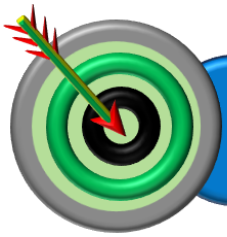
Chapter
06

# Evolution



## OBJECTIVES

- INTRODUCTION
- ORIGIN OF LIFE
- EVOLUTION OF LIFE FORMS – A THEORY
- WHAT ARE THE EVIDENCE FOR EVOLUTION
- ADAPTIVE RADIATION – DEFINITION & EXAMPLES
- BIOLOGICAL EVOLUTION
- MECHANISM OF EVOLUTION
- HARDY WEINBERG PRINCIPLE
- A BRIEF ACCOUNT OF EVOLUTION

# ORIGIN AND EVOLUTION OF MAN

# INTRODUCTION

**Evolutionary Biology:**

It is the study of history of life forms i.e. the changes in flora and fauna that have occurred over millions of years on earth.

**Evolution**

- The word evolution means to unfold or unroll or to reveal hidden potentialities. Evolution simply means an orderly change from one condition to another.
- Evolution term was introduced by Herbert Spencer.
- It can be best explained by Darwin's concept of **'Descent with modification'.**
- This is the story of origin of life and evolution of life forms or biodiversity on planet earth in the context of evolution of earth and against the background of evolution of universe itself.

## 6.1 ORIGIN OF LIFE

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

- **What is Universe?**
  - The universe is a huge cluster of galaxies. Galaxies contain stars and clouds of gas and dust. Considering the size of universe, earth is indeed a speck i.e. The universe is vast.
  - Stellar distances are measured in light years. When we look at stars on a clear night sky we are, in a way, looking back in time. What we see today is an object whose emitted light started its journey millions of year back and from trillions of kilometers away and reaching our eyes now.
  - However, when we see objects in our immediate surroundings we see them instantly and hence in the present time. Therefore, when we see stars we apparently are peeping into the past.
  - The Big Bang theory attempts to explain to us the origin of universe.

- **Big Bang theory-** Proposed by **Georges Lemaitre.**
  - According to it, the universe originated about 20 billion years ago due to a thermonuclear explosion of a dense entity. This single huge explosion which is unimaginable in physical terms, is called as big bang.
  - The universe expanded and hence, the temperature came down.
  - The gaseous clouds of hydrogen and helium which were formed by big bang condensed under gravitation and converted into many flat discs like structures called nebula, made up of atoms and small particles. Solar nebula was one of them, which formed our solar system.
  - The very hot central part of solar nebula became still hotter and converted into the sun.
  - Later on, due to condensation of atoms and dust particles moving around the sun other planets were formed.
  - In the solar system of the Milky Way galaxy, earth was supposed to have been formed about 4.5 billion years back.
  - There was no atmosphere on early earth. It was formed later.
  - Water vapour, methane, carbondioxide and ammonia released from molten mass covered the surface. The UV rays from the sun brokeup water into Hydrogen and Oxygen and the lighter H2 escaped. Oxygen combined with ammonia and methane to form water, CO2 and others.
  - The ozone layer was formed. As it cooled, the water vapor fell as rain, to fill all the depressions and form oceans. Life appeared **500 million years** after the formation of earth, i.e., almost **four billion years** back.

- **Theories For Origin of Life**

**(A) Theory of special creation -**

- The greatest supporter of this theory was Father Suarez. This is a mythology based theory.
- This theory has three connotations-

(a) All living organisms (Species or types) that we see today were created as such.

(b) The diversity was always the same since creation and will be the same in future.
(c) The earth is about 4000 years old.

- All these ideas were strongly challenged during the nineteenth century based on observations of Charles Darwin. Charles Darwin concluded that existing living forms share similarities to varying degrees not only among themselves but also with life forms that existed millions of years ago. Many such life forms do not exist anymore. There had been extinctions of different life forms in the years gone by just as new forms of life arose at different periods of history of earth. There has been gradual evolution of life forms.
- From fossils records and their dating, we can conclude that earth is very old, not thousands of years as was thought earlier but billions of years old.

**(B) Cosmic Panspermia theory –**

- Some scientists believe that life came from outer space.
- Early Greek thinkers thought units of life called spores were transferred to different planets including earth.
- 'Panspermia' is still a favourite idea for some astronomers.

**(C) Theory of spontaneous generation (Abiogenesis/Autogenesis) –**

- This hypothesis was supported by ancient Greek philosophers.
- According to this theory life came out of decaying and rotting matter like straw, mud, etc. spontaneously.
- They believed that the mud of Nile river could give rise to fishes, frogs, crocodiles etc when warmed by light rays.

**(D) Theory of biogenesis - Proposed by Harvey & Huxley**

- They stated "New life can be originated on earth only by pre-existing life."

**Experiment of Louis Pasteur:**

- His experiment is also known as 'Swan neck flask experiment'.
- He prepared sterilized syrup of sugar and killed yeast by boiling them in flasks.
- He took two flasks one of broken neck and another of curved neck (swan neck flask/ "S" shaped neck flask

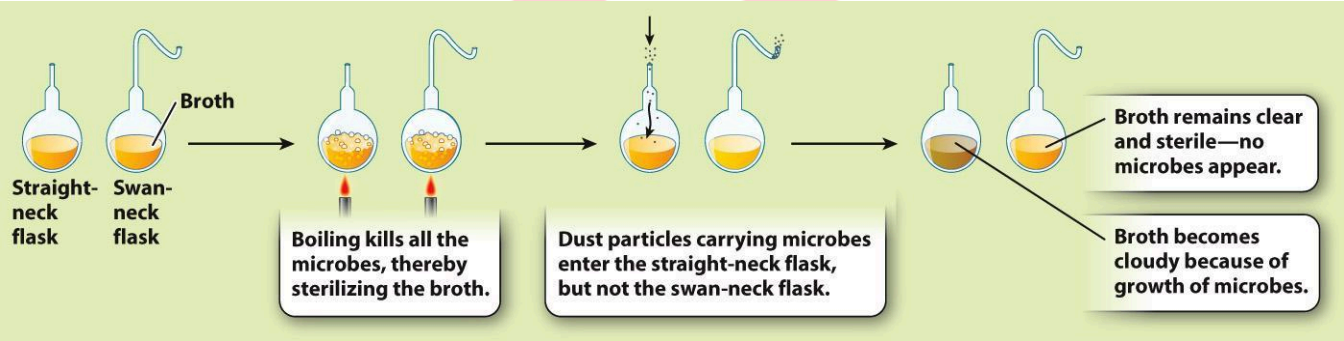



**Fig.:** Louis Pasteur's swan neck flask experiment

- Louis Pasteur by careful experimentation demonstrated that life comes only from preexisting life.
- He showed that in pre-sterilized swan neck flasks, life did not come from killed yeast because germ laden dust particles in the air were trapped by the curved neck which serves as filter while in another flask open to air (broken neck), new living organisms arose from 'killed yeast'.
- Spontaneous generation theory was dismissed once and for all. However, this did not answer how the first life form came on earth.

**(E) Oparin - Haldane theory (Modern theory) -**

- Oparin of Russia and Haldane of England proposed that the first form of life could have come from pre-existing non-living organic molecules (e.g. RNA, protein, etc.) and that formation of life was preceded by chemical evolution, i.e., formation of diverse organic molecules from inorganic constituents.
- Oparin's theory was published in his book **'ORIGIN OF LIFE'.**

- **First life originated in sea water, so water is essential for origin of life**.

**(i) Chemical Evolution (Chemogeny)**

- The primitive conditions on earth were high temperature, volcanic storms, lightening and reducing atmosphere containing $CH_4$, $NH_3$ etc.
- Early earth had free atoms of all those elements which are essential for formation of protoplasm (C, H, O, N etc.).
- Hydrogen was maximum among all of them.
- Due to high temperature hydrogen reacted with oxygen to form water and no free oxygen was left, which made the atmosphere reducing.
- Hydrogen also reacted with nitrogen and formed ammonia.
- Hence Water and ammonia were probably the first inorganic compounds formed on earth.
- Methane ($CH_4$) was the first organic compound.
- As the earth cooled down, the water vapour fell as rain, to fill all the depressions and form primitive oceans. During this, molecules continued to react with each other and formed various simple and complex organic compounds.

Clue Finder

The water of oceans became a rich mixture of macromolecules/ complex organic compounds. Haldane called it Hot dilute soup/ pre biotic soup.

- Hence the possibilities of life were established in the water of primitive oceans because these macromolecules (Proteins, polysaccharides, fats/lipids, nucleic acids) form the main components of protoplasm.
  We have no clear idea about how the first self-replicating metabolic capsule of life arose, but many attempts were made to solve the mystery of arise of life on earth. From these macromolecules how first life was originated, will be studied in Biological evolution.

Atomic Stage
(C, H, O, N, S)
⇓
Molecular Stage
$(H_2O\ (Vapour), N_2, CO_2, CH_4)$
⇓
Simple Organic Compounds
(Sugar, Amino Acids, Fatty Acids Etc.)
⇓
Complex Organic Compounds
(Proteins, Polysaccharides, Fat/Lipids Nucleic Acid)
⇓
Biological Evolution

- **Harold Urey & Stanley Miller Experiment**

**In 1953, S.L. Miller**, an American scientist created similar conditions at laboratory scale which were thought to be on primitive earth.

- He took $CH_4$, $NH_3$, $H_2$ and water vapour at 800° C in a large flask.
- He created electric discharge by using two tungsten electrodes as source of energy.
- He observed the formation of simple amino acids like glycine, alanine, and aspartic acid.
- In similar experiments other scientists observed, formation of sugars, nitrogen bases, pigment and fats.

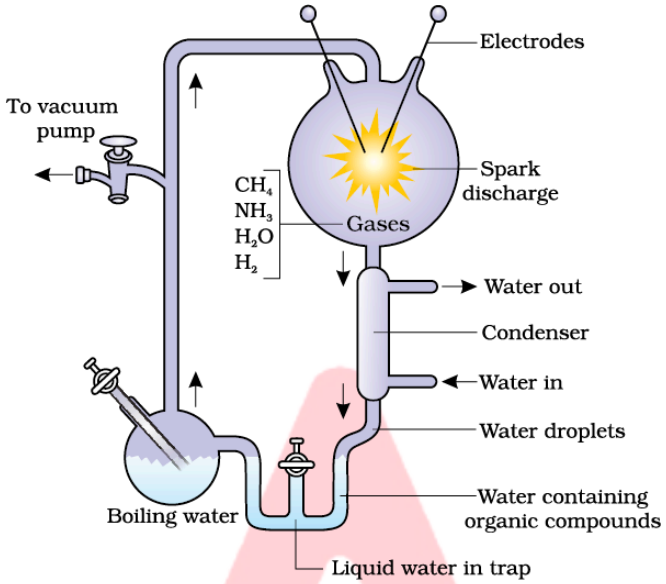



**Fig.:** Diagrammatic representation of Miller's experiment

- **Evidences from meteorites:**
  - Analysis of meteorite contents also revealed similar compounds indicating that similar processes are occurring elsewhere in space
  - With these limited evidences, the first part of the conjectured story, i.e., chemical evolution was more or less accepted.

**(ii) Biological evolution (Biogeny)**

**(a) Origin of protobionts-**

- Some colloidal drop like structures formed in primitive oceans by aggregation of macromolecules (Proteins, polysaccharides, lipids, nucleic acids), which are called as protobionts.

**Critical Thinking**

- These protobionts-
  - were unable to reproduce
  - could grow by absorbing molecules from their surroundings
  - could exhibit simple metabolism
  - could maintain internal environment by partially isolating themselves from the surroundings
- Some models of protobionts like coacervates (by Oparin) and microsphere (by Sydney Fox) were also synthesized artificially in laboratory
- **Origin of protocells (Eobionts)-**
- Nucleic acid developed the ability of self duplication due to a sudden change called mutation.
- Nucleic acid and proteins combined to form nucleoproteins. Nucleoproteins were the first sign of life.
- Clusters of nucleoproteins surrounded by lipid coat called protocell, the first form of life.
- These first non-cellular forms of life could have originated 3 billion years ago.
- Altman (1980) discovered that some RNA molecules have enzymatic activity, called as ribozymes. It means at the time of origin of life, RNA molecule could carry out all the processes of life (replication, protein formation etc) without the help of either protein or DNA. Hence this concept called as RNA World.

**(b) Origin of first cellular form (Prokaryotes) –**

- This first cellular form of life did not possibly originate till about 2000 million years ago. (2 bya).
- The first living beings were single celled bacteria like prokaryotes with naked DNA.
- They were probably chemoheterotrophs and anaerobic

**Clue Finder**

Cyanobacteria (Blue green algae) were the first organisms which released in the environment

**Oxygen revolution :** Liberation of free oxygen by cyanobacteria was a revolutionary change in the history of earth. It includes some major changes like-

- Primitive reducing atmosphere turned into oxidizing, which triggered oxidation of methane and ammonia
- Ozone appeared which absorbs ultraviolet radiation and Beginning of aerobic life.

**(c) Origin of Eukaryotic cell :** Nucleus, mitochondria and other cell organelles developed in the cell and metabolically it became more active. These free living unicellular eukaryotic organisms originated about 1.5 billion years ago in the primitive ocean.

**TOPIC CENTRIC EXERCISE 01**

**Q1. Life originated on earth almost**

(a) 8 billion years ago (b) 6 billion years ago
(c) 4 billion years ago (d) 1 billion years ago.

**Q2. Miller's experiment mixture had the following, except**

(a) methane (b) $O_2$
(c) hydrogen (d) water vapour.

**Q3. During the course of origin of life what was the sequence of substances released from the molten mass covered the earth surface?**

(a) Water, oxygen, nucleic acids, enzymes
(b) Amino acids, ammonia, phosphates, nucleic acids
(c) Carbon dioxide, amino acids, nucleic acids, proteins

(d) Water vapour, methane, carbon dioxide, ammonia

**Q4. The first cellular form of life did not possibly originate till about …….years ago:**

(a) 2000 million (b) 8 billion

(c) 2000 billion (d) 1 billion

**Q5. Theory of natural selection was given by**

(a) Lamarck (b) Darwin

(c) Alfred Wallace (d) JBS Haldane.

## 6.2 EVOLUTION OF LIFE FORMS - A THEORY

- Based on the observation made during sea voyage by Charles Darwin in sail ship H.M.S. Beagle around the world. He was appointed as a naturalist for this voyage to study the vast flora and fauna of the different continents and islands.
- He said that every living organism, whether animal or plant, has its own characteristicsThese are the details of appearance or behaviour. For example, we have four limbs and bearing four limbs is one of our characteristics (that is why we are called tetrapods).
- While moving from one place to another during his voyage, Darwin observed that even different looking and differently behaving organisms share some similarities among themselves.
- These similarities may either be in the body structure or in the behaviour. He also observed that living organisms share similarities not only among themselves but also with those organisms which became extinct from earth.
- Based on his observations, Darwin concluded that all the existing life forms share similarities to varying degrees and also may share common ancestors. More are the similarities, more closely they are related and more closely they are related, more recently they shared common ancestors.
- Hence, we can say that if two organisms share common ancestor in the recent history, it would be present in the same epoch, period or era. And if they share common ancestor in distant history, it would be present in the different epoch, period or era; depending upon how distantly they share it.
- **Hence, we can conclude from it that the geological history of the earth closely correlates with the biological history of earth**. There had been extinctions of different life forms in the years gone by just as new forms of life arose at different periods of history of earth. There has been gradual evolution of life form.
- A common permissible conclusion is that earth is very old, not thousand of years as was thought earlier but billions of years old.

### Concept of Natural Selection

- Darwin not only talked about the similarities but also about the differences or variations among the organisms. He said that every population has its own characteristic features that differ from the characteristics of other populations.
- Nature poses the same challenges to all living organisms in the form of harsh climate, food scarcity, natural disasters like flood, droughts, etc. The characteristics that enable some organisms to survive better than others in the same environment, are said to be selected by nature.
- Some used the word '**fitness'** for this capability to survive better. But, Darwin only referred to the 'reproductive fitness' which means those organisms who are better fit in their environment produce more number of offsprings than others or we can say their reproduction rate is higher than the others. These, therefore, will survive more and hence are selected by nature.
- Darwin used the phrase 'natural selection' for this and said that it is the natural selection which is responsible for the evolution. There was one more naturalist called Alfred Wallace, who worked in the Malay Archepelago. Like Darwin, he also talked about the fitness of organisms.
- He also came to the similar conclusions that those organisms which can adapt better in their environment, are selected by the nature.

**TOPIC CENTRIC EXERCISE 02**

**Q1.** **If two organisms are more closely related then which of the following is a possibility?**
(a) They will share common ancestor in the future
(b) They share a common ancestor in the distant history
(c) They share a common ancestor in the recent history
(d) They will not at all share any common ancestor

**Q2.** **……., a naturalist who worked in Malay Archipelago had also come to similar conclusions around the same time as that of the Darwin?**
(a) Alfred Wallace (b) Lamarck
(c) Louis pasteur (d) Hugo de vries

**Q3.** **How old is our universe?**
(a) 10 billion years old (b) 20 billion years old
(c) 15 billion years old (d) 200 billions years old

**Q4.** **Who discarded the theory of spontaneous generation forever?**
(a) Louis Pasteur (b) Thomas Malthus
(c) Alfred Wallace (d) Stanley L. Miller

## 6.3 WHAT ARE THE EVIDENCES OF EVOLUTION

### (1) PALAEONTOLOGICAL EVIDENCES

- Study of fossils is called palaeontology.
- Fossils are impression or remains of hard parts of life-forms found in rocks.
- 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. Such types of rocks are called as sedimentary rocks.
- Mostly fossils are found in sedimentary rocks.
- Different-aged rock sediments contain fossils of different life-forms who probably died during the formation of the particular sediment.
- A study of fossils in different sedimentary layers indicates the geological period in which they existed.
- Some of them represent extinct organisms (e.g., Dinosaurs).
- The study shows that life-forms varied over time and certain life forms are restricted to certain geological time spans.
- New forms of life have arisen at different times in the history of earth. i.e. evolution has taken place.
- The geological history of earth closely correlates with the biological history of earth.
  Generally, fossils found in older rocks are of simpler types and found in newer rocks are of complex type
  By fossils we can study the evolutionary pedigree of animals like horse, elephants and man etc.

