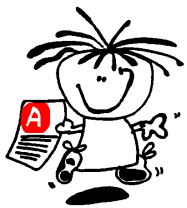


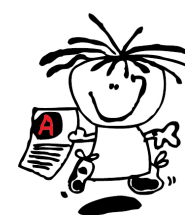
# GR 12 LIFE SCIENCES: HUMAN EVOLUTION

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We trust that working through these notes, questions and answers on Human Evolution will help you master this topic and to prepare thoroughly for your final exam.

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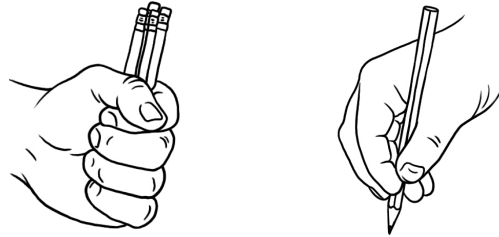
## Anatomical similarities between African apes and humans

Humans share the following characteristics with other primates:

- ▶ opposable thumbs that allow monkeys to have a **power grip**, while humans are capable of a **power grip** as well as a **precision grip (fine motor ability)**



**Apes: power grip**



**Humans: power grip and precision grip (fine motor grip)**

- ▶ two hands, each with five fingers; and two feet each with five toes
- ▶ long arms that rotate freely as shoulder joints allow movement in all directions
- ▶ naked fingertips and toes ending in flat nails
- ▶ a reduced snout with weakened sense of smell (reduced olfactory brain centres)
- ▶ stereoscopic vision as the eyes face forward providing depth of field - 3D vision
- ▶ eyes have cones (as well as rods) making colour vision possible
- ▶ brain centres that process information from hands and eyes are enlarged
- ▶ no tail
- ▶ sexual dimorphism where males and females are clearly distinguished
- ▶ have molars and premolars with rounded cusps



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## Anatomical differences between African apes and humans

African apes	Humans
▶ Quadrupedal - knuckle-walkers	▶ Bipedal - walk upright on two legs
▶ Foramen magnum (opening for spinal cord) at back of skull	▶ Foramen magnum closer to front of skull (central under skull)
▶ C-shaped vertebral column	▶ S-shaped vertebral column
▶ Arms longer and stronger than legs	▶ Arms shorter and weaker than legs
▶ Knee joints smaller and weaker	▶ Knee joints larger and stronger
▶ Opposable (grasping) big toe with power grip	▶ Non-opposable (forward-thrusting) big toe in line with other toes
▶ Flat feet	▶ Curved foot arch
▶ Long and narrow pelvis	▶ Short and wide pelvis
▶ Smaller, less developed brain	▶ Large, developed brain
▶ Large, prominent canines	▶ Smaller canines; the same size as other teeth
▶ Thin tooth enamel	▶ Thick tooth enamel
▶ Large, prominent jawbone with no chin (prognathism)	▶ Rounded jaw with developed chin (reduced prognathism)
▶ Wider, sloping face	▶ Narrow, flat face
▶ Narrow, rectangular palate	▶ Wider, more curved palate
▶ Prominent cranial and brow ridges	▶ Reduced cranial and brow ridges

## EVIDENCE OF COMMON ANCESTORS FOR LIVING HOMINIDS (including humans)

- ▶ The evolutionary theory does not state that humans evolved from the chimpanzee or the gorilla, but it proposes that they share a **common ancestor**.
- ▶ Scientists are searching for a common ancestor of all living hominids.
- ▶ The big question scientists have to answer is whether the common ancestor was ape-like or human-like.
- ▶ Remains of earlier hominids are very rare.

- ▶ There are three **main lines of evidence** that indicate hominids may have shared a common ancestor:
  - ▶ **Fossil evidence**
  - ▶ **Genetic evidence**
  - ▶ **Cultural evidence**

## Fossil evidence

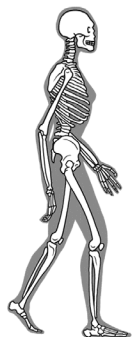
- ▶ Paleontologists study fossils to provide more information on the structure, movement, lifestyle and environment of a particular species.
- ▶ Certain features of hominid fossils indicate how changes occurred over time.
- ▶ Hominid fossils are rarely complete and consist mainly of fragments.
- ▶ Most hominid fossils are teeth, jaw bones or skull fragments.
- ▶ The remains of feet, hands, pelvic bones or vertebral columns are scarce.
- ▶ Long bones e.g. femurs are more commonly found.
- ▶ In the search for a common ancestor for hominids, palaeontologists look particularly at the following features of hominid fossils:
  - ▶ bipedalism
  - ▶ brain size
  - ▶ dentition (teeth)
  - ▶ prognathism
  - ▶ palate shape
  - ▶ cranial and brow ridges

## Bipedalism

- ▶ The greatest observable difference between apes and humans lies in the difference in posture and method of locomotion.
- ▶ Apes are four-footed (quadrupedal) with gorillas and chimpanzees demonstrating a particular manner of walking, i.e. knuckle-walking.
- ▶ Humans, however, are bipedal and walk upright.



Chimpanzee (quadrupedal)



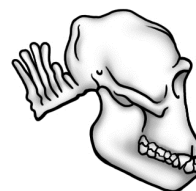
Human (bipedal)

- ▶ Hominid fossils show evidence of a transition from quadrupedalism to bipedalism.

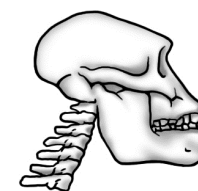
Various explanations are given for the transition from quadrupedalism to bipedalism. Many anthropologists question whether these advantages were sufficient to cause the significant changes involved in the evolution of bipedalism.

**Advantages of bipedalism** include:

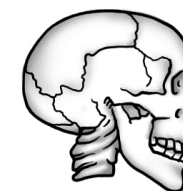
- ▶ Upright bodies expose a smaller surface area to the sun which reduces risk of overheating while hunting, foraging or escaping predators.
  - ▶ Upright bodies expose a larger surface area to air currents which causes cooling and reduces dependency on water.
  - ▶ Hands are free to use tools, prepare food, carry young, hunt or fight.
  - ▶ Vision extends further over the tall grass of the savannah to find food or avoid predators.
  - ▶ Adaptability to occupy a wider range of habitats.
- ▶ For early hominids to become bipedal and walk upright, their skeletons had to change quite considerably.
  - ▶ The following **changes in structure** are observed in humans:
    - ▶ In bipedal humans the foramen magnum shifted forward so that the skull rests on top of the vertebral column and the eyes face forward. The foramen magnum is positioned centrally at the bottom of the skull. In quadrupedal apes the head is positioned in front of the vertebral column with the foramen magnum at the back of the skull.



A



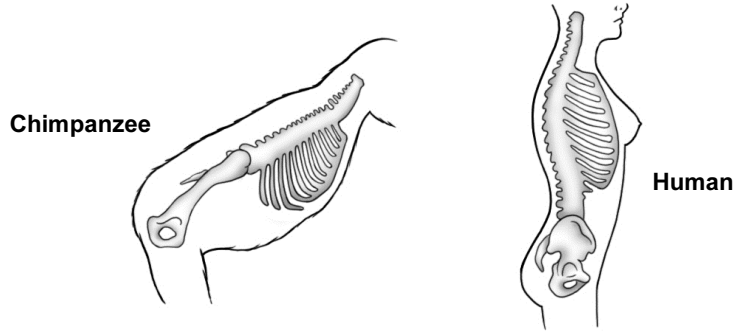
B



C

- A. Chimpanzees: foramen magnum is at the back of the skull
- B. Early *Homo* species: foramen magnum is closer to the front for stable upright walking
- C. *Homo sapiens*: foramen magnum is directly above the spine to balance the head above the vertebrae

- ▶ The human vertebral column is S-shaped for flexibility and shock absorption. The vertebral column of apes is C-shaped.

