# 29. Evolution

## 1. Introduction

Evolution (Gk. E-out, volver-to roll) is unrolling or unfolding of nature that brings about an orderly change from none form or condition to another resulting in descendants becoming different from ancestors. Evolution is rather a law of nature. It occurs in all domains-steller, inorganic, physical, chemical and biological. When not specified evolution, means organic evolution. The term was coined by spencer(1820-1903).

Darwin(1859) has termed evolution to be descent with modifications. However evolution not only deals with modifications but all types of diversities that include both differences and similarities, adaptive and nonadaptive characteristic of organisms.

## 2. Origin of Life

Life is an inherent capacity that an organism possesses to maintain and reproduce itself. The origin of life is considered a unique event in the history of universe. When the earth formed some 4.6 billion years ago, it was lifeless and inhospitable to living organism. One billion years later it was already teeming with prokaryotic life forms, ancestors to all present living things. The last common ancestor of all presently living organisms must have had those characteristics which are now shared by the organisms which constitute the five living kingdoms.

### 2.1 Origin of Universe

Universe or Cosmos is the whole existing space and matter that is differentiated into several galaxies, with each galaxy having several stars and clouds of gas and dust. The study of universe is known as cosmology while the study of origin of universe is called cosmogony.

(1) **Big-Bang theory** - Most accepted theory to explain the origin of universe is the Big-Bang theory. It was proposed by Abbe Lemaitre in 1931. According to this theory the universe came into existence some 15 billion years ago. The Big-Bang theory talks of a singular huge explosion unimaginable in physical terms. The universe expanded and hence, the temperature came down. Hydrogen and helium formed sometime later. The gases condensed under gravitation and formed the galaxies of the present day universe. 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 water vapour, methane, carbon dioxide and ammonia released from molten mass covered the surface. The ultraviolet rays from the sun broke up water into hydrogen and oxygen and the lighter $H_2$ escaped. Oxygen combined with ammonia and methane to form water, $CO_2$ and others. The ozone layer was formed. As it cooled, the water vapour 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.

(2) **Nebular Hypothesis** - About 4.5 billion years ago, our solar system from the gaseous clouds called solar nebula (Kant: which started to collapse under the force of its own gravity and became a flattened spinning disc of atoms and particles. Its central region became the 'sun' and atoms and dust grains orbiting the centre of gaseous disc. Later on, these orbiting atoms and dust grains aggregated into clumps and grew into planets such as Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus and Neptune. The origin of earth is also understood by this theory.

## 3. Theories on the Origin of Life

There are several theories about the origin of life.

### 3.1 Theory of Special Creation

The theory of special creation was proposed by Hebrew et al and greatest supporter of this theory was father Suarez. According to this theory life was created by supernatural power. According to the Bible, the world was created within six days.

### 3.2 Theory of Catastrophism

Georges Cuvier(French scientist, 1769-1832) and Orbigney (1802-1837) were the chief advocates of this theory. It states that there have been several creations, each preceded by a catastrophe (a sudden, extensive disaster or misfortune) due to some geological disturbance. Each catastrophe completely destroyed the life, and each creation consisted of life quite different from that of the previous one.

### 3.3 Cosmozoic Theory or Theory of Panspermia

Cosmozoic theory was proposed by Richter (1865) and supported by Arrhenius (1908). Cosmozoic theory is also called theory of panspermia or spore theory. This theory states that life had reached the earth from some other heavenly body in the form of resistant spores of simple organisms (called cosmozoa) in meteorites or in spaceships.

### 3.4 Theory of spontaneous generation (Theory of Abiogenesis or autobiogenesis)

The theory believes that under certain conditions nonliving substances give rise to living beings spontaneously.

### 3.5 Theory of Biogenesis

However, living beings are neither produced spontaneously nor created. Instead, life comes from pre-existing life or omnisvivum ex vivo. The phenomenon is called biogenesis (Gk. Bios-life, genesis- birth). Biogenesis was proved by the work of three scientists- Redi (1668), Spallanzani(1767) and Pasteur (1867).

Louis Pasteur (in 1864) used swan-necked flasks and prepared a meat broth in these flasks, and boiled them for several hours. He then left the flask unsealed on a laboratory bench and there was a free exchange of air with the environment, so the system did not

lack oxygen. Still, the flask remained free for microbial contamination for months, because, their swan-necks were shaped so as to trap viable microbial particles and to allow only air to enter the flask. After several months when he broke the neck of one of these flasks. Contamination by air and proliferation of micro-organisms in the fluid ensued. This experiment thus disproved the concept of spontaneous generation completely.

## 3.6 Modern hypothesis of origin of life (Oparin - Haldane theory-biochemical origin of life)

The modern hypothesis of origin of life was formulated by Haeckel. This idea was elaborated in the chemical theory by two workers independently: a Russian biochemist A.I.Oparin in 1923 and an English biologist J.B.S. Haldane in 1928. It was summarized by oparin in his book "The origin of life" published in an English edition in 1938.

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. The Oparin-Haldane theory (also called protobiogenesis) was experimentally supported by Stanley Miller in 1953 and separated the entire process into the following steps:

(I) Origin of Earth and its primitive atmosphere

(II) Chemical evolution (chemogeny) and

(III) Biological evolution.

