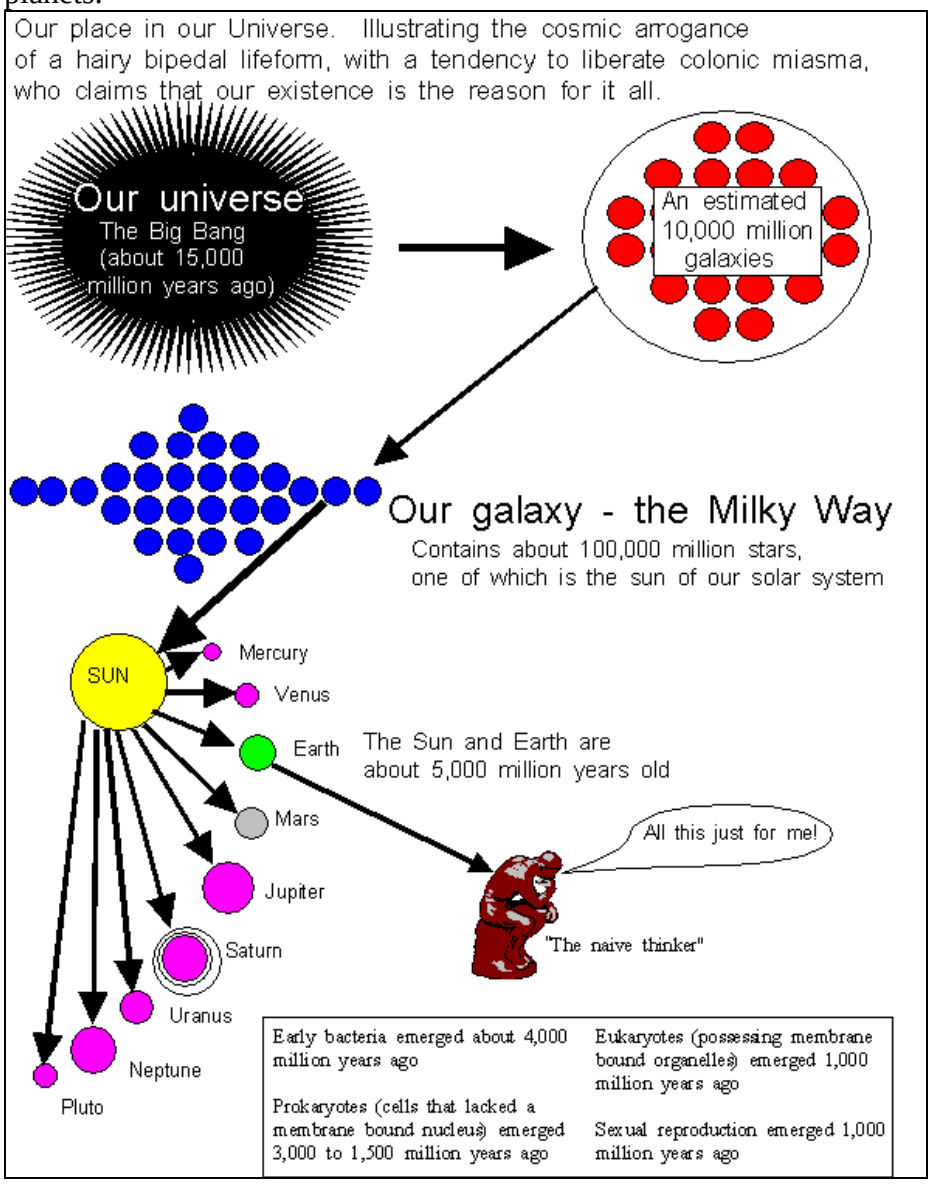
THE BIG BANG

"To begin at the beginning"

It appears that everything began about 15,000 million years ago with our Big Bang when everything (time, space, matter and energy), came into being. Naturally, it is not known whether there had been previous abortive Big Bangs. Probably most universes collapse shortly after their formation but at least one (ours) has not done so yet.

