# Evolution Scope

| TOPIC | SUBTOPIC | KEY INFORMATION |
|---|---|---|
| **EVOLUTION** | Evidence for evolution | • Role of the following as evidence for evolution:<br>✓ Fossil record<br>✓ Biogeography<br>✓ Modification by descent (homologous structures)<br>✓ Genetics |
| | Sources of variation | • Meiosis:<br>✓ Crossing over<br>✓ Random arrangement of chromosomes<br>• Mutations<br>• Random fertilisation<br>• Random mating |
| | Lamarck and Darwin's theories | • State the general theories according to the Exam Guidelines but apply it to a given example |
| | Natural and artificial selection | • Describe the processes<br>• Tabulate the differences |
| | Punctuated equilibrium | • Define, describe & be able to identify examples |
| | Speciation | • Apply the example given in a paper according to the format in the Examination Guidelines<br>• Be able to identify the geographic barrier and speciation of one species becoming different species |
| | Mechanisms for reproductive isolation | • Refer to Examination Guidelines for different mechanisms |
| | Evolution in present times | • Any ONE example according to Examination Guidelines |
| | Human evolution: similarities of humans and African apes | • With the aid of diagrams, as it applies to the characteristics in the Examination Guidelines |
| | Human evolution: anatomical differences between humans and African apes | See Examination Guidelines:<br>e.g.<br>• Long and narrow vs. short and wide<br>• Large canines vs. small canines<br>• The significance of the evolutionary changes<br>e.g. Foramen magnum more in front and under the scull |
| | Trends in human evolution | • Interpretation of phylogenetic trees proposed by different scientists showing possible evolutionary relationships as it applies to hominid evolution |
| | Out of Africa hypothesis | • According to the examination guidelines<br>• Focus on species found in Africa or found ONLY in Africa |

*Adapted from DBE revision guidelines*

StudySmartly
Enriching minds

Study copy distributed by EduResource ZA | eduresourcza.com

# Evolution

## Key concepts

- origin of ideas about origins
- theories of evolution
- Darwin's theory of evolution by natural selection
- formation of a new species
- artificial selection
- mechanisms of reproductive isolation
- evolution in present times

## Origin of Ideas

**Evolution** - change over time

**Theory vs Hypothesis**

A **theory** is an explanation of something that has been observed in nature which can be supported by facts, generalisations, tested hypotheses, models and laws.

A **hypothesis** is a possible solution to a problem.

### Evidence for evolution

- Fossils - Remains of dead matter preserved in rocks
- Biogeography - the study of the distribution of fossils
- Genetics - the study of heredity
- Other - embryology, vestigial organs, comparative anatomy (not part of syllabus)

**Biological evolution** refers to any genetic change in a population that is inherited and becomes a characteristic of that population over several generations.

### Genetic evidence & Variation

genetics deals with the similarities in and differences of related organisms. Genetic evidence that organisms are closely related and are likely to have a common ancestor includes:

- identical DNA structure
- similar sequence of genes
- similar portions of DNA with no functions
- similar mutations (mitochondrial DNA)

### What causes variation?

- Meiosis (crossing over & Random arrangement of chromosomes)
- Random fertilisation
- Random mating
- Mutations

StudySmartly
Enriching minds

Study copy distributed by EduResource ZA | eduresourcza.com

# Evolution

## By natural selection

## Theories of evolution

We look at ideas of Jean Baptiste de Lamarck and Charles Darwin

## Lamarckism

Law of use and disuse : if a structure was used more often, that structure then became bigger in the following generations. Similarly, if a structure was not being used, then this structure would become smaller and might eventually disappear.

Inheritance of acquired characteristics : organisms could inherit these changed structures from their parents. Characteristics developed during the life of an individual (acquired characteristics) could be passed on to its offspring.

### Lamarckism - Why cacti have long roots?

All cacti had short roots originally.
Cacti frequently stretched their roots.
They did this to reach deeper for water in the soil.
As a result, the roots became longer.
The characteristic of long roots acquired in this way was then passed on to the next generation.
Eventually all the plants had longer roots.

## Why Lamarckism was rejected?

Lack of supporting evidence as to how organism change.
Organisms so don't change because they want to.

### Lamarckism - Why giraffes have long necks?

All giraffes had short necks originally.
These giraffes frequently stretched their necks.
They did this to reach the leaves that were available only higher up on the trees.3
As a result, their necks became longer.
The characteristic of long necks acquired in this way was then
passed on to the next generation.
Eventually all the giraffes had longer necks.

**You should be able to apply Lamarckism in any example**

StudySmartly
Enriching minds

Study copy distributed by EduResource ZA | eduresourcza.com

# Evolution
## By natural selection
## Theories of evolution

### Darwinism

Charles Darwin's theory of evolution by natural selection is based on the four main observations made by him while on his around-the-world trip on the ship, the HMS Beagle.

