

EVOLUTION

Introduction:

→ Evolution is the study of history of various life forms on the earth that how the organisms gradually modified from simpler forms to the present complex forms over millions of years.

Origin and Evolution of Life:

- The earth is said to have come into existence about **4.5 billion years ago** and life on earth came into existence only a billion years after that.
- Several scientists performed experiments to postulate the theory of evolution:

Scientist	Theory/ Experiment	Conclusion
Abbe Lemaitre	The Big Bang theory (the most accepted)	The universe expanded from a huge thermonuclear explosion
Oparin and Haldane	Chemical evolution preceded organic evolution	Simple organic molecules originated from inorganic constituents



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Stanley Miller and Harold Urey	Synthesis of biomolecules in a closed flask by creation of similar conditions (electrical discharges, mixture of CH_4 , NH_3 , H_2 in 2:1:2 and water vapour at 800°C) as primitive atmosphere on laboratory scale	Formation of biomolecules such as amino acids from ammonia, simple sugars, nitrogen bases, pigment and fats was observed in the flask.
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- The first non-cellular forms of life present inside a self-replicating metabolic capsule. These were RNA, proteins, polysaccharides, etc.

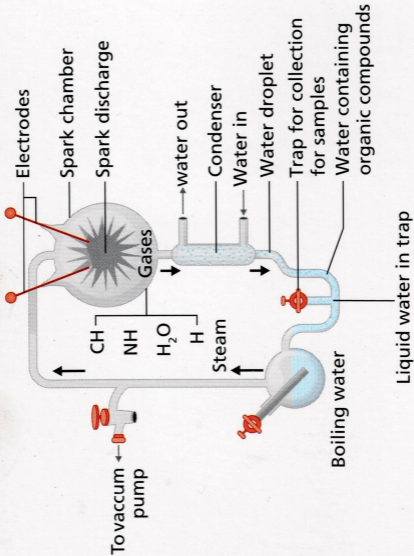
Theories of Origin of Life:

- **Theory of special creation** states that life has been created by God by his divine act of creation.
- **Theory of panspermia/cosmozoic creation** states that life on earth originated from spores or panspermia that came from outer space.
- **Theory of spontaneous generation/ abiogenesis** states that life originated from non-living decaying and rotting matter like straw, mud, etc.
- **Louis Pasteur** rejected the theory of spontaneous generation and demonstrated that life came from pre-



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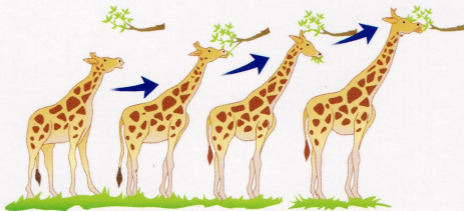
existing life. He showed that life did not evolve from killed yeast cells in pre-sterilised flask. But in open flask, new living organisms evolved (Swan Neck flask experiment).



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Theories of Evolution:

- **Theory of inheritance of acquired characters** was given by Lamarck who stated that the evolution of life forms occurs due to use and disuse of organs.
- **Example:** giraffes developed elongated necks to forage leaves on tall trees. Therefore, this character was adapted and passed to succeeding generations.



- **Theory of natural selection** was given by Charles Darwin who stated that the fitness of an individual means reproductive fitness. Therefore, better adapted individuals will form more progeny as well as survive better and gets selected by nature.



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- **Branching descent** and **natural selection** are the two key concepts of Darwinian Theory.
- **Alfred Wallace** reached similar conclusions like Darwin and in 1858 they jointly gave this theory based on certain observations like- limited natural resources, over population, competition for resources, struggle for existence and survival of the fittest.

Mechanism of Evolution:

- **Hugo de Vries** conducted experiments on *Oenothera lamarckiana* plant and proposed the **mutation theory of evolution**.
- According to de Vries, mutations are random and directionless which generates evolution and caused speciation. Hence called it **saltation** (single step large mutation).
- **Modern synthetic theory of evolution** was given by **Huxley** in 1942 which states that introduction of genetic variation in a population, natural selection and reproductive isolation forms the basis of the origin of species.