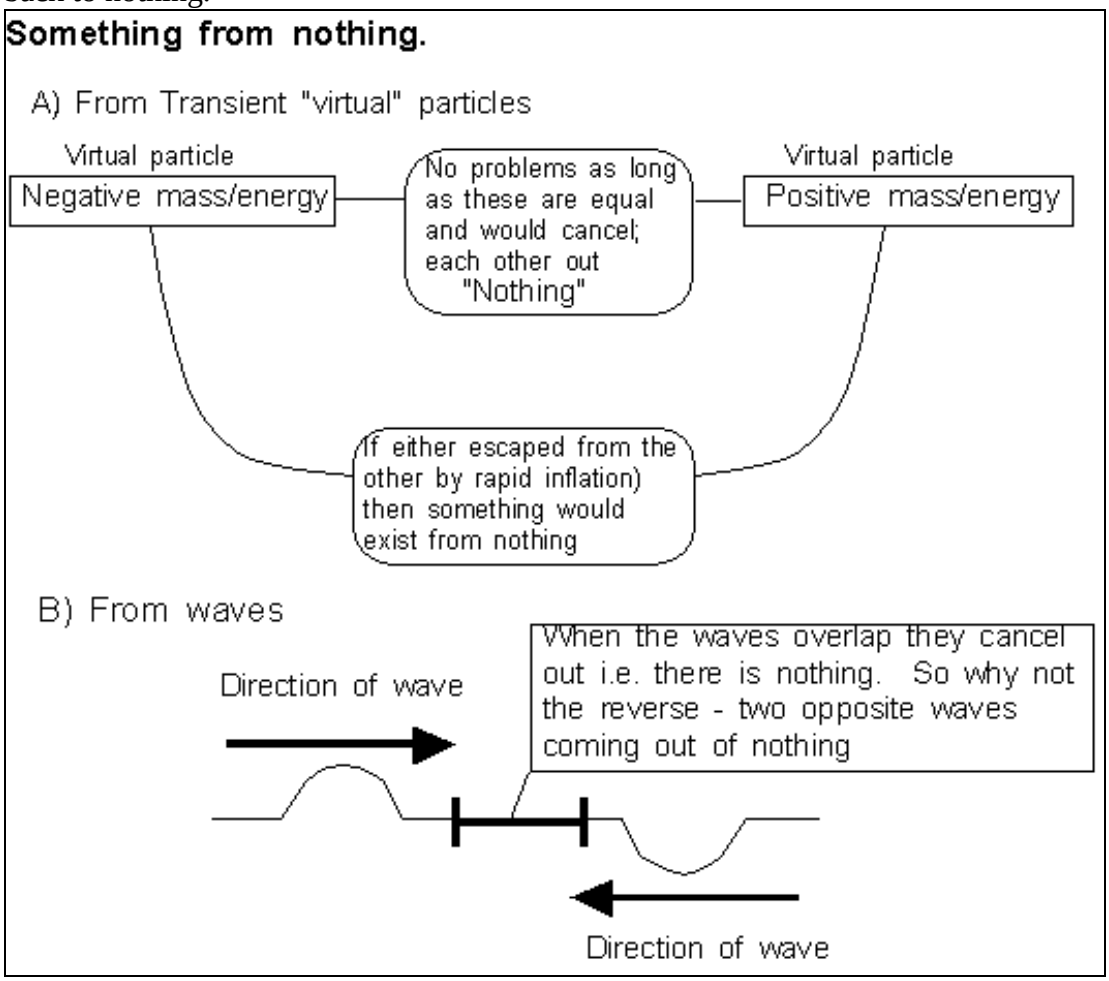
The evidence for the Big Bang is that we are in a Universe that is expanding, there is radiation coming from all directions, and ratios of deuterium and helium are as would be predicted from mathematical models.

After the Big Bang things began to quieten down with the formation of our galaxy which is 100,000 light years in diameter containing 100,000 million stars. There are at least 10,000 million other galaxies and an estimated 100,000,000,000,000,000,000 planets.



It is not known exactly how the Big Bang occurred but the requirement for a violent explosion seems evident if the current Universe then occupied a space of 10^{-33} cms. But how did the Universe come into existence seemingly out of nothing? The essential realization is that, if the Universal Bank could be closed, with time, space, matter and energy in all its forms were all recalled and all debts paid, *then there might be nothing left.* Surprisingly creating something out of nothing is a trick that earth-bound Banks do all the time! Banks often give total loans of more paper money than they have resources. But because those to whom the Bank had lent paper money ("nothing") by and large succeed and create real things the whole enterprise succeeds (the American west was developed using such loans - if everyone, as was their right, had demanded gold for their paper money the Banks would have collapsed). The Universe apparently came into being using a similar trick. It is uncertain whether the Big Bang contained irreversible features such that the "Universal Bank" might not have to close, and it is uncertain whether the Universe will continue to expand or will contract back to nothing "the Big Crunch."

Energy and/or matter "virtual particles" can come into existence out of nothing (they have been detected) for an *almost* negligible time before canceling themselves out back to nothing.



But if in that time these "original entities" were able to escape annihilation and separated then, in theory, a universe could be created. If these "original entities" happened to travel at the speed of light then relativity tells us that they could have

escaped annihilation as they would be everywhere simultaneously (time does not pass at the speed of light).

Key dates for your calendar
Big bang about 15,000 million years ago
Galaxies formed 10,000 million years ago
Sun and solar system formed 5,000 million years ago
Earth formed 4,500 million years ago
Life developed about 3-4,000 million years ago
Multicellular organisms developed about 700 million years ago
Life moved from seas to the land about 400 million years ago
Trees and forests came into being 370 million years ago
The crawl from the swamps onto land started 360 million years ago
Dinosaurs became extinct 65 million years ago. *We never met them*
Chimpanzees (with whom we share 98 percent of our genes) split from our ancestors about five to seven million years ago (the common ancestor has not been fully identified "the missing link")
The oldest hominoid was *Australopithecus* (southern ape) which first appeared about 4 million years ago. *Australopithecus* was about four feet high, lived in social groups, had 400 ccs of brain and was bipedal
Stone tools were being used in Africa about 2.5 million years ago
Homo erectus developed about 2 million years ago
Homo sapiens developed about 500,000 years ago
Neanderthals were using fire about 100,000 years ago
Cro-Magnons were artistic and were using tools extensively 40,000 years ago

Karl Popper has pointed out that, ultimately, theories (including those about the origin of the Universe) can never be proven, they can only be disproven (and the so-called theories that explain the laws of science are only theories that have not yet been disproven). The onus is not on scientists to "prove" their theories but to find evidence that disproves each theory so that a better theory can emerge. It appears that scientists are close to explaining how the Universe could have come into existence, but they will never be able to prove it. They will be able to postulate *how* but never be able to answer the Ultimate Question "*Why*." But they can ask "Why not?" and this is much more difficult to answer. The paradox is that the definitive answer to the Ultimate Question is a question. Perhaps the Universe is just one of those things that happen from time to time?

