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LIFE SCIENCES

LAST PUSH 2017

EVOLUTION

Evolution

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Foreword

The purpose of this manual is to assist grade 12 learners in preparation for 2017 end of year examination.

The activities in this document are meant to be a guide and not to replace any study material/ text book.

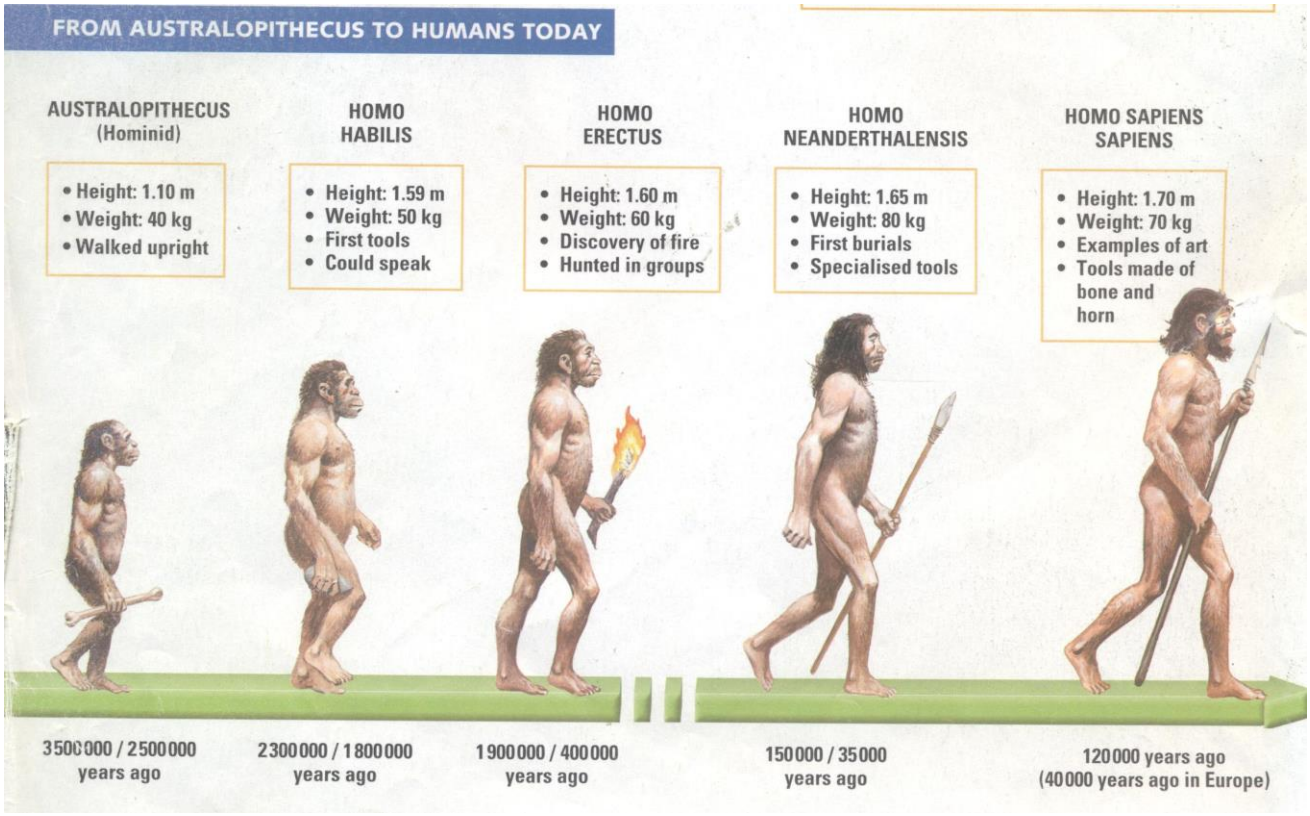
It aims to assist learners with practice model activities.
The manual focuses on selected challenging content of evolution informed by experience of dedicated subject advisors and diagnostic report