Brief Account of Evolution:

- **Proterozoic era 2500–541 million yrs. ago (mya):** First cellular forms of life appeared (about 2000 mya). Some



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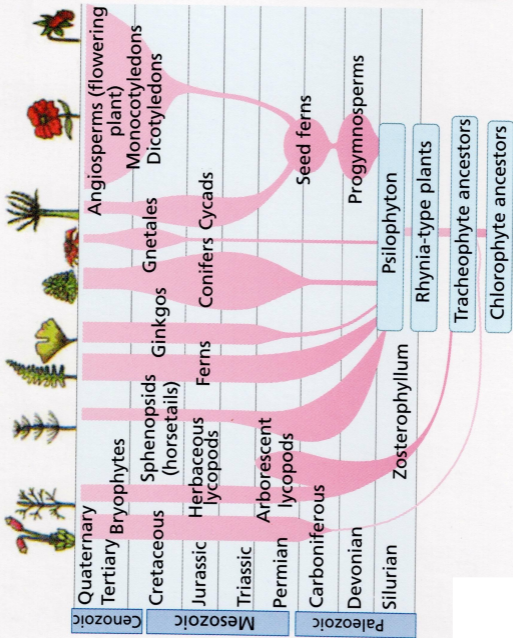
of the cells performs photosynthesis and releases O_2 . Slowly, single celled organisms became multicellular organisms.

- **Paleozoic era 541–252 mya:** Invertebrates were formed (around 500 mya), first land plants (around 450 mya) appeared, arthropods invaded the land (around 400 mya), jawless fishes and amphibious fishes with stout were evolved (around 350 mya), Sea weeds and few plants were reported (around 320 mya).
- **Lobefins** evolved to be the first amphibians and ancestors of modern day frogs and salamanders. **Coelacanth**, a lobefin was caught in 1938 in South Africa which was thought to be extinct.



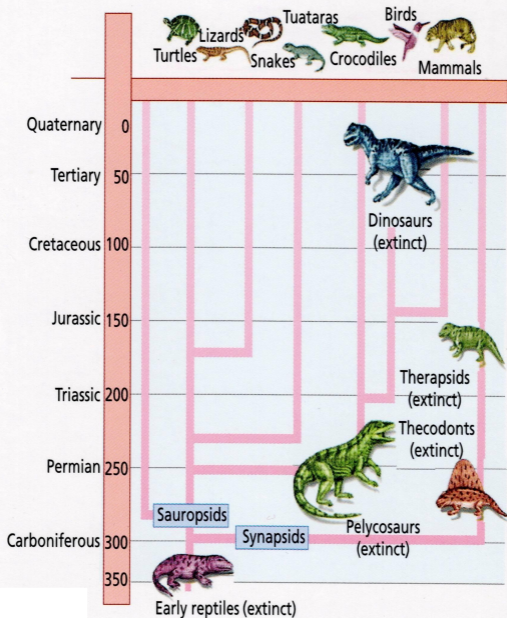
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- **Mesozoic era 252–66 mya:** Age of reptiles and gymnosperms. Some of the land reptiles, e.g., *Ichthyosaurs* evolve into fish-like reptiles (around 200 mya), land reptiles were dinosaurs (Tyrannosaurus rex was the largest), toothed birds emerged.
- **Cenozoic era 66–0 mya:** Age of Mammals and Angiosperms. Dinosaurs disappeared (around 65 mya), first mammals were shrew-like.

Human Evolution:

Various stages of human evolution can be summarized as:

Human Ancestors	Origin period	General features
<i>Dryopithecus</i>	20–25 mya	More ape-like, hairy, ate soft fruits and leaves, large brain, arms and legs of same length.
<i>Ramapithecus</i>	14–15 mya	More man-like, walked more erect, teeth like modern man.
<i>Australopithecus</i> (The first ape man)	2 mya	Man-like primates, hunted with stone weapons but ate fruits, having brain capacity 400-600cc, probably lived in East African grasslands.



