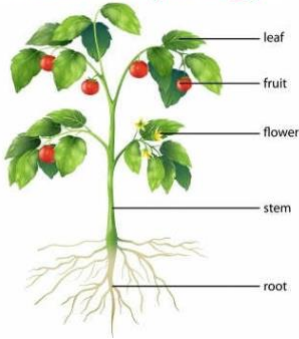




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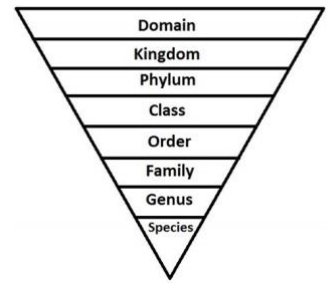
Plant Morphology



basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

Taxonomy (plant and animal)



Botany

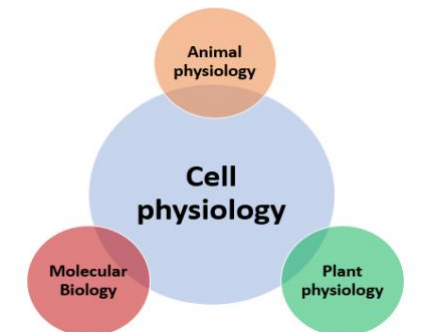
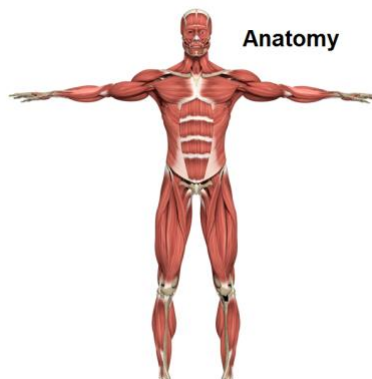
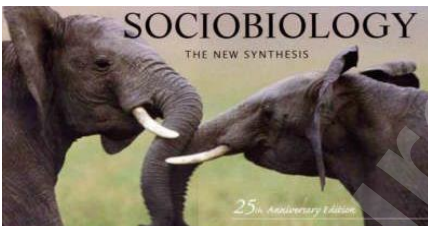
LIFE SCIENCES

GRADE 12

INCUBATOR PROGRAMME 2018



BOOK 10: EVOLUTION



TOPIC 10

KEY CONCEPTS

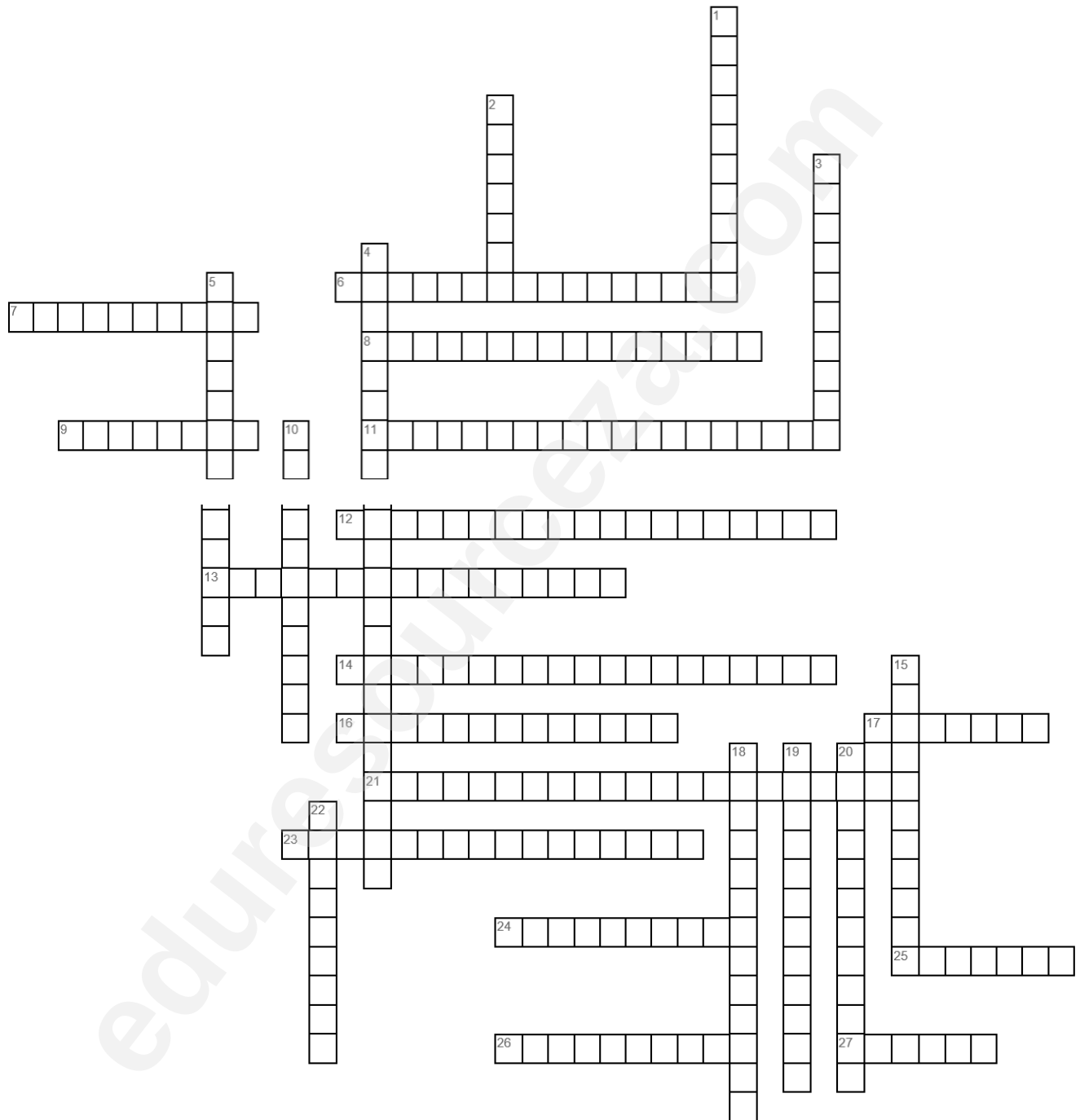
1. EVOLUTION BY NATURAL SELECTION

- Definition of biological **evolution, hypothesis, theory, species, population, speciation**,
- **Evidence** for evolution: Fossil record, Biogeography, Modification by descent (homologous structures), Genetics
- Factors that contribute to **genetic variation** include: meiosis, different types of mutations (point mutations, frame-shift mutations), Random fertilization and Random mating.
- **Continuous** and **discontinuous** variation
- Apply the ideas of Charles Darwin (Darwinism) and Jean Baptiste de Lamarck (Lamarckism) to explain evolution. Eg.
 - explain the evolution/development of **longer necks** in modern **giraffes**
 - explain how modern **cacti plants** may have developed **longer roots** when compared to their ancestors with shorter roots.
- Justify why **Darwin's** idea is more **acceptable** in the science community today and **Reasons** for Lamarck's theory being **rejected**.
- Compare **Darwin's ideas** of evolution to the **ideas of Punctuated Equilibrium**.
- The role/impact of **variation** in natural selection (Darwin's theory of evolution by natural selection)
- Differentiate between **natural selection** and **artificial selection**
- Explain how humans select a **domesticated animal** species or **crop species** through artificial selection.
- The Effect of Speciation and Extinction on biodiversity
- Describe how natural selection led to the process of speciation
- Example of Speciation through geographical isolation (Animals eg. Galapagos finches, Galapagos tortoises, any mammal and Plants eg. Baobabs in Afrika and Madagascar; Proteas in South Africa and Australia) on different land masses
- **Mechanisms of reproductive isolation** (Breeding at different times of the year, Species-specific courtship behavior, Adaptation to different pollinators, Infertile offspring, Prevention of fertilization)
- Natural selection and evolution in present times:
 - ✓ Use 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

2. HUMAN EVOLUTION

- Interpretation of a phylogenetic tree
 - Characteristics that humans share with African apes
 - Anatomical differences between African apes and humans
 - (i) The evolutionary/structural **changes** in the (skull, spine and pelvic girdle) fossils of Homo species and
 - (ii) the **significance/importance** of each change as they evolved from the African apes.
 - Three primate genera
 - ✓ **Ardipithecus**
 - ✓ **Australopithecus** (Karabo, Littlefoot, Taung Child, Mrs Ples)
 - ✓ **Homo** (Homo habilis, Homo erectus)
 - ✓ **What** organism (Ardipithecus, Australopithecus, Homo), **When** organism existed, Fossil sites **where** they were found, scientist **who** discovered them, characteristics they had.
 - **Evidence for common ancestors for living hominids**
 - ✓ **Fossil** evidence
 - ✓ **Anatomical features** of fossils of 3 primate genera
 - ✓ **Genetic** evidence (mitochondrial DNA)
 - ✓ **Cultural** evidence
2. Evidence for the Out of Africa hypothesis
- ✓ **Fossil** evidence
 - ✓ **Genetic** evidence (mitochondrial DNA)

Evolution



Across

- 6 genus to which Little Foot, Mrs Ples, Karabo and the Taung Child belong
- 7 An informed supposition that is based on observation but not yet proven. It can thus be accepted or rejected by experimentation.
- 8 the gradual movement of landmasses as a result of the movement of tectonic plates (sublayers of the Earth's crust)
- 9 sudden change to the genetic composition of an organism
- 11 using parents with particular desirable characteristics to obtain a combination of these desirable characteristics in the offspring
- 12 a population of a particular species may become split by geographical barrier eg. A river. As a result the two parts of the population cannot interbreed and there is no gene flow between the two populations
- 13 branched diagram showing evolutionary relationships amongst organisms
- 14 the change in the genetic composition of a population from one generation to another, that is, changes that happen gradually and include micro- and macro-evolution
- 16 type of variation in a species where a characteristic is categorized without any transitional forms – only a few alleles are present, eg. In the human ABO blood group system
- 17 remains of organisms that have existed in the past
- 21 mechanisms that prevent different species from reproducing with each other
- 23 only species with favourable characteristics survive
- 24 a group of organisms of the same species that occupy a particular habitat
- 25 a group of similar organisms that can breed to produce fertile offspring
- 26 The development of new species from existing species
- 27 a verified statement formed by scientific on the basis of observations and experimental information allows them to test hypothesis

Down

- 1 type of variation in a species where a series of phenotypes occur – thus there are various alleles eg. The length of people
- 2 locomotion involving the use of a pair of hind limbs only
- 3 the process by which plants or animals die off so that not even one individual member of the entire species exists
- 4 model for evolution that suggests that species may show little change for a long time and then show rapid bursts of speciation
- 5 A study of the distribution of organisms in different parts of the world
- 10 similar structures in different organisms indicating common ancestry
- 15 having a pointed face because of projecting jaws and nose
- 18 an opening in the skull through which the spinal cord passes
- 19 the study of fossils which provides evidence for evolution
- 20 the variety of life on earth, that is, the different kinds of species on earth
- 22 genotypic and phenotypic differences amongst organisms of the same species

EVOLUTION

1. Define *evolution* and *biological evolution*.

- **Evolution** is a process whereby the present day organisms are derived from pre-existing different species that developed into their current form through a process of gradual change over millions of years
- **Biological Evolution** is a special type of evolution that refers to changes that living things have undergone over long periods of time.