- Populations can produce far more offspring than needed.
- Sizes of most natural populations and resources remain relatively constant.
- There is a natural variation of characteristics among members of the same species.
- Some characteristics are inherited and are passed on to the next generation

His conclusions:

All organisms are involved in a struggle for survival and only those best suited to the environment would survive there.

Organisms that survive are more likely to reproduce, and therefore pass on their useful characteristics to their offspring.

Over many generations, reproduction between individuals with different genetic makeup changes the overall genetic composition of the population.

### Theory of natural selection

Organisms best suited to a particular environment produce the most offspring.

Some species are better equipped to face changing conditions in their environment.

Such changes include:

- type and availability of food
- shelter,
- competition
- or predation.

Having favourable traits that are suitable to the changing environmental conditions may lead to the formation of new species (speciation). *Natural selection always acts on variation already present in a population and the environment is the selective pressure for change.*

### Darwinism - Why cacti have long roots?

As a result of **genetic variation** in the cacti population, *some cacti plants had longer roots than others.*

As a result of drought, competition for water occurred.

Plants with shorter roots died and those with longer roots survived.

This is called **natural selection.**

The **allele** for longer roots was passed on to subsequent generations.

Eventually all the plants had longer roots.

| | Lamarckism | Darwinism |
|---|---|---|
| **make-up of a population** | members of population are all the same | members have similar characteristics with a measure of variation |
| **transformation of a species/population** | individuals are able to transform during a life time | populations, not individuals, transform over time and only through genetic means |
| **mechanism of change** | individual chooses which traits to pass on to offspring<br><br>changes are directed to meet survival | natural selection – the environment exercises selective pressure causing change<br><br>variation exists regardless of organisms needs. |

**You should be able to apply Darwinism in any example**

StudySmartly
Enriching minds

Study copy distributed by EduResource ZA | eduresourcza.com

# Evolution

## By natural selection

## Theories of evolution

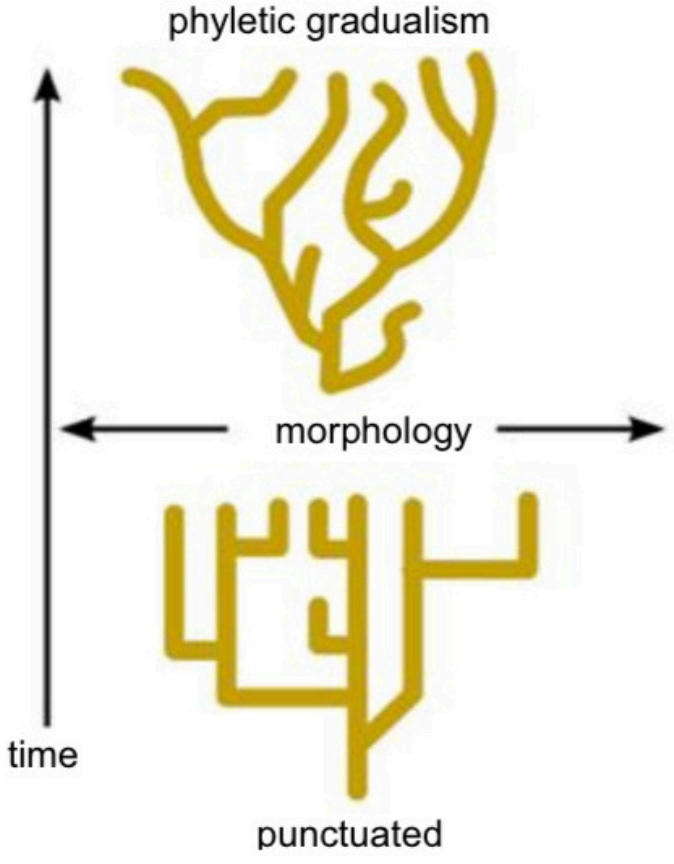
### Punctuated equilibrium

developed by Niles Eldredge and Stephen J. Gould in 1972

Punctuated equilibrium refers to a form of evolution characterised by long periods of little or no change followed by short periods of rapid change.

**Darwin** had proposed that species evolve gradually with small changes over a period of time (**gradualism**) - the physical (phenotypic) characteristics of a population change gradually

**Eldredge and Gould** noticed that in the fossil record, there were long periods of time where species did not change or changed very little. This was interspersed with periods of rapid change. Therefore, new species were formed over a short period of time. The main evidence for this type of evolution was the absence of transitional fossils (the "missing-links").




