

1. Details of Module and its structure

Module Detail	
Subject Name	Biology
Course Name	Biology 03 (Class XII, Semester - 1)
Module Name/Title	Evolution - Mechanism of Evolution & Brief History of Evolution – Part 6
Module Id	lebo_10706
Pre-requisites	Some basic concepts of Genetics, Origin of life.
Objectives	After going through this module the learner will be able to: <ul style="list-style-type: none">• Discuss the major evolutionary trends in the evolution of man viz. bipedal locomotion and development of brain and their adaptive importance• Explain the compelling causes for the evolution of man• Understand the relationship between humans and our closest living relatives• Identify the major fossil groups of man namely <i>Australopithecus</i>, <i>Homo habilis</i>, <i>Homo erectus</i> and <i>Homo sapiens</i>
Keywords	New world monkeys, old world monkeys, hominids, bipedal locomotion, cranial capacity, Dryopithecus, Ramapithecus, Australopithecus, Homo habilis, Homo erectus, Homo sapiens, Neanderthal, Cro-Magnon

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1. Introduction

Study of human evolution is known as **palaeoanthropology**.

Primates evolved about 65 million years ago, when the last of the dinosaurs were becoming extinct. About 40 million years ago, these early primates split into two surviving groups-the prosomians and anthropoids. The prosomians today include tarsiers and lemurs which feed on fruits, leaves and flowers. They are nocturnal and so have large eyes. The anthropoids are monkeys, apes and humans. About 30 million years ago, some early anthropoids made it to the South America where they evolved into the arboreal New World monkeys recognizable by their flat nostrils and in many by a grasping prehensile tail. How they made it to South America is not known. All other anthropoids occupied tropical and subtropical areas of Africa, Asia and some of the islands of Pacific. They are grouped under old world monkeys (hominoids). The nostrils of

these old world monkeys are closely set and the tail when present is not prehensile. The hominoids include the gibbons, the apes and humans. Paleoanthropologists have unearthed fossils of approximately 20 species of extinct hominoids that are more closely related to humans than to chimpanzees. These species are known as **hominids**.

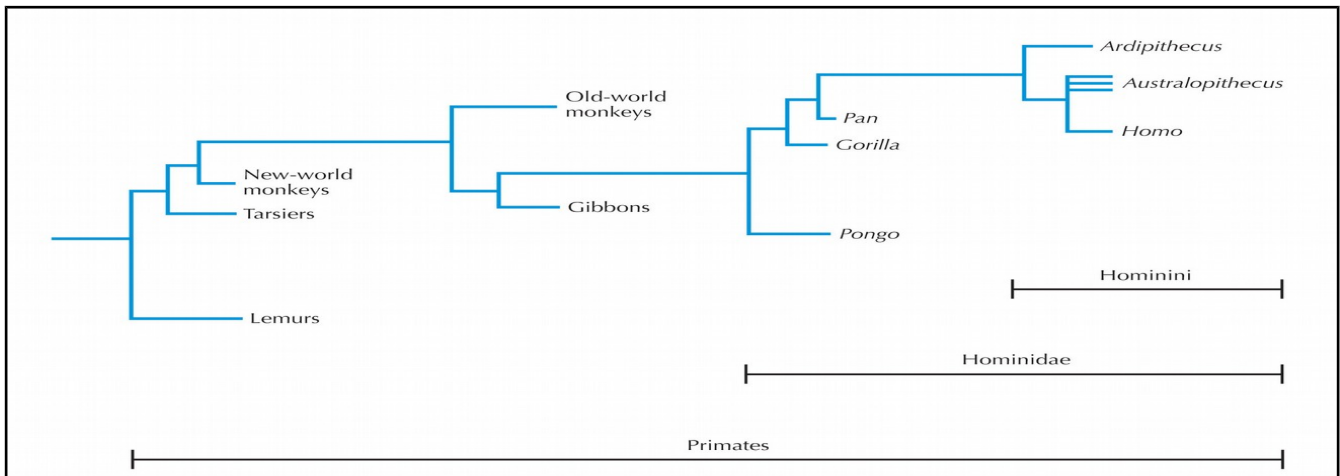


New world monkeys



Old world monkeys

2. Hominids and the distinguishing features of man:



Hominids: As is evident from the phylogenetic tree given below, the family Hominidae contains several branches: Orangutans (Pongo), Chimpanzee (Pan), gorilla (Gorilla) and Humans (Homo). Note that chimpanzees (Pan) represent the tip of a separate branch of hominoid evolution and

that they acquired the derived characters of their own after they diverged from their common ancestor with humans. **The early hominids are thus not chimpanzees.**

Distinguishing characters of humans: A number of characters distinguish man from other hominoids.