2. State the difference between a *hypothesis* and a *theory*.

HYPOTHESIS	THEORY
Hypothesis is a possible prediction or explanation of phenomena after observation.	Theory is a scientific explanation of events which is supported by same results obtained via research, investigations and studies by many scientists.
Based on guess or speculation and on limited data	It is supported by a lot of evidence
Hypothesis can be either accepted or rejected	Theories are reliable and the basic ideas persist in science

3. Why can the Theory of Evolution be regarded as a scientific theory?

- Various hypotheses relating to evolution have been tested and verified over time.

EVIDENCE FOR EVOLUTION

4. Describe how each of the following provides evidence for evolution:

(a) Fossil record

- The remains of millions of extinct organisms are preserved as fossils within ancient sediments that record several billion years of Earth's history.
- Generally, the oldest sedimentary rocks contain the fossils of simpler, more primitive, forms of life (e.g. bacteria, algae, invertebrates), while fossils of more complex organisms (e.g. flowering plants, mammals) are found in much younger sediments.
- The overall trend from simpler ancestral forms to more complex forms as you go through the rock succession clearly shows a pattern of evolutionary change over time.

(b) Modification by descent (homologous structures)

- The limbs of all classes of vertebrates have a similar arrangement of skeletal bones, although they are modified to perform different functions, generally for different modes of locomotion.
- This arrangement is so similar that all classes of vertebrates must have arisen from a common ancestor

(c) Biogeography

- There are ancient fossils of plants and animals distributed across several continents. For example, *Glossopteris* trees, *Mesosaurus*, a reptile and two therapsids: *Lystrosaurus* and *Cynognathus* (mammal-like reptiles).
- The age of these fossils show that they lived during the Triassic and Permian periods, just before Gondwana split into separate continents.
- This provides that these had large populations across the supercontinent before it was separated as a result of continental drift.

(d) Genetics

- All living organisms share a universal code of three DNA bases (codons) that are used to specify each amino acid.

VARIATION

5. Define a *species* and a *population*.

- **Species** - Organisms that are morphologically similar and have similar behaviour but do not necessarily need to live in the same area. They are capable of interbreeding to produce fertile young. eg. *Paramecium caudatum* and *Paramecium Aurelia*.
- **Population** - interbreed, live in same area and belong to same species e.g. bee population.

6. Describe how each of the following contributes to variation amongst individuals of the same species:

(i) Meiosis

- Crossing over

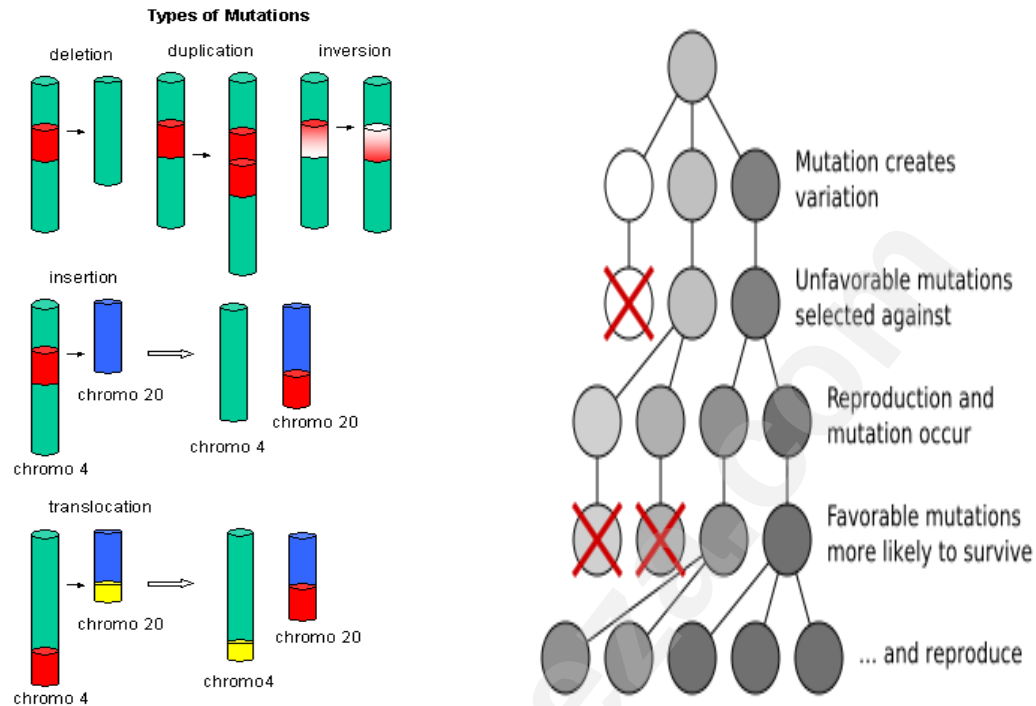
- Homologous chromosomes/bivalents pair up
- Each chromosome has two chromatids
- Non-sister chromatids overlap/cross over
- Points at which crossing over takes place are referred to as chiasmata
- Genetic material is exchanged between non-sister chromatids
- After the process of crossing over chromosomes have alleles from its homologous partner
- This means that each gamete formed will have a mix of alleles from both parents
- Brings about variation in the gametes formed and also the offspring

- Random arrangement of chromosomes

- Each pair of homologous chromosomes may line up either way on the equator of the spindle
- Independently of what the other pairs are doing
- This means that gametes will have differing number/mix of both parental chromosomes

(ii) Mutations

- Mutations are **alterations** in the DNA of chromosomes.
- Many mutations may be **neutral** or '**silent**' (i.e. they have no observable effect on the organism).
- **Harmful** mutations become evident because they may alter the **survival capacity** of the organism.
- Errors/mistakes/changes may occur during transcription/DNA replication
- Point mutations: replacing/substituting one base of a codon with another
- Small change that may possibly result in one amino acid changing in a protein
- Frameshift mutations: addition/deletion of one or more bases of a codon:
 - Resulting in changing the order/sequence of all the bases of the codons
 - Resulting in forming a different protein with different functions
 - Lead to different phenotypes

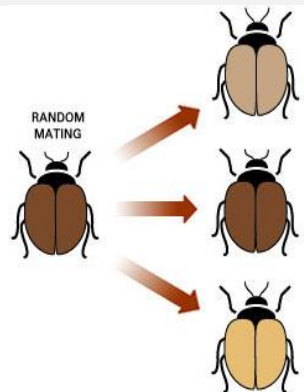


(iii) Chance fertilisation

- Firstly, the egg cells and sperm cells produced by meiosis are different from each other. Since there is random fertilization of these different gametes, there will be different combinations of genetic material off spring.

(iv) Random mating

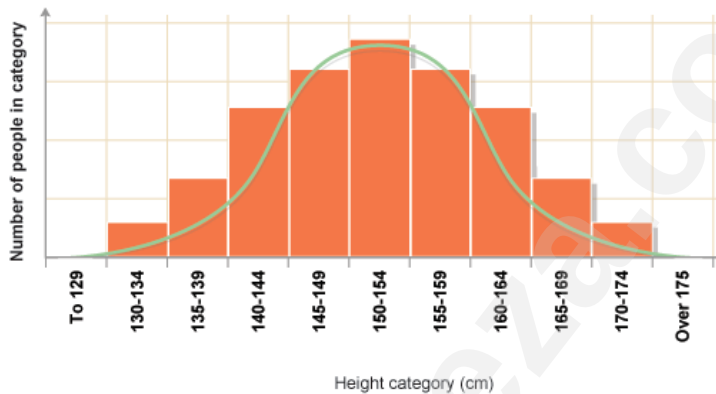
- A population is one where all individuals are potential partners. This assumes that there are no mating restrictions, neither genetic or behavioural, upon the population, and that therefore all recombination is possible. ...
- The choice of mates coming down to chance, this increases the number of heterozygotes in the offspring



7. Differentiate between *continuous variation* and *discontinuous variation*.

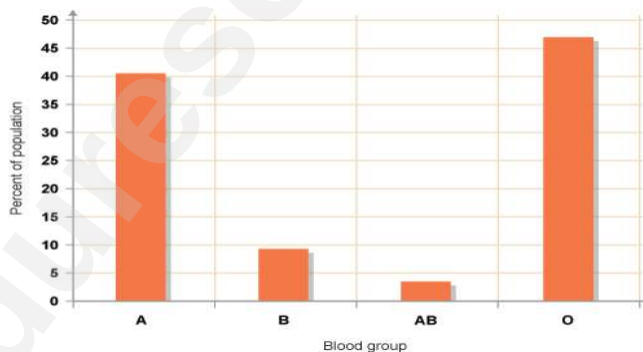
Continuous Variation

- Human height is an example of continuous variation.
- Height ranges from that of the shortest person in the world to that of the tallest person.
- Any height is possible between these values.
- For any species a characteristic that changes gradually over a range of values shows continuous variation.
- Examples of such characteristics are: height, weight, foot length



