Aakash + BYJU'S NOTES

Evolution

Key Takeaway

1. Evolution
2. Big Bang Theory
3. Special Creation and Catastrophism
4. Spontaneous Generation
5. Cosmozoic Theory and Biogenesis
6. Chemical Evolution
   - Enclosing the pre biotic system
   - Origin of Heterotrophs and Autotrophs
   - Chemosynthesis and Photosynthesis
7. Modern Theory of Origin of Life

Key Takeaway

8 **Evolution of Life Forms**

9 **Evidences for Evolution**

- Fossils
- Morphological and Anatomical Evidences
- Embryological
- Biogeographical
- Biochemical

10 **Biological Evolution**

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- Darwinism
- Mutation theory

Key Takeaway

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Plants

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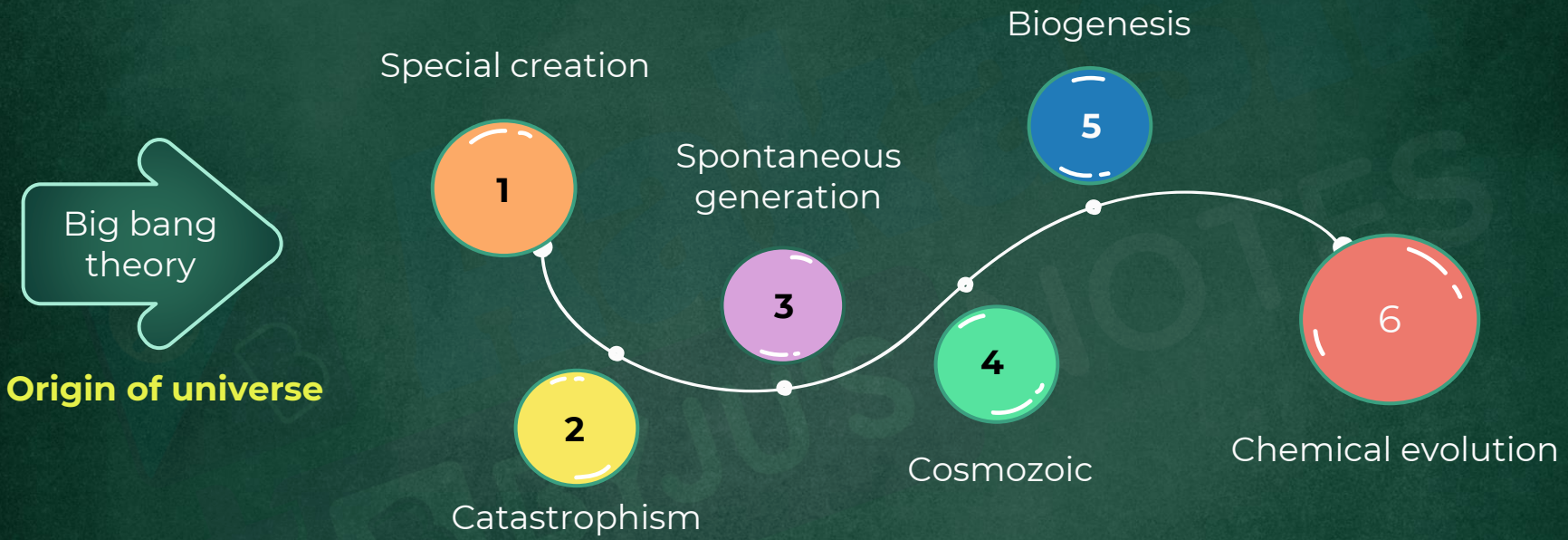
Man

Summary

Evolution

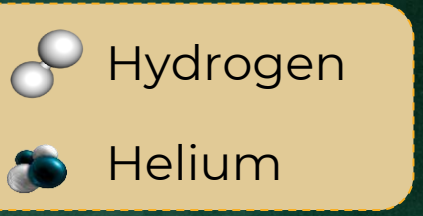
Evolution is **change** in form to another.

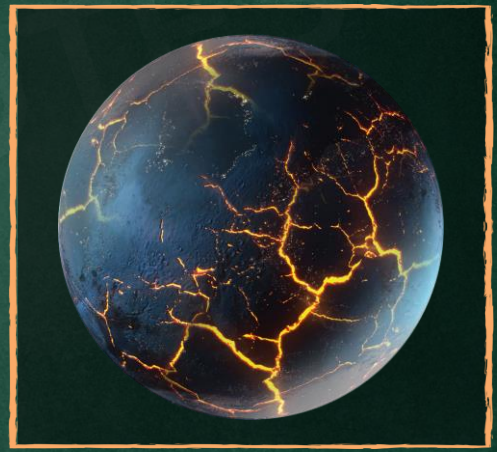


Theories on origin of life

Big Bang Theory

- **Single huge explosion**, unimaginable in physical terms that gave birth to the universe
- Universe is about **20 billion years old**
- Decrease in temperature led to the formation of Hydrogen and Helium gases
- By gravitation, the swirling mass of gases condensed forming galaxies and planets
- Earth was **formed 4.5 billion years** ago approximately
- **Volcanic eruptions** reoccurred and very inhabitable hostile environment on earth was created
- Hence, earth was like a **black ball with no atmosphere**
- From the molten mass of volcanic eruptions, **water vapour, methane, carbon - dioxide** and **ammonia** released and covered the earth's surface





Big Bang Theory

- The **UV rays** from the sun **broke-up water** into **hydrogen**, **oxygen** and the **lighter H_2 escaped**.
- Oxygen combined with ammonia and methane to form water, CO_2 and other molecules.
- Oxygen reacted and **formed ozone layer** (which act as a **shield** for our present environment) around primitive Earth.
- As water vapour condensed, it fell as **rain**, to fill all the depressions and **form oceans**.
- Life originated approximately **4 billion years** ago when it became suitable to support life.

Special Creation and Catastrophism

Special Creation

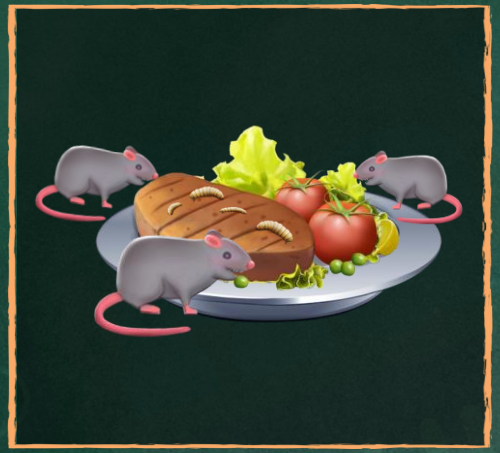
- God/supernatural power created Earth and all possible life forms on **Earth**

Catastrophism

- After a gap of certain period (**age**), the world undergoes a catastrophe (**sudden calamity**)
- **Catastrophe :** Kills almost all the living organisms
- God creates a new generation or new life from inorganic matter

Spontaneous Generation / Abiogenesis

Life spontaneously emerges from non-living matter present on earth.



Life emerges spontaneously from decaying material

No life emerges when material is airtight

- However, Louis Pasteur disproved spontaneous generation by careful experimentation and demonstrated that **life arises only from pre-existing life**.

Cosmozoic Theory and Biogenesis

Cosmozoic theory

- **Greek thinkers** thought **units of life** called **spores** or **seeds** or **sperms** were **transferred** to the earth **from outer space** through **meteorites**
- The transfer of spores was termed **Panspermia**
- It states that life is present throughout the universe
- **Cosmozoic theory :** Transfer of life from one planet to another


Meteorite

Biogenesis

- **First cellular life form :** originated approx. 2000 million years ago
- **Life from life**, (*omnis vivum ex. vivo*) was proved by Redi, Spallanzani and Pasteur independently
- **Pasteur** gave a definite proof of life arising **from pre-existing life using microbes** and sterilization methods.
  - He performed **"swan neck flask" experiment**.

Chemical Evolution

Oparin – Haldane Hypothesis

- **First life** emerged from **pre-existing non - living organic molecules** (E.g., RNA, proteins)

Simple organic micromolecules

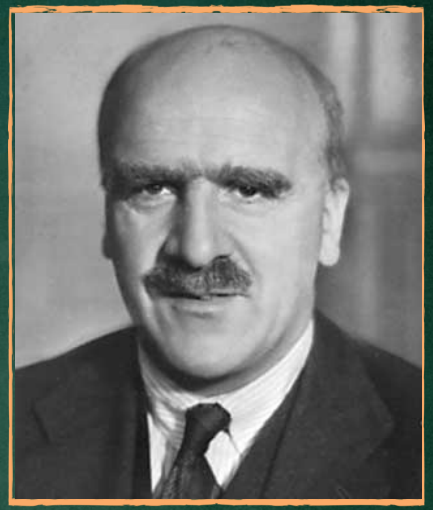
↓

Large complex macromolecules

↓

Origin of life

Oparin

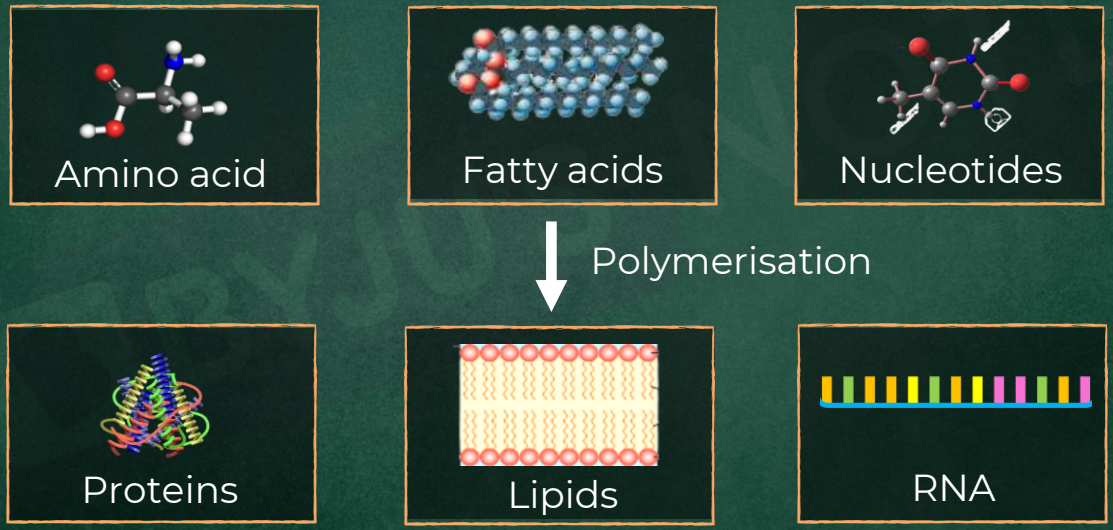


Haldane

Chemical Evolution

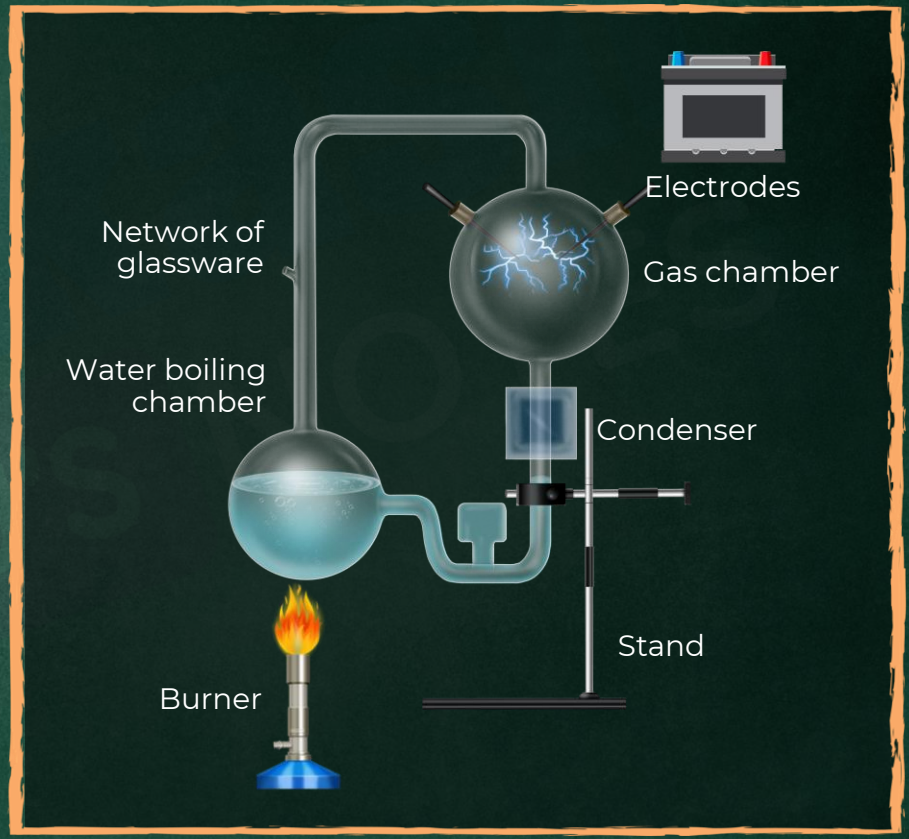
Oparin – Haldane Hypothesis

- Formation of life was preceded by chemical evolution i.e., formation of diverse organic molecules from the inorganic constituents.
- The **conditions on earth** were – high temperature, volcanic eruptions, reducing atmosphere containing CH_4, NH_3 , etc.