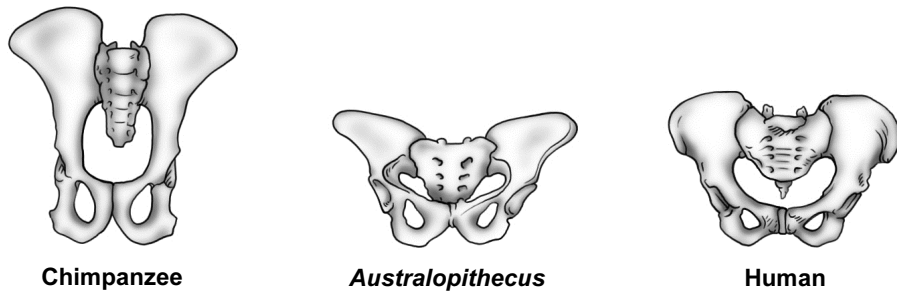


- ▶ Humans have shorter arms and longer legs, while apes have shorter legs and longer arms.
- ▶ In humans the knee-joints have become larger and stronger to support greater body weight.
- ▶ The human big toe is parallel with the other toes and helps to maintain balance. Apes have opposable big toes with a grasping action for climbing and moving in trees.
- ▶ A foot arch developed in humans, whereas an ape's foot is flat.

*The foot arch acts as a shock absorber and enables the rolling action over the ball of the foot which is more energy efficient.*



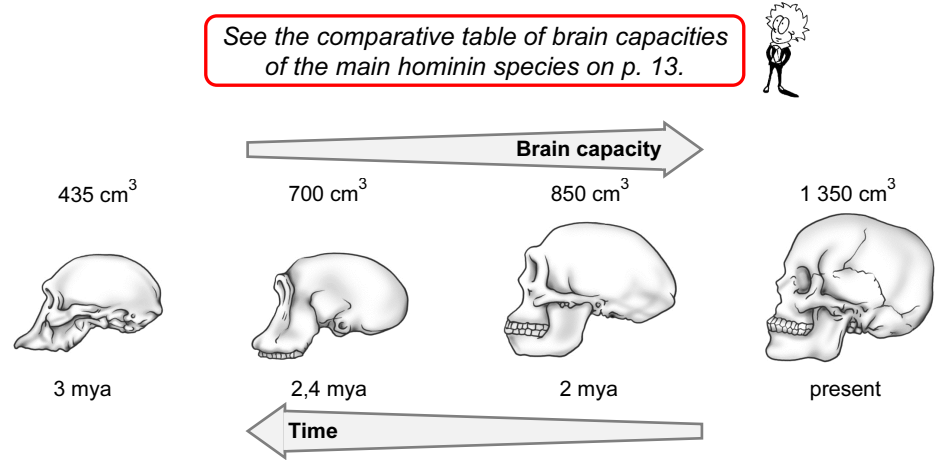
- ▶ The human pelvic girdle has become larger, shorter and wider to support the greater weight due to the upright posture. The pelvic girdles of apes are long and narrow.



**Brain size**

- ▶ Hominid fossils indicate that the size of the **cranium** increased in most fossils over time.
- ▶ We may conclude that, in general, the size of the brain (**brain capacity**) increased over time.

*See the comparative table of brain capacities of the main hominin species on p. 13.*



- ▶ The cranium of apes is small and elongated and contains a small, less developed brain.
- ▶ Chimpanzee brains have an average size of approximately 395 cm<sup>3</sup>.
- ▶ Humans have a more rounded skull with an enlarged cranium which contains a large, highly developed brain.
- ▶ The average size of the human brain is approximately 1 400 cm<sup>3</sup>.
- ▶ The more complex human brain gave rise to:
  - › well developed hand-eye coordination (to make and use tools)
  - › the capacity for language
  - › the use of fire

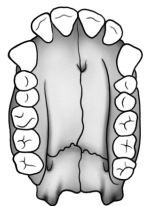
*The larger brain contributed to the survival of humans in that they could successfully adapt to changing environments.*



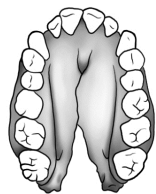


### Dentition (teeth)

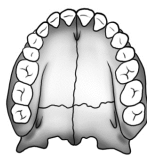
- ▶ The size of teeth decreased with the course of evolution.



Chimpanzee



A. afarensis



Human

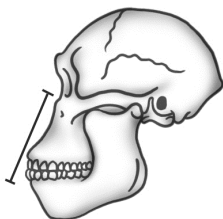
- ▶ Apes have large prominent canines that are larger than other teeth.
- ▶ In apes, there is a large gap (diastema) between the incisors and the canines. It provides space for the protruding canines on the opposite jaw so that the mouth can close.
- ▶ The human canines are the same size as the other teeth.
- ▶ The diastema disappeared completely over time.
- ▶ The tooth enamel became thicker over time. In apes it is very thin, in hominins it is thicker and in humans it is very thick.

### Prognathism

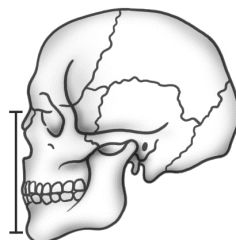
- ▶ Apes have large, protruding jaws (snout or muzzle) without a chin.
- ▶ Their jaws protrude beyond the upper part of the face, which results in a sloping face.
- ▶ As the teeth become smaller over time, so the jaws become less protruding (reduced prognathism) and more rounded. The face appears flatter and less sloping.



Gorilla  
(Ape)



Australopithecus  
(Fossil ancestor)



Homo sapiens  
(Human)

- ▶ Humans have a narrow, flat face with rounded jaws and a protruding chin.
- ▶ The forehead appears more vertical as a result of the larger cranium that contains a larger brain.

### Palate shape

- ▶ The palate in apes is narrow and rectangular and became more U-shaped over time in early hominins (*Australopithecus*).
- ▶ In humans the palate became wider and more curved.

The curved palate of modern humans aided the development of speech.



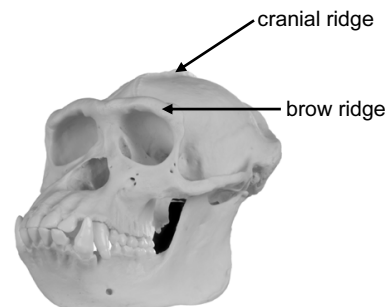
### Cranial and brow ridges

- ▶ Apes have prominent cranial and brow ridges for attachment of well-developed chewing muscles.



Male gorillas have the most prominent cranial ridges of any of the living hominids.

- ▶ As evolution progressed over time, both cranial and brow ridges decreased in size.
- ▶ Cranial ridges began to disappear in early hominins, but brow ridges were still well developed.
- ▶ Cranial and brow ridges are completely reduced in humans.



Chimpanzee skull with prominent cranial and brow ridges



Human skull with completely reduced cranial and brow ridges

**Genetic evidence**

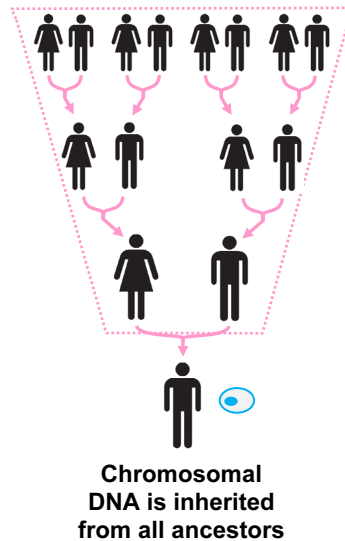
- ▶ Besides fossils, the field of genetics is another source of evidence of common ancestors for living hominids.
- ▶ DNA comparisons are made between living hominids, as DNA breaks down in dead cells and it is very rare to extract DNA from a fossil.

