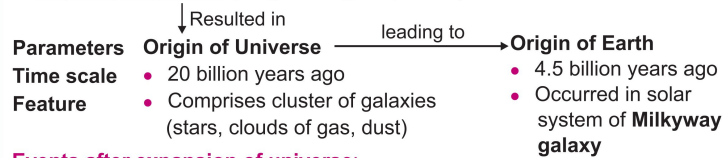


Evolution

1 EVOLUTION

- **Evolutionary biology** is the study of history of life forms on earth
- Stellar distances are measured in light years
- **Big bang explosion** (Singular huge explosion)



Events after expansion of universe:

- Temperature declined
- $H_2 + He$ formed
- Gases condensed
- Galaxies of present day formed

Hypothesis for Origin of life on early earth:

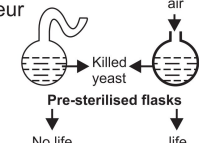
- No atmosphere existed on early earth.
- Water vapours, methane, carbon dioxide and ammonia released from molten mass covered the surface.
- $H_2O \xrightarrow{U.V \text{ rays}} H_2 + O_2$
- $NH_3 + CH_4 + O_2 \rightarrow CO_2 + H_2O + \text{other contents}$
- H_2O vapour falls as rain to fill all the depressions and form oceans.
- Ozone layer was formed

2 ORIGIN OF LIFE

- **Life appeared** 500 million years after the formation of earth, i.e, almost **4 billion years ago**.
- **First non-cellular forms of life**
 - **Probably originated 3 billion years ago**
 - Would have possibly originated from giant molecules (RNA, protein, polysaccharides, etc.)
 - These capsules **reproduced** their molecules perhaps.
- **First cellular forms of life**
 - **Possibly originated 2 million years ago**
 - Arose in water environment (aquatic)
- **This version of Biogenesis i.e., the first form of life arose slowly through evolutionary forces from non-living molecules is accepted by majority.**

3 THEORIES FOR ORIGIN OF LIFE

- The origin of life is considered a unique event in the history of universe

Theory	Proponents	Connotations
Special creation	Conventional religious literature	<ul style="list-style-type: none"> • All living organisms that we see today were created as such • Diversity was always the same since creation and will be the same in future also • Earth is 4000 years old
Cosmozoic/ Panspermia	Early Greek thinkers, Astronomers	<ul style="list-style-type: none"> • Life came from outerspace • Units of life called spores were transferred to different planets including earth
Spontaneous generation	—	<ul style="list-style-type: none"> • Life came out from decaying and rotting matter like straw, mud. etc. • Disapproved by Louis Pasteur
Theory of Biogenesis	<p>Louis Pasteur</p> 	<ul style="list-style-type: none"> • Life comes only from pre-existing life • He showed that in pre-sterilised flasks, life did not come from "killed yeast"

Oparin-Haldane hypothesis or Chemical Evolution

Oparin - Russia,
Haldane - England

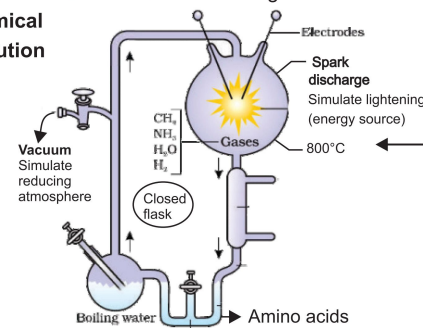


Fig.: Diagrammatic representation of Miller's experiment

- Formation of life was preceded by chemical evolution i.e., formation of diverse organic molecules from inorganic constituents.
- First form of life could have come from pre-existing non-living organic molecules (e.g. RNA, proteins, etc.)
- This hypothesis was proved by Miller's experiment, **1953, S.L. Miller (American scientist)**
- In similar experiments others observed, formation of sugars, nitrogen bases, pigments and fats.
- **Analysis of meteorite content also revealed similar compounds indicating that similar processes are occurring elsewhere in space.**