Study copy distributed by EduResource ZA | eduresourcza.com

# Evolution
## By natural selection

## Speciation

Formation of new species

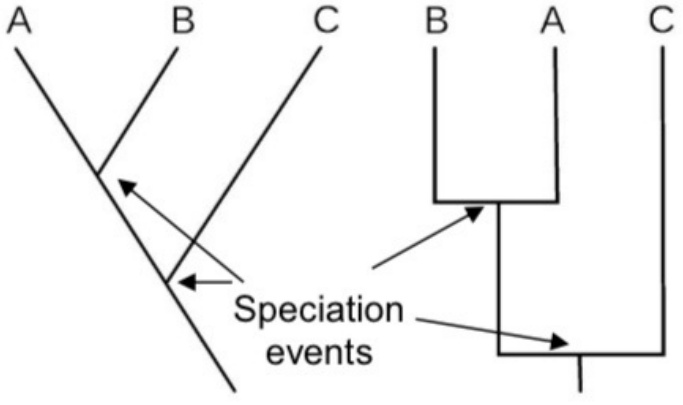
**Biological species**- a group of organisms with similar characteristics that interbreed with one another to produce fertile offspring.

## Geographic/Alopatric speciation

Geographic speciation occurs when part of a population becomes isolated from the parent population due to physical barriers. Such barriers could be continental drift, oceans, rivers, mountains, or other natural disturbances such as volcanos or earthquakes.

## General description

A population is separated by a geographical barrier and splits into two populations.
The two populations cannot mate and so gene flow between the two populations stops.
The two populations are exposed to different environmental conditions and selective forces.
Natural selection works independently on both populations simultaneously
The two populations become different from the original population both genotypically and phenotypically.
Even if the populations were to come together again, they would not interbreed with one another and therefore would have become different species.




A cladogram showing speciation. The point where organisms split is where speciation occurs. If a line does not reach the top of the tree, the organism has become extinct.

Study copy distributed by EduResource ZA | eduresourcza.com

# Evolution

## By natural selection

## Artificial selection

**Artificial selection** - human-driven selective force, e.g. breeding of plants and animals to produce desirable traits

| Natural selection | Artificial selection |
|---|---|
| The **environment or nature** is the selective force. | **Humans** represent the selective force. |
| Selection is in response to **suitability to the environment.** | Selection is in response to **satisfying human needs.** |
| Occurs within **a species.** | May involve **one or more species** (as in cross breeding). |

## Mechanisms of reproductive isolation

**Reproductive isolation** is the mechanism that prevents two species from mating with one another and making fertile hybrids, even when not separated by a geographic barrier.

| Strategy | Description |
|---|---|
| **breeding at different times of the year** | Different species will have different breeding seasons or, in the case of plants, will flower at different times of the year, in order to prevent cross-pollination. |
| **species-specific courtship behaviour** | Some animals have very specific courtship behaviours that do not attract individuals of other species, even if they are closely related species.<br>Courtship behaviour is a physical or chemical signal that an organism is ready to mate. This can include anything from being brightly coloured, to singing elaborate mating songs or mating dances, to the secretion of pheromones in order to attract a mate. |
| **adaptation to different pollinators (plants)** | Many plants and their flowers are specifically adapted for specific pollinators. Some closely related species of plants have different characteristics such as flower shape, size, colour, reward type (nectar or pollen), scent and timing of flowering all play a role in attracted certain pollinators to them. Also, cross-pollination between the different species is prevented. |
| **infertile offspring in cross-species hybrids** | Even if two species are able to physically mate and produce offspring, they will still be reproductively isolated due to the fact the most hybrid offspring are infertile. |

