A VIEW OF EVOLUTION BY A CHRISTIAN BIOLOGIST

Elizabeth Jordaan[1] and G.C. Loots[2]

ABSTRACT

This paper, which originated as an address to a gathering of Dutch Reformed Ministers in Potchefstroom, deals with the response of a Christian to concepts of evolution. The paper looks at the concept of "the beginning", the origin of life, genetics, mutation and natural selection, the origin of diversity or speciation, man as a biological species, the missing link (in which attention is given to various theories), and finally theories of human evolution. These include the neoteny theory, the savannah theory and the aquatic theory. Following a discussion of the various aspects of these theories, the authors go on to a discussion of the evolution of intelligence and culture, and reach the conclusion that "for a Christian, evolution may help him to understand more about God and his love and his work, and also then to have more security in the belief in God".

INTRODUCTION

Students of the biological and physical sciences are confronted with the concept of evolution quite early on in their courses of study. Their first impulse is usually to reject the concept out of hand, for up to now the majority of Afrikaans-speaking students have grown up with the idea that everything remotely connected with evolution is by definition atheistic. The layman usually only recognizes organic evolution - the evolution of living things. But that is not all that is meant by evolution at all. There is a sort of instinctive tendency to compare the concept of evolution with the Genesis story of creation, but is this contrasting of science and the Bible valid? The Bible is the true Word of God, and God in turn is the source of all scientific endeavour. God can also be glorified by his handiwork being opened up by man, and surely man can interpret

[1] College of Agriculture, Potchefstroom.

[2] Dept of Zoology, PU for CHE.

God's handiwork and so come to a better understanding of his Greatness.

There has never been a culture, primitive or sophisticated, that has not had an explanation for the origin of the world we live in (König, 1982). By his very nature man needs an explanation for everything he encounters. Any particular explanation might not be the correct or the most useful one, but it usually suffices until a better one is presented. Man has always wanted to know by which forces and processes the universe and everything contained in it came into being. The Bible does not provide a scientific explanation. The unique character, and with it the primary significance of Genesis, lies in the affirmation of a single God-creator in a world that knew only innumerable idols and gods caught in an eternal struggle for supremacy - and none of these gods or idols could explain adequately why or how man and the universe came into being. The purpose of this paper is therefore not to attempt to harmonize the concept of evolution and the Bible, for they are two completely different ways of interpreting something that man can neither prove nor disprove. Knowledge allows man to understand more of the universe he inhabits and man's hunger for knowledge and freedom can be brought into harmony with religion.

The word *evolution* means to *change* or *to unfold* (Holmes, 1979). But there is a difference between the philosophical concept of evolution and the scientific concept of evolution. The former tries to explain evolution by turning it into a form of religion, and the second tries to explain it in terms of human standards, something that is to be observed in the world around us. This is done by means of postulating theories on a subject that has fascinated man for ages. Theories are all very well, but can only be proved as facts when they are supported by results of experiments done in the laboratory, and this is of course not possible when it comes to biological evolution.

The concept of evolution was first established in the biological sciences with the study of organic evolution, but this soon

extended into other fields as well. Students of inorganic fields of study such as the life histories of stars and the formation of chemical elements have also adopted theories of evolution, and gradually scientists are coming to the realization that biological evolution, which is generally thought of when evolution is mentioned, is only one aspect of evolution in all its ramifications. Evolution can in the last analysis be defined as a directional and essentially irreversible process, occurring in time, which in due course gives rise to an increase of variety and an increasingly higher level of organization in its products (Morris, 1981). But: EVOLUTION IS NOT SELF-SUFFICIENT AND SELF-SUPPORTING: IT IS DIRECTED BY GOD.

WHEN WAS "THE BEGINNING"?

The mysteries surrounding the origins of the universe have occupied men's minds since the dawn of history. Many explanations attempt to go beyond the bounds of man's imagination, for man is not content to have no explanation. Theories have been proposed based on man's observations of the universe as he sees it in an attempt to present the natural world as an event that is taking place within the context of time. It is essential, in the light of this, to keep an open mind about "the beginning". For everything in the universe there must have been a beginning - somewhere in time. But where did time come from? Time is an entity that we cannot fully understand. We can't even begin to define it because of this inability fully to understand it without reference to matter and to space. To make intelligible use of time we conveniently divide it into components that we do understand, such as hours, days and weeks - and then it becomes a man-made concept. Through physical laws an attempt is then made to conceive of and to understand what is observed.

Surprisingly precise figures can be provided for the physical age of the universe, and there are various ways in which this can be done. It is fascinating to see what can be done with modern technological equipment to obtain such details

and be able to determine ages that range from 500 000 to 10 000 million years - which is regarded as being the upper limit in time. The universe is estimated to be 10 000 million years old, with our sun being between 4 700 and 5 000 million years of age, and considered to be in its "middle age". The most reliable dating technique is based on radio-activity. Radio-active matter, such as uranium, thorium, etc. decays in accordance with precisely-known laws to form other elements. For example, lead is formed of uranium through a series of other intermediate elements, so that, if uranium is found in a rock, the age of the rock can be calculated from the relative proportions of materials left behind. If this procedure is applied to rocks from the earth's crust, the greatest age yet revealed has been 3 700 million years. Different ways of calculating time and age corroborate each other (Gibbon, 1981).

One theory about the origin of the universe is the "Big Bang" theory. Most scientists agree that there could have been something like the Big Bang. This proposes that everything started from a vast primeval explosion which scattered gas and dust particles throughout space. The scattered matter is then thought to have formed galaxies and other cosmic bodies, and the process is thought to be going on still.

In the present universe, matter is distributed throughout enormous expanses of space in the shape of thousands of millions of stars and galaxies. At some time in the past, however, these individual masses (the total weight of which is calculated to be in the region of 7 octillion tons, that is, 7×10^{48}) must have been concentrated together in one enormous primeval mass, which, if it were to be placed in the position held by the sun, would not have reached out even half-way to the orbit of Mercury - the planet nearest the sun (58 million km). But a pinhead of this mass would have weighed half a million tons - such was the density. In that case the birth of the universe is seen as the result of this primeval concentration of matter being torn apart by an explosion of inconceivable violence, so that the fragments were hurled out and are still

speeding through space today. This event is calculated to have taken place 10 000 million years ago, and in this way all matter is seen to have been in one place at one single point in time. Thus the universe as a whole came into being at a certain stage (Hinkelbein, 1972).

In the beginning there was nothing - no time, no space, no matter and no energy. Everything was created out of nothing. Ten thousand million years ago, the radius of space, its volume, was zero. The energy level was zero, and if space and energy do not exist, matter disappears (Hinkelbein, 1972). Man has not the power to tell what comes behind space or time, nor what existed before. Maybe one should add a fourth dimension to space and time, something called time-space, for what we experience as three-dimensional is in reality something different, higher, extradimensional. It has no limits but is infinite - and renders the question as to what came before absurd, as the human mind cannot encompass it.

One of the basic principles of physics is that matter can neither be created nor destroyed (Gibbon, 1981). Matter can be transformed into energy and vice versa, but the creation of everything requires, ultimately, a Superior Being, God.

Space, time and matter are inseparably interwoven so that none can exist without the others. Space is necessary for matter to exist, and matter can only exist in time. All these concepts are based on human logic - and it can be deduced from physics that the universe is not complete, it is not a finished artefact. It is in the process if evolving, just as it has been from the first day. The same events are occurring that have occurred from the day it all began. Logic cannot provide an explanation for everything, so we have to start searching outside the realms of physical fact: we have to involve the concept of God the creator and return by this route to theology. Modern views suggest that we should not hold too primitive an Image of God. Anyone who imagines the origin of the world in a naive way, or who dogmatically

accepts the literal meaning of the words of Genesis, will miss not only the actual course of events, but also everything that Genesis tries to explain. God is timeless, He was before the beginning of time. For Him there is no "before", no "now" and no "after". He is there, from "eternity to eternity". The limitations of space do not apply to God. He cannot be understood in terms of matter and thus cannot be conceived of in the shape of images created by man.

THE ORIGIN OF LIFE

What is life? The simplest and best way to distinguish between the living and the non-living is that living things (plants and animals) are able to reproduce - they can make copies of themselves (Gibbon, 1981). Life as we know it is unique to the planet Earth, until someone can come up with proof that life exists on other planets. Does life evolve inevitably on a planet with the right chemical substances or did it come into existence once only? No scientist has yet been able to create life, although many have tried. We know what components are necessary to sustain life, e.g. oxygen and water, and we also know what the chemical combinations are that make life possible, but man cannot create that final spark - that is left to God.

Life began, in scientific terms, when somehow, somewhere, a combination of chemical reactions produced a molecule that was capable of making copies of itself by triggering further chemical reactions. For this combination to occur spontaneously and completely by chance, would be as impossible as it would be for iron atoms to come together and, completely by chance, to form a steam locomotive, such is the complexity of the process. These chemicals that formed the first living molecules are the fundamental material of life, and are kept together by the living cell.

The part of earth that contains living organisms is called the biosphere (Gibbon, 1981). This is the skin of the earth

and includes the earth's crust, the oceans and the atmosphere. In the beginning the biosphere was no bigger than the liquid layer of the primordial ocean (De Chardin, 1966). Without water, there can be no life, thus it is only logical to assume that the first forms of life originated in this primitive ocean. The elements that formed this shapeless, drifting mass were not just an agglomeration but a thin, interwoven web with many processes that took place (De Chardin, 1966). Laboratory experiments have been carried out where gases like carbon dioxide, methane and ammonia (supposed to have been constitutive elements of the primitive atmosphere) were mixed with water in a sealed tube. Electric sparks or ultra-violet radiation was passed through the tube, and as a result of this, molecules regarded as precursors of life were formed (Gibbon, 1981). The early atmosphere of the earth had been ideal to get life started. These first molecules or living cells did not need oxygen to live, but used carbon dioxide instead - in the same way that some anaerobic plants do today. They produced oxygen as a by-product and so the first oxygen came to be introduced into the atmosphere. This was the first step towards building an ozone layer (or atmospheric layer) that is essential to life on land, as it blocks out harmful ultra-violet radiation and X-rays from the sun. The fundamentals of life had been established, and from then on the story of life - and of evolution, then - has been one of competition between various life forms, competition for available food and for protection against each other.

