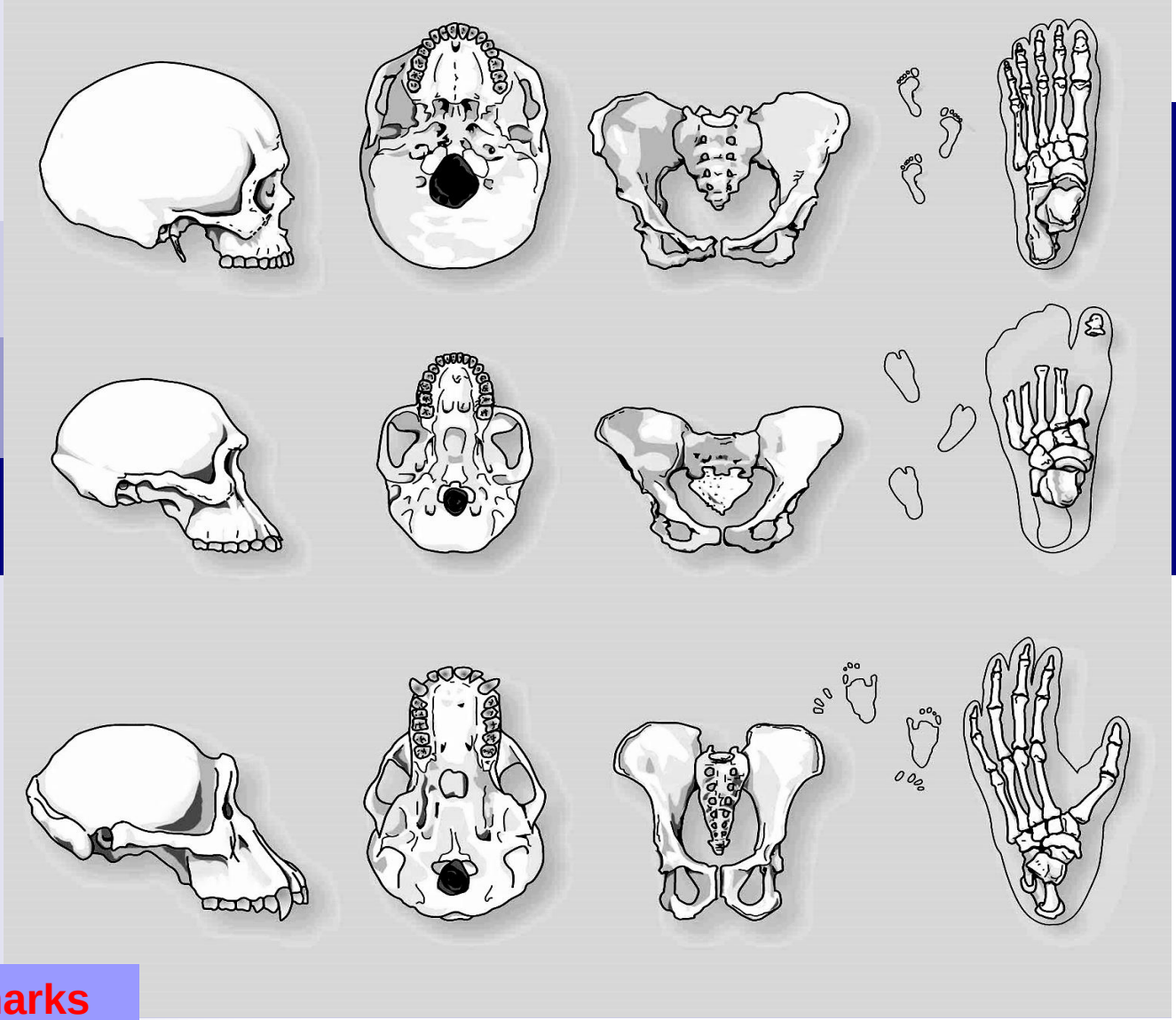
# Evolution



**Paper 2: 54 marks**

# Examination Guidelines

**Introduction**

Review the nature of science

- Distinguish between a hypothesis, and a theory.
- **Also understand what is a <u>Scientific Theory</u>**

# Hypothesis and Theory

| TERM | DEFINITION | EXAMPLE |
|---|---|---|
| **Hypothesis** | **A prediction of the possible outcome of a Scientific Investigation. This is done before the investigation starts.** | **The brighter the light, the smaller the diameter of the pupil of a human eye will be.** |
| **Theory** | **An explanation of some aspect of the natural world based on observation of data and tested hypotheses. This is done after a Scientific Investigation.** | **Different life forms originate from a common ancestor.** – *Charles Darwin* |
| **Scientific Theory** | A **scientific theory is an explanation that has been tested repeatedly and verified.** | *The Cell Theory* |

# What is evolution?

- **The Theory of Evolution postulates that all different species arose from simple life forms that existed in the past but they look different now because things change over long periods of time.**
- **Biological evolution refers to the changes that life forms have undergone over long periods of time – distinct from the evolution of the Earth itself.**
- **Biological Evolution means that all present-day species …**
  - **have descended from, and are related to, those that lived in the past.**
  - **may look different because they became modified over time**

# Definition of Biological Species

- Living organisms that have similar features and are able to interbreed. If 2 individuals produce fertile offspring, they are of the same species. (Kind)
- A Population refers to individuals of the same species found in a specific area at the same time.

# Theories of evolution

**Jean Baptiste de Lamarck (1744 – 1829):**
**Two ideas** of Lamarck in explaining evolution:
1. Use and disuse.
2. Inheritance of modified characteristics.

**Charles Darwin (1809 – 1882)**
 Charles Darwin's Theory of Evolution by Natural Selection.
The gradual development of new species – **Gradualism**.

**Punctuated Equilibrium**
The theory states that changes in life forms occurred in spurts of time.
**Stephen J Gould and Niles Eldredge (1972)**
According to this theory there were **long periods** where species did **NOT change** and then there were periods during which many new species formed in a **short period of time.**

# GRADUALISM vs PUNCTUATED EQUILIBRIUM

**Jean Baptiste de Lamarck**

Explain the  two "laws" of De Lamarck
- Law of use and disuse
- Law of inheritance

Explain examples of the application of de Lamarck's theory  (such as in the long neck of giraffe or the legs of snake)

# Lamarck's theory

## Use and disuse of organs

- Changes in the environment create new needs that cause organisms to modify their existing organs to meet the need. Repeated use of the organ would cause it to enlarge and become more efficient. Disuse of a organ would cause it to degenerate

- **Inheritance of acquired characteristics**

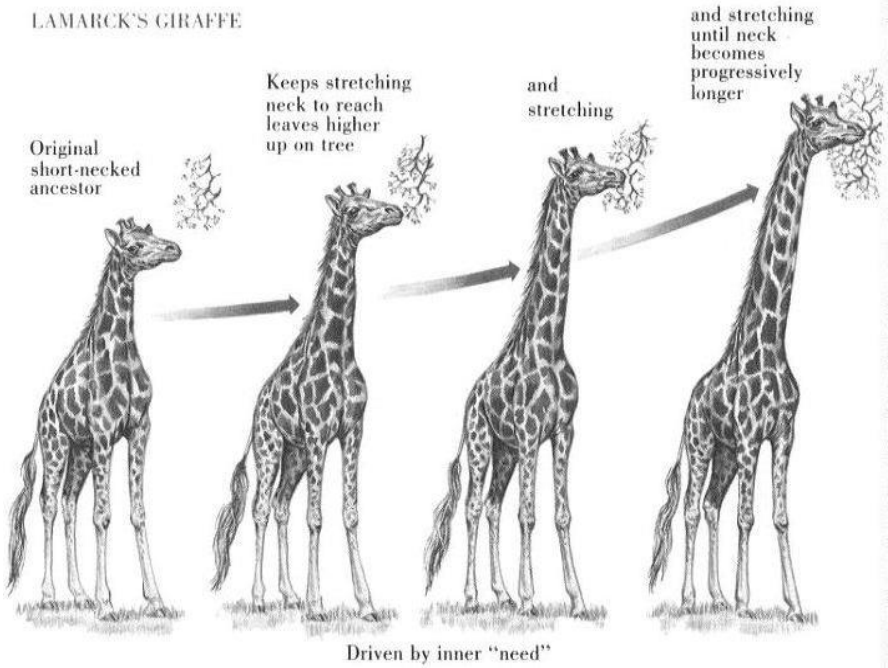
The modification an organism acquired during its life time could be pass on to its offspring.