Discontinuous Variation

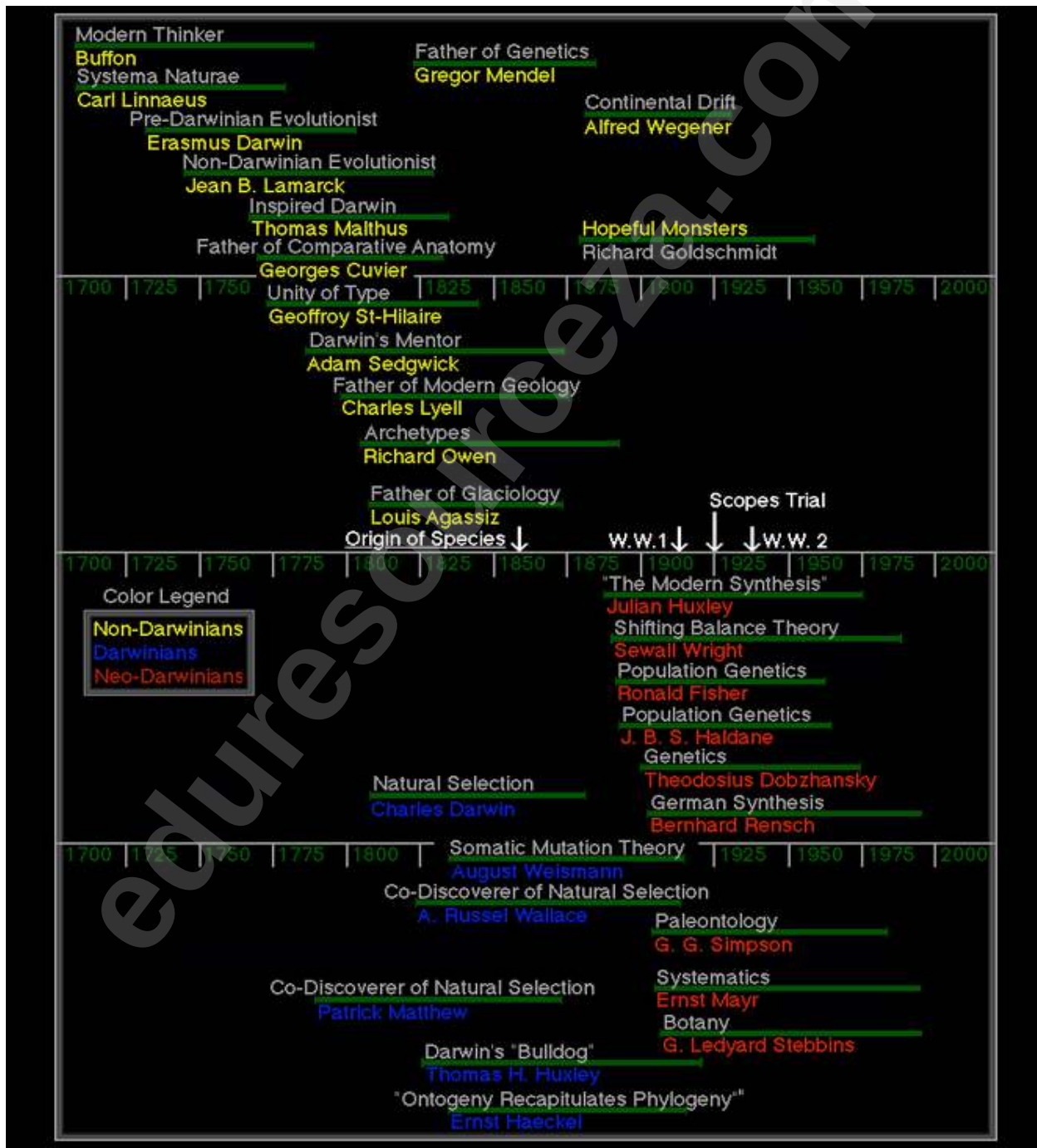
- Human blood group is an example of discontinuous variation.
- There are only 4 types of blood group.
- There are no other possibilities and there are no values in between.
- So this is discontinuous variation.
- A characteristic of any species with only a limited number of possible values shows discontinuous variation. Eg. gender (male or female), blood group (A, B, AB or O), eye colour.



ORIGIN OF THE IDEA ABOUT ORIGINS (A HISTORICAL DEVELOPMENT)

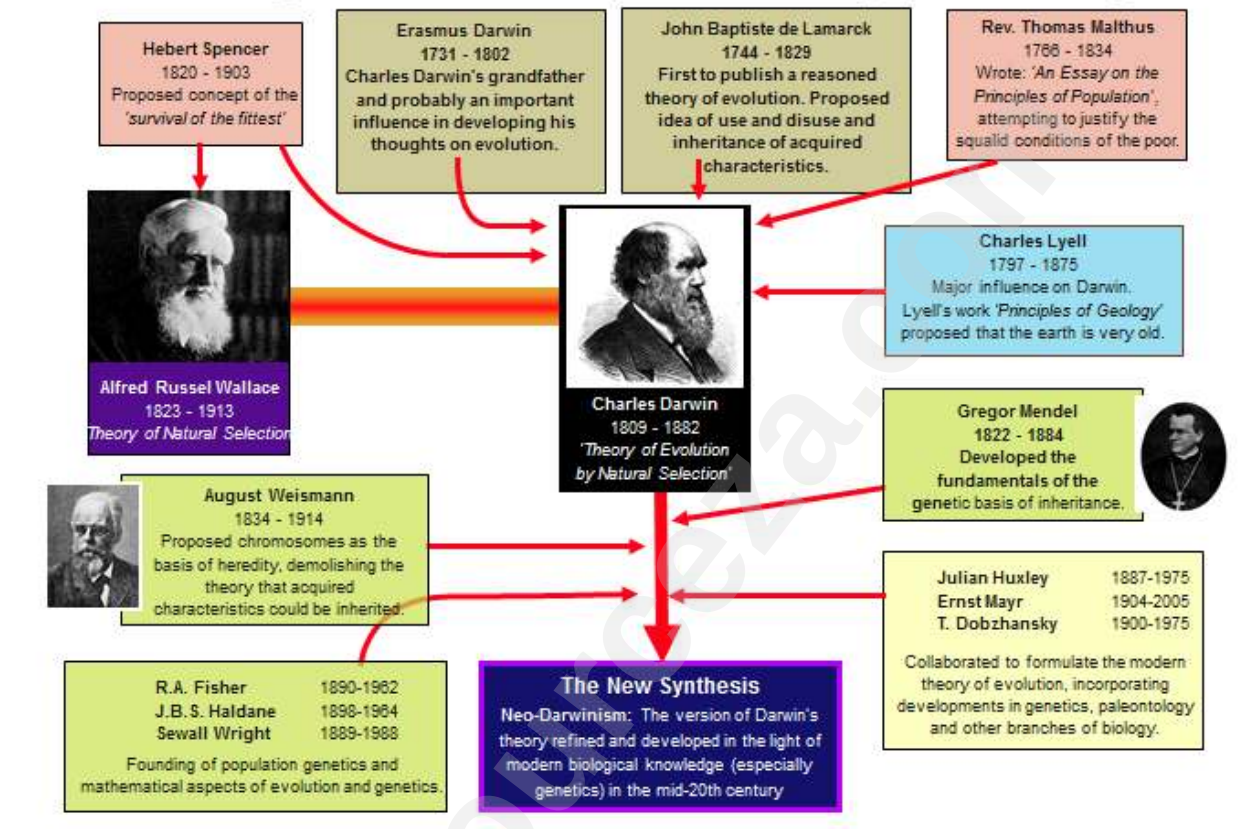
8. Draw a timeline of the development and the contribution of different scientists towards our understanding of evolution, including the following:

- Lamarckism
- Darwinism
- Punctuated equilibrium



<http://www.ucmp.berkeley.edu/history/evotmline.html>

History of Evolutionary Thought



LAMARCKISM (JEAN BAPTISTE DE LAMARCK – 1744–1829)

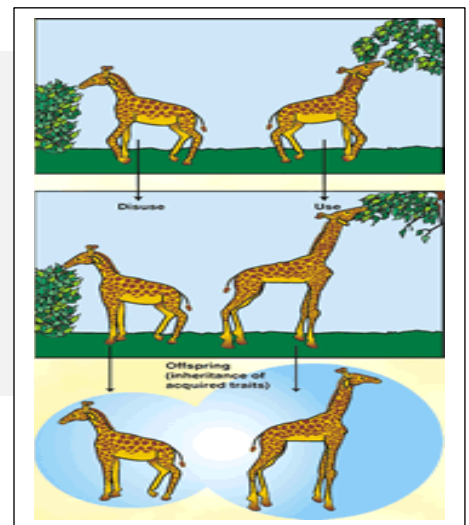
9. Describe what is meant by each of the following 'Laws' used by Lamarck to explain evolution:

(a) 'Law' of use and disuse

- Organs' become modified or adapted according to use
- Used more- became bigger
- Not used – smaller and disappeared

(b) 'Law' of the inheritance of acquired characteristics

- modifications brought about by use or disuse were able to be transmitted to offspring.
- i.e animals adapted to their environment
- Passed these on to next generation



10. Give reasons for Lamarck's theory being rejected.

- Acquired characteristics are not inherited/do not cause any change to the DNA of an organism's gametes (sperms or ova).
- Organisms did not evolve because they want to evolve; instead these changes took place randomly, in response to the environment.
- There is very evidence to support Lamarck's idea that changes brought about by adaptation to the environment are inherited from parent to offspring.
- Lamarck's theory is deterministic

DARWINISM (CHARLES DARWIN –1809–1882)

11. State the observations upon which Darwin based his theory:

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

12. Describe 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 characteristics that make them less suited, die.
- The organisms that survive, reproduce
- and thus pass on the favourable characteristic to their offspring.
- The next generation will therefore have a higher proportion of individuals with the favourable characteristic.

ARTIFICIAL SELECTION

13. State what is meant by *artificial selection*.

*Artificial selection is also known as **selective breeding**, since humans determine which genes will be passed on to future generations. Farmers, scientists and pet breeders choose their best individuals to interbreed so that they may produce the best characteristics.*

14. Describe *artificial selection* using an example of each of the following:

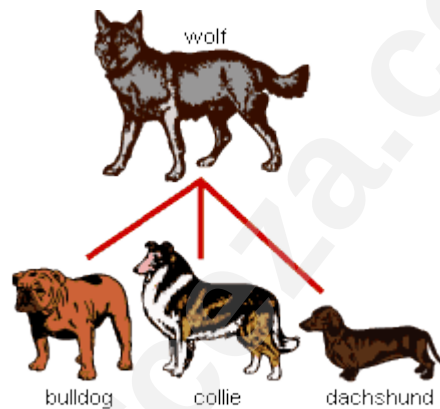
(a) A domesticated animal species

In South Africa farmers select goats which are able to withstand heat and drought and allow them to inbreed as they are resistant to diseases and produce good meat.