Evolutionary research is carried out by virtually every branch of biology. There are certain areas of research that were mainly concentrated on issues such as the material of evolution, the rate of evolution, the causes of evolution and the evolution of adaptation (Mayr, 1977). In this paper certain aspects of these areas will be considered.

GENETICS

The basis of evolution is to be found in the fingerprint of

life - the genetic code. The whole process of evolution rests on a change from one form into another, and to understand this, a closer look at the genetic coding system is essential. This genetic code is something that determines, for example, the colour of the hair, whether the organism is to have a tail, etc. All the hereditary characters are carried by the genes in the chromosome system in the cell. Man's genetic code is carried in 46 chromosomes. These chromosomes are constituted of DNA, and DNA are the messengers that bring the code to the body. The DNA consist of building blocks (Figure 1) of which there are only four. These building blocks are called nucleotides and their names are abbreviated as A, T, C and G. These four blocks are arranged in sequence in the DNA so that a long chain is formed. One molecule of DNA consists of two of these chains parallel to each other. Each building block is connected with a chemical bond to one in the other chain. Together these chains form a double helix structure or something like a spiral staircase (Figure 1). A gene is part of this chain with a code that spells a specific character. It is a unit or a hereditary factor that consists of a small part of DNA and has a particular effect on the physical characteristics. As the four building blocks occur in different orders along the length of a gene or chromosome, it is as if the plans for building and maintaining the whole living organism are written out in a four-letter alphabet. All living organisms on earth share the same four-letter alphabet and DNA language. A four-letter alphabet may seem restrictive, but today's computers are based upon an even simpler language of binary arithmetic, a two-letter language in which the only answer to any question is a simple Yes or No. With a four-letter alphabet, the number of bits of information (yes/no answers) that can be packed in is four times the number of nucleotide pairs, and a single chromosome can contain 5 000 million nucleotide pairs, while each human chromosome contains 46 chromosomes. How much information is then contained within each chromosome's 20 000 million particles? This is the equivalent of more than 3 000 million letters of the alphabet. Printers say that there are, on an average, about six letters per word,

so that one chromosome may contain information equivalent to 500 million words. With a book having 300 words on a page, one chromosome is then equivalent to 4 000 books, each with 500 pages. This, it seems, is what it takes to describe the construction, care and maintenance of the human body. Single-celled bacteria need less information and have smaller DNA libraries, and therefore there is less chance of copying a mistake when the DNA is replicated. With complex creatures with long chromosomal DNA molecules, the copying of mistakes - mutations - becomes more likely (Gibbon, 1981; Gibbon and Cherfas, 1982.)

(Figure 1: see at end of article)

This four-letter alphabet or system of sub-units is arranged in a specific sequence in the chain. Three sub-units in a sequence are called a codon or a unit - the genetic code or gene (Figure 1). The DNA is therefore a kind of blueprint that carries the knowledge of the structure and composition of the body in one single cell. Man has approximately three billion codes forming about 30 000 genes. All the DNA in the body that is encompassed in the chromosomes is nearly 175 cm long and thinner than one-millionth of a cm. If we should increase the thickness to that of a violin string, it would be 14 km long (Gibbon and Cherfas, 1982). The genetic code is the reason for the diversity in the story of life because every living thing has a unique DNA message.

MUTATION AND NATURAL SELECTION

The purpose of the DNA code is to produce proteins that form the real building blocks of the body. The code of the DNA is read and proteins are formed. Many mistakes can occur in the reading of the message, and then the wrong protein can be formed. DNA also has to be replicated to replace old material, and in the course of sexual reproduction, when the DNA has to divide. The new organism then receives half of the father's and half of the mother's DNA. When the replication

takes place, three types of mutation may occur. First, one code may be reversed, part of the code, an A or a C, may be left out, and the other codes might be inserted (Figure 2). The DNA in the cell may fold up and wind itself around itself, and sometimes certain parts may be cut off and a chromosome mutation take place (Figure 3). Most of the mutations are harmful and the organism then dies. But sometimes a mutation may be profitable and this organism, due to the mutation, can out-compete the organism without the mutation. The profitable mutation can then accumulate in the cell until its working is required. For example: a mutation occurs which causes the animal to develop a thick fur. A thousand years later all the descendants of the ancestor carry this genetic message. It is still in abeyance, for it is not necessary yet. An ice age begins to develop, and suddenly the stimulus for growing fur triggers the genetic code transcriptors into action and the genetic message is carried via the DNA to the proteins. All the off-spring that live at the time start growing fur. The fur acts as an insulator against the cold and animals are able to survive. Other animals, that did not undergo that specific mutation become extinct. The animals that survive ultimately look very different from their remote ancestor.

(Figures 2 and 3: see at end of article)

When a mutation occurs, it does so entirely without purpose. The mutation in the above example did not "know" that an ice-age was coming. It mutated completely by chance. The only purpose of the DNA is to replicate itself and to produce proteins. A mutation can occur when an organism is subjected to harmful radiation or contact with toxic substances - or entirely spontaneously.

Darwin postulated a theory which he called natural selection. This is a process through which the environment selects the best-adapted organisms for survival - in other words, the survival of the fittest (Darwin, 1979). This is the determining factor in evolution. The least adaptable oranism is consistently

eliminated. For example: a mutation occurs that causes an albino zebra to be born, i.e. it does not have the characteristic black stripes. This zebra is consequently very conspicuous and is easily spotted by lions, and is eliminated early on, before being able to pass on the genetic message of albinism to any off-spring. Natural selection cannot be proved, for it takes years to select only the fittest. This theory is not fool-proof - it is, rather, a mechanism that operates in nature, and might be a mechanism for evolutionary processes.

With mutations and with natural selection, off-spring are produced which may look entirely different from the remote ancestors and biologists may even classify them as different species.

(Figure 4: see at end of article)

Imagine an ancestor A with a specific DNA. A mutation occurs and accumulates with a constant rate in the following generations. Part of the population becomes separated, and no inter-breeding takes place. A thousand years later one finds an organism B which outwardly differs from A in, for example, the fact that the hair is now stiff and red and not black and curly. Other members of A undergo another mutation - when B has already been established in a new environment, and form organism C. From A through to B and C a line divides into two separate branches, and the result is two organisms B and C that are entirely different from each other. B and C each follow their own evolutionary part and after another couple of thousand years one would not recognize them as having had the same common ancestor, A. They are now different species. The number of differences between them are an indication of the time that has elapsed since the separation and mutation of ancestor A.

THE ORIGIN OF DIVERSITY OR SPECIATION

All animals and plants are classified into groups that have the same characteristics. This is taxonomy, the study of rules,

principles and the practice of classifying. Living organisms (species) are grouped together in genera that are grouped together, in turn, in classes. Classes are grouped together in phylums. Everything is given a name. This was the first task given to Adam. Every animal on earth that man knows of has a name. As soon as a new species is discovered, it is immediately classified and given a name. It is believed by some people that all living creatures were created simultaneously at one point in the past, but this is not so. New plant species are cultured even today, and evolution is still taking place.

The biological definition of species runs as follows: species are groups of inter-breeding natural populations that are reproductively isolated from other such groups. A member of a species cannot, therefore, inter-breed with a member of another species (Mayr, 1977) and reproduce off-spring capable of reproducing sexually. Every species has its own unique niche, having found its own specific answer to the demands of its environment, is able to adjust to changes and variations in its total environment and may form a population that experiments with other and new niches. Originally a population may acquire a new combination of genes and thus be more successfully adapted to its environment. Every population that makes such a shift may be an evolutionary pioneer and eventually become a new species. Not every evolutionary experiment, though, is a success: it is a fact that most of them are failures.

The rates of evolution of different organs are often drastically different. Some may rush far ahead while others may stagnate. As a result there is not a steady and harmonious change of all the parts of a "type", but rather a mosaic of evolution. The organism might have primitive and advanced characters at the same time, like *Archaeopteryx*, a bird-like reptile that is sometimes called the "missing link" between reptiles and birds.

How is it then that a new structure can suddenly come into being? Did it go through an evolutionary process in replacing the old form, or is it entirely new? An evolutionary novelty

is a newly-acquired structure or property that permits the performance of a new function, which, in turn, will open a new adaptive zone (Mayr, 1977).

A new ability may open a whole new life to the species. A pre-existing structure may be modified owing to an intensification of function, e.g. an intensification of the running function has led to the conversion of the five-toed foot of the pre-historic horse *Echippus* to the one-toed foot of today's horse, *Equus*. The most important cause of the origin of new structures is a change of function, e.g. many primitive fishes had two independent organs for respiration, gills and primitive lungs. In landdwelling animals the simple bag-like lungs were converted into the highly complex respiratory organs of mammals and birds, and the gills into endocrine glands of parts of the digestive system. In more modern fishes, the lungs have been converted into a swimming bladder or into sense organs. Usually when an animal shifts into a new niche or adaptive zone, the shift is initiated by a change in behaviour, e.g. a shift to eating leaves and berries instead of grass.

With all this evidence as background, a few more misconceptions need to be clarified:

* Evolution is not primarily a genetic event. Mutation merely supplies a gene pool with genetic variation. It is selection that induces evolutionary change.

* A character is not the product of a single gene, and a change in character is therefore not an indication that a single gene has mutated. Virtually all characters are polygenic, i.e. more than one gene can express the characters.

* Genes cannot be classified into superior and inferior ones. It is not the gene that is selective, but the external environment (Mayr, 1977).

The species are the real units of evolution. Without speciation,

there would not be any diversity. The species concept is then the keystone of evolution.