### (1) Origin of Earth and its primitive atmosphere

The early atmosphere of primitive earth was strongly reducing, it contained hydrogen, methane, ammonia and water vapours. The early atmosphere was without free oxygen (non-oxygenic). It was bound in water, carbon monoxide and carbon dioxide and in metallic oxides on the surface rocks and particles. There was no layer of ozone to absorb ultraviolet rays coming on to earth from the sun. The energy requiring synthetic processes, that occurred on primitive earth in past, during chemical evolution obtained energy from the following sources: Solar radiation on ultraviolet radiation, Electric discharges, Volcanic eruptions, Ionizing radiations and cosmic rays.

### (2) Chemical Origin of life (Chemogeny)

**Oparin** suggested that from the simple compound like nitrides, oxides, ammonia, methane, cyanide etc more and more complex organic compounds were formed gradually under the influences of electric charges, ultra-violet rays or corpuscular radiations.

These form oxy and hydroxyl derivatives forming aldehydes, ketones and acids. Small chain of compounds was formed from the condensation of these hydroxyl derivatives. Sugar and starch were the main products. These then lead to the formation of fatty acids and glycerol through many ways of reaction like oxidation-reduction, polymerization, etc. Combinations of hydrocarbons, ammonia and water under the influence of freely available energy reached to form amino acids. The evidence for the formation of amino acids was provided by the experiment conducted by Stanley Miller (1953)

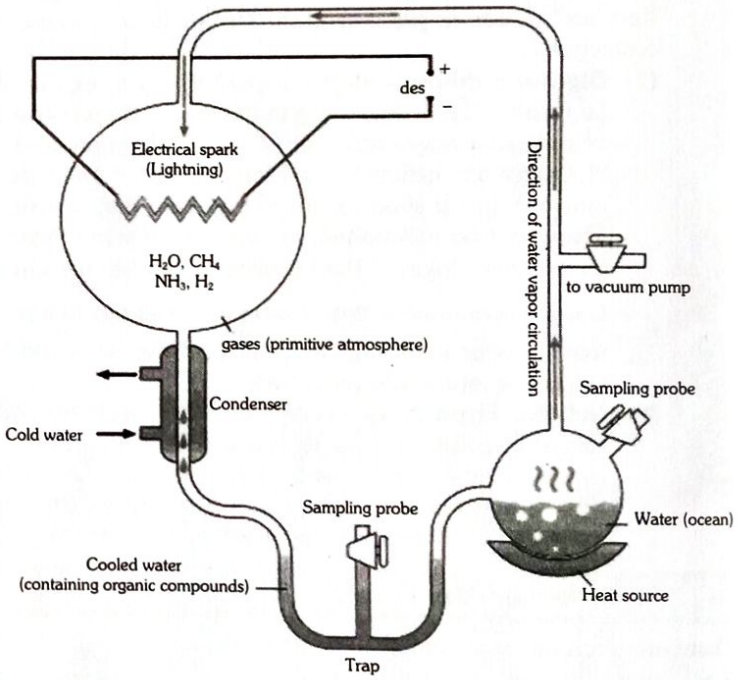



**Figure ;–** Miller's Experiment

- **Evidence of Chemogeny** - Stanley Miller (1953), a graduate student of Harold C. Urey (1893-1981) designed an apparatus for simulating conditions prevalent on earth at the time of abiogenic evolution of organic substances.
  - The apparatus had a spark chamber with two electrodes (for simulation of lighting), a flask for boiling (simulation of raining and Haldane's soup). A control apparatus was also prepared but without electrodes in spark chamber. Miller used a mixture of methane, ammonia, hydrogen (2 : 1 : 2) and water.
  - The mixture was exposed to electric discharges, followed by condensation and then boiling. It was continued for 18 days. The experiment was repeated a number of times. The products were extracted and identified through chromatography.
  - **Observation-** He found a large number of simple organic compounds including some amino acids such as alanine, glycine and aspartic acid.
  - Miller proved that organic compounds were basis of life. The formation of the simple compounds like amino acids, sugars, fatty acids was followed by the formation of complex organic molecules like polysaccharides, fats, proteins, nucleic acids etc from these simple compounds.
  - The evidence for this was provided by the experiment performed by Sydney F. fox from Florida University in 1957. The synthesis of carbohydrates, fats and amino

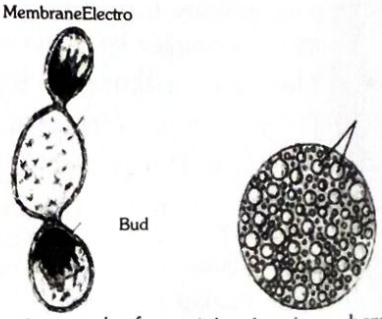



**Figure : –** Electron micrograph of a proteinuria microsphere

acids and other complex organic substances probably occurred in sea, which had been described by Haldane as 'The hot dilute soup'.

- In the hot organic soup the molecules of simple organic substances came together in increasing number, collided, reacted and aggregated forming new molecules of increasing size and complexity and larger number of amino acid molecules became linked together forming long polypeptide chains.
- **The formation of protein molecule is considered a land mark in the origin of life** - The accumulation of organic substances in the soupy sea was possible before there were living things, because there were no bacteria and molds and no living things which could bring about their decay and there was no free oxygen, which had oxidised them.
- **Formation of Proteinoids** - Experiment evidence has come forth for the synthesis of complex organic compounds from simple ones. S.W. Fox has synthesized polypeptides by heating a mixture of amino acids from 160 to 210°C for several hours. He called these molecules proteinoids.
- **Origin of Coacervates :** The large organic molecules which were synthesized abiotically on primitive earth later came together, and due to intermolecular attraction, they formed large colloidal aggregates. Such water bound aggregates have been named microspheres by Sydney Fox. Microspheres exhibit general resemblance to spherical bacteria.