4 EVIDENCES OF EVOLUTION

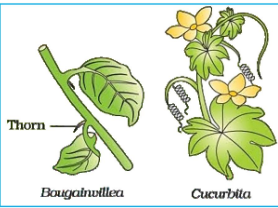
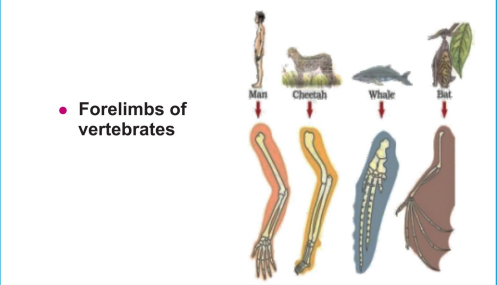
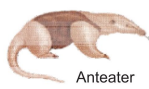





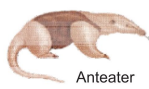





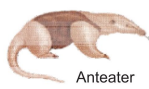





1. Palaeontological evidences (Evidences from fossils)

- **Fossils** are remains of hard parts of life forms found in rocks.
- **Age of fossils** is determined by **radioactive-dating method**.
- Fossils of different life forms in different **sedimentary layers** indicates the **geological period** in which they existed (**epochs, periods, eras**)
- Rocks form sediments and a cross-section of earth's crust indicates the arrangement of sediments one over the other during the long history of earth.
- Different-aged rock sediments contain fossils of different life-forms who probably died during the formation of the particular sediment. Some of them appear similar to modern organisms. **They represent extinct organisms (e.g., Dinosaurs).**

2. Embryological evidences

- Proposed by **Ernst Heckel**
- Based upon the observations of certain features during embryonic stage common to all vertebrates that are absent in adults e.g., embryos of all vertebrates develop a row of vestigial gill slits functional only fish and not found in another adult vertebrates.
- It was **disproved by Karl Ernst von Baer**. He noted that embryos never pass through the adult stages of other animals.

3. Morphological and anatomical evidences

Parameters	Homologous organs	Analogous organs								
Common ancestry	✓	✕								
Anatomical structures	Similar but developed along different directions due to adaptations to different needs.	Not similar but resulted in selection of similar adaptive features in different groups of organisms, thus, evolving for the same function.								
Function performed	Different	Similar								
Type of evolution	Divergent	Convergent								
Examples	<div></div> <div></div> <div><ul style="list-style-type: none">• Thorn of <i>Bougainvillea</i> and tendril of <i>Cucurbita</i>• Forelimbs of vertebrates• Vertebrate hearts, Vertebrate brains</div>	<table><tr><th>Placental mammals</th><th>Australian marsupials</th></tr><tr><td> Anteater</td><td> Numbat (anteater)</td></tr><tr><td> Lemur</td><td> Spotted cuscus</td></tr><tr><td> Bobcat</td><td> Tasmanian tiger cat</td></tr></table> <ul style="list-style-type: none">• Wings of butterfly and birds• Eyes of octopus and mammals• Flippers of Penguins and Dolphins• Sweet potato (root modification) and potato (stem modification)	Placental mammals	Australian marsupials	 Anteater	 Numbat (anteater)	 Lemur	 Spotted cuscus	 Bobcat	 Tasmanian tiger cat
Placental mammals	Australian marsupials									
 Anteater	 Numbat (anteater)									
 Lemur	 Spotted cuscus									
 Bobcat	 Tasmanian tiger cat									

• Molecular homology

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

5 ADAPTIVE RADIATION

- The process of evolution of different species in a given geographical area starting from a point and literally radiating to other areas of geography (habitats)

Examples

Darwin's finches

- Small black birds
- Evolved from **seed eating** birds in **Galapagos Island**
- Altered beaks arose, enabling them to become insectivorous and vegetarian finches.