Dogs belong to a single species, *Canis familiaris*, but that species is comprised of about 400 different breeds. Since they are a single species, they can mate and have viable offspring. Recognized dog breeds take generations to establish through selective breeding or artificial selection. Many of the breeds we have today are the result of people's desire to have dogs with specific features that make them suitable for performing particular tasks, such as retrieving, protection, assistance, hunting, and companionship, to name just a few. The process of breeding a new type of dog often involves

- identifying desired features,
- finding dogs with those features,
- then performing a series of matings to produce offspring with the appropriate combination of traits.
- After a number of generations, a new breed may be established.



(b) A crop species

Maize plants with full kernels were allowed to cross – pollinate by farmers so that the genes for full kernels could be passed onto the new maize plants.



15. List similarities between *natural selection* and *artificial selection*.

- Both create a trend towards organisms better suited for their environment or "purpose".
- Natural Selection and Artificial both involve an organism's traits being determined by how much they favoured.
- Then, the organisms with favourable traits pass those traits on to future generations. Both processes eventually forms a new species.

16. Tabulate differences between *natural selection* and *artificial selection*.

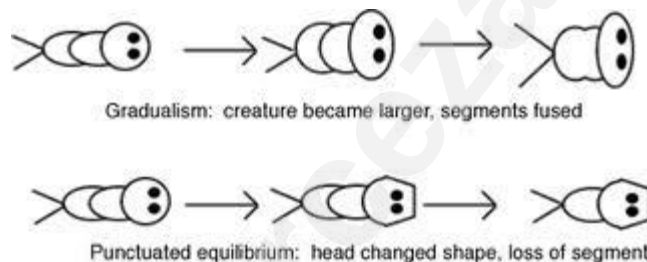
Natural Selection	Artificial Selection
Nature is the selective force	Humans are the selective force
Selection is based on adaptation to be environment	Selection is based on what is desirable to humans
Selected individuals are able to survive in the wild since they are adapted to the environment	Selected individuals may survive only under controlled conditions since their characteristics were not selected according to adaptation to the environment

PUNCTUATED EQUILIBRIUM

Based on Darwinism, it is thought that evolution takes place through an accumulation of small or gradual changes that occur over a long period of time. This is supported by the many transitional fossils in the fossil record which show the progressive changes over time.

17. Describe how punctuated equilibrium explains the speed at which evolution takes place:

- According to punctuated equilibrium, evolution is not gradual as proposed by Darwinism.
- Evolution involves long periods of time where species do not change or change very little (known as equilibrium).
- This alternates with (is punctuated by) short periods of time where rapid changes occur through natural selection.
- As a result, new species are formed in a short period of time, relative to the long periods of no/little change.
- This is supported by the absence of transitional fossils (usually termed missing links) indicating the period of rapid change.



FORMATION OF NEW SPECIES

Flow diagram to illustrate the concept of speciation:

population → mutations → no possibility of breeding with old species → new species formed



18. Define a *species* and a *population*.

- **Species** - Organisms that are morphologically similar and have similar behaviour but do not necessarily need to live in the same area. They are capable of interbreeding to produce fertile young. eg. *Paramecium caudatum* and *Paramecium Aurelia*.
- **Population** - interbreed, live in same area and belong to same species e.g. bee population.

19. Differentiate between *speciation* and *extinction* and state the effect of each on biodiversity.

- **Biodiversity** on the planet earth is the net-result of two major processes: speciation and extinction.
- **Speciation** is the formation of new and distinct species in the course of evolution. All evolutionary changes in species are due to genetic changes.
- **Extinction** is the dying out or termination of a race or species. Extinction occurs when a species can no longer reproduce at replacement levels. Most extinctions are thought to have resulted from environmental changes that affected the species in either of two ways. The doomed species might not have been able to adapt to the changed environment and thus perished without descendants; or it may have adapted but, in the process, may have evolved into a distinctly new species.
- Speciation minus extinction equals biodiversity, the planet's genetic raw material for future evolution in response to changing environmental conditions.
- In the long-term give-and-take between extinction and speciation, mass extinctions and depletions temporarily reduce biodiversity.
- However, they also create evolutionary opportunities for surviving species to undergo adaptive radiations to fill unoccupied and new biological roles or niches.
- Although extinction is a natural process, much evidence indicates that humans have become a major force in the premature extinction of species.
- As human population and resource consumption increase over the next 50-100 years, we are expected to take over more and more of the earth's surface and net primary productivity (NPP).
- During this century, this may cause the premature extinction of up to a quarter of the earth's current species. This could constitute a new mass depletion and possibly a new mass extinction.
- On our short time scale, such major losses cannot be recouped by formation of new species; it took millions of years after each of the earth's past mass extinctions and depletions for life to recover to the previous level of biodiversity.
- Genetic engineering cannot stop this loss of biodiversity because genetic engineers do not create new genes.
- Rather, they transfer existing genes or gene fragments from one organism to another and thus rely on natural biodiversity for their raw material.

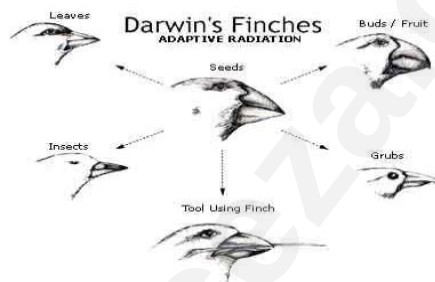
20. Give a general account on speciation through geographic isolation:

- If a population of a single species
- becomes separated by a geographical barrier (sea, river, mountain, lake),
- then the population splits into two populations.
- There is now no gene flow between the two populations.
- Since each population may be exposed to different environmental conditions,
- 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 reproduce with each other.
- They have thus become different species.

21. Describe speciation through geographic isolation using any ONE of the following examples:

(a) Galapagos finches

- These finches, better known as 'Darwin's Finches' show **adaptive radiation**.
- This is where species all deriving from a common ancestor have over time successfully adapted to their environment via natural selection.
- Previously, the finches occupied the South American mainland, but somehow managed to occupy the Galapagos islands, over 600 miles away. They occupied an ecological niche with little competition.
- Different environmental conditions and different food sources meant that variations in beak size that occurred naturally would lead to natural selection
- The finches became that were better adapted to a particular environment survived long enough to reproduce and pass their characteristics on to the next generation.



(b) Galapagos tortoises

- Darwin discovered two different varieties of tortoises on two different islands on the Galapagos Islands.
- One had a domed shell and short neck (Short - necked tortoise A can feed on grasses at ground level) and the other one had a longer neck.
- The two islands had very different vegetation.
- One of the islands (island X – Tortoise B), was rather barren, dry and arid.
- It had no grass but rather short tree-like cactus plants.
- On the other island (island Y – Tortoise A), there were no cactus plants but it had a good supply of water and grass grew freely across the island.
- The diagrams below show the two main varieties of tortoises on the Galapagos Islands.



Tortoise A **Tortoise B**
Two main varieties of tortoises on the Galapagos Islands

- Allopatric speciation occurs when new species evolve because populations are physically separated from the original population
- In the case of the tortoises (A and B) they were physically separated from the original mainland population and from each other on separate islands.
- The two island populations adapted to their particular environments and changed genetically and physically (phenotype) over a long period of time became reproductive isolated.

(c) **Plants on different land masses (linked to continental drift)**

- Baobabs in Africa and Madagascar

- Madagascar is one of the most diverse places on Earth.
- It is home to many groups of endemic organisms with close within-group relationships.
- Madagascar, is the fourth-largest island in the world, sits in the Indian Ocean several hundred kilometers off Africa's southeastern coast and provides a home to a remarkable variety of plant and animal species, including the aye aye, fossa, chameleon, and baobab tree.
- Understanding where that diversity comes from requires understanding not just the living world, but the geologic, geographic, and climactic histories that have shaped the evolution of lineages on the island and have provided opportunities for species to [evolve](#) and diversify in isolation.
- Its species are a mix of those that have been living and evolving there for many tens of millions of years and those that arrived more recently and subsequently diversified.
- Some of Madagascar's present species are there because they "rode there" on the continents and were left on the island when it separated from India.
- Others arrived on the island after its split, immigrating from other places.
- When the continent splits, the two halves of the [population](#) are separated, and over many generations, they evolve into separate species.
- Many different processes can cause plate tectonics, the rise of mountain ranges, a shift in the course of a river, or just climate change that causes an unfavorable habitat to develop that ends up splitting a species' range into two.
- Dispersal, on the other hand, occurs when a species spreads or immigrates from one area to another.
- If part of a population moves to a new area, the two subpopulations may eventually evolve into separate species.

- Proteas in South Africa and Australia

- The protea family spread through the southern hemisphere by riding on fragments of the ancient supercontinent Gondwana.
- The family is common in Australia and includes waratahs, grevilleas, proteas, banksias and even macadamia trees.
- Varieties are also found in South Africa, Southeast Asia, New Guinea, New Caledonia, New Zealand and Madagascar.
- "Most of the areas in which they grow are pieces of ... Gondwana that started fragmenting hundreds of millions of years ago."
- "After [the idea of] continental drift became accepted in the late 1960s and early 1970s it also became accepted that the Proteaceae became primarily distributed as a result of continental drift."
- Some groups of protea found both in Australia and Africa have been dated at about 40 million years old, millions of years after Gondwana split.
- This makes them too young to have arrived by continental drift because according to geological records the last time Africa was connected to the rest of Gondwana was more than 100 million years ago.
- So, how did they arrive in Australia?
- Some protea seeds are light and aerodynamic, making it likely they were distributed on the wind.

(d) **Any example of mammals on different land masses**

- LEMURS

- The evolutionary and biogeographic processes experienced by the lemurs are not unusual.
- The simplest explanation for this pattern is that, like the lemurs, the groups first arrived on the island by dispersal as a single lineage and then rapidly diversified.
- Most of the species on Madagascar today seem to be descended from individuals that dispersed there from Africa long after Madagascar was established as a separate island. For example, phylogenetic, genetic, and anatomical evidence all suggest that lemurs split from other primates on Africa around 62 million years ago and that the ancestral lemur lineage had dispersed to Madagascar by around 54 million years ago. Once on the island, the lemur lineage diversified. Now there are at least 50 species of lemur, all endemic to Madagascar.
- This diversification was likely spurred on by other geologic and climactic characteristics of Madagascar.
- The east coast of the island is lined with a mountain range — and this causes different parts of the island to get drastically different amounts of rain.
- Hence, the island is made of many different habitat types — from deserts to rainforests — that have shifted and changed over the past 88 million years.
- This likely provided many opportunities for subpopulations to become isolated and evolve traits for specializing in different niches.
- And that likely encouraged lineages to diversify.