Where did life come from?

What constitutes life is difficult to define and it may be that life does not come into existence at a particular point, except in human classifications. The interaction of environments and self-replicating, occasionally mutating, entities may make development of life almost inevitable.

Is life only present on our planet?

Since there are an estimated 100 billion billion planets in the Universe is seems unlikely that life only happened on one. Why have we no evidence of life elsewhere in the Universe and, if life does exist elsewhere, why have we not been visited by civilizations more advanced than ours? There are five possible answers:

- Interstellar spaceflight is impossible: this seems unlikely
- Aliens for some reason do not wish to visit us; no comment!
- Alien civilizations are rare, do not exist, or destroy themselves (as I write scientists are performing experiments in particle accelerators to determine what may have happened just after the Big Bang. I find this worrying)
- The distances (and thus the time) involved make interstellar travel unlikely (the nearest star system is 4.5 light years away)
- Alien life forms that might visit us would be too intelligent to want to bother. If they had the technology for interstellar travel what would they have to gain from studying our primitive achievements? Some human life forms that claim to have been abducted and studied by aliens are not renowned for being typical examples of humanity.

Perhaps we have been lucky not to have been visited. The history of evolution suggests that more developed life forms tend to displace, or at least exploit, less developed life forms.

To survive in a changing environment an entity, be it chemical or living, would have to be very stable (almost independent of the environment) or able to undergo changes in response to those of the environment. Carbon is a stable element and some carbon based compounds can replicate themselves and carbon became the basis of what would become life on earth.

Natural selection

The environment has continually changed, and entities were (and are sorted) according to environmental pressures. Some entities were favoured by prevailing environmental conditions and some were not. Chemicals and, later, organisms were sorted just as stones on the seashore are sorted by the waves (the environment). Some entities varied (mutated) from the average and had greater individual survival potential in favourable environments. This is natural selection.

The principle of natural selection applies not just to life but to all entities, ranging from stones on a beach and perhaps even including Big Bangs and other Universes.

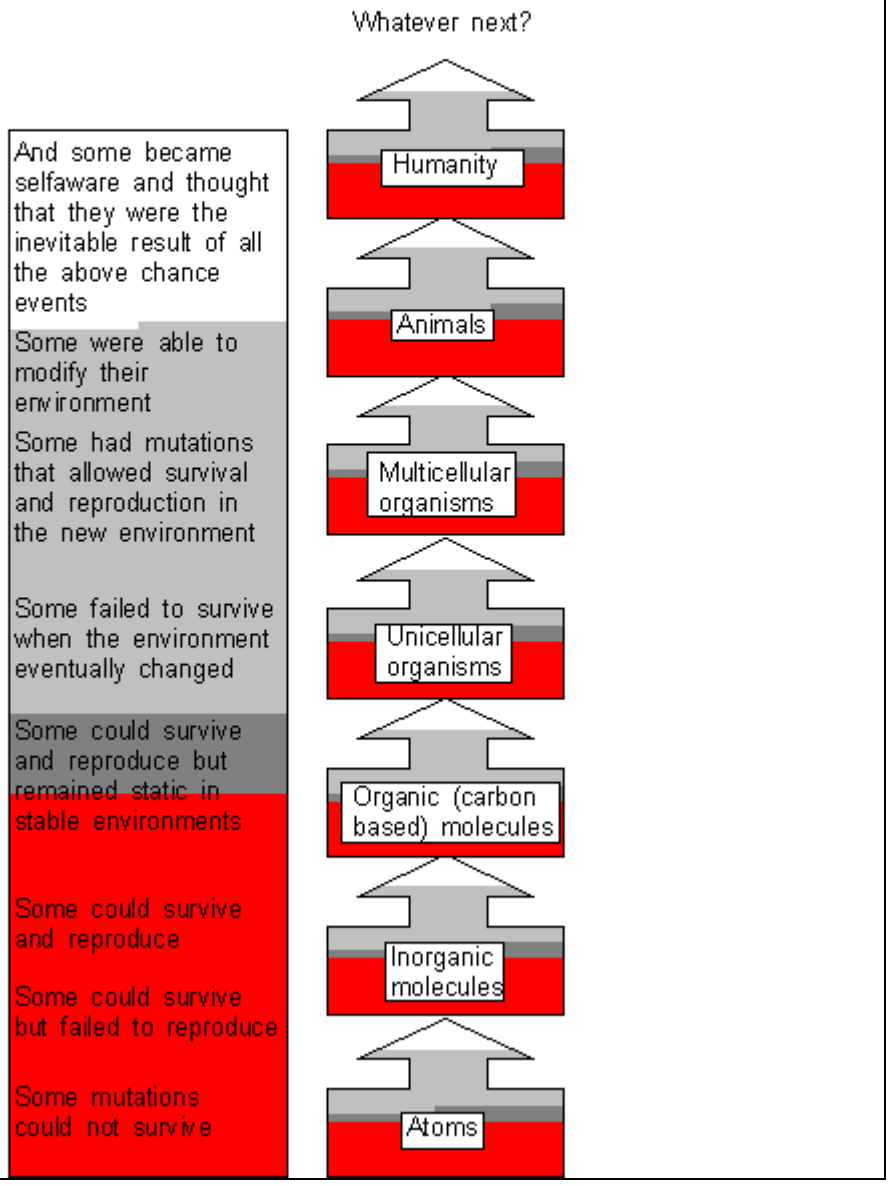
Darwin's fundamental realization was that variations occurred *before* the sorting process of natural selection and that the mechanism of evolution was 1) The occurrence of random variations inherited from "parent" organisms (and that these specific variations were not induced by the environment) and 2) natural selection then sorted out the more beneficial variations in the prevailing environment whose possessors would be more likely to survive and pass on their inheritance to their offspring.