**Clue Finder**

How the ages of the fossils are calculated?
**Answer:** We can calculate the age of rocks by relative proportions of radioactive element and non-radioactive element in a sample of rock. This method is called radioactive dating.
There are several methods used to determine the age of fossils-
(1) Uranium Lead method
(2) Radio carbon method
(3) Potassium argon method
(4) Electron spin resonance (ESR) method – this is the modern and most accurate technique.

### (2) GEOLOGICAL TIME SCALE

- It is the chronological order of the history of organic evolution on earth.
- The time after formation of the earth (4.5 billion years) is divided into 6 Eras, some Eras further divided into Periods and periods of recent era are divided into smaller time spans called Epochs.

- Intense geological disturbances have occurred on earth time to time, in which most of the pre existing organisms perished out and the few remaining ones evolved into new and varied organisms.

| GEOLOGICAL TIME SCALE | | | |
|---|---|---|---|
| **Era** | **Period** | **Epochs** | **Life forms** |
| **COENOZOIC** (Age of Birds, Mammals and Angiosperms ) | **QUATERNARY** | Holocene (Age of Man) | Mental age, supremacy of man |
| | | Pleistocene (ICE AGE) | Human appeared, social life of human started |
| | **TERTIARY** | Pliocene | Apelike ancestors of human appeared |
| | | Miocene | |
| | | Oligocene | Anthropoid apes evolved from monkeys<br>Rise of monocots |
| | | Eocene | Eohippus appeared |
| | | Palaeocene | Origin of primates |
| **ROCKY MOUNTAIN REVOLUTION** | | | |
| **MESOZOIC** (Age of Reptiles) | **CRETACEOUS** | | Extinction of Dinosaurs & archaeopteryx Origin of primitive placental mammals and Modern birds<br>Angiosperms also appeared |
| | **JURASSIC (Golden age of Dinosaurs)** | | Dominance of dinosaurs, origin of first toothed birds and marsupial mammals<br>Gymnosperms and ferns also dominated |
| | **TRIASSIC** | | Origin of dinosaurs and oviparous mammals |
| **APPALACHIAN REVOLUTION** | | | |
| **PALAEOZOIC** | **PERMIAN** | | Origin of mammal like reptiles, first Gymnosperm appeared |
| | **CARBONIFEROUS (Golden age of amphibians)** | | Amphibians were dominant and origin of reptiles (seymauria)<br>First seed plant originated |
| | **DEVONIAN (Golden age of fishes)** | | Fishes were dominant and origin of amphibians |
| | **SILURIAN** | | Jawless fishes were dominant and Origin of true fishes |
| | **ORDOVICIAN** | | Giant mollusks were dominant<br>Origin of jawless fishes (1st vertebrates), origin of chordata |
| | **CAMBRIAN** | | Trilobites (Extinct arthropods) were dominant |
| **SECOND GREAT GEOLOGICAL REVOLUTION** | | | |
| **PROTEROZOIC** | | | Origin of protozoa, sponges, coelenterate, annelida & mollusca |
| **FIRST GREAT GEOLOGICAL REVOLUTION** | | | |

| | | | |
|---|---|---|---|
| **ARCHAEOZOIC** | | | Prokaryotes originated and dominated (Era of invisible life) Eukaryotes also evolved |
| **AZOIC** | | | No life, Only **chemical evolution** took place |

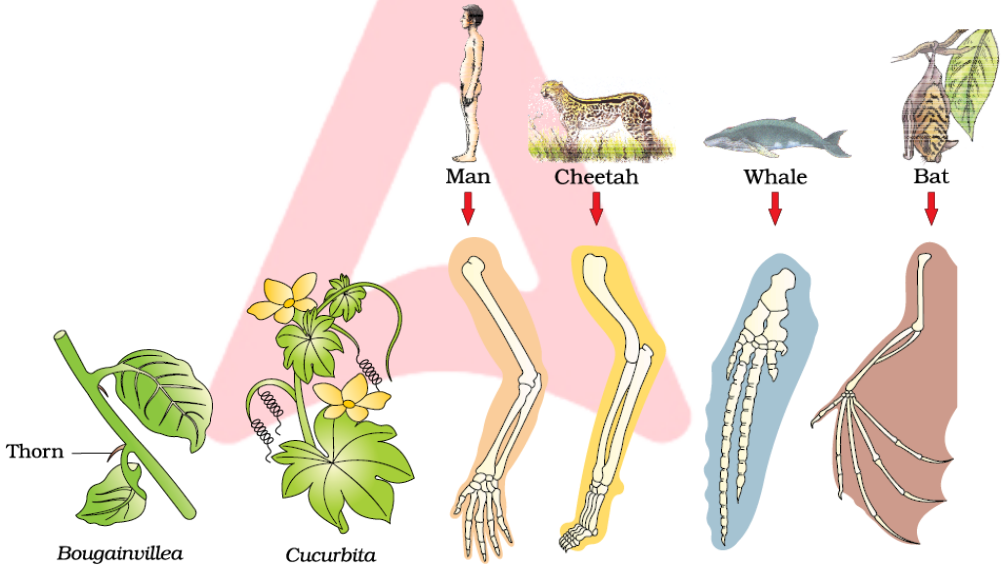
**(3) EVIDENCES FROM COMPARATIVE MORPHOLOGY AND ANATOMY**

- Similarities and differences are found among organisms of today and those that existed years ago. Such similarities can be interpreted to understand whether common ancestors were shared or not.
- These similarities are of two types -
  (A) Homology
  (B) Analogy

**(A) Homology -** The organs which have common origin, embryonic development and same fundamental structure but perform similar or different functions are called as Homologous organs and this phenomenon is called Homology.

**Examples of homologous organs :**

**(i) Forelimbs of mammals -** Whales, bats, Cheetah and human (all mammals) share similarities in the pattern of bones of forelimbs though these forelimbs perform different functions. In these animals, forelimbs have similar anatomical structure - all of them have humerus, radius, ulna, carpals, metacarpals and phalanges in their forelimbs.




(a) (b)

**Fig. :** Example of homologous organs in (a) Plants and (b) Animals

**(ii) Thorn of Bougainvillea and tendril of Cucurbita (both are modification of axillary bud).**

**(iii) All vertebrate hearts**

**(iv) All vertebrate brain**

**(v) Mouth parts of insects -**

| **Cockroach** | **Honey bee** | **Mosquito** |
|---|---|---|
| (Biting & chewing) | (Chewing & lapping) | (Piercing & Sucking) |

In each of these insects mouth parts comprise labrum, mandible maxilla etc.

(vi) **Testes in male and ovaries in female**

**(vii) Potato and Ginger -** both are modified shoot

**(viii) Radish and Carrot -** both are modified roots

**(ix) Molecular homology -** Homology found at molecular level. For example the plasma proteins found in the blood of man and apes are similar.

**(B) Analogy -** The organs which have different origin and fundamental structures but perform similar functions are called Analogous organs and this phenomenon is called as analogy.

**Examples of analogous organs:**

**(i) Wings of butterfly and birds -** They are not anatomically similar structures though they perform similar functions i.e. used for flying.

**(ii)** Eye of the octopus and of mammals

**(iii) Flippers of Penguins and Dolphins**

**(iv) Sweet potato** (root modification) **and potato** (stem modification)

**(v)** Sting of bee and scorpion

- When different structures evolve for the same function due to the similar habitat, this is called **convergent evolution**.
- Analogy doesn't indicate common ancestry and it is based on convergent evolution where different group of organisms have similar adaptive features due to similar habitat or towards the same function, hence analogous structures are a result of convergent evolution

**Critical Thinking**

- When the same structures develop along different directions due to adaptations to different needs, this is called as **divergent evolution.**
- Homology indicates **common ancestry** and based on divergent evolution.

**TOPIC CENTRIC EXERCISE 03**

**Q1. Thorn of Bougainvillea and tendril of Cucurbita**

(a) Homology (b) Analogy

(c) Both a and b (d) None of these

**Q2. The homologous organs show similarity in**

(a) appearance (b) function

(c) origin (d) size.

**Q3. Which of the following are homologous organs?**

(a) Wings of birds and locust

(b) Wings of birds and pectoral fins of fish

(c) Wings of bat and butterfly

(d) Legs of frog and cockroach

**Q4. Select the correct statement(s).**

(a) Forelimbs of whales, bats, cheetah and humans perform similar functions.

(b) Industrial melanism demonstrates natural selection.

(c) Fossils are remains of hard parts of life-forms found in rocks.

(d) Both (b) and (c)

**Q5. Fossils act as evidences of organic evolution. Which one of these features does not justify the feature of fossils?**

(a) They are remains of hard parts of life forms that existed in the past.

(b) They are the remains of decayed and decomposed body parts.

(c) Fossils present in the lower strata of the earth are older than those present in the upper strata.

(d) Study of fossils in different sedimentary layers indicates the geological period in which they existed.

## 6.4 WHAT IS ADAPTIVE RADIATION ? (ADAPTIVE DIVERGENCE)

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) is called **adaptive radiation.**

**Examples:-**

- **Darwin's finch -** During the journey of Galapagos Islands (a group of 22 smaller islands), Darwin observed an amazing diversity of creatures. Of particular interest, small black birds later called Darwin's Finches amazed him.
  He realized that there were many varieties of finches at Galapagos island. All the varieties, he conjectured, evolved on the island itself. From the original **seed-eating** features, many other forms with altered beaks arose, enabling them to become insectivorous and vegetarian finches.

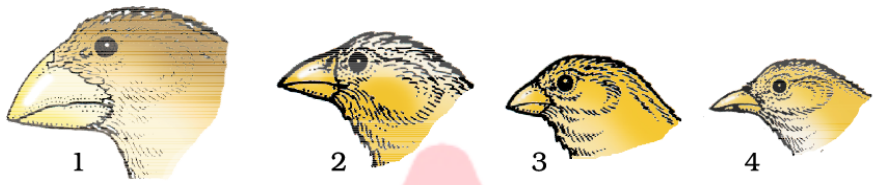



**Fig.:** Variety of beaks of finches that Darwin found in Galapagos Island

- **Australian Marsupials -** A number of marsupials, each different from the other evolved from an ancestral stock, but all within the Australian island continent.
- **Placental Mammals -** A number of placental mammals have evolved from a common ancestral type in other parts of world also. Placental mammals in Australia also exhibit adaptive radiation.

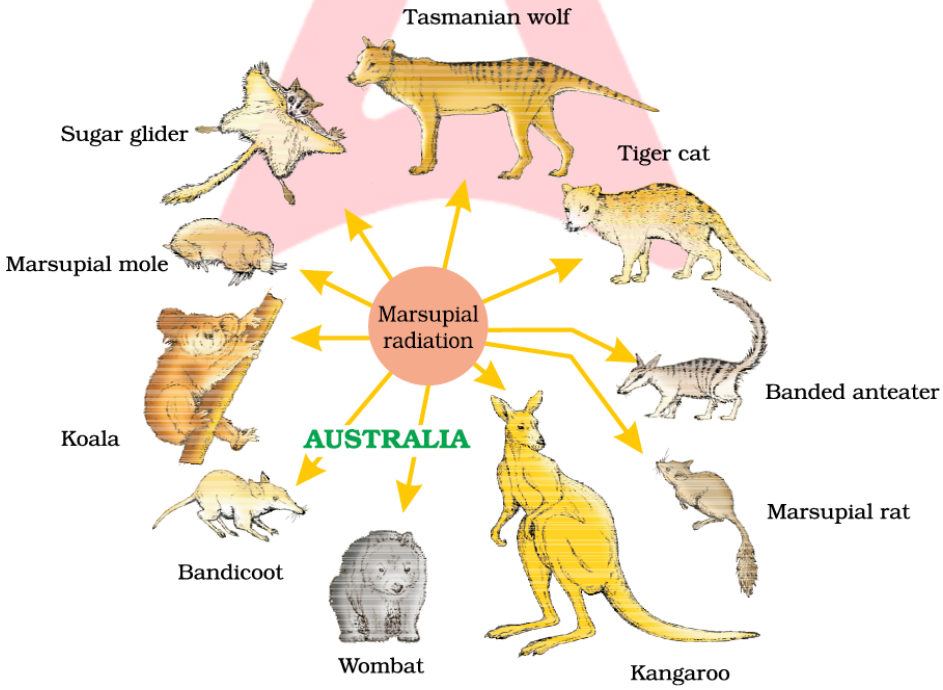



**Fig.:** Adaptive radiation of marsupials of Australia

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

Placental mammals in Australia also exhibit adaptive radiation in evolving into varieties of such placental mammals each of which appears to be 'similar' to a corresponding marsupial.
e.g. Wolf (placental) and Tasmanian wolf (marsupial)

**Clue Finder**

**Parallel evolution**- When adaptive convergence is found in closely related species, it is called as **parallel evolution**. Parallel evolution occurs when two independent but similar species evolve in the same direction and thus independently acquire similar characteristics.

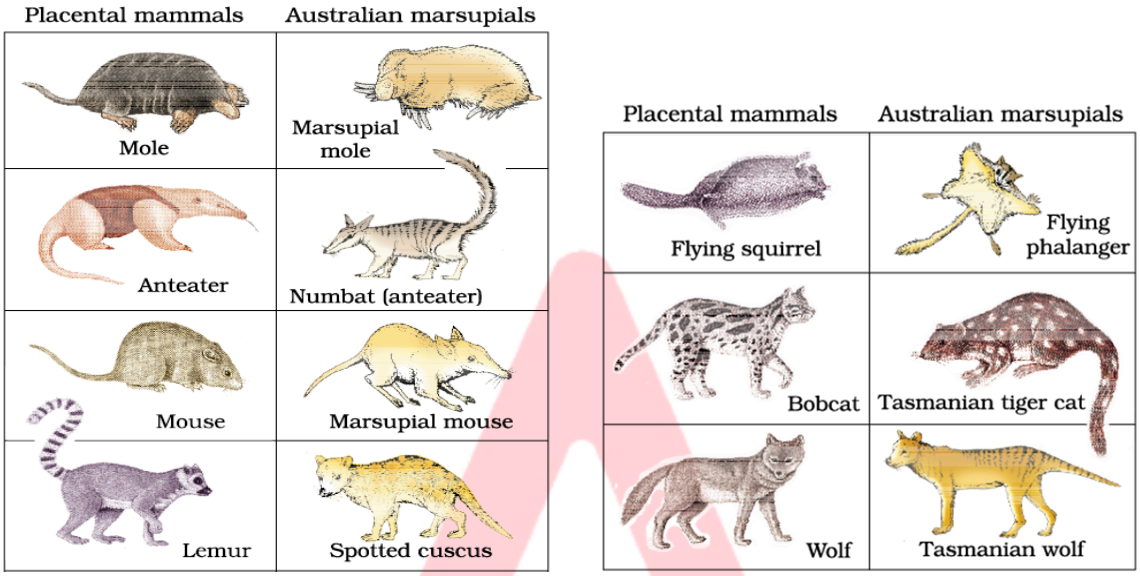



**Fig.:** Picture showing convergent evolution of Australian Marsupials and placental mammals

**EVIDENCES FROM VESTIGIAL ORGANS**

- The organs which are present in reduced form and do not perform any function in the body but are functional in related animals are called vestigial organs.
- They are remnants of organs which were complete and functional in their ancestors. e.g. Nictitating membrane ,Muscles of pinna (auricular muscles) ,Vermiform appendix

**Critical Thinking**

**EVIDENCES FROM ATAVISM (REVERSION)**

- Sometimes in some individuals such characters suddenly appears which were supposed to be present in their ancestors but were lost during the course of evolution, this phenomenon is known as atavism or reversion.

e.g. Tail in new born baby

**Critical Thinking**

**EVIDENCES FROM CONNECTING LINKS**

- Some organisms possess characters of two separate groups called as connecting links, which proves that members of higher groups have evolved from the lower group. **Examples:**
  - **Virus -** Between living and non living
- **Archaeopteryx :**
  - It is a missing link between reptiles and birds.

- **Evidences From Biochemistry**
  - Similarities in proteins and genes performing a given function among diverse organisms give clues to common ancestry.
- **Evidences From Embryology**
  - Baer's law: This was proposed by Von Baer (father of embryology). He stated that "in embryonic stages general characters appear firstly and specialized characters appear later".
  - Muller proposed 'Recapitulation theory', According to which "Ontogeny recapitulates phylogeny". Ontogeny is the study of embryological development of individual organisms while phylogeny is the evolutionary history of that organism.