# How did Lamarck explained the long necks of giraffes?

**Lamarck**

- All giraffes had short necks✓ originally
- Giraffes frequently stretched✓/used their necks to reach
- for leaves of tall trees✓
- necks become longer✓
- The long necks acquired✓ in this way

  could be passed on to the next generation✓ /were inherited




Snake

# Explain that Lamarck's theory is not accepted by most Life Scientists today

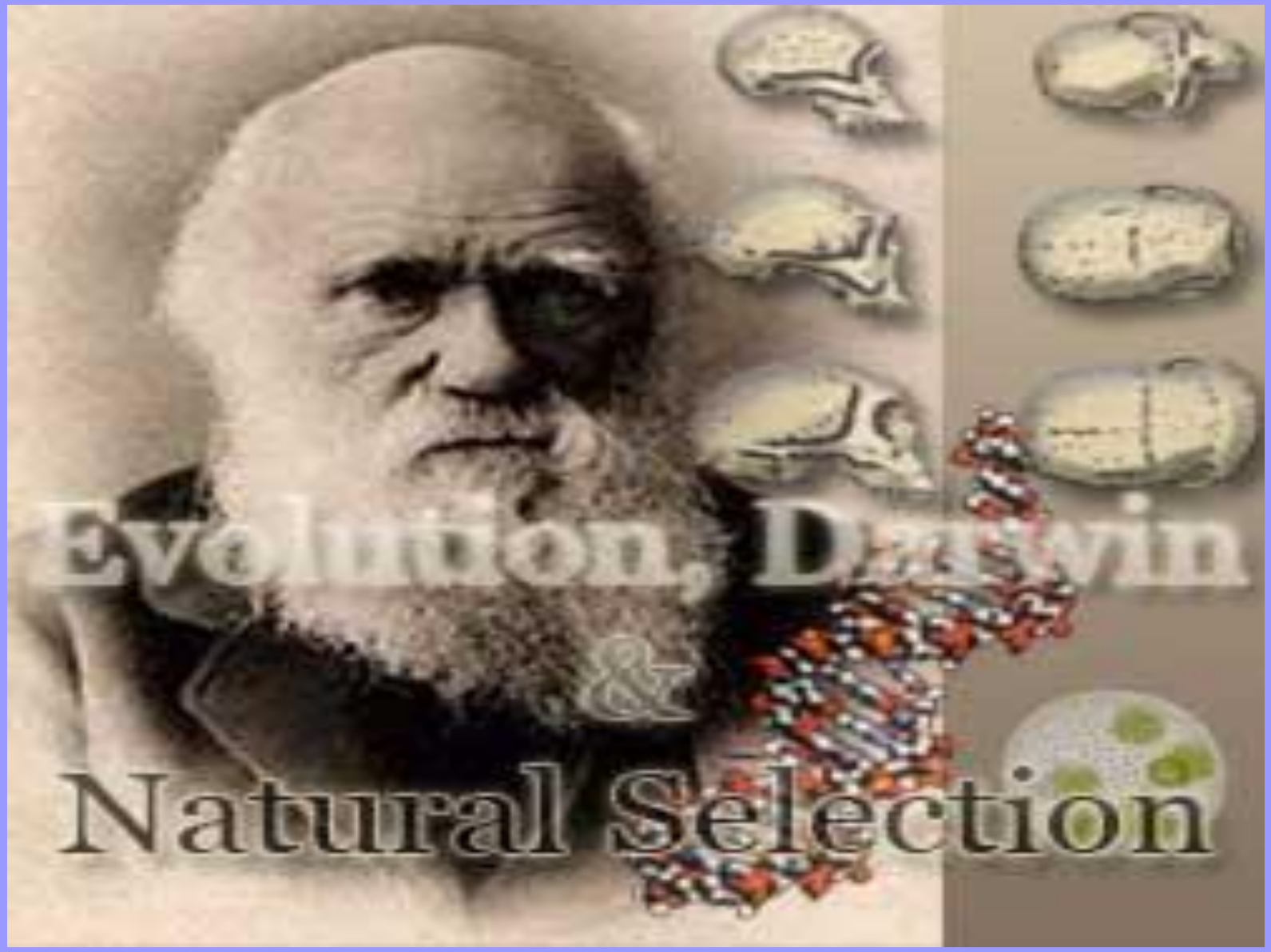
**Acquired characteristics**✓are **not inherited**✓/do not cause any change to the DNA of an organism's gametes (sperms or ova)

**OR**

**Organisms did not evolve because they want**✓ **to evolve**✓

**OR**

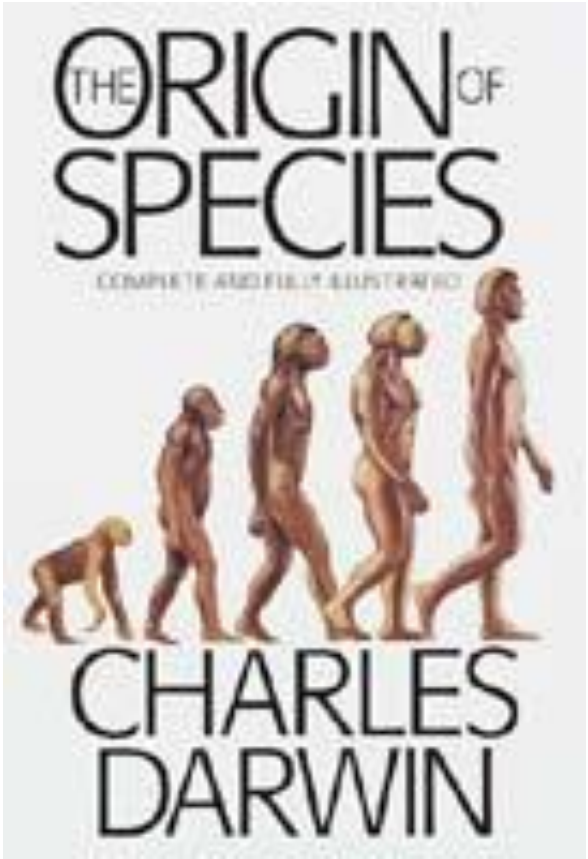
Lamarck believed in **determinism** (internal drive of organisms to change)


Evolution, Darwin
&
Natural Selection

# Charles Darwin

## Observations on which Darwin based his theory:

- Offspring of the same species produce a **large number** of offspring
- Offspring show a great deal of **variation**
- The offspring produced **compete** with each other for resources
- Of the large number of offspring produced, only a **few survive-** ones with best adapted characteristics
- Survival of organisms as a result of **natural selection**



# Darwin's theory of evolution by natural selection

- Most species produce a **large number** of offspring in their life-times
- **Variation:** Offspring of the same species show a great deal of variation
- **Competition**: These offspring compete with each other for food, shelter etc
- **Survival:** Only a small number of offspring survive
- **Genetics**: Organisms pass Genetic traits on to their offspring. later used the term **survival of the fittest**
- **Natural selection** : Those organisms with the Most Beneficial Traits are more likely to Survive and Reproduce.