  On this basis it can be concluded that microsphere-like aggregates could have been the forerunners of first living organisms. Later these colloidal bodies were named coacervates by Oparin
- Coacervates had the following features.
  (i) Each coacervate was cluster of macromolecules surrounded by a membrane.
  (ii) The coacervate was colloidal body containing a mixture of biologically important macromolecules, such as proteins, nucleic acids, lipids, polysaccharides, etc
  (iii) The coacervates grew by absorbing molecules from their environment. They could divide by budding like bacteria.
  (iv) Many chemical reactions including the decomposition of glucose took place inside the coacervates.
  (v) The sun provided the energy for chemical reactions. It is thought that the first cells arose in the same way as coacervates.
  (vi) According to parin, coacervates were the sole living molecules which gave rise to cells. Coacervates and microspheres mimic living cells.

**(3) Biological evolution (Biogeny)**

Due to aggregation, giant molecules of nucleoproteins were formed by the union of nucleic acid and proteinoid molecules.

**Protoribosomes :** These nucleoproteinoid particles had fibrous or globular appearance. The nucleo-proteinoid microparticles might have been a model for early ribosomes are named protoribosomes.

**Protoviruses :** Some giant nucleoproteinoid molecules had certain characteristics of a 'free living gene' These could be compared to present day viruses having nucleic acid core and protein covering. These were called 'protoviruses' or protobionts by Oparin.

The first cells formed were similar to present day mycoplasma and viruses. The protobionts most probably gave rise to monera (cells without a well defined nucleus). The fossils of such primitive protobionts have been obtained form rocks in Africa about 3 billion years old. These were named Eobacteriumisolatum. It is presumed that first living organisms were chemoheterotrophs and obtained energy by the fermentation of complex organic substances available to them from the sea broth. These multiplied rapidly in an environment with a cupious supply of dissolved nutrients. With the rapid increase in the number of chemoheterotrophs, the nutrients from sea water began to disappear and gradually exhausted. This led to the evolution of several other modes of nutrition, such as – parasitism, saprophytism, predation, chemosynthesizers or chemoautotrophs.

- **Chemoautotrophs :** Drop in temperature stopped synthesis of organic molecules in the water bodies. Organic content of primordial soup decreased due to continuous withdrawal by chemoheterotrophs. Some of the early prokaryotes got converted into chemoauptotrophs. They developed the ability to synthesize organic materials from inorganic raw materials with the help of energy obtained from reduced inorganic substances of the medium some present-day chemoautotrophs are iron bacteria, nitrifying bacteria, sulphur bacteria.
- **Anaerobic photoautotrophs :** Evolution of chlorophyll molecule enabled certain protocells to utilize light energy and synthesize carbohydrates. These were the photosynthetic cells. The first photosynthetic cells (photoautotrophs) were anaerobic. They did not use water as a hydrogen source. Similar to present day sulphur bacteria, they cleaved hydrogen sulphide into hydrogen and sulphur. Hydrogen was used in the synthesis of organic compounds (food) and sulphur was released as a waste produced.

$$6CO_2 + 12H_2S \xrightarrow[\text{Chemical energy}]{\text{Fermentation}} C_6H_{12}O_6 + 6H_2O + 12s$$

- **Aerobic photautotrophs –** It is presumed that accumulation of $CO_2$ in atmosphere and formation of chlorophyll molecules resulted in the evolution of autotrophic forms. The first aerobic photoautotrophs were cyanobacteria-like forms. These used water as hydrogen source and carbon dioxide as source of carbon in photosynthesis. These released free oxygen in the atmosphere and are also called oxygen producing photosynthesizers. These appeared about 3300 to 3500 million (3.5 billion) years ago. With the increase of photoautotrophs, oxygen was liberated in the sea and then into the atmosphere.

This free oxygen then reacted with methane and ammonia present in the primitive atmosphere and transformed them into $CO_2$ and free $N_2$.

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

$$4NH_3 + 3O_2 \rightarrow 2N_2 + 6H_2O$$

These events ultimately transformed the ancient reducing oxygen-free atmosphere into the oxidizing atmosphere with plenty of free oxygen. The rising level of atmospheric oxygen led to the appearance of first one-called eukaryotic organisms.

- **Evolution of Eukaryotes -** The eukaryotes cells have evolved from the archaic prokaryotic cells. Archaebacteria (Arche, ancient) are described as the ancient bacteria representing the probable first forms of life. These will continue to live in conditions which have prevailed on primitive earth.
The archaebacteria are said to be the oldest of the 'living fossils' that had separated from the main moneran line (bacteria evolution) long ago.
**There are two views regarding their mode of origin.**
**(i) Symbiotic Origin-** According to Lynn Margulis of Boston University, some anaerobic predator host cells engulfed primitive aerobic bacteria but did not digest them. The oxygen respiring bacteria established themselves permanently inside host cells and developed mutual association. Such predator host cells became the first eukaryotic cells. The predators that captured both aerobic bacteria as well as photosynthetic blue green algal cells evolved into eukaryotic plant cells. The aerobic bacteria established themselves as mitochondria and blue green algae as chloroplasts.
**(ii) Origin by Invagination :** According to this view organelles of eukaryotic cells might have evolved by invagination of the surface membrane of primitive prokaryotic cells.