MAN AS A BIOLOGICAL SPECIES

Man is a species of animal, *Homo sapiens*, and is also a product of evolution. He shares many characteristics with other animals, but man is not "merely an animal". Man is unique; he differs from all the other animals in many properties such as speech as the most sophisticated and complex form of intellectual communication, having tradition, culture - and an enormously extended period of growth and parental care. Man is as much a product of evolution as is any other organism. He not only has a biological heritage, but also a cultural one. Man's gradual shift from the status of animal to that of "not merely an animal" and the forces that brought about this evolution are by no means fully understood, and are a source of constant and virulent controversy, in part because the reconstruction of man's biological history is still largely a matter of guesswork (Mayr, 1977).

Man is so strikingly similar to certain other mammals in biological terms that no biologist can question this close relationship. Linnaeus placed man in the same order as apes and monkeys, viz the primates. He classified man as a hominid (man-like creature), and not as an anthropoid (ape-like creature), but later regretted it. He said: "I demand of you, that you show me a generic character by which to distinguish between man and ape. I myself assuredly know of none. I wish someone would indicate one to me. But if I had called man an ape or vice versa, I would have fallen under the ban of all the ecclesiastics. It may be that as a naturalist I ought to have done so" (Gibbon and Cherfas, 1982).

There are still two questions:

* Did the hominid line branch off an anthropoid line, and is there a missing link?

* Through what stages did the hominid line pass after its separation from the anthropoid line, before the truly human level was attained?

BROTHERS UNDER THE SKIN

Man's closest relatives among the primates are the so-called anthropoid apes. They consist of three groups, perhaps regardes as three genera. These are the chimpanzee and the gorilla (genus *Pan*) in Africa, the orang-utan (*Pongo*) in the East Indies and the Gibbon group (*Hylobates*) in South-eastern Asia and the East Indies.

TABLE 1 (a generalized reproduction)

Differences in anatomy between man and anthropoid apes

Characteristic	Man	Apes
1. Brain size	Large	Average: 1/3 of human
2. Eyebrow ridge	Small or none	Heavy
3. Teeth	No flangs, teeth small	Fangs, teeth robust
4. Face	Short, steep, under brain	Long, in front of brain, protruding to form a muzzle
5. Dental arch	Rounded, with sharp angles	Laterally compressed with side rows of teeth, almost parallel
6. Thumb	Opposite the fingers for a more accurate grip	Not opposite the fingers
7. Joint between skull and vertebral column	Almost in the centre at the base of the skull	At back of skull
8. Big toe	Shift to the front as an aid to walking	Sideways for grip
9. Vertabral column	Alternate curved backward and forward	Straight or curved, uniformly backwards

10. Pelvis	Broadened to accommodate increase in brain-size for birth	Narrow
11. Leg	In upright posture, straight in knee and hip joint	Curved, the knees turned outwards
12. Hair	Virtually no hair except for head	Thick fur on whole body

If two genes are identical in all aspects, then they are copies of one original, that is, they share a common ancestor. Through molecular biology, the chromosome maps of different animals are compared. The number of differences between them can be regarded as an indication of the time that has elapsed since the separation from the ancestor, as they have evolved in a context of time. Man is also a product of such a process.

With chromosome analysis, the genetic code on the DNA can be decoded. In such a way it is then determined that the DNA of man and of the chimpanzee only differ by about 1%. They share 99% of their DNA - thus there is, in the biological sense, only a 1% chance of being human. Only 6 mutations distinguish between the genetic codes of man and of chimpanzee - six mutations that make man (Gibbon, 1981, Gibbon and Cherfas, 1982). The greater the difference between two species, the longer are they regarded as having been separated in time. With man and chimpanzee in so close a relationship, is it not logical to apply this concept to them as well? Is it therefore wrong to say that man and chimpanzee shared a common ancester, not so very far back in the past? NB: THE CHIMPANZEE IS NOT MAN'S ANCESTOR - THEY SHARE A COMMON ANCESTOR.

With immunological studies, the blood relationship between man and ape has been established. With the process of immunodiffusion, it has been determined that man's and ape's antigenes are practically identical. Using a comparison of the albumin of blood between the two groups, it was established that

the Old World Apes (gorilla, chimpanzee and orang-utan) separated 30 million years ago from the New World Apes (monkeys). Man separated only 5 million years ago from the Old World Apes (Gibbon, 1981; Gibbon and Cherfas, 1982).

When DNA is melted, the time for the chemical bonds between the chains to melt is taken. For impure DNA, i.e. mixed DNA from two animals, the melting point is lower than that of pure DNA, i.e. from one animal only. When the DNA of man and of chimpanzee is mixed, the melting point differs by 1% from that of the melting point of pure human DNA. The difference between man's and baboon's DNA is 9%, and between that of the lion and the ape 102%. To classify two species as different, it needs to be only 4-6% (Gibbon and Cherfas, 1982).

What then is man? In biological terms only, he is an upright, hairless, ground-dwelling ape with a swollen head and brain, no muzzle, small teeth, a reduced sense of smell, excellent eyes, astonishing skills and the power of speech. A biologist that is neither ape nor human will definitely classify apes and humans as species of the same genus.

IN SEARCH OF THE MISSING LINK

Direct evidence from the evolutionary relationship of man and apes can only be supplied by palaeontological studies, that is, by the discovery and the examination of fossil remains of the past. Darwin wrote *The descent of man* in 1871 - when there was no fossil evidence to support his theories. Jibes about "missing links" have provided plenty of ammunition for satirists and cartoonists, who were strongly prejudiced against any suggestion that man, so "fearfully and wonderfully made", and more akin to angels than to the bestial, could possibly be related to such ugly caricatures of man as gorillas and chimpanzees, in the sense that they were supposed to take their origin from a common ancestral stock millions of years before (Clark, 1967). The search for fossils that could contribute

to the knowledge of man's past sometimes led to great confusion for the sequence of human evolution is not a simple matter of one species evolving into a succeeding one without any side-branches that become extinct.

For a long time the study of fossil man was essentially a search for a connecting form, the so-called "missing link". At first no one quite knew what to look for. The earliest reconstructions pictures a creature that was an intermediate between man and chimpanzee. This implied that man had the chimpanzee as his immediate ancestor, and that the chimpanzee had stopped evolving altogether as soon as it had given rise to the human line. These assumptions are completely wrong. The additional assumption that the living anthropoids are primitive and man was at one time or another represented by them, is also wrong. Numerous fossil discoveries have made it clear that the antropoids have evolved as much since branching off from the head line as had the human line (Mayr, 1977).

The first tree-dwelling creature in the line of hominid evolution was *Ramapithecus*, which lived nearly ten million years ago in Europe and Asia (Gibbon, 1981). Experts do not always like to admit how little is known about *Ramapithecus*. There are just a few fossil fragments, identified, from the shape of the jaw, as an ancestor of the human line. From here there is a gap of seven million years before more human hominids appear on the scene. The threads of the story are picked up where the last of the *Ramapithecus* line lived alongside the early forms of our own line (*Homo*), and two other hominid lines (*Australopithecus Africanus* and *Australopithecus robustus*), which were related to the *Homo* line but with no certaintly of having been our immediate ancestors.

The search for the missing link started with renewed eagerness when an extraordinarily primitive and apelike skull was found in a sandstone cave 20 m up a steep cliff in the Neanderthal Valley near Düsseldorf in Germany. Since then many other

remains of the same extinct type of man have been found. So distinctively humanoid are the skeletal characteristics of Neanderthal Man that some authorities regard him as being nearly human, to the extent that they have named him *Homo neanderthalensis*. Others, however, immediately revolted against the idea of Neanderthal Man being an ancestor of man. Some maintained that it was the bones of an old soldier who had isolated himself from his people and who had died alone (Clark, 1967). But how can a dying old soldier climb up a steep cliff, crawl into a cave and bury himself under 1½ m of mud? None could argue with this, and it was conceded that it was a very old extinct human form. It was later dates as being nearly 400 000 years old. Reconstructions usually showed Neanderthal Man as being an ugly, unattractive savage. But this is not so. If Neanderthal Man were placed in a busy New York street, neatly shaven and dressed in a suit, he would probably pass unnoticed.

Thirty years later, in 1971 fossil remains consisting of a skull cap and thigh bone were discovered in Tara. It was named *Pithecanthropus erectus*, meaning the "erect apeman". Several skulls, jaws and teeth were subsequently found near Peking in China. Later the name was changed to *Homo erectus*, as these remains show more affinities with the characteristics of man than those of apes (Reader, 1981).

The first Australopithecine was discovered in South Africa by Raymond Dart in 1924, and this gave a new dimension to fossil evidence. Raymond Dart was professor of Anatomy at the Witwatersrand University. A student of his noticed a fossil baboon skull gracing the mantelpiece of friends. She told Dart, and he, unaware of any fossil primates south of Egypt, asked to examine it. Dart confirmed that it was a fossil baboon and a very primitive species. It has been found during lime quarrying near Taung in the Transvaal. Dart asked a colleague at the Geology department to bring him more specimens as he was due to visit the area. The fossils are revealed when limestone workers blast and quarry the limestone deposits.

The geologist himself tells how he arrived at the quarry just after blasting operations had taken place. "One large piece of rock had apparently been split in two," he said. "Embedded in the one fragment was the 'missing link' fossil, the face itself hidden in the rock. The brain portion was found to be quite loose, but it fitted exactly into position in the skull." He carefully packed the find and mailed it to Dart. Dart's version of the story is as follows. Two large boxes of rocks arrived when he was donning white tie and tails for a wedding to be held at his house. With collar unfixed, the guests arriving and the groom waiting, he hurriedly wrenched open the boxes. He found the contents of the first disappointing, but in the second he immediately recognized a fossil brain cast with distinctly hominid features, and also the back of the forehead and face into which the cast fitted. "I stood in the shade, holding the brain as greedily as any miser hugs his gold," he wrote. "Here, I was certain, was one of the most significant finds ever made in the history of anthropology." These pleasant daydreams were interrupted by the bridegroom himself tugging at his sleeve. "Come on, Ray", he said, "You've got to finish dressing immediately - or I'll have to find another best man. The bridal car should be here any moment" (Reader, 1981).