  Natural Selection from generation to generation caused the population to gradually change …

  leading to the evolution of new **species**

# How would Darwin account for the long necks of the giraffes

- As a result of genetic variation✓in the giraffe population some giraffes have longer necks✓ than others
- Environmental change✓/competition for resources occurred causing those with shorter necks to die✓
- and those with longer necks to survive✓
- This is natural selection✓/survival of the fittest
- The genes✓/genotype for longer necks
- were passed on to subsequent generations✓ most of which now have long necks

# Outline differences between de Lamarck and Darwin's theories

| **Lamarck's** | **Darwin's** |
|---|---|
| Variation of offspring brought about **individuals** in the population changing | Offspring **inherit variation** |
| Individuals want to change | Environmental factors working randomly |
| Change because of adaptation to environment | Natural selection – best suited to the environment to survive |
| **Individuals** in the population change | The **population** as a whole changes |
| Changes brought about by adaptation to the environment are inherited from parent to offspring | Characteristic are passed on from generation to generation to enable individuals to survive in the environment |

**Darwin said variation in a population is essential for Natural Selection. Describe factors which contribute to variation in a population.**

- Random arrangement✓of chromosomes during meiosis in the formation of gametes

  Crossing over✓

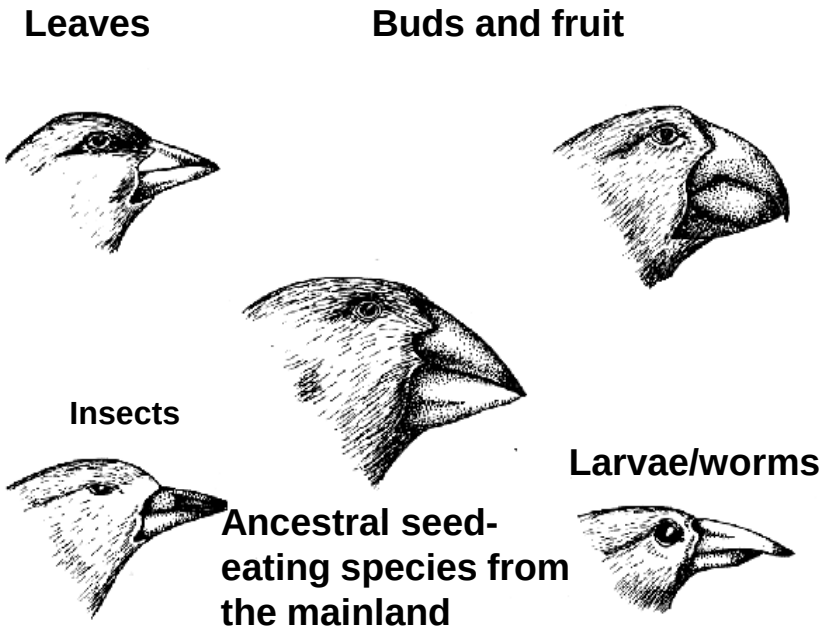
  **OR** meiosis✓
- Random fertilisation of gametes✓
- Mutations✓
- Random Mating

# CONTINUOUS and DISCONTINUOUS VARIATION

- **CONTINUOUS VARIATION:** A range of variations within a species, example from tall to short and many in-between.

- **DISCONTINUOUS VARIATION:** Small number of variations, example ability to roll your tongue or NOT.

# Finches of Galapagos



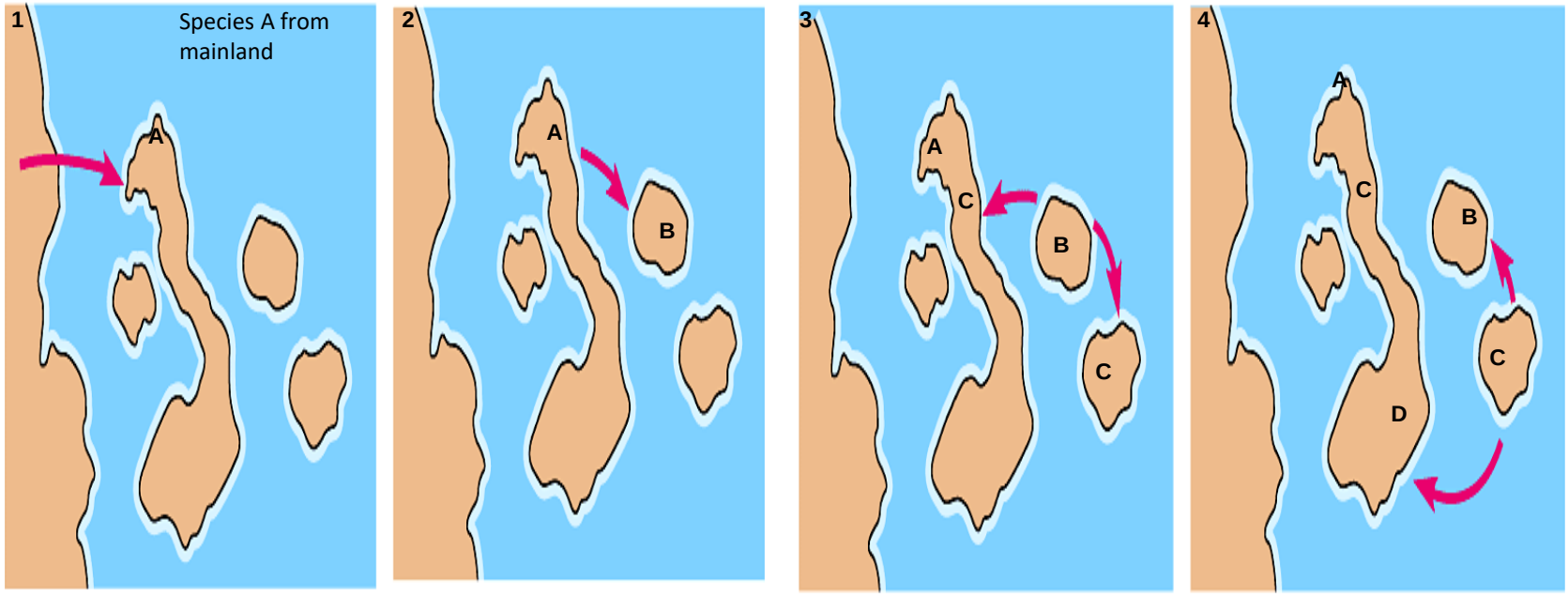

Natural selection example 1


small ground finch
medium ground finch
large ground finch
sharp-beaked ground finch
cactus finch
large cactus finch
small tree finch
large tree finch?
vegetarian finch
woodpecker finch
warbler finch

# Natural selection:

**Explain how Darwin would have used the example of the tortoises to explain speciation.**

- During continental drift✓
- the tortoise populations were isolated/separated✓ from the original population
- on different islands ✓
- living under different environmental conditions✓
- and through natural selection developed into new species✓
- not able to interbreed after a period of time✓


1
Species A from mainland
A
2
A
B
3
A
C
B
C
4
A
C
B
C
D

# SPECIATION

Species as a group of organisms that can interbreed and produce fertile offspring

According to Darwin, various isolation mechanisms are responsible for speciation.

1. Geographic isolation
2. Reproductive Isolation

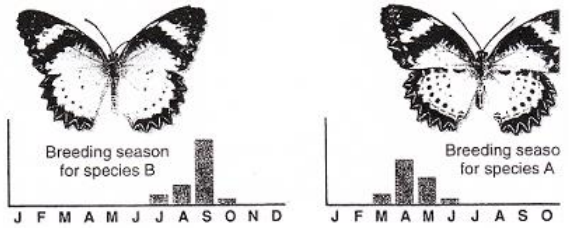
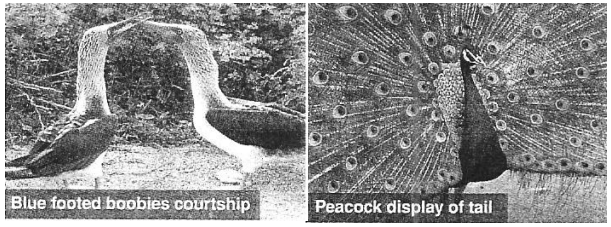
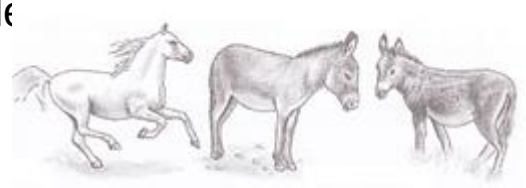
**Examples of reproductive isolation mechanisms:**