**Remember:** Living hominids include orangutan, gorilla, chimpanzee and humans.

- ▶ Organisms contain two types of DNA:
  - ▶ **chromosomal DNA** (in the nucleus)
  - ▶ **mitochondrial DNA** (mtDNA in the mitochondria)

**Chromosomal DNA**

- ▶ Chromosomal DNA occurs in the nuclei of all cells and contains all the genetic information pertaining to the characteristics of the organism.
- ▶ Chromosomal DNA is transferred by both parents (mother and father) to their offspring, thus chromosomal DNA is inherited from all ancestors.
- ▶ A comparison of the chromosomal DNA of living hominids may determine how closely related they are.
- ▶ The more similarities found in the DNA, the closer the relationship.
- ▶ Although every person is unique, 99,9% of all human DNA is identical, with only a small variation in 0,1%.
- ▶ This small genetic variation between people also serves as evidence of the close relationship between all humans.
- ▶ Humans and apes share 96 - 98% of the same DNA.
- ▶ 98% of human DNA corresponds with chimpanzee DNA, which makes them the closest related hominid to humans.
- ▶ The above-mentioned evidence supports Darwin's initial idea that humans and apes share a common ancestor.

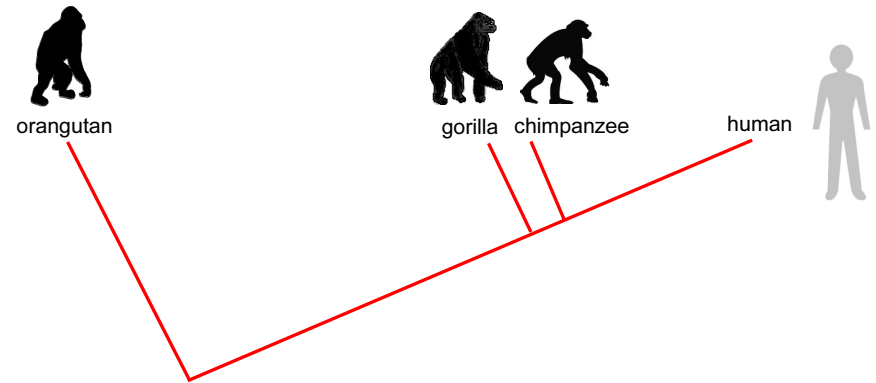


**Mitochondrial DNA (mtDNA)**



*In the Module on Genetics and inheritance, you were introduced to mtDNA. Read through this section to refresh your memory.*

- ▶ By comparing the mtDNA of living hominids, scientists can attempt to determine when the evolutionary paths of humans and African apes separated.
- ▶ If there are many differences, the separation occurred earlier.
- ▶ This means there was more time for mutations to occur so there is more variation.
- ▶ If there are fewer differences, the separation occurred more recently.
- ▶ There was thus less time for mutations to occur and there is less variation.
- ▶ In this way, scientists determined that a common ancestor for all living hominids may have existed 15 mya and that the evolutionary paths of humans and chimpanzees separated about 6 mya.



**Cladogram that indicates when the evolutionary paths of living hominids possibly separated**

**Cultural evidence: tools**

- ▶ The production and use of tools and other cultural practices like fire-making, burial rites, art and hunting techniques are suggested as further evidence of common ancestors for living hominids.
- ▶ The development of speech and language is another cultural change that distinguishes modern humans from primates.

- ▶ Improved communication and social interaction in a community were crucial for effective hunting and defence.

*This section focuses on the range of tools found in fossil sites.*



- ▶ Tool-making is associated with increased intelligence and well-developed hands.
- ▶ The part of the brain responsible for coordinating the movement of the hands is much larger in humans than in other primates.



*Scientists are not sure if the use of tools stimulated brain development or an enlarged brain facilitated the use of tools.*

- ▶ Although apes are known to use a variety of objects like sticks and stones as tools to access food, they do not, however, make tools.

*Apes often use sharp stones to break bones to get at the bone marrow.*



- ▶ The **Homo** genus has a fine motor grip that enabled them to design and produce their own tools.



**NB:** *Australopithecus* genus (also known as *ape-men*) are not associated with tool-making.

- ▶ Most of the tools found in fossil-rich areas are made of stone.
- ▶ Although hominids may have used tools composed of other materials like bone, ivory or wood, most would have decomposed over time.
- ▶ Tools vary from simple, sharp stones to carefully sculpted cutting blades.
- ▶ It is sometimes difficult to distinguish between deliberately shaped stone tools and stones that happen to be suitably shaped for cutting.

*Various early **Homo** species are named in the following section. You will be introduced to the **Homo** genus in more detail later in the module on p. 12.*



- ▶ The first hominids that probably made and used tools were **Homo habilis** (handy man).
- ▶ The main advantage of tool technology is access to a wider variety of food including harder plant materials and meat.
- ▶ They could kill larger prey and improve preparation of food material for cooking and eating.
- ▶ There are three main tool cultures:
  - **Oldowan**
  - **Acheulian**
  - **Mousterian**

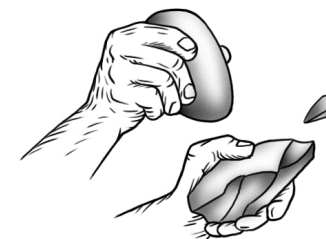
### Oldowan tool culture

- ▶ The oldest tools found, form part of the **Oldowan tool culture**.



*A tool culture is the way in which tools from a specific area were made and used.*

- ▶ It is named after the site where these tools were first found: Olduvai Gorge, Tanzania.
- ▶ These tools date back from 2,6 to 1,5 mya.
- ▶ These tools are associated with **Homo habilis**.
- ▶ All these simple tools are often formed with a single blow.
- ▶ The tools include:
  - **Choppers:** It is a hard rock core from which sharp-edged **flakes** were cut using a larger, harder rock, the **hammerstone**.
  - **Flakes:** These are simple, thin, sharp stones cut from a hard rock core and used to cut meat from bone.
  - **Scrapers:** These are smaller flakes that were used to clean and prepare hide (animal skins) for making clothes or shelter.



Making a chopper in the Oldowan tool culture



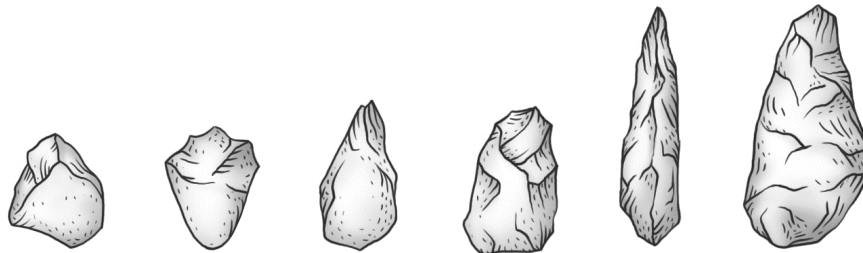
**Acheulian tool culture**

- ▶ A later and more advanced tool-making tradition that developed was **Acheulian tool culture**.
- ▶ It is named after the site where the tools were found: Saint Acheul in France.
- ▶ The tools date from 1,5 mya to 250 000 years ago.
- ▶ The *Homo*-species, ***Homo erectus*** and ***Homo ergaster***, may have developed these tools.
- ▶ All these tools are made by reworking existing tools and show signs of repetitive flaking to shape the edges.
- ▶ The tools were heavier and larger than those of the Oldowan tool culture and displayed a wider variety.
- ▶ They were not just shaped by stone, but also wood and bone.
- ▶ Tools include:
  - ▶ **Hand axes:**
    - They are oval-shaped with a pointed end and sharpened on both edges.