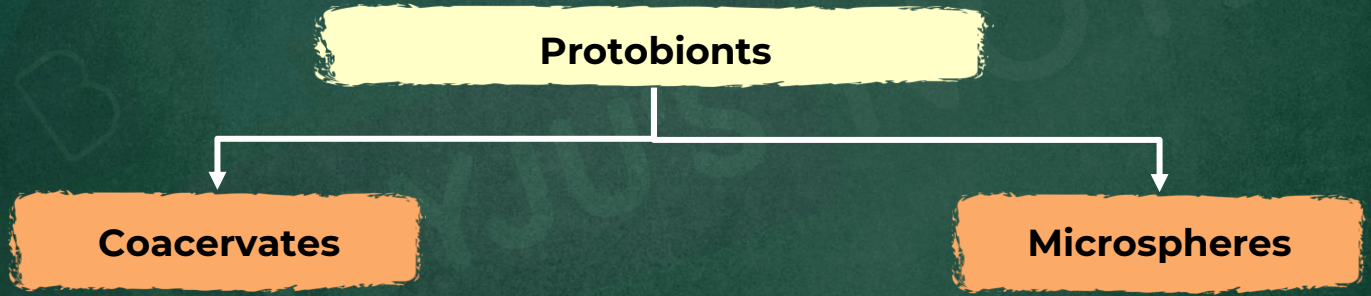
Miller Experiment

- In 1953, **S.L. Miller**, an American scientist created **similar conditions at a laboratory scale**.
- He **created electric discharge in a closed flask** containing CH_4, H_2, NH_3 and water vapour at **800°C**, and observed formation of amino acids.
- In similar experiments, others observed **formation of sugars, nitrogen bases, pigment and fats**.
- **Analysis of meteorite content** also revealed similar compounds indicating **that similar processes are occurring elsewhere in space**.



Enclosing the Prebiotic System

- **Three conditions** needed to fulfill the origin of life :
  - supply of self-replicators i.e., **self-producing molecules**
  - **copying** of these replicators - subject to error via **mutation**
  - system of replicators required a perpetual **supply of free energy** and **partial isolation** from the general environment
- **Protobionts** : aggregates of artificially produced prebiotic molecules and separate molecules from the surrounding



Large protein + polysaccharides = Coacervates
Does not have lipid outer membrane
Do not reproduce

Organic compound (artificial) + cool water = Microspheres
Have bilipid outer membrane

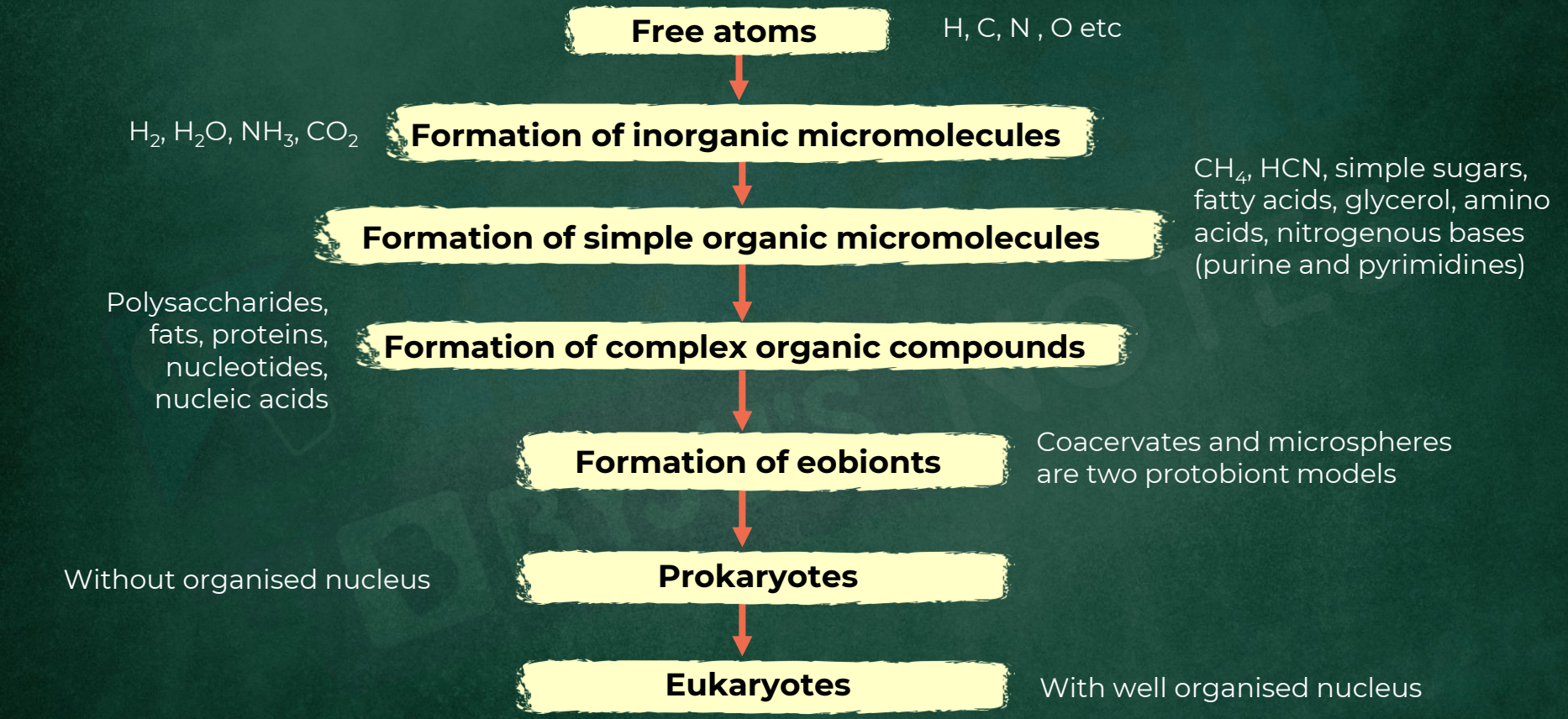
Origin of Heterotrophs and Autotrophs

Heterotrophs	Autotrophs
• The **first living organisms** originated among organic molecules and in oxygen free atmosphere • **Obtained energy by the fermentation** of organic molecules • **Anaerobic**, capable of respiration in the absence of oxygen • **Required organic material as food;** hence, **chemoheterotrophs**	• When the **supply of existing organic molecules was exhausted**, some of the **heterotrophs** might have **evolved into autotrophs** • Organisms were **capable of producing** their **own organic molecules** by **chemosynthesis** or **photosynthesis**

Chemosynthesis and Photosynthesis

Chemosynthesis	Photosynthesis
• Organisms – **chemoautotrophs** • **Anaerobic** in nature • Have ability to **synthesise organic molecules** from inorganic raw materials • **E.g.,** sulphur bacteria, iron bacteria, nitrifying bacteria	• Organisms – **photoautotrophs** • Use **solar energy** to **synthesise food** with the help of **chlorophyll** • Lacked the biochemical pathways to produce oxygen, **anaerobic** and utilized hydrogen from sources other than water

Modern Theory of Origin of Life



Evolution of Life Forms

Darwin's observation

- Every living organism, whether animal or plant, has its own '**characteristic**'
- All existing **life forms shares similarities to varying degrees** and **may also share common ancestors**
- Geological history of the Earth closely correlates with the biological history of Earth

Natural selection

- Characteristics that enable some organisms to survive better than others in the same environment, are said to be selected by nature
- Better fit organism in an environment has higher reproduction rate than others
- This capability to survive is called **fitness** or **reproductive fitness**

Evidences for Evolution

Fossils

Morphological and Anatomical

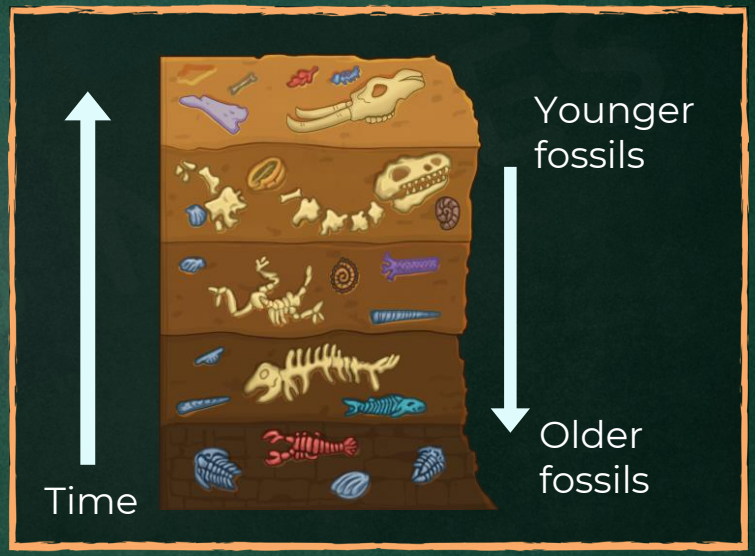
Embryological

Biogeographical

Biochemical

Evidences for Evolution : Fossils

- These are preserved remains or traces of **hard parts of ancient life-forms** like bones, teeth, shells, woods, etc. in rocks
  - **Number and nature of fossils in early rocks :**
    - **Number** - less than in later eras
    - **Nature** - Simple marine invertebrates
  - **Distribution in successive strata:**
    - **Proterozoic era** - few fossils
    - **Paleozoic era** - abundant fossils of invertebrates
    - **Mesozoic era** - fossils of great reptiles (Dinosaur)
    - **Cenozoic era** - abundant fossils of mammals

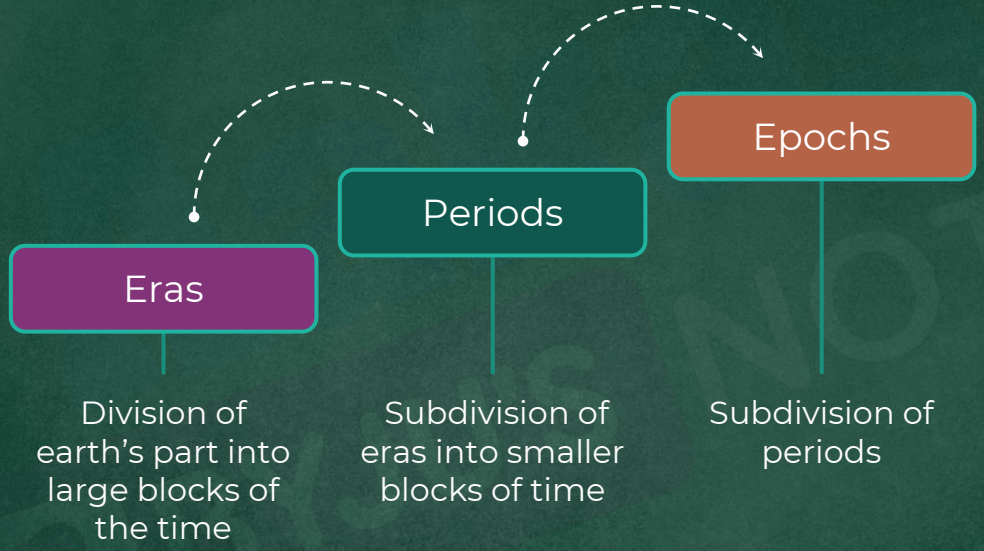


Evidences for Evolution : Fossils

- **Disparity between the past and present forms of life :**
  - Early organisms were very different from their modern forms
- **Missing links (Transitional forms) :**
  - Fossil organisms show characters of two different groups

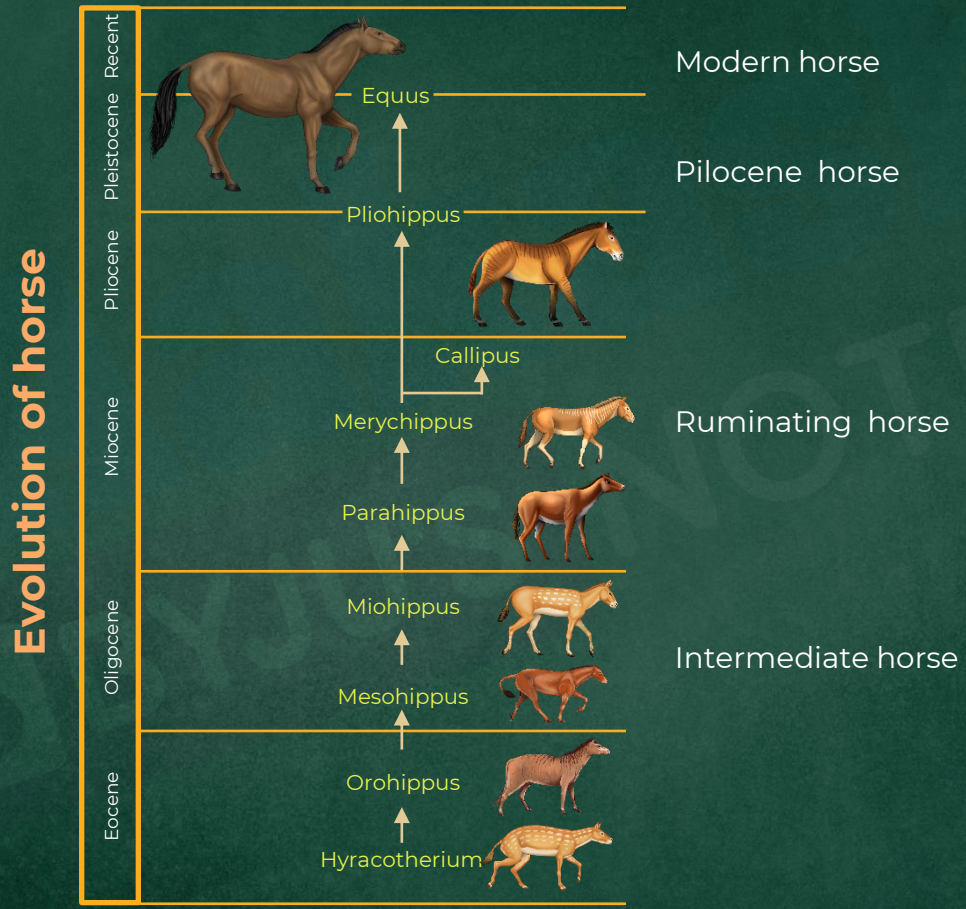
Evidences for Evolution : Fossils

- **Timeline of evolution :**



- **Fossil parks :**
  - Birbal Sahni Institute of Palaeobotany, Lucknow (20 million years old fossil forests)

Evidences for Evolution : Fossils



Evidences for Evolution : Fossils

Radioactive/ Carbon dating

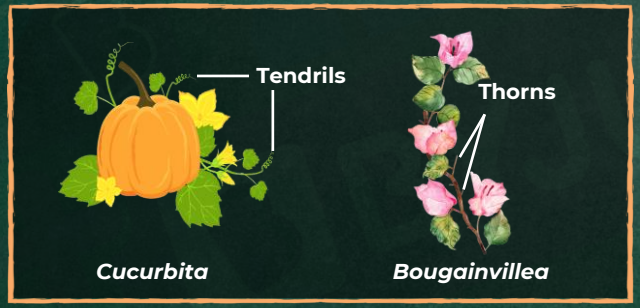
- It is a method for **determining the age of an object** containing organic material by **measuring amount of C-14 present**.