- Breeding at different times of the year
- Species-specific courtship behaviour (animals)
- Adaptation to different pollinators (plants)
- Infertile offspring (e.g. mules)



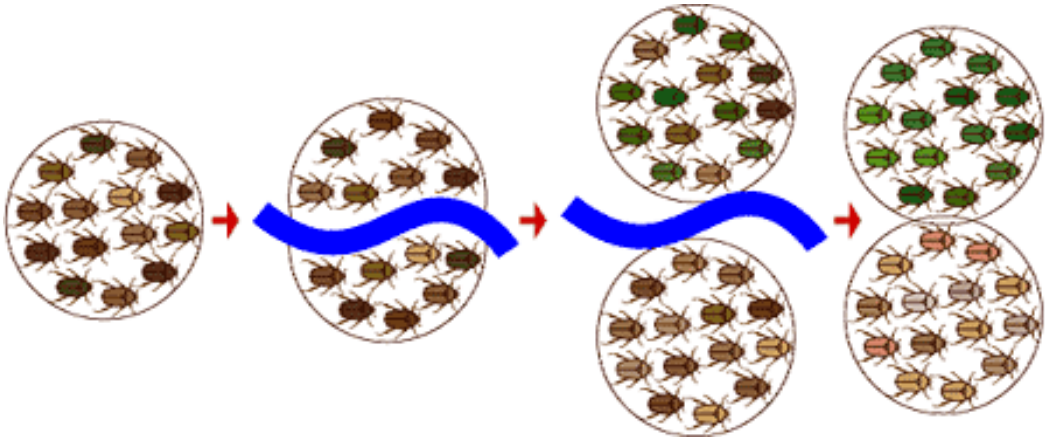
**The Earth 300 million year ago** **Earth today**

Darwin used the concept of Biogeography of animals as evidence for allopatric speciation. The fact that similar organisms are present on different continent indicate that they shar a common ancestor

| Type of barrier | Example 1 | |
|---|---|---|
| Adaptation to different pollinators | Two species of orchid have different length nectar tubes and are pollinated by different species of moths. |  |
| Breeding at different times of the year | Two species of mayflies emerge during different weeks in springtime. |   |
| Species-specific courtship behaviour | Two similar species of birds have different mating rituals. |   |
| Infertile offspring | Two species of frogs are mated in the lab and produce viable, but sterile, offspring. | Horse x donkey = mule  |

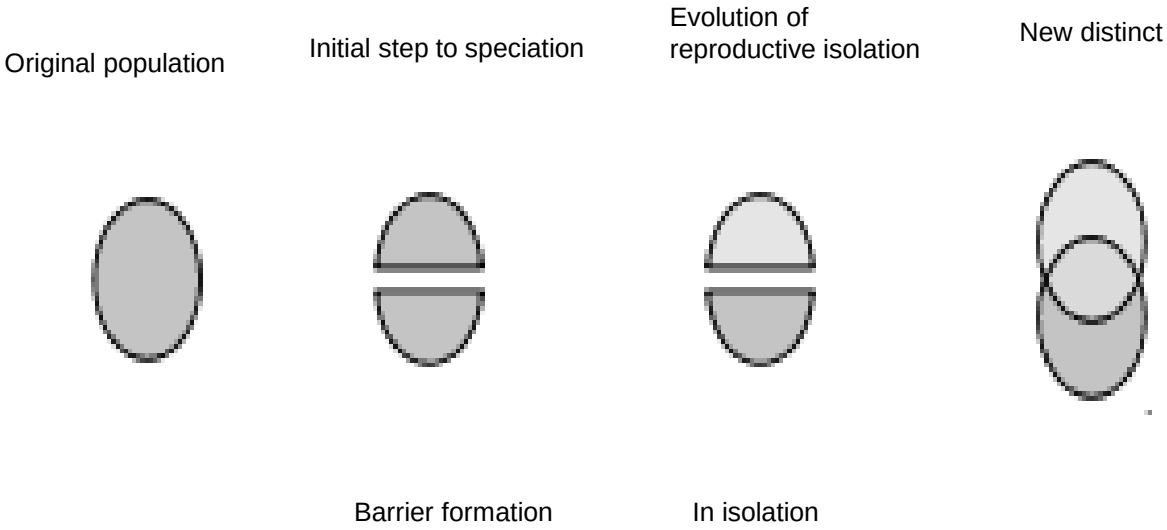
# Speciation through Geographical Isolation

- Speciation (formation of **new species** at ecological, reproductive and genetic level)
- Macro-evolution (patterns, trends and rate of change among lineages over geological times



# SPECIATION due to Geographic Isolation

- In speciation, species diverge because of a geological barrier like, mountain , river, volcano, crack ect.




## Describe how the theory of evolution suggests speciation occurs when a population becomes separated by a geographical barrier.

- The population will split up into **two groups** by a geographical barrier.
- Now there is no gene flow between the 2 populations.
- Each group undergoes **natural selection** independently because each group may be exposed to different environmental conditions.
- Each group may become genotypically
- and phenotypically different.
- This may prevent them from interbreeding/become reproductively isolated leading to the formation of a new species. Examples used – Finches of the Galapagos islands.

# ARTIFICIAL SELECTION

- Also called Selective Breeding, it is the process by which humans breed with animals or plants to get desired traits for our benefit. This is achieved by selecting a certain male and female to mate (pollinate in plants) to produce desired results in the offspring. Eg Guide-dogs for the blind and modern maize cultivars.

# Proposed evidence for evolution

## How is the geological time scale used as evidence or evolution

- Macroevolution refers to the changes that have led to development of the larger taxa (groups) of life forms such as the different phyla, classes, orders, families and genera that we see in the **(1) fossil record**
- Since these changes have taken place over millions of years, it has become more convenient for scientists to develop a **geological time scale** that show the history of life

:

# Paleontology providing evidence for evolution

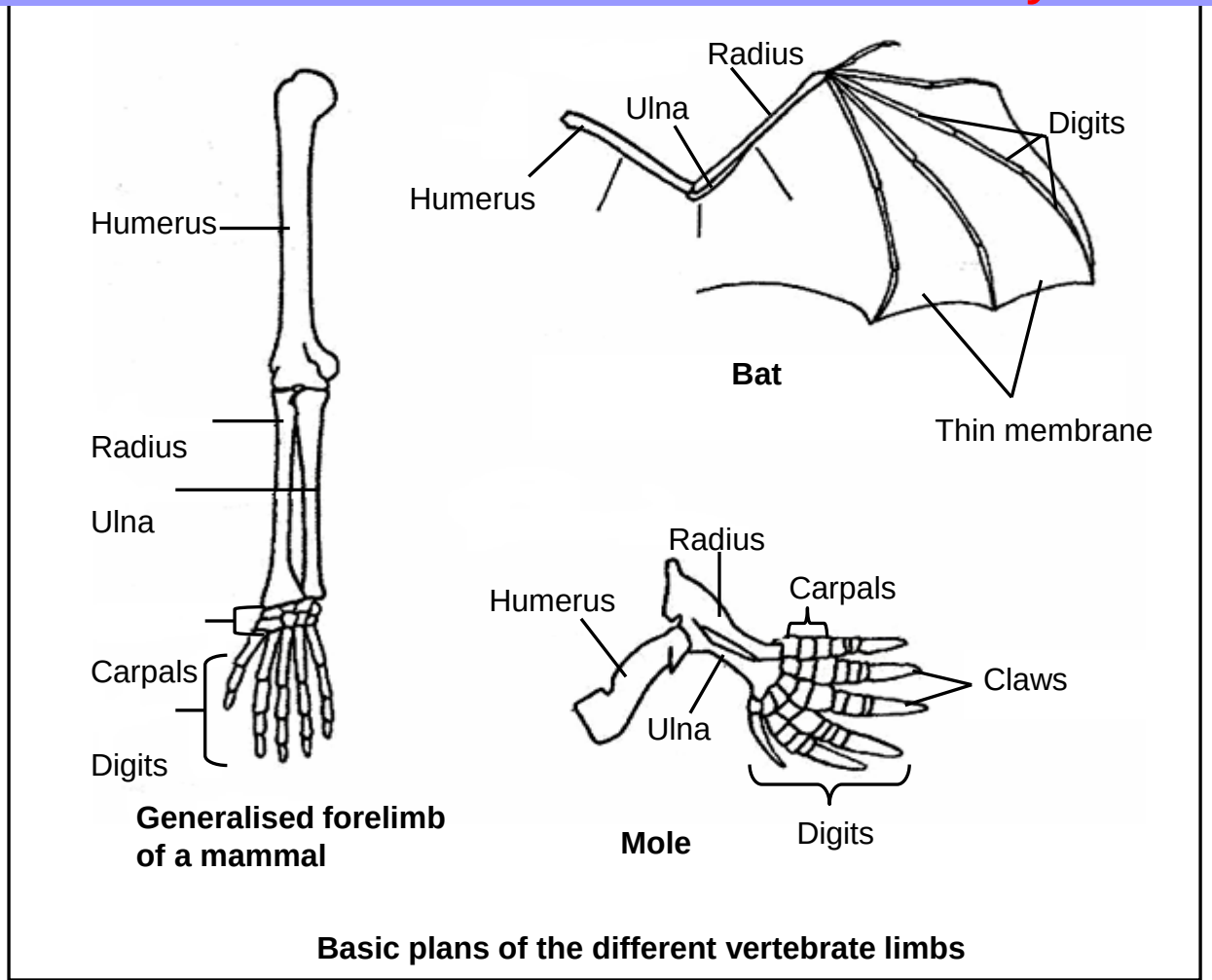
## How do fossils provide evidence for evolution?