- Humans stand upright and walk on two legs—**bipedal locomotion.**
- Humans have a much larger brain than other hominoids.
- They can manufacture and use complex tools.
- Humans also have reduced jaw bones and jaw muscles.
- The derived human characters at the molecular level are being studied by the scientist by comparing the genomes of humans and chimpanzees. The genome of the two are 99% identical. The 1% difference can result in a large number of differences in a genome that contain 3 billion base pairs. It is these genomic differences that separate humans from other hominoids.

The evolution of man is centered around these characteristics.

Of particular significance in human evolution is:

1. **Development of upright posture----Bipedal locomotion**
2. **Increase in brain size.**

3. Impelling causes for Bipedal locomotion:

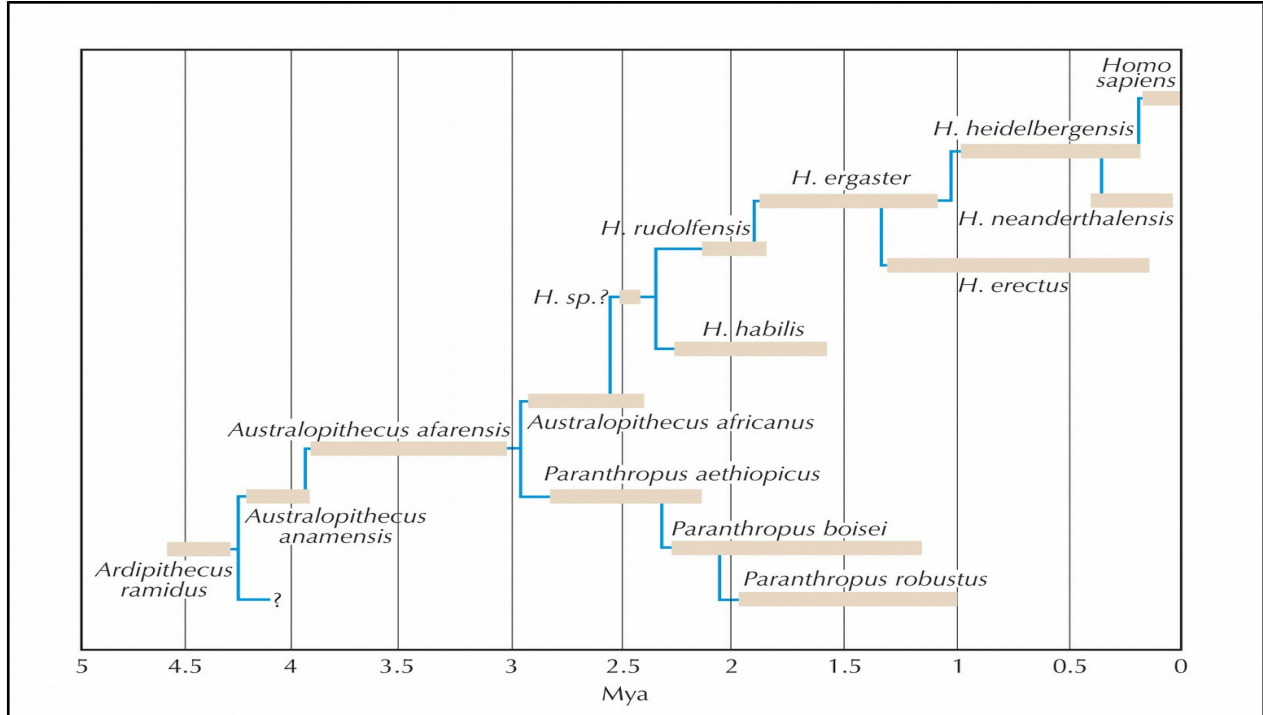
About 30-35 million years ago our anthropoid ancestors were tree dwellers. Roughly around 20 million years ago, the Indian Plate collided with Asia and the Himalayan range was formed. The climate became drier. There was dwindling of the forests resulting in open grassland (savannas) with fewer trees. Vegetation also changed. **Thus, a change in climate and vegetation resulted in new habitats.** It was probably the invasion of these new habitats that must have been the

cause for the forest dwelling apes that lived on the trees to come down on the ground. Bipedal locomotion was an adaptation for these hominids to move over the open grounds. They had greater stamina for long distance travel, more efficient hunting and improved ability to carry food. The common ancestor of man and apes are likely to have used all the four limbs for movement but with the establishment of bipedal locomotion more time was spent in an upright posture. By about 4 million years ago our hominid ancestors were bipedal and fully erect. In addition, an upright posture gave the homonids increased height and range of vision which would have advantages for them living in the open savannas.