Fig.: Variety of beaks of finches that Darwin found in Galapagos Island

Australian marsupials

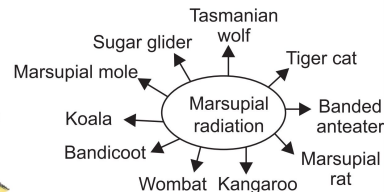


Fig.: Adaptive radiation of marsupials of Australia

- When more than one adaptive radiation appeared to have occurred in an isolated geographical area (representing different habitats), one can call this **convergent evolution**.

Examples

Placental mammals	Australian marsupials
Mole	Marsupial mole
Anteater	Numbat (banded anteater)
Mouse	Marsupial mouse
Lemur	Spotted cuscus
Flying squirrel	Flying phalanger (Sugar glider)
Bobcat	Tasmanian tiger cat
Wolf	Tasmanian wolf

6 BIOLOGICAL EVOLUTION

- Metabolic capabilities of different cellular forms** of life under the influence of natural selection **contributed to biological evolution**.
- Rate of appearance of new forms is linked to the life cycle or the life span.** e.g., Microbes have the ability to multiply and become millions within hours whereas fish or fowl would take millions of years as life span of these animals are in years.

Theories for the evolution of life forms:

Lamarck's theory of evolution

- Given by French naturalist Lamarck
- Main postulates** :
 - Use and disuse of organs
 - Inheritance of acquired characters

- Example:** Long neck in Giraffes is attributed to stretching the neck while foraging leaves on tall trees

Darwin's theory of natural selection

- Darwin visited Galapagos island, **Ship - H.M.S Beagle**
- Observations by Charles Darwin:**
 - Existing living forms share similarities to varying degrees not only among themselves but also with life forms that existed millions of years ago.
 - The **geological history of earth** correlates with the **biological history of earth**.

- Influence of the work of **Thomas Malthus** on Darwinism:
 - Population can grow exponentially
 - Limited resources
 - Nature keeps control/check on population size which are, hence, nearly stable

Darwin's postulates:

- According to Darwin, variations are **small** and **directional** and evolution for Darwin was **gradual** process.
- Darwin asserted that in a population exist **variations**, which are **heritable** and which make **resource utilisation** better for few will enable only those to **reproduce** and leave **more progeny**.

- Those characteristics which enable some to survive better in natural conditions (climate, food, physical factors etc.) would outbreed others that are less-endowed to survive under such natural conditions.
- The fitness, according to Darwin, refers **ultimately and only to reproductive fitness**.
- Adaptive ability is inherited and has a genetic basis
- Fitness is the end result of the ability to adapt and get selected by nature.**
- Branching descent** and **natural selection** are the two key concepts of Darwinian theory of evolution.
- Habitat fragmentation** and **genetic drift** may accentuate variations leading to **speciation**.
- Weaknesses of Darwinism** :
 - Unable to explain the origin of variations
 - Could not explain speciation
 - Ignored work done by Mendel.

Mutation theory



- Given by **Hugo de Vries** in first decade of 20th century
- Worked on **evening primrose**
- New species originate as a result of **mutations** which are single step (**saltation**) **large, random** and **directionless** variations arising **suddenly** in a population



- Alfred Wallace**, a naturalist who worked in **Malay Archipelago** had also come to similar conclusions as Charles Darwin around the same time.
- When we describe story of this world we describe evolution as a process. When we describe the story of life on earth, we treat evolution as a consequence of a process called natural selection.**
- Evolution is **not a directed process** in the sense of determinism. It is a **stochastic process** based on chance events in nature and chance mutations in the organisms.
- Artificial selection** : By intensive breeding programme, man has created breeds that differ from other breeds (e.g., dogs)

7 EXAMPLES OF EVOLUTION BY ANTHROPOGENIC ACTION

1. Antibiotic resistant microbes
2. Herbicides resistant varieties
3. Pesticides resistant varieties
4. **The case of Industrial melanism** : Classical example of natural selection among variants in **moth population observed in England**.