KEEPING SPECIES SEPARATE (MECHANISMS OF REPRODUCTIVE ISOLATION)

When one species gives rise to two new species (speciation), the two species cannot reproduce with each other even if they mix. They remain as separate species due to mechanisms that restrict gene flow between them.

Reproductive isolation means that two different species can live in the same habitat but are unable to breed due to specific behavioural patterns and physiological processes.

These **behavioural patterns and physiological processes** that **prevent two closely related but distinct species from creating offspring together**, are known as **reproductive isolating mechanisms**.

22. Describe how each of the following reproductive isolation mechanisms help in keeping species separate:

A. Breeding at different times of the year

💡 Reproductive isolating mechanisms can be categorized according to when and how they operate:

Prezygotic (pre-fertilization) mechanisms include:

habitat preference

behavioral incompatibility

structural incompatibility

physiological incompatibility

Postzygotic (post-fertilization) mechanisms include:

zygote mortality

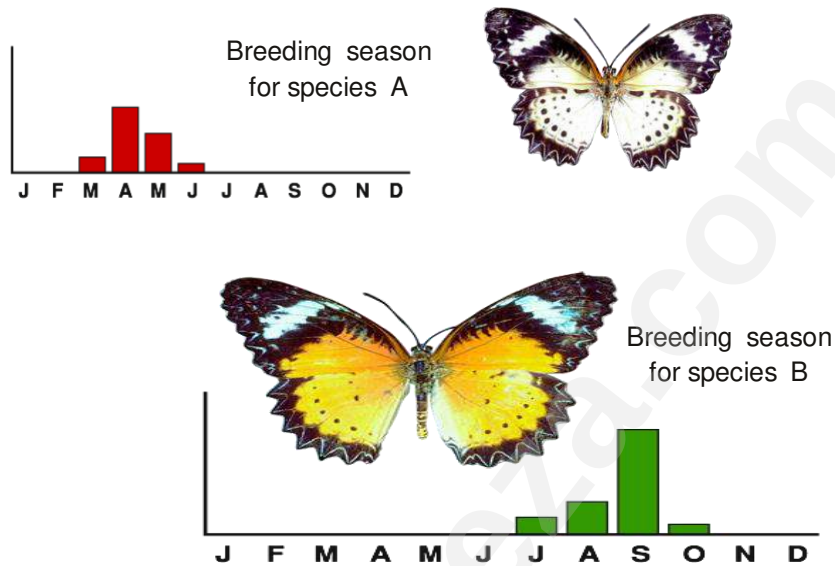
poor hybrid fitness

hybrid sterility

💡 **Temporal** (time-based):

Species may have different activity patterns; they may be nocturnal or diurnal, or breed at different seasons.

In this hypothetical example, the two species of butterfly will never mate because they are sexually active at different times of the year



B. Species-specific courtship behaviour (animals)

Behavioral:

- Species may have specific calls, rituals, postures etc. that enable them to recognize potential mates (many bird species have elaborate behaviors).



Courtship behaviour in male blackbuck



Greater Crested Tern courtship behaviour

C. Adaptation to different pollinators (plants)



(a) Honeybee drinking nectar from a foxglove flower



(b) Ruby-throated hummingbird drinking nectar from a trumpet creeper flower

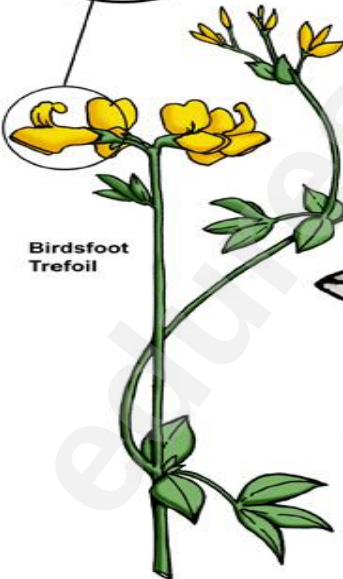
Plant Adaptations and Pollinators

The flag petal with lines leading downward to focus the bee on the right spot on the flower

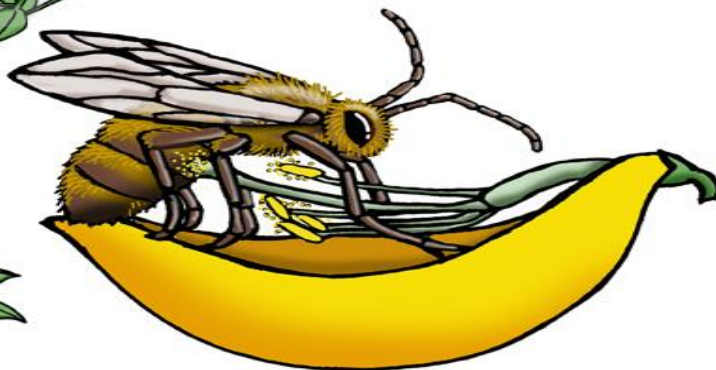
The bee's feet work the fused side petals open exposing a keel petal inside. When the bee steps down onto the keel, its weight triggers the keel to bounce down – like a trampoline, and the petals spread.



The stamens inside the keel are covered with pollen and pop up to dust the bee's belly. If the bee has been to another blossom already, the pistil, which also touches the bee's belly, gets a dose of the pollen already stuck there. Pollination has occurred!



Birdsfoot
Trefoil



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D. Infertile offspring (e.g. mules)

- **Postzygotic** isolating mechanisms act **after fertilization** to prevent successful reproduction.

- **Hybrid inviability:**

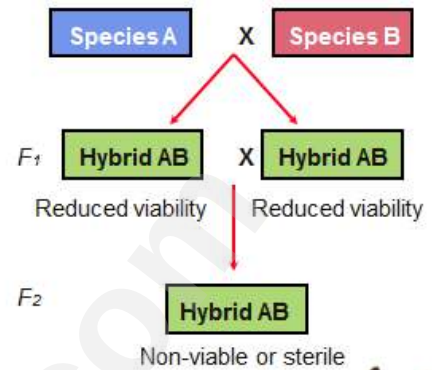
- The fertilized egg may fail to develop properly
- Fewer young may be produced and they may have a low viability (survivability).

- **Hybrid sterility:**

- The hybrid of two species may be **viable** but **sterile**, unable to breed (e.g. the mule).

- **Hybrid breakdown:**

- The first generation may be fertile but subsequent generations are infertile or non-viable.



This mule is a hybrid between a horse and a donkey

EVOLUTION IN PRESENT TIMES

23. Explain that natural selection and evolution are still occurring in present times by using any ONE of the following examples:

(a) The use of DDT and the consequent resistance to DDT in insects which can be explained in terms of natural selection

- Initially mosquitoes were not resistant to DDT when it was first introduced to them.
- However, as time goes on, a gene mutation occurred in one of the mosquitoes.
- It lived, and reproduced to have baby mosquitoes that are immune to DDT.
- The mosquitoes that were not resistant to DDT died off, while the gene mutation mosquitoes that were DDT – resistant lived on.
- It is the survival of the fittest.

The following flow diagram to show natural selection in insects in present day.



(b) Bill (Beak) and body size of Galapagos finches

Natural selection is still occurring on Daphne Major, which is a Galapagos Island where small, medium and large beaked finches were present. There was variation in the size of beaks.

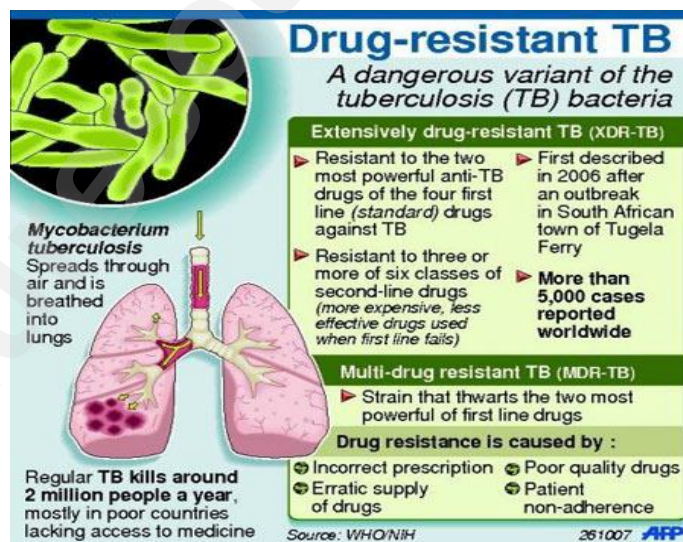
- Between 1976 – 1978 there was a serious drought.
- Many of the small to medium beak finch species could not survive the drought and died.
- Environmental selection pressure eliminated finches with small beaks due to a lack of food.
- During normal wet seasons plants used to produce small and large seeds.
- The small seeds could be eaten by the finches with small and medium beaks.
- During the drought the small seeds were depleted and larger seeds were plentiful.
- Therefore the finches with larger beaks had a competitive advantage during the drought period where larger seeds were available.
- The deeper bigger beaked finches were able to break open the coats of large seeds in order to get to the seeds.
- Presently only large beaked finches have been able to survive and were naturally selected due to their advantageous gene of having larger beaks.



- (c) The 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

Question: Why will the antibiotic that was previously useful in 'fighting' a bacterial infection not work the next time if it was not completed the first time?

Answer: A **mutation** has occurred in the bacteria, which makes them **resistant against the drug** because the medication was not completed and the bacteria that survived actually mutated and became drug – resistant.



- **MDR-TB** is when the bacterium mutates and fights against the first two drugs given for TB because it was not initially completed by the patient.
- When patients is then given a second chance dose of three of more different drugs to help cure TB. This is known as **XDR-TB**. It is very expensive and may not be as effective as the first line drugs given, had the patient completed the course.