**Examples:**

- The tadpole larva of amphibians resembles with fishes. This indicates origin of amphibians from fishes.
- During the development of heart in higher vertebrates like birds and mammals, it initially exhibits the 2 - chambered states same as fishes. Later on, it develops into 3- chambered as in amphibians and reptiles and finally in the last embryonic stages it becomes 4- chambered as such in the adults. This proves that all vertebrates have evolved from common fish like ancestors and also that both birds and mammals have evolved from reptiles.
- In 1866, **Ernst Haeckel** explained it in detail and called it **'Biogenetic law'**.
- Ernst Haeckel law was based on the observation of certain features during embryonic stage common to all vertebrates that are absent in adult for example the embryos of all vertebrates including humans develop arow of vestgial gill slits just behind the head but it is functional organ only in fish and not found in any other adult vertebrates.
- It means an organism shows its ancestral adult stages during its embryonic development. In other words embryos of advanced species pass through stages represented by adult organisms of more primitive species.
- **It shows that all organisms have common ancestry.**

- However, this proposal was disapproved on careful study performed by **Karl Ernst von Baer**. He noted that embryos never pass through the adult stages of other animals.

**TOPIC CENTRIC EXERCISE 04**

**Q1. Bobcat is a placental mammal while tasmanian tiger cat is a marsupial. This shows**
(a) convergent evolution (b) divergent evolution
(c) parallelism (d) inheritance of acquired characters.

**Q2. Select the odd one w.r.t Australian marsupials.**
(a) Lemur (b) Numbat
(c) Tasmanian wolf (d) Spotted cuscus

**Q3. Which evidence of evolution is related to Darwin's finches?**
(a) Evidences from biogeographical distribution
(b) Evidences from comparative anatomy
(c) Evidences from embryology
(d) Evidences from paleontology

## 6.5 BIOLOGICAL EVOLUTION

Biological evolution is defined as any genetic change in a population that is inherited over several generations. Till now we discussed about the concept of evolution and its different evidences like fossils, homologous structures, artificial and natural selection, etc. Now we will be dealing with the theories of evolution put forward by various biologists.

### (1) Lamarck's Theory of Evolution

- His theory is often called as the **Theory of Inheritance of Acquired Characters or the Theory of Use and Disuse of Organ.**
- The first attempt to explain origin of species and their adaptation to the environment was done by Jean Baptist de Lamarck (1744-1829). He was the greatest French naturalist. Lamarck's theory was published in 1809 (year of Darwin's birth) in his book **'Philosophie Zoologique'**.
- According to this theory the organisms undergo changes to adapt themselves to the environment. The changes acquired by the organisms during their life time are passed on to the next generation. He took the example of long neck of Giraffe, they continuously stretched their neck to reach to the vegetation on trees.
- This acquired change was passed to the next generation. He also gave the principle of Use and Disuse. Use of an organ leads to strengthening of the organ, and disuse will lead to weakening of the organ.

**Lamarck arranged his theory in the form of four postulates.**

(i) Internal forces tend to increase size of the body.

(ii) Formation of new organs is the result of the need or want continuously felt by organisms Doctrine of Appetency/Desires.

(iii) Development and power of action of an organ is directly proportional to its use.

(iv) All changes acquired by the organism during its life are transmitted to the offsprings by the process of inheritance.

He said that evolution of life forms has occurred but the driving force according to him was use and disuse of organs. Use of an organ leads to the strengthening and disuse leads to the weakening of that organ. He gave the example of Giraffes and explained that the ancestors of giraffe were bearing a small neck and forelimbs.

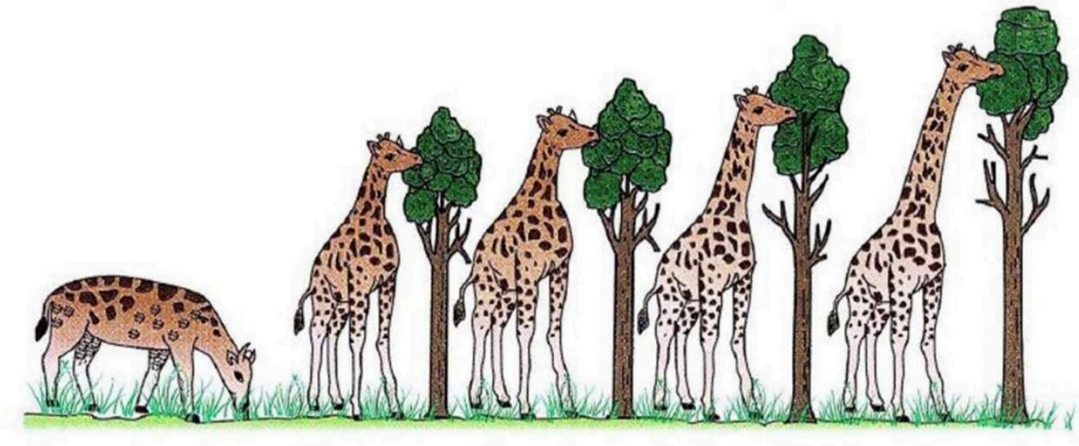


**Fig.:** Diagram showing elongation of neck in giraffe according to Lamarck

But in an attempt to eat (forage) the leaves on tall trees, they had to stretch their necks. Lamarck proposed that this acquired character, i.e., stretching of neck was passed on to the next generation resulting in the present time long necks. Nobody believes this conjecture any more.

**(2) Darwin's Theory or Darwinism**

The main concept of Darwinian theory is natural selection. He presented his theory after Lamarck's theory. It is possible that the work of Thomas Malthus on 'populations' influenced Darwin.

Thomas Malthus, an English economist, is widely known for his theories on populations and the increase or decrease in size of populations in response to various factors. One of the factors he studied was natural resources.

**According to Wallace's Chart, the main points of Darwin's theory of Natural Selection were as follows:**

(i) High rate of reproduction
(ii) Total number almost constant
(iii) Struggle for existence
(iv) Variations
(v) Survival of fittest
(vi) Natural selection

All the successful organisms have a high Biotic Potential or Reproductive Rate. The organisms produce a large number of offsprings that can possibly survive, example a mice produces a dozen of mice at one time.

1. Not all but only some individuals which survive, reach adulthood, and those which reach adulthood, reproduce at different rates, this is called 'Differential Reproduction'.
2. The success in survival and reproduction depends upon the characteristic traits of an organism, example only those rabbits will survive which are fastest. There is 'Struggle for Existence' and in this there will be 'Survival of Fittest. The Phrase 'Survival of Fittest was first used by Herbert Spencer. The same context was asserted by Darwin as 'Natural Selection'.

So, evolution is the change in the genetic composition of the population which is brought about by natural selection which acts upon the variability in population.

★ **Causes of Variations:**

1. Mutation is the ultimate source of variations.
2. At the next level is recombination.
3. Intermingling of two widely separated populations.

- Weakness of Darwinism: He was not able to explain the cause of discontinuous variations observed by himself in nature and the mode of transmission of variants to the next generation.
- In 1868, Darwin put forward the Theory of Pangenesis. According to this theory, every organ of the body produces minute hereditary particles, called Pangenes or Gemmules and they are carried

through the blood into the gametes.

- Darwin also talked about the rate (speed) of appearance of new forms. He said that the appearance of new forms is linked to the life span of that organism. For example, the microscopic microbes have shorter life spans so they divide faster and become millions of individuals within hours.
- Hence microbes have more chances to evolve faster. But if we talk about any other organism like fish or fowl, they will take millions of years to evolve because their life spans are much longer (i.e., in years) than microbes.

To explain evolution, Darwin talked about two things

**i. Branching descent**

**ii. Natural selection**

Branching descent explains the 'pattern of evolution and natural selection explains the 'mechanism' of evolution. Branching descent and natural selection are the two key concepts of Darwinian theory of evolution.

**Branching descent:** He said that the evolution is a branching process. With time, new life forms appear, and these new life forms arise as 'branches' from the previously existing life forms. Hence branching descent points towards the concept of common ancestry.

**Natural selection**: He emphasised that the selection of 'useful variations' by nature is the main (but not exclusive) mechanism for evolution to occur, which has already been discussed.

**(3) Mutation Theory**

In 1901, **Hugo de Vries** proposed the **Mutation Theory** on the basis of his observation on the wild variety of evening primrose *Oenothera lamarckiana*.

According to mutation theory, new species originate as a result of large, discontinuous variations which appear suddenly.

**The main features of mutation theory are as follows:**

i. Mutations arise from time to time amongst the individuals of a naturally breeding population.
ii. Mutations are heritable and establish new forms or species.
iii. Mutations are large and sudden and are totally different from fluctuating variations of Darwin, which are small and directional.
iv. Mutations may occur in any direction.

**TOPIC CENTRIC EXERCISE 05**

**Q1. Evolution of wolf and tasmanian wolf are results of**
(a) divergent evolution (b) convergent evolution
(c) anthropogenic action (d) mutation.

**Q2. Which of the following shows adaptive radiation?**
(a) Darwin's finches (b) Peppered moth
(c) Australian marsupials (d) Both (a) and (c)

**Q3. Branching descent and natural selection are two key concepts of**
(a) Darwinian theory of evolution (b) Lamarck theory of evolution
(c) Malthus theory on population (d) Hugo de Vries theory of mutation.

**Q4. _____ is the end result of the ability to adapt and get selected by nature.**
(a) Extinction (b) Fitness
(c) Competition (d) Both (a) and (b)

**Q5. Hugo de vries worked on the _____ mutations. to put forth the idea of**
(a) evening primrose (b) Pisum
(c) Brassica (d) none of these

## 6.6 MECHANISM OF EVOLUTION

- Speciation is an evolutionary process by which new species arise. When new species arise, evolution is said to occur.
- Now what is the cause or mechanism of origin of new species? Even though Mendel had talked of inheritable 'factors' influencing phenotype, Darwin either ignored these observations or kept silence.
- According to Darwin, inheritable variations are the cause as they keep on accumulating from one generation to other and, ultimately, give rise to new species. But Hugo deVries had different views.
- Hugo deVries conducted his study on the evening primrose plant in the first decade of twentieth century (1901) and talked about mutations. According to him, 'mutations' were the cause of evolution and not the minor variations that Darwin talked about.
- Mutations are the large changes arising suddenly in the genomic sequence (the DNA/RNA sequence) of an organism. These mutations arise suddenly in a population and those mutations which arise in the germ cells of an organism pass on to the next generation.

**The mutations are random and directionless.**

Differences between Variations and Mutations: Although variations and mutations both point towards the speciation but there some differences between them which can be summarised as:

i. The Darwinian variations are small which means they cannot bring the sudden change in the life forms and they can bring the change only when they accumulate. While mutations are large and they bring sudden change even in a span of single generation. Mutations do not need the accumulation.

ii. The variations are directional whereas the mutations are random and directionless and they can appear in all possible directions.

**iii.** Darwin said that evolution is a slow and gradual process which takes a lot of time to proceed but deVries believed that evolution occurs suddenly. **The single step large mutation which can cause speciation was named saltation by de Vries.**

**Natural Selection (As Evidence of Evolution)**

Darwin and Wallace talked about the natural selection, i.e., the selection done by nature. An interesting example of natural selection comes from the Industrial Melanism.

(1) Industrial Melanism: Before emergence of industrialisation (i.e., in 1850s) in England, white-winged moths were more in number than the dark-winged or melanised moths. But after industrialisation, i.e., in 1920, the condition was reversed. It was seen that in the post-industrialisation period, the number of dark-winged moths increased much more than white-winged moths in the same area of England. What could be the reason for this phenomenon?

**This could be explained as follows:** The moths rest on tree trunks. Before industrialisation, no air pollution was there. The tree trunks were lighter in colour as no deposition of smoke and soot took place on the tree trunks. And also there was a thick growth of almost white-coloured lichen on the tree trunks. Under this condition it is difficult for a predator (bird) to spot or find the white-winged moths against the light background of tree trunks but easy to spot the dark-winged moths. Hence, the birds killed and ate dark-winged moths resulting in the decrease in the number of dark-winged moths.

**Fig.:** Figure showing white - winged moth and dark - winged moth (melanised) on a tree trunk
(a) In unpolluted area (b) In polluted area

- But after industrialisation set in, the pollution increased and the tree trunks became darker in colour first, due to smoke and soot deposition and secondly due to absence of lichens on the tree trunks (as they

do not grow in polluted area).

- Smoke has $SO_2$ that eradicated the lichens so the dark brown colours of the bark was exposed. As a result, the white-winged moths could not camouflage themselves, i.e., hide in the background and therefore, were predated by the birds. This resulted in the decrease in the number of white-winged moths.
- This explanation was further supported by the fact that in the rural areas, the count of melanic (dark-winged) moths was low and of white-winged was more as industrialisation did not occur in these areas.
- Hence, this all explains that in a mixed population having different variants (types) of moths, those that can better adapt will survive and will produce more offsprings or we can say that they will be naturally selected. Natural selection brings evolution. But remember no variant is completely wiped out.

**Critical Thinking**

- **Antibiotics or drugs resistance:** We continuously use drugs and antibiotics against microbes. With course of time, some microbes developed 'resistance' against these drugs by bringing changes or modifications in their structures. Those which became resistant, survived and hence selected by the nature.
- **Herbicide resistance (developed in wild varieties):** Similarly herbicide and pesticide resistance developed in the weeds and pests respectively after prolonged use of herbicides and pesticides. This is also an example of natural selection which supports the process of evolution

- All mentioned evidences also suggest that evolution is a stochastic process which is based on many probabilities. It is based on chance events in the nature and chance mutations in the organisms. And we can see in the example of moths, the survival of moths was dependent on the pollution created by man and if industrialisation would not have occurred, any other probability would have been there which would have determined the survival of moths. Hence, many probabilities are there for every phenomenon occurring in the nature and evolution cannot be seen as a directed process in the light of determinism.

**TOPIC CENTRIC EXERCISE 06**

**Q1.** **Theory of inheritance of acquired characters was given by**
(a) Wallace (b) Lamarck
(c) Darwin (d) de Vries.

**Q2.** **Which of the following evidences does not favour the Lamarckian concept of inheritance of acquired characters?**
(a) Absence of limbs in snakes
(b) Melanisation in peppered moth
(c) Presence of webbed toes in aquatic birds
(d) Lack of pigment in cave-dwelling animals

**Q3.** **According to Lamarck, a giraffe has a long neck because**
(a) a creator designed it that way
(b) catastrophes eliminated short-necked forms
(c) its ancestors stretched their necks to get food
(d) ancestral giraffes with slightly longer necks than others got more food and left more surviving offspring.

**Q4.** **Mutations are mainly responsible for**
(a) constancy in organisms
(b) variations in organisms
(c) maintaining genetic continuity between parents and offsprings
(d) increasing the population rate.

**Q5. Which of the following is the correct term for the single step mutation responsible for speciation?**

(a) Founder's effect (b) Saltation
(c) Branching descent (d) Natural selection

## 6.7 HARDY-WEINBERG PRINCIPLE

It was proposed by **'G.H.Hardy** and **W.Weinberg'** in 1908. This principle states that a population is said to be in genetic equilibrium if it is not undergoing any kind of evolutionary change. Genetic equilibrium means that the frequency of occurrence of alleles of a gene is supposed to remain fixed and even remain the same through generations. Hardy-Weinberg principle stated it using algebraic equations. Main concepts of this principle are:

(1) This principle says that allele frequencies in a population are stable and is constant from generation to generation.

(2) The gene pool (total genes and their alleles in a population) remains a constant. This is called genetic equilibrium.

(3) Sum total of all the allelic frequencies is 1.

**This can be explained as follows:**

- The term allele is employed for any of the two forms of a gene, present on the same locus in the two homologous chromosomes and allelic frequency is the frequency with which a particular allele occurs in a population.
- For example, in a population of diploid organisms, a gene has two alleles A and a. Suppose the frequency of occurrence of allele A is p and of a is q. Then what is the probability that allele A will appear on both the chromosomes of a diploid individual? It will be simply the product of its probabilities, i.e., pxp = $p^2$. Hence, we can say that the frequency of AA individuals in this population is simply $p^2$.
- Similarly the frequency of aa individuals in this population is $q^2$ and the frequency of Aa individuals (with allele A on one chromosome and allele a on other chromosome) in this population is 2pq (or 2 x px q).
- We can see that the probability of occurrence of hybrid condition (Aa) is twice (2x pq) than that of homozygous genotype (AA or aa) having $p^2$ and $q^2$ frequencies.
- Hardy-Weinberg principle says that the sum total of all the allelic frequencies of a gene is 1 and the possible frequencies of above mentioned genotypes, i.e., AA, aa and Aa are $p^2$, $q^2$ and 2pq, respectively. So mathematically this statement can be written as:

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

- We can see that this equation is a binomial expansion of $(p + q)^2$.
- Interpretation: Hardy-Weinberg principle can be used to mathematically interpret whether evolution has occurred in a population or not. Disturbance in the genetic equilibrium or Hardy-Weinberg equilibrium, i.e., change in frequency of alleles in a population, would be interpreted as resulting in evolution. When frequency measured, differs from expected values, the difference indicates the extent of evolutionary change.
- Factors affecting Hardy-Weinberg principle: Following five factors are known to affect Hardy-Weinberg equilibrium. Therefore, if any of the following phenomena occurs, change in frequency of alleles takes place that may result in the evolution:

**(1) Gene migration or gene flow**
**(2) Genetic drift**
**(3) Mutation**
**(4) Genetic recombination**
**(5) Natural selection**

(1) **Migration:** Migration, defined in genetic terms as the movement of individuals from one population into another, can be a powerful force in upsetting the genetic stability of natural populations. The

phenomenon of movement of alleles from one population to another is called gene migration. It can either occur by

(a) Migration of a section of population from one area to another, or by

(b) Interbreeding between members of two populations resulting in interchange of alleles. If the characteristics of the newly arrived animal differ from those already there, the genetic composition of the receiving population may be altered, if the newly arrived individual or individuals can adapt to survive in the new area and mate successfully.