Significance

- Gives clues to organisms that are **long extinct**
- Show intermediate forms of species as they **underwent speciation**
- By comparing **fossils** from **different species**, scientists figure out which **species are related to which others**

Evidences for Evolution : Morphological and Anatomical Evidences

Homologous structures	Vs	Analogous structures
• Similar in anatomy but different functions		• Not similar anatomically but perform similar functions
• Common origin		• Different origin



Different function - Tendril support and thorns protect plants
Same structures - Modified branches

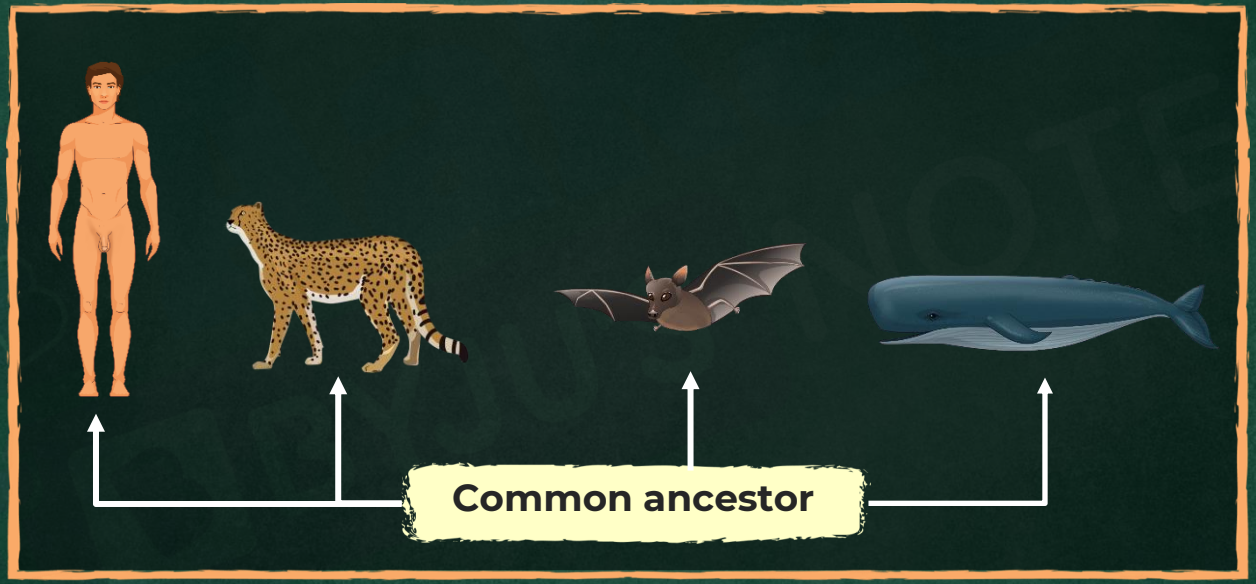
Same function - Flying
Different structures - Wing

Evidences for Evolution : Morphological and Anatomical Evidences

Homologous structures examples	Vs	Analogous structures examples
• **Hearts in various vertebrates** (fishes, amphibians, birds and mammals) • Similarity in basic plan but varied degree of specialization		• **Eye of octopus and of mammals** : Different internal structures but with common function of vision
• **Brain of vertebrates** : similar in basic structure but progressive complexity		• **Flippers of penguins and dolphins** : Different internal structure and origin but common function of swimming
• **Biochemical** : Proteins found in the blood of man and ape are similar		• **Sweet potato and potato** : Modified underground root and stem respectively but common function of storage of food

Evidences for Evolution : Morphological and Anatomical Evidences

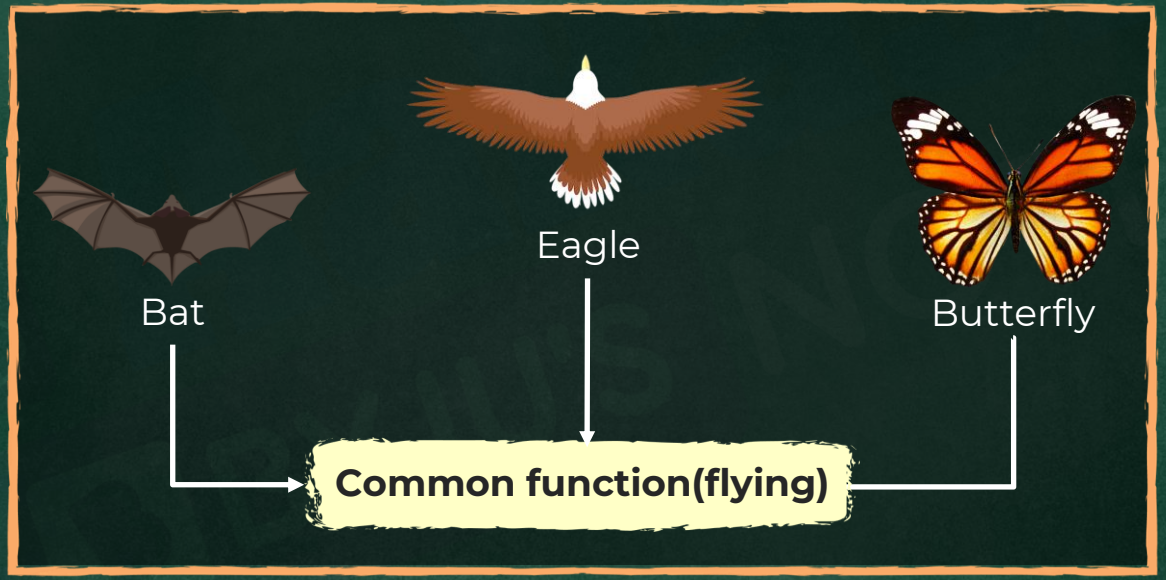
Example of homologous organs in animals



Divergent evolution

Evidences for Evolution : Morphological and Anatomical Evidences

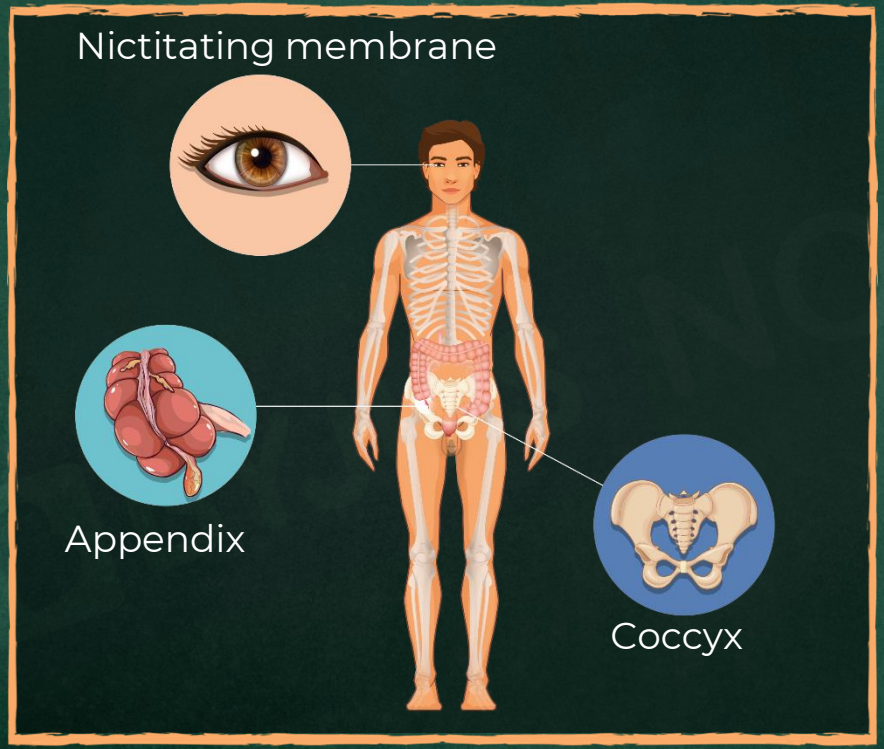
Analogous structure in birds



Different structures evolved due to adaptation to similar needs: Convergent evolution

Evidences for Evolution : Morphological and Anatomical Evidences

Vestigial organs : Remnants of organs which were complete and functional in ancestors



Evidences for Evolution : Morphological and Anatomical Evidences

Connecting link : Organisms sharing characters of two different groups

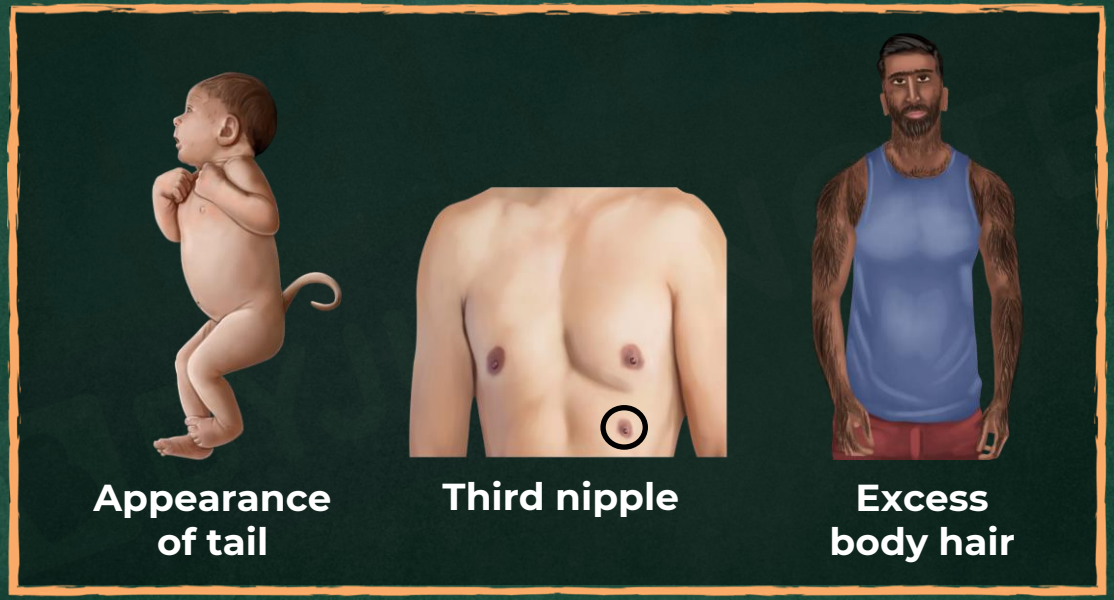
Reptiles ←  → Mammals

Duck-billed platypus

- E.g., The duck billed platypus, is a connecting link between **reptiles** and **mammals**.
- Mammal like features are **mammary** glands, hair, diaphragm, etc, and like reptiles, they lay **eggs**.