Fossils provide evidence of life forms that existed in the past/that are now extinct✓

The interpretation of fossil records help to understand patterns of development amongst species

# 2. Comparative anatomy

Comparison of homologous structures among organisms shows similarities and differences eg. homologous bone structures in the front limbs of different vertebrates that indicate a common ancestor – Modification by Descent




**Basic plans of the different vertebrate limbs**

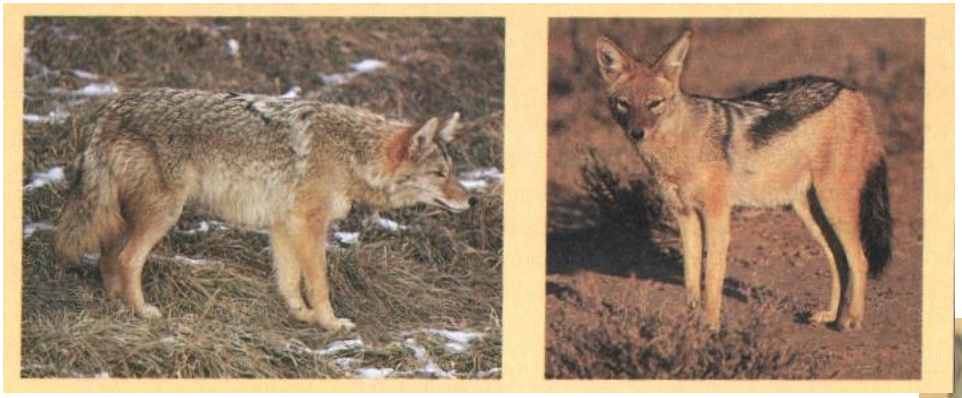
## 3. Genetics

The following features show possible common origin of different organisms

- Identical DNA compounds
- Similar sequence of genes
- Similar portions of DNA with no function
- Identical protein synthesis
- Similar metabolic pathways

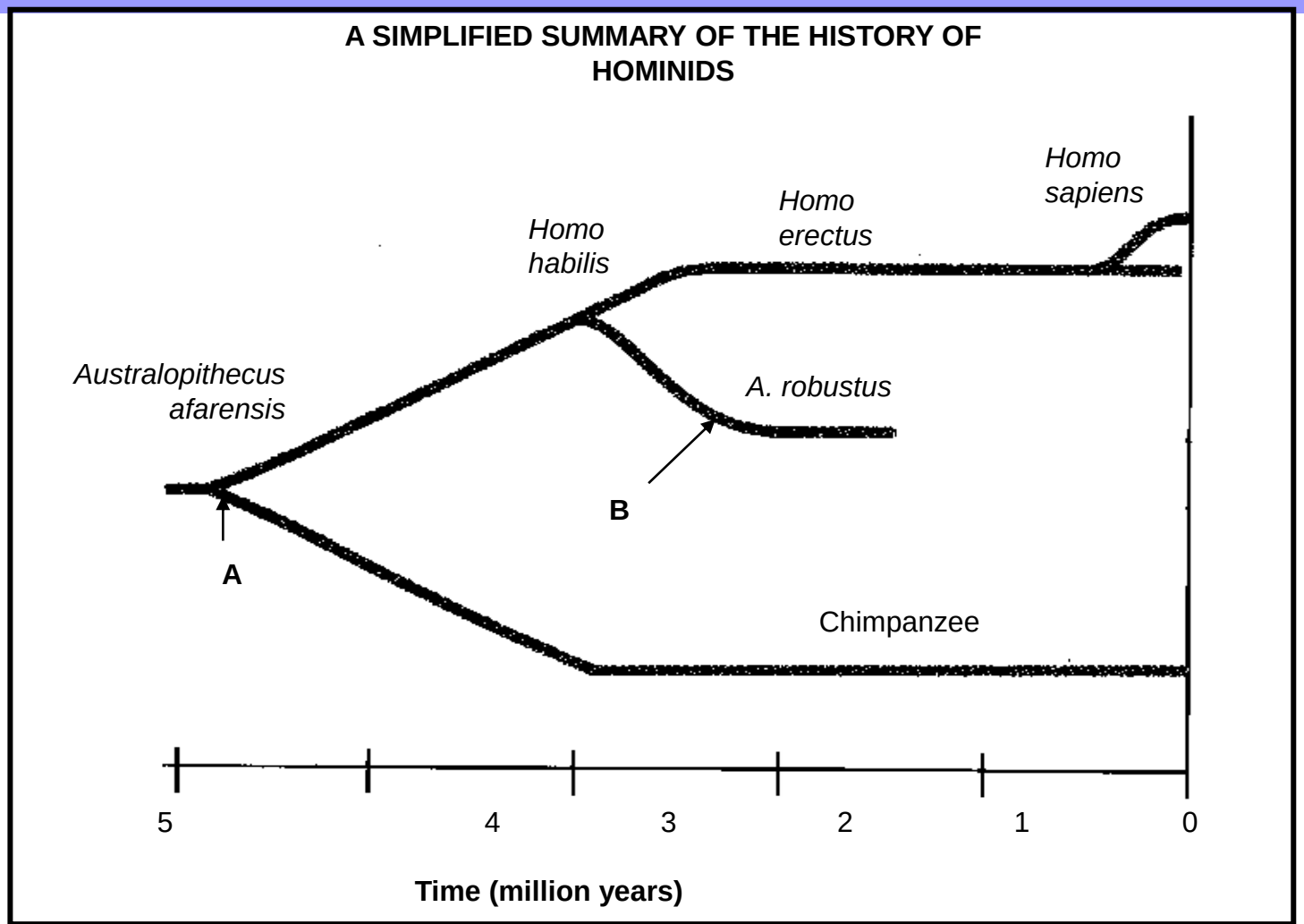
## 4. Biogeography

Different but closely related species in similar biomes across the world have similar features in adapting to that biome, indicating that they probably developed from a common ancestral species