*As both sides of the stones are sharpened, they are known as **bifacial tools**.*

- They are shaped using soft and hard hammering tools.
- They were used for cutting wood and killing large animals.
- ▶ **Picks:** thick, pointed stones
- ▶ **Cleavers:** large cutting tool with long, wide 'blade' section



**Different hand axes in Acheulian tool culture**

**Mousterian tool culture**

- ▶ The third tool culture that developed was **Mousterian tool culture**.
- ▶ It is named after the region where the tools were found: Le Moustier in France.
- ▶ These tools date back from 250 000 to 50 000 years ago.
- ▶ These stone tools were mostly flakes, scrapers and points and were possibly used by ***Homo neanderthalensis*** and ***Homo sapiens***.
- ▶ There was more variety in blade shapes for use as spear points or as awls.

*An awl is a sharp pointed object that was used to make holes.*



- ▶ Hand axes from this culture had more carefully shaped blades.
- ▶ These tools formed part of sophisticated **tool kits**.



*Refined tools gave access to better food, clothing and shelter which lead to more complex and comfortable lifestyles.*

**100 000 years ago - recent human history**

- ▶ Approximately 100 000 years ago until the recent history of humans, tools were mainly small stone flakes shaped into refined spearheads and knives with improved, longer blades.
- ▶ Smaller blades also known as **microliths** formed part of arrowheads and fish hooks.
- ▶ ***Homo sapiens*** also domesticated animals (cattle, sheep, horses, donkeys) and cultivated fruit and vegetables to provide for their needs.
- ▶ This led to a more settled existence and the establishment of villages and towns.
- ▶ ***Homo sapiens*** produced clothing and various art forms: e.g. drawings, ornaments, sculptures and jewellery.
- ▶ More modern ***Homo sapiens*** also utilised different metals (copper, bronze, iron) in their advancing technology.

# MAJOR PHASES IN THE HOMINID EVOLUTION (from 6 mya to present)

- ▶ The main **hominin** genera within the **hominid** group are the following:
  - ▶ **Ardipithecus**
  - ▶ **Australopithecus**
  - ▶ **Homo**
- ▶ The timeline of human evolution probably began 6 - 7 million years ago.

Scientists disagree and differ widely about the origins of humans. This study guide aims to provide a broad overview of the scientific evidence available and the conclusions of various scientists based on this data.



## ARDIPITHECUS

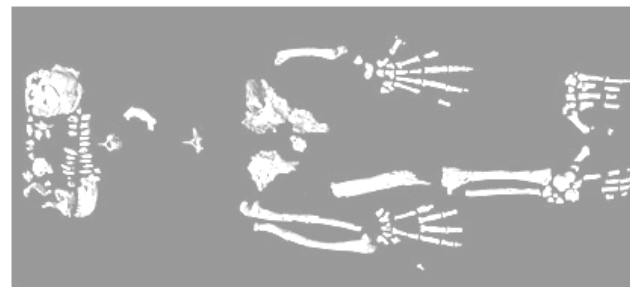
- ▶ *Ardipithecus ramidus* was an early hominin that lived approximately 5,8 - 4,4 million years ago.
- ▶ About 17 *Ardipithecus* fossils were found in the Afar valley of Ethiopia in 1993.
- ▶ These beings show ape-like as well as australopithecine characteristics, indicating that *Ardipithecus* could be a transitional form between the apes and *Australopithecus*.

### General characteristics of *Ardipithecus*

- ▶ Probably bipedal.
- ▶ Foramen magnum positioned centrally below skull, but more to the front than in apes.
- ▶ Pelvis is wider at the top, and narrow and long at the bottom as in apes.
- ▶ Long arms (almost as long as the legs) for climbing trees.
- ▶ Opposable, grasping big toe.
- ▶ Small brain capacity of approximately 300 - 350 cm<sup>3</sup>.
- ▶ Ape-like teeth, but smaller canines and molars; a diastema is present.

- ▶ Protruding jaw (snout/muzzle) without a chin.
- ▶ Sloped face.
- ▶ Palate is narrow and rectangular.
- ▶ Small brow ridges.

The structure of the feet, pelvis, legs and hands indicated that **Ardipithecus** was bipedal on the ground, but quadrupedal when climbing trees.



An incomplete skeleton of an *Ardipithecus* fossil

## AUSTRALOPITHECUS

- ▶ Australopithecines are regarded as the first bipedal primates.
- ▶ They have both ape-like and human-like characteristics and they are sometimes called ape-men.
- ▶ The genus name *Australopithecus* literally means 'southern ape'.



Individuals belonging to this genus are called **australopithecines**.

- ▶ It is estimated that australopithecines lived in Africa between 4,5 and 1,4 million years ago.
- ▶ During this time the African forests increasingly made way for sparse woodlands, grasslands and savannas.
- ▶ *Australopithecus* fossils were found mainly in Eastern and Southern Africa.

### General characteristics of *Australopithecus*

- ▶ Bipedalism and upright walking.
- ▶ Foramen magnum is positioned centrally below the skull.

- ▶ Pelvis is short and wide.
- ▶ Long arms for tree climbing.
- ▶ Fingers long and curved; non-opposable big toe.
- ▶ Brain capacity larger than that of the apes, approximately 380 - 500 cm<sup>3</sup>.
- ▶ Teeth more human-like; smaller canines than apes, but larger than humans; small diastema.
- ▶ Protruding jaw without a chin.
- ▶ Sloping face (less sloping than in apes).
- ▶ U-shaped palate.
- ▶ Large brow ridges.
- ▶ The 3,8 million year old footprints discovered in Laetoli, Tanzania are one of the oldest fossils indicating evidence of bipedalism of *Australopithecus*.
- ▶ *Australopithecus* probably developed simultaneously with the *Homo* genus and is therefore not regarded as a human ancestor.
- ▶ Various *Australopithecus* fossils of different species have already been found in Africa.
- ▶ The following five well-known australopithecines are discussed:
  - › **Taung child**
  - › **Mrs Ples**
  - › **Lucy**
  - › **Little Foot**
  - › ***Australopithecus sediba***

Although australopithecines were bipedal, they also climbed trees.



Footprints that confirm bipedalism in *Australopithecus*

### Taung child (*Australopithecus africanus*)

- ▶ In 1924 the fossil skull of a hominin was found by Professor Raymond Dart at Taung, northwest of Kimberley.
- ▶ It was the skull of a child of about 3 - 4 years old.
- ▶ The skull had human as well as ape-like characteristics:
  - › a small brain capacity (340 cm<sup>3</sup>) similar to apes
  - › human-like teeth
  - › foramen magnum in a more central position, indicating bipedalism
- ▶ The Taung skull is classified under *Australopithecus africanus*, who lived about 3 - 2 million years ago.



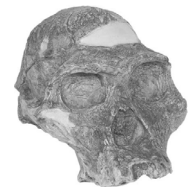
Taung skull

### Mrs Ples (*Australopithecus africanus*)

- ▶ In 1947 a complete adult skull and various bones were found by Dr Robert Broom in the Sterkfontein Caves in South Africa.
- ▶ This skull was about 2 - 3 million years old and was also classified as *Australopithecus africanus*.
- ▶ The brain capacity is estimated to be similar to that of a chimpanzee.
- ▶ From the position of the foramen magnum it could be deduced that Mrs Ples was bipedal and walked upright.
- ▶ The jaws indicated that there were no protruding canines, and the dentition indicated a diet of mainly plant material with little meat.



Mrs Ples has been called the missing link numerous times, but is actually only one of the links in the many branches of the human evolutionary chain.