Along with the advantages of bipedal locomotion was increasing brain size as recorded by cranial capacity. Freeing of the arms from their locomotor duties enabled them to be used for carrying objects and manipulating the environment. Their hands were no longer needed for walking and could be used for a variety of other tasks such as gathering food or using sticks and stones as weapons. They could now hunt larger animals. They could provide better care for their infants and this allowed them to continue to evolve larger brains that were more adapted towards learning. These animals were the early ancestors of humans.

They began breaking stones to create sharp edges which could be used to cut wood, meat, and bone. Around one million years ago, they learned how to keep fires burning and began cooking their food. Cooked food required less chewing and so their jaws evolved to become smaller.

There was competition between different groups of early humans. Those who could make better weapons, and those who were more skilled at using them had an advantage over the others. Increased competition, better parental care, better communication, and an increasingly complex lifestyle, all of these factors resulted in the evolution of a larger and more adaptable brain. Groups that evolved larger brains outcompeted and replaced groups that did not.



Postulated time spans and relationships of hominin species

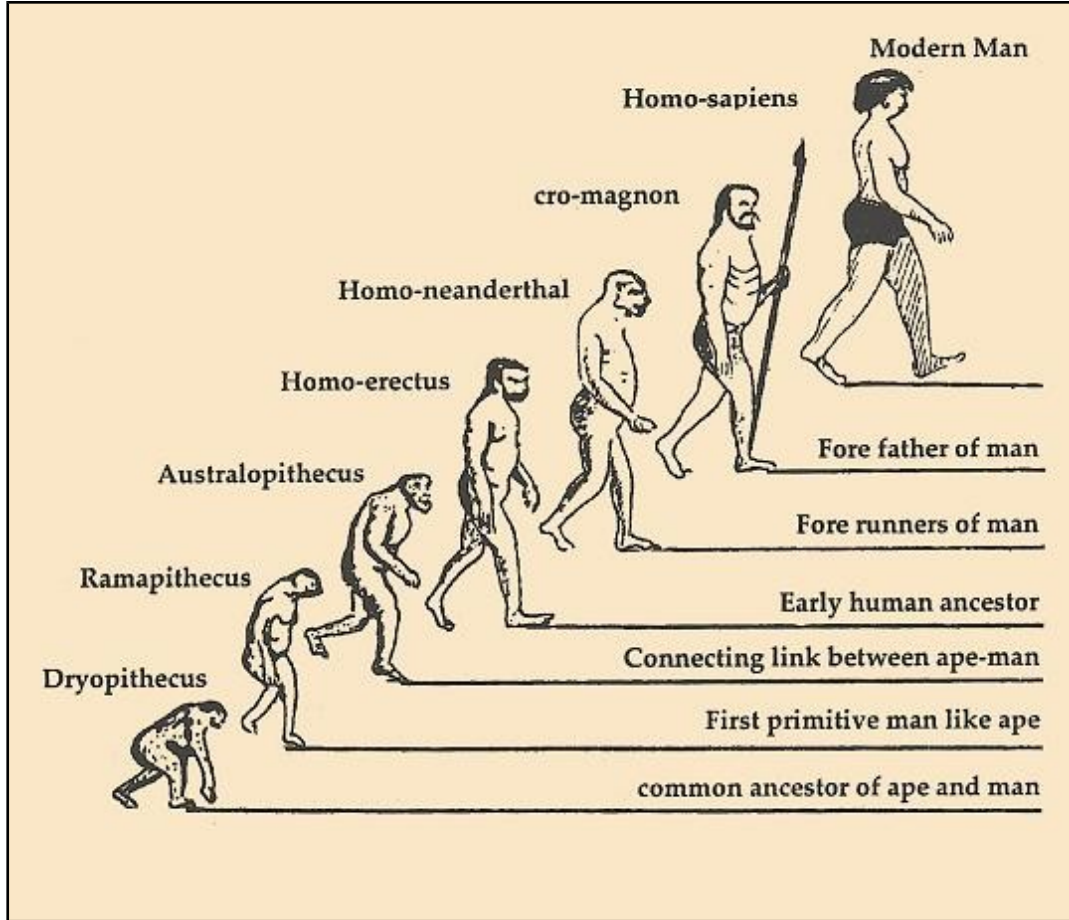
4. *Dryopithecus*: fossil ape

- Appeared during the middle Miocene era=15-25 million years ago.
- *Dryopithecus africanus* has a close similarity to chimpanzee and is considered to be the common ancestor of both apes and man or a direct forerunner of man.
- In middle Miocene, there existed in Africa, Europe and Asia (India) several species of ape, ape like animals (gorillas, chimpanzee) constituting the sub-family Dryopithecinae which are probably the common ancestors of present day apes (pongidae) and man (hominidae). They spent some time on ground and some tree climbing. Only two limb bones of *Dryopithecus* have been recovered=one humerus and one femur. In India, *Dryopithecus* bones have been recovered from the Shivalik hills, Dehradun(some evolutionist thus have named it as *Sivapithecus*). An almost complete lower jaw of *Dryopithecus* have been recovered in Bilaspur district of H.P.

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- Arms and legs of *Dryopithecus* were of the same length. Their legs and heels indicated that they must have assumed a semi erect posture.
 - They varied in size, ranging from small animals up to the size of gorilla.
 - Limb bones indicated that these Miocene apes were much lighter than the modern apes, more slender than modern descendant and yet not specialized for brachiation.
 - Skull resembled the smaller old world monkeys rather than anthropoid apes.
 - Teeth were like modern apes i.e. with enlarged pointed tusk like canines (not found in man)
 - Used to feed on fruits, leaves, seeds.

