The fossil record of human origins and evolution

(from exhibits at the National Museum, Nairobi, Kenya, compiled for www.AfricanWorldHeritageSites.org)

The fossil evidence for our ancestors over the last seven million years continues to increase as palaeoanthropologists (people who study human fossils) make new discoveries. The story of human evolution is always changing as new evidence is found and existing evidence is re-interpreted. Many of the most important fossils found so far are displayed at the Nairobi National Museum and shown in the photographic guide below.

Most of the evidence for human evolution has been found in eastern and southern Africa, and Kenya has produced fossils that tell most of our evolutionary story. However, these fossils are very rare and are often only fragments.

There are many fossil sites in Africa that have yielded remains of early man. Kenya is particularly rich in fossil sites, with over 100 located mainly in the eastern branch of the Great Rift Valley, around Lake Victoria and the coastal region. However, fossil hominins (human ancestors) have only been found in a few of these sites, where sedimentary rocks have been exposed by weathering (e.g. strong winds or rain) and other geological processes (e.g. earthquakes) to reveal the fossils to palaeontologists.

Our place in the family tree: a note on names

All living apes and humans belong to a superfamily called the Hominoidea, but we are unique in being the only surviving species that belongs to the hominini tribe. Therefore we and our ancestors are called hominins, to distinguish us from the great apes.

The first step

From about ten million years ago the climate in some parts of Africa including eastern Africa, began to get cooler and drier so that continuous tropical forests began to break up into smaller patches of savannas/grasslands. Among the animals that adapted to this new environment were the first hominins, who lived partly in the trees and partly on the ground. They were also the first hominins to stand up and walk on two legs most of the time.

Down from the trees

Although we belong to the same family, the Hominidae, as the great apes, we are adapted to a very different way of life. The living great apes (chimpanzees, gorillas etc) are still adapted to an arboreal lifestyle (life in the trees), whereas we are terrestrial (ground-living). But when did our ancestors leave the trees? And when did they begin to walk on two legs?

A host of hominins

Although the current evidence for the very first hominins is not conclusive, more than four million years ago a group of undoubtedly bipedal hominins first appeared. They are called australopithecines. The first known australopithecine is *Australopithecis anamensis*.

Artists impression of *Australopithecus anamensis (NMK)*

About 3.5 million years ago the australopithecines evolved into several species to adapt to different ways of life in the woodland savannas of Africa. This evolutionary diversification is called an adaptive radiation.

There were at least five different kinds of early australopithecines, of which up to three existed at the same time. The early australopithecines were

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sometimes called gracile (slender) australopithecines, because of their smaller teeth and more delicately built skull. But they could not all be our direct ancestor, so which ones were?

Palaeoanthropologists are still debating how the different kinds of australopithecines were related to each other and which ones were likely to be our direct ancestors. New findings in different parts of Africa continue to change our views on the relationships between the different australopithecine species.

Bigger brains
The early australopithecines had brains similar in size to those of chimpanzees (about 400 cm^3), but this increased over the next one million years.

Climbing trees
Despite their adaptations for walking upright, some early australopithecines were still adapted to climbing trees. Lucy (the famous specimen of *Australopithecus afarensis*, found in Ethiopia's Awash Valley) probably still had a grasping hind foot. Although Lucy's arms are within the human range, they are relatively long compared with the rest of her body.

Why be a biped?

We are very good at walking and running on two legs: we are bipeds. We can cycle a bike, drive a car and dribble a football with incredible skill. But why did this adaptation evolve in hominins?

Many different theories have been suggested to explain why hominins evolved as bipeds, but we do not know which ones were the most important. Here are some examples:

- Spotting and avoiding predators;
- Energy-efficient locomotion – since only two limbs are active;
- Freeing the hands for making tools, collecting food and looking after babies;
- When standing upright, only a small surface area is exposed to the sun and this minimises heat absorption.

Mighty Jaws

The early australopithecines gave rise to an evolutionary offshoot about 2.5 million years ago, the robust australopithecines, which had huge teeth, powerful jaws and a massive skull.

The robust australopithecines were actually about the same size as, or slightly bigger than the early gracile ones, but their brains were about 25% bigger, and their cheek teeth and jaws were massively developed for a much tougher diet.

The first robust australopithecine was *Paranthropus aethiopicus* which lived about 2.5 million years ago in Kenya. It had a smaller brain, teeth and jaws than later kinds (*Paranthropus boisei* from East Africa and *Paranthropus robustus* from South Africa) which lived a million years later.

As the climate continued to get drier soft items suitable for smaller teeth went off the hominin menu. Over time the teeth and jaws of robust australopithecines evolved ever bigger to cope with a tougher diet of seeds, nuts roots and tubers

The end of the australopithecines
After more than three million years, why did the australopithecines disappear? We do not really know, but it could have been caused by competition with more efficient herbivores (plant eaters) and omnivores (animals that eat anything). In particular, one group may have squeezed the australopithecines out of existence with the added advantage of new technology and even bigger brains.