Mrs Ples

## Lucy (*Australopithecus afarensis*)

- ▶ Lucy is a fossilised female skeleton found by Donald Johanson at Hadar in the Afar valley, Ethiopia in 1974.
- ▶ The skeleton dates back 3,5 million years.
- ▶ The shape of the pelvis indicated that Lucy was female.
- ▶ The skeleton was about 1 m long and showed evidence of bipedalism.
- ▶ The face had ape-like characteristics, i.e. a low forehead, flat nose, protruding lower jaw and large canines.
- ▶ The arms were long and the legs short.
- ▶ The brain capacity of 400 cm<sup>3</sup> was similar to that of apes.



Lucy fossil skeleton

*Australopithecus africanus* - 'southern ape of Africa'  
*Australopithecus afarensis* - 'southern ape of Afar'



## Little Foot (*Australopithecus species*)

- ▶ In 1994 the ankle and foot bones of an australopithecine fossil was discovered in the Sterkfontein Caves by the palaeoanthropologist Dr Ron Clarke.
- ▶ The fossil was named Little Foot.
- ▶ The rest of the skeleton was found in 1997.
- ▶ The excavation of the complete skeleton from the rock is still in progress.
- ▶ It has already been determined that Little Foot was bipedal because of the position of the foramen magnum.
- ▶ The arms are short and the bones of the hand are very similar to those of the modern human, with short palms and fingers.
- ▶ The species to which Little Foot belongs will only be determined when the entire skeleton has been removed.



Dr. Ron Clarke with Little Foot

**palaeontology** - the study of plant and animal fossils

**anthropology** - the study of the origin and social relationships of humankind

**archaeology** - the study of artefacts left behind by early human populations

**palaeoanthropology** - the study of human evolution by studying fossils of humans and artefacts



The Sterkfontein Caves are limestone caves situated northwest of Johannesburg. The largest number of hominin fossils in the world are found here. More than 700 ape-like hominin fossils have already been discovered. It is known as the **Cradle of Humankind** because scientists believe that this region could be the site of human origin.

## *Australopithecus sediba* (2 - 1,7 mya)

- ▶ In 2008 two fossils, those of a young woman and boy, were discovered in the Cradle of Humankind in the Malapa area by Professor Lee Berger and his 9-year-old son, Matthew.



This was the first time that a new hominin species had been found in South Africa since Dr Robert Broom discovered Mrs Ples in Sterkfontein in 1947.



- ▶ These fossils represent a new species, *Australopithecus sediba*, which was announced to the world in April 2010.
- ▶ The fossils are between 1,78 and 1,95 million years old and the most complete early hominins discovered so far.
- ▶ *Australopithecus sediba* is considered a transitional fossil between the older *Australopithecus africanus* and the first *Homo* species, and possibly gave rise to the origin of modern humans.
- ▶ *Australopithecus sediba* has a small brain and large brow ridges in comparison to modern humans, but the shape indicates a more advanced brain than that of other australopithecines.

- ▶ Early australopithecines were able to walk upright, but could not run fast or walk for long distances.
- ▶ Similarly, *Australopithecus sediba* had long arms and short hands adapted for tree climbing, while the pelvis was similar to that of early *Homo* species and adapted for walking long distances.
- ▶ Professor Berger and his colleagues believe that *Australopithecus sediba* could probably be the ancestor of modern humans.



Matthew Berger (Professor Berger's son) found the fossil of the young boy and it was named **Karabo**.

## HOMO

- ▶ The genus *Homo* appeared in Africa about 2,2 million years ago.

### General characteristics of *Homo*

- ▶ Bipedalism with upright walking.
- ▶ Central foramen magnum at the base of the skull, directly above the vertebral column.
- ▶ Pelvis is short and wide.
- ▶ Legs are long in relation to arms; longer femurs for greater stride.
- ▶ Short, straight toes; non-opposable big toe; enlarged heel bone; opposable thumb.
- ▶ Larger brain with a brain capacity of approximately 600 - 1 400 cm<sup>3</sup>.
- ▶ Smaller teeth (no protruding canines), no diastema.
- ▶ Jaws more rounded with a prominent chin in *Homo sapiens*; older species have protruding jaws.
- ▶ Flat face.
- ▶ Wide, curved palate.
- ▶ No brow ridges in *Homo sapiens*; older species have large brow ridges.

### Differences between genera *Australopithecus* and *Homo*

- ▶ The brain of *Homo* was much larger and better developed. *Homo* could make and use tools, make fire and develop language.
- ▶ The skull of *Homo* was more human-like with less prominent brow ridges, a flatter face, smaller teeth and a more rounded jawbone.

- ▶ The following *Homo* species are discussed:
  - ▶ ***Homo habilis***
  - ▶ ***Homo erectus***
  - ▶ ***Homo neanderthalensis***
  - ▶ ***Homo sapiens***

### *Homo habilis*

- ▶ *Homo habilis* lived in Africa, together with other *Australopithecus* species, about 2,2 - 1,6 million years ago.
- ▶ *Australopithecus africanus* probably gave rise to *Homo habilis*.
- ▶ In 1960 a *Homo habilis* fossil was discovered in Tanzania.
- ▶ The body of *Homo habilis* was smaller than that of *Australopithecus* and it was ape-like.
- ▶ They also had a larger brain (640 cm<sup>3</sup>) than *Australopithecus*, which meant they had better skills in using their hands to make tools.
- ▶ *Homo habilis* was the first group that used stone tools.



The name ***Homo habilis*** literally means '**handy man**'.



### *Homo erectus*

- ▶ *Homo erectus* is a species that is closer to modern humans than to *Australopithecus*.
- ▶ *Homo erectus* literally means '**upright man**' and they lived 1,8 - 0,3 million years ago.
- ▶ They were probably the first hominins to migrate from Africa to Europe and Asia.
- ▶ The most complete *Homo erectus* fossil is 1,5 million years old and was found near Lake Turkana in Kenya. It is known as the **Turkana boy**.



Other well-known *Homo erectus* fossils that have been found include the **Peking man**, discovered in China (400 000 years old), and the **Java man** fossil skull (700 000 years old) found in Java, Indonesia.



- ▶ *Homo erectus* had large bodies, similar to those of modern humans.
- ▶ Their skulls were thick with low, prominent foreheads, heavy brow ridges and no chin.
- ▶ Both jaws were relatively massive with large teeth.
- ▶ Their brain capacity was about 1 000 cm<sup>3</sup>.
- ▶ *Homo erectus* made and used stone and bone tools.
- ▶ They were successful hunters and the first species that learnt to use fire.



### ***Homo neanderthalensis***

- ▶ The Neanderthals were a group of people that lived between approximately 230 000 and 30 000 years ago in Europe and Western Asia.
- ▶ The first fossil was discovered in 1856 in the Neander Valley in Germany.
- ▶ Their skulls were long and flat, with a low forehead, broad nose and a prominent brow ridge above the eyes.
- ▶ Although their brains were larger than *Homo sapiens*, language was not well developed and their technological development was limited.
- ▶ They were hunters, wore clothes made from animal skins, built shelters in caves and used fire.
- ▶ They buried their dead, which is an indication of some form of 'spiritual life' or advanced culture.



### ***Homo sapiens***



- ▶ This group is considered to be the direct ancestors of modern humans.
- ▶ Presumably, *Homo sapiens* appeared about 200 000 years ago.
- ▶ It is claimed that the appearance of *Homo sapiens* resulted in the disappearance of the Neanderthals.
- ▶ *Homo sapiens* developed better skills and had more advanced technology.