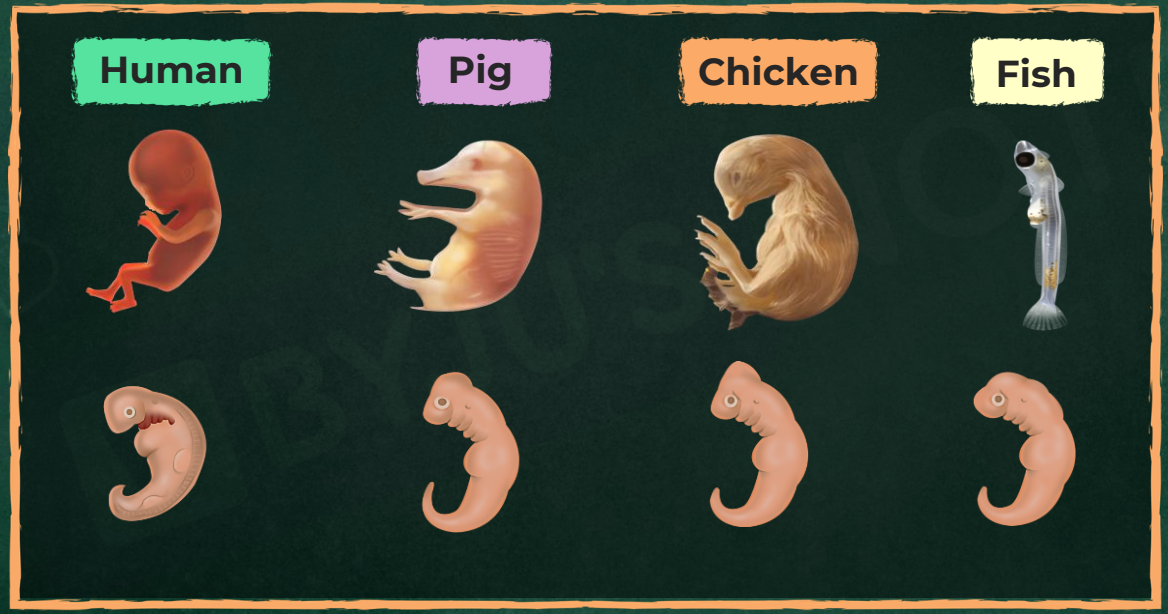
Evidences for Evolution : Morphological and Anatomical Evidences

Atavism : The reappearance of a trait that had been lost during evolution



Evidences for Evolution : Embryological

- **Similarity in early development** among all multicellular animals from a fertilized egg (zygote) to formation of primary germ layers
- **Resemblance among vertebrate embryos** :



Evidences for Evolution : Embryological

- **Resemblance among invertebrates** : Trochophore larva of annelids and molluscs
- **Development of vertebrate organs** (e.g., heart, brain, kidney) is the possible path of evolution
- **Progressive metamorphosis** : Ammocoete larva of Lamprey (presumed that Lamprey has evolved from *Branchiostoma*)
- **Retro regressive metamorphosis** : *Sacculina* and *Herdmania*
- **Temporary embryonic structure** : Bird embryo with tooth buds and gill clefts, Whale embryo with hair and early tadpole of frog with tail

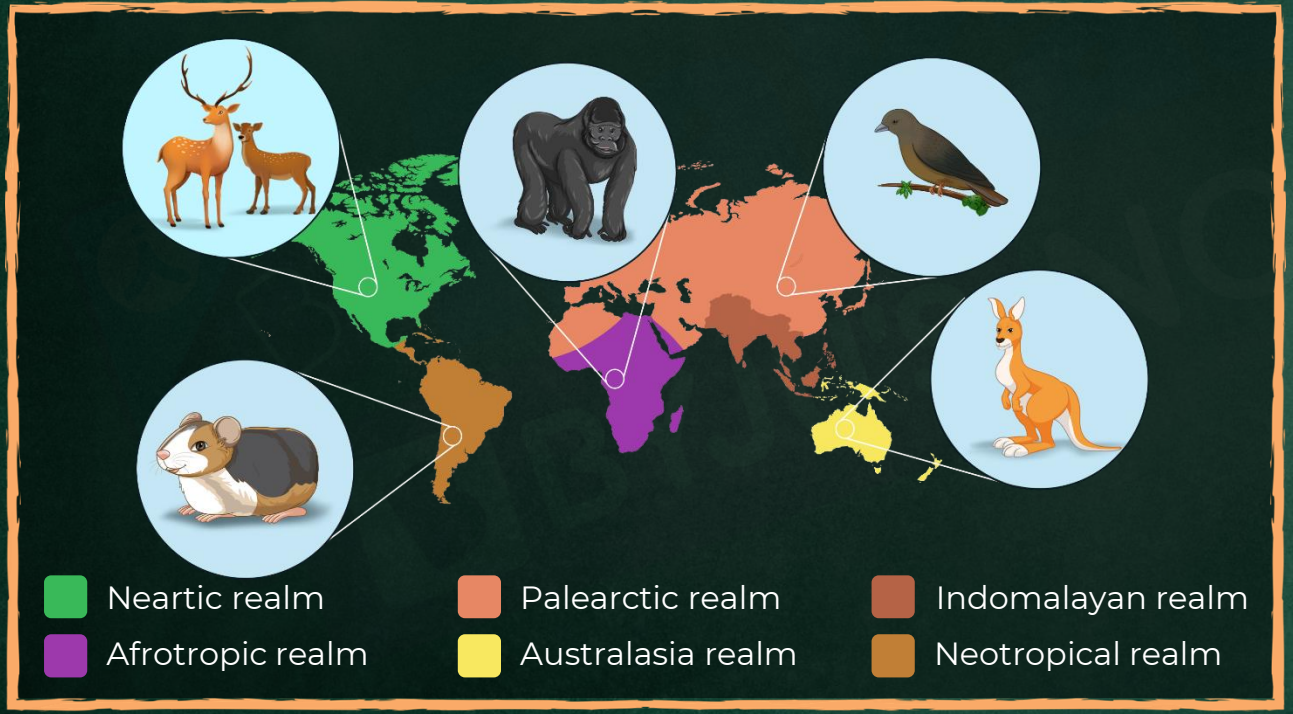
Biogenetic law

- Proposed by **Ernst Haeckel**
- It states that “each embryo's developmental stage represents an adult form of an evolutionary ancestor”.
- **E.g.,** Vestigial gill slits present in the embryos of all vertebrates including humans, but functional organ only in fish
- Occurrence of ancestral traits in embryo - **Palaeogenesis**

Evidences for Evolution : Biogeographical

Distribution of animals and plants in different parts of the earth

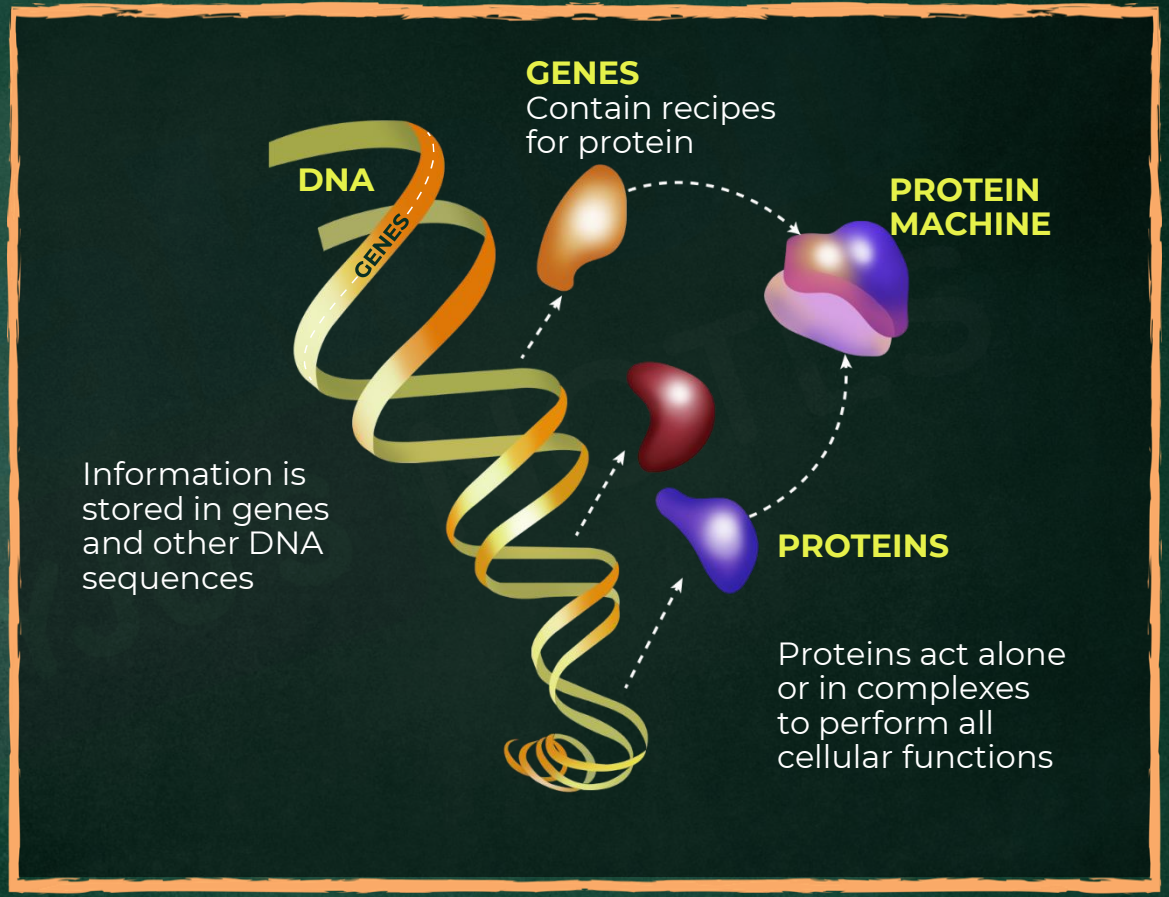
- **Discontinuous distribution :** of closely related species are widely spread
- **E.g.,** Elephants found in Africa and India are not found in similar climate of Brazil



- **Restricted distribution :** Parts separated from mainland have unique flora and fauna.
- **E.g.,** Australia has egg laying mammals and pouched animals

Evidences for Evolution : Biochemical

- **Similarities in proteins** and **genes** performing a given function among diverse organisms give clues to common ancestry.
- These **biochemical similarities** point to the same **shared ancestry as structural similarities** among diverse organisms.



Biological Evolution : Lamarckism

Lamarck's theory

- Given by **Jean Bapist de Lamarck**, French naturalist
- Theory was discussed in his book "**Philosophie Zoologique**" published in 1809
- **Key point** - Organisms change their characteristics and these changes are inherited by offspring

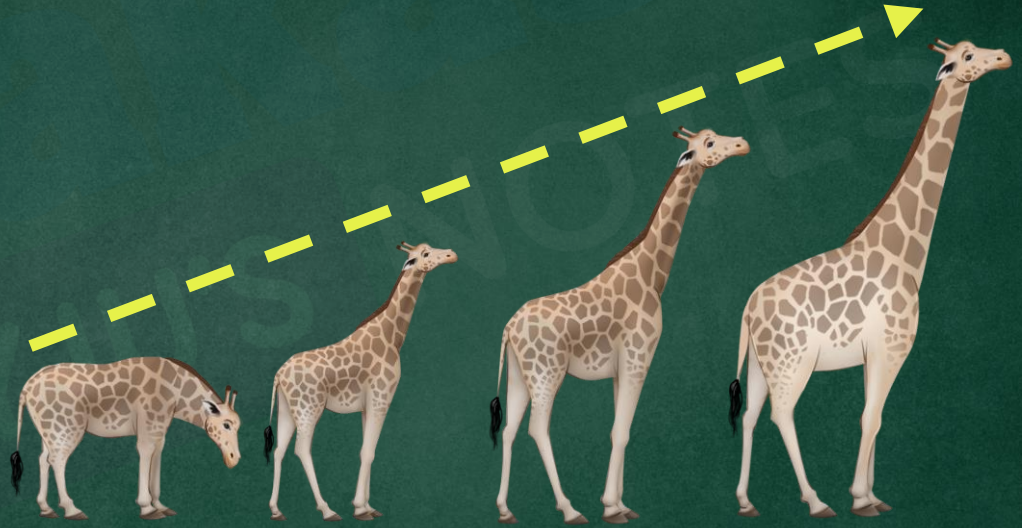
Lamarck's theory : Postulates

- **Internal forces** - increases size of the body
- **Doctrine of Appetency/ desires** - formation of new organs due to continuous need or want felt by the organism
- Development and power of action of an organ $\propto$ Use
- **Inheritance** - transfer of the acquired changes to the offspring
- **Use and disuse** of organs: If an organ is constantly used it would be better developed whereas disuse of organ results in its degeneration

Biological Evolution : Lamarckism

Lamarck's theory : Example

- **Ancestors of Giraffe** had **small neck** and **forelimbs**
- Due to loss of grass with time, they began to stretch their neck to reach out to eat the leaves from tall trees
- Hence, **with time** this lead to **neck and forelimbs elongation**.