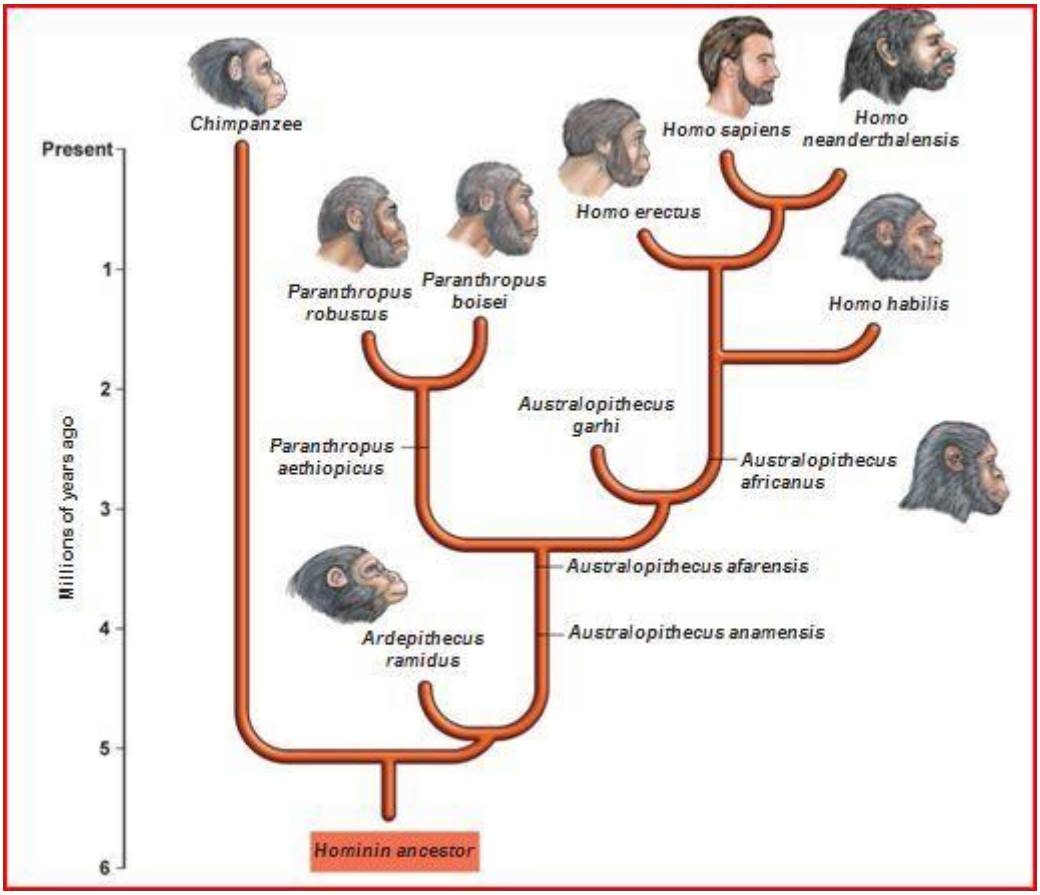
This manual is distributed free of charge, as a learning support material to all Life Sciences teachers and learners in Mpumalanga province and it is fully funded by Mpumalanga Department of Education

The materials are compiled from different sources. We hope that the guide will serve as a valuable and helpful resource for both learners and teachers.

Well wishes to class of 2017.

Evolution


FROM AUSTRALOPITHECUS TO HUMANS TODAY
AUSTRALOPITHECUS (Hominid)
• Height: 1.10 m
• Weight: 40 kg
• Walked upright
HOMO HABILIS
• Height: 1.59 m
• Weight: 50 kg
• First tools
• Could speak
HOMO ERECTUS
• Height: 1.60 m
• Weight: 60 kg
• Discovery of fire
• Hunted in groups
HOMO NEANDERTHALENSIS
• Height: 1.65 m
• Weight: 80 kg
• First burials
• Specialised tools
HOMO SAPIENS SAPIENS
• Height: 1.70 m
• Weight: 70 kg
• Examples of art
• Tools made of bone and horn
3500000 / 2500000 years ago
2300000 / 1800000 years ago
1900000 / 400000 years ago
150000 / 35000 years ago
120000 years ago (40000 years ago in Europe)


Chimpanzee
Homo sapiens
Homo neanderthalensis
Present
Homo erectus
Paranthropus robustus
Paranthropus boisei
Homo habilis
1
2
Australopithecus garhi
Paranthropus aethiopicus
Australopithecus africanus
Millions of years ago
3
Australopithecus afarensis
4
Ardepithecus ramidus
Australopithecus anamensis
5
Hominin ancestor
6

EVOLUTION Paper 2: 66 marks	**Terms 3/4**	**6 weeks**

CONTENT	ELABORATION
Introduction	❑ Definition of biological evolution ❑ Difference between a hypothesis and a theory ❑ The Theory of Evolution is regarded as a scientific theory since various hypotheses relating to evolution have been tested and verified over time
Evidence for evolution	❑ Role of the following as evidence for evolution: • Fossil record – Link to Grade 10 • Biogeography – Link to Grade 10 • Modification by descent (homologous structures) • Genetics
Variation	❑ Definition of a biological species and a population ❑ A review of the contribution of each of the following to variation that exists amongst individuals of the same species: • Meiosis - Crossing over - Random arrangement of chromosomes • Mutations • Random fertilisation • Random mating ❑ Continuous and discontinuous variation
Origin of an idea about origins (a historical development)	❑ Ideas on evolution in the order of their origin are as follows: • Lamarckism • Darwinism • Punctuated Equilibrium
Lamarckism (Jean Baptiste de Lamarck – 1744–1829)	❑ Lamarck used two 'laws' to explain evolution: • 'Law' of use and disuse • 'Law' of the inheritance of acquired characteristics ❑ Reasons for Lamarck's theory being rejected

