PHYLUM PROTOZOA

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Orders

- 1. Gymnomyxa (Sarcodina) 1. Foraminifera 2. Radiolaria 3. Others not found fossil
- 2. Flagellata or Mastigophora

3. Infusoria (not fossil)

4. Sporozoa (not fossil)

The Protozoa include the lowest forms of animals, such as Amæba, Vorticella, and Globigerina. The body is usually very small, and consists in many cases of one cell only, in others of more than one, but the cells never form tissues as they do in all other animals. A cell consists of protoplasm —a viscid or semi-fluid living substance containing granules; in the centre of the cell is a denser, usually spherical body called the *nucleus*—sometimes more than one is present.

(In some Protozoa (the Gymnomyxa) the protoplasm is naked) and consists of an inner granular mass and a thin, clear, outer layer; such forms are further characterised by having no definite shape) by being able to take in food at any part of the body, and by possessing the power of throwing out lobes or filaments of protoplasm known as *pseudopodia*. In others (the *Flagellata* and *Infusoria*) the protoplasm is surrounded by a firm membrane or cuticle which gives the animal a definite form; the food is generally taken in at one permanent aperture, and pseudopodia are seldom present, but the surface is provided with *cilia* or *flagella*, which are fine threads of protoplasm having a definite form and a rhythmic movement.)

Reproduction in the Protozoa takes place usually by fission (i.e. division into two parts) and sometimes by the

formation of spores. In some cases conjugation of two or more individuals occurs, representing to some extent sexual reproduction. In some of the Protozoa there is no skeleton, but in others a shell is formed.

The Protozoa can be divided into four main groups: (1) the Gymnomyxa, (2) the Flagellata, (3) the Infusoria, (4) the Sporozoa; no examples of the last two divisions have been definitely recognised in the fossil state.

CLASS I. GYMNOMYXA (SARCODINA)

The members of this group possess no external membrane (cuticle), and are able to throw out pseudopodia, by means of which movement takes place and food is obtained.

The Gymnomyxa or Sarcodina are divided into several orders, of which only two have been found fossil, namely, the Foraminifera and the Radiolaria.

ORDER I. FORAMINIFERA

The Foraminifera are characterised by their thread-like pseudopodia, which frequently branch and anastomose; and by possessing in most cases a shell or test, which may be calcareous, arenaceous, chitinous, siliceous, or gelatinous.

The calcareous forms are by far the commonest, and in these, two kinds of shell may be distinguished, namely, the vitreous or perforate and the porcellanous or imperforate. In the vitreous, the shell often has a glassy appearance, and is perforated by innumerable tubes for the passage of the pseudopodia kin some forms (e.g. Rotalia) these tubes are $\frac{1}{30000}$ of an inch in diameter, but in others (e.g. Operculina) only $\frac{1}{10000}$ of an inch. In the porcellanous forms the shell, when viewed by reflected light, is opaque and white, having the appearance of porcelain; it is not perforated by tubes, but possesses one or two large apertures through which most of the pseudopodia pass out some, however, are given off from the layer of protoplasm which covers the surface of the shell. In these porcellanous Foraminifera the shell is sometimes pitted, producing at first sight the appearance of

perforation.

(In the arenaceous forms the shell consists of foreign particles joined together by a cement. The particles are usually grains of sand (commonly quartz), but sometimes sponge-spicules, or the shells of other Foraminifera. The cement may be formed of chitinous, calcareous, or ferruginous material. The shell is often imperforate.

The chitinous forms (e.g. Gromia) do not occur as fossils.

The shell of the Foraminifera varies considerably in form and structure; in some genera it consists of a single chamber, when it is said to be unilocular, as in Lagena (fig. 3 F) which is generally flask-shaped. In other cases it consists of several chambers communicating with one another, either by perforations in the walls (septa) between them, or by larger openings. In these multilocular forms the shell grows by the addition of a new chamber at the end of the one last formed; this takes place by the protrusion, through the aperture or mouth of the shell, of a mass of protoplasm, at the surface of which the wall of a new chamber is formed either by the secretion of material or by cementing of foreign particles. The arrangement of the chambers in the multilocular Foraminifera is very varied; they may be placed in a straight line as in Nodosaria (fig. 3 H), in a curved line as in Dentalina, in a plane spiral as in Cristellaria (fig. 3 G), or in a helicoid spiral as in Rotalia (fig. 3 L, M). The earlier whorls in some spiral forms are partly or entirely covered by the later ones, so that sometimes the last whorl only is visible on the exterior

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(e.g. Cristellaria); but when the later chambers are merely attached to the extremities of the earlier ones, all the whorls can be seen (e.g. Operculina). Some genera, such as *Textularia* (fig. 3 E), have two rows of chambers placed side by side; others (*Tritaxia*) have three. In some cases (e.g. Orbitolites) there are numerous chambers arranged in concentric rings instead of in a spiral.



Fig. 1. A, section of a foraminifer in which each septum is formed of a single lamella. B, in which the septum is formed of two lamellæ. a, passages between the chambers; b, septum; c, anterior wall of last chamber; d, supplemental skeleton. (After Carpenter.)

In the porcellanous and the simpler vitreous Foraminifera each septum (fig. 1 A, b) consists of a single lamella which is really the front wall of the preceding cha.nber; but in the higher vitreous forms each septum (fig. 1 B, b) is formed of two lamellæ, owing to the fact that when a new chamber is added to the shell a new wall is secreted next to the front wall of the last chamber. The shell of the vitreous Foraminifera is at first thin, but may afterwards increase in thickness by the addition of material at the surface; in the higher vitreous forms the outer layers constitute what is known as the supplemental skeleton (fig. 1 B, b), which is traversed by numerous canals connected with canals in the septa and other parts. \ddagger

A considerable number of the Foraminifera, especially the higher forms, are <u>dimorphic</u> that is to say, there are two forms of the same species. This fact was first noticed in specimens of *Nummulites* from the Eocene deposits. In one form, the first or initial chamber, which is seen at the



Fig. 2. Dimorphism of Nummulites lævigatus, Bracklesham Beds (Eocene), Selsea. A, section of the entire shell of the megalospheric form. $\times 9$. B, section of the central part of the microspheric form. $\times 9$.

centre when the shell is split, is large and more or less spherical and is called the <u>megalosphere</u> (fig. 2 A); in the <u>other it is much smaller and is known as the microsphere</u> (fig. 2 B). These two forms are found associated together and were, at one time, described as different species. In the microspheric type the shell commonly, but not always, grows to a larger size than in the megalospheric type, and individuals of the former are much less numerous than of the latter; in other respects the two are similar. The relationship of the microspheric and megalospheric shells has been elucidated by a study of the life-history of

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Polystomella and other living Foraminifera. When reproduction takes place in the microspheric form all the protoplasm passes out of the shell and divides into spherical masses, each of which secretes a shell and develops into a megalospheric individual. In the reproduction of the megalospheric form the protoplasm divides into small rounded portions which pass out of the shell as moving spores zoospores; it is believed that two zoospores from different individuals conjugate and give rise to a microspheric individual. There are, therefore, two modes of reproduction one asexual, the other apparently sexual, which alternate

For convenience of reference the Foraminifera may be divided into three groups, the characters of which are based on the structure and composition of the shell; but this cannot be regarded as a natural classification since it sometimes separates allied forms, and also in some types which are usually calcareous we occasionally meet with species in which the shell consists largely of sandy material.