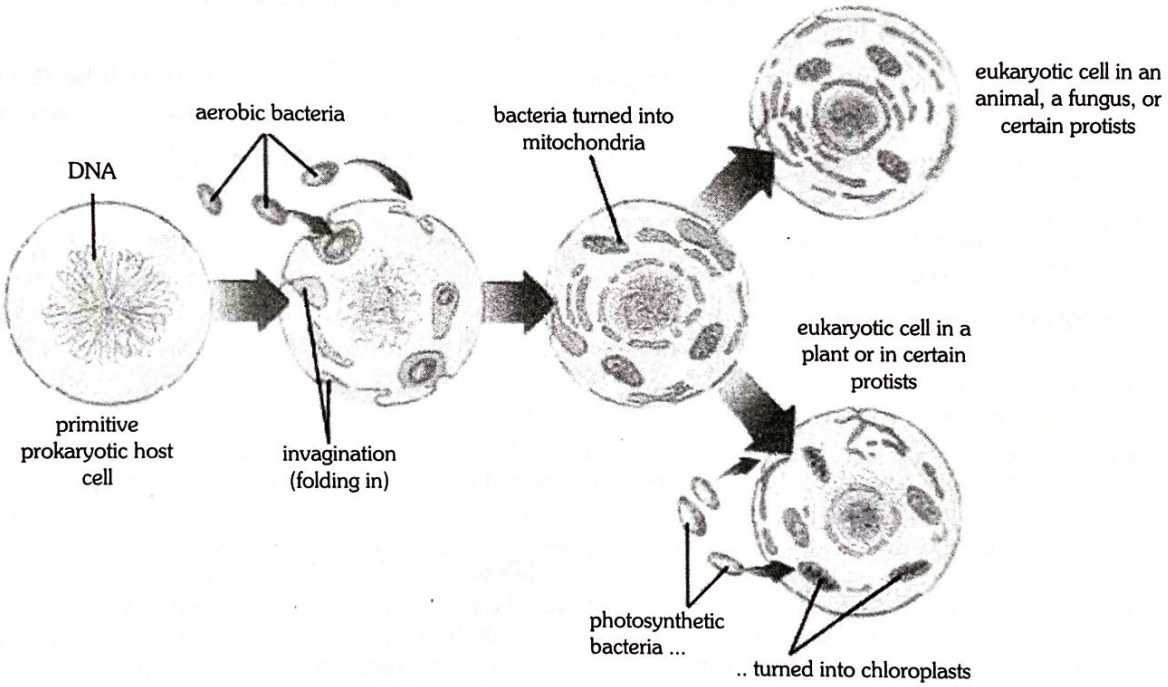



**Fig : – Diagrammatic representation of formation of chloroplast and origin of a eukaryotic call by invagination**

| Major events in origin of life | |
|---|---|
| Universe | 15 billion years |
| Solar system | 4.5-5.0 billion years |
| Earth | 4.6 billion years |
| Abiotic chemical evolution, anaerobic life | 4.0 billion years |
| Beginning of traces of oxygen | 3.8 billion years |
| Anoxygenci photosynthesis (Bacteria) | 3.5-3.8 billion years |
| Oxygenci photosynthesis (Cyanobacteria) | 3.3-3.5 billion years |
| Eukaryotes | 1600 million years |
| Simple land plants | 459 million years |
| Mammals | 220 million years |

- **Origin of Multicellular Organisms -** Once the unicellular organisms were formed, the cell could gather to form colonies. Later, cell differentiation led to the multicellular organisms. The latter gave rise to all the different forms of life by gradual modification over the ages. The advantage of multicellularity is based on division of labour between the component cells.

Another possible route to multicellular organization might have been through the failure of daughter cells of unicellular organisms (such as bacteria, yeast of algae) to separate after nuclear division and cytokinesis. Initially this would generate a mere mass of undifferentiated cells. At a later stage such aggregates must have been transformed into multicellular organisms by specialization of individual cells for particular tasks. This division of labour then requires that the activities of the whole organisms are integrated by a control and command system. Specialisation leads to complexity of organisation. This method of the formation of complex forms of life from simpler ones by gradual change in called organic evolution. We have no idea about how the first self replicating metabolic capsule of life arose. The first non-cellular forms of life could have originated 3 billion years back. They would have been giant molecules (RNA, protein, polysaccharides, etc.) these capsules reproduced their molecules perhaps. The first cellular form of life did not possibly originate till about 2000 million years ago. These were probably single-cells. All life forms were in water environment only.

## 4. Evidences of Evolution

The evidence of organic evolution indicate that present day forms have arisen by gradual changes from pre-existing forms and more complex forms have evolved from simpler forms. Evidence that evolution of life forms has indeed take place on earth come from many quarters.

### 4.1 Palaentological Evidence

Palaeontology is the study of past life based on fossil records. Their study reveals the existence of life in past and illustrates the course of evolution of plants and animals. The direct evidence of organic evolution comes from the study of fossils. The term fossil (Latin, fissilium, something dug out) refers to the petrified remains or impressions of organism that lived in past and got preserved in the sedimentary rocks.