It was indeed a precious find. A fossil brain cast is formed when the skull cavity of the dead creature, lying undisturbed in a cave, fills with debris, such as, for instance, bat droppings, sand and lime. This subsequently fossilizes along with the bone. These casts are extremely rare - five are known to have come from South Africa. The Taung specimen represented a creature that was advanced beyond apes in two distinct characteristics - its teeth and its improved brain capacity. The central position of the foramen magnum (the hole in the skull through which the spinal cord passes) gave an indication that the creature might have walked upright. This specimen was named *Australopithecus africanus*, meaning the "Southern ape of Africa" (Reader, 1981). The fossil was a juvenile specimen and had many ape-like characteristics.

In 1936 Robert Broom discovered more Australopithecine fossils in the Sterkfontein caves near Krugersdorp. He first named it *Plesianthropus transvaalensis* - "nearma of the Transvaal" - but later the name was changed to *Australopithecus robustus,* a more robust Australopithecine. Along with skulls, jawbones, teeth and other bones, a partial skeleton was also found, providing the first direct evidence that *Australopithecus* had walked upright.

In 1961 the attention of palaeontologists switched from South Africa to East Africa, when a hominid fossil was found in Olduvai Gorge, and was dated as being 1,75 million years old. Stone tools form the core of the work of Lewis Leakey, his wife, Mary, and their discoveries at Olduvai Gorge. Fossil bone may reveal the physical characteristics of the creatures whose flesh once covered them - their height, weight, relative proportions of their bodies - but the tools they have left behind add a dimension of understanding. A stone tool may have lain undisturbed for more than a million years, but we may be certain that the hand that made it differs hardly at all from the hand that picks it up today. On the morning of 17 July 1959, Mary took the dogs and walked across the site where the first stone tools had been found in 1931, and where she and Lewis suspected there might be an old living floor. At about 11 a.m. she noticed a skull eroding from the top of the bed. She brushed away some of the covering soil and two teeth were revealed, unquestionably hominid. She was very excited but the fossil was not *Homo.* It was also an australopithecine, which they named *Zinjanthropus bosei.* - Zinj being the old name for East Africa, anthropus meaning *man* and Bosei, who had been Leakey's benefactor. The name thus means Bosei's East African Man. Many thousands of years earlier, before the Leakeys began to unravel its secrets, a group of hominids had camped at the Olduvai Gorge. The site was beside a lake whose waters rose and fell periodically. It became littered by debris left by their habitation. The hominids moved away and shortly thereafter the rising waters combined with a shower of volcanic ash to preserve some clues of their presence and their lifestyle. Organic matter such as skins, wood and the

like soon rotted away, but the bones of the animals they consumed - many of them broken, to extract the marrow - were covered over before the weathering effects of sun and rain could fragment them further. Among the bones, the hominids left many stone tools of their culture, and on the same living floor lay the impressively complete skull that Mary had discovered.

In 1964 Leakey and his group uncovered a new site that geochronologists dated at 1,7 million years of age. Archaeologists felt that before erosion, the floor had evidence of a crude shelter. Palaeontologists identified animals the occupants must have killed and eaten. Anatomists determined that three individuals were represented among the hominid remains, and believed they had died of natural causes, suggesting that the bodies had been left outside the encampment when the rest of the group had moved on. The corpses could have been devoured by scavengers, as some skull fragments and foot bones bear characteristics teeth marks and the widespread scattering of the few remains is characteristic of hyena activity. Several more specimens had been found, all typically human. They were named *Homo habilis* - handy man. Leakey also found some *Homo erectus* (upright man) fossils in the upper layers, and drew the conclusion that the sequence *Homo habilis, Homo erectus* and *Homo sapiens* made a perfect evolutionary continuum (Reader, 1981).

Thus, three hominids existed at the same time at the Olduvai Gorge - the robust australopithecine, represented by Zinj, *Homo erectus* and *Homo habilis*. The puzzle as to the line of hominids that culminated in *Homo sapiens* remains.

Apart from fossils there is other evidence of man-like creatures in the Olduvai area. On the morning of 2 August Mary Leakey joined her research team in clearing the surface of a solidified volcanic ash-bed at Laetoli in north-eastern Tanzania. Assistants were deployed around the perimeter while many worked for three hours on a small patch near the centre. She used a dental pick, a soft and great care. Time passed slowly, there was little conversation and the uninitiated may have been struck

by the strangeness of the scene - seven adults of their knees, tediously sweeping away a tiny patch of wilderness in the company of giraffe and antelope. Then, at 10h45, Mary Leakey straightened abruptly. She lit a cigar, leaned forward again, scrutinizing the excavation before her and announced: "Now this really is something to put on a mantelpiece." She had uncovered a human-like footprint fossilized in the ash. It was a clear imprint with heel, toes and arch all well-defined. "This must be *Homo,*" she said.

In 1976 geo-chronologists had reported that the Laetoli ash surface was 3,6 million years old, so the footprint Mary had found was, in effect, the earliest undisputable evidence of man's bipedal gait. While she knelt there, the rest of the team gathered round to congratulate her and admire the discovery, but everyone was also aware of the fact that it was a very private moment whose import was not easily shared. The sight of the footprints left by an ancestor so long ago combined the commonplace and the miraculous in a way that language cannot accommodate. As the assistants returned to their own work in search of their own discoveries, Mary, still on her knees, still puffing at the cigar and still gazing at the footprint, said quietly, "Ah, it is pretty" (Reader, 1981).

The Laetoli footprints are entirely human, but whether they be called *Australopithecus* or *Homo,* there can be no doubt that the hominids had already acquired the habitual, upright, bipedal free-striding gait of modern man - three million six hundred thousand years ago. The earliest tools known to date are about 2 million years old. Hominids, it seems, were walking upright with their hands free for at least 1,6 million years before the advent of stone tools. For millions of years the combination of zoological inheritance and environmental circumstance was quite enough to ensure the survival of those small, lightly built animals of erect posture. Then some among their number perceived the value of the cutting edge and discovered how to reproduce the rare accident that created it. They began making stone tools. That event marked the beginning of the

impetus towards culture - no less a product on inheritance and circumstance than any other development in the 3 000 million years that life had existed on earth, but one that distinguished man from any other creature and had brought a radical change to the world in just 2 million years. As culture has burgeoned, man has increasingly manipulated the environment to his own ends, and become ever more dependent upon the brain that made it possible. Now the cognitive brain is the survival tool of the species (Clark, 1967; Mayr, 1977; Reader, 1981).

The evidence of human evolution is rarer than diamonds and the study of this is therefore an intriguing mixture of science and of treasure-hunting. The ideal fossil evidence would be a sequence of complete fossil skeletons spanning a known period of time, but the nature of the fossilization process virtually eliminates all chance that such an ideal could ever be achieved. Figure 5 illustrates the supposedly evolutionary process of *Homo sapiens*.

Figure 5: see at end of article.

THEORIES ON HUMAN EVOLUTION

Theories are postulated as to why human evolution differs so much from the evolution of the anthropoids. Three of these try to explain why man became upright, started using his hands and became superior to the animals.

The savannah theory

There are two classes of factors that account for human evolution, namely changes in behaviour and changes in the environment.

The second half of the Tertiary was characterized (Figure 6) by an increasing desiccation of the portion of Africa and Asia inhabited by the hominids. This resulted in the opening-up of a new habitat, ranging from wooded savannas to areas

that were very arid, almost desert-like (Morgan, 1982). The occupation of this newly-available habitat by the hominids favoured not only bipedal locomotion but also a shift in diet towards a greater portion of meat. Various behavioral changes were correlated with these ecological changes.

Figure 6: see at end of article.

The forest areas of the African continent dwindled and large areas became covered with grass and scrub. the hominidae are descendants from those ancestors who left the trees and moved out onto the grassy plains or savanna, while gorillas and chimpanzees are descended from the ones who remained in the trees. Forest-dwelling apes are not normally troubled by food shortages - they are vegetarians surrounded by plentiful yearround supplies of fruit and lush vegetation. These would have been scarcer on the savanna, so the ancestors began to vary their diet. Initially they did this by catching small game, or scavenging upon the remains of kills made by large carnivores. Thus they gradually turned themselves into meat-eaters, and finally hunters (Morgan, 1982). The ancestral ape learned to stand upright to see further over the plains searching for prey, and he learned to run fast on two legs to pursue game while leaving his hands free to carry a weapon. Bipedal locomotion, particularly in the early stages, must have been a rather ineffectual form of locomotion for a four-legged animal. Its greatest selective advantage was presumably that it freed the forelimbs for new tasks. It permitted the use of hands of the efficient manipulation of tools, handling of weapons and carrying of food. But why has none of the other large terrestrial primates adopted bipedalism (Mayr, 1977)? The need for the invention and the manufacture of improved weapons and tools increased. Man had to learn to cut up large prey into smaller pieces for purposes of transportation/to base camps and distribution. Co-operation among several males was required to achieve success in the hunting of large game. Eventually this result in a considerably diversified division of labour and responsibility between leader, scouts, caretakers

of base camps and perhaps specialists in various weapons (Mayr, 1977). All these activities sharpened man's intelligence and he developed a larger brain because he needed more brain power.

As a forest dweller he had been accustomed to a leisurely and well-shaded life, so that when he was chasing his prey in sunshine he became liable to over-heating. Therefore he gradually discarded most of his body hair to keep cool (Morgan, 1982). This is a good explanation for man's nakedness - but then, why did other hunters, like the lion, not also do this?

Planning, co-operation, a division of labour and memory would not be particularly useful without a far more efficient system of communication than is available to the anthropoids. The capacity for speech is the most distinctive human characteristic, and it is quite likely that speech is the key invention which triggered the step from hominid to man. Speech improved, vocabulary enlarged and man became a socialized creature (Mayr, 1977). He became an efficient hunter, learnt the secret of fire and had more leisure time to spend on painting, music and dancing, and so he gradually created his own culture (Reader, 1981).