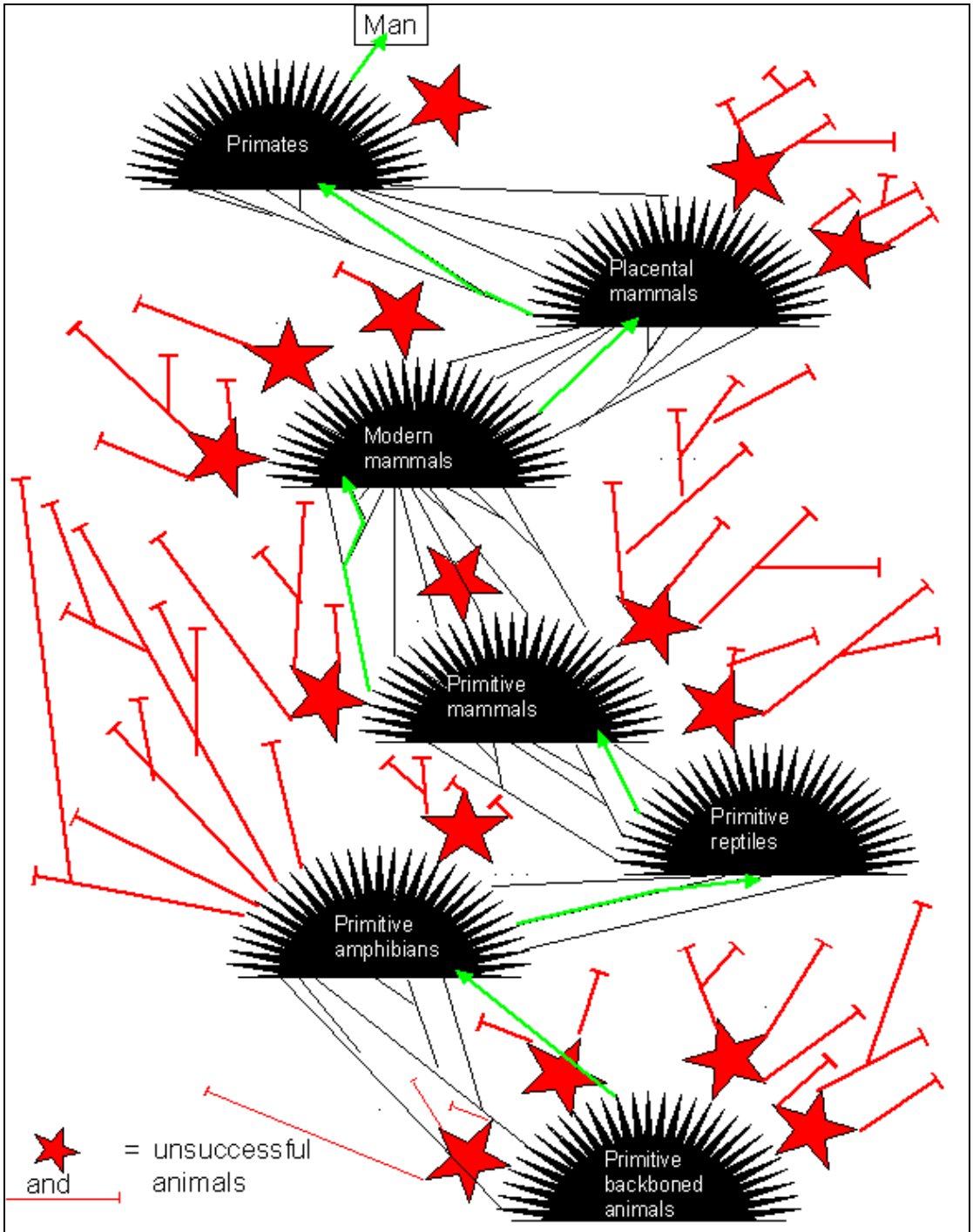
In the case of life on earth the environment sorted living entities that contained inherited "genetic" information and the variations were termed mutations. Natural

selection sorted the successful individual organisms and thereby selected the genetic information, the genes, which would survive in the longer term (see under genetics in the section on reproduction). Evolution, unlike natural selection, is irreversible in that it would be most unlikely that a mutation could unmutate. Over time cumulative natural selection would occur and chains of organisms, each link of which would only have survival value for the local environment at the time, would develop. Surviving "successful" chains would only be recognized in retrospect and, had environments differed, then the end result could have been very different (for example dinosaurs and not man might have been the survivors). Seen in this light it is truly cosmic arrogance for man to consider himself as the end result of anything other than a succession of fortunate environmental changes and random mutations "mistakes" since life began.