StudySmartly
Enriching minds

Study copy distributed by EduResource ZA | eduresourcza.com

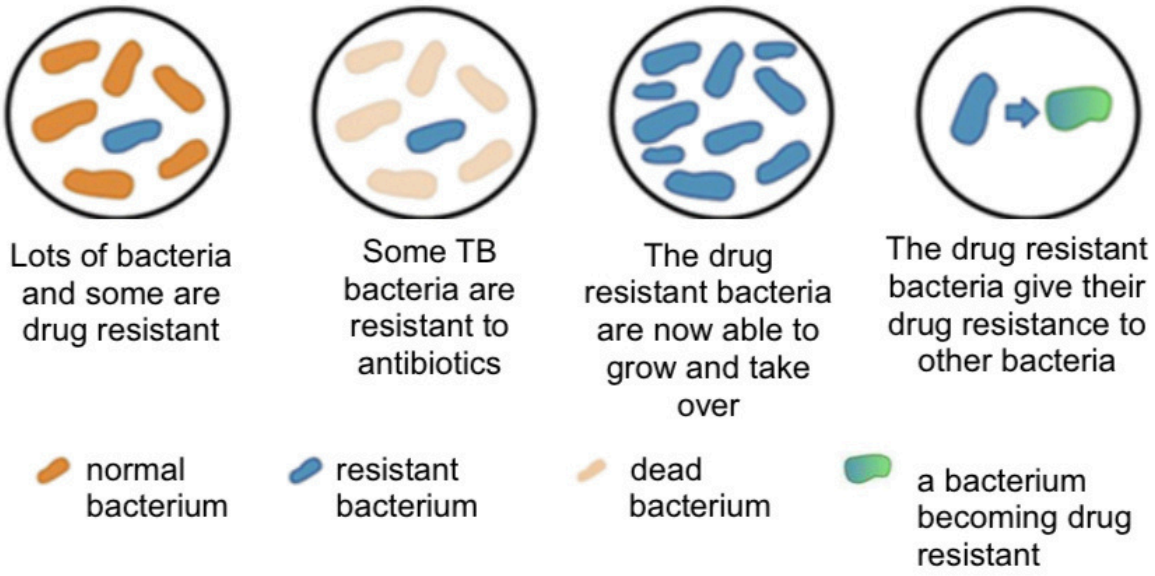
# Evolution

## By natural selection

## Evolution in present times

Pathogens (viruses and bacteria) evolve quickly because there is lots of natural variation amongst them and the fact that mutations occur most often in rapidly reproducing organisms.

### Resistance to Antibiotics – TB




Patients need to complete full course of their treatment, otherwise the bacterium may develop resistance and they may end up sick again.

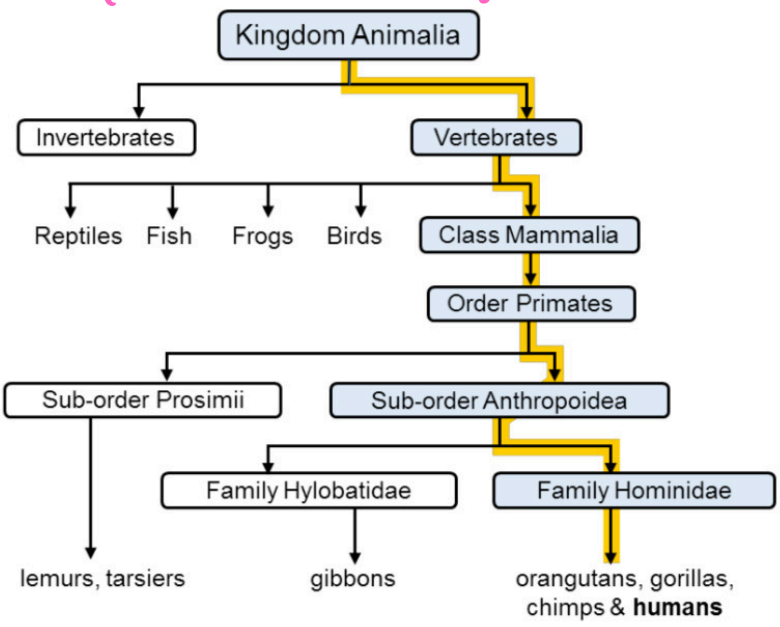
Study copy distributed by EduResource ZA | eduresourcza.com

# Evolution

## Human evolution

## Key concepts

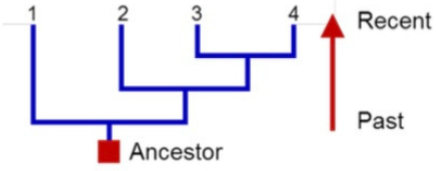
- Interpretation of a phylogenetic tree
characteristics that humans share with African apes
- differences of humans from the apes / other primates.
- Fossil, genetic and cultural evidence that support the idea of common ancestors for living hominids
- The 'Out of Africa' hypothesis
- Importance of the Cradle of Humankind (and that of other fossil sites in South Africa and Africa)
- Alternatives to evolution.

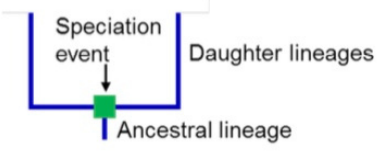



A **Phylogenetic tree** evolutionary relationships of ancestral species and their descendants

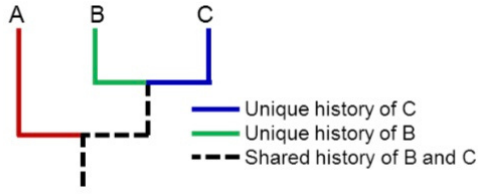
## Phylogenetic tree interpretation

The root of the phylogenetic diagram represents the ancestor, and the tips of the branches, the descendants of that ancestor (see below, left). To move upwards is to move forward in time.