**Table : Geological Time scale of Earth (To be read from below upward)**

| Era | Period | Epoch | Animal groups | Plant groups |
|---|---|---|---|---|
| **Conozoic** (Era of modern life) | **Quarternary** | Recent (Holocene)(0.01) | Modern man dominant; modern mammals, birds, fishes, insects | |
| | | Pleistocene 2 | Extinction of great mammals, primitive man common | |
| | **Tertiary** | Pliocene 6-7 (Age of mammals) | Emergence of man; formation and adaptive radiation of modern mammals. | Adaptive radiation of flowering plants. |
| | | Miocene 26 | Mammals at peak, first man-like apes formed | |
| | | Oligocene 38 | Extinction of archaic mammals. Rise of first monkeys and apes. | |
| | | Eocene 54 | Diversification of placental mammals. | |
| | | Palaeocene 65 | Rise of first primates. | |
| **Mesozoic** (Era of medieval Life) | **Cretaceous** 135 | | Extinction of giant reptiles and toothed birds; rise of modern fishes and birds, and of placenta mammals. | Dominance of flowering plants. |
| | **Jurassic** 145 (Age of eptiles) | | Rise of toothed birds and therian mammals; reptiles dominant; dinosaurs became large. | Origin of flowering plants |
| | **Triassic** 225 | | Rise of first dinosaurs and egg-laying mammals; extinction of primitive amphibians, adaptive radiation of reptiles. | Abundance of cycade and conifers |
| **Palaezoic** (Era of Ancient Life) | **Permian** 280 | | Extinction of many marine invertebrates, such as trilobites; rise of modern insects, beetles appear. | Origin of conifers |
| | **Carboniferous** 350 (Age of amphibians) | | Origin of reptiles and winged insects. Adaptive radiation of amphibians. | Abundance of tree-ferns forming coal forests. |
| | **Devonian** 400 (Age of fishes) | | Origin of amphibians, fishes abundant; spiders appear. | Earliest mosses and ferns. |
| | **Silurian** 440 | | Origin of jawed fishes and wingless insects; earliest coral reefs. | Earliest spore-baring plants |
| | **Ordovician** 500 (Age of invertebrates) | | Origin of vertebrates (Jawless fishes); invertebrates abundant. | |
| | **Cambrian** 570 | | All invertebrate phyla established; trilobites[2] dominant. | |
| **Proterozoic** (Era of early life) | 1000<br>2000<br>3000 | | Primitive metazoans (sponges, cnidarians). Primitive eukaryotes, scanty fossils. Prokaryotes. | |
| **Archeozoic** | 3500<br>4600[1] | | Origin of life; no recognizable fossils. Origin of solar system. | |

1. Time from beginning to present (Millions of year).
2. Extinct marine arthropods related to crustaceans.

**(1) Determination of age of fossils-**Fossils can be arranged in chronological sequence according to their age only when their correct age is determined.

- **Radioactive Dating Technique :** Radioactive isotope of carbon ($C^{14}$) is used to determine the age of upto 45,000 years old fossils, while radioactive uranium ($U^{238}$) or potassium ($K^{40}$) are used for older rocks. This dating system has been designed at 'The clock of Rocks'. Ex:- Carbons dating (Libby, 1949) – Radioactive C-14 occurs naturally. It enters food chains and is, therefore, found in all living beings and their remains. C-14 decays to form nitrogen-14. Half life of C-14 is 5730 years.
- **Relative Method :** In this method fossils age is determined by relative method or by digging method in which fossil present in upper strata has less age than fossils in deeper strata.

**(2) Geological time scale-** It is correlation between time periods of the past and fossiliferous rocks. First geological time scale was proposed by Italian scientist Giovanni Avidivina (1760). Our earth is 4.6 billion years old. First life appeared about 3800 million years ago. Divisions of Geological Time Scale

- **Eons-** Geological time scale has two major divisions and six divisions. Major divisions are called eons. The two eons are cryptozoic and phanerozoic.

  **Cryptozoic eon** is also called Precambrian and has rarity of life forms. The eon stretches, from 4600-600 million years.

  **Phanerozoic** eon had abundant life forms spread from 590 million years ago to the present.
- **Eras-** Divisions of geological time scale are called eras. Three eras belong to cryptozoic eon and three to phanerozoic eon.
- **Periods-** The eras of phanezoic eon have subdivisions called geological periods.

  Periods are usually distinguished on the basis of system of rocks and their associated fossils, e.g., carboniferous, createceous
- **Epochs-** A period or subdivision of geological time scale may be further distinguishable into categories called epochs.

**(3) Various evidence from palaeontology which support organic evolution is as follows:**

- **Early Fossils-** Fossils of earliest life are scantly. Fossils of 3100 million years ago consisted only prokaryotic organisms. They included bacteria and blue-green algae.
- **Distribution of fossils in different strata-** The distribution of fossils in the rocks of different ages fully agrees with the concept of evolution. It shows that fossil forms become more and more complex as we proceed from earliest to recent rocks. From the fossil records it has been concluded that evolution has taken place form simple to complex in a gradual manner. In support of it, the evidence are : The rocks of the earliest era, namely, archaeozoic do not show fossils. Proterozoic era show scant fossils, while palaeozoic has abundant fossils. Early palaeozoic shows fossils of marine invertebrates, while rocks of middle and later part of this era shows fossils of fishes and amphibians. Rocks of mesozoic era shows fossils of great reptiles, primitive birds and mammals. Early Cenozoic shows typical mammals and later part shows apes and man.