CONTENT	ELABORATION
Darwinism (Charles Darwin – 1809–1882)	❑ Darwin's theory of evolution by natural selection: • Organisms produce a large number of offspring. • There is a great deal of variation amongst the offspring. • Some have favourable characteristics and some do not. • When there is a change in the environmental conditions or if there is competition, • then organisms with characteristics, which make them more suited, survive • whilst organisms with unfavourable characteristics, which make them less suited, die. • The organisms that survive, reproduce • and thus pass on the allele for the favourable characteristic to their offspring. • The next generation will therefore have a higher proportion of individuals with the favourable characteristic. • In this way, the characteristics of a population gradually change over a long period of time.
Punctuated Equilibrium (Eldredge and Gould – 1972)	❑ Punctuated Equilibrium explains the speed at which evolution takes place: • Evolution involves long periods of time where species do not change or change gradually through natural selection (known as equilibrium). • This alternates with (is punctuated by) short periods of time where rapid changes occur through natural selection • during which new species may form in a short period of time.
Artificial selection	❑ Artificial selection involving: • A domesticated animal species • A crop species
Formation of new species	❑ Biological species concept: similar organisms that are capable of interbreeding to produce fertile offspring ❑ Speciation and extinction and the effect of each on biodiversity ❑ Speciation through geographic isolation: • If a population of a single species • becomes separated by a geographical barrier (sea, river, mountain, lake) • then the population splits into two. • There is now no gene flow between the two populations. • Since each population may be exposed to different environmental conditions/the selection pressure may be different • natural selection occurs independently in each of the two populations • such that the individuals of the two populations become very different from each other • genotypically and phenotypically. • Even if the two populations were to mix again • they will not be able to interbreed. • The two populations are now different species. ❑ Speciation through geographic isolation in ONE of the following: • Galapagos finches • Galapagos tortoises • Plants on different land masses (linked to continental drift) - Baobabs in Africa and Madagascar - Proteas in South Africa and Australia • Any example of mammals on different land masses
Mechanisms of reproductive isolation (Keeping species separate)	❑ A brief outline of reproductive isolation mechanisms that help to keep species separate: • Breeding at different times of the year • Species-specific courtship behaviour • Adaptation to different pollinators • Infertile offspring • Prevention of fertilisation

CONTENT	ELABORATION
Evolution in present times	❑ Any ONE example of natural selection and evolution in present times: • Use of insecticides and consequent resistance to insecticides in insects • Development of resistant strains of tuberculosis-causing bacteria (MDR and XDR) to antibiotics, due to mutations (variations) in bacteria and failure to complete antibiotic courses • HIV resistance to antiretroviral medication • Bill (beak) and body size of Galapagos finches
Evidence of common ancestors for living hominids, including humans	❑ Interpretation of a phylogenetic tree to show the place of the family Hominidae in the animal kingdom ❑ Characteristics that humans share with African apes ❑ Anatomical differences between African apes and humans, with the aid of diagrams, as it applies to the following characteristics: • Bipedalism (foramen magnum, spine and pelvic girdle) • Brain size • Teeth (dentition) • Prognathism • Palate shape • Cranial ridges • Brow ridges ❑ Lines of evidence that support the idea of common ancestors for living hominids including humans: • Fossil evidence: Evidence from fossils of different ages show that the anatomical characteristics of organisms changed gradually over time. • Emphasis on evolutionary trends provided by the anatomical features of fossils of the following three genera: - *Ardipithecus* - *Australopithecus* - *Homo* as well as: - The age of each fossil found/time-line for the existence of the three genera - The fossil sites where they were found: emphasis on the fossil sites that form a part of the Cradle of Humankind - The scientists who discovered them • Genetic evidence: mitochondrial DNA • Cultural evidence: tool-making
Out of Africa hypothesis	❑ Evidence for the Out of Africa hypothesis: • Fossil evidence: information on each of the following fossils that serve as evidence for the Out of Africa hypothesis: - *Ardipithecus* (fossils found in Africa only) - *Australopithecus* (fossils found in Africa only, including Karabo, Littlefoot, Taung Child, Mrs Ples) - *Homo* (fossils of *Homo habilis* found in Africa only; oldest fossils of *Homo erectus* found in Africa, while the younger fossils were found in other parts of the world) • Genetic evidence: mitochondrial DNA ❑ Timeline for the existence of different species of the genus *Homo* and the significant features of each type of fossil to illustrate the differences amongst them ❑ Interpretation of phylogenetic trees proposed by different scientists showing possible evolutionary relationships as it applies to hominid evolution

TERMS and DEFINITIONS

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.
Hypothesis:	a **suggested** explanation for an observable phenomenon or proposal that *predicts* a possible outcome.
Theory:	an explanation for something which is **reasonable** or *scientifically acceptable*, but which has not yet been proved to be true.
Theory of evolution:	is regarded as a scientific theory since various hypotheses relating to evolution, have been tested and verified over time.
Micro-evolution:	**small** changes that take place **within a species** to adapt to survive.
Macro-evolution:	**large** changes in **many species** that take place over a **long period** of time.
Fossil:	the **imprint, traces or preserved remains** of an organism that once lived. A fossil may be plant and animal body parts as well as impressions in rocks or traces left by the organisms.
Fossilisation:	the process that took place to produce the fossil over a period of time.
Anthropology:	the study of the human race, including the different belief systems, customs and social habits.
Palaeontology:	the study of the earliest known periods of human existence, e.g.: the Stone Age.
Archaeology:	the study of ancient times by examining the buried remains of buildings, tools, animal and plant fossil remains found in rock strata.
Archaeologist:	a scientist that digs up, studies and traces fossil remains in rock strata. Archaeologists use carbon dating to determine when the animals and plants lived.
Biodiversity:	the variety of different plant and animal species found on earth where diversity is the **result** of change over time.
Natural selection:	is the **process** of change over time, that takes place in species.
Species:	a group of organisms that are **similar in appearance**, share the **same DNA sequences**, perform the **same mating rituals** and **interbreed** to produce viable offspring.
Population:	a group of organisms of different ages, that belong to the **same species**, live in the **same area** and **interbreed**.
Variation:	small changes that will assist an organism where phenotypic variation (physical appearance) is as a direct result of genetic variation.
Continuous variation:	the variation of a trait in a population, where the trait