Parameters	Before industrialisation (1850s)	After industrialisation (1920s)
Figure		
Tree trunks	White, covered by lichens	Became dark due to deposition of soot and smoke
White moths	More	Less
Melanised moths	Less	More
Predators feed on	Melanised moths	White winged moths

- Lichens do not grow in polluted area (**pollution indicator**)
- **Agent of natural selection** : Predator/birds
- Moths that were able to camouflage themselves (i.e., hide in the background) survived **but no variant is completely wiped out**

8 A BRIEF ACCOUNT OF EVOLUTION

Form of life	Appeared around
1 st non cellular form	3 bya
1 st cellular forms	2000 mya
Invertebrates	350 mya
Sea weeds and few plants	320 mya

- **Lobed fin fish** (Coelocanth) Possibly evolved into **Amphibians** (Frogs, salamanders) Possibly evolved into **Reptiles** (Turtles, Tortoises, Crocodiles)
 - Primarily aquatic
 - 1938, fish caught in South Africa was earlier thought to be extinct
- **Probable reason** → Land reptiles were dinosaurs which disappeared 65 mya
 - Climatic change
 - Evolved in birds
- Some land reptiles went back to water to evolve fish like reptiles eg. *Ichthyosaurus* (200 mya)
- Modern day descendants of reptiles e.g., Turtles, Tortoises, Crocodiles
- **Lay thick shelled eggs which do not dry up in sun**
- **Mammals** (Arose from ancestral extinct reptiles)
 - **Viviparous** i.e., protect young ones inside mothers body
 - More intelligent in sensing and avoiding danger.

- **A Likely Reason for Restricted Distribution of Pouched Mammals in Australia**
Due to **continental drift**, when South America joined North America, these animals were overridden by North American fauna. Due to the same continental drift pouched mammals of Australia survived because of **lack of competition** from any other mammal.
- The first mammals were like shrews. • Whales, dolphins, seals and sea cows are aquatic mammals.

9 HARDY-WEINBERG PRINCIPLE

- Allele frequencies in a population are stable and is constant from generation to generation. This is called **genetic equilibrium**.
- The **gene pool** (total genes and their alleles in a population) remains a **constant**.
- Sum total of all the allelic frequencies is 1 and is represented as :
 $p + q = 1$ [p = Frequency of recessive allele (a); q = Frequency of dominant allele (A)]
 $p^2 + q^2 + 2pq = 1$ [p^2 = Frequency of homozygous dominant (AA); q^2 = Frequency of homozygous recessive (aa); $2pq$ = Frequency of heterozygotes (Aa)]
- When frequency measured, differs from expected values, the difference **indicates the extent of evolutionary change** or **disturbance in genetic equilibrium**.
- **Factors affecting Hardy-Weinberg equilibrium** :
 1. **Gene migration** : When migration of a section of population to another place or population occurs, gene frequencies change in the original as well as in the new population.



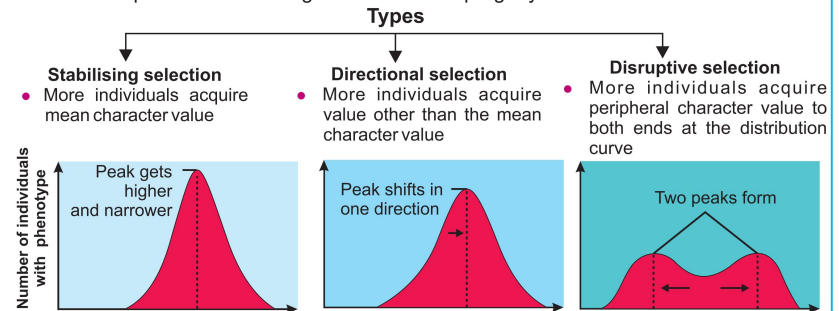
- Emigration (–)
- Some genes/alleles lost



- Immigration (+)
- New genes/ alleles added

- When gene migration occurs multiple times, it is called **gene flow**.