I. Porcellanous Forms

Shell calcareous, porcellanous, not perforated by canals, but provided with one or two large apertures through which the pseudopodia pass out.

Miliola (fig. 3 A—D). Shell multilocular, the early chambers spiral, the later chambers coiled on an elongated axis, each chamber forming half a convolution. In some cases all the chambers are visible externally on both sides of the shell (fig. 3 D); in others, owing to the lateral prolongations of the chambers, only the last one or two are seen (fig. 3 A—C); or it may be that more chambers are shown on one side than on the other. The external features of the shell consequently vary considerably, and on account of this and changes in the plane of coiling, the forms included under the term *Miliola* are now regarded as constituting a number of distinct genera to which



Fig. 3. Foraminifera (recent). A, B, Pyrgo murrhina. B, section. C, Quinqueloculina seminula. D, Spiroloculina limbata. E, Textularia barretti. F) Lagena sulcata. G, Cristellaria rotulata. H/Nodosaria radicula. I, K, Globigerina bulloides. L, M, Rotalia beccari. (After Brady.) All enlarged.

the following names have been given: Pyrgo, Fabularia, Spiroculina, Miliola, Quinqueloculina, etc. Carboniferous to present day. Ex. Quinqueloculina seminula, Eccene to present day; Pyrgo ringens, Eccene to present day; Spiroloculina planulata, London Clay to present day.

Orbitolites. Shell discoidal, generally rather large, composed of either a small spiral part at the centre, or of one or more large central chambers, around which are many concentric rings divided into numerous chambers by radially arranged septa; the chambers of adjacent rings communicate by radial openings, and at the external margin of the last ring are pores opening to the exterior. Above and below this layer of chambers there may be other layers of smaller chambers arranged concentrically. Eocene. Ex. O. complanata.

Alveolina. Shell fusiform or elliptical, sometimes nearly globular, composed of many whorls coiled around the long axis of the shell; each whorl completely covers the one preceding it, and is divided into long chambers by septa parallel with the axis of the shell; these are divided into smaller chambers by partitions at right angles to the septa. One row of perforations in the septa. Cretaceous, but chiefly Eocene. Ex. A. bosci, Eocene. Sub-genus Alveolinella, with several rows of perforations in the septa, and chambers further divided. Late Tertiary and Recent. Ex. A. quoyi.

II. Arenaceous Forms

Shell composed of grains of sand or other particles cementer together by chitinous, calcareous, or ferruginous material. Young stages sometimes calcareous.

Saccammina. Shell usually free, compact, formed of a single spherical, pyriform, or fusiform chamber with a projecting aperture at one or both ends, or of a number of chambers united end to end. Surface smooth or nearly smooth. Recent. Ex. S. sphærica. Saccamminopsis is similar in form, but apparently with a thin calcareous test. Ordovician and Silurian. Ex. S. fusuliniformis (= carteri), Carboniferous.

Lituola. Shell free, composed of coarse grains, plani-spiral in the young, later stages uncoiled, straight. Septa labyrinthine. Aperture single in early stages, later sieve-like. Carboniferous to present day. Ex. L. nautiloidea, Chalk.

Orbitolina. Shell partly sandy; conical or flattened, with convex upper, and usually concave lower surface; consisting of central compressed chambers surrounded by concentric rings of subdivided chambers. Cretaceous. Ex. O. concava, Upper Greensand.

Endothyra. Shell free, largely calcareous; spiral, nautiloid, or rotaliform; chambers numerous, composed of an outer calcareous, perforated layer, and an inner compact layer formed of small grains cemented together. Aperture simple, at the inner margin of the last chamber. Carboniferous to Trias. Ex. E. bowmani, Carboniferous Limestone.

Textularia (fig. 3 E). Shell arenaceous (in the young it is vitreous and perforate); conical, pyriform, or cuneiform; composed of numerous chambers in two alternating parallel series. Aperture slit-like on the inner edge of the last chamber. Carboniferous to present day. Ex. *T. globulosa*, Chalk.

III. Vitreous Forms

Shell of calcite, vitreous, perforated by numerous minute canals for the passage of the pseudopodia.

Lagena (fig. 3 F). Shell unilocular, very finely perforated. Form globose, ovate, or flask-shaped. A single terminal aperture, sometimes at the end of a long neck; rarely two apertures. Surface smooth, ribbed, striated, or spinous. Upper Cambrian to present day. Ex. L. striata, London Clay to present day; L. sulcata, Cretaceous to present day.

Nodosaria (fig. 3 H). Shell composed of a number of thambers which are circular in transverse section, arranged in a straight line, and separated by constrictions. Aperture at the apex of the last chamber. Surface smooth or ornamented with granules, spines, or ribs. Silurian to present day. Ex. N. zippei, Gault and Chalk.

Cristellaria (fig. 3 G). Shell compressed, lenticular or elongate, multilocular, coiled in part or entirely in a plane spiral; each coil usually covers the one preceding it. Upper Cambrian to present day. Ex. C. rotulata, Chalk to present day. **Globigerina** (fig. 3 I, K). Shell perforated by large canals; chambers globular, few, arranged in a helicoid spiral (trochoid), each chamber opening by a large aperture into the central cavity of the spire. No supplemental skeleton. Pelagic forms usually with spines. Cretaceous to present day. Ex. G. cretacea, Chalk.

Orbulina. A single spherical chamber, with perforations of two sizes; with smaller chambers (similar to a *Globigerina*) inside the large spherical one. Lias to present day. Ex. O. universa, Cretaceous to present day.

Rotalia (fig. 3 L, M). Test very finely perforated, multilocular. The chambers arranged in a helicoid spiral, so that on the upper surface all the whorls are seen, on the lower only the last one. The aperture is in the form of a curved slit on the lower surface of the last chamber. The septa are perforated and usually formed of two layers with canals between the layers. A supplemental skeleton is often present. Lower Cretaceous to present day. Ex. R. beccari, Miocene to present day.

Calcarina. Test lenticular, spiral, with only the last whorl visible on the base. Supplemental skeleton greatly developed, traversed by numerous canals, and projecting as long spines from the margin. Chalk to present day. Ex. C. calcitrapoides, Chalk.

Fusulina. Shell fusiform, composed of elongated whorls; each whorl completely covers the preceding one, and is divided by septa into a number of chambers, which may be again divided into smaller chambers. Adjoining chambers communicate by a slit at the middle of the base of each septum. Septa folded, each consisting of a single layer. Aperture in the form of a fissure. Carboniferous. Ex. F. cylindrica, Carboniferous Limestone.