Evolution of humankind

Humanity did not develop because of a purpose. All our ancestors merely coped better than others with the environment at the time. We are not at the apex of a pyramid of achievement. We are the remnants at the top of a pyramid of discards.





Evolution of man. A simplified flow chart illustrating that many more mutations fail than succeed.Those that survive do so because of phenomenal good luck not because there was any purpose or planning. Rather natural selection repeatedly prunes the tree of variation

It is most humbling. No wonder the implications of Darwin's theory do not meet with universal acceptance.

When natural selection acts on organisms that produce variations by shuffling *two* genetic pack of cards (sexual reproduction) then evolution proceeds faster than by non-sexual reproduction which only involves variation in *one* genetic pack of cards.

Thus sexually reproducing organisms were at an advantage (see under genetics in the section on reproduction).

An organism that has a mutation has to integrate with the rest of its (genetically determined) intrinsic attributes to allow increased survival to reproduce in the environment - if this were not so then mutations would proliferate unchecked and total survival prospects for whole organisms would literally disintegrate - and this explains why most successful mutations were small in nature. A large mutation in an individual would be unlikely to be of survival value unless the environment instantly changed to favour that mutation. Not impossible. Just very unlikely. The vast majority of mutations that occur are disadvantageous to the organism as a whole which would not survive to reproduce.

Only a small minority of mutants survive to offer an increased chance of reproduction but these mutants would become predominant and they, rather than their less adapted relatives, would produce *further* mutations some of which would in turn favour survival for reproduction. In time descendants of the original organisms that did not show significant life-enhancing variations would die out because they would not have adapted to the changing environments.

Evolution only occurs when mutations are exposed to natural selection. Contrary to popular thought natural selection usually *restrains* evolution which would otherwise happen at the mutation rate. In practice "the tree of possible mutations is pruned by natural selection."

As generations passed cumulative changes would cause some organisms to develop such "genetic distance" from their ancestors that interbreeding to produce fertile offspring could not occur - a new species would have branched off.

DARWINIAN EVOLUTION REQUIRES:

- A fairly stable inheritance pattern
- Copying and thus perpetuation of that pattern in offspring
- The offspring to vary occasionally - mutations
- Different survival and reproduction potential conferred by mutation
- Sorting pressure, natural selection, by a changing environment (otherwise things would become static)

Evolution thus has no direction or purpose (many possible adaptations that should have occurred if evolution had a purpose have not occurred). Just because we are able to identify a chain of advantages that survived does not mean that the chain was planned or that there was a purpose. What we see today are just the fortunate survivors of a sequence of advantages relevant at the time. If environments had been different we would not be here today in the form that we are.

It is tempting to claim that certain features evolved to fulfill a purpose but this is "the sin of anticipation in retrospect." Many believe that the thumb evolved to allow tools to be grasped yet no one would believe that the thumb evolved to press the space bar

on a computer keyboard. Yet the computer keyboard is still a tool. Stated more explicitly no organism evolves actively, organisms are evolved passively.

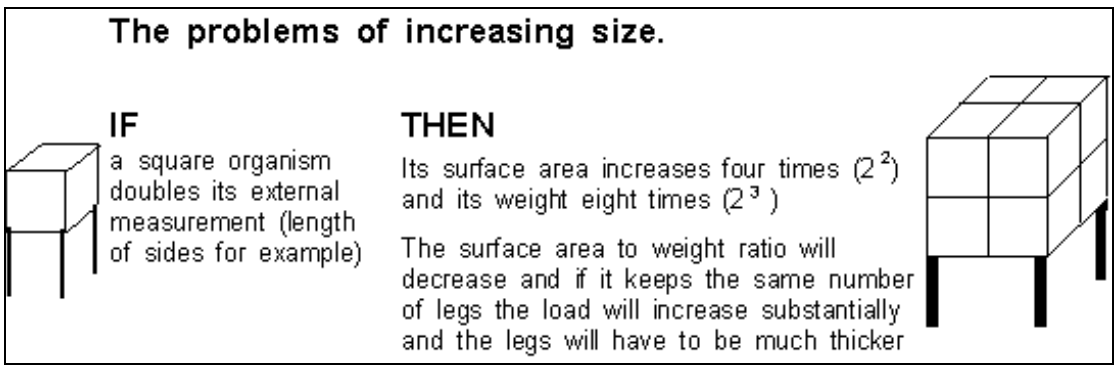
We are in a post-Darwinian era when we have the genetic capability to induce or correct mutations *for a purpose* although this author suspects that we will not face up to the implications of this and that silicon based life forms will take over and, in the not too distant future, computers which will possess all the arbitrary characteristics of life, including the capacity to run factories reproducing themselves, and will sit around wondering if they were the inevitable result of purposeful evolution.