2. **Genetic recombination: Variations due to recombination during gametogenesis**
3. **Mutation**: Microbial experiments show that **pre-existing advantageous** mutations when selected will result in observation of new phenotypes. Over few generations, this would result in speciation.
4. **Genetic drift**: Change in gene frequencies in a small population by chance. Sometimes the change in allele frequency is so different in the new sample of population that they become a different species. The original drifted population becomes founders and effect is called **founders effect**.
5. **Natural selection** : A process is which heritable variations enabling better survival are enabled to reproduce and leave greater number of progeny.



10 A BRIEF ACCOUNT OF EVOLUTION OF PLANTS

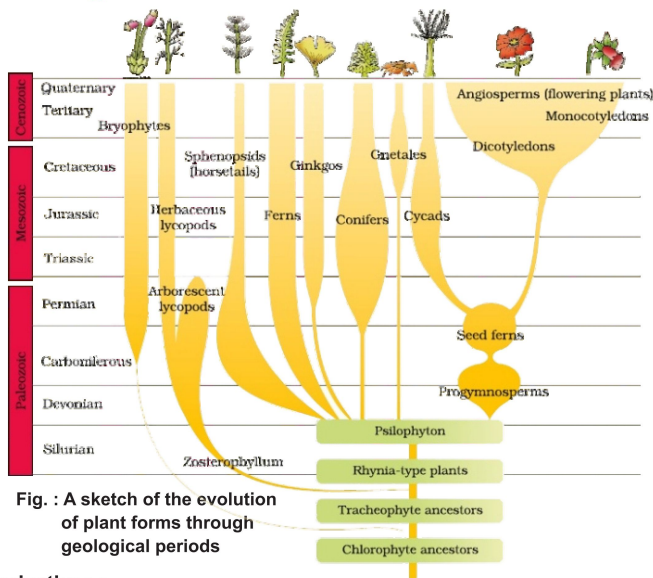


Fig. : A sketch of the evolution of plant forms through geological periods

Derivatives :

- Different types of plants evolved in different periods of time: Palaeozoic, Mesozoic and Coenozoic
- **Chlorophyte ancestors** : Bryophytes : **Tracheophyte ancestors** : Lycopods
- *Psilophytons* were common ancestors for Progymnosperms, Ferns, Ginkgos, Conifers, Gnetales, Sphenopsids
- **Origin of monocotyledons is more recent than that of dicotyledons**
- Giant ferns (pteridophytes) were present (200 mya) but they all fell to form coal deposits slowly.

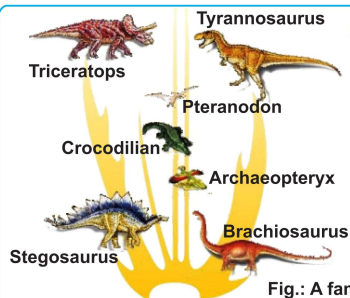


Fig.: A family tree of dinosaurs and their living modern day counterpart organisms like crocodiles and birds

12 A FAMILY TREE OF DINOSAURS

Derivatives :

- **Triceratops** – three horned dinosaur with bony frill around back of its head.
- **Stegosaurus** – Large triangular bony plates along the back and spiked tail
- **Tyrannosaurus rex** – 20 feet in height, had huge fearsome dagger-like teeth
- **Brachiosaurus** – Long giraffe like neck, long forelimbs

