypothesis is useful for analytical purposes, but it is clearly not adequate to describe what actually happened. We know that life must have evolved continuously from the beginning three and a half billion years ago, and so there must have been progressive change on that timescale. Ancestral species themselves had ancestral species, though their nature and location is another step back in time.

What we see as a species is a class of individuals, linked by procreation, in a period of apparent morphological stability, even after or because of the relentless sifting of natural selection. Such a period may be very long in human terms. Mutations which could eventually lead to morphological change may nevertheless be accumulating with time. Those which lead to evolution of the brain likewise accumulate with time, because brain and morphology evolve together from the same cause and interact in the process of forming modern man. There is no way of detecting this in fossil remains, and it may be difficult to detect in present individuals because of the very long timescale, but evolution of the individual as a whole led to the learning systems which ultimately distinguished modern man from his more animal-like ancestors.

Time is the only direction in evolution, space complicates the outcome. Furthermore, if there is evidence that the continuous process of mutation reaches saturation in the effect which it has on the characteristics of species, say some of the more complex mammals like ourselves, the question is what next? There will always be something next, because the causes of mutation continue to befall the population as they always have in the past: the process of change does not stop. At least 95%, and perhaps 99% of all species which have existed on Earth are extinct. So, extinction?

Part of the change today is that the big “islands” which have been fundamental to evolution for the whole of life on Earth, at least since it left the oceans and moved onto land, are no longer entirely separated. The rapidly growing population of human beings and their increasing movement around the globe are overriding the divisions, and bringing more people and the life forms on which they depend into juxtaposition. The “islands” are beginning to merge into the biggest island of them all: the Earth.

To define the process strictly, it is not evolution but co-evolution (op. cit.). Everything else alive changes too, also driven by the forces which produce mutations, and naturally selected in their turn by their total environment which comprises all other entities living at the same time, including us. Whereas most species become completely extinct, some of the earliest life forms remain more or less in their original forms alongside the mutated species which were derived from them e.g. viruses and bacteria, not least because of the “island” effect and isolation. Any new species are likely to emerge from earlier forms, as they did before, but their evolution and their effect on man will perforce take quite a different route.

The quote at the beginning of the paper looks increasingly apposite, as we consider the extraordinary complexity of life forms produced by evolution. Man is but one example which has existed for the short period of the last two million years. It was all driven by mutation, isolation and the climate. If there had been perfect mixing, nothing of note would have happened over three and a half billion years, because each life form needed some protection from the others. Similarly if all individuals had enjoyed exactly the same unchanging climate, there would have been no reason for differentiation; it would all look blandly the same. These are the simple forms or differences of things, which are few in number, and the degrees and co-ordinations wherof made all this variety. Once life had been initiated, the rest was evolution.

This model is difficult to represent, because of the complexities of time and space. Mutations which have resulted in evolution have spread like ripples through populations of individuals, but almost all have been eventually been extinguished by the circumstances of their environments, which fluctuated stochastically with the changing geology of the Earth.

Species, therefore, are what I have called semi-homogeneous through time. The concept of variables which were homogeneous through time was coined by John Maynard Keynes who was furious at the misuse of mathematics on his economic model. He described the mathematical equations as "symbolic pseudo-mathematical methods" which were "meaningless concoctions…because economics in too many respects is not homogeneous through time" (3). The present situation shows that economics has unfortunately not evolved beyond the state to which he objected so vehemently.

However, semi-homogeneous through time seems a useful half-way house between the poles of the current assumptions of absolute homogeneity on the one hand and complete non-homogeneity on the other, when discussing species and real-time evolution. What is remarkable is that Keynes was also related to another man who had views about evolution: Charles Darwin.

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25 January 2010
17 February 2010 added second Bacon quotation

References

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