The *only* question to ask about evolution is "Why no one had Darwin's insights centuries before he did?" His insights, like most significant insights, are obvious once the imaginative leap has been made. The mechanism is simple (although the consequences are hugely complex). If it were incorrect refutation would be easy. As it is we can see evolution down microscopes. For example bacteria are being evolved all the time by environments (specifically antibiotic environments) to develop antibiotic resistance.

Organisms were initially single celled and were (sea)water based. They, or early multicellular organisms, would have been spherical and nutrients had to diffuse in from the environment. This limited size. A squashed sphere (a disc) would have allowed nutrients to diffuse in but, as internal areas became specialized, a front and a back developed and a rod-like body developed. Unicellular organisms could not become big enough or complex enough be selected for complex existences (although they could reproduce much faster to exploit relatively simple environments), whereas multicellular organisms had a better chance of surviving selection pressure in complex environments.

Our more remote ancestors came from the oceans, almost certainly via fresh water in estuaries (we are left with some remnants of our ancestry in that we have diving reflexes, partial webbing of the fingers and we can hold our breath under water for several minutes).

Eventually organisms invaded the land. Any organism that evolved to be mobile, living in the air and moving on the land, would have to be reasonably large and this creates problems.



If a "cubic animal" doubles the length of one of its edges, then the surface area increases with the square of the length and the volume (and usually the weight) by the

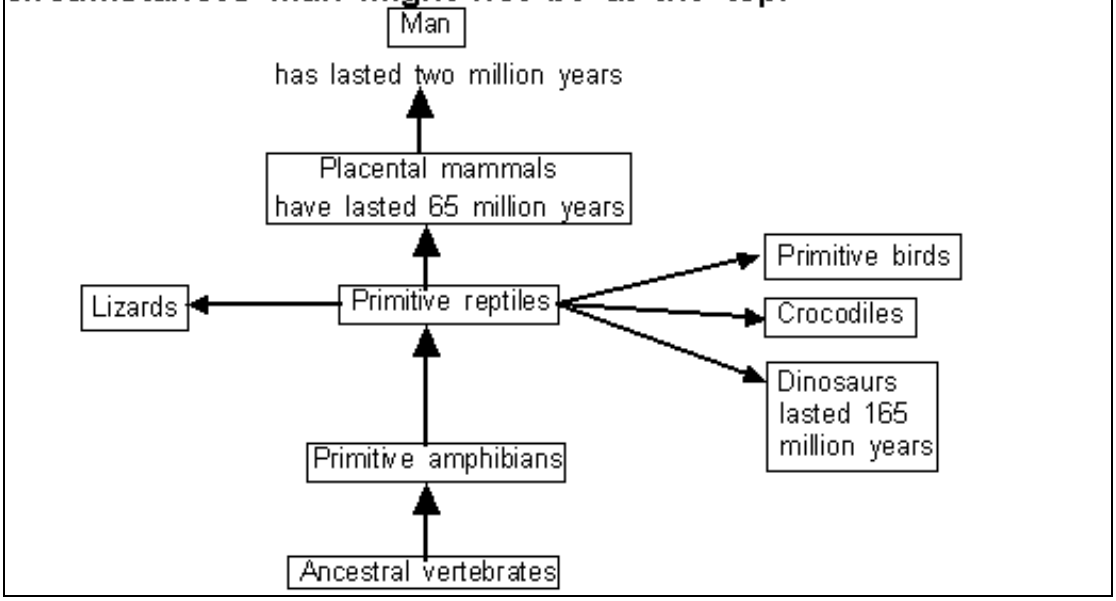
cube of the length. The problem is that the surface area available for certain functions (such as gas exchange and absorption by the gut) has to be in proportion to the body mass to be supplied. The problem was solved by cumulative selection of mutations which thereby came to possess increased surface areas such as honeycombed lungs and multiple projections into the gut.

The geological periods, the evolution of man, and the various kingdoms of life are shown below, followed by the geological period and what happened in each.

Geologic periods, timings, and notable features

Era	Period	Time in years since begining of each period	Epoch	Notable feature(s)
Cenozoic: the age of mammals, has lasted about 65 million years	Quaternary	2 million +	Holocene	Modern species. Man dominant.
			Pleistocene	Large mammals. Ice ages
	Tertiary	65 million	Pliocene	Modern type mammals appear
			Miocene	Grassy plains and grazing mammals
			Oligocene	Modern mammal families arise
			Eocene	Modern mammal type arise
			Paleocene	Primitive mammals
Mesozoic: the age of reptiles, lasted about 165 million years	Cretaceous	130 million		Flowering plants, extinction of large reptiles
	Jurassic	180 million		Reptiles dominant on land, and in sea and air.
	Triassic	230 million		Dinosaurs and trees
Paleozoic; lasted about 340 million years	Permian	280 million		Progress of reptiles, amphibians displaced. Ice ages
	Carboniferous	400 million		Initial reptiles. Amphibians spreading
	Devonian	350 million		Fish, early trees, forests, early amphibians
	Silurian	450 million		Plants developing on land
	Ordovician	500 million		Vertebrates developing
	Cambrian	570 million		Invertebrates appear