The neoteny theory or retention of larval characters beyond normal period

Neoteny is an occurrence of adult characteristics in juvenile forms, or the attainment of sexual maturity by juveniles (Holmes, 1979) (also a retention of larval characters beyond the normal period). This is a phenomenon which occurs repeatedly in the evolutionary history of various species. An example of neoteny is that of the Mexican salamander. An adult salamander, after a larval stage very like the tadpole stage of a frog, loses its gills and emerges from the water as an air-breathing, land-dwelling, four-legged animal. Sometimes, however, the metamorphosis from tadpole to salamander fails to take place. The immature salamander remains in the water, retains all

the larval characteristics (external gills, lidless eyes, teeth in both jaws) and in that condition mates and reproduces its kind without ever attaining salamander adulthood. This is assumed to happen because under certain conditions the larval form is better suited to survive than the adult form. Neoteny, then, is an evolutionary trick by which an animal retains, throughout its life, features which in its ancestors were typical of an immature stage of existence, sometimes even a fetal stage (Morgan, 1982). It is possible to regard man as being not a hunting ape, but as a neotenic ape - an ape that became child-shaped.

With climatic changes that brought about a decline in the tropical forest, a creature such as *Ramapithecus* was in trouble. The most successful off-spring would be the ones that coped best with the changing conditions, and that meant moving out of the trees and onto the ground, into the spreading plains of Africa. The changes produced by neotenous development are much quicker than other evolutionary changes, hardly requiring any genetic mutation at all (Gibbon, 1981). Most animals complete the bulk of their brain development before birth, and even man's nearest relations, the chimps, complete their brain growth by the end of the first year of life. In humans, though, the brain is only a quarter of its final size at birth, and growth continues for nearly 25 years. This slow development is a feature of neoteny, and it means that the brain can grow to a size that would be impossible prior to birth. If all this development were to take place in the womb, the baby would simply have too big a head to be born without killing the mother. One result of this continuing growth of the brain is that infants and even young adults are out in the world, learning about it, while the brain is still growing (Gibbon, 1981; Gibbon and Cherfas, 1982). Thus, by one simple evolutionary step, neoteny, ancestors of man gained the powerful advantage of better brains, an upright posture and a longer childhood. It is argued that human beings are comparatively hairless (Morgan, 1982) because the features of every ape fetus is at one stage hairless. Infant apes are noted for their curiosity and playfulness, but in all cases, except in man,

this phase of inventive exploration dies out fairly quickly. Humans retain this streak of curiosity well into adult life. This inclination to find out what lies beyond the next hill was all the driving force our ancestors needed to conquer the world (Gibbon, 1981).

Neoteny is not an explanation of evolutionary change - it is only a mechanism by means of which such changes as happened in human evolution may be brought about.

The aquatic theory

This theory starts with the observation that among those morphological and physiological features commonly regarded as being unique to man, a surprising number are not really unique at all. They are quite common among those species of animals which had left the land and returned to an aquatic existence. Among mammals, the first to return to the water, some 70 million years ago, were the cetaceans (whales, dolphins and porpoises). Like all mammals, they are warm-blooded, breathe air, give birth to live off-spring and suckle their young, but they have lost their hair, and resemble fish so closely that Catholics were allowed to eat them. More than 50 million years ago, the elephant-related animals returned to the sea and formed the sirenians or sea cows. Between 25 and 30 million years ago some bear-like mammals took to the water. Those were the ancestors of fur-seals, sea lions and walruses. Despite the improbability of such dramatic changes in lifestyle, the fact remains that the adaptation of aquatic habits happened again and again. Most surviving mammalian orders include species that evolved specific adaptations for aquatic life. The theory postulates that one other primate also did this - man.

LOSS OF BODY HAIR

Homo sapiens has been described as the naked ape, and nakedness is one of the striking differences between man and the apes.

Man is not all naked, but the hair is much shorter and finer, and therefore much less conspicuous. Hominids did not lose hair as a cooling device when running or to enable him to free himself of parasites. If he did he would surely have died of cold, without an insulator. It has also been suggested that the nakedness would be for sexual attractiveness, but characters usually gained through sexual selection evolve by a process of exaggeration of some feature which is already characteristic of the species, e.g. the tails of birds of paradise, and not then the acquisition of some new character.

The fetus of the ape is at one stage quite naked, while the human fetus, at the sixth month, is completely covered with a fine coat of hair, known as lanago. This would seem to suggest that man could have gone through an aquatic period in his evolutionary history, since the arrangement of the tracts of hair reminds one of the passage of water over a swimming body. Virtually all the hairless mammals in the world today are either aquatics or wallowers. The longer an aquatic animal has been in the water, the more complete is the hair loss. Fur as an insulator is very valuable as it traps a layer of air next to the skin, but for a fully aquatic animal like the dolphin, fur would be a handicap, because it would limit its streamlining and cut down on its swimming speed. One major factor is size. The larger aquatics are naked, while smaller ones, like the otter and the beaver, have adapted to the watery habitat by changing the nature of the fur, rather than by shedding it. An animal like *Australopithecus* - about four foot tall - would not have been small enough to follow the latter road. Climate also has an influence - most sea lions retain their hair, for they often spend weeks ashore on cold beaches. In Africa this is not necessary, however.

It has been commented that the women spent long periods in the water, with the children hanging on to their hair. This offers a possible explanation why the hair of the scalp did not disappear along with the body hair. It would also offer an explanation why woman's scalp hair begins to grow

more thickly during pregnancy.

SUBCUTANEOUS FAT

Marine mammals like dolphins replaced fur as insulation with layer of fat under the skin all over their bodies. This protects them against the cold, makes their bodies buoyant, stores energy and helps to give them a rounded, streamlined outline. It is also one of the features which distinguishes *Homo sapiens* from all other primates. Terrestrial animals also have fat in their bodies, but it is differently located and has fewer functions. Orang-utans may become potbellied in their old age, but will never have fat thighs, fat cheeks or fat fingers. Only the aquatics and *Homo sapiens* dispose of a fat surplus by thickening the subcutaneous fat layer. This distinctively human trait is apparent at a very early age. Humans produce infants which weigh almost twice as much as those of the apes. Viewed as an aid to bouyancy and heat insulation in water, the plumpness of the average human baby makes evolutionary sense. When the aquatic animal returned to the land, perspiration as a method of temperature control was a solution to over-heating.

TEARS

All mammals have tear glands to moisten the eyes. Very few mammals, however, excrete a fluid at moments of emotional agitation so that it can weep. Man is the only weeping primate. Tear glands are not triggered off by drinking too much salt water - as are the nasal glands of sea birds. A study of mammals who actually shed tears (seals, sea otters) supports the hypothesis that there is a strong connection between weeping and a marine habitat, and also that among mammals emotional stress is the chief stimulus to the shedding of tears. When the female of the sea otter is deprived of her young, she would weep over the affliction just like humans (Morgan, 1982). Tears produced by chopping onions and those produced by distress have biochemical differences. Tears of emotion have different proteins. Evolution seldom produces a purposeless

function, and tears, like urine, are waste products - presumably the chemicals produced in the body by stress. Why this should belong only to marine mammals is not clear.

BIPEDALISM

For the man of today it is faster and easier to progress on two legs than on four because we have been progressively adapted for it in the course of millions of years. The pattern of the muscles of the human body and the arrangment of internal organs originally evolved to suit the requirements of the quadruped. Thus, bipedalism would have been slower, more precarious and very strenuous. The motivation to adpt it would have had to have been very powerful. Hardy (1960) suggested that the first impuls towards bipedalism came when the ancestral primate waded into the sea. It would not have been able to advance very far into the water on four legs, and still keep its head above the water. The natural reaction would have been to stand up and proceed on two. The next point to consider is what would happen when the aquatic ape ventured out of its depth. If he was by then sufficiently accustomed to water not to panic, he would find that treading water would keep him vertical and his head above the water. A vertical position in the water is a favourite posture. Seals will float in this position, staring fixedly, for up to half and hour at a time. When a sea otter or man gets tired of gazing and begins to swim away, the position changes to the horizontal. But the position of the spine and limbs does not change. They align in one straight line, quite different from the 90° angle of a land-dwelling quadruped. A shift in the pelvis of *Homo sapiens* and seal has been observed. The vertical position now would not be precarious or unique, for being vertical in the water does not lead to instability and falling down. If, after a few million years of aquatic life, the primate returned to the land, he would adopt and maintain the erect posture of earlier. The shift of the pelvis and the more flexible spine of aquatic life would bring better balance to a terrestrial creature. No mammal, except man and marine mammals, can balance a ball

on the nose!

COPULATION

The most usual method of copulation in all human cultures is face-to-face. The scientific term for this is ventro-ventral. The female sexual canal is lifted forward to accommodate this posture - and in other anthropoids this canal lies at a different angle. Compared to aquatic mammals, this is not a unique method. The majority of all marine mammal species behave in this way. They copulate face-to-face, and the females have ventrally directed sexual canals. It is a direct consequence of the re-alignment of the spine and the hind limbs.

SWIMMING AND DIVING

Almost all the primates, except man, are afraid of water. It is sometimes claimed that the capacity to swim and dive cannot be part of our evolutionary heritage since one has to learn how to do these things. This is not true. Doctors have discovered that children, right after birth, have a swimming reflex, and that small children can teach themselves to swim. It has been discovered that human babies are able to swim long before they are able to walk. They have a remarkable breath control and will not cough or panic under water. They also have a natural buoyancy because of the fatty tissue. In Russia a gynaecologist has let babies be born under water. After birth, the newborn is guided gently to the surface by the midwife to take its first breath. This is exactly what happens at the birth of a dolphin. Mothers who have experienced this method of childbirth reported that this way of giving birth was unusually free of pain and discomfort.

Man is the only diving terrestrial animal. He dives deeper than a beaver, most species of otter and some of the dolphins and porpoises. Man is known to share some of the physiological diving adaptations of the aquatic mammals. He has a diving reflex - a marked reduction in heart rate and cardiac output,

which factors reduce the body's oxygen consumption.

SPEECH

The capacity to speak is one of the three major hallmarks of humanity. Even more dramatically than bipedalism and the use of tools, it sets man irrevocably apart from all the rest of the animal kingdom. The question of how and why an anthropoid ape began to speak is central to all our efforts to understand man and his evolution.