Amphistegina. Shell lenticular, with sharp edge; the upper and lower surfaces unequally convex; formed of numerous chambers coiled in a plane spiral, each coil completely enclosing the preceding one on one side and partly on the other. Septa formed of a single layer. Supplemental skeleton at the centre of the shell. Aperture similar to that of *Rotalia*. Eocene to present day. Ex. A. haueri, Miocene.

⁷ Nummulites (figs. 2, 4). Shell lenticular in form, and composed of a large number of whorls coiled in a plane spiral. Usually each whorl completely covers the preceding one by means of the lateral prolongations of the chambers, so that externally only the last whorl of the shell is visible. The whorls are divided into chambers (c) by septa (b) which are slightly curved backwards; each chamber communicates with the neighbouring one by means of a median fissure at the inner margin of the septum. Each septum is formed by two imperforate lamellæ between which are irregular spaces. A supplemental skeleton is present, part of it forming what has been termed



Fig. 4. Nummulites, showing vertical and horizontal sections. a, marginal cord with canals (supplemental skeleton); b, septum, with canals; c, chambers; d, test; e, pillars of the supplemental skeleton. (After Zittel.) Enlarged.

the 'marginal cord' (a). The general shell-substance is minutely perforated, and a system of canals traverses the septa and supplemental skeleton. Aperture in the form of a slit at the inner margin of the last chamber. The shell splits readily into two similar parts along the median plane, owing to the relatively large size of the parts of the chambers occurring there. Eocene and Oligocene; maximum development in the Middle Eocene. In the English Eocene the genus is found in the Barton and Bracklesham Beds. Ex. N. lævigatus, Bracklesham Beds.

Operculina. Similar to *Nummulites*, but whorls fewer and rapidly enlarging, all visible externally; each of the earlier

whorls partly encloses the preceding one. Upper Cretaceous to present day. Ex. O. complanata, Miocene.

Lepidocyclina. Test lenticular, circular or stellate, flat to inflated, minutely perforated. In the microspheric form the early chambers show a spiral arrangement; in the megalospheric form the early part consists of chambers which are variable in number and size. The early part is followed by a median layer of chambers arranged in concentric rings, usually alternating with the chambers of adjacent rings, and with rhombic, diamond-shaped, hexagonal or other outline; the chambers communicate with those of the same and adjacent rings by apertures. Above and below the median layer are numerous layers of smaller chambers, flattened and irregular in form, placed one above the other and arranged more or less concentrically. Eocene to Miocene. Ex. L. mantelli, Oligocene.

Distribution of the Foraminifera

The majority of the Foraminifera are marine, most of them living on the sea-bottom. A few, however, as for instance *Globigerina*, exist at or near the surface in the open ocean, and these are very important on account of their abundance, especially in warm seas. The distribution of the pelagic Foraminifera in the open ocean, as well as those which live on the sea-floor in shallow water, is influenced largely by temperature; the former are more numerous in warm regions and in warm ocean-currents than in colder water, whilst the species of the latter often have their range determined by temperature and depth.

The Foraminifera found in the Palæozoic deposits are mainly vitreous and arenaceous forms. They appear first in the Upper Cambrian, but are comparatively rare until the Carboniferous, in which some beds are formed largely of their shells, as for instance, the Saccammina limestone of the north of England and Scotland, the Endothyra-limestone of North America, and the Fusulina-limestone of Russia, China, Japan and North America. The Foraminifera are mostly of small size in the Permian of England; they are comparatively rare in the Trias, but become abundant in the Jurassic, where, however, rock-building types are generally absent. In the Lias the introduction of numerous vitreous species (*Nodosaria, Cristellaria*, etc.), many of which appear to be allied to forms now living in tropical or warm-temperate regions only, is noteworthy; some porcellanous forms belonging to the *Miliola* group are also fairly common. A larger number of genera and species are found in the Middle and Upper Jurassic than in the Lias.

^AThe Order continues to be well represented in the Cretaceous formations, particularly in the Gault and Chalk— Orbitolina, Calcarina, Globigerina, Rotalia, etc; being common. Some beds of the Chalk, especially the Micraster zones and the Chalk Rock, are largely composed of Foraminifera such as Globigerina, Textularia, Bolivina, Flabellina.

The Foraminifera attain their greatest development in Tertiary and recent times. In the Eocene deposits Nummulites is often extremely abundant and of large size, forming the greater part of the massive Nummulitic Limestone of Southern Europe, Egypt, Asia Minor, and the Himalayas; Miliola, Orbitolites, Alveolina, Operculina, and Lepidocyclina are also important rock-building forms in the Eocene period. In the English Eocene, Foraminifera are numerous in the Thanet Sands and the London Clay; in the Barton and Bracklesham Beds Nummulites, Quinqueloculina, Alveolina, etc. occur. In the Oligocene Nummulites and Lepidocyclina are still present. Amphistegina is abundant in the Miocene.! A large number of forms occur in the Pliocene deposits of East Anglia and of St Erth in Cornwall.

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ORDER II. RADIOLARIA

In the Radiolaria the body consists of a central mass of protoplasm, enclosed in a membrane known as the central <u>capsule</u> (fig. 5, 2). The intracapsular protoplasm contains one or more nuclei, and is continuous, through pores in the capsule, with a layer of protoplasm outside the capsule; this layer gives off thread-like pseudopodia, which occa-



Fig. 5. Heliosphæra inermis. ×350. Recent. (After Bütschli.) 1, skeleton; 2, central capsule; 3, nucleus. Pseudopodia project from the surface.

sionally unite. A skeleton (fig. 5, 1) is generally present and is usually composed of silica; but in one group of Radiolaria it consists of a substance which was formerly regarded as horny in nature and termed acanthin, but is now believed to consist of strontium sulph. te. The skeleton shows great diversity of form and complexity (fig. 6); it may be entirely outside the central capsule or partly within, and consists either of isolated spicules, or of a lattice-like or reticulate structure of varying shape, frequently with projecting spines. The Radiolaria are all marine and mainly pelagic; the majority live between the surface and a depth of 200 fathoms, but a few forms occur in much deeper water. They have a very wide geographical distribution, being found in all climates, but show the greatest variety of forms in the seas between the tropics, they are also abundant in individuals in the Arctic seas, but the variety of forms is



Fig. 6. Fossil Radiolaria. A, Lithocampe tschernyschewi, Devonian. B, Trochodiscus longispinus, Carboniferous. C, Podocyrtis schomburgki, Barbados Earth (Tertiary). All largely magnified.

relatively small. In some of the deeper parts of the Pacific and Indian Oceans the empty shells of these animals settle and accumulate on the sea-bottom, forming a siliceous deposit known as 'Radiolarian ooze'. Only those Radiolaria in which the shell consists of silica are preserved as fossils.