# Our place in the animal kingdom

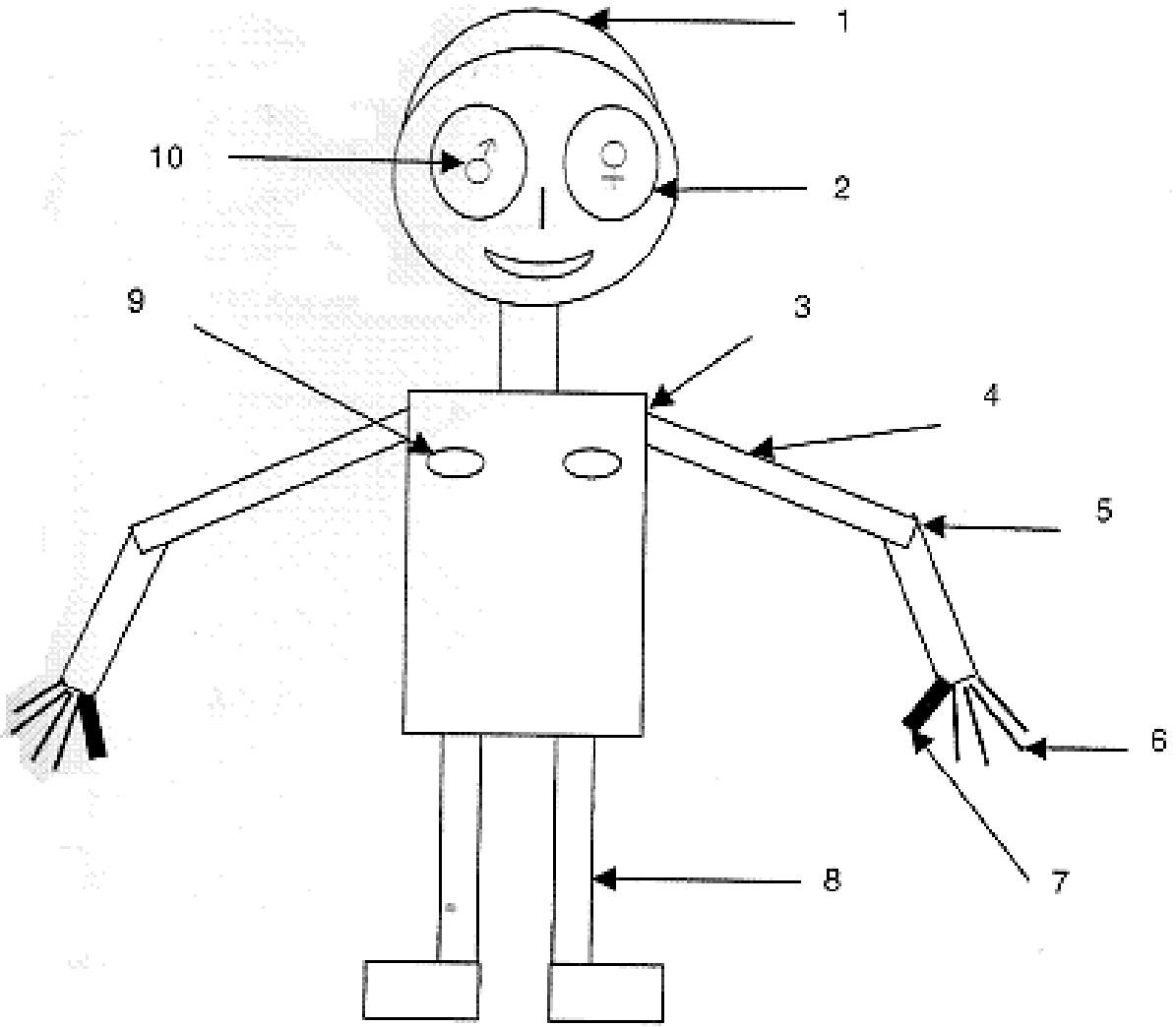
Interpret evolutionary trends using  phylogenetic trees and cladograms



# Structural characteristics of *Homo sapiens* that are similar to other primates.

- Upright posture✓
- Long upper arms✓
- Freely rotating arms✓
- Elbow joints allowing rotation of forearm✓
- Rotate hands at least 180º✓
- Flat nails instead of claws✓/bare finger tips
- Opposable thumbs✓ which work in opposite direction to their fingers
- Large brains/skulls compared to their body mass✓
- Eyes in front✓/binocular vision/stereoscopic vision
- Eyes with cones✓/colour vision
- Sexual dimorphism✓/distinct differences between male and female
- Olfactory brain centres reduced✓/reduced sense of smell
- Parts of the brain that process information from the hands and eyes are enlarged✓
- Two mammary glands only✓

# Similarities between Homo Sapiens and other primates



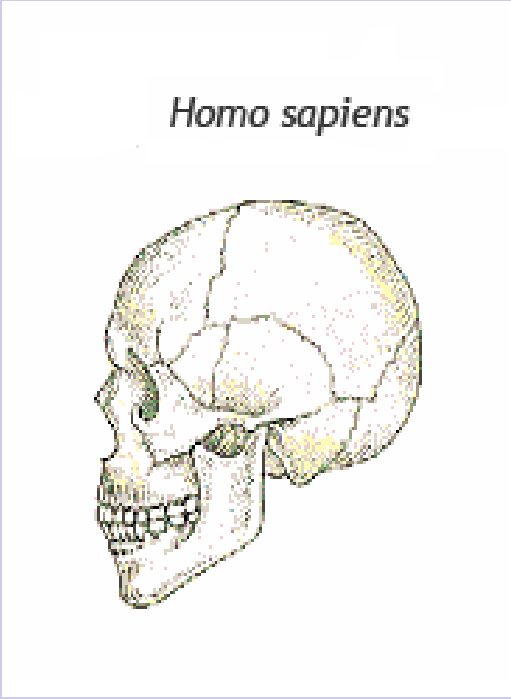
# Characteristics that make us different

| ***Homo sapiens*** | ***Other primates*** |
|---|---|
| Larger cranium✓ /brain | Smaller cranium ✓/brain |
| Face sloping/Forehead slope less backwards | Flat face✓/ Foreheads slope much backwards |
| Foramen magnum bottom of the skull | Foramen magnum at the back of the skull✓ |
| Lower jaw has a well developed chin | Lower jaw has poorly developed chin |
| More protruding jaws✓ | Less protruding jaws✓/prognathous |
| Smaller canines✓ | Larger canines✓ |
| Smaller spaces between the teeth | Larger spaces between the teeth |
| Brow ridges are not as pronounced | Brow ridges pronounced✓ |
| Jaws with teeth on a gentle/round curve | Jaws with teeth in a rectangular/U shape |

# Trends in Human Development

- Shift of foramen magnum to a more forward position
- A more rounded skull and Increased cranium size
- A flatter face due to:
  - Less sloping forehead
  - Less protruding jaws (decreased prognathous)
  - A more developed chin
  - A more rounded jaw
  - Increased size of skeleton
  - Change in dentition
  - More rounded head

**Identify on skull**



# Primate Fossils

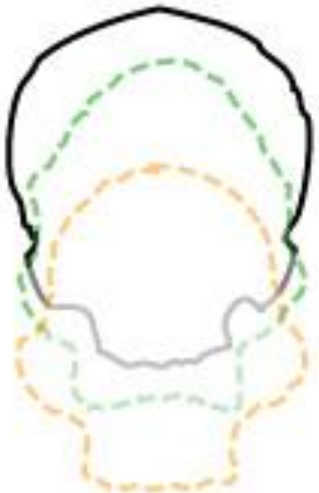
***Australopithecus*** ***Homo erectus*** ***Homo sapiens***