**Clue Finder**

**Gene pool:** A total collection of all genes and its allele in a population is called gene pool. Thus, gene pool will have all genotypes i.e., genes of the organisms.

**Gene flow:** If genes are exchanged between two different populations of a species, it is gene flow.

(2) **Genetic Drift / Sewall Wright Effect / Non-directional factor:** Natural selection is not the only force responsible to bring about changes in gene frequencies. There is the role of chance or Genetic Drift also.
Genetic Drift causes the change in gene frequency by chance in a small population. In a small population, the individual alleles of a gene are represented by a few individuals in a population. These alleles will be lost if these individuals fail to reproduce. Allele frequencies appear to change randomly, as if the frequencies were drifting, thus, a random loss of alleles in small population is Genetic Drift. A series of small populations that are isolated from one another may come to differ strongly as a result of Genetic Drift. Genetic Drift has two ramifications are described below.

(a) **Bottle neck effect**: It is the decrease in genetic variability in a population, e.g., cheetah population in Africa decreased due to hunting. Their decreased numbers have limited cheetah's genetic variability, with serious consequences. The present cheetah population is susceptible to a number of fatal diseases. If any of these diseases attacks the cheetah population, the path of extinction of cheetah cannot be reversed.

(b) **Founder's effect**: When one or a few individuals are dispersed and become the founders of a new, isolated population at some distance from their place of origin, the alleles that they carry are of special significance. Even if these alleles are rare in the source population, they will be a significant fraction of the new population's genetic endowment. This effect by which rare alleles and combinations of alleles may be enhanced in new populations - is called the founder's effect

**Clue Finder**

The founder's effect is particularly important in the evolution of organisms on islands, such as Galapagos Islands which Darwin visited. Most of the kinds of organisms that occur in such areas were probably derived from one or a few initial founders.

**Fixation of new mutations:** Genetic drift fixes new alleles, genes that arise by mutation, from time to time and eliminate the original gene, thereby changing the genetic makeup of small population.

**Fixation of new mutations:** Genetic drift fixes new alleles, genes that arise by mutation, from time to time and eliminate the original gene, thereby changing the genetic makeup of small population.

(3) **Mutation:** Replica Plate Experiment of Lederberg and Lederberg

(i) Mutations are random (indiscriminate) with respect to the adaptive needs of organisms.

(ii) Most mutations are harmful or with no effect (neutral) on their bearer.

(iii) Mutation rates are very slow.

**Critical Thinking**

The Lederberg Replica Plating Experiment, a beautiful example of the genetic basis of a particular adaptation was demonstrated in bacteria. E.coli bacteria are usually grown in the laboratory by plating dilute suspensions of bacterial cells on semi-solid agar plates. After a period of growth, discrete colonies appear on the agar plates. Each of these colonies originates from a single bacterium through a large number of cell divisions. The Lederberg's inoculated bacteria on an agar plate and obtained a 'master plate' containing several bacterial colonies. They, then created several replicas of this master plate by a simple procedure. However, when they attempted to make replicas using plates containing an antibiotic such as penicillin, most colonies found on the master plate did not grow on the replica plates. The few colonies that did grow were obviously resistant to penicillin.

(4) **Genetic recombination:** During gamete (sperm or ovum) formation, the alleles present on the parental chromosomes separate and form new combinations. This results in the genetic recombination. The crossing over during meiosis is a major source of variations in a population. The offsprings produced from these gametes show 'new' combination of characters and are called recombinants.

(5) **Natural selection:** Nature selects those variations which are heritable (i.e., able to be inherited) and which make the survival more better so that the individuals bearing these useful variations are enabled to reproduce and thence produce more number of progeny. Hence, natural selection also leads to change in allelic frequencies. However the effects of natural selection on different traits can be (a) Stabilising (b) Directional, or (c) Disruptive.

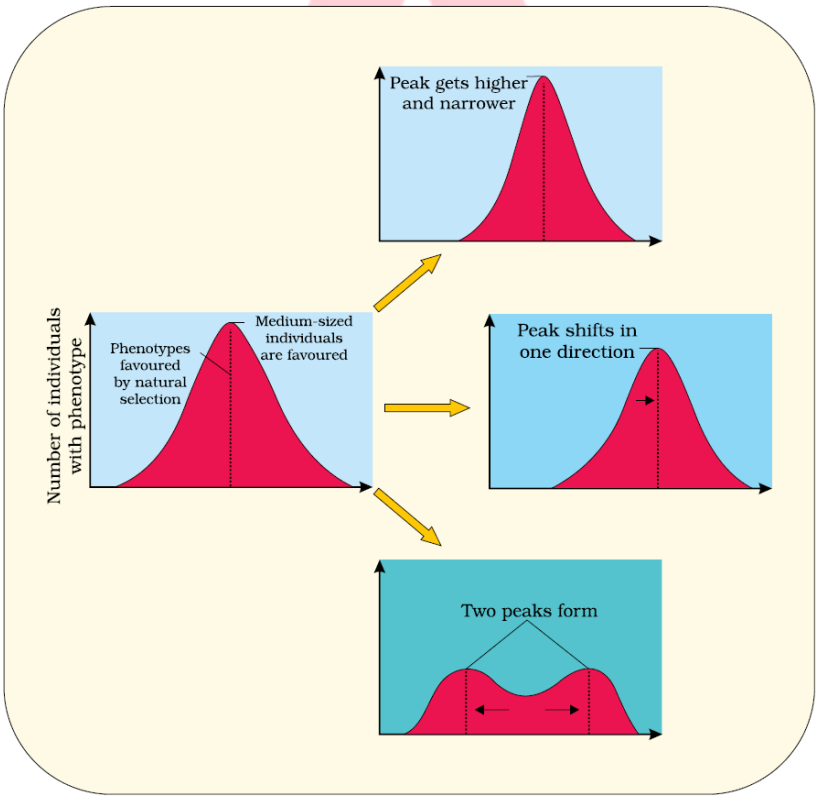



**Fig.:** Diagrammatic representation of the operation of natural selection on different traits : (a) Stabilising (b) Directional and (c) Disruptive

(a) **Stabilising selection:** If nature favours those individuals in the population which possess the mean character value, then it is said that natural selection leads to the stabilisation of the traits (figure a). Let us take the example of the character human height. Tall, dwarf and medium - sized individuals are the variants of this character. If nature favours or selects the medium-sized individuals, then the selection is said to be stabilising. The peak of bell-shaped graph gets higher and narrower as nature tries to decrease the peripheral character values.

(b) **Directional selection:** If selection acts to eliminate one extreme form and supports the other extreme (then the peak shifts in the direction which is selected by the nature .For example, in the above mentioned example, if either tall or dwarf individuals are selected (rather than medium-sized) then it is called directional selection. Industrial melanism in moths also provides good example of directional selection.

(c) **Disruptive selection:** If the selection does not favour the mean character value, rather favours both the peripheral character values then this kind of selection is called disruptive selection .Two peaks are formed at the two extremes of curve and a kind of depression forms in the centre. For example, if nature selects both tall as well as dwarf individuals but not the medium-height individuals, this is called disruptive change.

**TOPIC CENTRIC EXERCISE 07**

**Q1. Genetic drift operates in**

(a) Small isolated population (b) Large isolated population

(c) Non-reproductive population (d) Slow reproductive population

**Q2. Gene pool is**

(a) Genotype of an individual in a population

(b) Different genes of all individuals of a species found in an area

(c) Pool of artificially synthesised genes

(d) Genes of a genus

**Q3. If nature selects both of the peripheral traits of a character then which kind of natural selection is said to be operating?**

(a) Stabilising (b) Disruptive

(c) Directional (d) Rotating

**Q4. Saltation means**

(a) Single step small mutation (b) Single step small variation

(c) Single step large mutation (d) None of these

## 6.8 A BRIEF ACCOUNT OF EVOLUTION

- About **2000 million years ago** (mya) **the first cellular forms** of life appeared on earth.
- The mechanism of how non-cellular aggregates of giant macromolecules could evolve into cells with membranous envelop is not known. Some of these cells had the ability to release $O_2$ .
- The reaction could have been similar to the light reaction in photosynthesis where water is split with the help of solar energy captured and channelised by appropriate light harvesting pigments. Slowly single-celled organisms became multi-cellular life forms.
- By the time of **500 mya**, **invertebrates** were formed and active. **Jawless fish** probably evolved around **350 mya**. **Sea weeds** and few plants existed probably around **320 mya**. We are told that the first organisms that invaded land were plants. They were widespread on land when animals invaded land. Fish with stout and strong fins could move on land and go back to water. This was about 350 mya.
- In 1938, a fish caught in South Africa happened to be a **Coelacanth** which was thought to be extinct. These animals called lobefins evolved into the first amphibians that lived on both land and water.
- There are no specimens of these left with us. However, these were ancestors of modern day frogs and salamanders.
- The amphibians evolved into reptiles. They lay thick shelled eggs which do not dry up in sun unlike those of amphibians. Again we only see their modern day descendents, the turtles, tortoises and crocodiles.
- In the next 200 millions years or so, reptiles of different shapes and sizes dominated on earth.
- Giant ferns (pteridophytes) were present but they all fell to form coal deposits slowly. Some of these land reptiles went back into water to evolve into fish like reptiles probably 200 mya (e.g. Ichthyosaurs). The land reptiles were, of course, the dinosaurs. The biggest of them, i.e., Tyrannosaurus rex was about 20 feet in height and had huge fearsome dagger like teeth.
- About 65 mya, the dinosaurs suddenly disappeared from the earth. We do not know the true reason. Some say climatic changes killed them. Some say most of them evolved into birds. The truth may live in between. Small sized reptiles of that era still exist today.
- Synapsids were mammal like reptile which gave rise to mammals.
- The first mammals were like shrews. Their fossils are small sized. Mammals were viviparous and protected their unborn young inside the mother's body. Mammals were more intelligent in sensing and avoiding danger at least. When reptiles came down mammals took over this earth. There were in South America mammals resembling horse, hippopotamus, bear, rabbit, etc.
- 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.

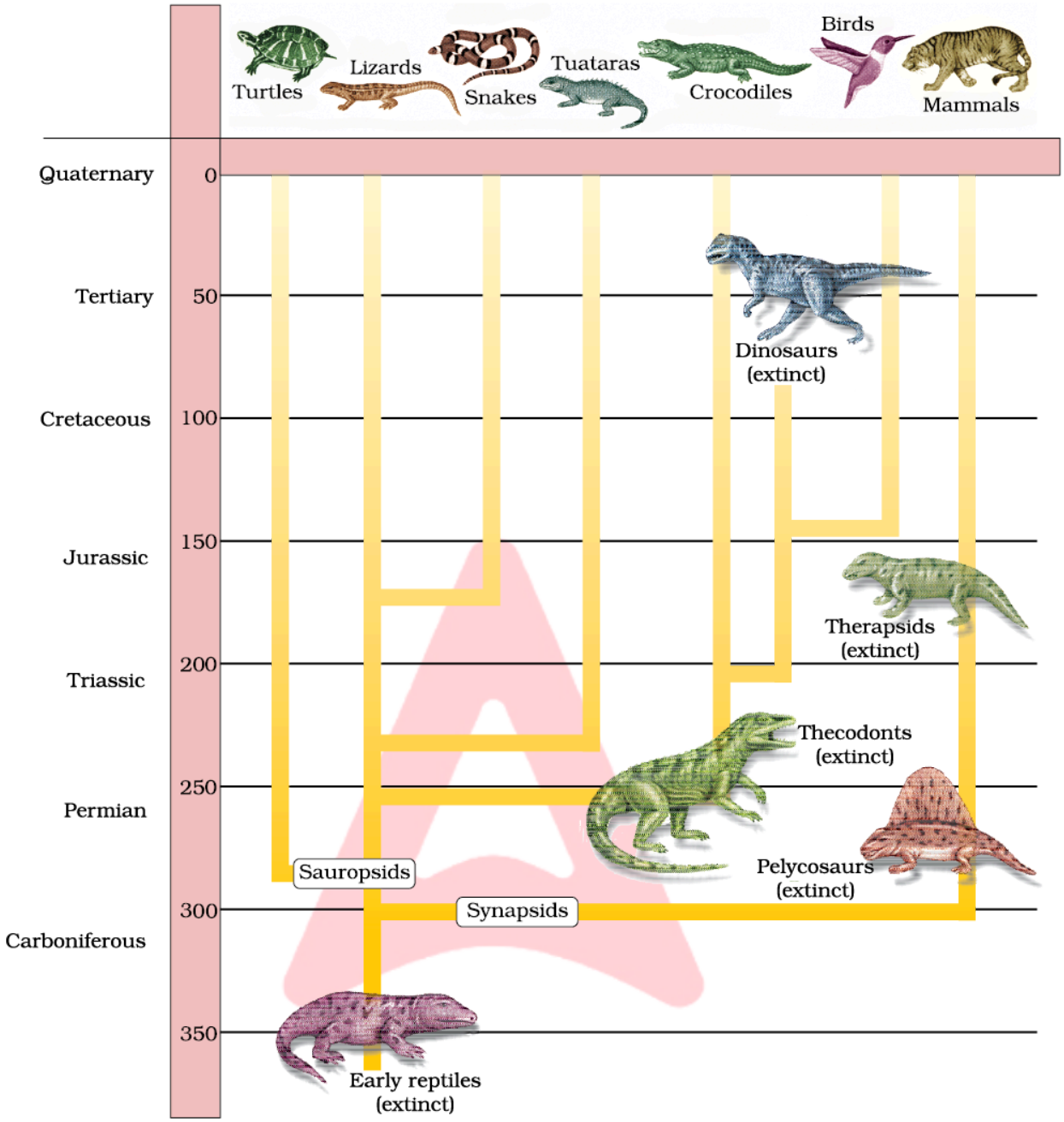



**Fig.:** Representative evolutionary history of vertebrates through geological periods

- we forget, some mammals live wholly in water. Whales, dolphins, seals and sea cows are some examples. Evolution of horse, elephant, dog, etc., are special stories of evolution. The most successful story is the evolution of man with language skills and self-consciousness.