Cayeux has described as Radiolaria some bodies found in the Pre-Cambrian rocks of Brittany; they are much smaller than later forms of the group, and are thought by some authors to be simply inorganic aggregations. Imperfectly

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preserved Radiolaria have been recorded from the Cambrian of Thuringia.

In Britain the earliest examples of the Radiolaria occur in the Ordovician rocks of the South of Scotland where they form beds of chert; others, which are perhaps of nearly the same age, have been found in a chert from Mullion Island (off the west coast of the Lizard). A few specimens have been noticed in the Carboniferous Limestone of Flintshire; whilst in the Carboniferous Limestone of South Wales and in the Lower Culm of Devon and Cornwall these organisms contribute largely to the formation of thick beds of siliceous rock (cherts, etc.)-some, at any rate, of these deposits appear to have been formed in shallow water. At several localities on the continent Radiolaria are fairly common in the Mesozoic formations, but in England only a few have been recorded from the Lias, the Lower Greensand, the Upper Greensand, the Cambridge Greensand, and the Chalk. In the Tertiary some have been obtained from the London Clay of Sheppey. A very important Radiolarian formation of late Tertiary age covers large areas in the Island of Barbados, and is known as the 'Barbados Earth'; it resembles very closely the modern Radiolarian ooze mentioned above, and is probably a deepsea deposit.



HUMAN EVOLUTION

In 1871 Charles Darwin was able to propose that we were most probably of African origin and most closely related to the Great Apes of Africa. Biochemical evidence now reinforces this conclusion and indicates that the divergence of our lineage, the Hominidae, from the African apes took place between 5 and 8 million years ago (m.y.a.).

There are no fossils now believed to lie within our hominid lineage before c.6.0 m.y.a. The earliest group of well-known undoubted hominid fossils comes from Laetoli in Tanzania, and dates from c.3.7 m.y.a. These belong to the genus *Australopithecus*, which is considered to range in time from c.5 m.y.a. to 1 m.y.a., and appears to have been confined to the continent of Africa. *Australopithecus* was a bipedal, small-brained hominid, which later diversified into 2-3 more robustly built species, as well as probably giving rise to members of our own genus, *Homo*.

The earliest fossil remains that are classified as Homo, and thought to be our direct ancestors, come from south-west Ethiopia and adjacent Kenya. They are dated to c.2 m.y.a. This species, named Homo habilis, possessed a somewhat larger brain than Australopithecus, and appears at approximately the same time as the earliest stone tools. The successor to Homo habilis was the much more modern-looking Homo erectus. The earlier specimens are from Kenya, and date to c.1.5-1.8 m.y.a. Only after c.1.0 m.y.a. do we find that this species of Homo has spread into Eurasia. Archaic forms of Homo sapiens are variously recognized from Afro-Eurasian specimens dated to c.300 000 years ago. Recent biochemical data suggest that modern humans, Homo sapiens sapiens, arose in Africa c.200 000 years ago. This fits in well with the available fossil evidence from Africa and the Near East, where human skeletal material with completely modern features is known from an earlier date than elsewhere. Humans are too complex to be "understood" by any one field. Thus we will look at a few major steps in evolution and some of the things affecting human evolution.

Humans are members of the order Primates which consists of about 180 species (there are 17 different orders of mammals which diverged 80-65 million years ago). Primates are a relatively old order of mammals. Most of the synapomorphies of this order are associated with an **arboreal** way of life: flexible digits, forward facing eyes, vision as a primary sense. These traits may have played a role in the evolution of brain size in the lineage leading to humans. Humans are a member of the family Hominidae which is believed to have diverged about 5 million years before the present (mybp) from the other members of the Old world monkeys. At least 20 mybp the Hominoids split off from the other old world monkeys. The dates are rough and get changed now and then.





Relationship of humans to African apes (= chimps, gorillas) and orangutan DNA hybridization indicates that **apes are our closest relatives**. Human/chimp/gorilla relationships not proven but chimps are most likely our closest relatives. The molecular clock says ~ **5 million years** ago the human-chimp line split.

While Chimp and gorilla have **knuckle walking**, the humans posses many traits associated with **bipedality**: vertebral column, shape of pelvis, angle of femur, **foramen magnum at base of skull**. Bipedality seems to be a major "innovation" which allowed humans to enter a new "adaptive zone". The first human (*Australopithecus afarensis*) seems to have an angle between the femur and tibia (Upper and lower leg) that is intermediate to that of humans and gorillas.

The evolution of modern humans from our hominid ancestor is commonly considered as having involved four major steps: evolving **terrestriality**, **bipedalism**, a large brain (**encephalization**) and **civilization**. There are (and have been) several competing hypotheses that have acknowledged these four steps, but put them in **a different sequence** during human evolution.

Origin of Homo sapiens: **Australopithecus afarensis** = first bipedal hominid, found in east Africa about 3.0-3.2 MYBP. Later forms became more slender (= "gracile"). *Homo habilis* and *H. erectus* (~1.5mybp) came later. The evolution of bipedalism may have freed the hands for us in other functions: carrying, tool use. The trends in the evolution of tool use (more types, more specific tasks, different types of materials, more efficient use of materials) seems to follow (lead??) the evolution of **increase cranial capacity**. These both seem to increase noticeably about 2 mybp. One theme that involves each of the different sequences of evolution is that there was some feedback that lead to the increase in cranial capacity, e.g., becoming bipedal creates selection pressure for a more elaborate brain to control motor function and to process incoming sensory information. This in turn would allow for more successful bipedalism, etc. The same argument could be leveled about culture leading to an increase in brain size, and vice versa, so the sequence cannot be resolved just on the logic of feedback loops alone.

Origin of "**modern humans'':** Two alternative scenarios for origins: 1) humans originated in more than one site ("Multiregional" model). Evidence supporting this are modern *Homo*

sapiens samples found in **Asia and Africa** 2) a single origin ("Noah's Ark" model: one origin and dispersal out from site of origin). *Homo sapiens* are believed to have originated ~100,000 - 200,000 years ago.

The analysis of the evolution of culture and civilization in humans clearly must be based in materials other than human bones alone. The evolution of tools is one reliable correlate (they are recognizable as being rocks reworked as tools and, being rocks, they preserve well). The patterns of tool form show some suggestive trends regarding civilization: through time **more types of tools** become apparent and there is **less variation among specimens** in the shape/form of a given tool. This has been interpreted as evidence for communication or "training", since 'word may have spread' on just how to improve that stone ax so that it can be used more effectively for certain tasks.

The spread of *Homo* out of Africa is presumed to have taken place about 1.5 MYBP by *Homo erectus*. This species seems to be on a trajectory of brain size and body size that looks **anagenetic**, whereas one lineage that lead to *Australopithecus robustus* seems to be on another line. In a broad sweep of time, the notion of the chimp leading to the Australopithecine, to Homo, to the Neanderthal to the modern American family standing in their driveway is a myth. There were lineages that diverged in a branching cladogram, some of which did not make it to the present. Evidence for this is provided by more than one distinct morphological type of early humans present at the same time (see below). As time gets closer to modern humans, however (*Homo erectus* on up), a phyletic gradualist anagenesis is more easy to accept.