- ▶ Therefore modern humans are not directly related to *Homo neanderthalensis*.
- ▶ *Homo sapiens* used tools made from bone as well as stone, which included spears, arrows, bows and hooks for fishing.
- ▶ Their clothes were made mainly from leather and plant material.
- ▶ They lived in tents and formed communities.
- ▶ As hunters they followed the annual animal migrations in the summer.
- ▶ They developed agriculture and cultivated the land.
- ▶ They wore jewellery and decorated their bodies with paint.
- ▶ They developed rituals that were linked to hunting, births and deaths.
- ▶ Like the Neanderthals, they buried their dead which indicates a development of advanced culture and spiritual rituals.

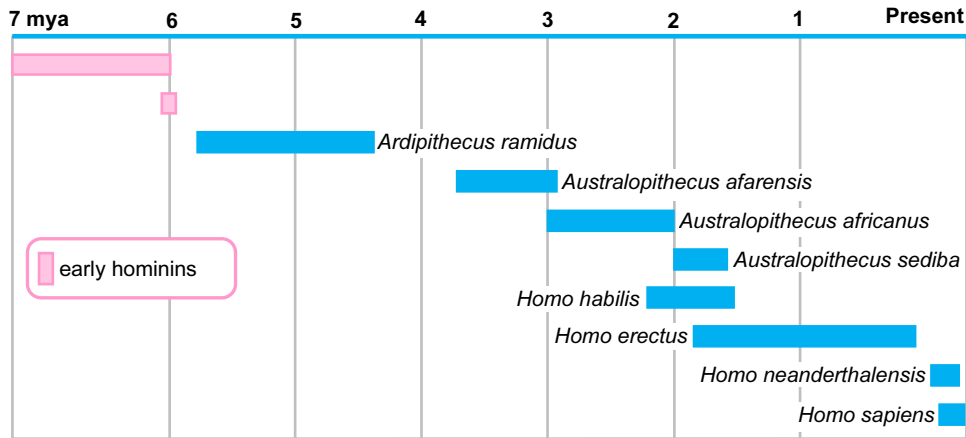
Sometimes modern humans are referred to as ***Homo sapiens sapiens***, a subspecies of ***Homo sapiens***.



- ▶ Due to a large brain capacity of about 1 400 cm<sup>3</sup>, modern humans have the ability to change their environment to suit their needs, unlike early *Homo* species who could not change their environments and therefore became extinct.
- ▶ Today, modern humans are on the brink of the sixth extinction as a result of their own destructive impact on the environment.

Comparative table of the average brain capacity of the most important hominin species	
Hominin species	Average brain capacity (in cm <sup>3</sup> )
<i>Australopithecus afarensis</i>	440
<i>Australopithecus africanus</i>	450
<i>Australopithecus sediba</i>	500
<i>Homo habilis</i>	640
<i>Homo erectus</i>	1 000
<i>Homo neanderthalensis</i>	1 500
Modern <i>Homo sapiens</i>	1 400





Timeline to illustrate evolution of hominins



It is not necessary to memorise this timeline. You may, however, be expected to interpret it in an exam question.

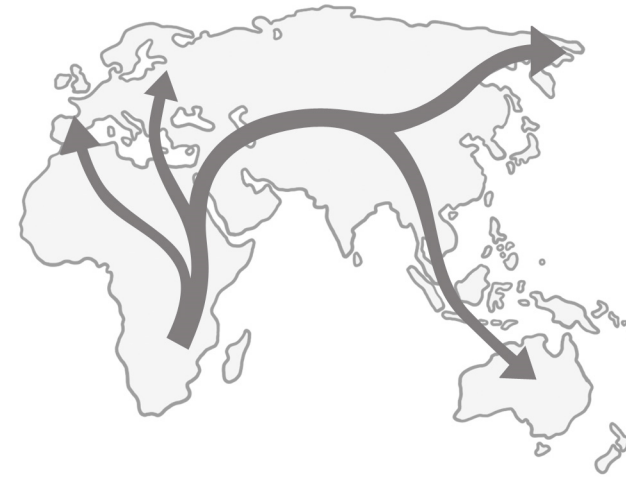
## 'OUT OF AFRICA' HYPOTHESIS

There are different hypotheses about the place where humans originated. The 'Out of Africa' hypothesis has the most support from scientists.



- ▶ According to the 'Out of Africa' hypothesis, *Homo sapiens* originated in Africa about 200 000 years ago and migrated relatively recently (50 000 ya) to the rest of the world.
- ▶ These early *Homo sapiens* had a higher level of technological skills, were better adapted to their new environment and out-competed other *Homo* species.
- ▶ This resulted in the more successful *Homo sapiens* replacing *Homo erectus* in Asia and Indonesia and *Homo neanderthalensis* in Europe.

*Homo erectus* was one of the earliest hominins in Africa. They were the first *Homo* species to leave Africa about 1,8 mya and became established in Europe, Asia and Indonesia.



'Out of Africa' hypothesis



The 'Out of Africa' hypothesis is also called the 'Replacement' hypothesis.

In contrast to the 'Out of Africa' hypothesis, there is an alternative model: the 'Multiregional' hypothesis. This model proposes that the *Homo* genus left Africa and simultaneously, across the world, gave rise to *Homo sapiens* (parallel evolution). Both models are supported by genetic and fossil evidence, but the 'Out of Africa' model is more widely accepted.

## EVIDENCE OF AFRICAN ORIGINS FOR ALL MODERN HUMANS

The following evidences support this hypothesis:

- ▶ Genetic links
- ▶ Fossils and artefacts of hominins found in Africa

### Genetic links as evidence for the 'Out of Africa' hypothesis

You have already been introduced to genetic evidence for a common ancestor for all living hominins on page 6. As it forms part of this section, it is a good idea to look over it again before you continue.



- ▶ Scientists increasingly make use of genetic studies where sections of DNA are used to determine ancestry.
- ▶ Different types of types of DNA are used:
  - › Chromosomal DNA (excluding Y-chromosomes)
  - › Mitochondrial DNA (mtDNA)
  - › Y-chromosome DNA

**NB:** Due to constant genetic reshuffling of **chromosomal DNA** (crossing over and random assortment in meiosis), it is difficult to trace genetic lineages. But, **mtDNA** (mother to child) and **Y-chromosome DNA** (father to son) do not undergo genetic reshuffling in meiosis and scientists can trace genes through generations over thousands of years.

### Chromosomal DNA (excluding Y-chromosomes)

- ▶ You already know that all humans share 99% of their DNA.
- ▶ This lack of variation indicates that they originated from a very small *Homo sapiens* population.
- ▶ This aspect of genetics supports the 'Out of Africa' hypothesis.



*Chromosomal DNA is rarely extracted from fossils, so it is not available for testing. mtDNA and Y-chromosome DNA are more commonly used to determine ancestry.*

### Mitochondrial DNA (mtDNA)

- ▶ You already know that normally mtDNA is only transferred from a mother to her offspring.
- ▶ Scientists compare the mtDNA of different populations with each other to determine the extent of genetic variation in a population.
- ▶ The group that shows the most variation, has the most mutations.
- ▶ This group had the most time for mutations to occur and therefore it is the oldest.
- ▶ Studies have shown that the highest levels of genetic variation occur in human populations in Africa.
- ▶ It is concluded that people from Africa are the oldest humans.
- ▶ This genetic evidence, combined with fossil evidence, show that modern humans originated in Africa about 200 000 - 100 000 years ago.

'Mitochondrial Eve' is the name given to the most recent female common ancestor of all living humans.

Our mitochondrial DNA is inherited from our mothers only. Mutations in mtDNA were studied in people to assess the genetic similarity of people from different countries. It was then combined with the expected rate of DNA mutations per generation to estimate the age of 'Mitochondrial Eve'.