- (d) **HIV resistance to anti-retroviral medication**

- HIV is a virus and AIDS is a disease caused by the virus.
- Scientists have developed several drugs to combat the HI- virus.
- At the beginning the treatment with ARV, the environment of the virus has changed.
- A few of the viruses may have the gene to be ARV resistance.
- Due to changing environmental conditions/ selection pressures most viruses will die.
- Resistant viruses will survive, live on and reproduce and the resistant gene is passed onto the next generation.
- Because viruses reproduce so rapidly and mutations may occur due to changes in environment/ selection pressure after a while, population of viruses become resistant to new antiretroviral in a short space of time. This is natural selection.
- the HIV which causes AIDS can also mutate against the first line of ARV's (antiretroviral tablets).
- This will lead to the need to formulate more stronger and expensive ARV's which may not be very effective if the HIV is in its last stages.

HUMAN EVOLUTION

Terminology:

Paleontology – this refers to the study of fossils

Fossil – remains of ancient life forms preserved usually in the rocks

Bipedalism - the act of walking on two feet.

Dentition - arrangement of teeth on a jaw

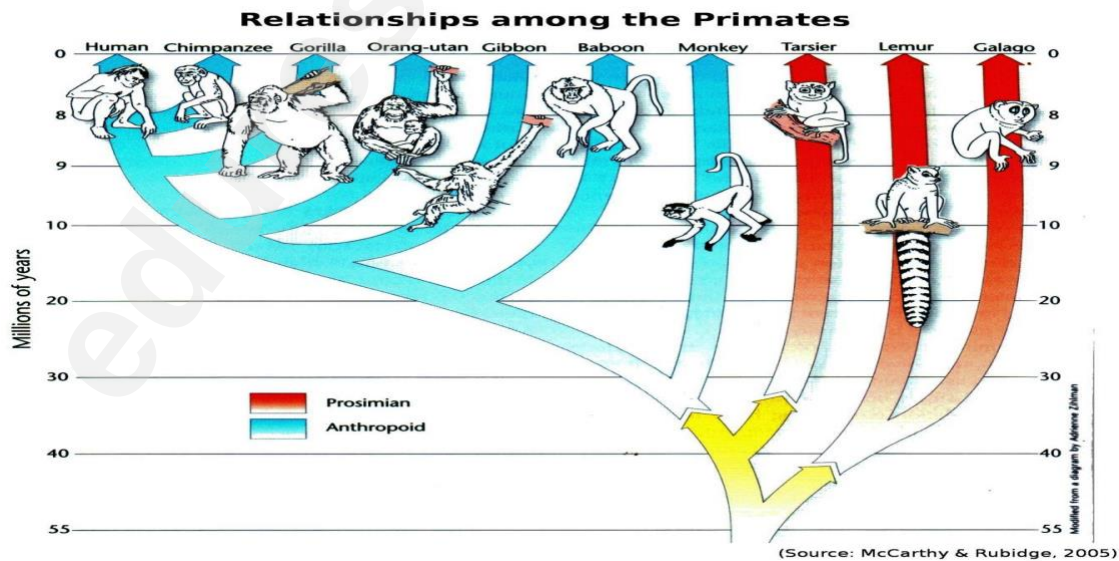
Phylogenetic tree - Diagram showing evolutionary relationships amongst organisms

Prognathous – having a pointed face because of projecting jaws and nose

EVIDENCE OF COMMON ANCESTORS FOR LIVING HOMINIDS, INCLUDING HUMANS.

24. Interpret a phylogenetic tree to show the place of the family Hominidae in the animal kingdom.

- According to the following phylogenetic tree are more closely related compared to humans and chimpanzee, but the humans, gorilla, orang-utans, etc., but all have one common ancestor:



25. Describe the following evidence that support the idea of common ancestors for living hominids including humans:

(a) Fossil evidence:

- Fossils are the remains of ancient life forms preserved usually in the rocks.
- Scientists determine the age of a fossil by using relative dating and radiometric dating
- In relative dating we can only tell whether a particular fossil was formed before or after another fossil or geological event, while Radiometric dating can be used to determine the age of a fossil.
- In addition to determining the age of a fossil scientist also determine the characteristics of the organism from a study of its fossils.
- Knowledge of these characteristics allow us to see relationships amongst different organisms.
- Homologous structures have the same basic plan even though they may look different or perform different functions.
- Scientists interpret the presence of homologous structures to mean that all the species which show homologous structures have risen from a common ancestor which became adapted to live in different environments.
- This is called modification by descent.
- A study of fossils of organisms found at different times in the past shows how certain characteristics changed over time such as the position of the foramen magnum, size of the cranium, the brow ridge, dentition and palate shape.
- The trends obtained from this study provide information about the sequence of evolution.

(b) Genetic evidence of mitochondria DNA:

- DNA evidence shows that all humans are genetically very closely related.
- Evidence for this comes from gene sequencing and in particular studies of mitochondrial DNA.
- DNA shows that all humans are genetically very closely related
- Through analysis of mitochondrial DNA, all humans have been linked to a common ancestor termed "African" or "Mitochondrial Eve".
- A mutation in the mitochondrial DNA of a female hominid that lived about 150 000 years ago in Africa is present in all humans
- Scientists state that organisms are closely related and are likely to have a common recent ancestor if they have:
 1. Identical DNA structure
 2. Similar sequence of genes
 3. Similar portions of DNA with no functions
 4. Similar mutations on mitochondrial DNA.

(c) Cultural evidence: tool making

- Cultural evidence from studies of tools and weapons, as well a language is also used to show similarities and differences between humans and other primates.
- Early hominids used stones that were found on the ground and the branches of trees as weapons and tools.
- The first made tools were made by Homo habilis about 2 million years ago
- Such weapons and tools were used for fishing, farming, hunting and for tearing up food for eating.

26. List characteristics that humans share with African apes.

- Large brain/skull compared to their body mass.
- Olfactory brain centres reduced/ reduced sense of smell
- Parts of the brain that process information from the hands and eyes are enlarged.

- Eyes in front/binocular vision/stereoscopic vision
- Eyes with cones/colour vision
- Freely rotating arms
- Elbow joints allow rotation of the forearm
- Flat nails instead of claws/bare finger tips
- Opposable thumbs which work in opposite direction to their fingers.
- Upright posture

27. Tabulate anatomical differences between African ape and humans as it applies to the following characteristics:

Feature	African Apes	Humans (Homo sapiens)
Bipedalism (foramen magnum, spine and pelvic girdle)	Foramen magnum in a backward position. Less curved spine. Long , narrow pelvis	Foramen magnum in a forward position. More curved spine. Short, wide pelvis
Brain size	Small cranium/brain size	Large cranium/brain size
Teeth (dentition)	Long canines and teeth are arranged in a longer lower jaw in a rectangular "U" shaped with cheek teeth in two parallel rows	Smaller canines occur and the teeth are arranged in a shorter lower jaw in a smoothly rounded arch.
Prognathism	Jaws of apes are more protruding (more prognathous)	The jaw of humans is less prognathous (protruding)
Palate shape	Long and rectangular	Small and semi-circular
Cranial ridges	Cranial ridge across the top of the cranium	No cranial ridge
Brow ridges	Brow ridges well developed	Brow ridges are not well developed

OUT OF AFRICA HYPOTHESIS

TERMINOLOGY

Theory - based on a number of different hypothesis, explanations, principles and laws.

Hominidae – order to which humans, chimps, apes, gorillas, lemurs and gibbons belong.

Transitional fossil – fossil having characteristics of species that arose before it as well as species that arose after it.

28. How did modern humans reach different parts of the earth if they have originated in Africa?

- *Out of Africa hypothesis explains the possible reason\ for the distribution of hominins across the earth.*
- *There was a mutation that occurred in the mitochondrial DNA of a female hominin that lived 150 000 years ago in Africa. This DNA is present in all humans.*
- *Modern humans originated in Africa and migrated out of Africa to other continents*
- ***This hypothesis states that: Most evolutionary development took place in Africa since most hominin fossils originate in Africa.***
- *The sophisticated hominins such as Homo erectus and neanderthalensis migrated to the rest of the world.*
- *Modern human population arose in Africa 200 000 years ago and then migrated across the globe 70 000 years ago and gave rise to all the non – African humans that exist today.*

29. Describe how the following lines of evidence support the ‘Out of Africa’ hypothesis.

The three phases of human evolution are: *Ardipithecus* phase, *Australopithecus* and the *Homo* phase

(a) Fossil records:

- A huge crack on the earth running down the length of East Africa from the Red sea to Mozambique is called the Rift Valley.
- The Rift Valley formed 25 million years and trapped mud and other living organisms which fossilised after death. Therefore the Rift valley is an ideal site for finding hominin fossils.
- Lucy and *Ardipithecus* species were found in east Africa.

There three *Australopithecus* fossils are:

a) *Australopithecus afarensis* (lived 3,6 mya):

- came from “**afar**” which means **Out of Africa**.
- It was discovered in Ethiopia
- It was named “Lucy” and discovered by an American paleoanthropologist *Australopithecus afarensis* was a first bipedal primate.
- It had a mixture of human and ape-like features and lived on the Savannah woodland. This fossil has a small body size, small canines indicating a diet of nuts, fruits and seeds, big toes in line with other toes as in humans and a protruding jaw and face.
- It had long arms for climbing trees to escape predators.

b) *Australopithecus africanus*-

- lived about 3,2 mya.
- Three such fossils were **found** in the **Sterkfontein Caves** in **South Africa** **Tuang child, Mrs Ples and Little Foot** are examples of ***Australopithecus africanus* fossils**
- They lived in the savannah woodland of South Africa.

- They had a long arms for climbing trees, a small brain size similar to apes, Foramen magnum and a S-shaped spine under/ ventral part of skull indicating they were bipedal.
- **Laetoli Footprints**- these were footprints found in hardened volcanic ash in Tanzania. It had footprints of the **Australopithecus** or **hominid species**.
- Their toe features were like that of humans who do not wear shoes.
- These footprints were discovered **3,6 mya**.
- The Laetoli footprint is an example of a **cast fossil**.

c) **Australopithecus sediba** or **Karabo** (lived about 1.9 mya):

- discovered on 15 August 2008 by palaeontologist Lee Burgers, 9 yr. old son in South Africa. Lee Burgers is a scientist at the Univ. of Witwatersrand.
- Sediba means "natural well" or "spring" in Sotho as these fossils were discovered near a deep well. They were fossilised in lime rich sand.
- sediba is said to be a **transitional species** as it is a **link** between **A. africanus** and the **Homo erectus species**.