Bigger brains and first tool kits
As the australopithecines declined in diversity they were replaced by the first humans. But the origin of humans is not a straightforward affair. The evolutionary history of the first humans is remarkable for two things: a rapid and huge increase in brain size coupled with the development of stone tool kits.

The first humans
Around 2.4 million years ago two new kinds of hominins appeared in East Africa. They are recognised as being the earliest humans: *Homo habilis* and *Homo rudolfensis*. At the same time simple stone tools appeared in the archaeological record, but we are not sure who made them (see Box 'The first stone tool makers').

Homo habilis was smaller in body size and had a brain capacity similar to that of the robust

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australopithecines. The arms of this hominin were probably long relative to the legs, but it walked upright.

Homo rudolfensis was bigger in body size and had a much larger brain (50% more) than that of *Homo habilis*. The arms of this hominin were relatively shorter than those of *Homo habilis*. Although we cannot be sure, it seems most likely that *Homo rudolfensis* was our direct ancestor and the maker of the first stone tools.

Between 200,000 and 160,000 years ago modern humans, *Homo sapiens*, evolved from *Homo helmei* in Africa. The first anatomically modern human skull was found in the Omo Valley, Ethiopia and is dated to about 160,000 years old (visit www.AfricanWorldHeritageSites.org for more information and photos of the Omo Valley)

Anatomically modern humans are distinguished from their ancestors by having:

- A rounded skull;
- No thick brow ridges;
- A prominent chin.

And then there was us: *Homo sapiens*

The first stone tool makers

Chimpanzees regularly use simple tools made out of wood, twigs, grass stems and even stones so it seems likely that early hominins could have done the same. However, most of these materials do not preserve in the fossil record so we do not know about the technologies of the earliest hominin species. As far as we know, the earliest members of the genus *Homo* were the first hominins to use tools to make other tools made of stone.

The first stone tool kit: early Stone Age

This is the oldest technology known to mankind. It is characterised by simple flaked cores where only a few flakes have been taken off. The cores may have been used as functional tools, while the flakes may have been used as knives to dismember game carcasses or to strip tough plants. The photo below shows a 2.3 million year-old stone 'core' tool found near Lake Turkana in Kenya

These early tools are called Oldowan after Olduvai Gorge in Tanzania where they were first found. The oldest appeared about 2.6 million years ago and were found in Gona, Ethiopia. Oldowan tools mark the beginning of a stone technological development that involved learning through copying to pass on skills down the generations. Tool types include spheroids or hammer-stones, scrapers and anvils, and unmodified stones or manuports.

An improved tool kit: Acheulean tools

Homo erectus produced stone tools which indicate an improved technological skill. This improved tool kit is called Acheulean after the site of St. Acheul in France where the first tools of this kind were found. However the oldest ones are found in East Africa and are dated 1.7 million years.

The Acheulean tools were made by *Homo erectus* and the subsequent descendants for more than one million years, becoming more refined over time, an indication of some form of communication and social structure. The Acheulean Industrial Complex is differentiated from the preceding Oldowan tool kit by the ability to detach large flakes, which were then modified further to make various tool types, the best examples being hand-axes, cleavers, knives, picks, collectively referred to as bifaces or Large Cutting Tools.

This technology has also been found in Europe and Asia. As *Homo erectus* travelled from Africa, the Acheulean tool kit and the knowledge to make it were taken along. These tools were probably used for more than one task.

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Dating past life: How old is this fossil?

There are two main ways of dating fossils:

Relative dating – dating a fossil in relation to rocks and other fossils of known age
Absolute dating – chemical methods that allow precise dating of fossils or rocks that surround them.

Relative dating: older and deeper
Fossils are generally found in sedimentary rocks formed from the sediments laid down in rivers lakes and seas. The most recent sediments are usually found on top, so that fossils from lower down in the rocks are usually older than those higher up.

If we know when a particular stratum (layer of rock) was formed, we can say whether a fossil is older or younger depending on whether it is found above or below it. If we know when certain extinct animals or plants lived in the past, finding their fossils can help us date other fossils found with them.

Absolute dating – the volcanic rock clock
There are several different ways of absolute dating of fossils and rocks depending on how old they are. These include radiocarbon, thermo-luminescence, fission track and electronic spin resonance dating methods. Radiocarbon dating is used to determine the age of fossil material that is younger than 50,000 years.

Carbon dating: How does it work? It measures the amount of radioactive carbon left on plant or animal remains. Once an animal or a plant dies it ceases to take up carbon and 14C starts to decay to 14N, with the half-life of the process being 5730 years. The half-life is the time taken for the initial 14C to decay to half the original value. Thus after 5730 years half the 14C is gone and by 11,460 years only a quarter remains.