Once a big brain is achieved and this provides the intellect for an organism to anticipate its environment, the notion that an organism evolves in response to changes of the environment becomes too simplistic. Humans evolved the power to alter their environment so as to protect themselves from its abiotic pressures. This means that they are **altering their own selective pressures** and a **dialectic** emerges between the organism and the environment such that these cannot be separated. Other organisms do this (beaver dams, deciduous trees), but in humans this cycle is accelerating. The rest is history.

DETAILS OF HOMINID SPECIES

The word "hominid" in this website refers to members of the family of humans, Hominidae, which consists of all species on our side of the last common ancestor of humans and living apes. Hominids are included in the superfamily of all apes, the Hominoidea, the members of which are called hominoids. Although the hominid fossil record is far from complete, and the evidence is often fragmentary, there is enough to give a good outline of the evolutionary history of humans.

The time of the split between humans and living apes used to be thought to have occurred 15 to 20 million years ago, or even up to 30 or 40 million years ago. Some apes occurring within that time period, such as Ramapithecus, used to be considered as hominids, and possible



ancestors of humans. Later fossil finds indicated that Ramapithecus was more closely related to the orang-utan, and new biochemical evidence indicated that the last common ancestor of hominids and apes occurred between 5 and 10 million years ago, and probably in the lower end of that range (Lewin 1987). Ramapithecus therefore is no longer considered a hominid.

The field of science which studies the human fossil record is known as paleoanthropology. It is the intersection of the disciplines of paleontology (the study of ancient lifeforms) and anthropology (the study of humans).

Hominid Species

The species here are listed roughly in order of appearance in the fossil record (note that this ordering is not meant to represent an evolutionary sequence), except that the robust australopithecines are kept together. Each name consists of a genus name (e.g. *Australopithecus*, *Homo*) which is always capitalized, and a specific name (e.g. *africanus*, *erectus*) which is always in lower case. Within the text, genus names are often omitted for brevity. Each species has a type specimen which was used to define it.

1. Sahelanthropus tchadensis

This species was named in July 2002 from fossils discovered in Chad in Central Africa (Brunet et al. 2002, Wood 2002). It is the oldest known hominid or near-hominid species, dated at between 6 and 7 million years old. This species is known from a nearly complete cranium nicknamed Toumai, and a number of fragmentary lower jaws and teeth. The skull has a very small brain size of approximately 350 cc. It is not known whether it was bipedal. *S. tchadensis* has many primitive apelike features, such as the small brainsize, along with others, such as the brow ridges and small canine teeth, which are characteristic of later hominids. This mixture, along with the fact that it comes from around the time when the hominids are thought to have diverged from chimpanzees, suggests it is close to the common ancestor of humans and chimpanzees.

2. Orrorin tugenensis

This species was named in July 2001 from fossils discovered in western Kenya (Senut et al. 2001). The fossils include fragmentary arm and thigh bones, lower jaws, and teeth and were discovered in deposits that are about 6 million years old. The limb bones are about 1.5 times larger than those of Lucy, and suggest that it was about the size of a female chimpanzee. Its finders have claimed that *Orrorin* was a human ancestor adapted to both bipedality and tree climbing, and that the australopithecines are an extinct offshoot. Given the fragmentary nature of the remains, other scientists have been skeptical of these claims so far (Aiello and Collard 2001). A later paper (Galik et al. 2004) has found further evidence of bipedality in the fossil femur.

3. Ardipithecus ramidus

This species was named *Australopithecus ramidus* in September 1994 (White et al. 1994; Wood 1994) from some fragmentary fossils dated at 4.4 million years. A more complete skull



and partial skeleton was discovered in late 1994 and based on that fossil, the species was reallocated to the genus *Ardipithecus* (White et al. 2005). This fossil was extremely fragile, and excavation, restoration and analysis of it took 15 years. It was published in October 2009, and given the nickname 'Ardi'. *Ar. ramidus* was about 120 cm (3'11") tall and weighed about 50 kg (110 lbs). The skull and brain are small, about the size of a chimpanzee. It was bipedal on the ground, though not as well adapted to bipedalism as the australopithecines were, and quadrupedal in the trees. It lived in a woodland environment with patches of forest, indicating that bipedalism did not originate in a savannah environment.

A number of fragmentary fossils discovered between 1997 and 2001, and dating from 5.2 to 5.8 million years old, were originally assigned to a new subspecies, *Ardipithecus ramidus kadabba* (Haile-Selassie 2001), and later to a new species, *Ardipithecus kadabba* (Haile-Selassie et al. 2004). One of these fossils is a toe bone belonging to a bipedal creature, but is a few hundred thousand years younger than the rest of the fossils and so its identification with *kadabba* is not as firm as the other fossils.

4. Australopithecus anamensis

This species was named in August 1995 (Leakey et al. 1995). The material consists of 9 fossils, mostly found in 1994, from Kanapoi in Kenya, and 12 fossils, mostly teeth found in 1988, from Allia Bay in Kenya (Leakey et al. 1995). *Anamensis* existed between 4.2 and 3.9 million years ago, and has a mixture of primitive features in the skull, and advanced features in the body. The teeth and jaws are very similar to those of older fossil apes. A partial tibia (the larger of the two lower leg bones) is strong evidence of bipedality, and a lower humerus (the upper arm bone) is extremely humanlike. Note that although the skull and skeletal bones are thought to be from the same species, this is not confirmed.

5. Australopithecus afarensis

A. afarensis existed between 3.9 and 3.0 million years ago. *Afarensis* had an apelike face with a low forehead, a bony ridge over the eyes, a flat nose, and no chin. They had protruding jaws with large back teeth. Cranial capacity varied from about 375 to 550 cc. The skull is similar to that of a chimpanzee, except for the more humanlike teeth. The canine teeth are much smaller than those of modern apes, but larger and more pointed than those of humans, and shape of the jaw is between the rectangular shape of apes and the parabolic shape of humans. However their pelvis and leg bones far more closely resemble those of modern man, and leave no doubt that they were bipedal (although adapted to walking rather than running (Leakey 1994)). Their bones show that they were physically very strong. Females were substantially smaller than males, a condition known as sexual dimorphism. Height varied between about 107 cm (3'6") and 152 cm (5'0"). The finger and toe bones are curved and proportionally longer than in humans, but the hands are similar to humans in most other details (Johanson and Edey 1981). Most scientists consider this evidence that afarensis was still partially adapted to climbing in trees, others consider it evolutionary baggage.



6. Kenyanthropus platyops

This species was named in 2001 from a partial skull found in Kenya with an unusual mixture of features (Leakey et al. 2001). It is aged about 3.5 million years old. The size of the skull is similar to *A. afarensis* and *A. africanus*, and has a large, flat face and small teeth.