Biological Evolution : Darwinism

Darwin's theory

- Given by **Charles Robert Darwin**
- Darwin was inspired by **Thomas Malthus** ideas
- Darwin asserted that variations which are heritable and which make resource utilisation better for few (adapted to habitat better) will enable to reproduce with more progeny

Biological Evolution : Darwinism

Darwin’s theory : Concept of fitness

- **Differential reproduction** - Some of the survived individual which reach adulthood to reproduce at different rates
- **Survival of the fittest,** in the struggle for existence, will **depend on** the **characteristic trait** of the organism.
- **Survival of the fittest** was first used by **Herbert Spencer** and this was, in the same context, asserted by **Darwin** as **"Natural Selection"**
- **Biotic potential :** Ability of an organism with a variation in a population to reproduce and increase in number when compared to the other organisms in the population
- **Cause of variation**: Recombination and intermingling of two widely spread populations

Biological Evolution : Darwinism

Darwin's theory : Branching descent and natural selection

Branching descent :

- Darwin said, the evolution is a **branching process**
- With time, **new life form appear** and **arise as branches** from previously existing life forms
- Branching descent points towards the **concept of common ancestry**

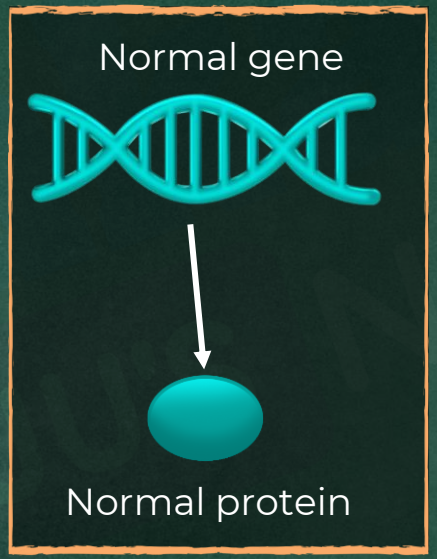
Natural selection :

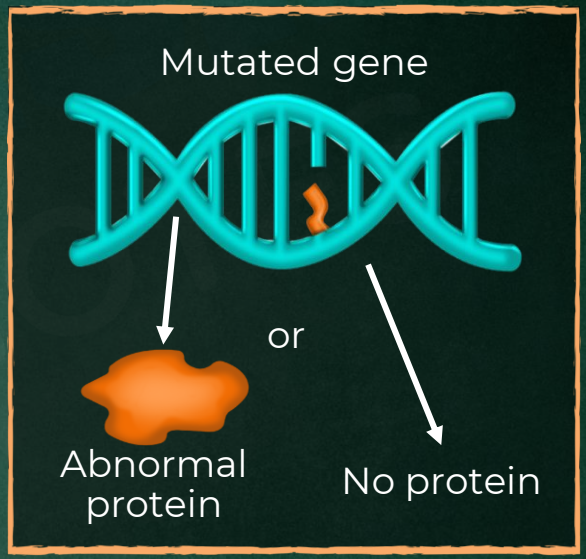
- Darwin emphasised that the selection of **useful variations** by nature is the main (but not exclusive) mechanism for evolution to occur

Biological Evolution : Mutation Theory

Mutation theory

- Proposed by **Hugo de Vries**
- Observed on wild variety of **evening primrose (*Oenothera lamarckiana*)**
- According to mutation theory, **new species originates** as a result of large, **discontinuous variation which appears suddenly (saltation)**
- Main features :
  - Mutations are large, **random** and **directionless**
- Mutations are **heritable** and **establish new species**
- Mutation **arise from time to time**





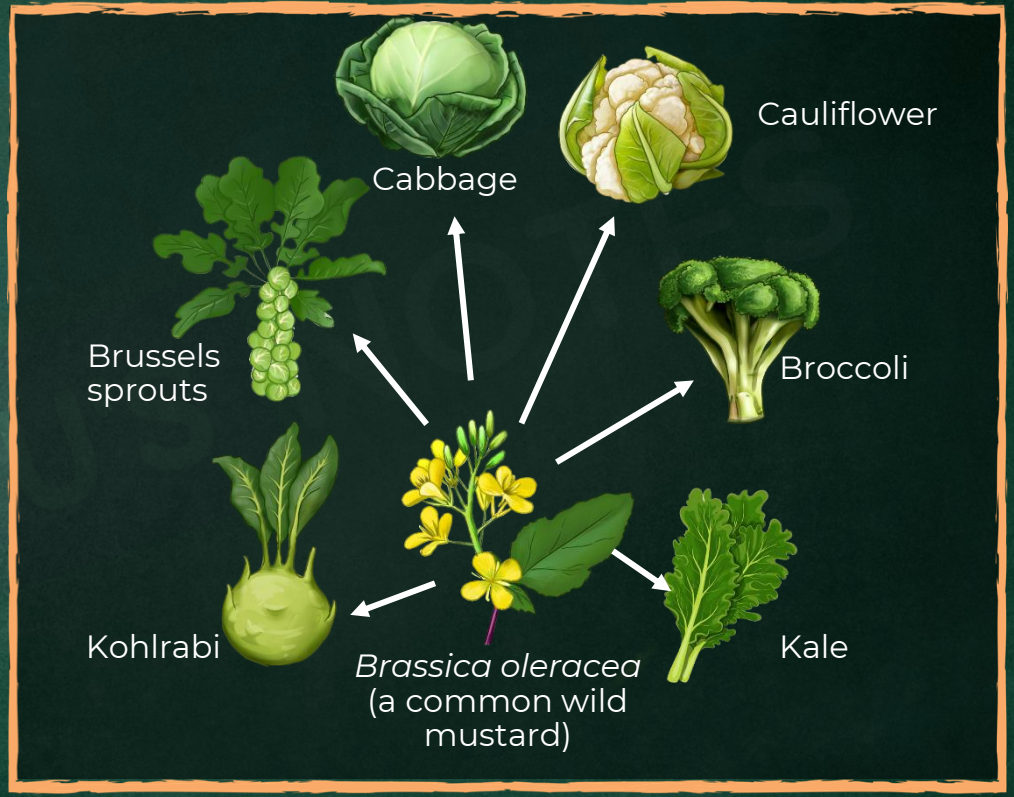
Difference Between Variations and Mutations

Variations	Vs	Mutation
• **Small** and **cannot bring sudden change** in life forms • Bring change only when the **accumulate**		• **Large** and **bring sudden change** even in a span of single generation • **Do not need accumulation**
• **Directional**		• **Random** and **directionless**
• Darwin said evolution is a **slow** and **gradual** process		• Hugo deVries believed that evolution occurs **suddenly.** • **Saltation :** Single step large mutation which causes speciation

Artificial Selection

It is a **selective breeding** of plants or animals **for desired traits**, which is **done artificially** using various breeding methods

- **Animal husbandry** : Breeding of cows, buffaloes to increase yield and quality of milk
- **Horticulture** : Breeding of various crops to improve yield, nutritional value and disease resistance
- **E.g.,** Generations of different vegetables like broccoli, kale, cauliflower etc
- **For security purpose** : Breeding of horses, camels, dogs etc.



Natural Selection

A process in which **organisms adapted better** to their environment tend **to survive** and **produce more offsprings**.

Industrial melanism : After industrialization, pollution increased and tree trunks became dark due to soot and smoke deposition. As a result, white winged moth could not camouflage themselves and were predated by birds

Before industrialization
(less air pollution)

White winged moth

More in number

Dark winged moth

Less in number

After industrialization
(more air pollution)

White winged moth

Less in number

Dark winged moth

More in number

Natural Selection

Antibiotic or drug resistance : Continuous use of drugs and antibiotics against microbes leads to resistance towards drugs

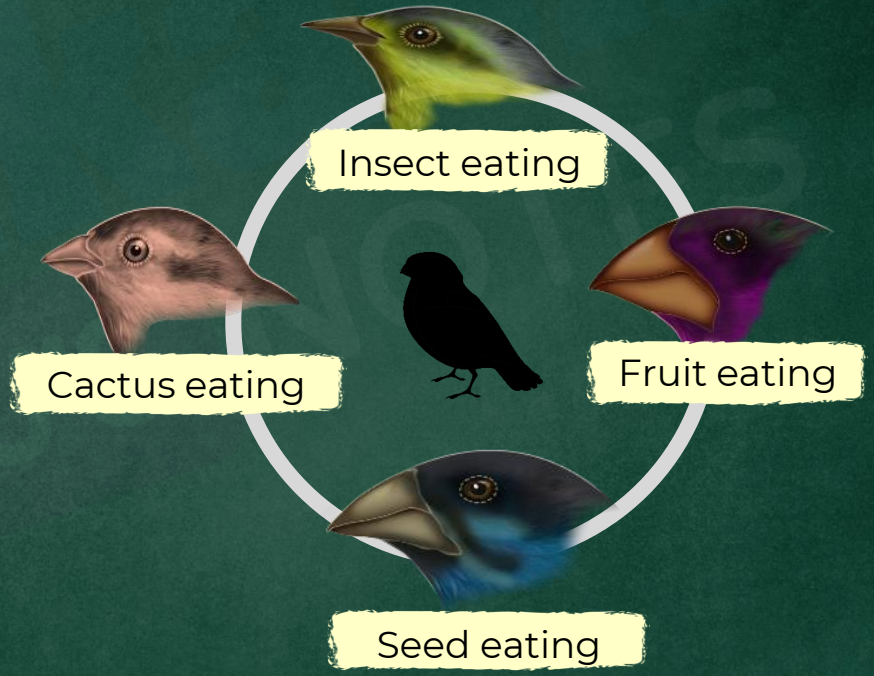
Herbicide resistance : Continuous use of herbicide and pesticide against weeds and pests leads to resistance. They survive better, despite the prolonged use of herbicides and pesticides.

Adaptive Radiation

When an ancestral species evolves into different species due to competition for food or space and occupy different habitat

Darwin's Finches

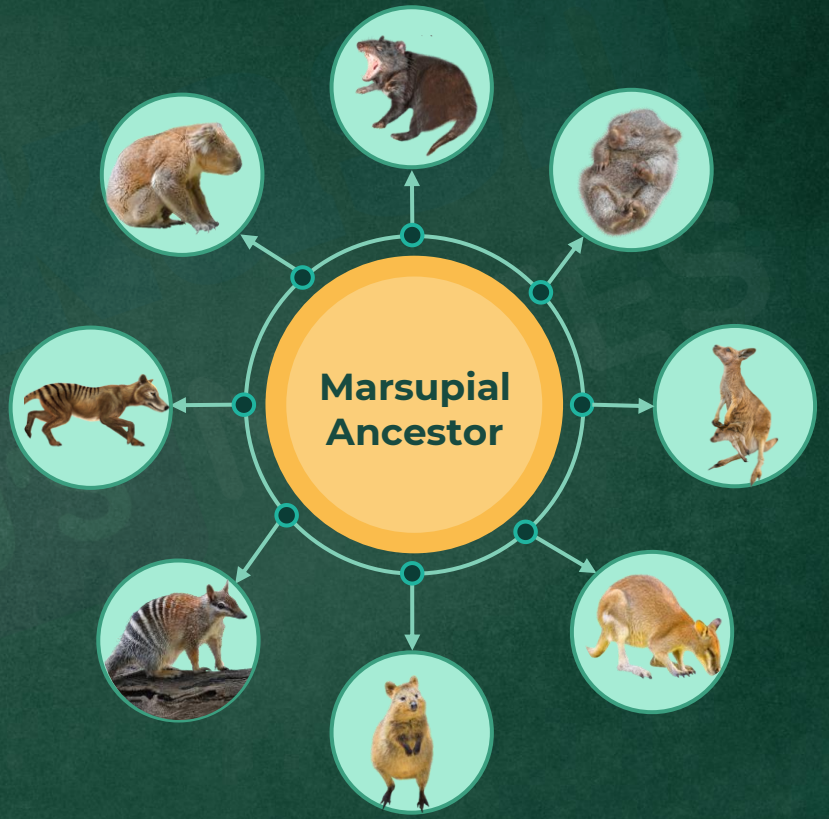
- Location - **Galapagos islands** (chain of islands in South America)
- Found : Varieties of **small black birds**
- **Differed in shape of beaks and feeding habits**
- Analysis after observation: Varieties **evolved from original seed eating** ancestor bird present in South America



Adaptive Radiation

Australian marsupials

- Location - **Island in Australia**
- Found - **Number of marsupials** (Koala, Kangaroo, etc)
- **Differed in morphology due to adaptation** to different environments



Adaptive Radiation

Placental mammals : Convergent evolution

- **Resemblance** of placental and marsupial mammals **in structure** and **ways of life** due to living in the similar ecological niches

Wolf
(Placental mammal)

Common ancestor 1

Resemble in **structure**

Lead **similar lives**

Live in **similar habitat**

Tasmanian wolf
(Marsupial mammal)

Common ancestor 2

Hardy-Weinberg Principle

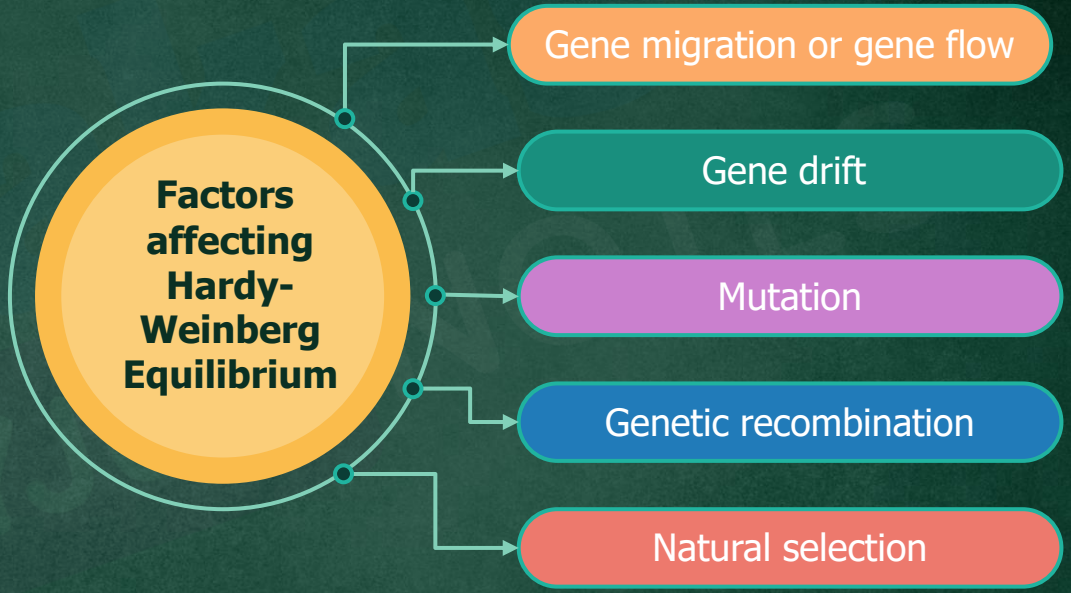
- Proposed by **G.H. Hardy and W. Weinberg** in 1908
- The Hardy- Weinberg equilibrium is a principle stating that **genetic variation** in a population will **remain constant from one generation to other** in the **absence of disturbing factors**.
- Main concepts :
  - **Allele frequencies** in a population = **Stable** and **constant** from generation to generation
  - **Gene pool** (total genes and their alleles in a population) = **Constant**
  - This is called **gene equilibrium**
  - **Sum total** of all the allelic frequencies = **1**