The most common method used to date Kenya's world-famous hominin (human-like) fossils is potassium-argon dating, which dates material older than 50,000 years

Potassium-argon dating: How does it work? Potassium-argon dating measures the amounts of radioactive potassium and agon gas in volcanic rocks that surround fossils. When volcanoes erupt they produce ash which settles on the surrounding ground. These ashes eventually form a kind of rock called tuff. As the volcanoes erupt at different times over hundreds of thousands or even millions of years, tuffs are laid down at different levels in the sedimentary rocks.

Volcanic rocks contain tiny amounts (0.01%) of radioactive potassium. The radioactive potassium decays to argon gas, a process with a half-life of 1.26 billion years. The high temperature of the volcano drives out any argon gas in the rock, setting the clock to zero. By measuring the relative amounts of radioactive potassium and argon gas in crystals such as those found in pumice (a type of volcanic rock) it is possible to precisely date fossils that are more than 1 million years old.

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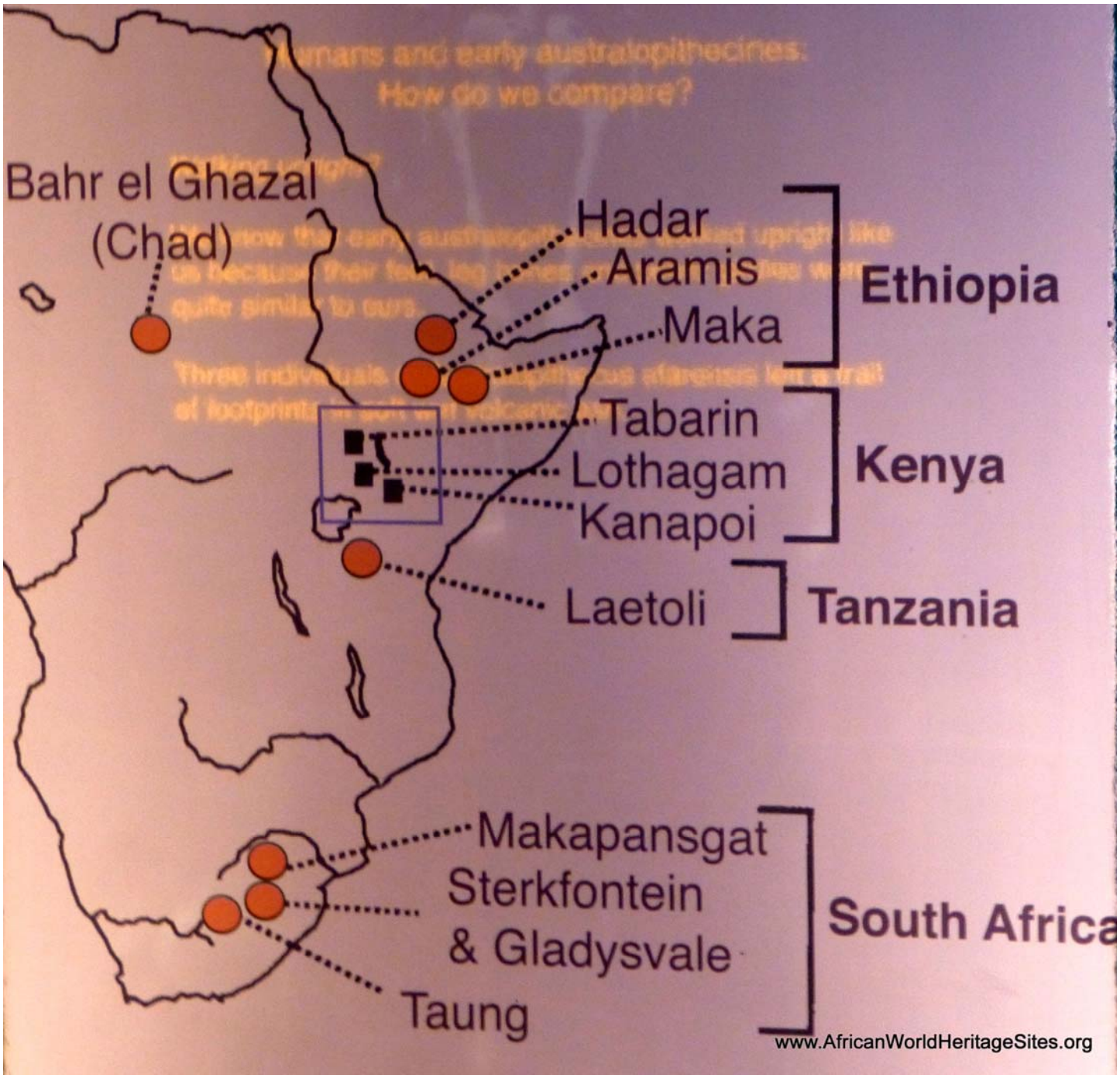
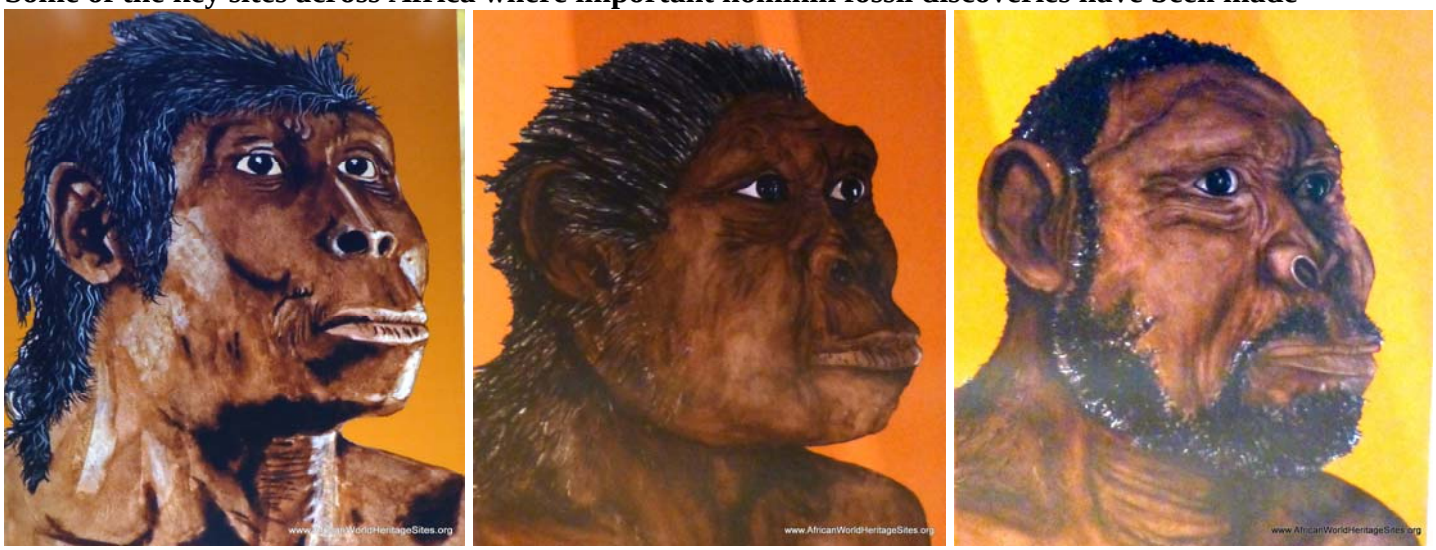