**Table : Types of Fossils, their Formation and Examples**

| Fossils | Fossilization process | Example |
|---|---|---|
| Entire organism | Frozen into during glaciations | Woolly mammoths found in Siberian permafrost (25000 years ago) |
| Entire organism | Encased in the hardened resin (amber) of coniferous trees. | Insect exoskeletons found in Oligocene rocks in Baltic coast. |
| Entire organism | Encased in tar | 'Mummies' of mammals and birds found in asphalt lakes of California) |
| Entire organism | Trapped in acidic bogs; lack of bacterial and fungal activity prevents total decomposition. | 'Mummies' found in bogs and peat in Scandinavia |
| Hard skeletal | Trapped by sedimentary sand and clay which form sedimentary rocks, e.g., limestone, sandstone and slit. | Bones, shells and teeth (very common in British isles). |
| Molds and casts | Hard materials trapped as above. Sediments harden to rock. The skeleton dissolves leaving its impression as a mold of the organism. This can be infilled with fine materials which harden to form a cast. Great detail is thus preserved. | Gastropods from Portland stone, Jurassic. Casts of giant horsetails (calamites) of carboniferous forst. Internal casts of molluscs shells showing muscle attachment points, fossils of pompeii city, which was buried by volcanic ash form mount vasuvirus in AD 79, presents molds & cast of men and their domestic animals. |
| Petrification | Gradual replacement by water-carried mineral deposits, such as silica, pyrites, calcium carbonate or carbon. Slow infilling as organism decomposes producing fine detail. | Silica replacements of the echinoderm micraster. |
| Impressions | Impressions of remains of organisms in fine-grained sediments of which they died. | Feathers of archaeopteryx in upper Jurassic. Jellyfish in cambrain found in British Columbia. Carboniferous leaf impressions. |
| Imprints | Footprints, trails, tracks and tunnels of various organisms made in mud are rapidly baked and filled in with sand and covered by further sediments. | Dinosaur footprints and tail scrapings indicate-size and posture of organisms. |
| Coprolites | Faecal pellets prevented from decomposing, later compressed in sedimentary rock. Often contain evidence of food eaten, e.g., teeth and scales. | Coenozic mammalian remains. |

- **Number and Nature of Fossils in Early rocks** - The rocks of early era (archaeozoic and protoerozoic) contain very few fossils and those of simple marine invertebrates. This shows that life evolved in sea and early forms were simple and soft bodied.
- **Disparity Between Fossils** - Present day organisms seem to be related to the fossils of quaternary period but differ from those of tertiary period. Fossils of quaternary period are similarly related to those of tertiary period but differ from the ones of cretaceous period

  The differences found in fossils of different periods are due to changes in form, structure and habits of organisms due to evolution or formation of modified organisms.
- **Extinct Organisms** - Study of palaeontology shows that a number of organisms existed on earth for some time and then disappeared. They include the mighty dinosaurs, the tooted birds like Archaeopteryx, pteridosperms, giant horsetails, tree-like lycopods, great mammals, ancestors of man, trilobites, etc.

  **Dinosaurs** (Terrible lizards) lived in Mesozoic era. Some of them were very large as compared to modern day land animals. For example, Brontosaurus or Apatosaurus was a swamp dwelling herbivorous animal of 4.5 m height, 20-25 m length and 450-500 metric tonnes in weight. Tyrannosaurus rex (king of dinosaurs) was a ferocious carnivore with a height of 6m, length of 16 m and weight of 6-8 tonnes.
- **Missing Links** - Transitional or intermediate forms between two groups of organisms which occur only in the fossil state are called missing links. Some examples are as follows :

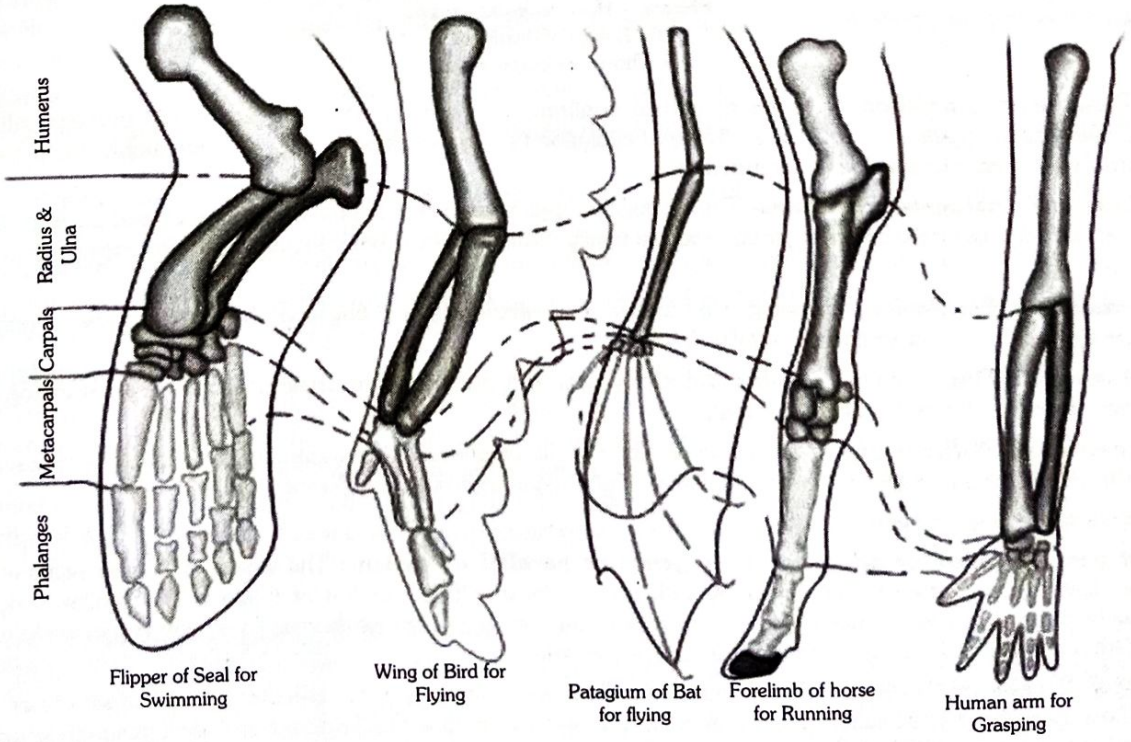
  **(a) Seymouria :** It is a Permian fossil of 51 cm length which is considered to be missing link between amphibian and reptilia. The adult was wholly terrestrial with strong limbs. Limb girdles were similar to those of reptiles. Ear drum was present in a large otic notch. The young was aquatic larva with lateral line canals. Intertemporal bone of skull also resembled that of amphibians.