7. Australopithecus africanus

A. *africanus* existed between 3 and 2 million years ago. It is similar to afarensis, and was also bipedal, but body size was slightly greater. Brain size may also have been slightly larger, ranging between 420 and 500 cc. This is a little larger than chimp brains (despite a similar body size), but still not advanced in the areas necessary for speech. The back teeth were a little bigger than in *afarensis*. Although the teeth and jaws of *africanus* are much larger than those of humans, they are far more similar to human teeth than to those of apes (Johanson and Edey 1981). The shape of the jaw is now fully parabolic, like that of humans, and the size of the canine teeth is further reduced compared to *afarensis*.

8. Australopithecus garhi

This species was named in April 1999 (Asfaw et al. 1999). It is known from a partial skull. The skull differs from previous australopithecine species in the combination of its features, notably the extremely large size of its teeth, especially the rear ones, and a primitive skull morphology. Some nearby skeletal remains may belong to the same species. They show a humanlike ratio of the humerus and femur, but an apelike ratio of the lower and upper arm. (Groves 1999; Culotta 1999)

9. Australopithecus sediba

A. sediba was discovered at the site of Malapa in South Africa in 2008. Two partial skeletons were found, of a young boy and an adult female, dated between 1.78 and 1.95 million years ago (Berger et al. 2010, Balter 2010). It is claimed by its finders to be transitional between *A. africanus* and *Homo* and, because it is more similar to *Homo* than any other australopithecine, a possible candidate for the ancestor of *Homo*. *A. sediba* was bipedal with long arms suitable for climbing, but had a number of humanlike traits in the skull, teeth and pelvis. The boy's skull has a volume of 420 cc, and both fossils are short, about 130 cm (4'3").

Australopithecus afarensis and africanus, and the other species above, are known as gracile australopithecines, because their skulls and teeth are not as large and strong as those of the following species, which are known as the robust australopithecines. (Gracile means "slender", and in paleoanthropology is used as an antonym to "robust".) Despite this, they were still more robust than modern humans.

10. Australopithecus aethiopicus

A. *aethiopicus* existed between 2.6 and 2.3 million years ago. This species is known from one major specimen, the Black Skull discovered by Alan Walker, and a few other minor specimens which may belong to the same species. It may be an ancestor



of *robustus* and *boisei*, but it has a baffling mixture of primitive and advanced traits. The brain size is very small, at 410 cc, and parts of the skull, particularly the hind portions, are very primitive, most resembling *afarensis*. Other characteristics, like the massiveness of the face, jaws and single tooth found, and the largest sagittal crest in any known hominid, are more reminiscent of *A. boisei* (Leakey and Lewin 1992). (A sagittal crest is a bony ridge on top of the skull to which chewing muscles attach.)

11. Australopithecus robustus

A. *robustus* had a body similar to that of *africanus*, but a larger and more robust skull and teeth. It existed between 2 and 1.5 million years ago. The massive face is flat or dished, with no forehead and large brow ridges. It has relatively small front teeth, but massive grinding teeth in a large lower jaw. Most specimens have sagittal crests. Its diet would have been mostly coarse, tough food that needed a lot of chewing. The average brain size is about 530 cc. Bones excavated with *robustus* skeletons indicate that they may have been used as digging tools.

12. Australopithecus boisei (was Zinjanthropus boisei)

A. boisei existed between 2.1 and 1.1 million years ago. It was similar to *robustus*, but the face and cheek teeth were even more massive, some molars being up to 2 cm across. The brain size is very similar to *robustus*, about 530 cc. A few experts consider *boisei* and *robustus* to be variants of the same species.

Australopithecus aethiopicus, robustus and boisei are known as robust australopithecines, because their skulls in particular are more heavily built. They have never been serious candidates for being direct human ancestors. Many authorities now classify them in the genus *Paranthropus*.

13. Homo habilis

H. habilis, "handy man", was so called because of evidence of tools found with its remains. *Habilis* existed between 2.4 and 1.5 million years ago. It is very similar to australopithecines in many ways. The face is still primitive, but it projects less than in *A. africanus*. The back teeth are smaller, but still considerably larger than in modern humans. The average brain size, at 650 cc, is considerably larger than in australopithecines. Brain size varies between 500 and 800 cc, overlapping the australopithecines at the low end and *H. erectus* at the high end. The brain shape is also more humanlike. The bulge of Broca's area, essential for speech, is visible in one *habilis* brain cast, and indicates it was possibly capable of rudimentary speech. *Habilis* is thought to have been about 127 cm (5'0") tall, and about 45 kg (100 lb) in weight, although females may have been smaller.

Habilis has been a controversial species. Originally, some scientists did not accept its validity, believing that all *habilis* specimens should be assigned to either the australopithecines or *Homo erectus*. *H. habilis* is now fully accepted as a species, but it is



widely thought that the 'habilis' specimens have too wide a range of variation for a single species, and that some of the specimens should be placed in one or more other species. One suggested species which is accepted by many scientists is *Homo rudolfensis*, which would contain fossils such as ER 1470.

14. Homo georgicus

This species was named in 2002 to contain fossils found in Dmanisi, Georgia, which seem intermediate between *H. habilis* and *H. erectus*. The fossils are about 1.8 million years old, consisting of three partial skulls and three lower jaws. The brain sizes of the skulls vary from 600 to 780 cc. The height, as estimated from a foot bone, would have been about 1.5 m (4'11"). A partial skeleton was also discovered in 2001 but no details are available on it yet. (Vekua et al. 2002, Gabunia et al. 2002)

15. Homo erectus

H. erectus existed between 1.8 million and 300,000 years ago. Like habilis, the face has protruding jaws with large molars, no chin, thick brow ridges, and a long low skull, with a brain size varying between 750 and 1225 cc. Early *erectus* specimens average about 900 cc, while late ones have an average of about 1100 cc (Leakey 1994). The skeleton is more robust than those of modern humans, implying greater strength. Body proportions vary; the Turkana Boy is tall and slender (though still extraordinarily strong), like modern humans from the same area, while the few limb bones found of Peking Man indicate a shorter, sturdier build. Study of the Turkana Boy skeleton indicates that *erectus* may have been more efficient at walking than modern humans, whose skeletons have had to adapt to allow for the birth of larger-brained infants (Willis 1989). *Homo habilis* and all the australopithecines are found only in Africa, but *erectus* was wide-ranging, and has been found in Africa, Asia, and Europe. There is evidence that *erectus* probably used fire, and their stone tools are more sophisticated than those of *habilis*.

16. Homo ergaster

Some scientists classify some African *erectus* specimens as belonging to a separate species, *Homo ergaster*, which differs from the Asian *H. erectus* fossils in some details of the skull (e.g. the brow ridges differ in shape, and *erectus* would have a larger brain size). Under this scheme, *H. ergaster* would include fossils such as the Turkana boy and ER 3733.