Hardy-Weinberg Principle

- Hardy-Weinberg equilibrium is represented by:

  $(p+q)^2 = p^2 + 2pq + q^2 = 1$

  - where, **p^2** is the frequency of homozygous dominant genotype
  - **q^2** is the frequency of homozygous recessive genotype
  - **2pq** is the frequency of heterozygous genotype



Hardy-Weinberg Principle

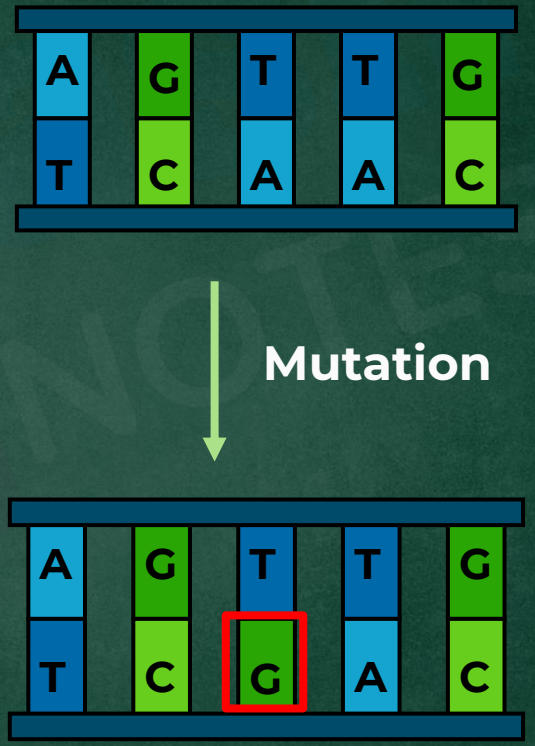
Factors affecting equilibrium: Migration or gene flow

- **Gene migration** : Migration of genes/alleles due to movement of few individuals from one population to another
- It can occur by
  - **Migration of section of population** from one area to another
  - **Interbreeding**
- **Gene pool** : Total collection of all genes and its allele in a population
- **Gene flow** : Exchange of genes between two different populations
- Thus, **gene flow disturbs Hardy-Weinberg equilibrium.**

Hardy-Weinberg Principle

Factors affecting equilibrium: Mutation

- **Change in nucleotide sequence** of genetic material due to errors in DNA copying or **exposure of mutagens**
- Mutation **introduce new genes/ alleles or delete old ones**
- This, **lead to a change in gene and allele frequency.**
- Mutations are
  - **random**
  - **harmful or with no effect**
  - **very slow**



Hardy-Weinberg Principle

Factors affecting equilibrium: Mutation

- Lederberg Replica Plating Experiment :
  - Devised by **Joshua Lederberg** and **Esther Lederberg**
  - Demonstrated on ***E.coli***
  - Cultivated the bacteria which developed into discrete colonies
  - Each of the colonies originated from a single bacterium through a large number of cell divisions
  - Through the master plate, replicas were created
    - **With penicillin** : Most colonies found on the master plate did not grow on the replica plates
  - Showed that **many mutations are random rather than directed**
  - Mutations are **not induced by penicillin**

Hardy-Weinberg Principle

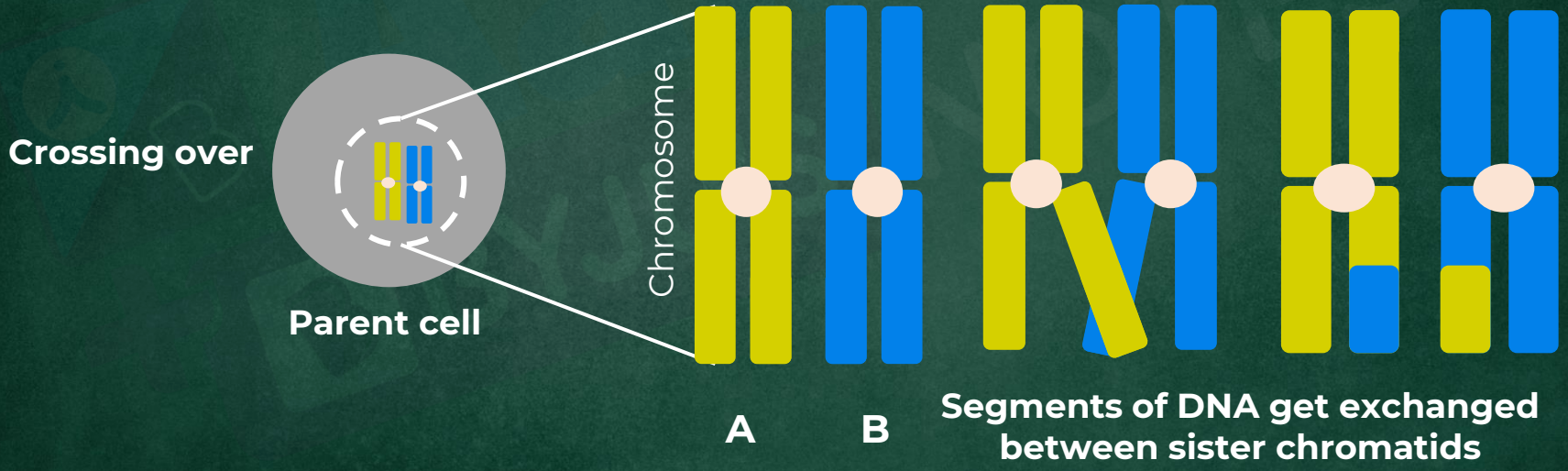
Factors affecting equilibrium: Genetic drift

- **Fluctuation** in gene/allele frequencies **due to chance of events**
- Causes change in gene frequency by chance in a small population
- It has two ramifications:
  - **Bottle neck effect** : Drastic reduction in population size due to natural disasters
  - **Founder's effect** : Reduction in genetic variation when small subset of a population establishes a new colony with few individuals in a population and act as founders.

Hardy-Weinberg Principle

Factors affecting equilibrium: Gene recombination

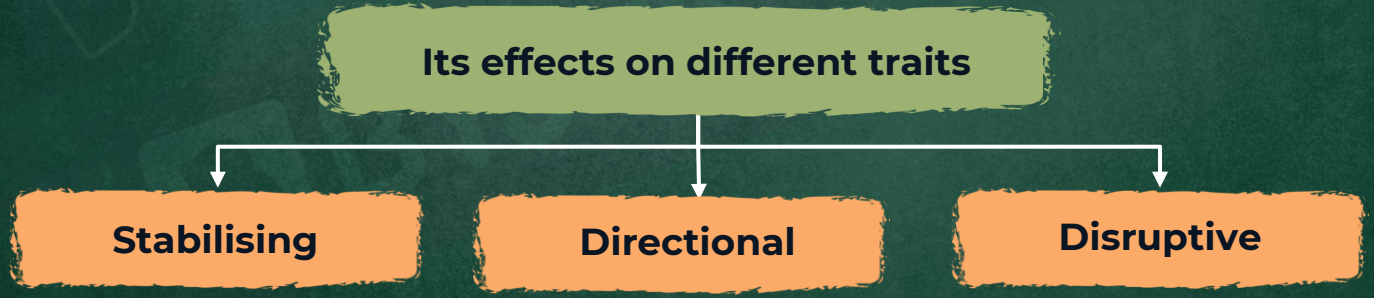
- Occurrence of **new combination** of alleles due to sexual reproduction
- Due to **crossing over** of chromosomes
- **Recombinants** - cross overed offspring with new combination of characters



Hardy-Weinberg Principle

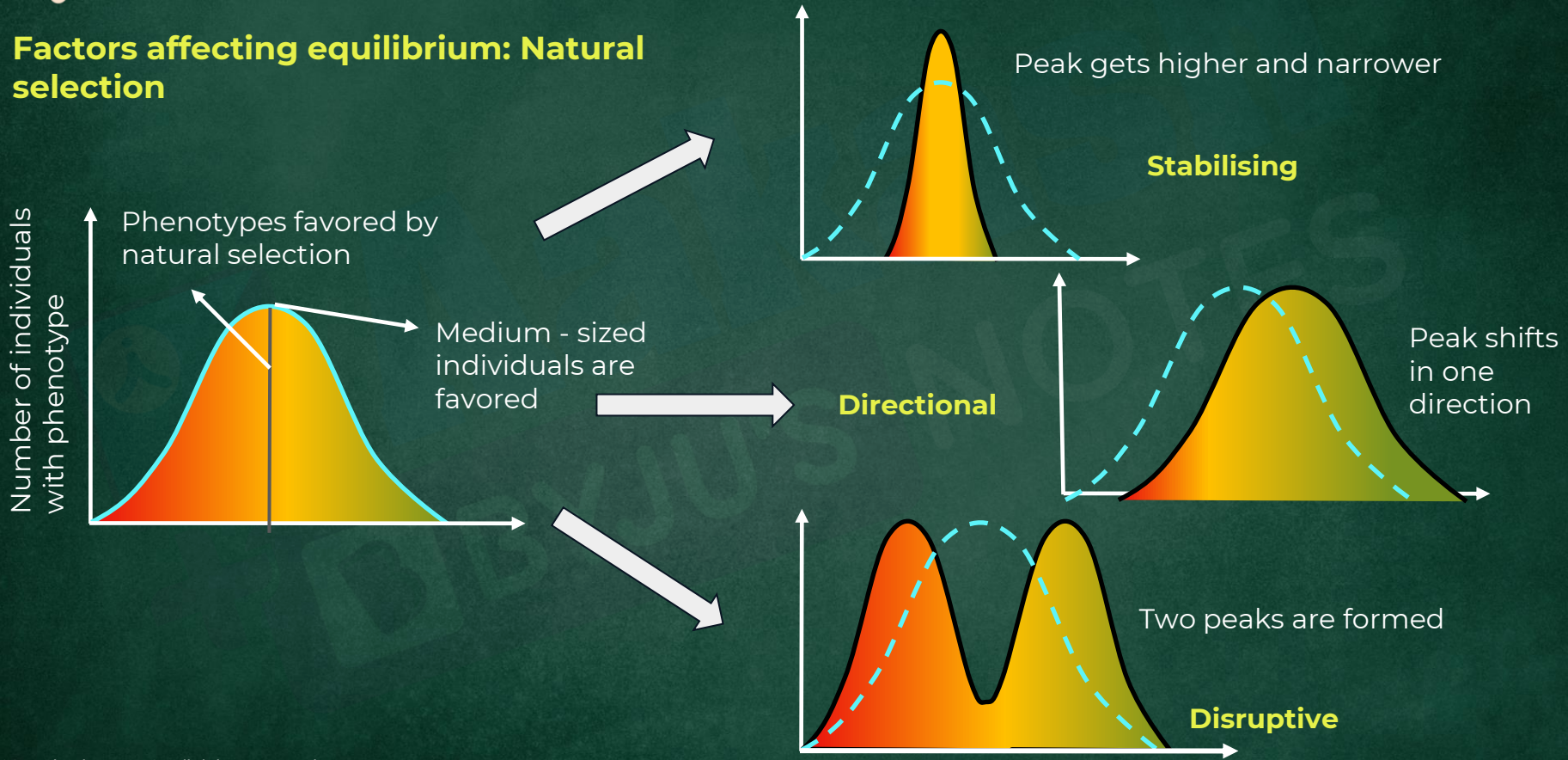
Factors affecting equilibrium: Natural selection

- It is a process in which **heritable variations enable better survival** and **produce more progeny.**
- Organisms which get selected by nature will have better survivability and changes in the allelic frequencies.
- Natural selection causes **unequal survival** and reproductive success of individuals.