Some of the key sites across Africa where important hominin fossil discoveries have been made



Artists impressions of (left to right) *Homo erectus, Homo habilis* and *Homo rudolfensis* (NMK)

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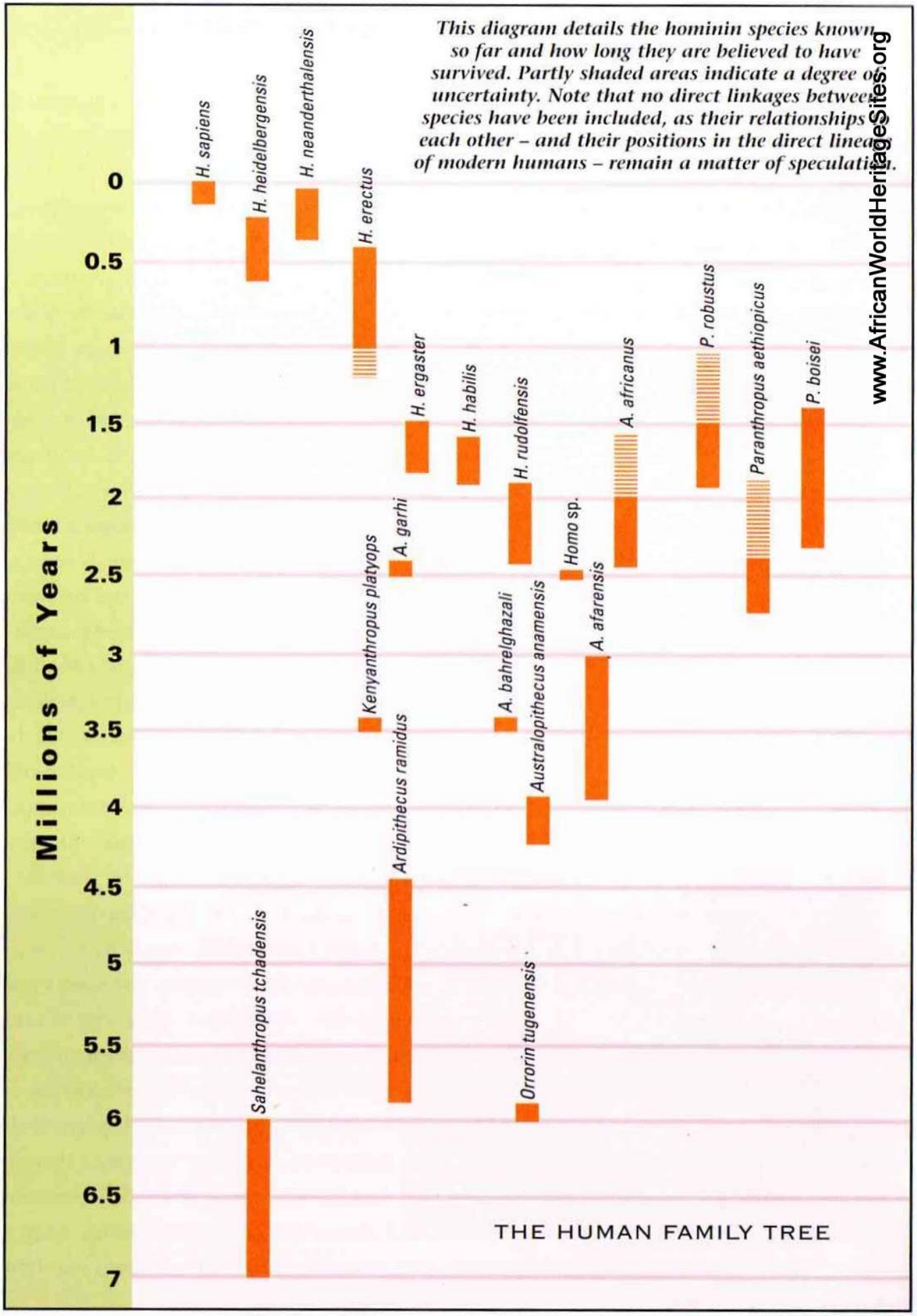

Diagram showing the timeline of known hominins over the past seven million years
(from B. Hilton-Barber and L.E. Berger 'Field Guide to the Cradle of Humankind (2002). Struik, Cape Town)

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Photographic guide to some of the key fossils from the human family tree

Proconsul heseloni (18 million years old)

Location: Rusinga Island, Lake Victoria, Kenya
Age: 18 million years old
Fossils: Almost complete skull
Found by: Mary Leakey in 1948

Why is it special?
Proconsul is one of the earliest apes
This is the only complete skull of Proconsul ever found

Discovery?
This skull was found on Rusinga Island in Lake Victoria by Mary Leakey on 1st October 1948. It was in many fragments which had to be carefully pieced together. It was taken to the Natural History Museum in London and only returned to Kenya in 1981.

Scientific significance?
At first it was thought to be the 'missing link' between apes and humans, but later it was realised that it was an early ape – a possible shared ancestor for modern apes and man.

What was it like?
It is believed that this animal weighed about 9kg and lived in the trees, eating fruits. Unlike monkeys it did not have a tail and had more flexible limbs.

How did it get its name?
The first specimen of Proconsul was found in 1931 and it was named by its discoverer, Arthir Hopwood, after Consul, a chimpanzee in London Zoo, England. Hopwood thought it looked like a chimpanzee ancestor, hence Pro-Consul.

At first this skull was identified as *Proconsul africanus*, but later several different species were recognised and this one was renamed *Proconsul heseloni* after Heselon Mukiri, Louis Leakey's assistant.

Orrorin tugenensis ('Millenium Man')

Location: Tugen Hills, Baringo, Kenya
Age: 6-7 million years old
Fossils: Fragments of limb bones, jaws and teeth
Found by: Kiptalam Cheboi in 2000

Scientific significance?
Potentially the most dramatic fossil find in 20 years because it appears to be over a million years older than any other hominin yet discovered. If confirmed, it places the creature at the point in time where the lineage split between ancestral hominins and apes.
Evidence for bipedalism: the head of the femur (thigh bone). Humans have a large head of the femur with a long neck. Chimpanzees have a small head of the femur with a short neck. *Orrorin tugenensis* seems to have a head of the femur more similar to ours, so perhaps it walked on two legs.

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Sahelanthropus tchadensis (‘Toumai Skull’)

Location: Toros-Menalla, Chad (Central Africa)
Age: 6-7 million years old
Fossil: Almost complete skull
Found by: Ahounta Djimdoumalbaye in 2001

Scientific significance?
This skull has stirred debate among anthropologists over whether it is a pre-human ancestor or an ancient ape. Humans have very small canines that allow side-to-side chewing. Chimpanzees have very large canines that allow only vertical chewing. *Sahelanthropus* has small canines like those of ours and other hominins, so perhaps it walked on two legs like later hominins, and is a pre-human ancestor. The discovery of more complete specimens may eventually shed some light on this debate.