17. Homo antecessor

Homo antecessor was named in 1977 from fossils found at the Spanish cave site of Atapuerca, dated to at least 780,000 years ago, making them the oldest confirmed European hominids. The mid-facial area of *antecessor* seems very modern, but other parts of the skull such as the teeth, forehead and browridges are much more primitive. Many scientists are doubtful about the validity of *antecessor*, partly because its definition is based on a juvenile



specimen, and feel it may belong to another species. (Bermudez de Castro et al. 1997; Kunzig 1997, Carbonell et al. 1995)

18. Homo sapiens (archaic) (also Homo heidelbergensis)

Archaic forms of *Homo sapiens* first appear about 500,000 years ago. The term covers a diverse group of skulls which have features of both *Homo erectus* and modern humans. The brain size is larger than *erectus* and smaller than most modern humans, averaging about 1200 cc, and the skull is more rounded than in *erectus*. The skeleton and teeth are usually less robust than erectus, but more robust than modern humans. Many still have large brow ridges and receding foreheads and chins. There is no clear dividing line between late *erectus* and archaic *sapiens*, and many fossils between 500,000 and 200,000 years ago are difficult to classify as one or the other.

19. Homo sapiens neanderthalensis (also Homo neanderthalensis)

Neandertal (or Neanderthal) man existed between 230,000 and 30,000 years ago. The average brain size is slightly larger than that of modern humans, about 1450 cc, but this is probably correlated with their greater bulk. The brain case however is longer and lower than that of modern humans, with a marked bulge at the back of the skull. Like erectus, they had a protruding jaw and receding forehead. The chin was usually weak. The midfacial area also protrudes, a feature that is not found in *erectus* or *sapiens* and may be an adaptation to cold. There are other minor anatomical differences from modern humans, the most unusual being some peculiarities of the shoulder blade, and of the pubic bone in the pelvis. Neandertals mostly lived in cold climates, and their body proportions are similar to those of modern coldadapted peoples: short and solid, with short limbs. Men averaged about 168 cm (5'6") in height. Their bones are thick and heavy, and show signs of powerful muscle attachments. Neandertals would have been extraordinarily strong by modern standards, and their skeletons show that they endured brutally hard lives. A large number of tools and weapons have been found, more advanced than those of Homo erectus. Neandertals were formidable hunters, and are the first people known to have buried their dead, with the oldest known burial site being about 100,000 years old. They are found throughout Europe and the Middle East. Western European Neandertals usually have a more robust form, and are sometimes called "classic Neandertals". Neandertals found elsewhere tend to be less excessively robust. (Trinkaus and Shipman 1992; Trinkaus and Howells 1979; Gore 1996)

20. Homo floresiensis

Homo floresiensis was discovered on the Indonesian island of Flores in 2003. Fossils have been discovered from a number of individuals. The most complete fossil is of an adult female about 1 meter tall with a brain size of 417cc. Other fossils indicate that this was a normal size for *floresiensis*. It is thought that *floresiensis* is a dwarf form of *Homo erectus* - it is not uncommon for dwarf forms of large mammals to evolve on islands. *H. floresiensis* was fully bipedal, used stone tools and fire, and hunted dwarf elephants also found on the island. (Brown et al. 2004, Morwood et al. 2004, Lahr and Foley 2004)



21. Homo sapiens sapiens (modern)

Modern forms of *Homo sapiens* first appear about 195,000 years ago. Modern humans have an average brain size of about 1350 cc. The forehead rises sharply, eyebrow ridges are very small or more usually absent, the chin is prominent, and the skeleton is very gracile. About 40,000 years ago, with the appearance of the Cro-Magnon culture, tool kits started becoming markedly more sophisticated, using a wider variety of raw materials such as bone and antler, and containing new implements for making clothing, engraving and sculpting. Fine artwork, in the form of decorated tools, beads, ivory carvings of humans and animals, clay figurines, musical instruments, and spectacular cave paintings appeared over the next 20,000 years. (Leakey 1994)

Even within the last 100,000 years, the long-term trends towards smaller molars and decreased robustness can be discerned. The face, jaw and teeth of Mesolithic humans (about 10,000 years ago) are about 10% more robust than ours. Upper Paleolithic humans (about 30,000 years ago) are about 20 to 30% more robust than the modern condition in Europe and Asia. These are considered modern humans, although they are sometimes termed "primitive". Interestingly, some modern humans (aboriginal Australians) have tooth sizes more typical of archaic *sapiens*. The smallest tooth sizes are found in those areas where food-processing techniques have been used for the longest time. This is a probable example of natural selection which has occurred within the last 10,000 years (Brace 1983).

CRANIA

The dark area at the bottom of the skull is the foramen magnum, the hole through which the spinal column passes. It has a forward position in australopithecine skulls, a strong indication that they were bipedal.

Note also that both the shape of the jaw and the teeth of australopithecines are very similar to those of modern humans. Australopithecines do not have the rectangular-shaped jaw or the large canine teeth of apes.





Homo sapiens





In the last 3-4 million years brain volume within the hominid lineage has increased from less than 400 ml to roughly 1400 ml. The first clear increase in hominid brain size is seen in early Homo at c.2 m.y.a. in East Africa (most reliably in cranial specimen KNM-ER 1470). This is an evolutionarily significant change that cannot be simply accounted for in terms of increased body size alone. From the appearance of *H*. erectus at c.1.7 m.y.a. to the present, the brain increases nearly twofold: from c.800 ml to 1500 ml in Late Pleistocene

H. sapiens, without any apparent change in body size.

With regard to brain reorganisation, left-right cerebral hemispheric asymmetries exist in extant pongids and the australopithecines, but neither the pattern nor direction is as strongly developed as in modern or fossil *Homo*. KNM-ER 1470 shows a strong pattern that may be related to handedness and tool-use/manufacture. The degree of asymmetry appears to increase in later hominids.

The appearance of a more human-like third inferior frontal convolution provides another line of evidence about evolutionary reorganisation of the brain. None of the australopithecine endocasts show this region preserved satisfactorily. There is a consensus among palaeoneurologists that the endocast of the specimen KNM-ER 1470 does show, however, a somewhat more complex and modern-human-like third inferior frontal convolution compared with those of pongids. This region contains Broca's area, which in humans is related to the motor control of speech. Unfortunately, later hominid endocasts, including *H. habilis* and *H. erectus* through archaic *H. sapiens* to the present, seldom show the sulcal and gyral patterns faithfully. Thus nothing palaeoneurological can be said with confidence about possible changes with the emergence of anatomically modern H. sapiens.

Both an increase in size and a reorganisation of the brain towards a more-human like configuration thus appear together at around 2 million years ago. For a fuller account of these changes, you might read an article by Wilkins and Wakefield Brain Evolution and



neurolinguistic preconditions. But as with most published articles, this is long and detailed, and for our purposes we can ignore a lot of the detail. One of the essential points they argue for is that this change in the organisation of *Homo habilis's* brain was quite profound.