Hardy-Weinberg Principle

Factors affecting equilibrium: Natural selection



Speciation and Isolation

- **Speciation** : Formation of one or more new species from existing ones

Modes of speciation
based on geographical relationship of a new species to its ancestral species

Allopatric

- When a continuous population in a range, splits into two or more **geographically isolated populations** and form new species

Sympatric

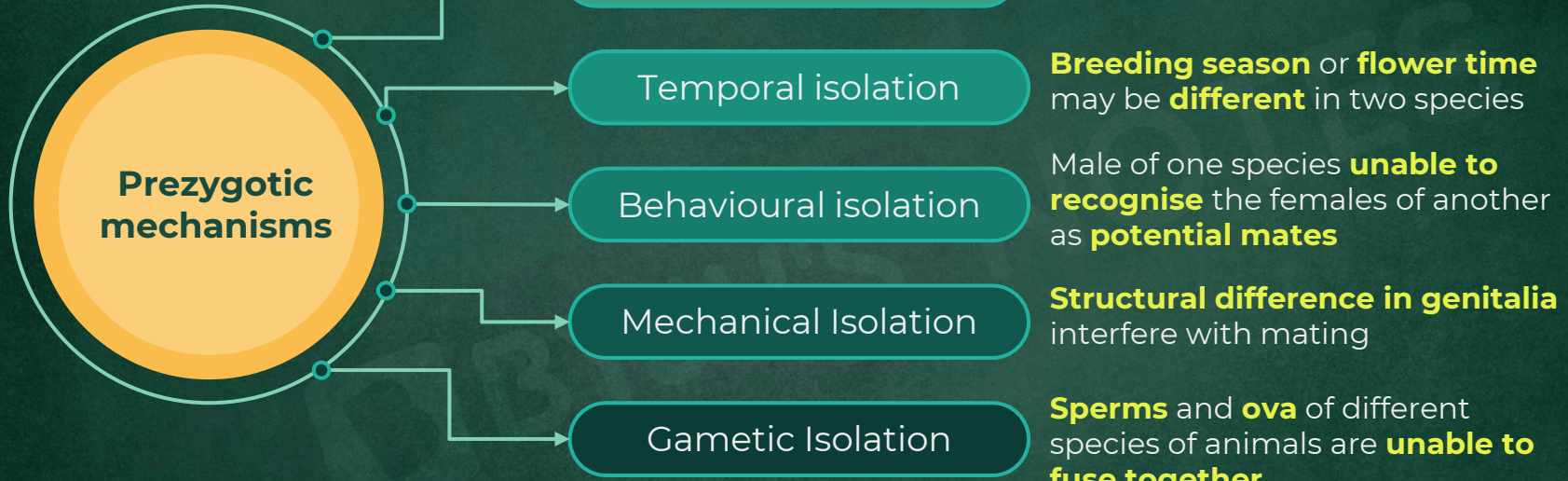
- Formation of species within a single population **without geographical isolation**

Speciation and Isolation

Species concept	Species is the **basic unit** of classification
Morphospecies concept	Species are **characterized by its morphology**
Biological species concept	Species taxon as a group of organisms that can **successfully interbreed and produce fertile offspring** **Sibling species** - almost identical morphologically but distinct due to absence of interbreeding
Evolutionary species concept	Single lineage of ancestor-descendant populations which has its **own evolutionary tendencies, separate from other such lineage**
Reproductive isolation	**Inability of a species to breed** successfully with related species due to geographical, behavioural, physiological, or genetic barriers or differences

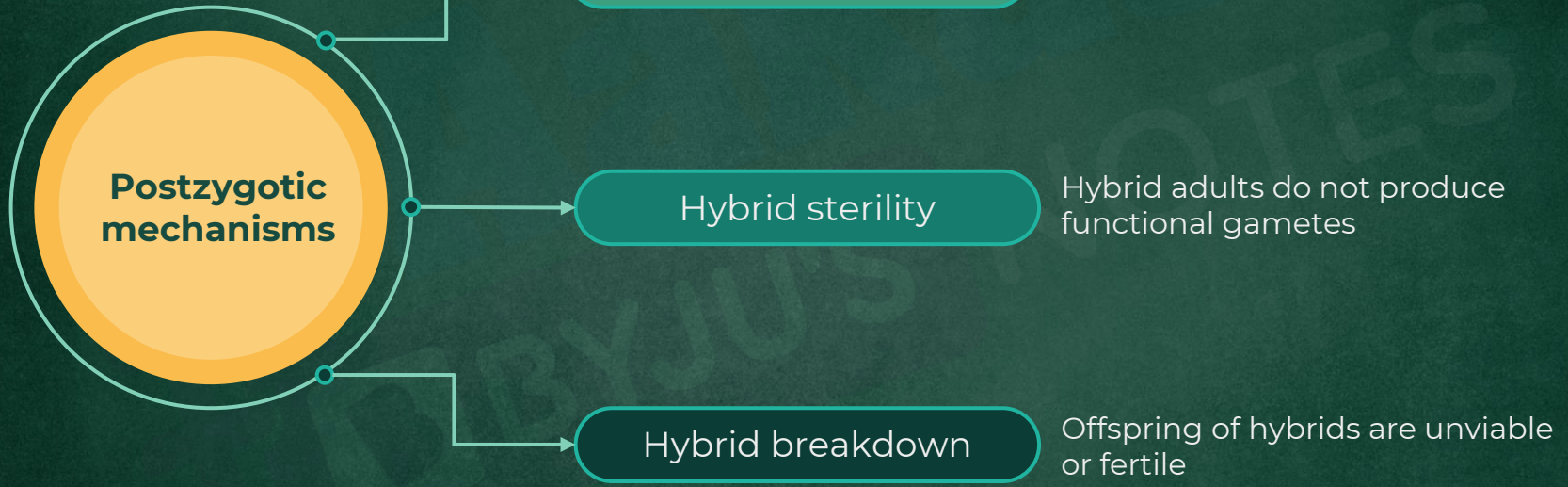
Speciation and Isolation

Barriers to hybridisation :

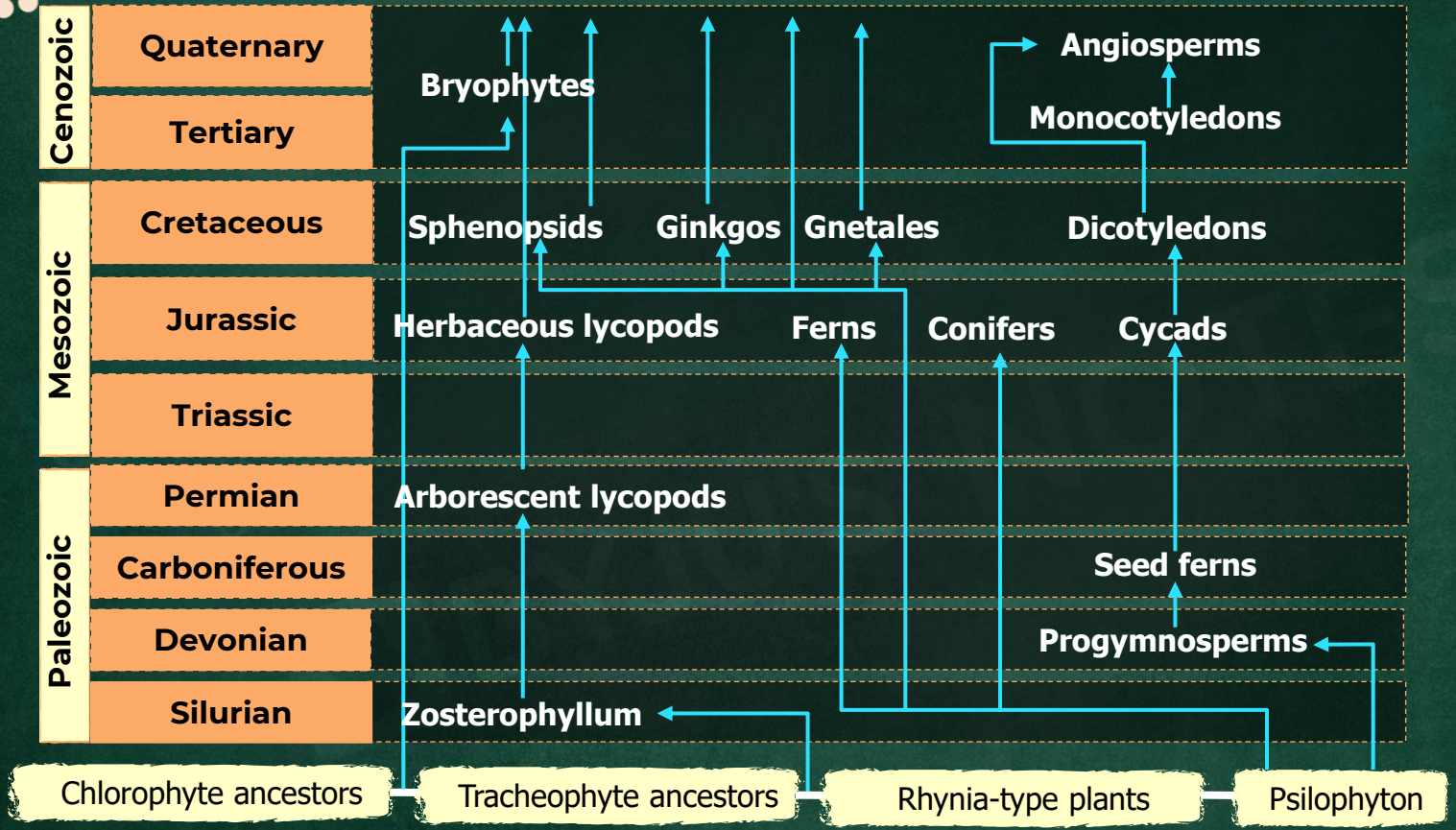


Speciation and Isolation

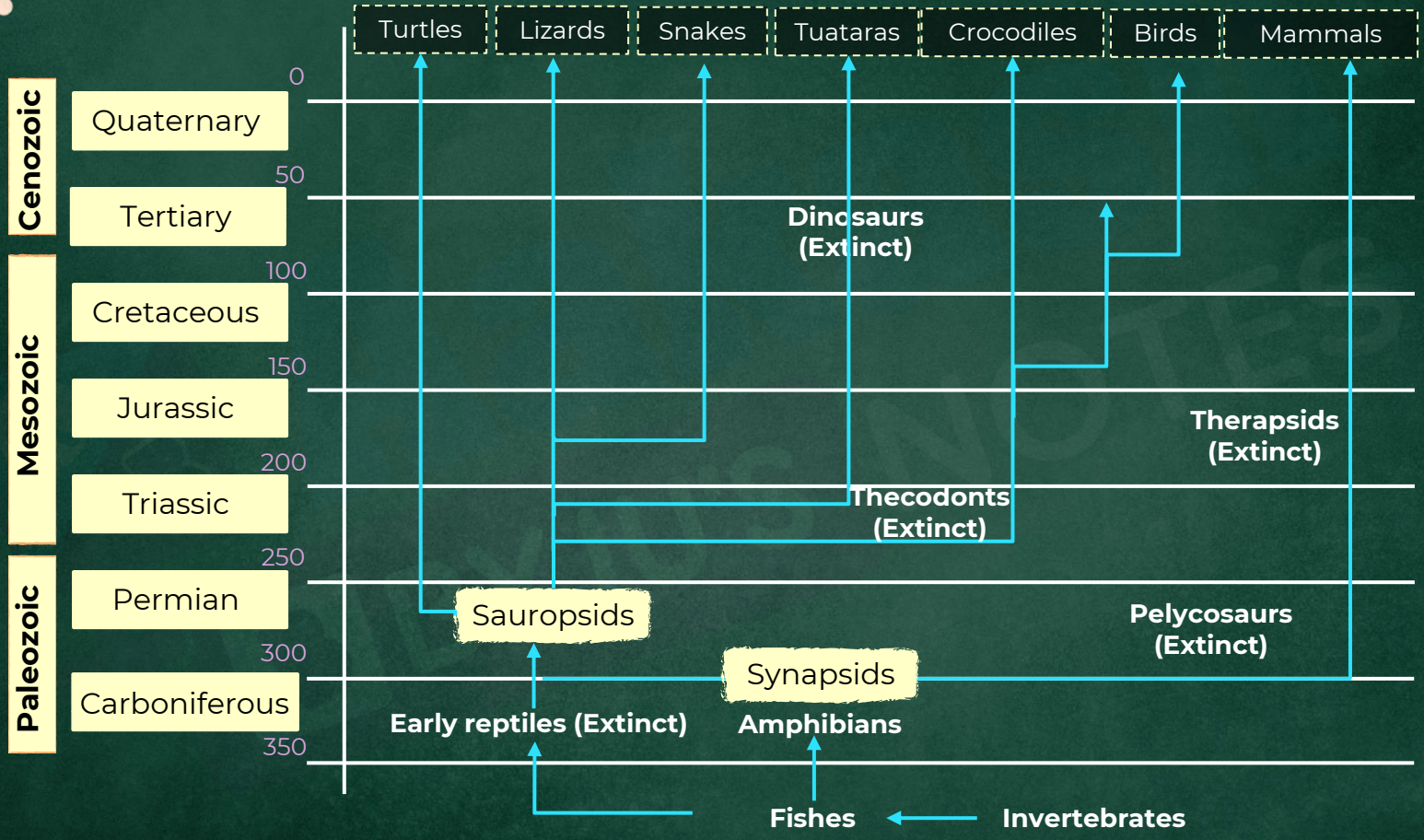
Barriers to hybridisation :