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<i>Homo habilis</i> (Handy man)	1.2–1.5 mya	First human-like being (hominid), brain capacity 650–800cc, herbivores, and fossils found in East Africa.
<i>Homo erectus</i> (Java man)	1.5 mya	Large brain with a capacity of 900cc, ate meat, fossils found in Java in 1891.
<i>Homo sapiens neanderthalensis</i> (Primitive man)	1,00,000– 40,000 years ago	Known as Neanderthal man. Brain size 1400cc, used hides to protect their body and were buried their dead bodies after death, fossils found in East and Central Asia.
<i>Homo sapiens</i> (Modern man)	75,000– 10,000 years ago (ice age)	Arose in Africa, developed cave art about 18,000 years ago, agriculture started around 10,000 years back and this led to human settlement and civilizations.





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Unit - VII: Genetics and Evolution

Evidences of Evolution:

- **Paleontological evidences** help in the study of the past life as well as their similarities with the present day organisms with the help of fossil (remains of hard parts of life-forms found in rocks) records.
- Study of fossils helps in discovering the extinct organisms (dinosaurs), connecting link (*Archaeopteryx*), phylogeny (horse evolution) and also in identifying the geological period in which an organism existed.



- **Embryological evidences** propounded by the **Von Baer** but later it was reinterpreted by the Ernst Haeckel. He observed that all vertebrates embryonic stage have certain common features that were absent in their adults.
- He gave the **theory of recapitulation** or biogenetic law which states that an

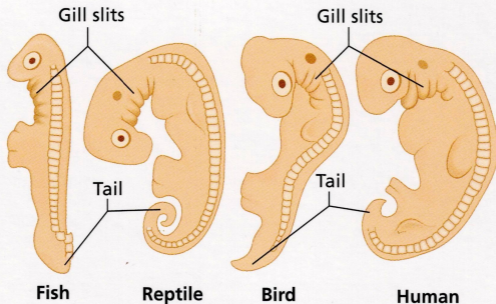




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individual organism in its development (ontogeny) tends to repeat the stages passed through by its ancestors (phylogeny), i.e., **ontogeny recapitulates phylogeny**.



Embryos and evolutionary history

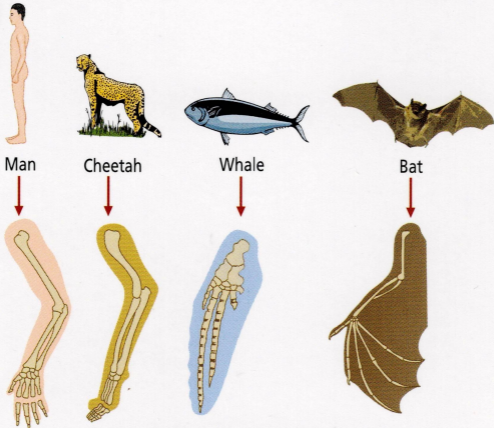
- **Homologous organs** shows similarity in basic anatomical structure and embryonic development but perform different functions.
 - This shows **divergent evolution**. e.g., Vertebrate's hearts or brains, Thorns of *Bougainvillea* and tendrils of *Cucurbita*.





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Homologous organs (ForeLimbs)

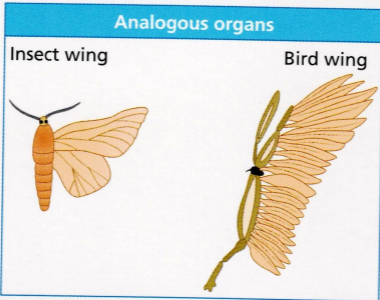
- **Analogous organs** perform similar functions but have different basic anatomical structure.
 - This shows **convergent evolution**. e.g., Eye of Octopus and of mammals, Sweet potato and potato.