# The Evolution of the Human Skull

**Australopithecines**
Brain Capacity of
400-530c.c.

**Homo Erectus**
Brain Capacity of
775-975c.c.

**Homo Sapiens**
(Brain Capacity of
1200-1600c.c.)



**Skull Size Comparison**

# The contribution of African fossils to the understanding of human evolution

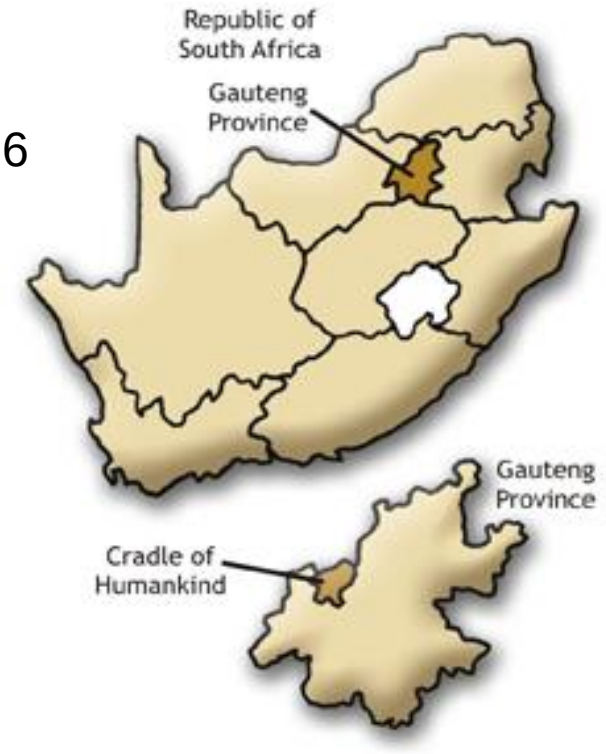
- Fossils found in the Cradle of Humankind and scientists' interpretation of these fossils
- Fossils found in the Great Rift Valley an their interpretation (Nutcracker man, Handy man, Toumai)

# The 'Out of Africa' hypothesis

Fossil evidence for the 'Out of Africa' hypothesis (Mrs Ples, Taung child, Little foot, Karabo,
Nutcracker man, Handy man,Toumai)
Migration of *Homo erectus from Africa into the rest of the world  Genetic evidence for the "out of Africa' hypothesis (DNA from Y chromosomes and mito-*
chondrial DNA)

# The contribution of African fossils to the understanding of human evolutior

- **Mrs. Ples** *(Australopithecus africanus),* Found at Sterkfontein caves by Robert Broom in 1947. 2.6 million year-old fossil)
  - **Little foot** (*(Australopithecus africanus),* 3.9 to 4.2 million year-old fossil Discovered by Ron Clark with the assistance of Steven Motsumi and Nkwane Molefe Sterkfontein Caves, July 1997 on the tibia was found.MOctober 2006 the fossil was brought to the surface.
  - **Taung child,** *(Australopithecus africanus),* Found at Taung ( North West Province) in 1924 by Raymond Dart 2.6 to 2.8 million year-old fossil
- **Karabo***(Australopithecus sediba)* Found at Malapa site in Cradle of Humankind by Lee Berger in April 2010 1.78-1.98 million year-old fossil regarded as Is the missing link between Austrolopithecus Africanus




- **Sientific interpretation of the African fossils found at the Cradle of Human kind.**

The scientific value of ‘Cradle of humankind’ lies in the fact that these sites provide us with a window into the past, to a time when our earliest ancestors were evolving and changing. Scientists have long accepted that all humans had their origins in Africa.

Through the use of biochemical evidence they have argued that the split of the human lineage (Hominidae) from that of the African apes took place around 5-6 million years ago.

- **Fossils found in the Great Rift valley**
  - Nutcracker man, *( Paranthropus boisei)*
    Appear 1.2 to 2.2 milljoen years ago, Fossil found by Mary and Louis Leaky in 1959 in Tanzania
  - Handy man,*( Homo Habilis)* ( Earliest species of Homo)
    Discovered by Peter Nzube in 1968 in Tanzania
  - Lateoli footprints,
    Found by Mary Leaky at Tanzania, 3600 million-years old in 1978
  - Toumai.( *Sahelanthropus tchadensis)*
    Found by Michael Brunet in Chad in 2001

•**Scientific interpretation of Nutcracker man, Handy man, Toumai.**

•Based on the fossil find in the Great Rift valley scientist thought of it as the cradle.

•This is because in 2001, the cranium of a 7 million year old fossil of Toumai was discovered in the central African country of Chad.

- The idea that our earliest ancestors had a southern or east African origin has been overturned.
- Now scientists believe that the cradle o human kind was Central Africa.
- How long this idea will last depends on whether an older hominid fossil is found anywhere else in the world

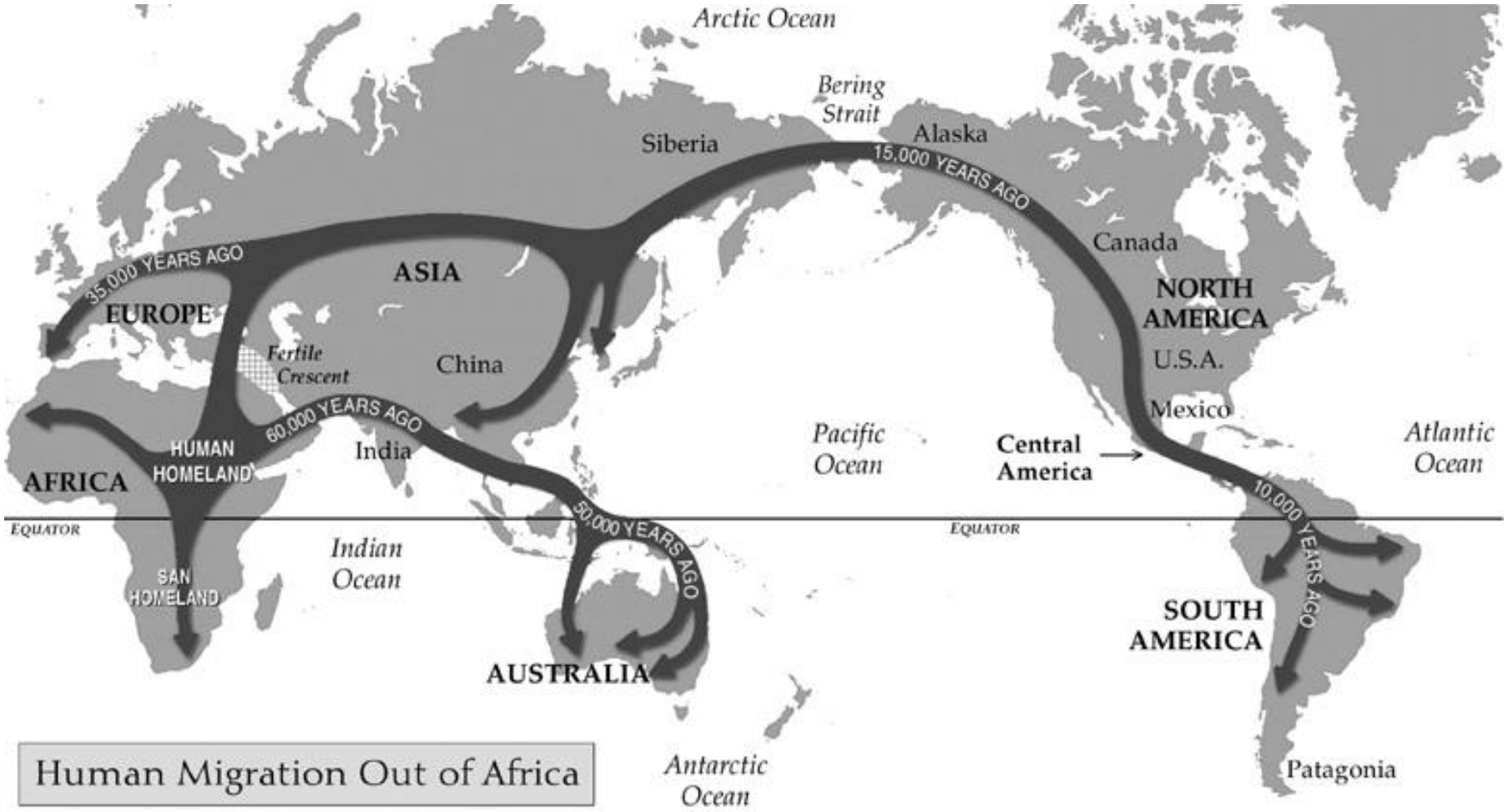
## •The “Out of Africa’ hypothesis

According to most scientists, humans originated from Africa and moved to other countries.