5. Ramapithecus:

- Lived in late Miocene and early Pliocene, about 8-14 million years ago
- Known from East Africa and India=Some evolutionist have needlessly named it as Kenyapithecus (so named because some of the fossils were found from Kenya)
- They lived in the open and it is presumed to have walked on all fours (quadrupedal). Since very little is known about the general body structure of *Ramapithecus*, it cannot be said whether they walked erect or not. Unfortunately some fragments of jaws and teeth and limb bones have been found to be intermediate between *Dryopithecus* and later hominidae.
- Skull was like that of man but the cranial capacity was like the apes.
- Dental formula was like that of a typical anthropoid 2-1-2-3 and proportion of teeth suggested that they were more closer to man than the apes. They had equal sized incisors and canines much like the modern man. Molars man like, diastema absent.
- They used to feed on nuts, seeds and fruits with hard covering.



Source: <http://wisebrain.info/phylogenetic-relationship-between-ape-and-man>

6. Australopiths:

Australopiths are homonids that lived 4-1.9 million years ago. The Australopiths got their name from the discovery of *Australopithecus africanus* (the first southern ape man) which lived in South Africa some 3-2.4 million years ago. It is a recent discovery in 1924-1925. Most of its remains have been found in Southern and Central Africa with some fragmentary and doubtful records or finds in Indonesia. The first fossil of human like apes to be unearthed was a skull cap of a child discovered by Raymond Dart in South Africa in 1925. This skull fossil had some human and some ape characteristics. In succeeding years, additional skulls, jaws and limb bones

have been collected from South Africa and Java. These characteristics are similar to primitive apes in certain characteristics and to man in many others- a mixture of human-ape trait.

1. They were small statured averaging about 4feet.
2. *Australopithecus africanus* had an **upright posture** and **bipedal locomotion**. They lived in the open.
3. Their brain size was one-third the size of the present day human. The cranial capacity was only about 500cc (450-600cc), about the size of the gorilla. Their brain was not small as compared to the body size suggesting that their intelligence was higher than apes (Apes have a much larger body as compared to their brain). Their brain was intermediate between man and *Dryopithecus*.
4. No overdevelopment of arms.

Points 2, 3, 4 and 5 suggest that Palate reduced but longer than in man

5. Dental arch was a smoothly rounded parabola. Canines reduced and did not project beyond the level of the teeth. Incisors too were reduced. Anterior premolar in lower jaw small and bicuspid.

In apes, the canines, premolars and molars form parallel rows, with incisors being set at right angles to them in front of the jaws while **in man** the entire tooth row is more evenly curved.