	ranges continuously from one extreme to another **preventing** the subdivision into distinct classes.
Discontinuous variation:	the variation of a trait in a population that can be ascribed to two or more **distinct forms.**
Artificial selection:	the selective breeding of plants and animals where specific traits are modified, to satisfy human needs.
Speciation:	the evolutionary process by which new biological species arise, due to the splitting of the lineage.
Genetic diversity:	is the level of biodiversity and refers to the total number of genetic characteristics in the genetic makeup of a species.
Genetic divergence:	the process of one species diverging over time, into two or more species where genetic characteristics are passed from one generation to the next. The sequence of the genes as they appear on the DNA that will differ from species to species, so when the genetics are altered, **divergence** takes place.
Extinction:	all the individuals of a species die and are eliminated permanently because they are unable to adapt to survive.

Evidence that Evolution has occurred:

Theories of human evolution are based on research and scientific evidence that support the concept of **continual change.** Sources like geology, anatomy, embryology, genetics and physiology have been used as explanations for the theories. Further lines of evidence are fossil records, modification of descent, Biogeography and genetics.

a) Fossil evidence: The evidence that shows characteristics that make us similar to or different from African apes comes largely from a study of fossils (thousands of fossil fragments). The first record of living material preserved as a **fossil,** is from the **Palaeozoic era** (540 million years ago).

b) Genetic evidence: Scientists state that organisms are closely related and are likely to have a common ancestor if they have:

- Identical DNA structure
- Similar sequence of genes and
- Similar portions of DNA with no functions

Species that are closely related have a greater similarity to each other than distant species.

c) Modifications by descent: modifications obtained from the study of the details of the structures of body parts and systems of organisms that belong to a specific phylum.

- **Homologous organs:** (homo = the same) similarity of the formation of a body part or organ due to a **common** evolutionary origin, e.g.: the structure of the

pentadactyl limb in seals, bats and humans. The bones, muscles and nerves are arranged in a **similar** manner in a front paw, wing and arm.

d) Cultural evidence: Cultural evidence from studies of tools and weapons, as well as language is also used to show similarities and differences between humans and African apes.

e) Biogeography: Biogeography is the study of the distributions of organisms in space and time. It can be studied with a focus on ecological factors that shape the distribution of organisms, or with a focus on the historical factors that have shaped the current distributions

VARIATION

Sources of variation

The genotypes and therefore phenotypes (appearance) of individuals are different from each other because:

a) **Crossing over** in Prophase I of meiosis involves an exchange of genetic material, leading to new combinations of maternal and paternal genetic material in each new cell resulting from meiosis
b) **Random arrangement of maternal and paternal chromosomes** at the equator during metaphase allows different combinations of chromosomes/chromatids to go into each new cell resulting from meiosis making them different
c) **Chance/ Random fertilisation** between different egg cells and different sperm cells formed by meiosis result in offspring that are different from each other
d) **Random mating** between organisms within a species lead to a different set of offspring from each mating pair
e) **Mutation** changes the structure of a gene and therefore the organisms genotype. Since the genotype influences the phenotype, it creates organisms with new, different characteristics from one generation to the next.

CONTINUOUS AND DISCONTINUOUS VARIATION

Continuous variation: Variation within a population in which a graded series of intermediate phenotypes falls between the extremes. Height in human beings, for example, exists in **continuous variation**

Discontinuous variation: This is where individuals fall into a number of distinct **classes** or categories, and is based on features that cannot be measured across a complete range. You either **have** the characteristic or you **don't**. Blood groups are a good example: you are either one blood group or another - you can't be in between.

ideas about origins:

Lamarckism **Jean Batiste de Lamarck** **(1744 to 1829)**	***Darwinism*** **Charles Darwin** **(1809 to 1888)**	***Punctuated Equilibrium*** (Theory proposed by Mayr in 1954 and recognised in 1972 after a paper was submitted by Eldredge and Gould)
De Lamarck suggested two main themes: 1. '**Use and disuse'**: the environment gives rise to changes in animals e.g.: blindness in moles, the presence of teeth in mammals, the absence of teeth in birds and **vestigial organs** (reduced pelvic structures present in a whale skeleton). 2. '**Inheritance of acquired characteristics**' that caused **change** in organisms de Lamarck used the giraffe to explain his theory - as the giraffe stretched its neck to reach higher leaves, it's neck stretched and grew longer with each generation. Lamarck's theories are based on his belief that there are two forces he saw as comprising evolution; • a force driving animals from simple to complex forms, and • a force adapting animals	Charles Darwin wrote *On the Origin of Species*, published in 1859. Here he concludes that organisms have **evolved by small, gradual changes** that took place over many successive generations. Darwin was influenced by the writings of Alfred Wallace and stated that the present species are **modified descendants** from the species of the past, i.e.: one common ancestor. Evolution can be explained as the **constant change** that has taken place. Darwin's book was the first theory about evolution to be published. His theory was supported by scientific evidence and was regarded as **credible**. The **process** of change was called **natural selection**. The **long-term** changes in the species were called **evolution**.	Punctuated Equilibrium explains the speed at which evolution takes place. • Evolution involves long periods of time where species do not change or change gradually through natural selection (known as equilibrium). • This alternates with (is punctuated by) short periods of time where rapid changes occur through natural selection. • During which new species may form in a short period of time.