Communication between primates is conducted by means of scent, touch, vocal and visual signals. Scent signals serve to communicate identity and states of mind and body such as anger, fear or sexual receptiveness. Touch signals serve to cement the mother/child relationship and socialization. Vocal signals are involuntary expressions of states of mind - panic, range, grief and alarm. Between primates, especially anthropoids, visual communication is the channel which has been developed to the highest degree of precision. Through the medium of a great variety of gestures, postures, movements, facial expressions and the management of spatial relations between individuals, they can convey to one another their immediate intentions and their social relationship.

Humans have a speech-producing mechanism that allows the nasal cavity to be either connected or to be disconnected from the other air passages. It seems highly probable that this capacity may have evolved for the convenience of the aquatic ape, to prevent any water in the nasal cavity from entering the lungs. The velum, that closes the nasal cavity in the throat, adopts the closed position during diving or swimming under water. It also increases the variety of sounds, by producing "nasal" consonants in speech (Lieberman, 1975). Among aquatic animals communication by sound is of paramount importance. Among the most highly adapted - the cetaceans - auditory perception is so dominant that it has even unsurped some of the functions of sight, e.g. echo-location (sonar).

When a terrestrial mammal moves to an aquatic environment, the operation of several of his normal methods of communication is disrupted. Scent loses its usefulness. Visual signals become far less practicable. In water a high proportion of these postures and movements is superseded by the need to keep afloat or to swim or to dive. The human sense of hearing has not grown correspondingly more acute, but it has become more sophisticated. It is adapted to the function of listening more attentively to one another, even at the cost of losing some incoming messages from the environment. Our hearing is extremely sensitive within the range of the human voice. The most remarkable human development in the field of vocal communication, is that we have acquired conscious control over the utterance of sound. This has been achieved together with the conscious control of breathing, a feature of all diving animals. Some aquatic animals make use of their talent for voluntary sound production to obtain information about their surroundings by means of echo-location. The only other living animal to have obtained nearly true speech is the dolphin. Dolphin vocalizations are divided into two groups:

* pulsing sounds (sonar) and

* whistling sounds. Response whistling does not begin until the first animal's whistling has been completed. They are not merely hearing, but listening to one another. It is also observed that man's brain size deviates from the mammalian norm to an extent which is shared only by the bottle-nosed dolphin. The conclusion can be made that speech also had an aquatic evolution.

WHERE AND WHEN DID IT HAPPEN? SOME REFLECTIONS

The crucial gap between apes and hominids is that between *Ramapethicus* and *Australopethicus*. The last may have used stone tools but had not yet attained the tool-making stage, thus it was not entirely human. As long as conditions are stablem as species may continue for ages, e.g. the coelecanth, a living

fossil lungfish. When conditions change rapidly, evolution goes into overdrive.

About three million years ago, drastic environmental changes took place in parts of Africa. The sea came in and flooded vast areas in the north of the continent. Parts of the forested areas were cut off from the rest of Africa, forming islands. Populations of apes, marooned on such islands, may have found their usual food resources dwindling and turned to the sea for a diet supplement. Thos apes, living along the coast, would most likely have wandered back and forth, searching for food by wading in the shallow water. Witnessing frequent volcanic eruptions and lava flows, abundant in those days, the apes may have made two important discoveries: Pebble tools and fire. Lava might have cooked plants and animals, and so the apes consumed and learned to appreciate cooked food. the two types of australopithecine might be the animal in question. These hominids had evolved in and near water, for protection against predators, and for food and drink. When the water retreated, the hominids returned to the mainland. Reconstructions of their appearance in textbooks would, by this theory, be more accurate if they were to be depicted naked. To return to terrestrial life from the aquatic or semi-aquatic world meant a return to a habitat when other sense organs would have to be used again. An increase in brain size would have been accelerated, partly by the requirement of speech for which they were now strongly pre-adapted. When the islands were joined to the headland again, some hominids left the island and migrated to the headland. They evolved separately and are now called *Homo habilis*. Meat-eating itself could now well have begun on the seashore. Some of the animals the hominids would have encountered in shallows or on beaches were large, docile and helpless on land, e.g. sea-turtles and dugongs. Their presence would have encouraged the hominids to begin thinking of themselves as predators, and the necessity for skinning their victims would have provided further incentives to develop the use of tools and to make these tools.

The human hand is a remarkable piece of equipment for the picking up of objects between thumb and forefinger, and is also adapted for groping and seizing living food on the sea-bed. It may be that man began using stone tools for breaking open shell-fish. Imagine a man on a particular shore, hammering with a stone and suddenly finding the stone splitting into thin flakes. He could then see the advantage of these sharp blades of flint, and would use them to spear fish and to become a hunter in the sea. In fashioning flints in turn he would see sparks flying and would discover how to make a fire and to cook the fish he had caught. It must be stated here that the whole purpose is to depict these early hominids not as being fully aquatic but as semi-aquatic beings. They may have spent about six to eight hours per day in the water searching for food. The rest of the time they would live on land, sheltering in caves on the beach or under bushes.

This is only one more hypothesis about human evolution, and it has no value until it has been put to the test. There is no fossil evidence of sealiving man, and at the moment, while logical conjecture may make it sound almost factual, it is still only a hypothesis to be investigated. It is worth remembering, however, that speculation is the fuel of scientific progress - without that, people may not even have discovered that the earth is round!

THE EVOLUTION OF INTELLIGENCE AND CULTURE

In genetic terms, the story of human evolution through a sequence of successive stages has to date culminated in the emergence of *Homo sapiens sapiens*. This actually means *wise wise man*. It is true that man is the only thinking species to inhabit the earth. One unique characteristics of humans is the way they respond effectively to environmental stress. Human beings, more than practically any organism, can live in practically any environment, because they can manipulate it to suit their own needs. Man also has the advantage of a superior brain. Of all the animals, man's brain size is outstanding, and the

most surprising fact is that he does not even begin to use all the available brain power (Sagan, 1977). From the point where man reached the level of having mental abilities, the evolutionary process changed from the purely biological to the sociological. When man evolved a language, he must certainly also have acquired the ability to think in abstract terms, otherwise the use of tools would never have set man on the road to technology (Gibbon, 1981). But is a language necessary for reasoning? This is an issue which has involved sociolinguists for a long time. In human beings reason has taken the place of instinct. Instinct in animals never reaches the level of free thought. Only man took the step towards the level where objects and experience have their own value, and man has become more independent of his environment to the level that he learnt to manipulate it (Lewis and Towers, 1969). It can be said that when man's brain size started increasing, intelligence began evolving. The connection between the evolution of intelligence and the level and awareness of pain in childbirth seems to be made in the Book of Genesis: as punishment for eating of the fruit of the tree of knowledge of good and evil, God says to Eve: "In pain shall thou bring forth they children" (Gen. 3:16). This punishment is not for any kind of knowledge she might have, but it involves the difference between good and evil, and it is a matter of abstract and moral reasoning. The extent of pain in childbirth can then be related to the extraordinarily fast expansion of the human brain, that had been a very recent phenomenon, for the birth banal did not have time to evolve along with the increase in brain size (Sagan, 1977).

There is a mental gap between man and animal. The evolution of conceptual thought goes along with the requirement of self-consciousness and a conscious observation of the environment. From fossil evidence it is clear that man acquired a higher mental ability early on in the evolutionary stages. Signs of the burial of the dead were found when *Homo neanderthalis* fossils were excavated, together with strange arrangements of flowers and rocks, which supports the suspicion that these early

men had a religion and believed in a life after death (Reader, 1981). Man is probably the only organism on earth with a relatively clear view of the inevitability of his own end. After the acquisition of cognitive skills man knew that he would die. Even at the time when the Eden story was written, the development of cognitive skills was seen as endowing man with god-like powers and awesome responsiblities. God says: "Behold, the man is become as one of us, to know good and evil, and now, lest he put forth his hand, and take also the Tree of Life, and eat, and live forever" (Gen, 3:22), he must be driven out of the Garden. God placed cherubim with a flaming sword east of Eden to guard the Tree of Life from the ambitions of man (Sagan, 1977). Perhaps the Garden of Eden is not so different from the world as it appeared to human ancestors some 3 or 4 million years ago during a legendary golden age when the genus *Homo* was perfectly interwoven with the other beasts and plants. Man now concentrates on ethics, religion and survival in a manner very different from that of animals. The mind of man is now capable of nearly anything - because everything is in it, all the past as well as all the future (Sagan, 1977).

CONCLUSION

All these theories are but speculation. If they were to be "proved" scientifically, one would have to experiment with something that took millions of years to come into being. All a scientist wants is a logical answer to observations. It might not be the finally correct answer, but for the moment it would satisfy. If we have been placed in this small corner of the Universe with the capability of becoming consciously aware of it, to influence it and if only modestly to change it, is it then sufficient merely to subject it to our will without considering behind it perhaps a duty, a cosmic purpose? Albert Einstein put it this way: "My religion consists of a humble admiration of the illimitable Superior Spirit who reveals Himself in the slight details we are able to perceive with our frail and feeble minds. That deeply emotional conviction of the

presence of superior reasoning Power, which is revealed in the incomprehensible universe, forms my idea of God" (Hinkelbein, 1972).

The whole idea of evolution for the Christian scholar is not interfere with his religious beliefs, but to strengthen them. For it is in the whole Universe and its development that we see the Hand of God, the Almighty, without whom we would not have been able to interpret what we are now able to conceive. Without God, there can be no meaning in all this, and no purpose. The wonder of everything would then just be reduced to cold fact, and not be embedded in something glorious and holy. For a Christian, evolution may help him to understand more about God and his love and his work, and also then to have more security in the belief in God. With a belief in God it is not necessary any more to ask about the purpose of man in the Universe, for the purpose is clearly to glorify God and to make Him smile upon his creation. Evolution can be studied by anyone who wishes to understand more about the world and its development, but it is not a matter of hard fact. As Lever (1958) put it: "Evolution is like a book with most of the pages gone. The one reading it gets only glimpses of something mysterious and for some it urges to know more, for others it is something to reject as useless. But the book is there, with all its missing pages, and in all its imperfection. You can take out of it what you want and fill in the gaps with speculation, but you will never know the whole story."