6. Simian gap absent= suggests that these species were incapable of killing large animal prey without tools. Some of these primates used pebbles of various types for killing their animal prey and others appear to have manufactured and used stone tools.
7. They had a prognathous face without chin, had a forehead more rounded than the chimpanzee, prominent eyebrow ridges but less so than in chimpanzee.

***Australopithecus africanus*, although ape like in many ways they are more closely allied to man and are unanimously accepted as links between ape like and human stages of our ancestry.** They represent an early stage in human evolution and may be referred to as hominids.

Australopithecus afarensis :

Very recently in 1974, paleoanthropologists discovered an *Australopithecus* skeleton that was 40% complete from Ethiopia. The skeleton suggested that this man lived about 3.24 million years ago (2.9-4 million years ago). The fossil was named “**Lucy**”. Lucy was small in stature; only about 1m tall. Lucy and similar fossils were designated as *Australopithecus afarensis* as they were quite different from *Australopithecus africanus*. *A. afarensis* existed as a species for at least 1 million years.

- *Australopithecus afarensis* had the head of the size of a soft ball suggesting a brain size about the same as that of the chimpanzee.
- They had a long lower jaw.
- Skeletons of *A. afarensis* suggests that they had arboreal locomotion, with arms relatively long in proportion to the body size (compared to the proportions in humans).
- Fragments of the pelvis and the skull bones indicate that they had bipedal locomotion (walked on two legs).

Discovery of *A. afarensis*, suggested that the hominid species had bipedal locomotion.

Another lineage of Australopiths consisted of “**robust australopiths**” and “**gracile australopiths**”. They had sturdy skulls with powerful jaws and large teeth, adapted for grinding and chewing hard, tough foods. Both *A. africanus* and *A. afarensis* had lighter feeding jaws and teeth adapted for softer food.

It is believed that *A. robustus* perished without leaving any descendants while the *A. africanus* evolved into hominids.

7. Early Homo:

Homo habilis (hardy man or first tool maker hominid) were the earliest fossils to have been placed as Homo by Robert Leaky on the basis of their jaw and skull. **They were the first**

hominid to use a complex set of tools. Although tools were found among Australopithecine fossils, the Australopiths were probably not the tool makers, because they had been evolving for more than a million years without any apparent development of tools. That probably must have been because of their brain size which was not very different from the modern apes.

- *Homo habilis* lived from about 2.4-1.6 million years in the early Pleistocene.
- They lived in Gona, in Ethiopia.
- They could walk fully erect.
- They had long arms and short legs
- They had a shorter jaw (Australopiths had longer jaws), cranial capacity of about 600-750cc (in-between modern man and *A. africanus*)
- The flat face and large molars of the *Homo habilis* resembled the *Australopithecus* lineage.
- They could make stone tools (***Habilis* means associated with stone tool- hence the name**) which were used for killing small animals and for digging underground food. So, they were omnivorous and had started hunting.

The complexity of Homo tools indicates a substantially more complex culture and social organization than the earlier Hominins.

A new hominid fossil was found that lived 1.9-1.6 million years ago and evolved in Africa. It was quite distinct from *H. habilis*. Paleoanthropologist named it as ***Homo ergaster***: Ergaster in Greek means “work” hence the name. *Homo ergaster* means the workman. The name was given because large stone tools were found near some of its fossils.

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- *Homo ergaster* had a substantially larger brain than *H. habilis*. It had a cranial capacity of over 900 cc.
 - They had long, slender legs with hip joints well adapted for long distance walking.
 - The *Homo ergaster* also had relatively short and straight arms suggesting that *H.ergaster* did not climb trees like earlier hominids.
 - Premolar and molar were smaller, more like the humans. Canines were also more like the humans- short and blunt.
 - Jaw was shorter and more lightly built than the earlier species resulting in a shorter and flatter face.
 - *Homo ergaster* were found in the arid environment and has been associated with much more sophisticated tools than earlier hominids.

It seems likely that *Homo* marked a dramatic increase in cognitive abilities over earlier Hominids.

Some evolutionist consider *Homo habilis* as the direct ancestor of later hominids such as *Homo erectus*, *Homo sapiens*, *Homo neanderthalensis*.

The next in the line of evolution in man was ***Homo erectus***. They originated in Africa and were the first hominid to migrate out of Africa. The oldest fossils of hominids outside Africa dating back 1.8 million years, were discovered in 2000 in the former Soviet Republic Of Georgia. *Homo erectus* finally migrated as far as the Indonesian archipelago. Comparison of *H. erectus* fossils with humans and studies of human DNA indicate that *H. erectus* became extinct sometime after 200,000 years ago.