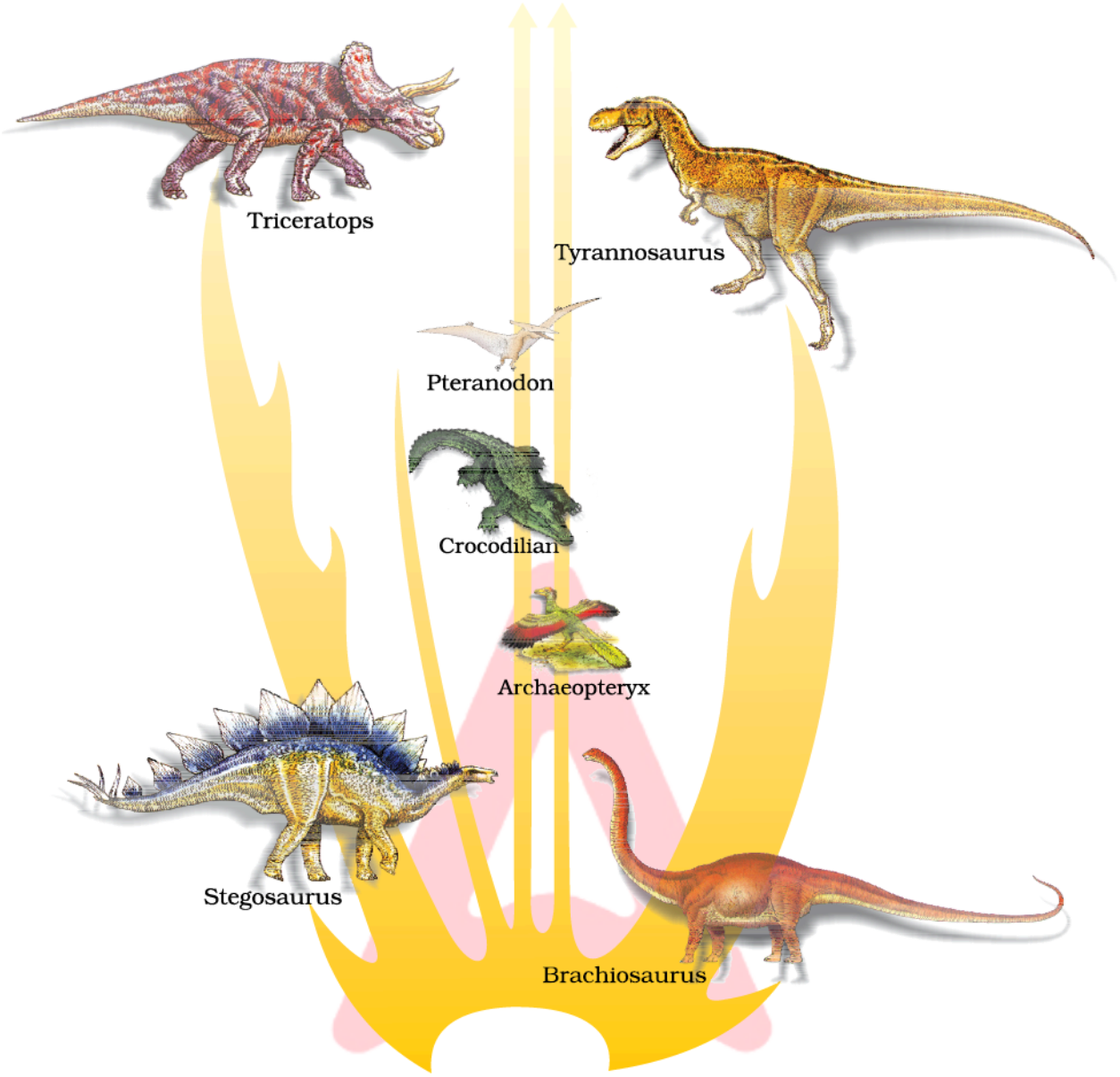



**Fig.:** A family tree of dinosaurs and their living modern day counterpart organisms like crocodiles and birds

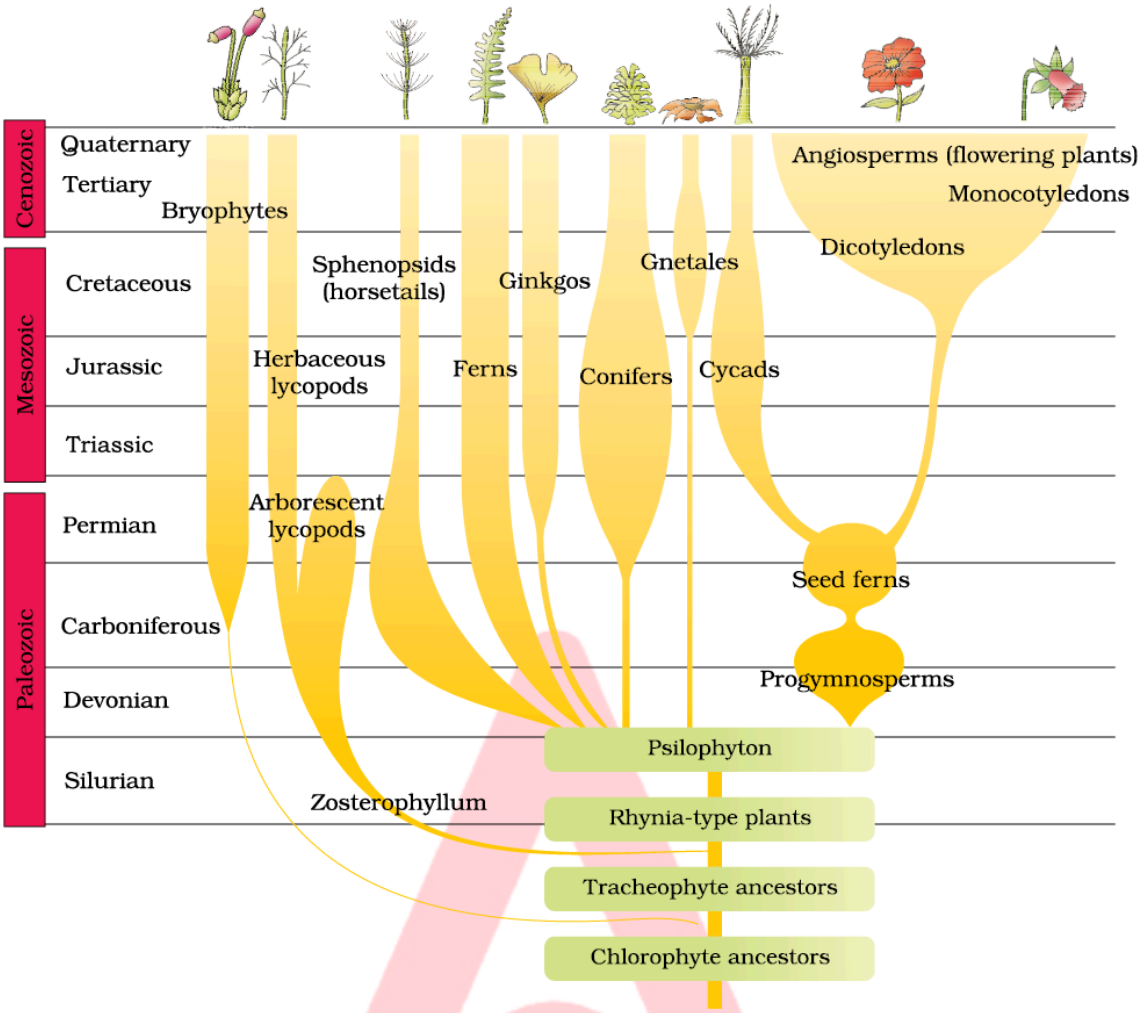



**Fig.:** A sketch of the evolution of plant forms through geological periods

**TOPIC CENTRIC EXERCISE 08**

**Q1.** **The first cellular form of life appeared on earth about:**
(a) 4000 mya (b) 500 mya
(c) 2000 mya (d) 3000 mya

**Q2.** **The mammal like early reptiles which gave rise to mammals, are called as:**
(a) Sauropsids (b) Thecodonts
(c) Coelacanth (d) Synapsids

**Q3.** **Dinosaurs disappeared from earth approximately:**
(a) 320 mya (b) 350 mya
(c) 65 mya (d) 200 mya

**Q4.** **Jawless fish probably evolved around……...:**
(a) 350 mya (b) 320 mya
(c) 200 mya (d) 65 mya

**Q5.** **The land reptiles were, of course, the dinosaurs. The biggest of them, i.e., …….was about 20 feet in height and had huge fearsome dagger like teeth:**
(a) Tyrannosaurus rex (b) Archeopteryx
(c) Ichthyosaurs (d) Stegosauras

## 6.9 ORIGIN AND EVOLUTION OF MAN

- Human is a member of order Primata of class Mammalia.

### EVIDENCES FOR COMMON ORIGIN OF HUMAN & APES:

**(1) Chromosomal similarities:-**

- Banding pattern of chromosome no. 3 & 6 of human and chimpanzee is 100% similar.
- Number of chromosomes are approx same in human (46) and apes (48).

**(2) The skull of baby chimpanzee is more like adult human skull than adult chimpanzee skull.**

**Clue Finder**

- Composition of Hb is same in both. Only one amino acid is different in human and gorilla.
- Menstruation cycle is present in females of both.
- Tail is absent in both and have grasping hands

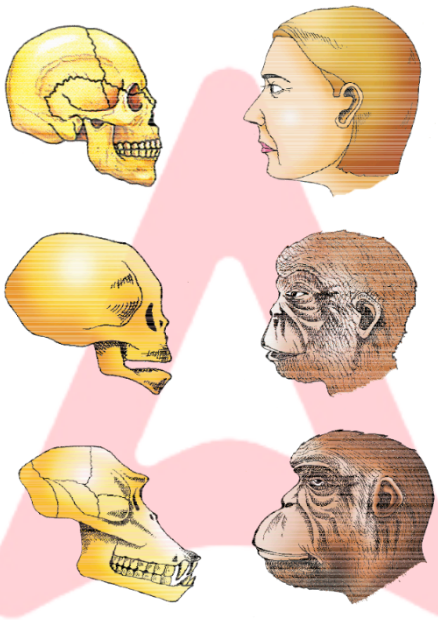


**Fig.:** A comparison of the skulls of adult modern human being, baby chimpanzee and adult chimpanzee. The skull of baby chimpanzee is more like adult human skull than adult chimpanzee skull

**(1) Origin and Evolution of Man**

(A) **Ape Fossils -** About **15 mya**, primates called ***Dryopithecus*** and ***Ramapithecus*** were existing. They were hairy and walked like gorillas and chimpanzees.

(i) ***Dryopithecus:*** It is considered as common ancestor of man and apes.

(ii) ***Ramapithecus:*** Fossils discovered from Shivalik hills in India.

**Note: *Ramapithecus* was more man-like while *Dryopithecus* was more ape-like.**

***(B)*** **Ape – man fossils – *Australopithecus***

- Few fossils of man-like bones have been discovered in Ethiopia and Tanzania. These revealed hominid features leading to the belief that about 3-4 mya, man-like primates walked in eastern Africa. They were probably not taller than 4 feet but walked up right.
- **2 mya, *Australopithecines*** probably lived in **East African grasslands**.
- Evidence shows they hunted with stone weapons but essentially **ate fruit**.
- It had complete erect posture and bipedal locomotion (first man who stood erect)

- It is also considered as connecting link between apes and man.

**(C) Prehistoric Man**

A number of other species of *Homo* appeared and became extinct from time to time on the evolutionary sense before the origin of *Homo sapiens*. These extinct species are called as prehistoric species of man.

***(i)* Homo habilis*:***

- This creature was called the first human-like being the hominid.
- The brain capacities were between **650-800cc.**
- They probably did not eat meat.
- First man who made tools of stones for hunting animals, hence called as first Tool maker man or Handy man.

***(ii)* Homo erectus*:***

**(a) Java man (*Homo erectus erectus/ Pithecanthropus erectus*):**

- Fossils discovered in Java in 1891.
- They existed about 1.5 million years ago.
- They had large brain with a cranial capacity around 900cc.
- They probably ate meat.
- First man who used fire for hunting, protection and cooking.

**Clue Finder**

Other important finds of *Homo erectus* have been made in places like China, Heidelberg (Germany):

- **Peking man (*Homo erectus pekinensis/ Sinanthropus erectus*)**
  - Fossils discovered by W.C. Pei from China
- **Heidelberg man**
  - Fossils discovered from Heidelberg (Germany)

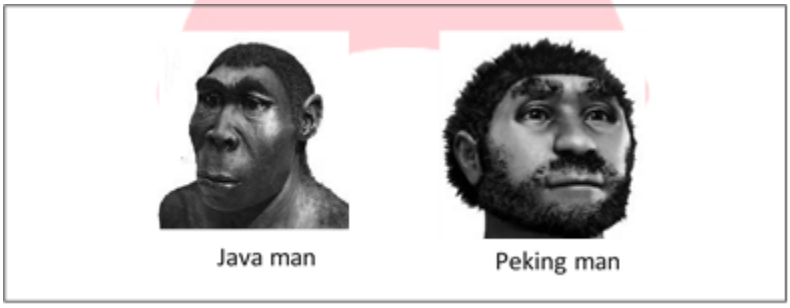



**Fig.:** Java man and Peking man

***(iii)* Homo sapiens*:***

**(a) Neanderthal man *(Homo sapiens neanderthalensis)*:**

- They lived near east and central Asia between 1,00,000- 40,000 years back.
- They had a brain size of **1400cc** (same as modern man).
- They used hides (skin of animals) to protect their body.
- They **buried their dead** and probably believed in **immortality of soul.**
- Development of speech centre and Language started.

**(b) Cromagnon man (*Homo sapiens fossilis*):**

- They had a cranial capacity of **1650 c.c.(maximum)**
- They painted beautiful paintings on cave walls.

- Pre-historic cave art developed about 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.

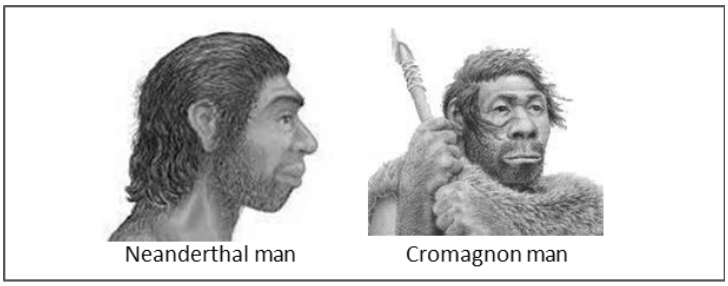



**Fig.:** Neanderthal man and Cromagnon man

**(c) Modern man (*Homo sapiens sapiens*):**

- During ice age between 75,000-10,000 years ago modern *Homo sapiens* arose.
- Pre-historic cave art developed about 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
- It arose in Africa and moved across continents and developed into distinct races (Caucasoid, Negroid, Mongoloid and Australoid).
- This is the **man of today** having a brain capacity of **1300 – 1600 c.c (avg. 1450cc)**.
- **Agriculture** was also started by this man.
- Agriculture came around **10,000 years back** and human settlements started.

**TOPIC CENTRIC EXERCISE 09**

**Q1.** **Which of the following statements is correct about the origin and evolution of man ?**
(a) Agriculture came around 50,000 years back.
(b) The Dryopithecus and Ramapithecus primates, existing 15 million years ago, walked like man.
(c) Homo habilis probably ate meat.
(d) Neanderthal men lived in Asia between 1,00,000 and 40,000 years back.

**Q2.** **Which of the following had the smallest brain capacity?**
(a) *Homo neanderthalensis* (b) *Homo habilis*
(c) *Homo erectus* (d) *Homo sapiens*

**Q3.** **Which of the following is correct about the first mammals?**
(a) They were like shrews. (b) Their fossils are small sized.
(c) Both a and b. (d) None of these

**Q4.** Which one of the following statements is incorrect?
(a) *Dryopithecus* was more ape-like.
(b) *Neanderthal man* lived in east and central Asia.
(c) *Homo erectus* is the real ancestor of modern man.
(d) *Ramapithecus* was more man-like.

**Q5.** **Prehistoric cave art developed about ……A……. years ago. Agriculture came around……. B…… years back and human settlements started. Choose an appropriate option for A and B to complete the given statement**
(a) A-18000; B-2000 (b) A-18000; B-10000
(c) A-10000; B-5000 (d) A-15000; B-500

**Q6.** **The scientific name of Neanderthal man is**
(a) Homo habilis (b) Homo sapiens neanderthalensis
(c) Homo erectus (d) Australopithecus boisei.

**Solved Examples**

**Ex: 1.** **Most advanced and theory of origin of life is that of:**

(a) Alfred Wallace (b) Oparin and Haldane
(c) Charles Darwin (d) Hugo de Vries.

**Sol.** **(b):** Oparin and Haldane gave chemical theory of evolution.

**Ex: 2.** **Which of the following is favorite idea of astronomers?**
(a) Special creation theory (b) Panspermia
(c) Biogenesis (d) Abiogenesis

**Sol.** **(b):** Early Greek thinkers thought units of life called spores were transferred to different planets including earth. 'Panspermia' is still a favourite idea for some astronomers.

**Ex: 3.** **Miller's experiments, in which simple amino acids were formed, this hypothesis was given by:**
(a) Pasteur's theory of life from life
(b) Oparin's hypothesis concerning origin of life
(c) Darwin's theory of origin of species
(d) Weismann's germplasm theory.

**Sol.** **(b):** Oparin of Russia and Haldane of England proposed that the first form of life could have come from pre-existing non-living organic molecules (e.g., RNA protein, etc.) and that formation of life was preceded by chemical evolution, i.e., formation of diverse organic molecules from inorganic constituents. Miller strongly supports the Oparin's hypothesis concerning the origin of life.

**Ex: 4.** **A of Russia and B of England proposed that the first form of life could have come from C non-living organic molecules. Choose the right option for A, B and C to compete the given statement.**
(a) A-Oparin, B-Haldane, C-post-existing (b) A-Haldane, B-Oparin, C-post-existing
(c) A-Oparin, B-Haldane, C-pre-existing (d) A-Haldane, B-Oparin, C-pre-existing

**Sol.** **(c):** Oparin of Russia and Haldane of England proposed that the first form of life could have come from pre-existing non-living organic molecules (e.g. RNA, protein, etc.) and that formation of life was preceded by chemical evolution, i.e., formation of diverse organic molecules from inorganic constituents.

**Ex: 5.** **Darwin travelled in which of the following ships?**
(a) HNS Eagle (b) HMS Galpagos
(c) HMS Beagle (d) Titanic

**Sol.** **(c):** Darwin travelled in HMS Beagle ship.

**Ex: 6.** **Sweet potato (root modification) and potato (stem modification) is example for:**
(a) homologous organs (b) Analogous organs
(c) divergent evolution (d) both (a) and (c).

**Sol.** **(b):** Sweet potato (root modification) and potato (stem modification) is example for Analogous organs

**Ex: 7.** **Which one of the following statements correctly describes the homologous structures?**
(a) Organs that have no function now, but had an important function in ancestors.
(b) Organs appearing only in embryonic stage and disappear later in the adult.
(c) Organs with anatomical similarities, but perform different functions.
(d) Organs with anatomical dissimilarities, but performing the same function.

**Sol.** **(c):** Homologous organs are those organs which are anatomically similar but perform different functions.

**Ex: 8.** **Homology cannot be explained by**
(a) vertebrate hearts and brains
(b) forelimbs of man and bat
(c) thorns and tendrils of Bougainvillea and Cucurbita
(d) eyes of mammals and octopus.

**Sol.** **(d):** eyes of mammals and octopus represents analogy i.e. it is the similar habitat that has resulted in selection of similar adaptive features in different groups of organisms but toward the same function.

**Ex: 9.** Darwin in his "Natural Selection Theory" did not believe in the role of
(a) parasites and predators as natural enemies
(b) survival of the fittest
(c) struggle for existence
(d) discontinuous variations.

**Sol.** **(d):** The theory of natural selection is based on the following factors:
(i) Rapid multiplication and limited food and space which leads to struggle for existence.
(ii) Struggle for existence and variations which leads to natural selection or survival of the fittest.
(iii) Natural selection and inheritance of useful variation over many generation which leads to formation of new species. Darwin in his "Natural Selection Theory" did not believe in the role of discontinuous variation in natural selection.

**Ex: 10** Which of the following statements is not correct regarding mutation theory?
(a) According to Hugo de vries Mutations are directional.
(b) Variations are gradual (continuous) and those which are helpful in adaptation would pass on to next generation.
(c) Accumulation of variation produces new species.
(d) Useful mutations are selected by nature.