to their local environments thereby differentiating them from each other. **Reason for theory being rejected:** It is agreed that **physically** stretching the neck cannot alter the **gene make-up** of the animal. Only the genetics of the organism can cause a physical change.	The result of this change over time results in **Diversity.**	

Observations upon which Darwin based his theory:

- Organisms of a species produce a large number of offspring.
- The offspring shoe a great deal of variation.
- Of the large number of offspring produced, only a few survive.
- Characteristics are inherited from the surviving parents to the offspring.

Darwin's theory of evolution by natural selection:

- Organisms produce a large number of offspring.
- There is a great deal of variation amongst the offspring.
- Some have favourable characteristics and some do not.
- When there is a change in the environmental conditions or if there is competition,
- the organisms with characteristics that make them more suited, will survive.
- While organisms with characteristics that make them less suited, will die.
- The organisms that survive, will be able to reproduce,
- thus they will pass the allele for the favourable characteristics on to their offspring.
- The next generation will therefore have a higher proportion of individuals with the favourable characteristics.
- In this way the characteristics of a population gradually change over a long period of time.

The **variation** between individuals is due to differences in **genes.** Only individuals who have characteristics that are adapted to the environment will survive. They reproduce and **pass the suitable** characteristics to the next generation by **natural selection** and so, **evolution** results. If the characteristics are not suitable for

survival, the organism cannot adapt and will die leading to eventual **extinction** of the species. **Conservation** is a process to ensure that biodiversity is maintained so that populations do not become extinct.

Artificial selection in plants and animals

Artificial selection is the selective breeding of plants and animals, where specific traits are modified, to satisfy human needs. Humans have conducted experiments to develop organisms with selected and desirable characteristics, like cattle that produce better quality and quantity meat and milk, drought resistant wheat and sugar cane with more sugar etc.

This is an **evolutionary mechanism** that results in:

- **new breeds** (animals)
- **new strains** (micro-organisms) and
- **new varieties** (plants).

New varieties of plants and animal breeds are produced relatively quickly by selecting parent organisms with the **desired traits**. The commercially viable organism would be homozygous for all the genes involved, whether dominant or recessive, for their desired trait.

Animals

	Inbreeding	**Outbreeding**
What is it?	**Inbreeding** is the mating or breeding of two **genetically related** individuals to enhance the desirable traits.	**Outbreeding** is the mating of individuals of totally **unrelated strains**. This leads to offspring that are better adapted for survival, than either of the parents. This phenomenon is termed **hybrid vigour**.
Examples:	• thorough bred racing and show jumping horses • milk producing cows • many varieties of dog breeds • sheep with better quality and quantity of wool production	• mongrel dogs are crossed from two different dog sub-species and are far stronger and hardier than highly pedigreed purebreds. • mules are a cross between a horse and a donkey and are much stronger and better suited to many more tasks than either parent.
Advantages:	Desirable traits are enhanced in the species without	When sub-species are crossed, a stronger more resilient breed

	contamination from other species, resulting is a very pure breed. Animals with undesirable or weak traits should be culled.	results since desirable traits are bred into the species.
Disadvantages:	The gene pool becomes restricted. The strain may become **homozygous** for multiple defective traits: • certain dog breeds like German shepherds are vulnerable to hip dysplasia (weak hips) and congenital femur dislocation • fighting dogs like the South African Boerboel often become very aggressive and go mad as adults resulting in them having to be put to sleep.	In some cases of cross species breeding, the hybrid may not be able to reproduce, because chromosomes cannot form homologous pairs during meiosis. This will result in **hybrid sterility**, e.g.: mules are unable to breed.

Plants: Artificial selection in plants is the **deliberate altering** of the genetic make-up. The interbreeding of desired traits continues until a new variety is produced. **Homologous recombination** of the chromosomes is used to generate genetic diversity. **Cross-pollination** between varieties would be part of the process. For example, fast growing wheat may be crossed with high-yielding but slow growing wheat. The offspring will be crossed again until a new species result that is fast growing and high yielding. Refer to Mendel's tall and short varieties of pea plants. Plant breeding and genetic engineering is used to produce crops that are high-yielding, fast growing, pest and disease resistant, drought resistant, frost resistant and require less water.

Similarities between natural selection and artificial selection (Not in Exam Guideline but can be asked):

- Organisms with the desirable traits survive and pass these traits on to their offspring
- Organisms that are weak or with the undesirable traits do not survive
- Hybrids are often sterile e.g.: mules, seedless fruit etc.