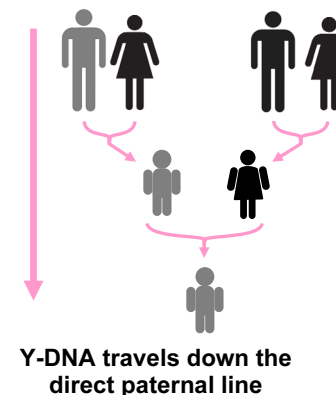
Researchers concluded that she lived in Africa about 200 000 - 150 000 years ago. This supports the 'Out of Africa' hypothesis.

### Y-chromosome DNA

*You already know that a female has two identical gonosomes (sex chromosomes) i.e. XX, and a male has two different ones, i.e. XY.*



- ▶ The DNA on the Y chromosome is only carried by males and can only be inherited from their fathers.
- ▶ The small Y chromosome undergoes no crossing over and exchange of genetic material during gamete formation (meiosis).
- ▶ Therefore, the Y chromosome remains largely unchanged over generations.
- ▶ Men sharing a common male ancestor will have essentially the same Y-DNA, even if the male ancestor lived many generations ago.
- ▶ Thus male ancestral descent can be traced back to a male ancestor in Africa.



*When a pedigree diagram is compiled over many generations, the Y chromosomes of the related male individuals, which were passed on from generation to generation, create an imaginary line known as the **Y-line**. The hypothetical common ancestor of this genetic lineage is often referred to as '**Y-chromosome Adam**'.*



# HUMAN EVOLUTION: QUESTIONS

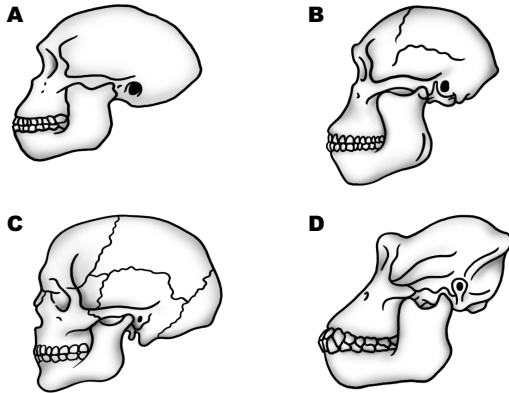
## QUESTION 1

Choose the correct answer between brackets and write it down next to the corresponding number in each of the following cases.

- 1.1 A/An (orangutan / human / gorilla / kangaroo) is not a hominid.
- 1.2 Hominids do **not all** have (an opposable thumb / flat toe and fingernails / a tail / premolars and molars with rounded cusps).
- 1.3 (Stereoscopic vision / bipedalism / two five-fingered hands) is a characteristic which distinguishes humans from the African apes.
- 1.4 (*Homo habilis* / *Homo sapiens* / *Gorilla gorilla* / *Australopithecus africanus*) is **not** a hominin.

## QUESTION 2

Study the skulls below and answer the questions that follow.

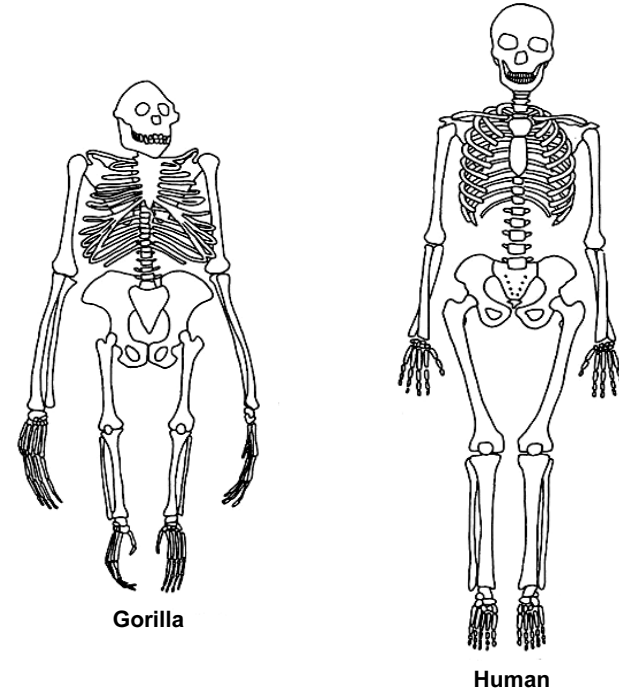


- 2.1 Which one of these skulls does not belong to a hominin?
- 2.2 Which of these skulls belong to bipedal organisms?
- 2.3 Which skull represents each of the following?
 

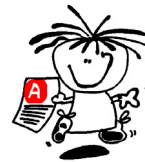
2.3.1 <i>Homo sapiens</i>	2.3.2 <i>Gorilla gorilla</i>
2.3.3 <i>Australopithecus africanus</i>	2.3.4 <i>Homo habilis</i>
- 2.4 Place these four skulls in the correct order, dating from the most primitive to the most advanced.

## QUESTION 3

Study the two skeletons illustrated below and answer the questions that follow. The diagrams are drawn to scale.



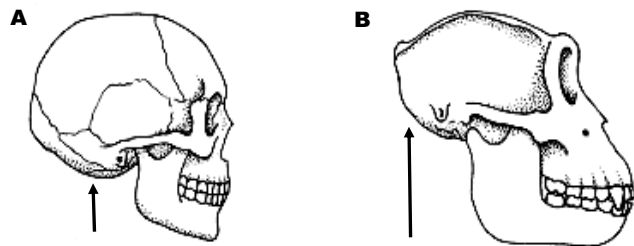
- 3.1.1 Tabulate THREE visible differences between the gorilla and human skeletons.
- 3.1.2 Name THREE characteristics visible above, that we share with other hominids.



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3.2 Study the diagrams below (A and B) of the skulls of the organisms shown above and answer the questions that follow.



- 3.2.1 Identify each of the organisms that are represented by A and B.
- 3.2.2 What does the arrow indicate in both diagrams?
- 3.2.3 Which diagram represents the skull of an organism that is bipedal for most of its adult life?
- 3.2.4 What role does your answer in Question 3.2.3 play in the transition to bipedalism?
- 3.2.5 Explain THREE possible advantages of bipedalism for the organism referred to in Question 3.2.3.

**QUESTION 4**

The theory of evolution does not propose that humans originated from chimpanzees or gorillas, but that they share a common ancestor.

- 4.1 Name the three main types of evidence that indicate the common ancestry of hominids.
- 4.2 What is included in cultural evidences?
- 4.3 What is meant by a *tool culture*?
- 4.4 To which tool culture do the oldest tools belong?
- 4.5 Besides the tool culture mentioned in Question 4.4, name another TWO tool cultures that occurred in France.

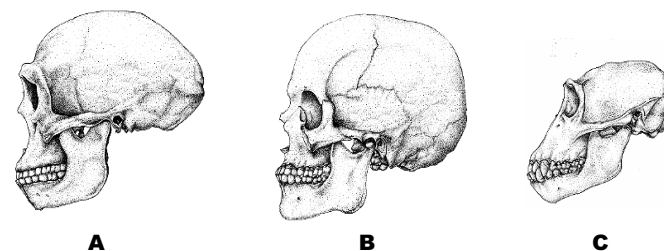


4.6 Complete the following table that illustrates the history of the development of tools.

Illustration of tools			
Tool culture to which tools belong			
Type of tools			
First hominin(s) to use this type of tool			
Time period in which tool was used			

**QUESTION 5**

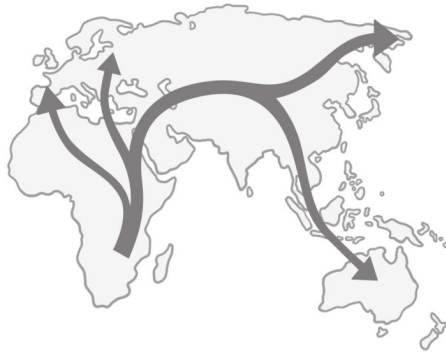
Diagrams A, B and C below illustrate the skulls of *Homo sapiens*, *Homo erectus* and *Pan troglodytes* (chimpanzee). The diagrams are drawn to scale.