Australopithecus anamensis

Location: Kanapoi, West of Lake Turkana, Kenya
Age: 4.2 million years old
Fossils: Fragments of limb bones, jaws and teeth
Found by: Kamoya Kimeu and Peter Nzuve in 1994

The tibia (shin bone) of ***A anamensis*** is similar to that of humans because it is wider and flat at the top due to extra spongy bone tissue which serves as a shock absorber in bipedal creatures.

Australopithecus bahrelghazali

Location: Bahrelghazali, Chad
Age: 3-3.5 million years old
Fossil: Mandible
Found by: Michel Brunet in 1993

The fossil consists of a mandibular symphysis with teeth, which is more modern in appearance than that of *A. afarensis*. But it may simply be a regional variant of A. afarensis. This is one of the very few fossil hominins from central Africa.

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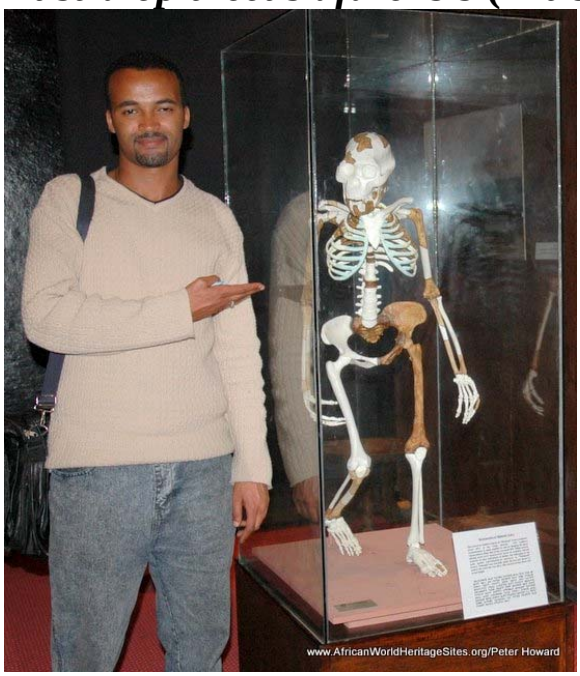
Australopithecus afarensis (‘Lucy’)



Location: Hadar, Ethiopia
Age: 3.2 million years old
Fossils: A partial skeleton that includes pelvis, leg bones, ribs, backbone (vertebrae), skull and arm bones
Found by: Donald Johanson in 1973

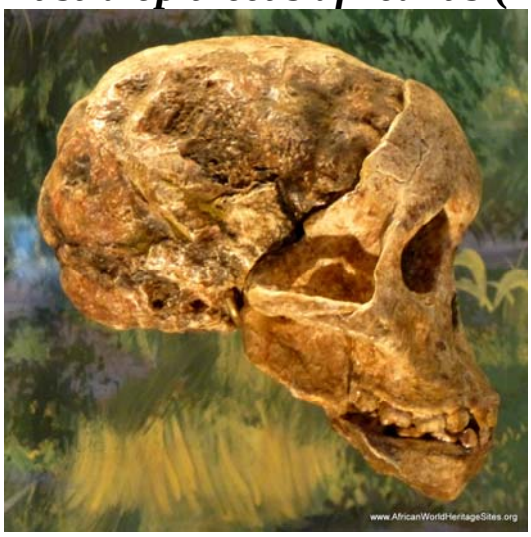
(Photo of a reconstructed skeleton in the Ethiopian National Museum, Addis Abeba, showing its small size compared with modern man)

Kenyanthropus platyops

Location: Lomekwi, west of Lake Turkana
Age: 3.4 million years old
Fossil: Skull
Found by: Justus Edung in 1999

This is a nearly complete skull (but heavily distorted) with a large flat face and small teeth. The brain size is similar to that of the australopithecines. We still do not know very much about *Kenyanthropus* and its relationships with other hominins. Some palaeoanthroplogists think it could be ancestral to one of the earliest kinds of human, *Homo rudolfensis*, while others believe it is just an australopithecine.

Australopithecus africanus (‘Taung Child’)



Location: Taung, South Africa
Age: 2-3 million years old
Fossil: Partial juvenile skull
Found by: M. de Bruyn in 1924

This specimen nick-named the ‘Taung Child’ belonged to an individual that died between the age of 3 to 4 years. The fossil consists of a partial skull with a face, partial endocast and partial mandible. The canine teeth are small and human-like. The position of the foramen magnum suggests that this hominin was a biped.