(b) **Mitochondrial DNA:**

When DNA is analysed for the purpose of tracing ancestry, a search is made for mutations since individuals who have the same mutations must share the same common ancestor. These mutations therefore serve as markers of descent.

Every cell has organelles called mitochondria within which the energy releasing process of cellular respiration takes place.

Mitochondria also contain DNA, referred to as mitochondrial DNA.

During fertilisation, only the nucleus of the sperm cell enters the egg cell to fuse with its nucleus.

The original egg cell therefore becomes the cell of the zygote after fertilisation.

The mitochondria of the egg cell continue as the mitochondria of the zygote.

In this way mitochondrial DNA is handed down from mother to child.

By following mutant nucleotides in the mitochondrial DNA, we are able to trace our female line of descent.

Analysis of mitochondrial DNA leads to an ancestral female who also lived in east Africa, around 150 000 years ago.

Scientists believe that other species of humans such as *Homo erectus*, *Homo heidelbergensis*, *Homo neanderthalensis* and *Homo floresiensis* were also present at this time. However these other species all became extinct and our species was the only one which survived.

On the basis of DNA analysis, scientists believe that early humans migrated across the continent of Africa from east Africa.

They moved out of the continent through north-east Africa in several groups.

Through many different and complex pathways they migrated into every habitable continent on Earth within 50 000 years.

30. **Give information on each of the following fossils that serve as evidence for the 'Out of Africa' hypothesis:**

- *Ardipithecus*
 - *Australopithecus*
 - *Homo*
- with regard to:

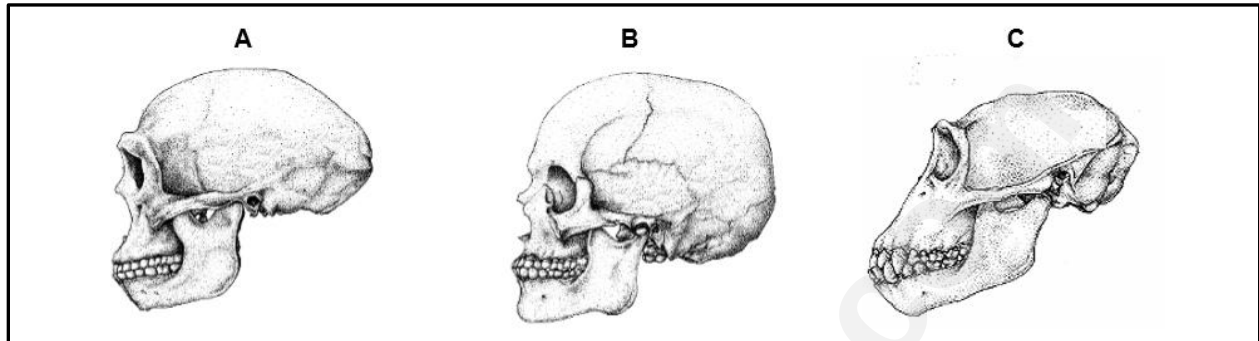
- The fossil sites (where they were found)
- The scientists (who discovered them)
- Emphasis on the evidence and evolutionary trends provided by fossils of these three genera in support of the Out of Africa hypothesis

Fossil	Fossil site	scientist who discovered it	Characteristics
Ardipithecus: Ardipithecus ramidus			
Australopithecus:			
Australopithecus afarensis	Ethiopia, Kenya, Tanzania	Donald Johanson	Brain size: 37-550 ml Forward position of the foramen magnum. Very prognathous. Heavy brow ridges Pelvis structure: bipedal and tree climbing.
Australopithecus africanus	Taung, sterckfontein	Raymond Dart	Brain size: 428-625 ml Forward position of foramen magnum. Prognathous Brow ridges Large teeth, canines not long. Long arms No cranial ridge
Australopithecus sediba	Malapa Cave in the cradle of humankind	Lee Burger	Brain size: 420 ml Less prognathous Brow ridges Large teeth, canines not long. Long arms No cranial ridge
Homo			
Homo habilis	Tanzania	Louis and Mary Leakey	Brain size: 650 ml Less prognathous Less pronounced brow ridges. Human-like teeth, smaller canines. Long arms.
Homo erectus	Java in Indonesia and then Swartkrans	Eugene Dubois	Brain size: 900 ml Prognathous Cranial ridges Short canines Longer legs and shorter arms
Homo sapiens	Ethiopia, Border Cave in KZN, Blombos Cave in Western Cape	Tim White	Brain size: 1200 -1800 ml. No brow ridges Small teeth Short arms

QUESTIONS

1. List features that humans share with primates. (5)
2. Tabulate five differences between humans and other primates (11)

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



- Which diagram A, B or C appeared last on earth according to scientists. (1)
- Tabulate THREE visible structural differences between DIAGRAM A and DIAGRAM B that illustrate evolutionary trends in human development. (7)
- Describe TWO lines of evidence which support the idea that the human population had its origins on the African continent. (4)

4. **The percentages of female Anopheles mosquitoes that were resistant to an insecticide each year are shown in the below. In 2000 there was a maximum number of resistant mosquitoes. The other numbers are percentages of the maximum.**

A new insecticide was used in 1996 and killed most of the mosquitoes. Only 4% of mosquitoes had genetic resistance to the insecticide.

Year	1996	1997	1998	1999	2000
Resistant mosquitoes	4%	25%	50%	90%	Maximum Number

- Explain why the number of mosquitoes resistant to the insecticide increased annually. Use natural selection theory to explain this. (To help you: The resistant mosquitoes are the individuals best adapted to the new environment (containing insecticide). Their adaptation is due to a mutation and is genetically inherited. Female mosquitoes each lay a large number of eggs.)
- What happened to the non-resistant mosquitoes in 1996 when they were sprayed with insecticide in every home?
- In 1997, were there a few non-resistant mosquitoes, or a lot? Why?

- d.) Do mosquitoes resistant to insecticide carry the malaria parasite?
- e.) Would you expect the number of people who died of malaria to decrease or to increase between 1996 and 2000? Explain why.

5. Study the diagram and answer the questions:

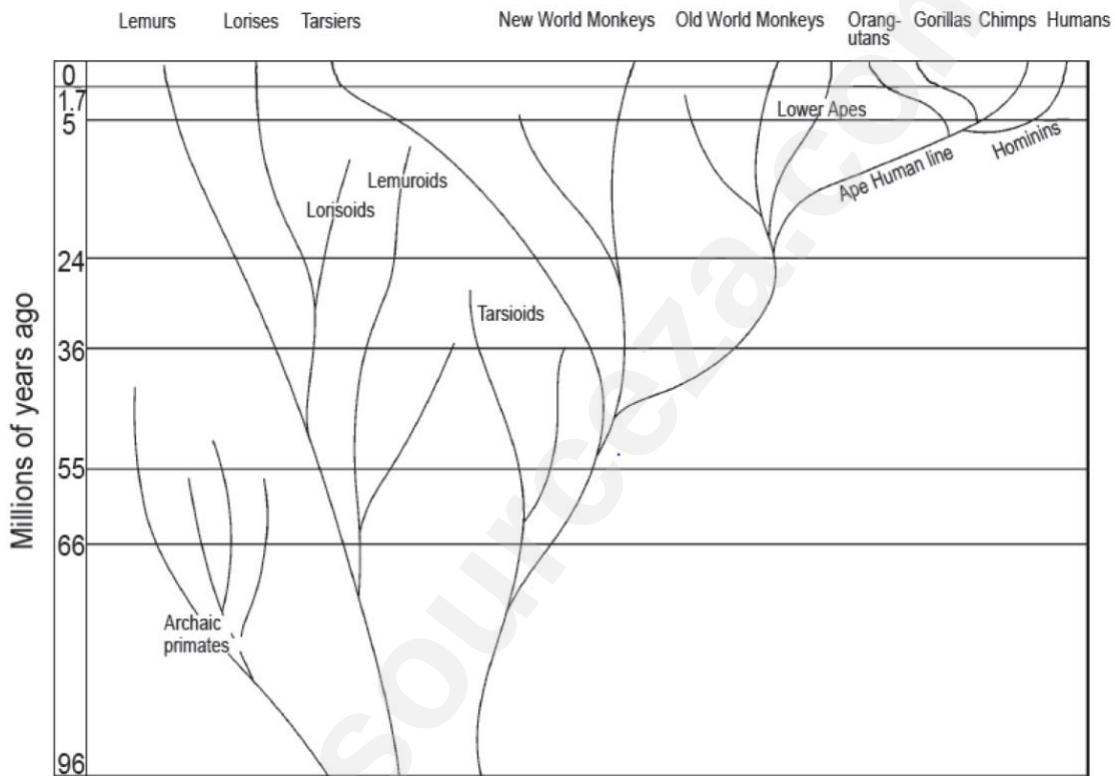


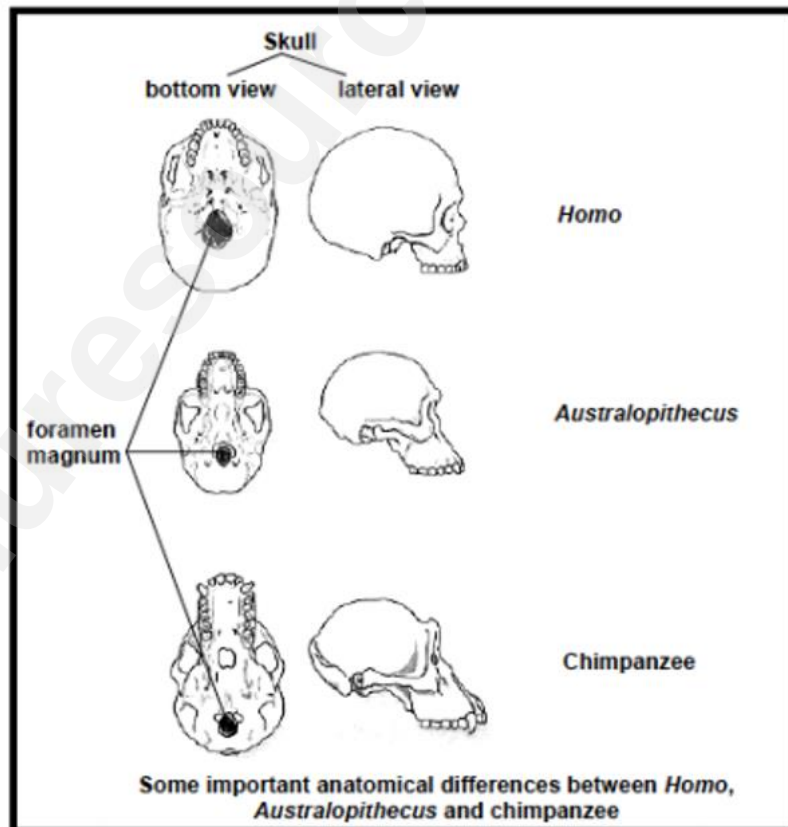
Diagram of primate evolution. It is based on fossils of extinct primates. The hominin line of evolution was separate from the lineages that led the modern apes.