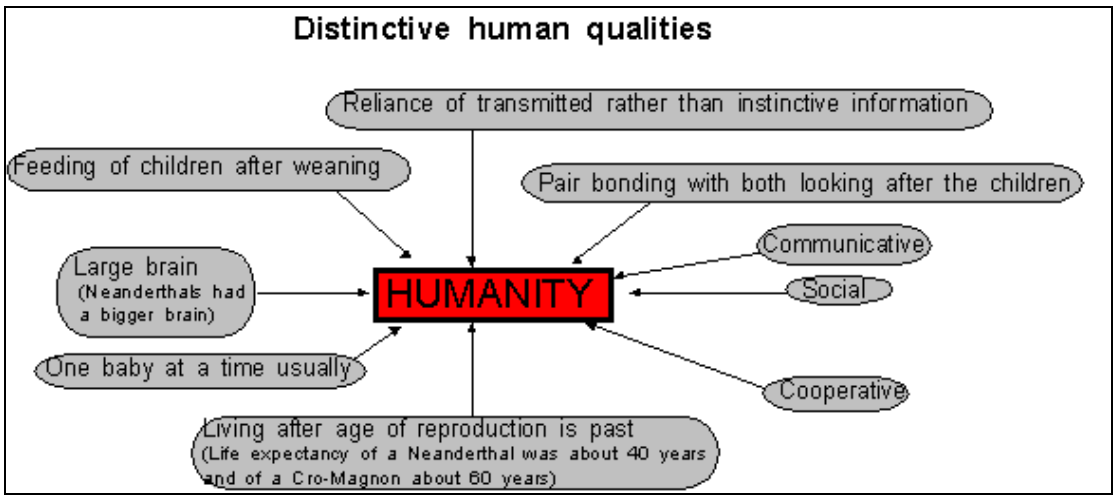
The evolution of man as seen in retrospect. Given different circumstances man might not be at the top.



The Classification of Living Kingdoms.

Single celled with no nucleus	
Single celled with a nucleus	
Fungi	Absorb nutrients from the environment
Plants	Photosynthesize
Animals	Some have spinal cords - **chordates** Most chordates have backbones - **vertebrates** Some vertebrates are warm-blooded, have hair and have mammary glands - **mammals** Some mammals have eyes in the front of their heads and have grapsing fingers and toes - **primates** (some of the earliest know mammals were primates) Of modern primates only *Homo sapiens* always walks upright

Having said all this and placed humanity as the latest development. I actually believe that computers constitute an evolutionary saltation that may well replace us all in terms of colonization of the galaxy (the galaxy is too big from time-limited carbon based life form to colonise).



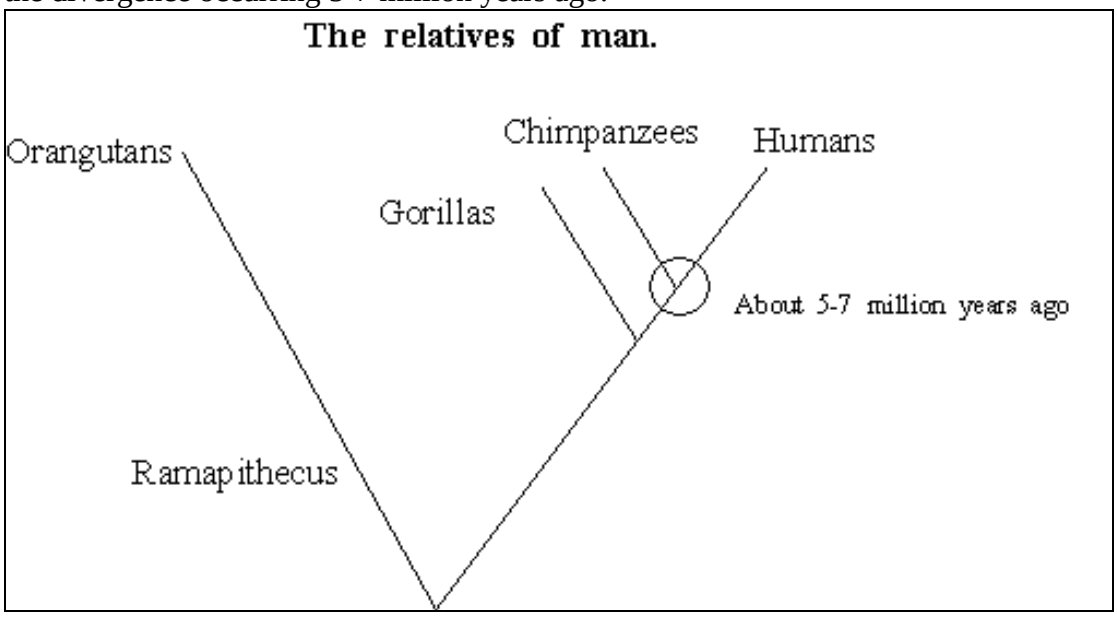
Natural selection favoured warm-bloodedness in some land-based animals as it allowed chemical reactions to be more predictable, reliable, quicker, and independent of the environmental temperature. However an ice age would kill off complex but

non-intelligent life and naturally select intelligent organisms that could keep themselves warm unless they happened to live in the tropics where there were less extremes of temperature. It may be that continuously warm areas provided many mutations but natural selection was more vicious (more selective) in the peripheral and less warm areas.