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Australopithecus africanus (‘Mrs Ples’)

Location: Sterkfontein Caves, South Africa
Age: 2.1 million years old
Fossil: Nearly complete skull
Found by: Robert Broom and John Robinson in 1947

Mrs Ples is the popular nickname for this nearly complete skull. Many fossils of this species, which are considered to be the distant relatives of all humankind, have been found in the Sterkfontein caves. The nickname Mrs Ples was derived from the scientific designation initially given to the skull by Dr Broom, *Plesianthropus transvaalensis* (near-man from the Transvaal). It should be noted that the sex of this skull is not completely certain and that Mrs Ples may in fact be Mr Ples.

Paranthropus aethiopicus (‘Black Skull’) (Ref: KNM – WT 17000 - 2.5 million years old)

Location: Lomekwi, West Turkana, Kenya
Age: 2.5 million years old
Fossil: Incomplete skull
Found by: Alan Walker in 1985

Why is it special?
It is the oldest robust australopithecine ever found in East Africa

Scientific significance?
Until its discovery, palaeontologists believed that there was a simple evolutionary line from the early ‘gracile’ australopithecines, which were the ancestors of robust australopithecines and early humans, However, the owner of the ‘Black Skull’ lived at the same time as some of the ‘gracile’ australopithecines. As a result of this discovery it was realised that there were more than two kinds of early man living at the same time.

What did it look like?
The ‘Black Skull’ has huge tooth roots, indicating that it had big teeth adapted for chewing hard nuts, seeds and grasses. To anchor the big chewing muscles it has an enormous bony crest along the head. Its brain is similar in size to that of the chimpanzee and it has a similar projecting muzzle.

How did it get its name?
The ‘Black Skull’ got its name because it was stained blue-black by manganese in the area in which it was preserved. At the press conference announcing its discovery Alan Walker said ‘pass me that black skull’ and the name stuck. The ‘Black Skull’ used to be called *Australopithecus aethiopicus*, which means ‘southern ape from Ethiopia’. However most palaeontologists now think that later robust australopithecines are so different from early ones that they should be in their own group and so now it is called *Paranthropus aethiopicus*, which means ‘Nearly man from Ethiopia’.

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Paranthropus boisei (Ref: KNM- ER 406 – 1.7 million years old)

Location: Koobi Fora, East Turkana, Kenya
Age: 1.7 million years old
Fossil: a nearly complete cranium
Found by: Richard Leakey in 1969

Why is it special?

- It was the first major discovery from Koobi Fora
- It is one of the most complete skulls ever found of a robust australopethicine

Discovery?

ER 406 was found by Richard Leakey in 1969 at Koobi Fora, on the eastern side of Lake Turkana

Scientific significance?

This skull is classified as a male *Paranthropus boisei*. It is one of the robust australopithecines sometimes known as 'nutcracker man' because of the huge teeth, wide zygomatic arches, and a crest along the top of the skull which anchored the chewing muscles.

What did it look like?

A comparison of this skull with others of the same species shows that there were significant differences in sizes between males and females. We see similar differences between male and female gorillas today, whereas men and women are much less different.

ER 406 shows evidence of an infection of the bone just above the left eye. Bone diseases are nearly absent from the early human record, so this is very unusual.

Did it make tools?

Early stone tools and remains of this species of robust australopithecine have been found in fossil layers of similar age. This raises the possibility that robust australopithecines as well as *Homo rudolfensis*, which lived at the same time, may have made stone tools. However we may never know whether they did or not.

How did it get its name?

Louis Leakey originally called this species *Zinjanthropus boisei*, which means 'Boise's East African Man'. Charles Boise was a businessman who sponsored Leakey's expeditions. Later it was reclassified as *Australopithecus boisei* (Boise's southern ape), but most palaeontologists now call it *Parathropus boisei*.

Homo rudolfensis (Ref: KNM – ER 1470 - 1.9 million years old)

Location: Koobi Fora, east of Lake Turkana, Kenya
Age: 1.9 million years old
Fossil: Partial skull
Found by: Bernard Ngeneo in 1972

Why is it special?

The earliest fossil with a large brain case
Played a key role in arguments about human origins

Scientific significance?

At one time this was the most controversial fossil in the world and even today not everyone agrees what it is. After the painstaking task of glueing more than 200 fragments together, Richard Leakey and his co-workers realised that this was a unique specimen, because it has a remarkable large brain case for such an old fossil. However, it has large teeth and thick jaws more like those of *Paranthropus.*

When it was first found, it was thought to be 2.6 million years old, which made it older than the small-brained australopithecines which were then thought to be ancestral to humans. This appeared to overturn the existing theories of human evolution. Soon after its discovery doubts were raised about its age since the pig fossils found beside it seemed to be from a later time. After many years of often heated arguments it has now been accepted that it is 'only' about 1.9 million years old. However, even with the new date it is still the earliest known fossil with the key human attribute of a large brain.