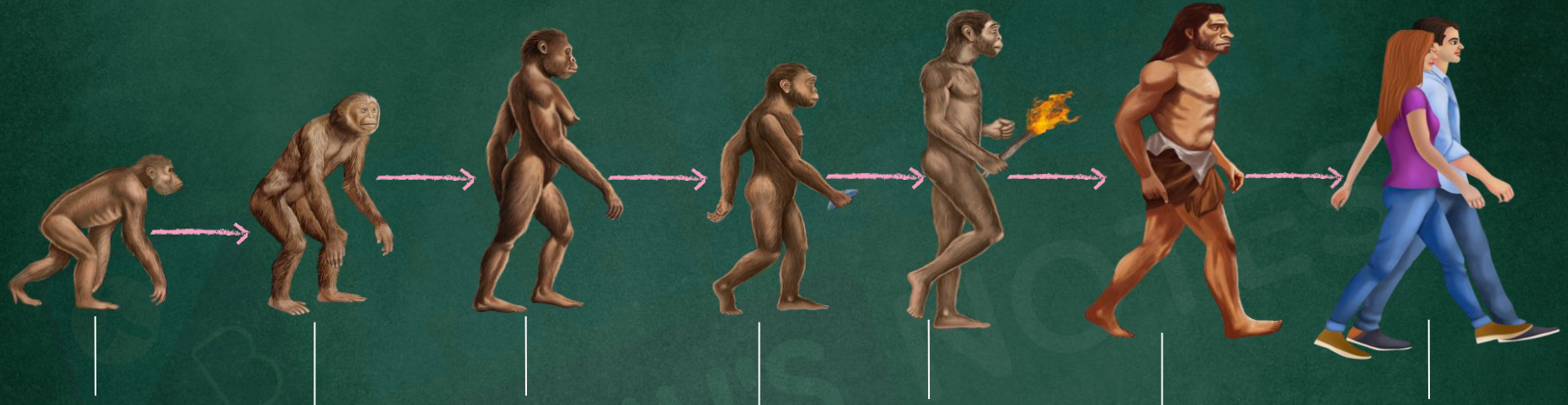
Origin and Evolution of Plants



Origin and Evolution of Animals



Origin and Evolution of Man



Dryopithecus

Ramapithecus

Australopithecus

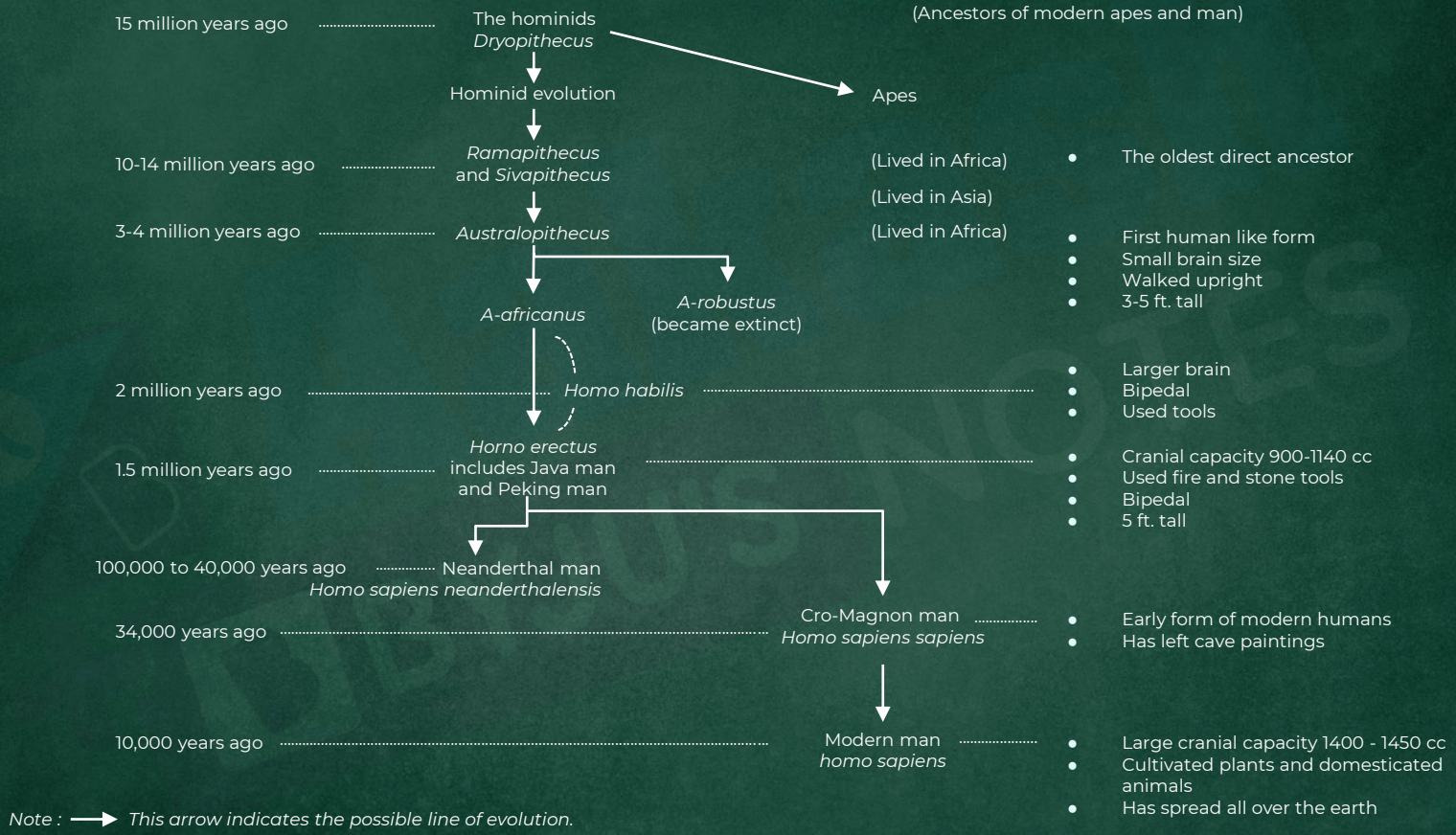
Homo habilis

Homo erectus

Neanderthal man

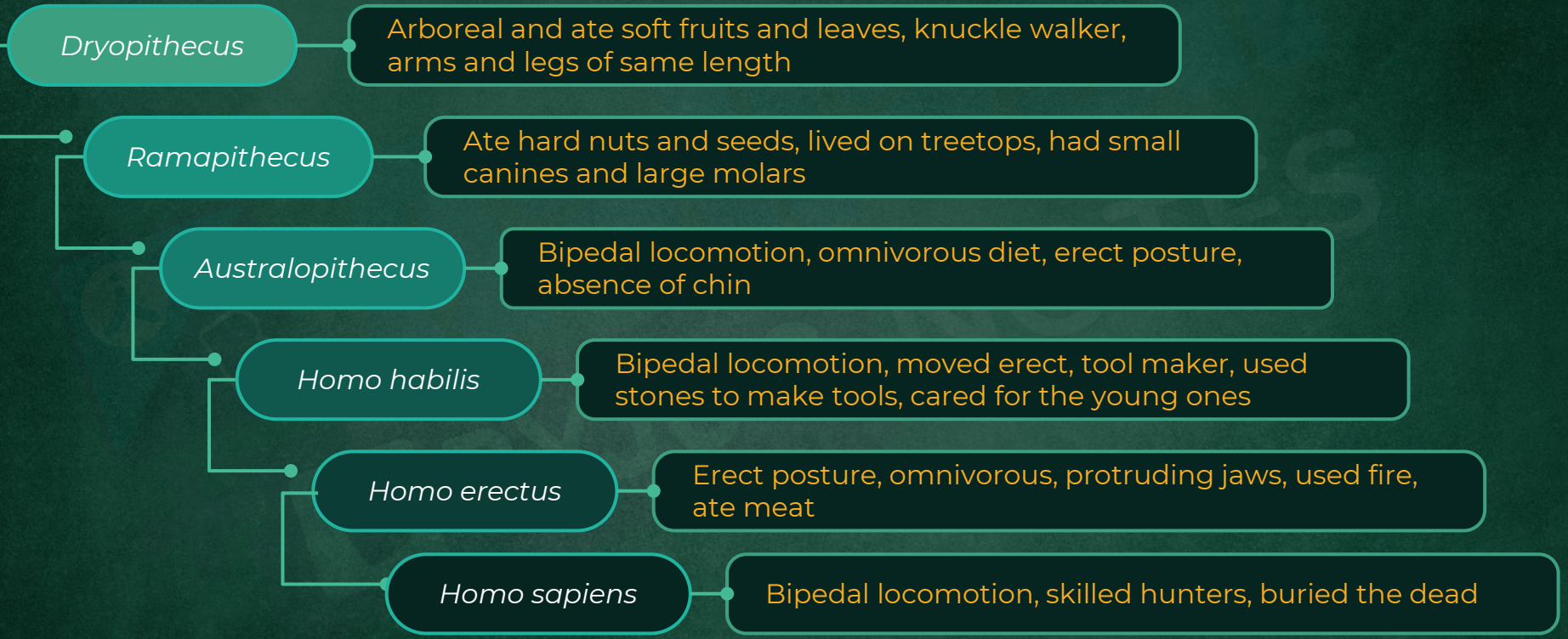
Homo sapiens

Origin and Evolution of Man



Note : → *This arrow indicates the possible line of evolution.*

Origin and Evolution of Man



Summary

Origin of universe and life

Big bang theory

Origin of universe

1. Special creation
2. Catastrophism
3. Spontaneous generation
4. Cosmozoic
5. Biogenesis
6. Chemical evolution

Theories on origin of life

Summary

Evidences for evolution

Fossils

Morphological and Anatomical

Embryological

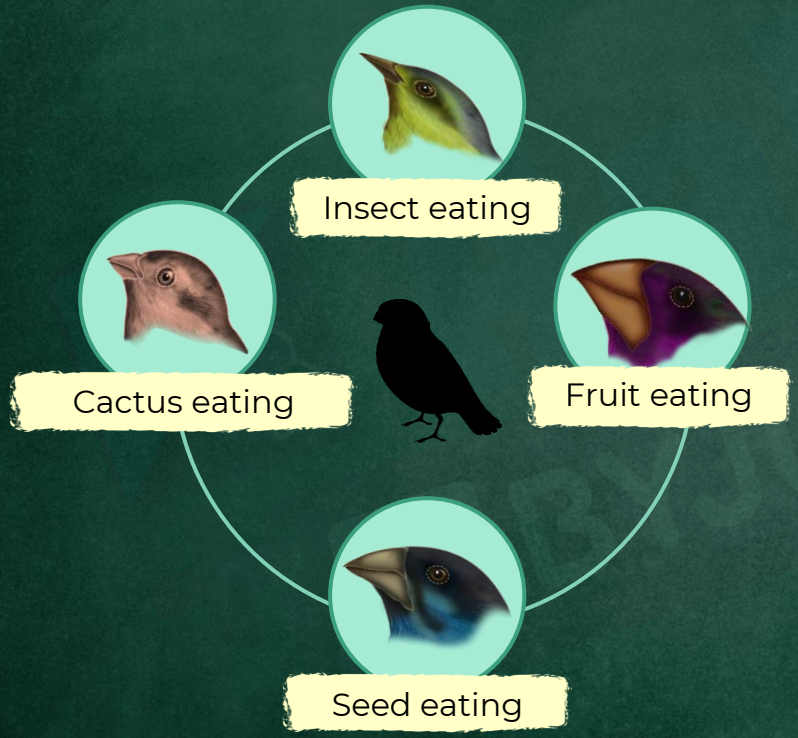
Biogeographical

Biochemical

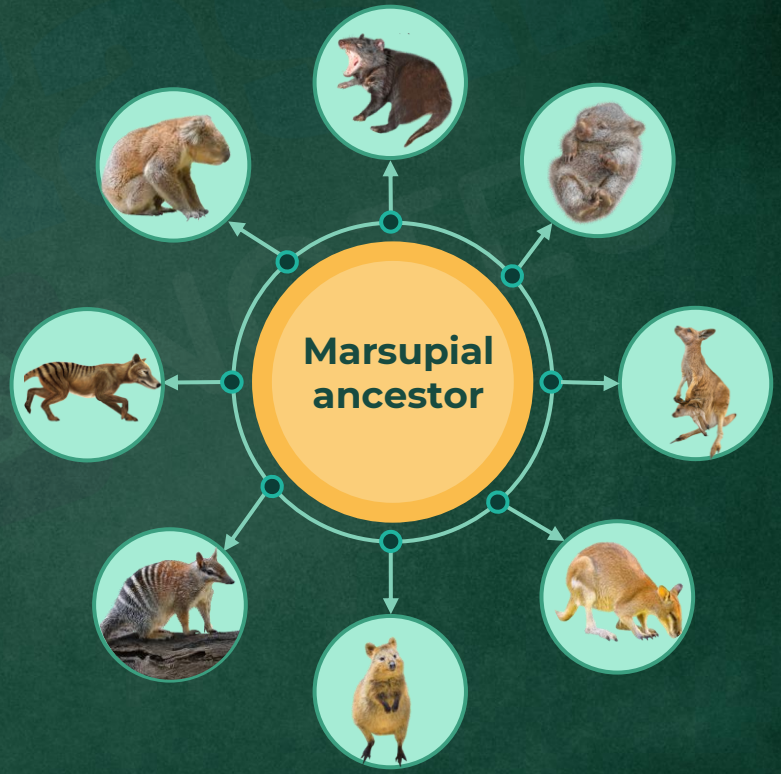
Summary

Adaptive radiation

Darwin finches



Australian marsupials



Summary

Hardy-Weinberg principle