11 A BRIEF ACCOUNT OF EVOLUTION HISTORY OF VERTEBRATES

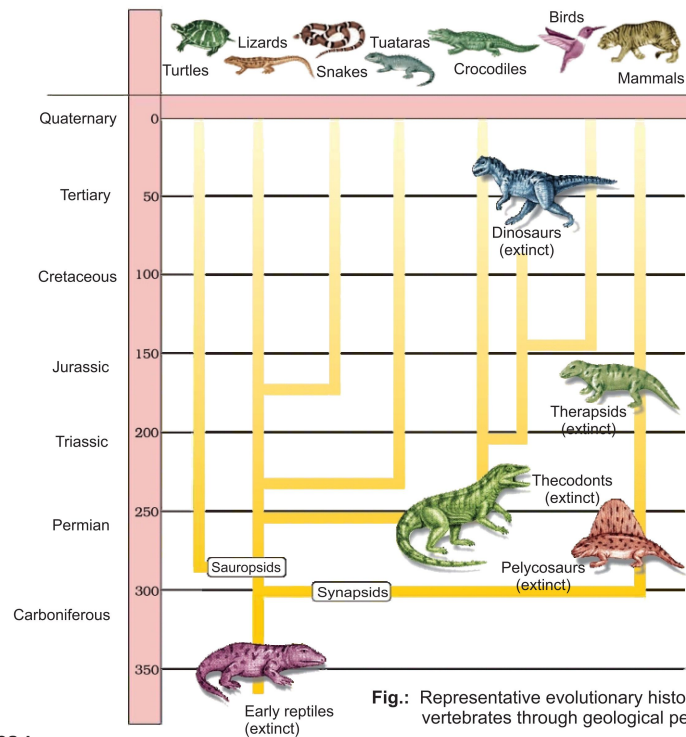


Fig.: Representative evolutionary history of vertebrates through geological periods

Derivatives :

- Turtles, Lizards, Snakes and Tuatara arose from common ancestor **sauropsids**
- **Thecodont** ancestors gave way to existing crocodiles and birds and extinct dinosaurs.
- **Story of origin of mammals** : Extinct reptiles → Synapsids → Pelycosaur → Therapsids → Mammals

- **Pteranodon** were possibly flying reptiles
- **Archaeopteryx** is a transitional fossil between non avian dinosaurs and birds
- **Brachiosaurus** and **Tyrannosaurus** arose separately, mostly likely, from a common ancestor.

13 ORIGIN AND EVOLUTION OF MAN

- Among the stories of evolution of individual species, the story of evolution of modern man is most interesting and appears to parallel evolution of human brain and language.

- The skull of baby chimpanzee is more like adult human skull than adult chimpanzee skull

Human ancestors	Years back	Cranial capacity	Specific features
<i>Dryopithecus</i> <i>Ramapithecus</i>	15 mya	—	<div> <div>more ape-like</div> <div>more man-like</div> <div>Hairy and walked like Gorillas and Chimpanzees</div> </div>
<i>Australopithecus</i>	2 mya	—	<ul style="list-style-type: none"> Few fossils of man-like bones have been discovered in Ethiopia and Tanzania. 3-4 mya, man-like primates walked in East African grasslands. They were probably not taller than 4 feet but walked upright. Evidence shows they hunted with stone weapons but essentially ate fruit.
<i>Homo habilis</i>	—	650 cc - 800 cc	<ul style="list-style-type: none"> First human-like being, the hominid Probably did not eat meat
<i>Homo erectus</i>	1.5 mya	900 cc	<ul style="list-style-type: none"> Fossils discovered in Java in 1891 Probably ate meat
Neanderthal man	1,00,000-40,000 years back	1400 cc	<ul style="list-style-type: none"> Lived in near East and Central Asia Used hides to protect their body and buried their dead
<i>Homo sapiens</i>	75,000-10,000 years ago (ice age)	—	<ul style="list-style-type: none"> Arose in Africa and moved across continents and developed into distinct races

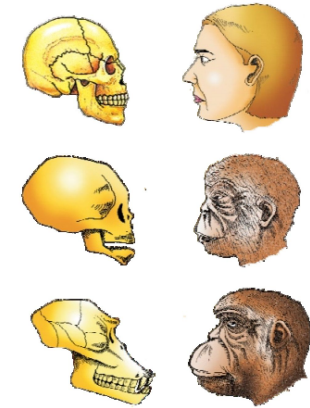


Fig.: A comparison of the skulls of adult modern human being, baby chimpanzee and adult chimpanzee.

- Pre historic cave art**-18,000 years ago. One such cave paintings by pre-historic humans can be seen at **Bhimbetka rock shelter in Raisen district of Madhya Pradesh**.
- Agriculture** came around **10,000 years back** and human settlements started.