Differences between natural selection and artificial selection (Not in Exam Guideline but can be asked:

Natural Selection	Artificial Selection
The environment or nature is the selective force	Humans are the selective force
Selection is in response to suitability to the environment	Selection is in response to satisfying human needs
It occurs within a species	May involve 1 or more species e.g.: cross breeding different traits in each species

Formation of new species

Speciation results because of:

- If a population of a single species
- Becomes separated by a **geographical barrier** (sea, river, mountain, lake)
- Then the population splits into two populations.
- There is now no gene flow through the two populations.
- Since each population may be exposed to different environmental conditions/the selection pressure may be different,
- Natural selection occurs independently in each of the two populations
- So that the individuals of the two populations become very different from each other
- Genotypically (their genes are different) and phenotypically (their physical appearance)
- Even if the two populations were to mix again,
- They will not be able to interbreed
- The two populations are now different species.

Keeping species separate:

When one species gives rise to two new species (speciation), the two new species cannot reproduce with each other if they mix. They remain as separate species due to mechanisms that restrict gene flow between them. This is termed r**eproductive isolation** and result because of:

- **Seasonal isolation:** when breeding/reproduction takes place at **different times** of the season or year. In plants, anthers and stigma mature at different times, to prevent cross-pollination.
- **Behavioural isolation:** animals behave differently during **courting and mating** rituals - females are not responsive, so no mating takes place.
- **Mechanical isolation:** when male and female **reproductive parts change**, making gene transfer impossible. In flowers, the stigma normally releases enzymes to stimulate the growth of the pollen tube. In this case, the enzyme will not stimulate growth, so pollen grain will not grow. In animals, the genitals

change so the sperm cannot be transferred into the female, should mating be attempted.

- **Gamete isolation:** when genes change, gametes become chemically altered, so fusion of the gametes is impossible. Should the gametes fuse, gamete isolation will prevent the recycling of the genetic material, e.g.: donkey + horse = **infertile offspring** called a mule.

Evolution in present times:

Natural selection and evolution are still taking place in present times.

- **DDT (d**ichloro-**d**iphenyl-**t**richloroethane)
  Many years ago, mosquito breeding areas were sprayed with an insecticide called DDT to prevent malaria by killing the mosquito larvae and were initially very effective. However, some insects with mutations in their **sodium channel gene** were resistant to DDT and with breeding took about 7 years for DDT to lose its effectiveness. The genetic trait that caused the resistance to DDT was **homozygous recessive** and eventually resulted in the evolution of the mosquito into a new DDT resistant species. However, the impact of DDT on the environment continues because it is non-biodegradable and toxic. DDT was washed from the soil and leached into underground water and eventually the sea. The weak solution of DDT was absorbed by micro-organisms and through the food chain link, the **concentration increased** and resulted in **bio-accumulation**. Cancer and many other diseases may result in humans. In animals and birds, the **toxin accumulation** results in uncharacteristic behaviour, egg-shell thinning and death. In 1972, the use of DDT was officially banned worldwide.

- **Resistant strains of TB**
  Tuberculosis is caused by a bacterium called *Mycobacterium tuberculosis* that attacks the lungs, kidneys and bones. Symptoms would include chest pains, fever, coughing, weight loss and shortness of breath. Eventually, mucus and pus block the alveoli causing them to burst, resulting in the person coughing infected spray droplets of blood. Loss of alveoli causes lack of oxygen, resulting in physical weakness. TB is also transmitted in infected milk. The TB bacteria are destroyed when exposed to sunlight and infected people should be isolated and treated with **antibiotics** for a minimum of six months. Children are immunised with inoculations at the local clinics. The TB bacteria have evolved into **'multi-drug resistant strains'** (MDR-TB), where normal drugs are ineffective. In 2006, **'extensively drug-resistant tuberculosis'** (XDR-TB) was identified. MDR-TB tends to develop when patients miss doses of antibiotics or do not complete the full treatment. This strain seems less virulent and does not appear to dominate naturally. But XDR-TB has a much higher mortality rate than MDR-TB and does not seem to transmit in healthy populations but appears to be more prevalent in individuals who are **HIV positive**. With the XDR-TB strain, from onset of the disease to death takes approximately 15 to 20 days as this strain does not respond to any of the drugs presently available in South Africa.

Human evolution

Evidence of common ancestors for living hominids, including humans

The term '*Homo*' refers to the genus and means 'human'. Studies of human evolution must include hominids such as the Australopithecines, as it is theorized that the *Homo* genus diverged (split) from them about four million years ago in Africa. Scientists have estimated that humans branched from their common ancestor with the chimpanzee about five to six million years ago. Other species of *Homo* like *Homo erectus* and *Homo neanderthalensis* have all become extinct. Substantial fossil proof exists to explain hominid evolution, although it is not enough to make specific conclusions.

Fossil Evidence:

- Archaeologists have provided **fossil evidence** to prove that relationships existed between the Early Stone Age cultures in Europe and Northern Africa.
- Discoveries in South Africa, Kenya and Zimbabwe have been used to prove and validate that Africa was the home of early man.

Genetic Evidence:

- **Mitochondrial DNA:** MtDNA is the smallest chromosome located in the mitochondria and forms part of the organisms' genome. In most species, mtDNA is inherited from the mother (maternal inheritance). The sequencing of the mtDNA shows a link in **phylogenetics** and **evolutionary relationships** between species. The age of the common ancestral mtDNA can be estimated to have existed approximately 140,000 to 290,000 years ago linking humans to **Mitochondrial Eve**.