**Sol.** **(a):** Mutations are random and directionless while Darwinian variations are small and directional.

# Exercise-01 Level -01

1. What is observed in evolution?
   (a) A sudden change occurring in a population
   (b) Descents with modification
   (c) It is a discontinuous process
   (d) All of the above
2. When did life appear on earth?
   (a) 500 billion years after the formation of Earth
   (b) Almost four billion years back.
   (c) Almost two billion years back
   (d) Both A and B
3. Embryological support for evolution was disapproved by
   (a) Ernst Mayr
   (b) Karl Ernst von Baer
   (c) Ernst Haeckel
   (d) None of these
4. Presence of homologous structures shows
   (a) Common ancestry
   (b) Divergent evolution
   (c) Convergent evolution
   (d) Both A and B
5. The process of evolution develops similar features in organisms with separate ancestries.
   (a) Divergent
   (b) Convergent
   (c) Adaptive radiation
   (d) Speciation
6. Industrial melanism is an example of
   (a) Saltation
   (b) Natural selection
   (c) Mutation
   (d) Lamarckism
7. Chemically theory for origin of life was given by
   (a) Stanley Miller
   (b) Oparin and Haldane
   (c) Darwin
   (d) Louis Pasteur
8. The mechanism of adaptive radiation was explained by
   (a) Miller (b) Darwin
   (c) Lamarck (d) Hugo de Vries
9. Darwin's finches occur in
   (a) Australia
   (b) Galapagos Islands
   (c) Siberia
   (d) India
10. Darwin's finches are an example of
   (a) Adaptive radiation

(b) Evolution without developing into new species
(c) Convergent evolution
(d) Gene flow

11. Mutations, discovered by Hugo deVries, are
(a) Small and directional
(b) Random and directionless
(c) Large and directional
(d) Small and directionless

12. According to Darwin, the driving force of evolution is
(a) Mutation (b) Natural selection
(c) Gene flow (d) Migration

13. Correct order is
(a) Coenozoic - Palaeozoic -Mesozoic
(b) Mesozoic-Palaeozoic-Proterozoic
(c) Palaeozoic-Mesozoic-Coenozoic
(d) Mesozoic-Azoic-Coenozoic

14. Evolution of long and muscular neck of present day giraffe occurred as giraffes stretched their necks higher to reach the higher canopy of tall trees. The given statement represents the view of about evolution.
(a) Miller (b) Lamarck
(c) Louis Pasteur (d) Oparian

15. Hugo Devries explained mutations as a source of genetic variations while working on
(a) Evening primrose
(b) Pisum sativum
(c) Biston betularia
(d) Snapdragon

16. The sum total of all allele frequencies for a particular locus is always
(a) 0 (b) 1
(c) more than 1 (d) Less than 1

17. In the Hardy-Weinberg equation, the frequency of heterozygous individual is represented by
(a) $q^2$ (b) pq
(c) 2pq (d) $P^2$

18. Name the type of natural selection that tends to reduce the genetic variations in the population without affecting the mean.
(a) Disruptive selection
(b) Directional selection
(c) Stabilizing selection
(d) Both a and b are correct

19. Jawless fish probably evolved around
(a) 400 mya (b) 350 mya
(c) 450 mya (d) 600 mya

20. Which of the following hominid has a brain capacity of 1400cc and used hide to protect their body.
(a) Homo habilis
(b) Homo erectus
(c) Homo sapiens
(d) The Neanderthal man

21. The naturalist who had the similar observations as that of Darwin was
(a) Alfred wallace (b) Oparin
(c) Haldane (d) L. miller

22. Which of the following is/are the connotation of theory of special creation?
(a) All living organisms were created as such
(b) The diversity will be same in future
(c) Earth is about 4000 years old
(d) All of the above

23. Which of the following is not Australian marsupial?
(a) Spotted cuscus
(b) Bobcat
(c) Tasmanian tiger cat
(d) Tasmanian wolf

24. Which of the following placental mammals appears to be similar to a corresponding marsupial NUMBAT?
(a) Anteater (b) Bobcat
(c) Mole (d) Wolf

25. According to Lamarck, a giraffe has a long neck because
(a) A creator designed it that way
(b) Catastrophes eliminated short-necked forms
(c) Its ancestor stretched their necks to get food
(d) all of these

26. If more individuals acquire peripheral character value at both the ends of the distribution curve; in such case natural selection has resulted in
(a) Stabilization
(b) Directional
(c) Disruption
(d) May be B or C depending upon population parameters

27. Hardy Weinberg equilibrium is based on which of the following equations?
(a) p+pq+q=1
(b) p+2pq+q=1
(c) $p+p^2q^2+q= 1$
(d) $p^2+2pq + q^2 = 1$

28. Which of the following fossil men was called first human-like being the hominid?
(a) Homo habilis
(b) African Ape Man
(c) Java man
(d) Neanderthal man

29. The concept of chemical evolution is based on
(a) Possible origin of life by combination of chemicals under suitable environmental conditions
(b) Crystallization of chemicals
(c) Interaction of water, air and clay under intense heat
(d) Effect of solar radiation on chemicals

30. A population will not remain in Hardy Weinberg equilibrium if
(a) Selective mating is present
(b) Random mating is present
(c) Both a and b
(d) None of these

31. According to fossils that have been discovered till now, the origin and evolution of man started from which country?
(a) France (b) India
(c) Africa (d) China

32. A hominid fossil discovered in java in 1891, now, extinct, having a cranial capacity of about 900 cc was:
(a) Homo erectus (b) Neanderthal man
(c) Homo sapiens (d) Australopithecus

33. Which of the following condition was not there in the earth at the time of origin of first life form
(a) High temperature
(b) Volcanic storms
(c) Reducing atmosphere
(d) Oxygen, methane, ammonia in the environment

34. The embryos of all vertebrates including human develop a row of vestigial gill slit just behind the head but it is a functional organ only in fish, this proposal was disapproved by
(a) Karl Ernst von Baer
(b) Ernst Heckel
(c) Louis Pasteur
(d) None of these

35. Which among the following statement is correct w.r.t. evolution:
(a) It is a stochastic process
(b) evolution is not a directed process in the sense of determinism
(c) Both a and b
(d) None of these

36. It is believed that the first organisms which inhabitated earth's surface were :
(a) Autotrophs (b) Mixotrophs
(c) Heterotrophs (d) Chromatotrophs

37. Who did an experiment to prove that "The organic compounds were the basis of life"?
(a) Darwin
(b) Stanley Miller and Harold C.Urey
(c) Melvin
(d) Fox

38. During chemical evolution, key biological compounds were synthesised :-
(a) in the atomosphere
(b) along the ocean shore
(c) in the ocean
(d) none of the above
(d) Reptilia and Mammalia

39. According to recapitulation theory which statement is correct :-
(a) Development of individual metazon shown embryonic characters of ancestors.
(b) Ontogeny repeats phylogeny
(c) Germplasm is immortal
(d) Every organisms is produced by its parents

40. Wings of locust, pigeon, and bat are example of :
(a) Vestigial organs
(b) Analogous organs
(c) Homologous organs
(d) Exoskeleton

41. Homology is exhibited by :
(a) Wings of butterfly, birds and bat
(b) Paddle of whale, forearm of horse and forelimbs of man
(c) Tail of monkey and bird
(d) Sting of scorpion and honey bee

42. Which evidence of evolution is related to Darwin's finches ?
(a) Evidences from biogeographical distribution
(b) Evidences from vestigeal organs
(c) Evidences from embryology
(d) Evidences from palaeontology

43. Potato and sweet potato :–
(a) have edible parts which are homologous organs

(b) have edible parts which are analogous organs
(c) have been introduced in India from the same place
(d) are two species of the same genus

44. Fossils are :
(a) animals living in burrows
(b) remnants of extinct animals and plants
(c) floating organisms
(d) fast runners

45. The age of fossils is determined by :
(a) analysis of bones
(b) radioactive $C^{14}$ dating
(c) electron microscopy
(d) weighing the fossils

46. Convergent evolution of two species is associated with:
(a) analogous organs
(b) recent common ancestor
(c) homologous organs
(d) different habitat

47. Name of the scientist who gave Mutation Theory:
(a) Wallace (b) Malthus
(c) Darwin (d) De Vries

48. One of the revolutionary concepts in biology was Charles Darwin's 'Origin of Species'. It deals with
(a) Gene mutation
(b) Use and disue of organs
(c) Germplasm Theory
(d) Natural selection leading to the survival of the fittest

49. Genetic drift rapidally operates in :-
(a) Small isolated population
(b) Large isolated population
(c) Fast reproductive population
(d) Slow reproductive population

50. Which of the following was not given by Darwin's theory of evolution ?
(a) Struggle for existence
(b) Over production
(c) Natural selection
(d) Genetic drift

51. According to Hugo de vries speciation due to mutation is also known as 'Saltation' which means:
(a) Single step variation
(b) Variations at regular intervals
(c) Single step large mutation
(d) Huge change due to Natural selection

52. Presence of coelacanth fish was observed in :
(a) South America (b) South Africa
(c) North America (d) North Africa

53. $(p+q)^2 = p^2 + 2pq + q^2 = 1$ represents an equation used in :
(a) Population genetics
(b) Mendelian genetics
(c) Biometrics
(d) Molecular genetics

54. First mammals were :
(a) Human (b) Apes
(c) Monkeys (d) Shrews

55. The most accepted view for origin of life is :
(a) Chemical evolution
(b) Spontaneous generation
(c) Religious literature
(d) Panspermia

# Exercise-02 Level -02

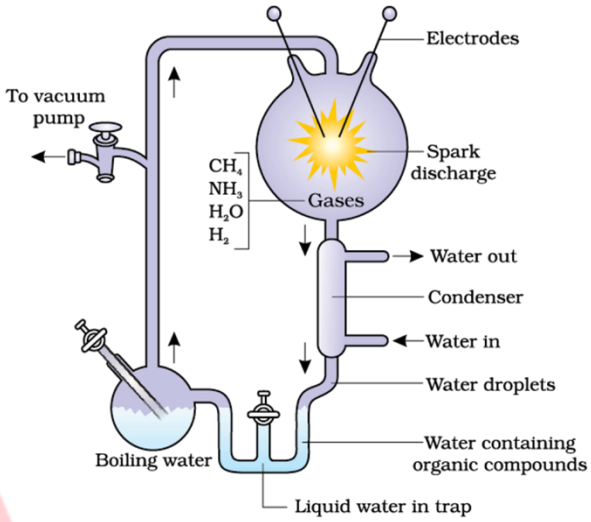
1. Differences between expected and observed allele frequencies in population represent that a
(a) The population is at hardy-Weinberg equilibrium.
(b) The population is evolving.
(c) The population is deviating from hardy-Weinberg equilibrium.
(d) Both (b) and (c) are correct.

2. Select the correct statement about Coelacanth.
(a) In 1938, a fish caught in North America happened to be a Coelacanth which was thought to be extinct
(b) Coelacanth called lobefins evolved into the first amphibians that lived in water only.
(c) There are no specimens of Coelacanth left with us.
(d) Coelacanth were ancestors of modern day Urochrodates.

3. Atmosphere of earth just before the origin of life consists of
(a) Water vapours, $CH_4$, $NH_3$ and Oxygen
(b) $O_2$, $NH_3$ and $CH_4$ but not water and oxygen
(c) $CH_4, NH_3, H_2$ and water vapours but not oxygen

(d) $CH_4, O_3, O_2$ and water vapours but not $NH_3$ and $CH_4$

4. Reproductive isolation can occur in a number of ways, but the net effect is always the same in that
   (a) Hybridisation must take place before new species can form
   (b) It causes geographic isolation between organisms
   (c) The rate of speciation slows down
   (d) Few or no genes flow between populations
5. Which of the following conclusions is from industrial melanism?
   (a) Camouflage causes the white moths to get caught by predators more even in rural areas during industrialisation.
   (b) During industrialisation, lichen will increase in number
   (c) Both a and b
   (d) In a mixed population, those that can better adapt, survive and increase in population size.
6. Which one correctly describes homologous structures?
   (a) Organs with anatomical similarities but performing different functions
   (b) Organs with anatomical dissimilarities but performing same function
   (c) Organs that have no function now but had an important functions in ancestors
   (d) Organs appearing only in embryonic stage and disappearing later in the adult
7. Gene pool of a population tends to remain stable if the population is large, without large scale mutations, without migration and with
   (a) Random mating
   (b) Selective Mating
   (c) Both a and b
   (d) None of these
8. What kind of evidence suggested that the man is more closely related with chimpanzee than with other hominoid apes?
   (a) Evidence from DNA extracted from sex chromosome only
   (b) Comparison of chromosomes morphology only
   (c) Evidence from fossil remains and the mitochondrial DNA alone.
   (d) Evidence from DNA extracted from sex chromosome, autosomes and mitochondria
9. Chemical evolution refers to-
   (a) Formation of organism from mud
   (b) Formation of diverse inorganic molecules from organic constituents
   (c) Formation molecules constituents of diverse organic from inorganic
   (d) Formation molecules constituents of diverse organic from dead organism
10. Select the incorrect option about the given figure.




   (a) The given figure diagrammatic represents representation of Pasteur experiment
   (b) X- Spark discharge
   (c) Y - Water containing organic compounds
   (d) Z- vacuum pump
11. Consider the following statements:
   (a) Comparative anatomy and morphology shows similarities and differences among organisms of today and those that existed years ago
   (b) The same structures in different organisms are derived from common ancestor.

   Choose the correct option.
   (a) Both (a) and (b) are true.
   (b) (a) is true but (b) is false.
   (c) Both (a) and (b) are false.
   (d) (a) is false but (b) is true.
12. The experiment that synthesis of organic compounds formed the basis of origin of life was performed by
   (a) Hershey – Chase experiment
   (b) Avery – Transforming experiment
   (c) Miller – Urey experiment
   (d) Griffith – Transforming experiment
13. Mutations are ____A___ while Darwinian variations are ____B___.
   (a) A-random and continuous, B-discontinuous

(b) A-minor and directional, B-major and directionless.
(c) A-small and directionless, B-random and directionless
(d) A-random and directionless, B-small and directional.

14. In stabilizing selection.
(a) Individual with the mean value of the trait are favoured
(b) Individual with the extreme value of the trait are favoured
(c) Individuals with the mean value of the trait are eliminated
(d) Individuals with the extreme value of the trait are unaffected

15. Identify the correct statements.
a. Mutations are random and directionless while Darwinian variations are small and directional
b. saltation are single step large mutation
(a) Both statements are correct
(b) Both statements are incorrect
(c) Only a is correct
(d) Only b is correct

16. Most biologists think that RNA was the first genetic material as
(a) Amino acids were produced in Stanley Miller's apparatus
(b) DNA is the universal genetic material of eukaryotes
(c) Existence of ribozymes suggests RNA was used to catalyze chemical reactions
(d) RNA is simpler than DNA

17. Oparin of__A___and Haldane of ___B___proposed that the first form of life could have come from____C___.
(a) A- Russia, 2- England, c- pre-existing non-living organic molecules
(b) A- England 2- Russia c- pre-existing non-living organic molecules
(c) A-Russia 2- England c- -existing non-living organic molecules
(d) A- Russia 2- England c- living matter

18. Identify the right statement about Embryological support for evolution.
(a) Proposed by Ernst Heckel.
(b) Embryonic stage common to all vertebrates that are absent in adult.
(c) This theory disapproved on by Karl Ernst von Baer.
(a) All statement are correct.
(b) All statement are incorrect.
(c) Only a is correct.
(d) None of these.

19. Primitive atmosphere was made up of the mixture of :
(a) Oxygen, ammonia, methane, water
(b) Hydrogen, ammonia, methane, oxygen
(c) Hydrogen, steam, methane, ammonia
(d) Oxygen, methane, water, nickle

20. Abiogenesis is the :
(a) origin of life from non-living material
(b) origin of life from living organism
(c) origin of viruses and microbes
(d) none

21. Darwin's Theory of Natural Selection was based on:
(a) Inheritance of acquired characters
(b) Mutation
(c) Enormous rate of reproduction in organisms, struggle for existence and survival of the fittest
(d) Changes due to the use and disuse of organs

22. Snakes do not have legs because :
(a) Legs are lost during their entry in tunnels
(b) Legs are lost during evolution
(c) The ancestors of reptiles did not have legs
(d) There are no legs in lizards

23. Struggle for existence and survival of the fittest form the basis of
(a) Mutation Theory
(b) Lamarckism
(c) Darwinism
(d) Weismann's Theory

24. Which of the following statement is correct?
(a) Dryopithecus was ancestor of man and ape
(b) Dryopithecus was ancestor of man and not of ape
(c) Apes were ancestor of man anatomically
(d) None of them

25. Which of the following statement is true ?
(a) *Homo erectus* is ancestor of *Homo sapiens*
(b) Neanderthal man is direct ancestor of modern man
(c) *Australopithecus* is direct ancestor of modern man
(d) Fossils of Cromagnon man first found in

America

26. In evolution the studies can be made at molecular level. For example the protein present in the blood of man and ape are similar. The base sequence in nucleic acids and amino acids sequence in protein in related organism is alike. These are the examples which one specifically referred to in :-
(a) convergent evolution
(b) molecular analogy
(c) molecular homology
(d) homoplastic appearance

27. Which of the following are not analogous organs ?
(a) fins of fishes and flippers of whales
(b) stings of honey bee and scorpion
(c) thorn of *bougainvillea* and tendril of *Cucurbita*
(d) wings of insect and wings of bird

28. Select the true statements :
(a) *Ramapithecus* and *Dryopithecus* were existing about 50 million years ago
(b) *Ramapithecus* was man like while *Dryopithecus* was more ape like
(c) *Ramapithecus* was more ape like while *Dryopithecus* was more man-like
(d) 1 & 2 both

29. Which one of the following phenomenon Supports Darwin's concept of natural selection in organic evolution ?
(a) Production of 'Dolly', the sheep by cloning
(b) Development of organs from 'stem cells' for organ transplantation
(c) Development of transgenic animals
(d) Prevalence of pesticide resistant insects

30. Which one of the following describes correctly the homologous structures ?
(a) Organs with anatomical similarities, but performing different functions
(b) Organs with anatomical dissimilarities, but performing same function
(c) Organs that have no function now, but had an important function in ancestors
(d) Organs appearing only in embryonic stage and disappearing later in the adult

31. On Galapagos island Darwin observed variation in beaks of birds (Darwin's finches) and he concluded:
(a) Interspecies variation
(b) Intraspecies variation
(c) Natural selection according to food
(d) Inheritance of acquired characters

32. Before industrialization set in England:
(a) Only white winged moths were present on trees
(b) White winged moths were less in number on trees
(c) Dark winged moths were less in number on trees
(d) White winged moths were absent

33. Which of the following statement is correct?
(a) The skull of adult chimpanzee is like modern adult human
(b) The skull of baby chimpanzee is like modern adult human
(c) Skull of baby chimpanzee is exactly similar to adult chimpanzee
(d) Skull of baby chimpanzee and adult chimpanzee has no resemblance to skull of human

34. Giraffe's neck and forelimbs get elongated during the course of evolution, due to :
(a) Inheritance of acquired characters
(b) Natural selection
(c) Geographical isolation
(d) Convergent evolution

35. In 1953 S. L. Miller created primitive earth conditions in the laboratory and gave experimental evidence for origin of first form of life from preexisting non-living organic molecules. The primitive earth conditions created include:
(a) Low temperature, volcanic storms, atmosphere rich in oxygen
(b) Low temperature, volcanic storms, reducing atmosphere
(c) High temperature, volcanic storms, non-reducing atmosphere
(d) High temperature, volcanic storms, reducing atmosphere containing $CH_4$, $NH_3$ etc.