8. Homo Erectus or Erect Ape Man

- Middle Pleistocene=8,00,000-3,00,00 years ago. Remains of Homo erectus were encountered in several places in Asia (Central and South east Asia), Africa and Europe
- He was moderately built, more than 5ft. tall and weighed 70 kg
- Straight limb bones, broad hip bones (pelvis broad and flattened). They walked erect and hence the name **Homo erectus-erect ape man**
- Proportionate length of arms and legs was much as in modern man suggesting that this may be a primitive character while the elongated arms of the apes are specialized.
- Cranial capacity 850-1200cc with an average of 1000cc=distinctly greater than Australopithecus (450-600cc) and less than modern man (1400-1600cc). These men were very clever by ape standard and dull by human standards.

During the same time there were two other men: Peking man (Cranial capacity: 850-1200cc: average 1000cc) and Java man (Cranial capacity: 850-1000cc: average 940cc).

A dutch physician E. Dubois discovered remains of Homo erectus from Java in 1891, hence the name **Java man**. The fossil consisted of a single skull cap, a jaw fragment and a femur.

- They had a retreating forehead, low and slanting and a prognathous face
- Massive jaws with large teeth. Although teeth were large, they were man like
- Chin absent-ape like
- Heavy eyebrow ridges-ape like

Similar group of fossils were found in a cave in China and were named **Peking man**. It was Davidson Black in 1927 who discovered a single tooth and a complete skull including parts of

lower jaw and teeth from caves near Peking. Later Weidenreich discovered remains of at least 40 individuals from Peking. These remains were very similar to fossils from Java and hence were collectively called *Homo erectus*.

No cultural remains have been found with Java fossil but Chinese fossil are associated with crude tools of chipped stone and bone. Peking man used fire-charred Deer bones indicate that he has learnt to cook indicating human intelligence.

9. Transition From *Homo Erectus* to *Homo Sapiens*

Pleistocene: This period was subdivided into four glaciers according to the alternating period of glaciations and warmer times. There were four major glaciers separated by three interglacial periods. The fourth post glacial period is in progress.

Several fragmentary remains which have been dubbed as pre-sapiens have been found from the last interglacial period.

10. Neanderthals: so called because their fossils were discovered in a cave in the Neander valley in Germany. They lived 1,30,000 years ago and became extinct 25,000 years ago. They lived in the last period of ice-age.

Discovered by Fuhlrott in 1856 in Germany. Numerous Neanderthal skull and skeleton have been found in Europe from France to Spain to Palestine and Central Asia.

- Body was short and stocky, strong with heavy weight muscles adapted to cold climate. Average height (males 1.7m, females 1.6m)
- These Neanderthals had a cranial capacity of about 1450cc, roughly same as that of the modern man.
- Thick skull bones with low slanting forehead and prominent eyebrow ridges.
- Chin absent.
- They were capable of making tools from stone and wood. They used stone tools, gathered food and used fire as we do. They used animal hides for making crude clothing.

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- They also buried their dead and followed rituals.
 - Although Neanderthals and other hominids were able to produce sophisticated tools, they showed little creativity and not much capability for symbolic thought.
 - They lived about 40,000 years ago and became extinct without contributing to the gene pool of the living humans.

It is believed that Neanderthals were capable of abstract thought and it is very likely that they had a language. There are even signs that they displayed care and concern for their fellows. Some authors regarded him as a separate species which became extinct and was replaced by *Homo sapiens*. At present the consensus is that Neanderthals were a race, a sub-species of *Homo sapiens*. It is quite probable that some Neanderthal genes have survived and are carried in living man.

Neanderthals were replaced by less rugged but culturally more advanced *Homo sapiens*, the **Cro-magnon man**. Thereafter, the success of human population depended on technologies and culture rather than greater body strength. It is quite possible that they were killed by invading *Homo sapiens* or may be they interbred with the invaders. Although latest view is that they did not merge with the invaders but became extinct.