- 5.1 Give the genus and species name of the skull illustrated in:
  - 5.1.1 A
  - 5.1.2 B
  - 5.1.3 C
- 5.2 Use the diagrams to determine the order in which these three species possibly appeared on the earth.
- 5.3 Tabulate THREE visible structural differences between A and B that illustrate evolutionary trends in human development.

**QUESTION 6**

Study the following representation of the 'Out of Africa' hypothesis and answer the questions that follow.



**'Out of Africa' hypothesis**

- 6.1 The 'Out of Africa' hypothesis states that *Homo sapiens* originated in Africa and spread from here to the rest of the world, replacing some other hominins, such as *Homo erectus* and *Homo neanderthalensis*. What evidence supports this hypothesis?
- 6.2 Why is Africa regarded as the 'Cradle of Humankind'?
- 6.3 Which *Homo* species was the first to leave Africa about 1,8 million years ago?
- 6.4 Name the THREE parts of the world where the first *Homo* species to leave Africa, migrated.
- 6.5 What resulted in *Homo erectus* in Asia and Indonesia and *Homo neanderthalensis* in Europe being replaced by *Homo sapiens*?
- 6.6 Africa is considered the place of origin of *Homo sapiens* because the people of Africa are the oldest. Explain how mitochondrial DNA (mtDNA) was used to reach this conclusion.
- 6.7 DNA from the Y-chromosome (Y-DNA) is only carried by men and can only be inherited from their ancestors. Explain this statement.
- 6.8 Explain how Y-DNA plays a role in the determination of male ancestral descent.

**QUESTION 7**

Describe TWO lines of evidence which support the idea that the human population had its origins on the African continent.

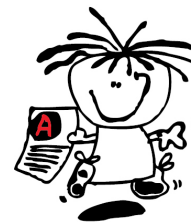
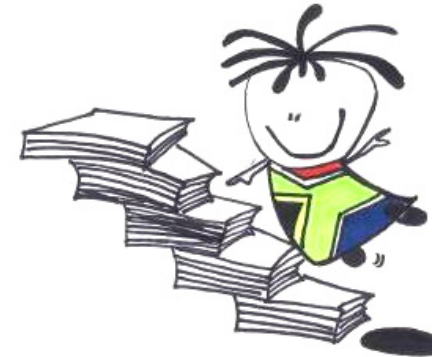


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# HUMAN EVOLUTION: ANSWERS

## QUESTION 1

- 1.1 kangaroo                      1.2 a tail  
1.3 bipedalism                  1.4 *Gorilla gorilla*

## QUESTION 2

- 2.1 D                                  2.2 A B C  
2.3.1 C                              2.3.2 D  
2.3.3 B                              2.3.4 A

- 2.4 D B A C (correct order)    **OR**  
*Gorilla gorilla; Australopithecus africanus;*  
*Homo habilis; Homo sapiens*

## QUESTION 3

3.1.1

Gorilla	Human
› arms longer and stronger than legs	› arms shorter and weaker than legs
› knee joints smaller and weaker	› knee joints larger and stronger
› opposable big toe with power grip	› non-opposable big toe in line with other toes
› long and narrow pelvis	› short and broad pelvis
› skull elongated and smaller	› skull larger and rounder
› large protruding canines	› smaller canines - same size as other teeth
› cranial ridge present	› cranial ridge absent
› reduced forehead	› pronounced forehead

- 3.1.2 › opposable thumbs  
› two hands with five fingers each, and two feet with five toes each  
› long arms that rotate freely due to the shoulder joint  
› stereoscopic vision  
› no tail



- 3.2.1 A - human B - gorilla  
3.2.2 The position of the foramen magnum.  
3.2.3 A / human  
3.2.4 The foramen magnum moved forwards so that the skull rests directly on top of the vertebral column and the eyes face forward. This ensures stable upright walking.  
3.2.5 › Hands are free to use tools, prepare food, carry young, hunt or fight.  
› Upright bodies expose a smaller surface area to the sun which reduces risk of overheating while hunting, foraging or escaping predators.  
› Upright bodies expose a larger surface area to air currents which causes cooling and reduces dependency on water.  
› Vision extends further over the tall grass of the savannah to find food or avoid predators.  
› Adaptability to occupy a wider range of habitats.

## QUESTION 4

- 4.1 fossil evidence, genetic evidence, cultural evidence  
4.2 The production and use of tools as well as other cultural practices like fire-making, burial rites, art forms, hunting techniques and improved communication with the development of speech and language.  
4.3 The way in which tools from a particular area were made and used.  
4.4 Oldowan tool culture  
4.5 Acheulian and Mousterian tool cultures



4.6

Tool culture to which tools belong	Oldowan	Acheulian	Mousterian
Type of tools	choppers, flakes and scrapers	hand axes, picks and meat cleavers	advanced tool kits including sharp needle-points and a range of stone blades
First homin(s) to use this type of tool	<i>Homo habilis</i>	<i>Homo erectus;</i> <i>Homo ergaster</i>	<i>Homo neanderthalensis</i> <i>Homo sapiens</i>
Time period in which tool was used	2,6 - 1,5 mya	1,5 - 0,25 mya	0,25 - 0,05 mya

## QUESTION 5

- 5.1.1 *Homo erectus*                      5.1.2 *Homo sapiens*  
5.1.3 *Pan troglodytes*  
5.2 C, A, B  
5.3

<i>Homo erectus</i>	<i>Homo sapiens</i>
› smaller cranium	› larger cranium
› less rounded cranium/skull	› more rounded cranium/skull
› shorter/smaller forehead	› longer/larger forehead
› prognathism - protruding jaw	› no prognathism - more rounded jaws
› no definite chin	› definite chin
› prominent brow ridges	› less prominent brow ridges
› larger zygomatic arch/cheek bone	› smaller zygomatic arch/cheek bone
› larger lower jaw	› smaller lower jaw

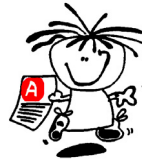


**QUESTION 6**

- 6.1 > genetic links  
> fossils and artefacts of hominins found in Africa
- 6.2 The area in the world that is richest in hominin fossils i.e. the 'Cradle of Humankind' is located in Africa (specifically South Africa) and the name indicates the idea that modern humans had their origin ('baby years') in this area.
- 6.3 *Homo erectus*
- 6.4 Europe, Asia and Indonesia
- 6.5 *Homo sapiens* had a higher level of technological skill and were better adapted to their new environment which ensured their survival.
- 6.6 Scientists determine the extent of a population's genetic variation by comparing the mtDNA of different populations. The group showing the most variation has the most mutations. This means this group had the longest time for mutations to take place and thus they are the oldest. Studies have shown that the greatest level of genetic variation in mtDNA occurs in human populations in Africa. From this it is concluded that the people of Africa are the oldest.
- 6.7 The small Y-chromosome only occurs in men and does not undergo any crossing over or exchange of genetic material during gamete formation (meiosis). Therefore, the Y-chromosome remains largely unchanged over generations.
- 6.8 Because the Y-DNA is only transferred by men and remains almost the same over generations, men who share a common ancestor will have almost the same Y-DNA. In this way the male ancestral descent can be determined using the Y-line.

**QUESTION 7**

- > The oldest fossils of australopithecines/hominins/ bipedals have only been found in Africa.
- > The oldest fossils of hominins have been found in Africa.
- > Analysis of mitochondrial DNA shows that the oldest female ancestors of humans are from Africa.
- > Analysis of Y chromosome shows that the oldest male ancestors of humans are from Africa.



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