Animals which mutate and, by luck, found that their mutation(s) allowed them access to an advantageous environment also were able to flourish. It seems that the ancestors of man (the primates) took to the trees and those who were most successful in this environment had:

- Rapid agile movements
- Good senses including stereoscopic vision
- A good brain which could learn new tricks
- Versatile limbs
- Balance
- Self awareness

The primates took to the trees, developed fingers with nails, eyes at the front (rather than the side) of the head and, by about 40 million years ago, developed a forelimb that was not weightbearing. Release of the forelimb from a weightbearing role allowed it to be used for other activities including swinging, grasping and later tool *use*. Instead of a forelimb there was an arm and a hand, which released the mouth from its predation and defence role, and allowed the mouth to be used for communication. Later man became a *make*r of tools. Apes developed from Old World monkeys about 24-30 million years ago. Humans share ancestors with chimpanzees, the divergence occurring 5-7 million years ago.



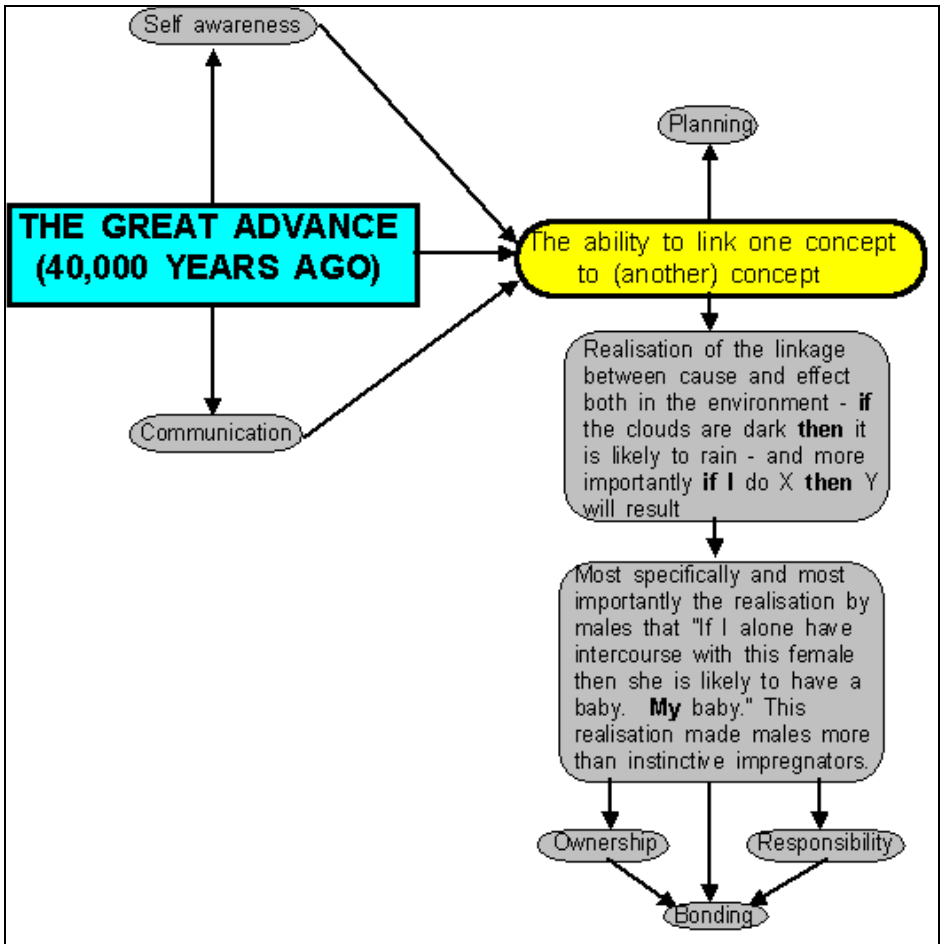
Some DNA studies have suggested that all present human beings can be considered to be derived from a single source about 200,000 years ago, almost certainly in Africa. Why this strain of our ancestors developed and all other strains, notably the Neanderthals, vanished is an interesting question.

Subsequently walking on two legs (bipedalism) extended the range of vision and left the upper limbs free for tool use and carrying food. Tool use was obviously extremely

useful but to use a tool implies that the animal concerned could conceive in a mind that an object could be so used, and once this had occurred then the next evolutionary leap forward was the making of tools, an ability which requires forethought and planning. The ancestors of man were thus successful because:

- They could use tools
- They could make tools
- They could reason logically
- They learnt to cooperate
- They developed language
- They developed self-awareness

About 40,000 years ago there was an abrupt change from previous animal existences. Art, sophisticated tool use and culture erupted. Why? Almost certainly there were several factors that acted together.



The multifactorial nature of the Great Advance towards humanity that occured about 40,000 years ago. To my mind the realisation that intercourse led to babies (something that occurs only nine months) must have been one of the greatest discoveries ever made

So there it is. We are basically a self-aware intelligent adaptable bipedal African ape with our nearest relative being chimpanzees. Every one of our ancestors reproduced before dying which makes each one of us highly unlikely, but not special.