11. Cro-Magnon Man

- Existed 30,000 years ago and became extinct 20,000 years ago
- They were found from southwestern France found from the cromagnon rock shelter site
- About 180cm in height (10-31cm taller than the Neanderthals) with a large skull, broad face, high rounded forehead, narrow nose and a prominent chin, without eyebrow ridges
- Their skeletons and musculature generally were less massive than the Neanderthals. Skeletal bones indistinguishable from modern man (Europeans)
- Cranial capacity 1600cc
- They were swift footed, cave dwelling forms, expert hunters. They were familiar with art and could sketch pictures of their animals

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- They made tools from finely chipped stones. Tools consisted of spear head and arrows. They made ornaments from ivory and decorated their body. They knew how to hide from animals
 - They performed religious burial ceremony

12. Homo Sapiens:

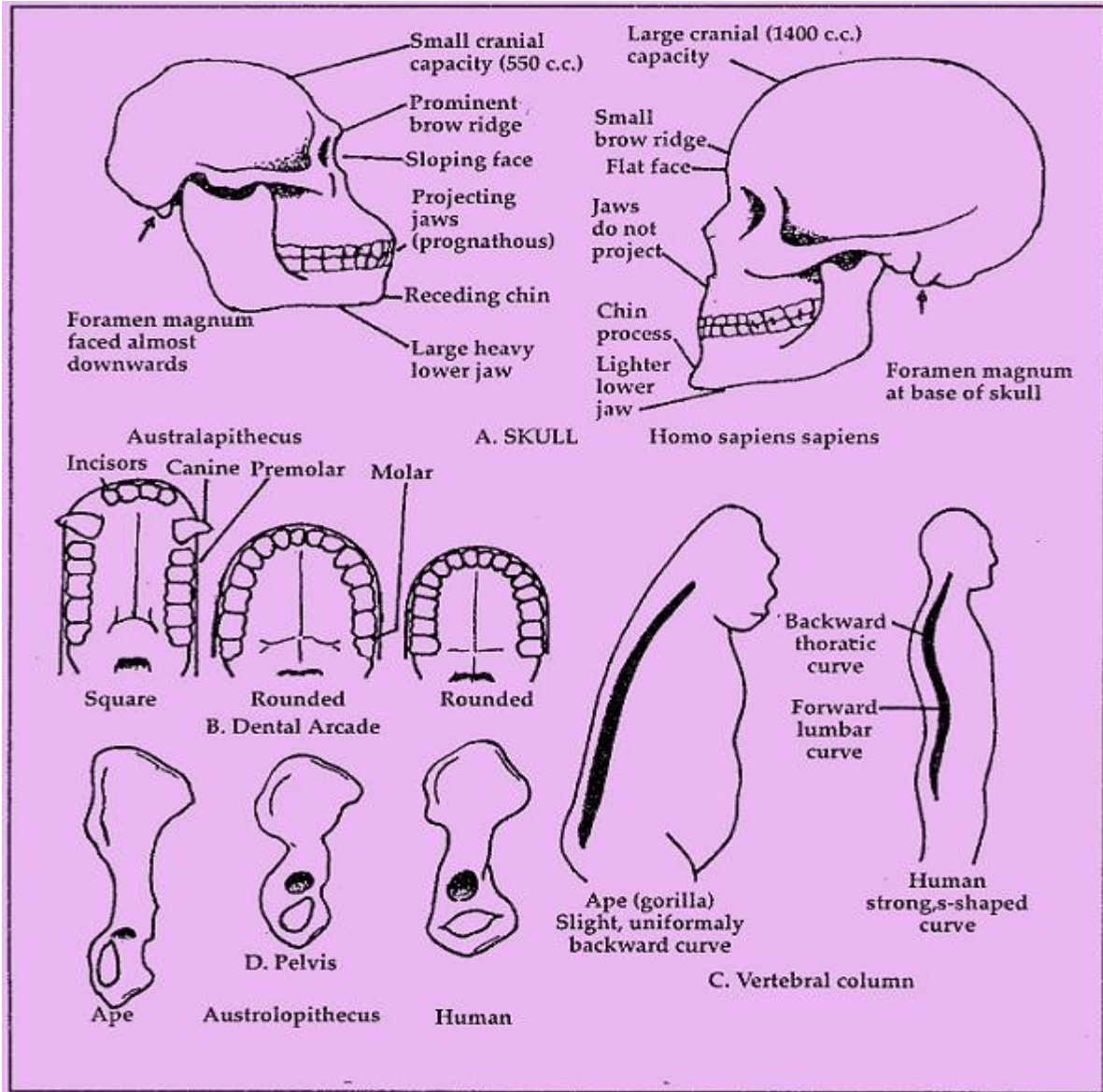
Evidence from fossils and DNA studies has suggested that the ancestors of humans originated in Africa. *Homo sapiens* then spread around the world. The oldest fossils of *Homo sapiens* outside Africa dates back about 50,000 years. Studies of the human Y chromosome suggest that the humans spread beyond Africa first into Asia and then to Europe and Australia.