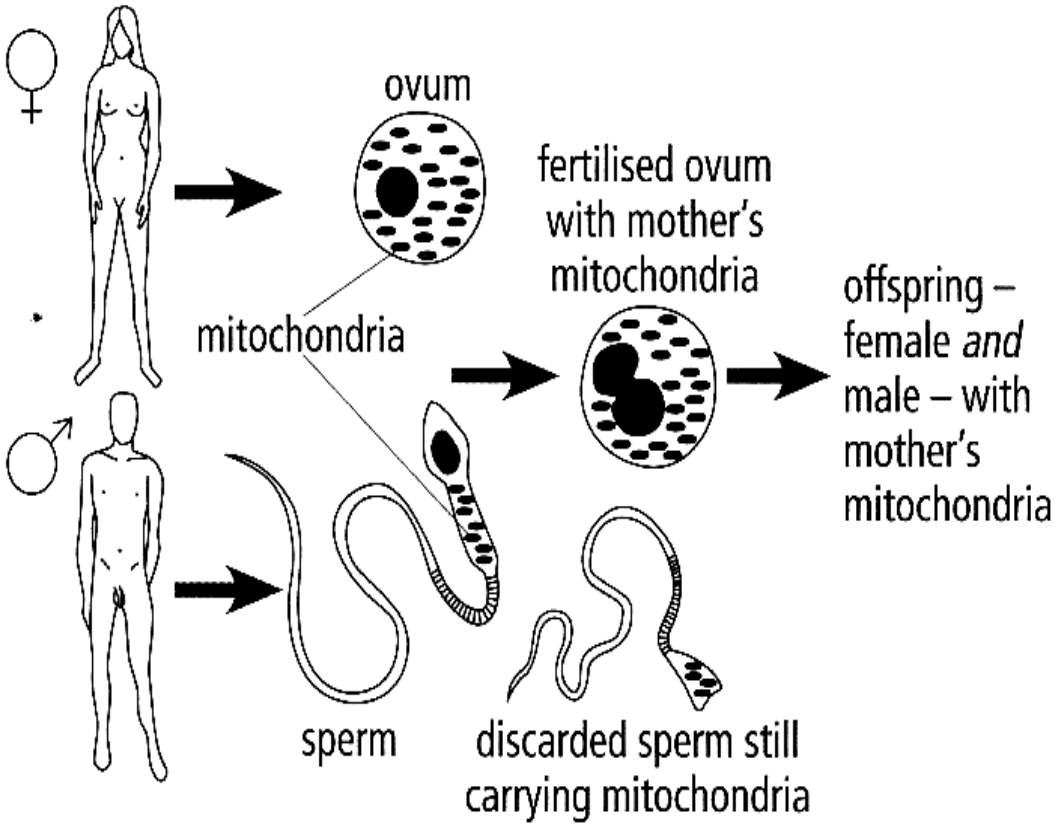
This hypothesis is based on fossil evidence and genetic evidence from fossils of Africa

•Examples of fossils

- **Mrs Ples, Taung Child, Little Foot** *(Australopithecus africanus)* **Nutcracker man**(*Paranthropus boisei*):-
- **Handy man**(*Homo habilis*
- **Toumai** (*Sahelanthropus tachadensis*):-
- **Karabo :** *(Australopithecus sediba)*


Arctic Ocean
Bering Strait
Siberia
Alaska
15,000 YEARS AGO
Canada
NORTH AMERICA
U.S.A.
Mexico
Central America
Atlantic Ocean
Pacific Ocean
35,000 YEARS AGO
ASIA
EUROPE
Fertile Crescent
China
60,000 YEARS AGO
India
HUMAN HOMELAND
AFRICA
EQUATOR
EQUATOR
50,000 YEARS AGO
10,000 YEARS AGO
Indian Ocean
SAN HOMELAND
AUSTRALIA
SOUTH AMERICA
Antarctic Ocean
Patagonia
Human Migration Out of Africa

When DNA is analysed for the purpose of tracing ancestry, a search is made for mutations since individuals who have the same mutation must share the same common ancestor These mutations serves **as markers of decent DNA from Y chromosome AND  Mutant genes from Mitochondrial DNA**

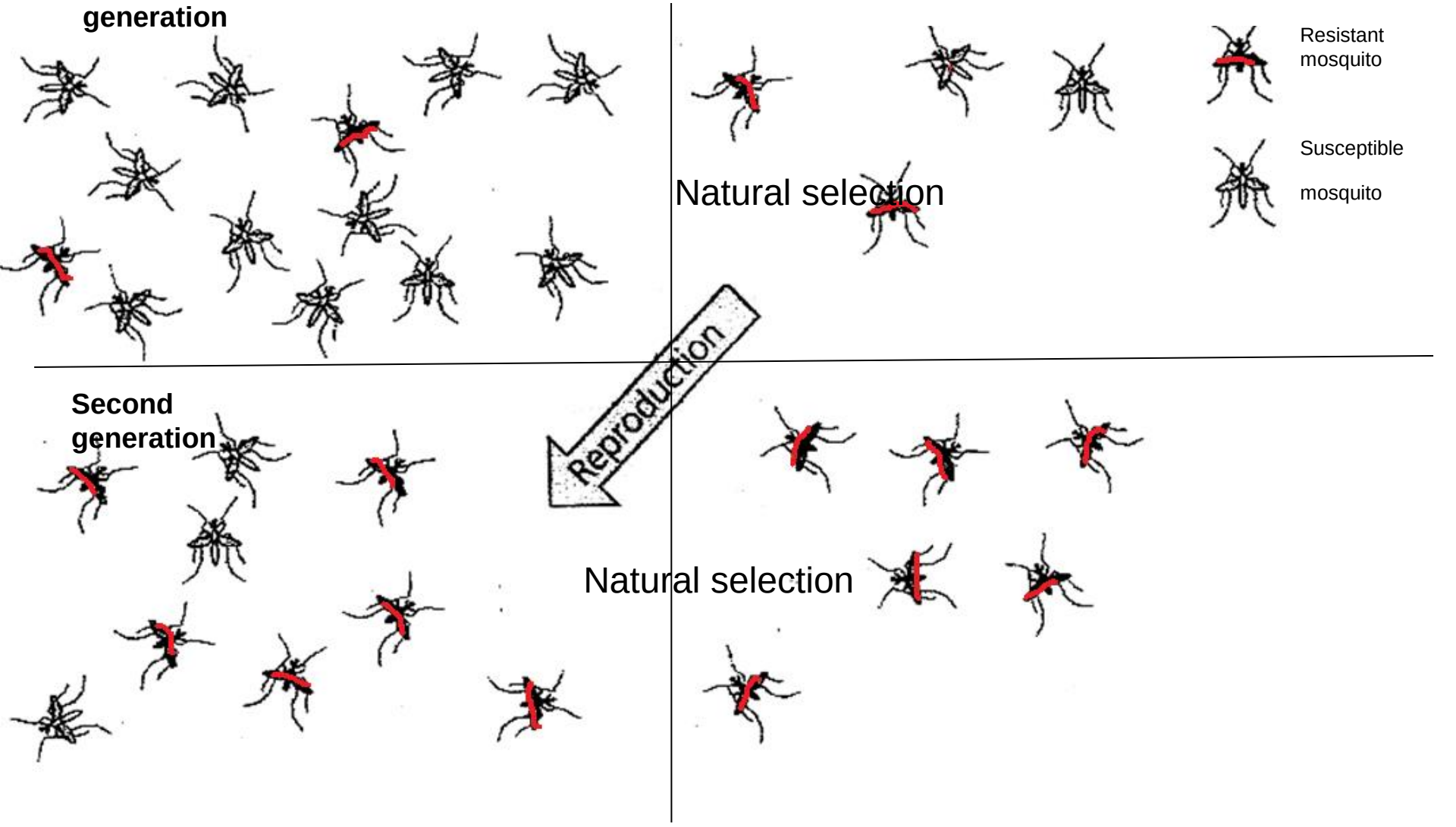


# Examples of evolution by natural selection still occurring in present times:

Use of DDT and consequent resistance to DDT in insects can be explained in terms of natural selection

Development of resistant strains of tuberculosis-causing bacteria (MDR and XDR) to anti-biotics

**Before pesticide application**



# The evolution of drug resistance in bacteria