Speciation is represented as a branching of the tree, as a single ancestral lineage gives rise to two or more daughter lines.
Each lineage has a part of its history that is unique and parts that are shared with other lineages




And each lineage has ancestors that are unique to that lineage and common ancestors that are shared with other lineages

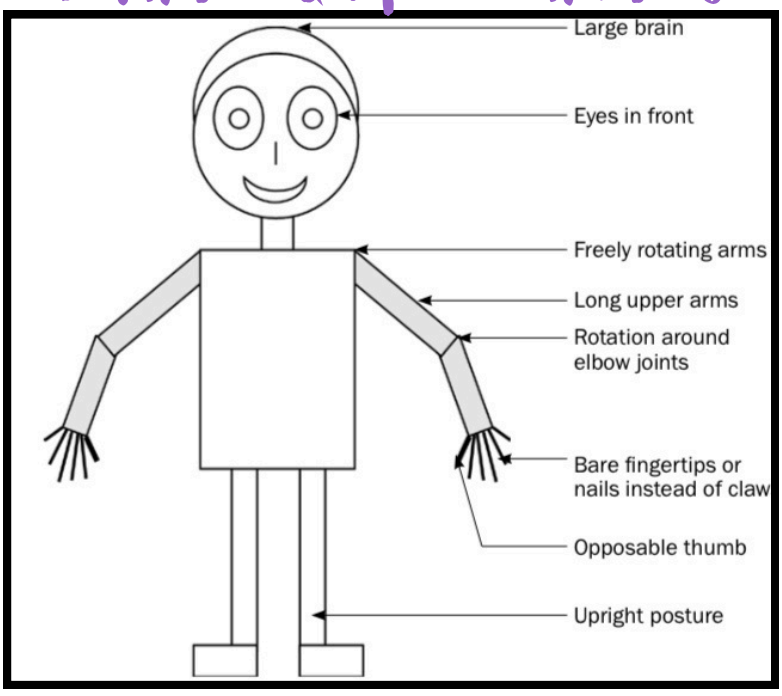
Belonging to the same Family Hominidae suggests that humans, chimpanzees, gorillas and orangutans share a common ancestor.

Study copy distributed by EduResource ZA | eduresourcza.com

# Evolution

## Human evolution

## Humans & Apes similarities




- **Large brains**: to process and store information.
- **Two eyes in the front** of the head: for good binocular vision.
- The **eyes have cones** : for colour vision & greater clarity.
- **Freely rotating arms**: arms can be lifted above the head to swing from branch to branch, or to pick fruit hanging relatively high above the ground.
- **Long upper arms**: apes are normally quadrupeds. Longer front limbs also make it easier to grasp and swing from branches.
- **Rotation around elbow joints**: this allows the limb to extend or flex to grasp and reach for objects. It also enables the flexing and rotation of the wrists.

- **Bare fingertips** or **nails instead of claws**: Protect sensitive these pads.
- **Opposable thumb**: Enables the hand to grip an object.
- **Upright posture**: Enables them to stand erect (upright) and use their hands for grasping; it also gives a better view of surroundings; give exposure of genitals to attract the opposite sex
- **Sexual dimorphism**: differences between males and females of the same species. Humans and apes are sexually dimorphic. This is linked to competition.

## Humans & Apes Differences

| Feature | Humans (*Homo sapiens*) | African apes |
|---|---|---|
| cranium | large cranium / brain | small cranium / brain |
| brow ridges | not well developed | well developed, prominent |
| spine | more curved (S-shaped) | less curved (C-shaped) |
| pelvic girdle | short and wide | long and narrow |
| canines | small | large |
| arrangement of teeth | small gaps between teeth | big gaps between teeth |
| palate shape | small, semi-circular | long, rectangular |
| jaws | small, less prognathous | large, more prognathous |
| cranial ridges | none | across top of cranium |
| foramen magnum | in a forward position | in a backward position |