The oldest known fossil of our own species was discovered in 2003 by researchers working in Ethiopia. The fossil discovered was 160,000 years old. The Ethiopian fossils support the molecular evidence about the origin of man.

All people today are classified as *Homo sapiens*. Our species of humans first began to evolve nearly 200,000 years ago in association with technologies not unlike those of the early Neanderthals. Symbolic thought may have emerged along with human language. This led to the construction of new tools. They were able to teach the other fellow mates how to make tools. Long range trade for scarce resources also became possible. All this led to an increase in the survival and reproductive fitness of humans. As the population increased in Africa, population pressure may have driven humans to migrate into Asia and then to Europe. Neanderthals may have been driven to extinction by the combined stresses of the last ice age and competition from the newly arrived humans. Compared to the Neanderthals, modern humans have more delicate skeletons. Their skulls are more rounded and less protruding brow ridges. They also have relatively high foreheads, smaller face, and pointed chins.

The *Homo sapiens* showed creativity and by 36,000 years ago they were able to make cave paintings.

Further human evolution is on the development of culture, learning etc. Evolution would now be more about evolving human cultures rather than evolving human brains.



Source: <http://wisebrain.info/phylogenetic-relationship-between-ape-and-man>

13. Summary

Estimated time	Hominid Type	Description
15- 25million years	<i>Dryopithecus</i>	Small in size, Arms and legs of the same length, semi erect posture, had large pointed canines, used to feed on fruits, leaves, seeds Middle Miocene period
8-14 million years	<i>Ramapithecus</i>	Quadrupedal locomotion, limb bones intermediate between <i>Dryopithecus</i> and later hominidae, cranial capacity like the apes, Dental formula 2-1-2-3, incisors and canines of equal size much like the modern man, molars man like, diastema absent, used to feed on nuts, seeds and fruits with hard covering. Late Miocene and early Pliocene period
4-1.9 million years	<i>Australopithecus africanus,</i> <i>A. robustus,</i> <i>A. afarensis,</i> <i>A. anamensis</i> Common ancestor of humans and apes	Small statured averaging about 4feet, bipedal locomotion, upright posture, prognathous face without chin, forehead more rounded than the chimpanzee, prominent eyebrow ridges but less than in chimpanzee, reduced canines, simian shelf absent, vegetarian Cranial capacity: 450-600cc Lived in Pleistocene period
2.4-1.6 million years	<i>Homo habilis</i> Hardy man First tool maker hominid	Small body, long arms, short legs, walked fully erect, flat face, large molars, cranial capacity 600cc-750cc , used primitive stone tools. Early Pleistocene
8,00,000-3,00,00 years	<i>Homo erectus</i> Forerunner of	Moderately built, more than 5ft. tall, large face, thick skull, and receding forehead, cranial capacity 850 cc -

	modern humans Peking man (Cranial capacity: 850-1200cc: average 1000cc) Java man (Cranial capacity: 850- 1000cc: average 940cc).	1200 cc, used fire, cooked meat, made hand axes, spread from Africa through Asia, lived in caves, were hunters and gatherers Middle Pleistocene
1,30,000years ago until 25,000years ago	<i>Homo sapiens</i> <i>Homo Neanderthalensis</i>	Neanderthals lived in caves, used weapons of stone, ate meat, cared for injured, buried their dead, mastered laws of nature, Their skull bones were thick, heavy eye brow ridges. The mouth projected above the chin. Cranial capacity: 1600cc
30,000 to 20,000 years ago	<u><i>Homo sapiens</i></u> <i>Cro-Magnon man</i>	About 180cm. in height, broad face, rounded forehead, narrow nose, prominent chin, large skull. Eye brow ridges not present, walked upright, used tools, made paintings, killed animals, possibly with bow and arrow, used chemical laws of nature for fire and paints. They were able to reason out. Swift footed, lived in caves and were good hunters. Cranial capacity: 1600cc
2,000Years ago to present	<i>Homo sapiens</i> <i>sapiens</i>	"Modern man" walks upright, uses tools and technology, mainly cultural and technical evolution from Cro-Magnon man, reached the moon, mastered laws of nature at the nuclear level. Cranial capacity: 950-1800cc with an average of 1400cc