Cultural evidence: tool-making

- The earliest hominids to use simple tools known as **Oldowan stone tools**, were *Homo habilis* that lived around 2.6 Ma and signifies the start of the Stone Age.
- *Homo habilis* fossils have been found in many parts of Africa with tools that were made of stone and used to aid hunting and cutting of food.
- *Homo erectus* developed more advanced tools that included **sharpened stones** placed on wooden handles, like an axe.
- They were also the first species to use **flints** and quartzite to make fire.
- Later fossil evidence shows tools like **scrapers** probably used to clean animal skins, slicers and **needles** used to sew animal pelts into the first form of clothes.
- From this point, tools progressed to **knives and blades** used by the Neanderthals used for hunting and protection.
- Fossil evidence shows that as the different species developed larger brains and greater intelligence, so their tools became more complex.

Characteristics that humans share with African apes:

- Olfactory brain centres reduced/ reduced sense of smell
- Eyes in front/ Binocular vision / stereoscopic vision
- Eyes with cones/ colour vision
- Freely rotating arms
- Elbow joints allowing rotation of forearm
- Flat nails instead of claws/ bare, sensitive finger tips
- Opposable thumbs
- Bipedal/ upright posture / foramen magnum in a more forward position
- Sexual dimorphism/ distinct differences between males and females
- Parts of the brain that process information from the hands and eyes are enlarged
- Longer upper arms
- Large brains / skulls compared to their body mass
- Five digits per limb

Anatomical differences between Humans (*Homo sapiens*) and African Apes

FEATURE	Humans (*Homo sapiens*)	African Apes
Cranium	Large cranium/brain	Small cranium/brain
Brow Ridges	Brow ridges are not well developed	Brow ridges well developed
Spine	More curved spine	Less curved spine
Pelvic girdle	Short, wide pelvis	Long, narrow pelvis
Canines	Small canines	Large canines
Palate shape	Small and semi-circular	Long and rectangular
Jaws	- Small jaws - Less protruding jaws/less-prognathous	- Large jaws - More protruding jaws/ more prognathous
Cranial ridges	No cranial ridge	Cranial ridge across the top of the cranium
Foramen Magnum	Foramen magnum in a forward position	Foramen magnum in a backward position

Out of Africa hypothesis and evidence for African origins of modern humans

This hypothesis states that modern *Homo sapiens* evolved in Africa about 200,000 years ago and migrated outwards to Europe and Asia, according to the Southern Dispersal theory.

Most scientists agree that **modern humans** *(Homo sapiens*) **evolved in Africa and spread outwards across the continents.**

The following lines of evidence have been used to support this hypothesis:

- Fossils of *Ardipithecus* were found **ONLY** in Africa
- Fossils of *Australopithecus* and *Homo habilis* were found **ONLY** in Africa
- The **oldest** fossils of *Homo erectus* and *Homo sapiens* have been found in Africa
- Analysis of mitochondrial DNA shows that the **oldes**t female ancestors of humans are from Africa
- Analysis of Y chromosome shows that the **oldest** male ancestors of humans are from Africa

Fossil Records:

Organism	When organism existed	Fossil site	Discovered by	Characteristics
Ardipithecus ramidus	5-4 mya	North-East Ethiopia	Tim White	Brain size: 300-350 ml Forward position of foramen magnum. Very prognathous (more protruding jaws). Heavy brow ridges. Pelvis structure: bipedal and tree climbing.
Australopithecus afarensis	4-2,7 mya	Ethiopia Kenya Tanzania	Donald Johanson	Brain size: 375 – 550 ml Forward position of foramen magnum Very prognathous Heavy brow ridges Canines large and pointed Long arms No cranial ridge
Australopithecus africanus	3-2 mya	Taung Sterkfontein	Raymond Dart	Brain size: 428-625 ml Forward position of foramen magnum Prognathous Brow ridges Teeth large; canines not long Long arms No cranial ridge

Organism	When organism existed	Fossil site	Discovered by	Characteristics
Australopithecus sediba	1,9-1,8 mya	Malapa Cave – in the cradle of humankind	Lee Burger	Brain Size: 420 ml Lee prognathous Brow ridges Large teeth; canines not long Long arms No cranial ridge
Homo habilis	2,2-1,6 mya	Tanzania	Louis and Mary Leakey	Brain size: 650 ml Less prognathous Less pronounced brow ridges Human-like teeth; smaller canines Long arms
Homo erectus	2-0,4 mya	Java in Indonesia and then Swartkrans	Eugene Dubois	Brain size: 900 ml Prognathous Cranial ridges Short canines 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 No brow ridges Small teeth Short arms

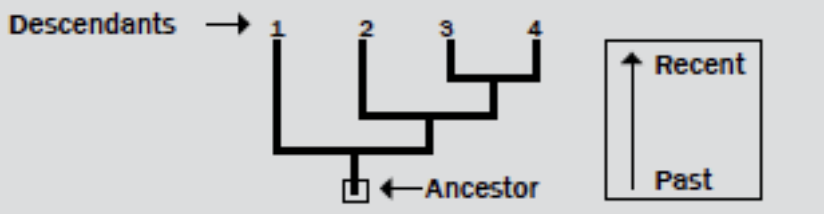
Phylogenetic trees:

A phylogenetic tree is a schematic form that shows the evolutionary relationships within a set of organisms or groups of organisms. *Phylo* = organism's phylum group and *genetic* = from the genes/relationship between the genes