Hominin- Hunan
Hominid - African ape

Study copy distributed by EduResource ZA | eduresourcza.com

# Evolution

## Major phases

## Human evolution

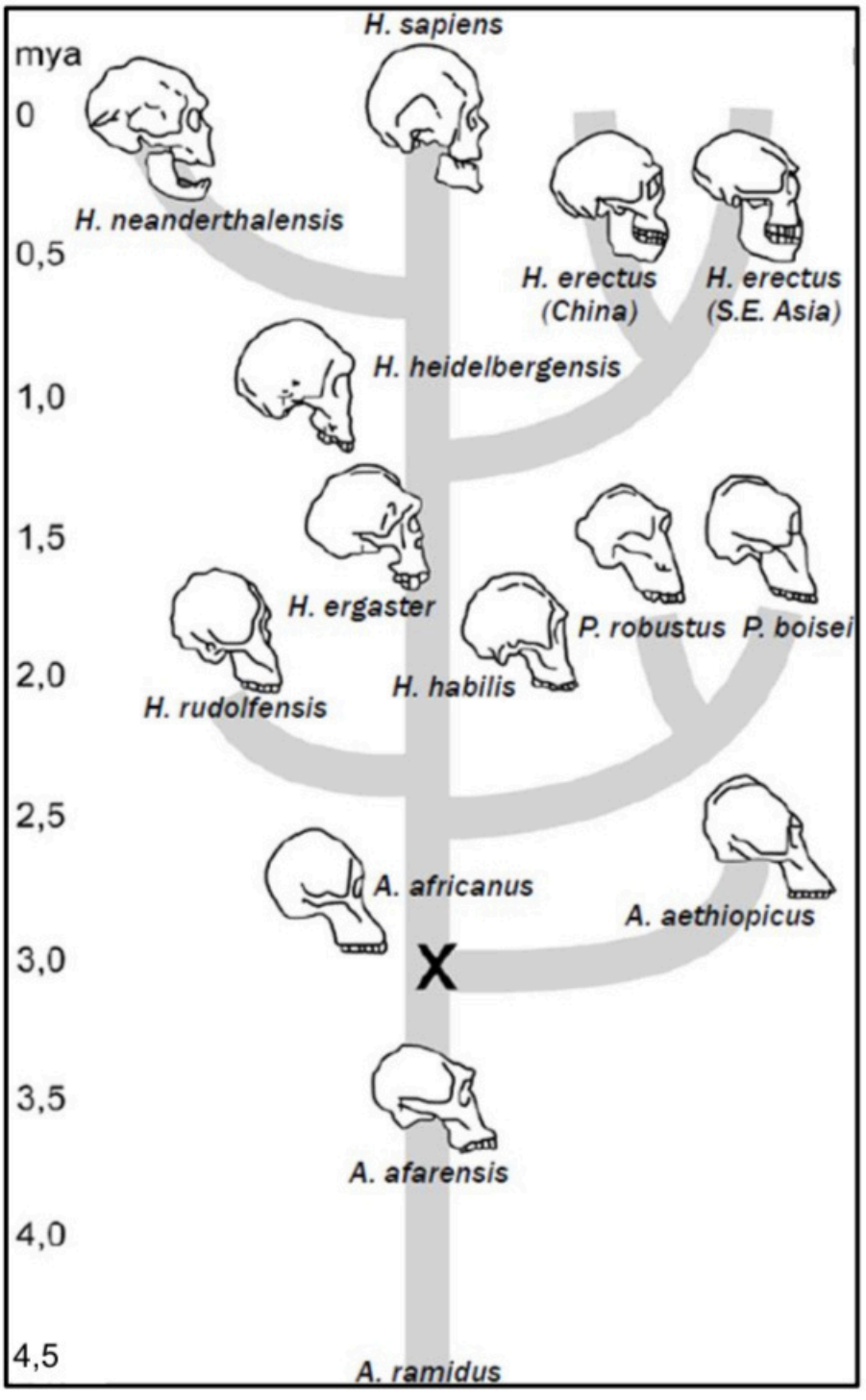
| Organism | When organism existed | Fossil site | Discovered by | Characteristics |
|---|---|---|---|---|
| *Ardipithecus ramidus* | 5 – 4 mya | North-East Ethiopia | Tim White | Brain size: 300–350 ml<br>Forward position of foramen magnum<br>Very prognathous (more protruding jaws)<br>Heavy brow ridges<br>Pelvis structure: bipedal and tree climbing |
| *Australopithecus afarensis* | 4 – 2,7 mya | Ethiopia, Kenya, Tanzania | Donald Johanson | Brain size: 375–550 ml<br>Forward position of foramen magnum<br>Very prognathous<br>Heavy brow ridges<br>Canines large and pointed<br>Long arms<br>No cranial ridge |
| *Australopithecus africanus* | 3 – 2 mya | Taung; Sterkfontein | Raymond Dart | Brain size: 428–625 ml<br>Forward position of foramen magnum<br>Prognathous<br>Brow ridges<br>Teeth large, canines not long<br>Long arms<br>No cranial ridge |
| *Australopithecus sediba* | 1,9 – 1,8 mya | Malapa Cave – in the cradle of humankind | Lee Burger | Brain size: 420 ml<br>Less prognathous<br>Brow ridges<br>Large teeth, canines not long<br>Long arms<br>No cranial ridge |
| *Homo habilis* | 2,2 – 1,6 mya | Tanzania | Louis and Mary Leakey | Brain size: 650 ml<br>Less prognathous<br>Less pronounced brow ridges<br>Human-like teeth – smaller canines<br>Long arms |
| *Homo erectus* | 2 – 0,4 mya | Java in Indonesia and then Swartkrans | Eugene Dubois | Brain size: 900 ml<br>Prognathous<br>Cranial ridges<br>Short canines<br>Longer legs and shorter arms |
| *Homo sapiens* | 200 000 years ago – present | Makapansgat in Limpopo; Border Cave in KZN; Blombos Cave in the Western Cape | Tim White | Brain size: 1200–1800 ml<br>No brow ridges<br>Small teeth<br>Short arms |