  **(b) Pelycosaurs :** (Thermomorphs) – They are a group of animals intermediate between reptilesand mammals that lived in lower Permian. Teeth and skull has mammalian tendencies. Abdominal ribs and intercentra of vertebral column were present, e.g., Dimetroden (carnivore), veranosaurus (carnivore), and edaphosaurus (herbivore).

  **(c) Toothed birds :** They arose in Jurassic and became extinct in cretaceous. Toothed birds are missing, links between reptiles and birds. They show the possible pathway of origin of birds from reptiles. The best studied of the toothed birds is archaeopteryx lithographica found in Jurassic rocks of solenhofen, Bavaria (Germany) by Wanger (1861). It lived about 180 million years ago. Archaeopteryx had both reptilian and avian characters.

  Archaeopteryx is often called lizards-bird because it possesses characters to both. It suggests the path along which birds evolved from reptiles. Because of their derivation from reptiles, birds have been called glorified reptiles by Huxley.

  **(d) Pteridosperms** (Cycadofislicales, seed ferns) : They are extinct fossil plants which are intermediate between ferns and seed plants. Rather they are plants with fern-like foliage and seeds. Pteridosperms evolved in palaeozoic and persisted upto Mesozoic.




## 4.2 Evidence from Morphology and Comparative anatomy

Comparative anatomy and morphology shows similarities and differences among organism of today and those that existed years ago. Such similarities can be interpreted to understand whether common ancestors were shared or not. The similarity can be discussed as follows :

(1) **Homology and Homologous Organs** - Homology is the similarity between organs of different animals based on common ancestry or common embryonic origin and built on the same fundamental pattern, but perform varied functions and have different appearance. For example 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, they have similar anatomical structure-all of them have humerus, radius ulna, carpals, metacarpals and phalanges in their forelimbs, hence, in these animals the same structure developed along different directions due to adaptations to different needs. This is divergent evolution and these structures are homologous. Homology indicates common ancestry. Other examples are vertebrate hearts or brains.

- **Homology in Brain Structure-** Ranging from fishes to mammals, the brain consists of similar series of parts-olfactory lobes, cerebral hemispheres, optic lobes, cerebellum, and medulla oblongata.
- **Homology in the Structure of Heart-** The heart is two chambered in fishes, consisting of one auricle and one ventricle. In amphibians, it is three-chambered. In higher reptiles, birds and mammals heart is four chambered and the oxygenated and deoxygenated bloods are completely separated. This presents a gradual modification in the heart of vertebrate series while the fundamental structure of heart remains same in all the groups.
- **Homology in insect's legs-** Legs in mole, cricket grasshopper, honey bee, mantids and water beetles are specialized for digging, jumping, collecting pollen, grasping prey and swimming respectively, but in all these cases the legs are formed of similar five podomeres.
- **Thorns and Tendrils of Some Plants-** A thorn of glory-of-the garden (Bougainvillea) and a tendril of passion flower (passiflora) or tendril of cucurbita are homologous organs in plants. they look different and help the plant in climbing in different manner but both arise in the axillary position and are modified branches.

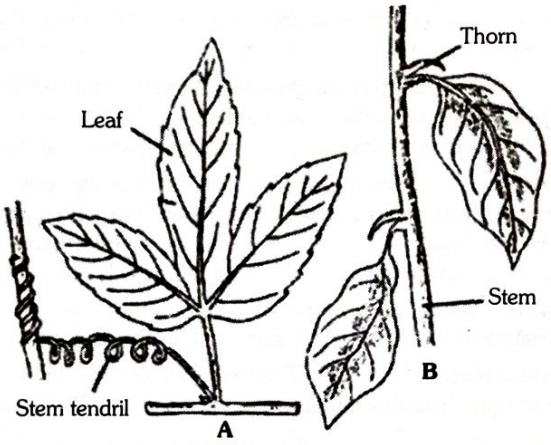



**Figure: – Homologous organs**
**A.** Tendril of Passiflora
**B.** Thorn of Bougainvillea

Presence of homologous in different groups confirm. Common ancestry and relationship between different groups and Difference in appearance are due to divergent evolution i.e., the ancestors migrated to different habitats and organs became modified in adaptations to new requirements.