36. The most accepted line of descent in human evolution is :
(a) *Australopithecus* → *Ramapithecus* → *Homo sapiens* → *homo habilis*
(b) *Homo erectus* → *Homo habilis* → *Homo sapiens*
(c) *Ramapithecus* → *Homo habilis* → *Homo erectus* → *Homo sapiens*

(d) *Australopithecus* → *Ramapithecus* → *Homo erectus* → *Homo habilis* → *Homo sapiens*
(d) The embryo takes a long time to develop

37. The theory of spontaneous generation stated that:
(a) life arose from living forms only
(b) Life can arise from both living and non-living
(c) Life can arise from non-living things only
(d) Life arises spontaneously, neither from living nor from the non-living

38. Select the incorrect statements :
(a) Natural selection is a heritable variation & by reproduction leave greater number of progeny
(b) During stabilisation of natural selection more individuals acquire value other than mean character value
(c) By the time of 500 million years ago invertebrates were formed and were active
(d) Reptiles lay thick shelled eggs which do not dry up in sun unlike those of Amphibians

39. Match the columns :

| | |
|---|---|
| (a) *Australopithecus* | (i) First human like |
| (b) *Homo habilis* | (ii)Used hides to protect the body |
| (c) *Homo erectus* | (iii) Ice age (75000-10000 years ago) |
| (d) Neanderthal man | (iv) Probably ate meat |
| (e) *Homo sapiens* | (v) Hunted with stone weapons and ate fruits |

(a) a-v, b-ii, c-iv, d-i, e-iii
(b) a-i, b-ii, c-iv, d-iii, e-v
(c) a-v, b-i, c-iv, d-ii, e-iii
(d) a-v, b-ii, c-ii, d-i, e-iv

40. Oxygen in atmosphere has been formed by:
(a) Evaporation of water
(b) Photosynthesis of blue green algae
(c) Metabolism of microorganisms
(d) Decaying organisms

41. Primitive atmosphere was reducing because :
(a) Hydrogen atoms were few
(b) Hydrogen atoms were active and in greater number
(c) Nitrogen atoms were more
(d) Oxygen atoms were more

# Exercise-03 Level -03

## Assertion & Reason Based Questions

1. **Assertion:** Anteater and numbat are the examples of convergent evolution
   **Reason:** They have different ancestors but adapted to similar conditions
   (a) Both Assertion and Reason are true and Reason is correct explanation of Assertion.
   (b) Both Assertion and Reason are true, but Reason is not the correct explanation of Assertion.
   (c) Assertion is true, but Reason is false.
   (d) Assertion is false, but Reason is true.
2. **Assertion:** Louis Pasteur by careful experimentation demonstrated that life comes only from pre-existing life
   **Reason:** He showed that in pre-sterilised flasks, life did not come from killed yeast while in another flask open to air, new living organisms arose from 'killed yeast
   (a) Both Assertion and Reason are true and Reason is correct explanation of Assertion.
   (b) Both Assertion and Reason are true, but Reason is not the correct explanation of Assertion.
   (c) Assertion is true, but Reason is false.
   (d) Assertion is false, but Reason is true.
3. **Assertion:** Ramapithecus was more man- like while Dryopithecus was more ape- like.
   **Reason:** They existed about 15 mya.
   (a) Both Assertion and Reason are true and Reason is correct explanation of Assertion.
   (b) Both Assertion and Reason are true, but Reason is not the correct explanation of Assertion.
   (c) Assertion is true, but Reason is false.
   (d) Assertion is false, but Reason is true.
4. **Assertion:** Evolution of modern humans exhibited a gradual increase in brain size.
   **Reason:** Homo habilis had the smallest brain capacity i.e. 1400cc.
   (a) Both Assertion and Reason are true and Reason is correct explanation of Assertion.
   (b) Both Assertion and Reason are true, but Reason is not the correct explanation of Assertion.
   (c) Assertion is true, but Reason is false.
   (d) Assertion is false, but Reason is true.
5. **Assertion:** - Branching descent and Natural selection are the two key concepts of Darwinian theory of evolution.
   **Reason: -** Inheritance of acquired characters was proposed by Darwin.
   (a) If both Assertion & Reason are True & the Reason is a correct explanation of the Assertion.
   (b) If both Assertion & Reason are True but Reason is not a correct explanation of the Assertion.
   (c) If Assertion is True but the Reason is False.
   (d) If both Assertion & Reason are false.
6. **Assertion: -** Darwin' s finches are classical example of adaptive radiation
   **Reason: -** Lamarck explained that beak sizes and shape in finches varied according to food habit of different finches.
   (a) If both Assertion & Reason are True & the Reason is a correct explanation of the Assertion.
   (b) If both Assertion & Reason are True but Reason is not a correct explanation of the Assertion.
   (c) If Assertion is True but the Reason is False.
   (d) If both Assertion & Reason are false.
7. **Assertion (A):** The first mammals were like shrews
   **Reason (R):** The essence of Darwinian theory about evolution is natural selection.
   (a) If both Assertion (A) and Reason (R) are True and the Reason (R) is a correct explanation of the Assertion (A)
   (b) If both Assertion (A) and Reason (R) are True but Reason (R) is not a correct explanation of the Assertion (A).
   (c) If Assertion (A) is True but Reason (R) is false.

(d) If Assertion (A) is false but Reason (R) is True.

8. **Assertion:** The geological history of earth closely correlates with the biological history of earth.
**Reason:** Earth is very vast relatively universe itself is a speck
(a) If both Assertion & Reason are True & the Reason is a correct explanation of the Assertion.
(b) If both Assertion & Reason are True but Reason is not a correct explanation of the Assertion
(c) If Assertion is True but The Reason is false
(d) If both Assertion & Reason are false

9. **Assertion:** A study of fossils in different sedimentary layers indicates the geological period in which they existed.
**Reason:** The study has showed that life-forms varied over time and certain life forms are restricted to certain geological time spans
(a) If both Assertion & Reason are True & the Reason is a correct explanation of the Assertion.
(b) If both Assertion & Reason are True but Reason is not a correct explanation of the Assertion
(c) If Assertion is True but The Reason is false
(d) If Assertion is false but Reason is true

10. **Assertion:** Fossils are remains of hard parts of life-forms found in rocks.
**Reason:** Evidences in the form of fossils are called paleontological evidence
(a) If both Assertion & Reason are True & the Reason is a correct explanation of the Assertion.
(b) If both Assertion & Reason are True but Reason is not a correct explanation of the Assertion
(c) If Assertion is True but The Reason is false
(d) If both Assertion & Reason are false

11. **Assertion:** Big-Bang theory talks of singular huge explosion unimaginable in physical terms that occurred millions of year back
**Reason:** Big bang theory explains origin of universe
(a) If both Assertion & Reason are True & the Reason is a correct explanation of the Assertion.
(b) If both Assertion & Reason are True but Reason is not a correct explanation of the Assertion
(c) If Assertion is True but The Reason is false
(d) If both Assertion & Reason are false

12. **Assertion:** Branching descent and Natural selection are the two key concepts of Darwinian theory of evolution
**Reason:** Natural selection is based on certain observations which are factual
(a) If both Assertion & Reason are True & the Reason is a correct explanation of the Assertion.
(b) If both Assertion & Reason are True but Reason is not a correct explanation of the Assertion
(c) If Assertion is True but The Reason is false
(d) If both Assertion & Reason are false

13. **Assertion:** Alfred Russel Wallace, a naturalist worked in Malay Archepelago
**Reason:** He also came to similar conclusion as of Darwin
(a) If both Assertion & Reason are True & the Reason is a correct explanation of the Assertion.
(b) If both Assertion & Reason are True but Reason is not a correct explanation of the Assertion
(c) If Assertion is True but The Reason is false
(d) If both Assertion & Reason are false

14. **Assertion:** The brain capacities of Homo-erectus were between 650-800 cc.
**Reason:** Homo-habilis probably eat meat.
(a) If both Assertion & Reason are True & the Reason is a correct explanation of the Assertion.
(b) If both Assertion & Reason are True but Reason is not a correct explanation of the Assertion
(c) If Assertion is True but The Reason is false
(d) If both Assertion & Reason are false

15. **Assertion**: About 15 mya, primates called Dryopithecus and Ramapithecus were existing.
**Reason:** They were hairy and walked like gorillas and chimpanzees. Ramapithecus was more man-like while Dryopithecus was more ape-like
(a) If both Assertion & Reason are True & the Reason is a correct explanation of the Assertion.

(b) If both Assertion & Reason are True but Reason is not a correct explanation of the Assertion
(c) If Assertion is True but The Reason is false
(d) If both Assertion & Reason are false

**Statement Based Questions**

16. **Statement I:** Evolution for Darwin was gradual while deVries believed mutation caused speciation and hence called it saltation
**Statement II:** Hugo deVries based on his work on evening primrose brought forth the idea of mutations – large difference arising suddenly in a population
(a) Both statements I and II are correct
(b) Statement I is correct but II is incorrect
(c) Statement I is incorrect but II is correct
(d) Both Statements I and II are incorrect

17. **Statement I:** The first cellular form of life were probably single-cells.
**Statement II:** Charles Darwin concluded that existing living forms share similarities to varying degrees among themselves but not with life forms that existed millions of years ago
(a) Both statements I and II are correct
(b) Statement I is correct but II is incorrect
(c) Statement I is incorrect but II is correct
(d) Both Statements I and II are incorrect

18. **Statement I:** 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
**Statement II:** Different-aged rock sediments contain fossils of different life-forms who probably died during the formation of the particular sediment
(a) Both statements I and II are correct
(b) Statement I is correct but II is incorrect
(c) Statement I is incorrect but II is correct
(d) Both Statements I and II are incorrect

19. **Statement I:** Homology indicates common ancestry
**Statement II:** Wings of butterfly and of birds look alike due anatomical similarity
(a) Both statements I and II are correct
(b) Statement I is correct but II is incorrect
(c) Statement I is incorrect but II is correct
(d) Both Statements I and II are incorrect

20. **Statement I:** All the varieties of Darwin finches were evolved on the island itself
**Statement II:** Different varieties of Darwin finches were evolved from insect eating finches
(a) Both statements I and II are correct
(b) Statement I is correct but II is incorrect
(c) Statement I is incorrect but II is correct
(d) Both Statements I and II are incorrect

21. **Statement I:** The essence of Darwinian theory about evolution is natural selection and mutation
**Statement II:** According to Darwin survivors will leave more progeny and there would be a change in population characteristic and hence new forms appear to arise.
(a) Both statements I and II are correct
(b) Statement I is correct but II is incorrect
(c) Statement I is incorrect but II is correct
(d) Both Statements I and II are incorrect

22. **Statement I:** According to Darwin minor variation are responsible for evolution .
**Statement II:** deVries believed that it is mutation which causes evolution and not the minor variations
(a) Both statements I and II are correct
(b) Statement I is correct but II is incorrect
(c) Statement I is incorrect but II is correct
(d) Both Statements I and II are incorrect

23. **Statement I:** Other examples of homology are the eye of the octopus and of mammals or the flippers of Penguins and Dolphins.
**Statement II:** Sweet potato (root modification) and potato (stem modification) is another example for analogy
(a) Both statements I and II are correct
(b) Statement I is correct but II is incorrect
(c) Statement I is incorrect but II is correct
(d) Both Statements I and II are incorrect

24. **Statement I:** Natural selection can lead to stabilisation (in which more individuals acquire mean character value)
**Statement II:** Natural selection is based on certain observations which are not factual
(a) Both statements I and II are correct
(b) Statement I is correct but II is incorrect
(c) Statement I is incorrect but II is correct
(d) Both Statements I and II are incorrect

25. **Statement I:** In 1938, a fish caught in South Africa happened to be a Coelacanth which was thought to be extinct

**Statement II:** There are no specimens of these left with us
(a) Both statements I and II are correct
(b) Statement I is correct but II is incorrect
(c) Statement I is incorrect but II is correct
(d) Both Statements I and II are incorrect

26. **Statement I:** The amphibians evolved into birds
**Statement II:** About 65 mya, the dinosaurs suddenly appeared on the earth
(a) Both statements I and II are correct
(b) Statement I is correct but II is incorrect
(c) Statement I is incorrect but II is correct
(d) Both Statements I and II are incorrect

27. **Statement I:** About 2000 million years ago (mya) the first cellular forms of life appeared on earth
**Statement II:** When migration of a section of population to another place and population occurs, gene frequencies change in the original as well as in the new population
(a) Both statements I and II are correct
(b) Statement I is correct but II is incorrect
(c) Statement I is incorrect but II is correct
(d) Both Statements I and II are incorrect

28. **Statement I:** Fossils discovered in Java in 1891 revealed Homo erectus
**Statement II:** Homo erectus had a large brain around 900cc
(a) Both statements I and II are correct
(b) Statement I is correct but II is incorrect
(c) Statement I is incorrect but II is correct
(d) Both Statements I and II are incorrect

29. **Statement I:** Pre-historic cave art developed about 18,000 years ago
**Statement II:** Agriculture came around 10,000 years back and human settlements started.
(a) Both statements I and II are correct
(b) Statement I is correct but II is incorrect
(c) Statement I is incorrect but II is correct
(d) Both Statements I and II are incorrect

30. **Statement I:** The Big Bang theory attempts to explain to us the origin of universe.
**Statement II:** These first non-cellular forms of life could have originated 3 billion years ago.
(a) Both statement I and II are correct
(b) Statement I is correct but II is incorrect.
(c) Statement I is incorrect but II is correct
(d) Both Statement I and II is incorrect

31. **Statement I:** Homologous organs are similar in basic structure and origin.
**Statement II:** Homologous organs serve different functions.
(a) Both statements I and II are correct
(b) Statement I is correct but II is incorrect
(c) Statement I is incorrect but II is correct
(d) Both Statements I and II are incorrect

32. **Statement I:** Before industrialization, there were more white-winged moths on trees than dark-winged.
**Statement II:** After industrialization, the proportion was same.
(a) Both statements I and II are correct
(b) Statement I is correct but II is incorrect
(c) Statement I is incorrect but II is correct
(d) Both Statements I and II are incorrect

## Match up Based Questions

33. Match the scientists with the theory or experiments they suggested or performed respectively.

| Column-I (Scientists) | | Column-II (Theories and Experiments) | |
|---|---|---|---|
| A. | Oparin and Haldane | p. | Experimentally proved Chemical theory of evolution |
| B. | SL Miller | q. | Swan Neck flask experiment |
| C. | Alfred Wallace | r. | Chemical theory of evolution |
| D. | Pasteur | s. | Worked in Malay Archipelago |

(a) A-(q); B-(p); C-(r); D-(s)
(b) A-(r); B-(p); C-(s); D-(q)
(c) A-(q); B-(r); C-(p); D-(s)
(d) A-(r); B-(p); C-(q); D-(s)

34. Match the human ancestors with the special characters.

| Column-I (Human Ancestors) | | Column-II (Theories and Experiments) | |
|---|---|---|---|
| A. | Homo erectus | p. | probably did not eat meat |

| | | | |
|---|---|---|---|
| B. | Australopithicus | q. | 900cc |
| C. | Homo habilis | r. | 1400cc |
| D. | Neanderthal man | s. | 650-800cc |

(a) A-(q); B-(p); C-(r); D-(s)
(b) A-(p); B-(q); C-(s); D-(r)
(c) A-(q); B-(r); C-(p); D-(s)
(d) A-(q); B-(p); C-(s); D-(r)