Study copy distributed by EduResource ZA | eduresourcza.com

# Evolution

## Human evolution

### Phylogenetic tree – evolution of humans



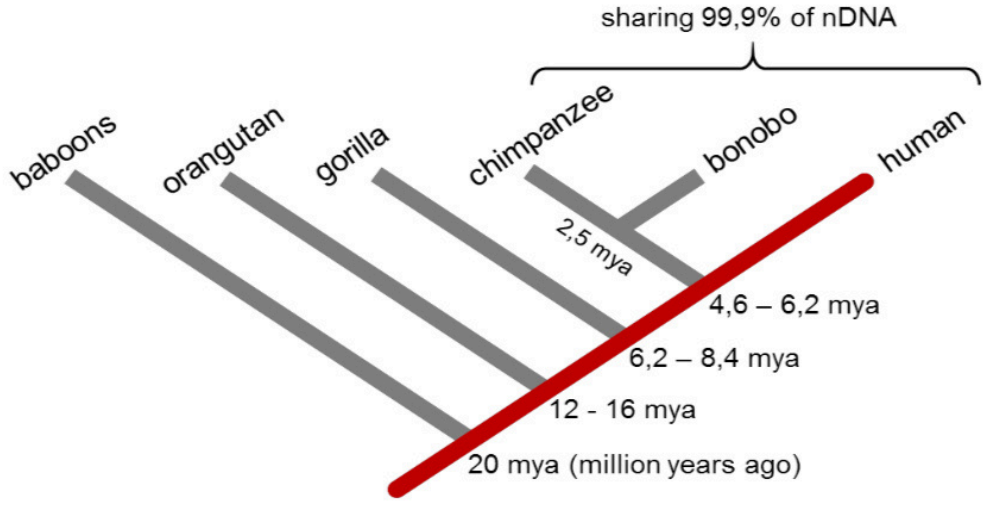

Study copy distributed by EduResource ZA | eduresourcza.com

# Human Evolution

## Evidence of common ancestry

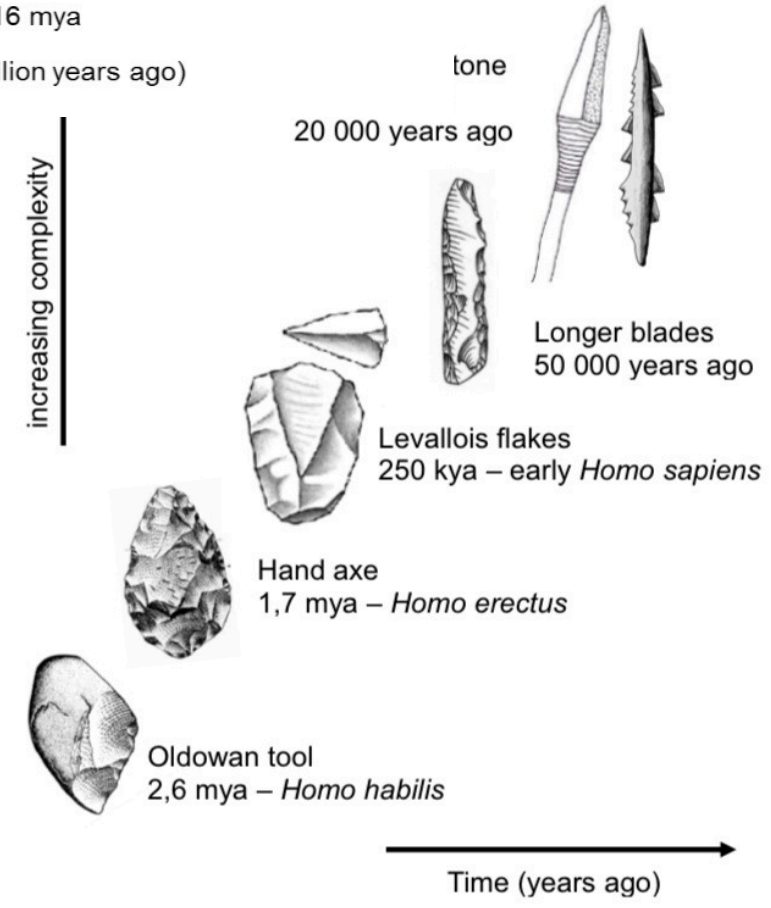
### Genetic evidence

Studies show that, of the African apes, the chimpanzee is the closest relative of humans. Chimps and humans share 98,8% of the same genes – there is a 1,2% difference (10 – 12 times larger than the difference between humans).
The analysis of mitochondrial DNA (mtDNA) and the differences that exist between the mtDNA of two different species enables scientist to determine how long ago the species separated.