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What did it look like?
Remains of skeletons suggest that *Homo rudolfensis* had similar body proportions to humans. It had a flat face with heavy brow ridges, thick jaws and large teeth.
How did it get its name?
At first ER 1470 was identified as a male *Homo habilis*, but later it was reclassified as *Homo rudolfensis* (Lake Rudolf man; Lake Rudolf is`the old name for Lake Turkana)

Homo habilis (Ref: KNM - ER 1813 - 1.9 million years old)

Location: Koobi Fora, East of Lake Turkana, Kenya
Age: 1.8 – 1.9 million years old
Fossil: Partial skull
Found by: Kamoyas Kimeu in 1973

Why is it so special?
It has a curious mixture of 'ancient' and 'advanced' features, and shows that not all early hominid skulls can be neatly classified
Scientific significance?
ER 1813 has small teeth and a small brain. It is more like *Homo habilis* found at Olduvai in Tanzania than it is to ER 1470, but its braincase size is more like that of *Australopithecus*. Some palaeontologists classify this species as *Australopithecus habilis*. One possibility is that male and female *Homo habilis* differed greatly in size and that this is the skull of a small female.
How did it get its name?
Homo habilis means 'handy man'. It was given this name because Louis Leakey and his co-workers, who were the first to discover remains of this early human species, believed that it was the first hominin to make and use stone tools called Oldowan tools. Now it is considered that *Homo rudolfensis* was the first stone-tool maker.

Homo erectus (Ref: KNM – ER3733 - 1.75 million years old)

Location: Koobi Fora, East of Lake Turkana, Kenya
Age: 1.75 million years old
Fossil: Complete skull
Found by: Bernard Ngeneo in 1975

Why is it special?
One of the best preserved early human skulls, identifiable as a female
Its discovery first confirmed that different types of hominids lived together
Scientific significance?
By comparing the skull of ER 3733 with those of two other *Homo erectus* specimens from Lake Turkana, palaeontologists came to the conclusion that ER 3733 was a mature female. Her face is much less robust than the others. ER 3733 was found in the same layer of rock as the robust australopithecine ER 406 (see above), suggesting that two completely different kinds of early humans lived in the same place at the same time.
What did she look like?
She was adult, because her skull bones are fused, her teeth are quite worn and her third molars (so-called wisdom teeth) had erupted before she died. Her teeth were smaller than those of the australopithecines, but her face was large with a projecting muzzle.
How did she get her name?
There is still some discussion between palaeontologists about how to classify these early humans from Africa. Some believe that they are an early form of *Homo erectus* (upright man) – best known as Peking Man from Asia. Others believe that they were different from *Homo erectus* and called them *Homo ergaster*.

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Homo erectus **('Turkana Boy' Ref: KNM – WT 15000 - 1.6 million years old)**

Location: Nariokotome, west of Lake Turkana, Kenya
Age: 1.6 million years old
Fossil: Nearly complete skeleton
Found by: Kamoya Kimeu in 1984

One of the best known specimens of *Homo erectus* is the 'Turkana Boy', an almost complete skeleton of a boy, which is dated to about 1.6 million years and was found at Nariokotome on the western side of Lake Turkana. Palaeoanthropologists have estimated that the boy was between 9 and 12 years old and was 1.6 metres tall at the time of his death. If the Turkana boy had grown to maturity he may have grown to 1.84 metres tall.
The 'Turkana Boy' was born as small and as helpless as human babies so that his head could pass easily through the birth canal. Also like us, his brain continued to grow after he was born. Therefore the brain of Homo erectus had a similar growth pattern to our own.
'Turkana Boy' shows key features that distinguish members of the species from earlier ancestors:

- Bigger brain (880 cm^3) – about 20% bigger than that of Homo rudolfensis
- Shorter face – smaller molars
- Projecting lower face – not flat
- Heavy brow ridges – short forehead
- Longer legs than arms – for more effective bipedal walking

Homo heidelbergensis

Location: Middle Awash Valley, Ethiopia
Age: 600,000 years old
Fossil: Partial skull
Found by: A.Asfaw in 1976

Homo helmei

Location: Eliye Springs, west of Lake Turkana
Age: 200,000 years old
Fossil: Almost complete skull
Found by: Danhofer family in 1980

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Homo sapiens (‘Herto’)

Location: Herto Bouri, Middle Awash Valley, Ethiopia
Age: 160,000 years old
Fossil: Almost complete skull
Found: 1997

The skull represents populations of anatomically modern humans on the African continent

Homo sapiens (‘Galana Boy’)

Location: Koobi Fora, east of Lake Turkana, Kenya
Age: 8 – 10,000 years old
Fossil: Deformed partial skull
Found: 1967

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