35. Match the Column

| Column-I | | Column-II | |
|---|---|---|---|
| A. | Darwin | p. | Embryological support for evolution |
| B. | Natural selection | q. | Homology |
| C. | Ernst Heckel | r. | Reproductive fitness |
| D. | Divergent evolution | s. | Industrial melanism |

(a) A - (r); B - (s); C - (p); D - (q)
(b) A - (r); B - (q); C - (p); D - (s)
(c) A - (r); B - (s); C - (q); D - (p)
(d) A - (q); B - (s); C - (r); D - (p)

36. Match the Column

| Column-I (Theory for evolution) | | Column-II (Observations) | |
|---|---|---|---|
| A. | Theory of Panspermia | p. | Analogous organ |
| B. | Theory of abiogenesis | q. | Natural selection |
| C. | Convergent evolution | r. | Life originated from spores |
| D. | Charles Darwin | s. | Living organism originated from non living |

(a) A-(q); B-(p); C-(r); D-(s)
(b) A-(r); B-(s); C-(p); D-(q)
(c) A-(r); B-(s); C-(q); D-(p)
(d) A-(q); B-(s); C-(r); D-(p)

37. Match the Column.

| Column-I | | Column-II | |
|---|---|---|---|
| A. | Primitive earth | p. | Single huge explosion |
| B. | Haldane | q. | Cell like structure resembles living cells |
| C. | Coacervates | r. | Reducing atmosphere |
| D. | Big bang theory | s. | Prebiotic soup |

(a) A - (q); B - (p); C - (r); D - (s)
(b) A - (p); B - (q); C - (s); D - (r)
(c) A - (r); B - (s); C - (q); D - (p)
(d) A - (q); B - (p); C - (s); D - (r)

38. Match the columns and find out the correct combination:

| Column-I | | Column-II | |
|---|---|---|---|
| (a) | Tyrannosaurus rex | (i) | 15 mya |
| (b) | first mammals | (ii) | Shrews like |
| (c) | Dryopithecus | (iii) | 20 feet |

(a) (a)-(i) (b)-(iii) (c)-(ii)
(b) (a)-(iii) (b)-(i) (c)-(ii)
(c) (a)-(iii) (b)-(ii) (c)-(i)
(d) (a)-(ii) (b)-(i) (c)-(iii)

39. Match the columns with respect to convergent evolution of Australian Marsupials and placental mammals.

| Column-I | | Column-II | |
|---|---|---|---|
| (a) | Bobcat | (i) | Tasmanian tiger cat |
| (b) | Anteater | (ii) | Flying phalanger |
| (c) | Lemur | (iii) | Numbat |
| (d) | Flying squirrel | (iv) | Spotted cuscus |

(a) (a)-(ii) (b)-(iii) (c)-(i) (d)-(iv)

(b) (a)-(ii) (b)-(i) (c)-(iii) (d)-(iv)
(c) (a)-(i) (b)-(iii) (c)-(iv) (d)-(ii)
(d) (a)-(iii) (b)-(ii) (c)-(i) (d)-(iv)

40. Match the following.

| Column-I | | Column-II | |
|---|---|---|---|
| (a) | Louis Pasteur | (i) | Natural selection |
| (b) | Oparin & Haldane | (ii) | 1st life from pre-existing non-living molecules |
| (c) | Darwin | (iii) | life comes from pre-existing life |
| (d) | Alfred Wallace | (iv) | Malay Archipelago |

(a) (a)-(ii) (b)-(iii) (c)-(i) (d)-(iv)
(b) (a)-(i) (b)-(iii) (c)-(iv) (d)-(ii)
(c) (a)-(ii) (b)-(i) (c)-(iii) (d)-(iv)
(d) (a)-(iii) (b)-(ii) (c)-(i) (d)-(iv)

41. Match the columns and find out the correct combination:

| Column-I | | Column-II | |
|---|---|---|---|
| (a) | Louis Pasteur | (i) | more ape-like |
| (b) | Dryopithecus | (ii) | Mutations |
| (c) | Prime rose | (iii) | Theory of biogenesis |
| (d) | Peppered moth | (iv) | T.H.Morgan |
| (e) | *Drosophila* | (v) | Industrial melanism |

(a) (a)-(ii); (b)-(iv); (c)-(iii); (d)-(i); (e)-(iv)
(b) (a)-(iii); (b)-(i); (c)-(ii); (d)-(v); (e) -(iv)
(c) (a)-(iv); (b)-(v); (c)-(i); (d)-(iii); (e) -(ii)
(d) (a)-(i); (b)-(ii); (c)-(iii); (d)-(v); (e) -(iv)

42. Match the following columns.

| Column-I | | Column-II | |
|---|---|---|---|
| (a) | Wallace | (i) | Essay on population |
| (b) | Malthus | (ii) | Biston betularia |
| (c) | Hardy law - Weinberg's | (iii) | $p^2 + q^2 + 2pq = 1$ |
| (d) | Industrial melanism | (iv) | Co-proposer of natural selection |

(a) (a)-(iii) (b)-(iv) (c)-(ii) (d)-(i)
(b) (a)-(ii) (b)-(i) (c)-(iv) (d)-(iii)
(c) (a)-(iv) (b)-(i) (c)-(ii) (d)-(iii)
(d) (a)-(iv) (b)-(i) (c)-(iii) (d)-(ii)

43. Match the columns and find out the correct combination:

| Column-I | | Column-II | |
|---|---|---|---|
| (a) | Ramapithecus | (i) | East African grasslands |
| (b) | Australopithecines | (ii) | 18,000 years ago |
| (c) | Fossils discovered in Java | (iii) | 15 mya |
| (d) | Pre-historic cave art | (iv) | 1891 |

(a) (a)-(iii) (b)-(i) (c)-(ii) (d)-(iv)
(b) (a)-(iii) (b)-(i) (c)-(iv) (d)-(ii)
(c) (a)-(i) (b)-(iii) (c)-(ii) (d)-(iv)
(d) (a)-(i) (b)-(iii) (c)-(iv) (d)-(ii)

44. Match the columns w.rt scientist and their theory:

| Column-I | | Column-II | |
|---|---|---|---|
| (a) | Darwin | (i) | Use and disuse theory |
| (b) | Lamarck | (ii) | Origin of species |
| (c) | Hugo de Vries | (iii) | Origin of life |
| (d) | A. S. Oparin | (iv) | Mutation theory |

(a) (a)-(ii) (b)-(i) (c)-(iv) (d)-(iii)
(b) (a)-(iv) (b)-(i) (c)-(ii) (d)-(iii)
(c) (a)-(i) (b)-(ii) (c)-(iii) (d)-(iv)
(d) (a)-(ii) (b)-(iii) (c)-(iv) (d)-(i)

45. Match Column-I with Column-II.

| Column-I | | Column-II | |
|---|---|---|---|
| (a) | Fore limbs of vertebrate | (1) | Analogous structures |
| (b) | Wings of insects and birds | (2) | Vestigial structures |
| (c) | Vermiform appendix in man | (3) | Natural selection |
| (d) | Darwin's finches | (4) | Homologous structures |

Select the correct option.

| | a | b | c | d |
|---|---|---|---|---|
| (a) | 2 | 4 | 1 | 3 |
| (b) | 4 | 1 | 2 | 3 |
| (c) | 3 | 2 | 1 | 4 |
| (d) | 1 | 4 | 3 | 2 |

46. Match the placental mammals given in column-I to their corresponding Australian marsupials given in column- II.

| | Column-I | | Column-II |
|---|---|---|---|
| (a) | Flying squirrel | (1) | Tasmanian tiger cat |
| (b) | Bobcat | (2) | Tasmanian wolf |
| (c) | Wolf | (3) | Spotted cuscus |
| (d) | Lemur | (4) | Flying phalanger |

Select the correct option.

| | a | b | c | d |
|---|---|---|---|---|
| (a) | 1 | 3 | 2 | 4 |
| (b) | 4 | 1 | 2 | 3 |
| (c) | 4 | 2 | 1 | 3 |
| (d) | 4 | 2 | 3 | 1 |

47. Match Column-I with Column-II.

| | Column-I | | Column-II |
|---|---|---|---|
| (a) | Fore limbs of vertebrate | (1) | Analogous structures |
| (b) | Wings of insects and birds | (2) | Vestigial structures |
| (c) | Vermiform appendix in man | (3) | Natural selection |
| (d) | Darwin's finches | (4) | Homologous structures |

Select the correct option.

| | a | b | c | d |
|---|---|---|---|---|
| (a) | 2 | 4 | 1 | 3 |
| (b) | 4 | 1 | 2 | 3 |
| (c) | 3 | 2 | 1 | 4 |
| (d) | 1 | 4 | 3 | 2 |

# Exercise-04 Previous Year Questions

1. The flippers of the Penguins and Dolphins are the example of the **(2024)**
   (a) Natural selection
   (b) Convergent evolution
   (c) Divergent evolution
   (d) Adaptive radiation

2. Which one of the following factors will not affect the Hardy-Weinberg equilibrium? **(2024)**
   (a) Genetic drift
   (b) Gene migration
   (c) Constant gene pool
   (d) Genetic recombination

3. Given below are some stages of human evolution. Arrange them in correct sequence. (Past to Recent) **(2024)**
   A. *Homo habilis*
   B. *Homo sapiens*
   C. *Homo neanderthalensis*
   D. *Homo erectus*
   Choose the correct sequence of human evolution from the options given below:

(a) B-A-D-C (b) C-B-D-A
(c) A-D-C-B (d) D-A-C-B

4. Select the correct group/set of Australian Marsupials exhibiting adaptive radiation. **(2023)**
(a) Tasmanian wolf, Bobcat, Marsupial mole
(b) Numbat, Spotted cuscus, Flying phalanger
(c) Mole, Flying squirrel, Tasmanian tiger cat
(d) Lemur, Anteater, Wolf

5. Which of the following statements is not true? **(2022)**
(a) Sweet potato and potato is an example of analogy
(b) Homology indicates common ancestry
(c) Flippers of penguins and dolphins are a pair of homologous organs
(d) Analogous structures are a result of convergent evolution

6. The factor that leads to Founder effect in a population is **(2021)**
(a) Genetic recombination
(b) Mutation
(c) Genetic drift
(d) Natural selection

7. Match the following **(2021)**

| List-I | | List-II | |
|---|---|---|---|
| A. | Adaptive radiation | (i) | Selection of resistant varieties due to excessive use of herbicides and pesticides |
| B. | Convergent evolution | (ii) | Bones of forelimbs in man and whale |
| C. | Divergent evolution | (iii) | Wings of butterfly and bird |
| D. | Evolution by anthropogenic action | (iv) | Darwin Finches |

Choose the correct answer from the options given below
(a) A-iii B-ii C-i D-iv (b) A-ii B-i C-iv D-iii
(c) A-i B-iv C-iii D-ii (d) A-iv B-iii C-ii D-i

8. Flippers of penguins and dolphins are examples of **(2020)**
(a) Convergent evolution
(b) Industrial melanism
(c) Natural selection
(d) Adaptive radiation

9. Which of the following refer to correct example(s) of organisms which have evolved due to changes in environment brought about by anthropogenic action? **(2020)**
1. Darwin's Finches of Galapagos islands
2. Herbicide resistant weeds
3. Drug resistant eukaryotes
4. Man created breeds of domesticated animals like dogs
(a) 1 and 3 (b) 2, 3 and 4
(c) Only 4 (d) Only 2

10. Embryological support for evolution was disapproved by **(2020)**
(a) Alfred Wallace (b) Charles Darwin
(c) Oparin (d) Karl Ernst Von Baer

11. From his experiments, S.L. Miller produced amino acids by mixing the following in a closed flask **(2020)**
(a) $CH_3$, $H_2$, $NH_4$ and water vapor at 800°C
(b) $CH_4$, $H_2$, $NH_3$ and water vapor at 600°C
(c) $CH_3$, $H_2$, $NH_3$ and water vapor at 600°C
(d) $CH_4$, $H_2$, $NH_3$ and water vapor at 800°C

12. After about how many years of formation of earth, life appeared on this planet? **(2020 Covid Re-NEET)**
(a) 50 million years (b) 500 million years
(c) 50 billion years (d) 500 billion years

13. Embryological support for evolution was proposed by **(2020 Covid Re-NEET)**
(a) Karl Ernst Von Baer (b) Charles Darwin
(c) Alfred Wallace (d) Ernst Heckel

14. A Hominid fossil discovered in Java in 1891, now extinct, having cranial capacity of about 900 cc was **(2020 Covid Re-NEET)**
(a) Neanderthal man (b) Homo sapiens
(c) Australopithecus (d) Homo erectus

15. The phenomenon of evolution of different species in a given geographical area starting from a point and spreading to other habitats is called **(2020 Covid Re-NEET)**
(a) Co-evolution
(b) Natural selection
(c) Adaptive radiation
(d) Saltation

## Answer keys

### TOPIC CENTRIC EXERCISE-1 : Answer Key

| | | | | |
|---|---|---|---|---|
| 1. (c) | 2. (b) | 3. (d) | 4. (a) | 5. (b) |

### TOPIC CENTRIC EXERCISE-2 : Answer Key

| | | | |
|---|---|---|---|
| 1. (c) | 2. (a) | 3. (b) | 4. (a) |

### TOPIC CENTRIC EXERCISE-3 : Answer Key

| | | | | |
|---|---|---|---|---|
| 1. (a) | 2. (c) | 3. (b) | 4. (d) | 5. (c) |

### TOPIC CENTRIC EXERCISE-4 : Answer Key

| | | |
|---|---|---|
| 1. (a) | 2. (a) | 3. (a) |

### TOPIC CENTRIC EXERCISE-5 : Answer Key

| | | | | |
|---|---|---|---|---|
| 1. (b) | 2. (d) | 3. (a) | 4. (b) | 5. (a) |

### TOPIC CENTRIC EXERCISE-6 : Answer Key

| | | | | |
|---|---|---|---|---|
| 1. (b) | 2. (b) | 3. (d) | 4. (b) | 5. (b) |

### TOPIC CENTRIC EXERCISE-7 : Answer Key

| | | | |
|---|---|---|---|
| 1. (a) | 2. (b) | 3. (b) | 4. (c) |

### TOPIC CENTRIC EXERCISE-8 : Answer Key

| | | | | |
|---|---|---|---|---|
| 1. (c) | 2. (d) | 3. (c) | 4. (a) | 5. (a) |

### TOPIC CENTRIC EXERCISE-9 : Answer Key

| | | | | | |
|---|---|---|---|---|---|
| 1. (d) | 2. (b) | 3. (c) | 4. (c) | 5. (b) | 6. (b) |

### Exercise-01 Level -01 Answer Key

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1. (d) | 8. (b) | 15. (a) | 22. (d) | 29. (a) | 36. (d) | 43. (b) | 50. (d) |
| 2. (b) | 9. (b) | 16. (b) | 23. (b) | 30. (a) | 37. (b) | 44. (b) | 51. (c) |
| 3. (b) | 10. (a) | 17. (c) | 24. (a) | 31. (c) | 38. (c) | 45. (b) | 52. (b) |
| 4. (d) | 11. (b) | 18. (c) | 25. (c) | 32. (a) | 39. (b) | 46. (a) | 53. (a) |
| 5. (b) | 12. (b) | 19. (b) | 26. (c) | 33. (d) | 40. (b) | 47. (d) | 54. (d) |
| 6. (b) | 13. (c) | 20. (d) | 27. (d) | 34. (a) | 41. (b) | 48. (d) | 55. (a) |
| 7. (b) | 14. (b) | 21. (a) | 28. (a) | 35. (c) | 42. (a) | 49. (a) | |

### Exercise-02 Level -02 Answer Key

| | | | | | | |
|---|---|---|---|---|---|---|
| 1. (d) | 7. (a) | 13. (d) | 19. (c) | 25. (a) | 31. (b) | 37. (d) |
| 2. (c) | 8. (d) | 14. (a) | 20. (a) | 26. (c) | 32. (c) | 38. (b) |
| 3. (c) | 9. (c) | 15. (b) | 21. (c) | 27. (c) | 33. (b) | 39. (c) |
| 4. (b) | 10. (a) | 16. (c) | 22. (b) | 28. (b) | 34. (a) | 40. (b) |
| 5. (d) | 11. (a) | 17. (a) | 23. (c) | 29. (d) | 35. (d) | 41. (b) |
| 6. (a) | 12. (c) | 18. (a) | 24. (a) | 30. (a) | 36. (c) | |

### Exercise-03 Level -03 Answer Key

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1. (a) | 7. (b) | 13. (b) | 19. (b) | 25. (a) | 31. (a) | 37. (c) | 43. (b) |
| 2. (b) | 8. (c) | 14. (d) | 20. (b) | 26. (d) | 32. (b) | 38. (c) | 44. (a) |
| 3. (b) | 9. (b) | 15. (a) | 21. (c) | 27. (a) | 33. (b) | 39. (c) | 45. (b) |
| 4. (c) | 10. (b) | 16. (a) | 22. (a) | 28. (a) | 34. (d) | 40. (d) | 46. (b) |
| 5. (c) | 11. (b) | 17. (b) | 23. (c) | 29. (a) | 35. (a) | 41. (b) | 47. (b) |
| 6. (c) | 12. (b) | 18. (a) | 24. (b) | 30. (b) | 36. (b) | 42. (d) | |

### Exercise-04 Previous Year Questions

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | (b) | 3. | (c) | 5. | (c) | 7. | (d) | 9. | (b) | 11. | (d) | 13. | (d) | 15. | (c) |
| 2. | (c) | 4. | (b) | 6. | (c) | 8. | (a) | 10. | (d) | 12. | (b) | 14. | (d) | | |