- a.) Which living primate species is our closest relative?
 - b.) Are we descended from this living primate species?
 - c.) How long ago did we share an ancestor with this species?
 - d.) Like humans, apes have no tails. When do you think this trait might have evolved?
Before or after the ape lineage split away from the human lineage?
6. The incomplete table below represents famous scientists, the fossil they discovered and the countries and the dates of discovery.

Scientist	Fossil	Place of discovery	Year of discovery
1	Toumai	2	2001
Raymond Dart	3	Sterkfontein caves	4
Robert Broom	5	6	7
8	Lateoili footprints	9	10
11	12	13	1994
14	Karabo	15	2008

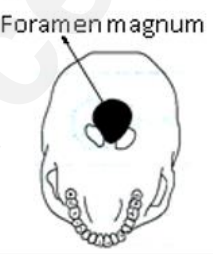
- The Great Rift Valley is seen as the cradle of humankind, provide a reason for this. (2)
- From the list above mention the fossils discovered at the Great Rift Valley. (3)
- Explain the significance of these findings. (6)

7. **A comparison of the anatomical features of organisms has helped scientists to propose evolutionary relationships**



- Tabulate FOUR observable differences between the side view of the skulls of Homo and the chimpanzee. (9)

- b.) Which ONE of the organisms (Australopithecus or chimpanzee) is/was a quadruped? (1)
- c.) Give ONE observable reason for your answer to QUESTION (b.). (1)
- (d) Name TWO fossils of *Australopithecus* found in South Africa. (2)
8. a.) Explain what is meant by the “Out of Africa” hypothesis. (3)
- b.) Explain how mitochondrial DNA and Y DNA contribute to the above mentioned theory. (6)
9. Study the diagrams below of the upper jaw, skull and the foot of two organisms A and B. The diagrams are NOT drawn to scale.

Organism	Upper jaw	Skull (bottom view)	Foot
A			
B			

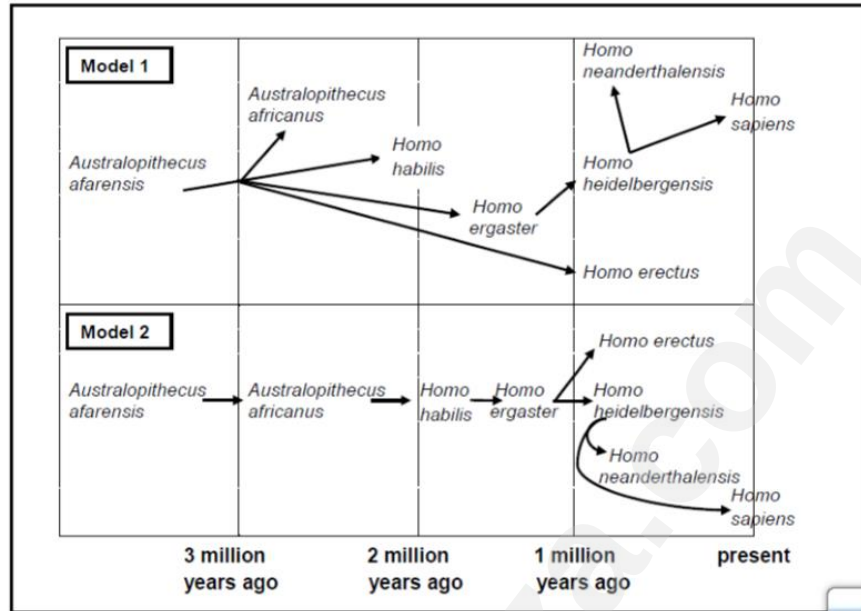
- 9.1 Name the order to which both the organisms belong.
- 9.2 With regard to the drawings above:
- (a) Tabulate TWO visible differences between the upper jaws of organisms A and B.
- (b) Name ONE visible difference between the feet of organisms A and B.
- 9.3 Which organism (A or B) is more likely to be bipedal?
- 9.4 Give a reason for your answer to QUESTION 8.3 above.

- 9.5 Explain how bipedalism could benefit the organism you identified in 3 above.
- 9.6 Provide 5 characteristics that organisms belonging to groups that A and B belong to probably share.
10. Study the table below, which indicates some of the hominid fossils found in different parts of the world.

SPECIES	AREA WHERE IT WAS FOUND	PERIOD OF EXISTENCE
<i>Australopithecus afarensis</i>	Eastern Africa	3,4–2,8 mya
<i>Australopithecus africanus</i>	Southern Africa	2,1–2,8 mya
<i>Australopithecus sediba</i>	Southern Africa	2,0–1,9 mya
<i>Homo habilis</i>	Sub-Saharan (Africa)	2,3–1,4 mya
<i>Homo erectus</i>	Africa, Europe, Asia	1,5–0,2 mya
<i>Homo heidelbergensis</i>	Europe, China	0,6–0,35 mya
<i>Homo neanderthalensis</i>	Europe, Western Asia	0,35–0,03 mya
<i>Homo sapiens</i>	Worldwide	0,2 mya–present

[Adapted from *The Evolutionary Road*, Jamie Shreeve, *National Geographic*, July 2010]

- 10.1 Explain TWO ways in which the information in the table supports the 'Out of Africa' hypothesis.
- 10.2 Describe how the analysis of mitochondrial DNA is used to support the 'Out of Africa' hypothesis.
- 10.3 How would Darwin have explained why only *Homo sapiens* and none of the other species mentioned in the table exist today?
11. Two palaeontologists suggested different models for the human evolutionary tree. The models they proposed are shown below.



- 11.1 State TWO similarities between the two models with regard to relationships among the different species.
 - 11.2 Describe TWO ways in which the models are different with regard to relationships among the different species.
 - 11.3 Fossilised skeletons of *Australopithecus sediba* were discovered in the Malapa Caves. When scientists analysed the fossils, they discovered that they shared some characteristics with the genus *Homo*. Between which TWO species would *Australopithecus sediba* be placed in Model 2?
 - 11.4 Comment on the trends in human development from *Australopithecus* to *Homo sapiens*.
- 12 Darwin noticed different types of tortoises on the Galapagos Islands. Two of these tortoises which are drawn to scale, are shown below.**



- 12.1** Tabulate TWO visible differences between the two species of tortoises.
- 12.2** Suggest what tortoise 2 might eat that tortoise 1 will not be able to eat.
- 12.3** The two species of tortoises shown above lived in different islands. Darwin suggested that they might have evolved from a common ancestor. Explain how this could have occurred.
- 13** There is diversity among individuals in a population; not all individuals survive to reproduce; offspring of those that do breed inherit characteristics that are best fitted to the environment.
These are the three key ideas that Charles Darwin had that guided him in his research into the origin of species. Explain very briefly how these three ideas can lead to:
(a) adaptations within individuals of a species
(b) the evolution of new species.
- 14** Indicate whether each of the following is a Theory or Hypothesis
a) In my class there is less tongue rollers than non-rollers.
b) Organisms change gradually with time
- 15** The number of the differences in the amino acid sequence of the β -haemoglobin chain between selected vertebrates and humans as shown below.

SPECIES	NUMBER OF AMINO ACID DIFFERENCES IN β -HAEMOGLOBIN CHAIN COMPARED TO HUMAN HAEMOGLOBIN (total chain length = 146 amino acids)
Human β -haemoglobin chain	0
Gorilla	1
Gibbon	2
Rhesus monkey	8
Mouse	27

Grey kangaroo	38
Chicken	45
Frog	67
Lamprey (jawless fish)	125

Study the data in the table and answer the following questions:

- Which two animals are the most closely related to humans? Give two reasons for your answer.
- Which one of the animals listed is the most closely related to the ancestral species that give rise to vertebrates? Substantiate your answer with a good reason.
- If you were to construct a similar table using the average of all the molecular, genetic and anatomical differences in each of these animals listed, would a similar sequence result? Think scientifically before you answer and provide a convincing reason to support your answer.
- The data in this table is based on comparison of the β -haemoglobin chain species that you are about to conduct a similar investigation about the differences in the molecular structure of the β - haemoglobin of the vertebrates listed. What statement will you make to describe your hypothesis?

16. The table below shows the population size of the dark coloured peppered moth as a percentage of the total peppered moth population and the amount of pollution in an industrial area over time.

YEAR	POPULATION SIZE OF DARK MOTHS (%)	AMOUNT OF POLLUTION(g/m)
1750	35	15
1760	37	20
1770	40	30
1780	55	65
1790	60	85
1800	80	100
1810	95	135
1820	100	145

- Give the table above a heading .
- Name the dependent variable in this investigation.
- Make a general conclusion about the relationship between the population

size and the amount of pollution.

c) Plot two line graphs on the same set of axes to represent the data above.

17. Explain, in your own words, the two main ideas that make up Darwin's theory of evolution.

ESSAYS

18. The anole lizard of the Caribbean Islands represents a group of about 150 closely related species, which evolved within the past 50 million years from a single species.

Use this example to describe how natural selection led to the process of speciation that gave rise to the 150 different species of lizards.

19. Fossils of the bipedal primates *Ardipithecus*, *Australopithecus* and early *Homo* species are used to support the 'Out of Africa' hypothesis.

State the 'Out of Africa' hypothesis. Describe the evidence that supports the 'Out of Africa' hypothesis and the evidence that shows that the three primate genera mentioned above, were all bipedal.

20. Describe the evolutionary changes in the skull fossils of *Homo* species and the significance of each change as they evolved from the African apes.
21. Describe how Lamarck and Darwin explained evolution, and compare Darwin's ideas to the ideas of Punctuated Equilibrium.