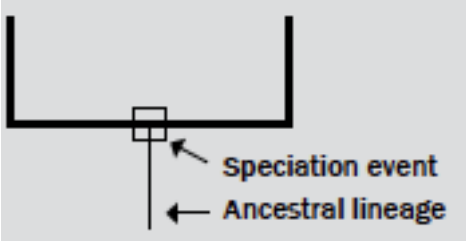
Hints on interpreting phylogenetic trees:

(Modified from Mind the Gap: Grade 12 Life Sciences)

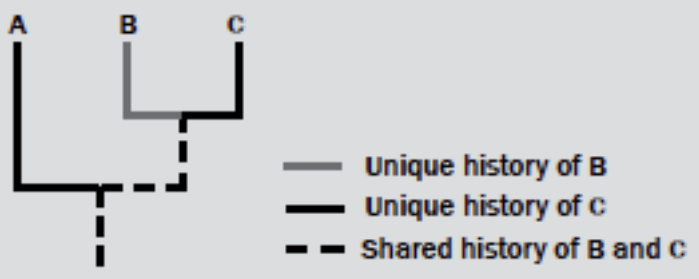
Reading a phylogenetic tree is similar to understanding a family tree. The base of the tree represents the oldest ancestor and the tips of the branches represent the most recent descendants of that ancestor. As you move from the base of the tree, to the tips of the branches, you are moving forward in time. .



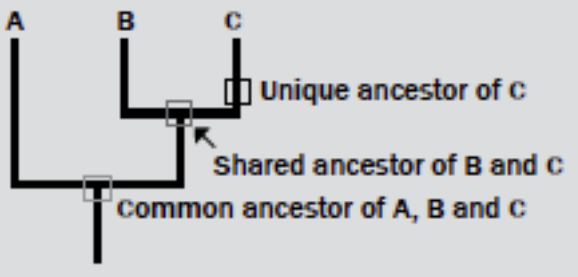
When speciation occurs, it is represented as branching on the tree.



Each lineage has a part of its history that is unique and parts that are shared with other lineages.

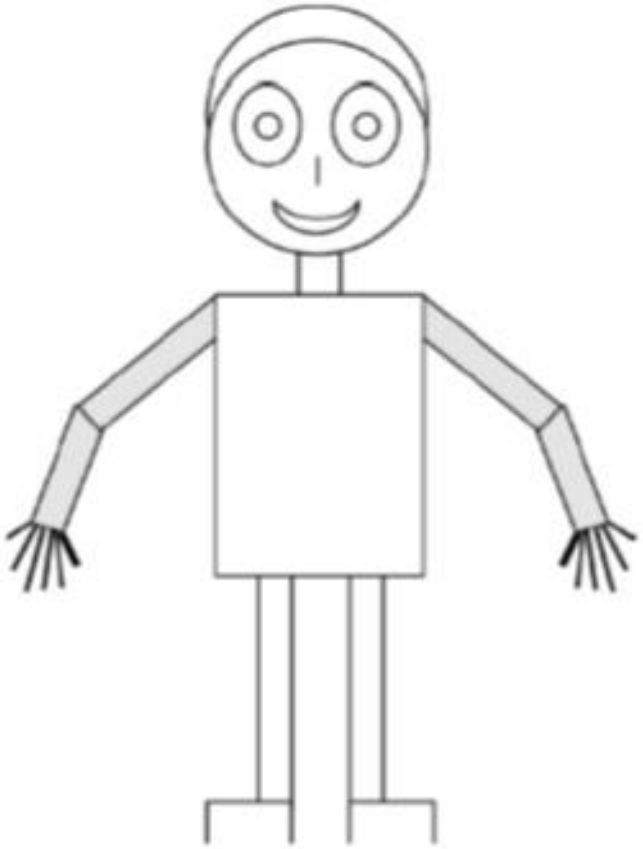


Similarly, each lineage has ancestors that are unique to that lineage and common ancestors that are shared with other lineages.



Evolution

1. Characteristics we share with African apes



2. Characteristics that make us different from the African apes

Web links

The article below is a good summary of some recent work published about a human skeleton found in Ballito Bay.
https://www.thetimes.co.uk/edition/comment/it-took-10-000-generations-to-make-an-iphone-8phfggzqz

Natural selection
http://www2.edc.org/weblabs/NaturalSelection/NaturalSelectionMenu.html

Exploring evolution
http://www2.edc.org/weblabs/ExploringEvolution/ExploringEvolutionMenu.html

The Hardy-Weinberg Equation
http://www2.edc.org/weblabs/Hardy%20W/HardyWeinbergMenu.html

Peppered Moths
http://www3.district125.k12.il.us/faculty/nfischer/Moth/default.htm

Biology in Motion – Evolution Lab
http://biologyinmotion.com/evol/

Sex and the Single Guppy
http://www.pbs.org/wgbh/evolution/sex/guppy/index.html

Wonderful animations
http://www.sumanasinc.com/webcontent/animation.html

Evolution
http://evolution.berkeley.edu/

Evolution
www.maropeng.co.za

Peppered moth simulation
https://www.biologycorner.com/worksheets/pepperedmoth.html

For videos:
www.eChalk.ca.uk.