If our account proves valid, by the time of H. habilis the marked sulcal division between the parietal and occipital lobes had "disappeared." In addition, there were other significant evolutionary changes affecting the hominid brain. These include the expansion of visual cortex and of the temporal lobe. The close proximity and resultant junction of the three posterior lobes culminated in a situation in which information was readily available for processing in an overlap of the three related association areas and which could result in amodal representation.

What they are claiming is that what happened when our brains got re-organised at the time of *Homo habilis*, away from the pattern found in other apes and into a human-like configuration, was that three functionally different areas of it got to pool their resources. Prior to that, the abilities which these areas supported were dealt with much more independently by ape brains.

One of the consequences of this is evidenced by how poor apes are at doing something called **cross-modal matching**. One example is if you get someone to sketch a letter of the alphabet on your back - an 'e', say - you can still recognise it as equivalent to a letter 'e', which you normally recognise through another sensory channel - vision. Hence the term 'cross-modal' - people can integrate across different sensory modalities. Humans are really good at this, and even infants can do it. Andy Metzoff at Seattle University had infants feel different shapes without being able to see them, and then showed them to them to see if they could tell those they'd touched from entirely new ones. They can. Apes find this sort of thing a lot harder.

Why? Because the different senses are being handled by anatomically separate bits of the brain, bits that consequently don't send much information back-and-for amongst themselves. But from *Homo habilis* on, human brains had lots of channels between these parts, so that hearing, seeing and feeling, for example, could be better integrated.

But Wilkins and Wakefield want to go further than this. They want to propose that the brain is dealing with a new sort of information that they term '**amodal representation**'. This is something else again. Let me introduce it this way. Most birds are tone deaf. You can get a pigeon to discriminate a tune, but it doesn't show much 'stimulus generalisation' subsequently. Meaning? If you change the key of the tune it has learned, it doesn't recognise it. So in the cognitive neuropsychological paradigm they are adopting, we can say that whatever it is the pigeon is remembering about the tune it has learned to recognise, that information isn't very abstract. It's not remembering anything about the relation between the notes. If it were, then a change in key wouldn't matter. But we can do this! Eric Clapton makes a living at it! Apes are better at it than birds. But otherwise they're about as musically inclined as dogs (ever tried dancing with a dog?). So early humans were, they suggest,



beginning to abstract something about a tune 'amodally'. That is, they weren't just able to encode a specific tune in memory, but they were storing something about the relation between the notes, so that if it was played back in a different key, they would still be able to recognise it, because the relation between the notes was the same, even though the notes were different.

Now, there is no guarantee that the information coming in through the different senses is amodally represented in the same way by each of the senses. So, even if you bring the information from the different senses together, there's no guarantee that they'll be compatible. It could be as if they 'talked' different languages. So either the whole booming, buzzing confusion of sensory data has to be stored in the same way, or some efficient translation device has to be constructed if the senses are to integrate with each other efficiently.

Wilkins and Wakefield suggest that the solution was amodal storage, and this occurred when the separate bits of the cortex came together in *Homo habilis*. The brain thus got bigger so as to better process the contents of its own workings!

The claim is that we humans have brains that deal with the world 'amodally'. It's a new way of handling things. This is the evolution of a new psychological ability. Not just brains getting bigger, or bits of them moving about in relation to other bits, but a whole new way of operating.



STAGES OF EVOLUTION OF MAN

The genus of the human being today is called *Homo* and the man today is called as *Homo sapiens*. From simple life forms that were unicellular to the development of multicellular organisms gave rise to the vertebrates. The vertebrates began evolving that led to the development of mammals. Among the mammals, humans are most closely related to primates



such as the orang-utan. The family to which human beings belong is called Hominidae. It was in the Miocene age that the family Hominidae split from the Pongidae(apes) family. Dryopethicus was the first in the evolution of man in the stages of evolution and some believe him to be the common ancestor of man and apes.

Dryopethicus

He was the earliest known ancestor of man. At the same time as his existence, Ramapethicus existed who was more human-like than Dryopethicus. Dryopethicus inhabited the European region and some parts of Asia and Africa. Stages of evolution of humans began from him. After Dryopethicus and Ramapethicus came to the genus Australopethicus which preceded the genus Homo.

AUSTRALOPITHECUS

- Australopithecus ramidus: Was 1.2 meters tall and the fossils show the foramen magnum that was large to indicate upright walking. The forelimbs were different from those of the earlier ape-like ancestors. They had teeth like humans.
- Australopithecus afarensis- 'Lucy' the famous fossil belonged to this species. They are said to have inhabited the African mainland. And they were shorter than the Australopithecus ramidus and had a small skull with flat noses and no chin. They were able to walk on two legs but the legs were slightly bowed which made their walk slightly ape-like. The bowed legs, fingers, and toes enabled them to climb trees and live there. They had large teeth and jaws.
- Australopithecus africanus– These also inhabited the African mainland. They were bipedal and had a small skull with small brains than Homo erectus but larger than their predecessors. Also, they had large teeth compared to current day humans and were herbivorous. They had large jaws.
- Australopithecus robustus– He was taller than his predecessors but still ape-like. They also weighed more than their ancestors. After the Australopithecus genus came the Homo genus. The first man in the genus was Homo habilis.

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HOMO

• **Homo habilis**– He had a face similar to his ancestors. The skull and brain size indicate that he may have been able to speak. The earliest tools made were from this era. Homo



habilis is known as the 'handy man' because he was the first to make and use tools. He was around 5 feet tall and erect.

- **Homo erectus** after Homo habilis came, the Homo erectus who was also upright. He had a smaller but longer face, less prominent or absent chin, larger brain size and prominent speech. He knew how to make and use tools, he made a fire and knew how to control it. Homo erectus was carnivorous. He knew the existence of groups and they began spreading from Africa to Asia and Europe. The Java Man and Peking Man had brain capacities similar to modern man at 1300cc. They were cave dwellers.
- Homo sapiens- After Homo erectus came, the Homo sapiens who separated into two types:

1) Homo sapiens neanderthelensis

They had a brain size larger than modern man and were gigantic in size. Also, they had a large head and jaw and were very powerful and muscular. They were carnivores and the tools from the era indicate they were hunters. They were also cave dwellers but their caves were more comfortable and they lived in groups and hunted for food gathering.

2) Homo sapiens sapiens

Also known as 'modern-day man' is what we are today. Compared to the Homo sapiens neanderthelensis, they became smaller in size and the brain size reduced to 1300cc. There was also a reduction in the size of the jaw, rounding of the skull and chin. Cro- Magnon was the earliest of the Homo sapiens. They spread wider from to Europe, Australia, and the Americas. They were omnivores, had skilful hands, developed the power of thinking, producing art, more sophisticated tools and sentiments.

Evolution is not a thing of the past and is continuing even now. Humans are undergoing 'natural selection' for many different traits based on their life and environment in the present. It is believed that the jaw size is reducing further and the wisdom teeth are soon going to become extinct.