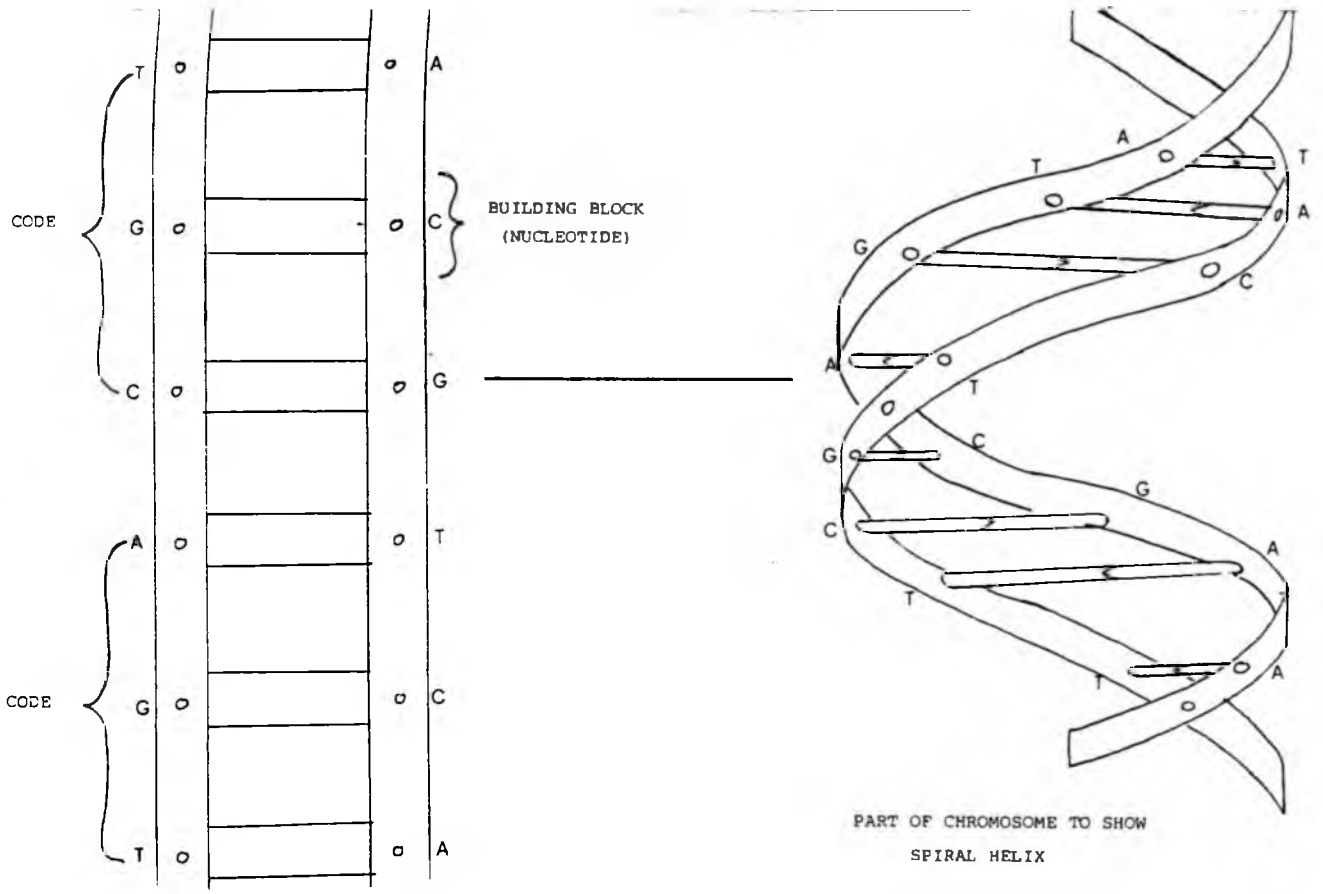

FIGURE 1: A PART OF THE DNA MOLECULE OF A CHROMOSOME (GIBBON, 1981)