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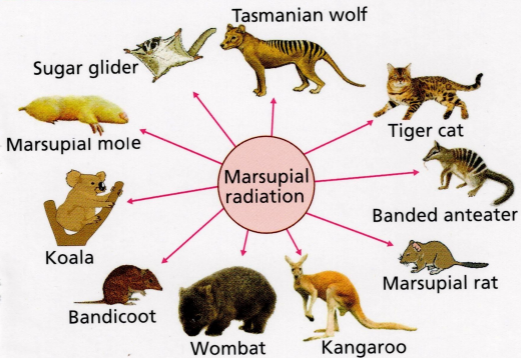
- **Biochemical evidences** are the similarities in metabolic processes, functioning of proteins and genes among diverse organisms. It indicates common ancestry.
- **Biogeographical evidences** shows that the species restricted to a region develop unique features. Also, species present in far separated regions show similarity of ancestry. This can be explained by following processes:
 - **Adaptive radiation** is the evolution of different species from an ancestor in a geographical area, starting from a point and radiating to other geographical area. e.g., **Darwin's finches** in Galapagos Islands, **Australian marsupials** and **Placental mammals** in Australia.





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- When more than one adaptive radiation occurs in an isolated geographical area, the phenomenon is called **adaptive convergence** or convergent evolution. e.g., Mole and Marsupial mole.
- **Natural selection evidences** states that the organisms with better heritable variation are survived and reproduced. It can be explained by two examples of natural selection by **anthropogenic actions**:





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- **Industrial melanism:** In England, before industrialization, there were more white-winged moths (*Biston betularia*) on trees. But after the industrialization, the number of dark-winged moths increased.
- Because after industrialization, tree trunks deposits with soot and smoke and hence, the dark winged moths survived because of suitable dark background while the white winged ones were easily picked up by the predators.



(a)

(b)

Figure showing white - winged moth and dark - winged moth (melanised) on a tree trunk (a) in unpolluted area (b) in polluted area

- **Chemical resistance:** Excess use of herbicides, pesticides, antibiotics or drugs has resulted in development of resistant varieties of organisms.

Hardy-Weinberg Principle:

- It is also known as **genetic equilibrium** and it states that allele frequencies in a population are stable and is





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constant from generation to generation. According to this, the sum total of all allelic frequencies is 1 (unity).

- **Example:** Consider, in a diploid organism, p and q represent the frequency of allele A and a, respectively. The frequency of AA is p^2 and that of aa is q^2 and of Aa is $2pq$. Hence, $p^2 + 2pq + q^2 = 1$.
- Evolution results due to the disturbance in Hardy-Weinberg principle. The below given factors are responsible for the disturbance:
 - **Gene migration/gene flow** involves migration of a population to another place that results in change of gene frequencies in both populations. Multiple gene migration result in gene flow.
 - **Genetic drift** occurs when the change in gene frequency is random and by chance. The change in allele frequency sometimes is so different in the new population that it results in the formation of new species. The original drifted population becomes the founder and the effect is known as **founder effect**.
 - **Mutation** is sudden change which results in new phenotypes.

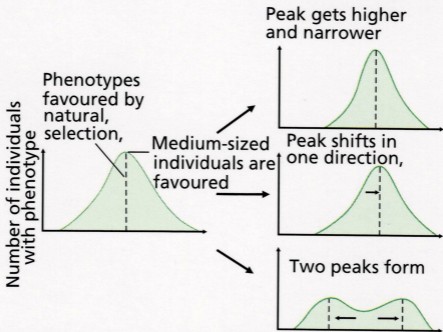




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- **Genetic recombination** is the reshuffling of gene combinations due to crossing over during gametogenesis.
- **Natural selection** has three effects, i.e., Stabilization (large number of individuals acquires mean character value), Directional change (more individuals acquire value other than the mean character value), Disruption (more individuals acquire peripheral character value at both ends of the distribution curve).