### Cultural evidence

- Oldowan tool culture
- Hand axes
- Flakes
- cooking with fire
- cave painting




Study copy distributed by EduResource ZA | eduresourcza.com

# Human Evolution
## Out of Africa Hypothesis

The '**Out of Africa**' hypothesis states that all modern humans originated in Africa, and then migrated out of Africa to the rest of the world.

Supported by:
- Genetic evidence
- Fossil evidence

## Genetic evidence

Using MtDNA- scientists conclude that:
- African populations of Homo sapiens have the greatest number of mtDNA markers and are thus the oldest.
- The most recent common ancestor whose genetic marker is found in all living humans, must have lived in eastern Africa approximately 150 000 years ago.

## Fossil evidence

- Fossils from the earliest hominin species, Ardipithecines and Australopi- thecines, have been found only in Africa and not anywhere else.
- Fossils for the earliest species of the genus Homo, Homo habilis, have also only been found in Africa.
- Fossil evidence for Homo erectus indicates this species lived in eastern and southern Africa between 1,9 – 1,4 million years ago. The earliest finds in Africa are the oldest fossils of Homo erectus discovered anywhere in the world.
- Finally, Homo sapiens emerged in Africa. The oldest Homo sapiens fossils were discovered in 2005 near Ethiopia's Omo River and are dated to between 195 000 and 160 000 years ago.

## Fossil sites in SA

**Sterkfontein**
- Robert Broom discovered Mrs Ples
- Ron Clarke, working with Stephen Motsumi and Nkwane Molefe, discovered Little Foot

**Malapa**
- Karabo (*Homo sediba*), dated 2 mya – a transitional species linking A. afarensis and the earliest form of the genus Homo.

## Importance of cradle of humankind

- The first adult skull was found at Sterkfontein.
- Little foot was found at Sterkfontein
- The first fossils of *Homo erectus* were found by Robert Broom at Swartkrans.

## Other fossil sites

- Taung (North-West Province): Taung child discovered here. It was the first ever specimen of *Australopithecus africanus*
- Louis and Mary Leakey discovered fossils of *Homo habilis* in Tanzania
- Donald Johansen discovered the first specimen of the species *Australopithecus afarensis* at Hadar, Ethiopia

Study copy distributed by EduResource ZA | eduresourcza.com

# Evolution Terminology

| Biological term | Description |
|---|---|
| Anthropology | The study of humans, including the different belief systems, customs and social habits. |
| *Australopithecus* | The genus of the fossil 'Little Foot' |
| Biogeography | The distribution of species in different parts of the world |
| Biological evolution | Any genetic change in a population that is inherited over several generations. These changes may be small or large, noticeable or not so noticeable. |
| Bipedalism | The ability of an organism to walk on two limbs |
| Extinction | The permanent disappearance of a species from earth |
| Foramen magnum | The opening at the base of the skull through which the spinal cord enters |
| Fossils | The mineralised remains of organisms that have lived in the past |
| Hominidae/Hominids | The family to which humans belong |
| *Homo habilis* | The first *Homo* species to use tools |
| Homologous structures | Similar structures on different organisms that suggest they have a common ancestor |
| Hypothesis | A tentative explanation of a phenomenon that can be tested and may be accepted or rejected |
| Natural selection | The process by which organisms best suited to survival in the environment achieve greater reproductive success, thereby passing advantageous characteristics onto future generations |
| Out of Africa hypothesis | The hypothesis that states that modern humans/*Homo sapiens* originated in Africa and migrated to other parts of the world |
| Palaeontology | Study of fossils |
| Phylogenetic tree/cladogram | A diagrammatic representation showing possible evolutionary relationships among different species |
| Population | A group of organisms of the same species living in the same habitat at the same time |
| Punctuated equilibrium | Type of evolution involving long periods of time when species do not change and short periods of rapid change |
| Quadrupedal | The ability of an organism to walk on four limbs |
| Speciation | Process whereby new species are formed from the original population |
| Species | A group of organisms which can interbreed to produce fertile offspring |
| Theory | Explanation of an observation that is supported by facts, models and laws |

Study copy distributed by EduResource ZA | eduresourcza.com