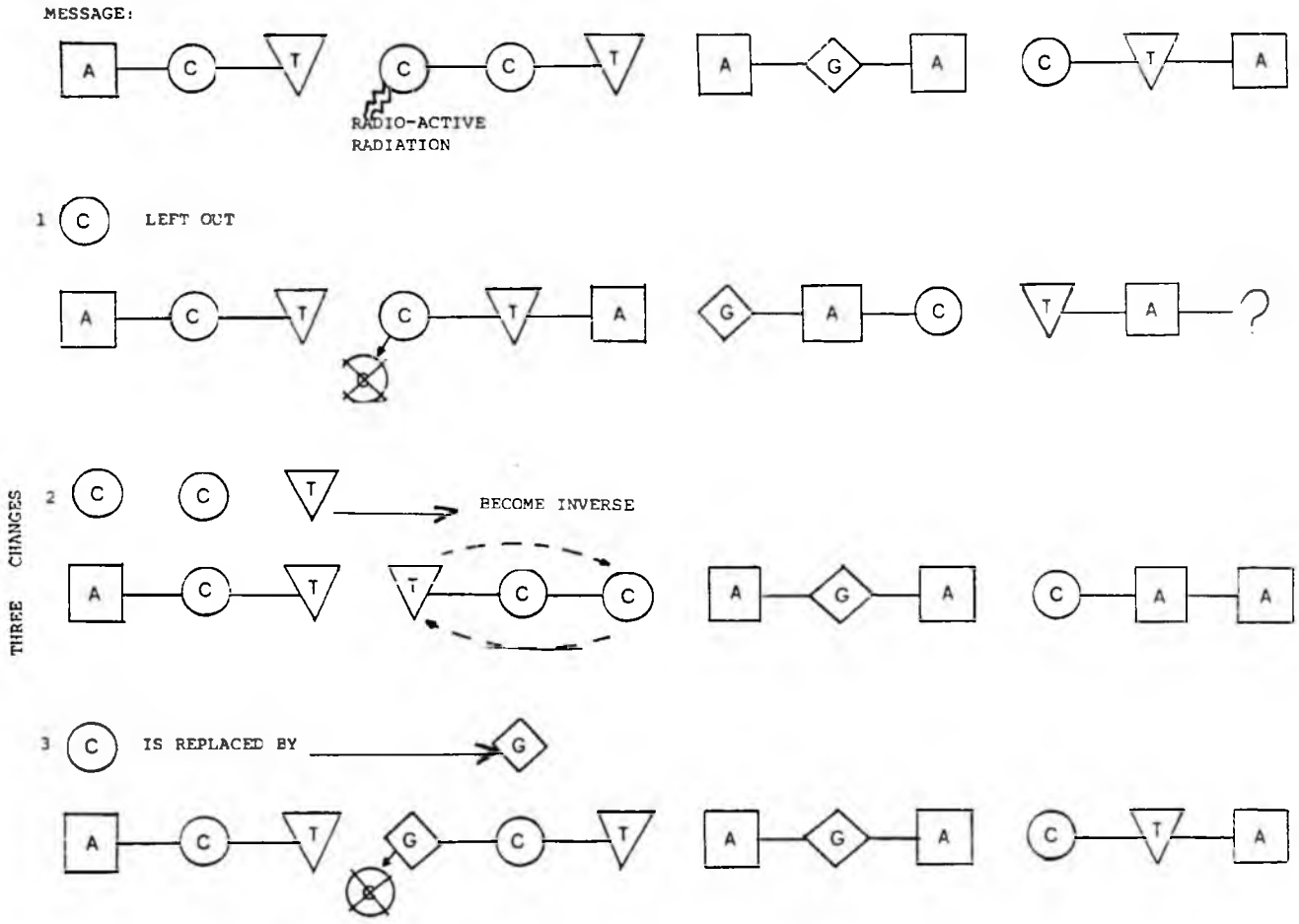

FIGURE 2: GENE MUTATIONS

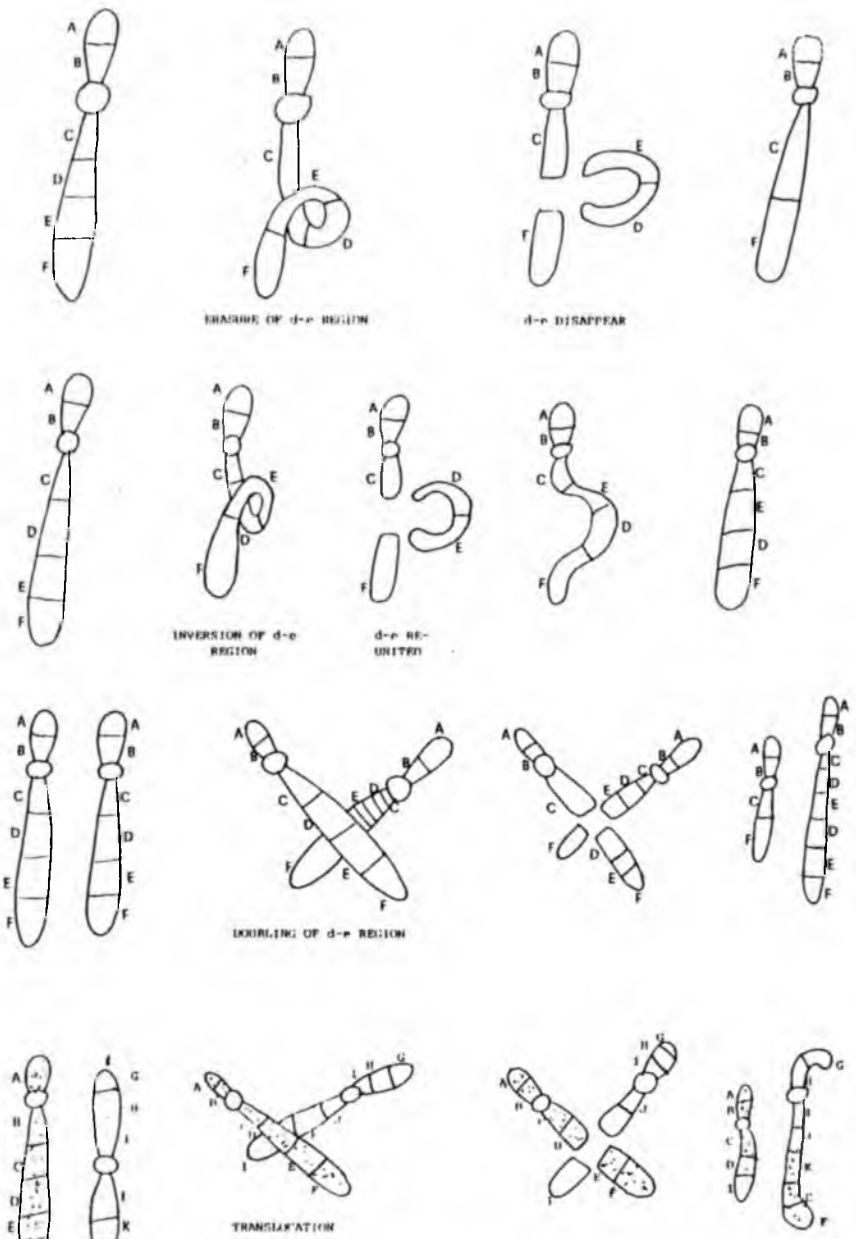

FIGURE 1: CHROMOSOMAL MUTATIONS

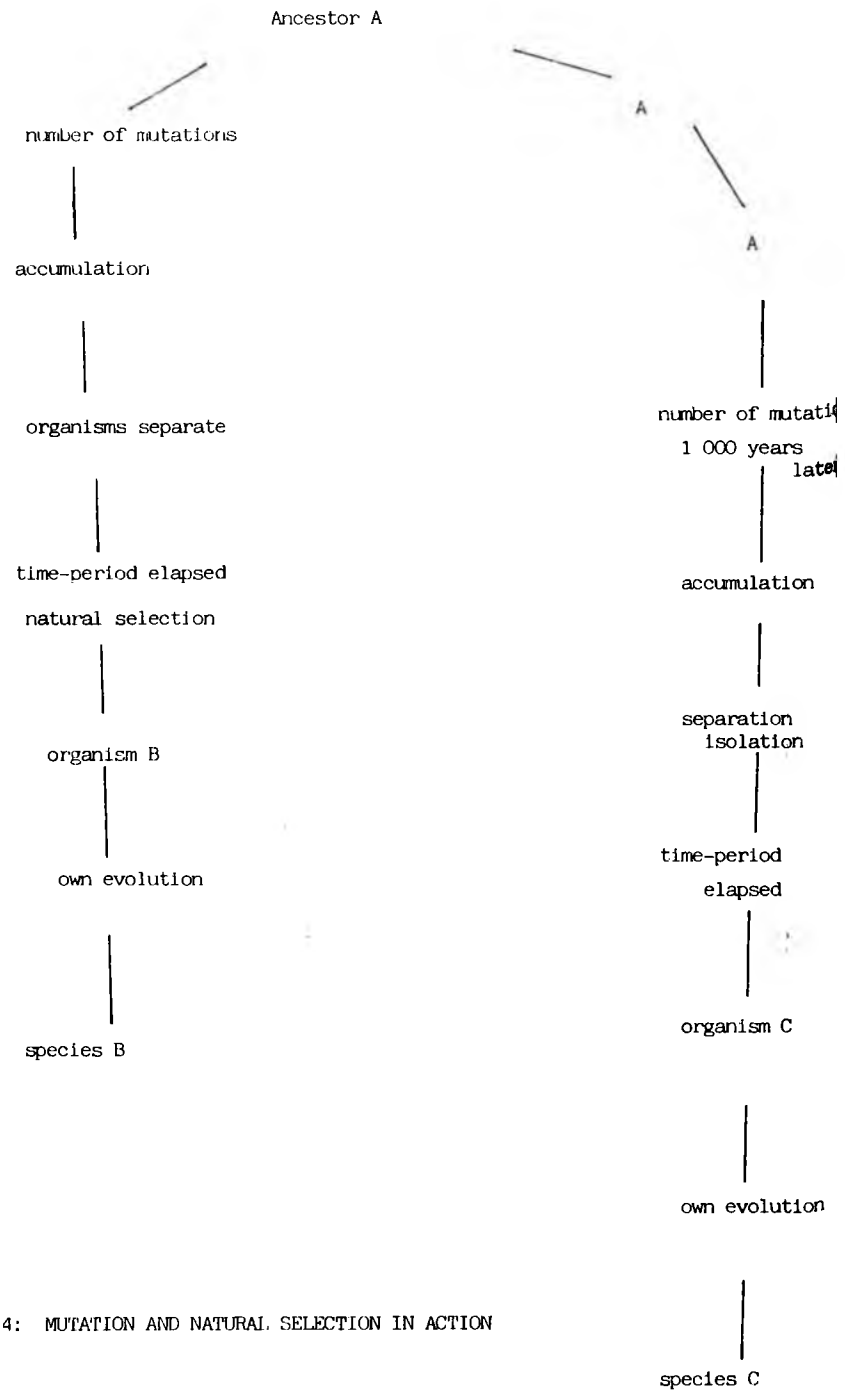

FIGURE 4: MUTATION AND NATURAL SELECTION IN ACTION

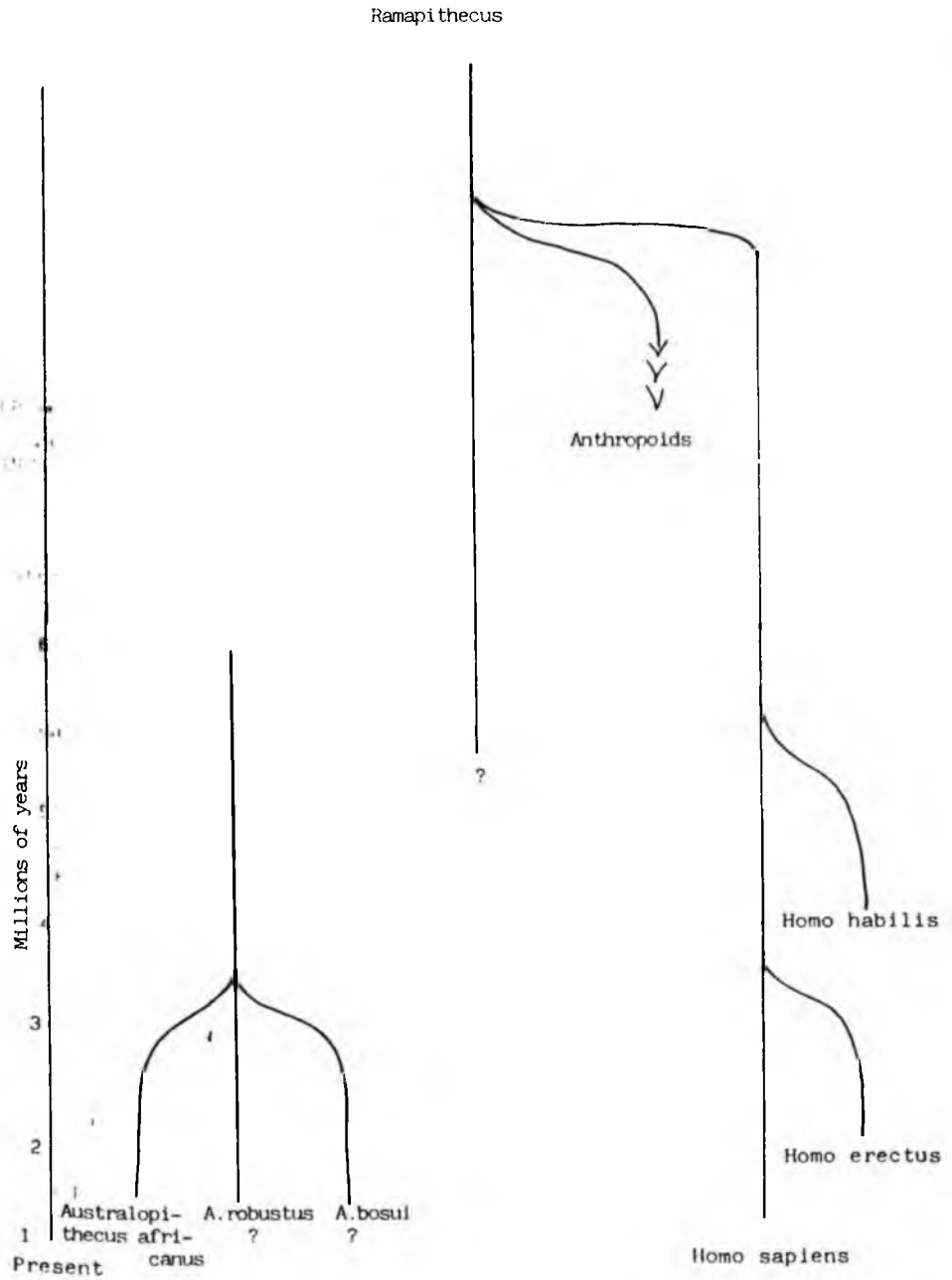

FIGURE 5: STAGES OF HUMAN EVOLUTION (OXNARD, 1979)

	GEOLOGICAL ERA	GEOLOGICAL PERIOD	EPOCH
Present	Cainozoic	Quaternary 3 MyBP	Recent - 11 000 years before present Pleistocene 3 MyBP Pliocene 7MyBP Miocene 25 MyBP Oligocene 40 MyBP Eocene 60 MyBP Paleocene 70 MyBP
70 million years	Mesozoic	Cretaceous 135 MyBP Jurassic 190 MyBP Triassic - 225 MyBP	
230 million years	Paleozoic	Permian 285 MyBP Carbonoferons 350 MyBP Devonian 400 MyBP Silurian 440 MyBP Ordovician 505 MyBP Cambrian 570 MyBP	
570 million years	Pre-Cambrium		

MyBP (million years before present)

FIGURE 6: TIME-SCALE OF EVOLUTION (Gibbon, 1981)

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