Operation of natural selection on different traits
(a) Stabilising (b) Directional and (c) Disruptive



TEST

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Unit - VII: Genetics and Evolution

1. The theory of evolution supported by the experiment conducted by Louis Pasteur is:
 - (a) Spontaneous generation theory
 - (b) Life comes only from pre-existing life
 - (c) Abiogenesis of life
 - (d) Big bang theory
2. Identify the examples of convergent evolution from the following:
 - (a) Flippers of penguins and dolphins
 - (b) Eyes of octopus and mammals
 - (c) Vertebrate brains
 - (d) Both (a) and (b)
3. Which of the following had the smallest brain capacity?
 - (a) Homo habilis
 - (b) Homo neanderthalensis
 - (c) Homo sapiens
 - (d) Homo erectus
4. Industrial melanism is an example of _____.
 - (a) Natural Selection
 - (b) Mutation
 - (c) Neo Lamarckism
 - (d) None of the above



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Solutions:

1. Option (b) is correct

The theory of evolution supported by the experiment conducted by Louis Pasteur is life comes only from pre-existing life. He proved it by conducting careful experiments. Before it, Pasteur rejected the theory of spontaneous generation which states that life originated from non-living matter.

2. Option (d) is correct

When structures of different organisms evolve for the same function and hence have similarity, such a condition is called as convergent evolution. Examples are flippers of penguins and dolphins and eyes of octopus and mammals.

3. Option (a) is correct

Homo habilis had the smallest brain capacity of about 650-800cc. On the other hand, *Homo neanderthalensis* had the largest brain capacity of about 1400cc.

4. Option (a) is correct

Industrial melanism is an example of natural selection. In this, moths living in the industrial areas adapted to match their bodies to the tree trunks (deposits with soot and smoke). So that, these black winged moths easily hide themselves from the predators.

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5. From his experiments, S.L. Miller produced amino acid by mixing the following in a closed flask:
- (a) CH_4 , H_2 , NH_3 and water vapor at 800°C
 - (b) CH_3 , H_2 , NH_4 and water vapor at 800°C
 - (c) CH_4 , H_2 , NH_3 and water vapor at 600°C
 - (d) CH_3 , H_2 , NH_3 and water vapor at 600°C
6. According to Hugo de Vries, the mechanism of evolution is _____.
- (a) Phenotypic variations
 - (b) Multistep mutations
 - (c) Minor mutations
 - (d) Saltation
7. In Hardy-Weinberg equation, the frequency of heterozygous individual is represented by:
- (a) p^2
 - (b) $2pq$
 - (c) pq
 - (d) q^2
8. Correct order is:
- (a) Paleozoic \rightarrow Archaeozoic \rightarrow Cenozoic
 - (b) Archaeozoic \rightarrow Paleozoic \rightarrow Proterozoic
 - (c) Paleozoic \rightarrow Mesozoic \rightarrow Cenozoic
 - (d) Mesozoic \rightarrow Archaeozoic \rightarrow Proterozoic



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Solutions:

5. Option (a) is correct

Stanley Miller synthesizes biomolecules such as amino acids in a closed flask by creation of similar conditions (electrical discharges, mixture of CH_4 , NH_3 , H_2 in 2:1:2 and water vapour at 800°C) as primitive atmosphere on laboratory scale.

6. Option (d) is correct

According to Hugo de Vries, mutations are random and directionless which generates evolution and caused speciation. Hence, called it saltation (single step large mutation).

7. Option (b) is correct

Hardy-Weinberg equation is represented by $p^2 + 2pq + q^2 = 1$. Here, p and q represent the frequency of allele A and a , respectively. The frequency of AA (homozygous dominant) is p^2 and that of aa (homozygous recessive) is q^2 and of Aa (heterozygous) is $2pq$.

8. Option (c) is correct

According to the geological time scale, the correct order of eras is Paleozoic \rightarrow Mesozoic \rightarrow Cenozoic. Paleozoic began 541 million years ago and ended about 252 million years ago. The time period of Mesozoic is 252-66 million years ago and of Cenozoic is 66 million years ago until today.