(2) **Analogy and Analogous Structures-** The analogous organs have almost similar appearance and perform the same function but these develop in totally different groups and are totally different in their basic structure and developed origin. Examples are as follows-

- **Analogy in Forelimbs :** The wing of a butterfly, bird pterodactyl and bat serve the same purpose of uplifting the body in the air, but their basic structure is totally different.
- **Analogy in Fins :** The fins of fishes and ichthyosaur and the flippers of whale have similar appearance and function but their structural details are totally different.
- **Leaves and Phyllode of Ruscus :** The phyllode of ruscus or cladode of asparagus are analogous to leaves of other plants both look alike and perform the same function of photosynthesis but are different in origin.

(3) **Adaptive radiation** (Explained later)

(4) **Convergent evolution or adaptive convergence or parallel evolution** : The whales and their relatives and the extinct reptiles, ichthyosaurs, attained fish-like body with their limbs modified into fins or flippers. This similar body-shape between animals of distantly related groups (a reptile and a mammal) represents the phenomenon of convergent evolution. The wings of bee, bird and bat afford another example of adaptive convergence.

(5) **Vestigial Organs or Vestiges** : The vestigial or rudimentary organs are the useless remnants of structures or organs which might have been large and functional in the ancestors. Vestigial of man are as follows: Vermiform appendix, Auricular muscles of external ear, Third eyelid (Nictitating membrane), Vestigial tail vertebrae, Wisdom teeth, Mammary glands in males

(6) **Atavism or Reversion** : Atavism or reversion is the appearance of thoseancestral characteristics in an organisms or in the organisms of a group, which do no occur normally or which represent the reminiscent of normal structures possessed by the individuals of other groups. Such abnormal structures are known as atavistic characteristic. e.g., cervical fistula, tail and extra mammary glands in man.

## 4.3 Evidences from Embryology

The aspects of embryology which lend support to the doctrine of organic evolution are:

(1) **Similarity in early Embryonic Development-** All the multicellular organism exhibit a common pattern of development. Their development starts from a unicellular fertilized egg or zygote. The fertilized egg after repeated cell divisions forms blastula, which finally develops into a two layered gastrula. The outer layer of gastrula represents future ectoderm and inner one future endoderm.

(2) **Resemblance Among Vertebrate Embryos-** The early embryos in the vertebrates exhibit remarkable similarity and it is not easy to differentiate a human embryo from the embryo of thick, lizard, frog or fish in early stages.

(3) **Recapitulation Theory / Biogenetic law-** Haeckel formulated the 'Recapitulation theory' or 'Biogenetic law'. It says 'Ontogeny recapitulates phylogeny'. It means that an individual during its development briefs its ancestral history. e.g., the early human embryo with a dorsal hollow nerve cord, a well developed notochord and a series of gills slits represents the fundamental chordate characters. With the development of piscine heart, paired aortic arches, primitive pronephros and a tail, it resembles a fish embryo. Later on, it resembles reptilian embryo, and finally develops mammalian characteristics. During the seventh month of intrauterine development the human resembles a baby ape, being completely covered with hair and having proportionately longer forelimbs. This provides support to recapitulation theory.

(4) **Retrogressive Metamorphosis-** The ascidian tadpole is free-swimming and possesses all the three chordate characters. On metamorphosis, it changes into sedentary degenerate adult. During metamorphosis, it loses all the chordate features like notochord, nerve cord and myotomes. This is called retrogressive metamorphosis. Larva has helped in determining its chordate nature.

## 4.4 Biogeographical Evidence

The study of the distribution of animals and plants in the world is called biogeography. The earth has been divided into six biogeographical realms on the basis of distribution of animals and plants. Australian, Neotropical, Ethiopian, Oriental, palearctic and nearctic.

## 4.5 Evidence from Taxonomy

The science of naming, describing and classifying organisms its known as taxonomy. It provides several evidences to suggest. The occurrence of evolution. The important ones are as follows:

(1) **Resemblances Amongst Organisms :** Classification is based on formation of groups and subgroups. The grouping is carried out on the basis of resemblances in morphological, anatomical, biochemical, cytological and other traits.

(2) **Arrangement of taxonomic groups :** Different taxonomic groups of plants and animals can be arranged in a sequence from simple to complex forms. The same indicates the path of evolution. Fishes have only internal ears, amphibians have both internal and middle ears. The condition persists in reptiles and birds. Mammals possess an external ear or pinna as well.

(3) **Connecting Links-** While classifying animals one comes across certain animals or small animal groups which exhibit characteristics of more than one group. Such animals or animal groups are called connecting links between those two groups. E.g.,

- **Viruses :** These are described as connecting link between nonliving and living.
- **Peripatus :** Peripatus is connecting link between annelid and arthropoda because it exhibits characteristics of phyla annelid and arthropoda.
- **Neopilina :** Neopilina belongs to class monoplacophora of phylum mollusca. It is a connecting link between annelids and molluscs.
- **Lung fishes :** Lung fishes Neoceratodus, lepidosiren and protopters are connecting links between fishes and amphibians.
- **Prototheria :** The egg laying mammals, echidna and ornithorhynchus, the only living prototherians of class mammalia, are connecting links between reptiles and mammals.

## 4.6 Biochemical Evidence

In the same line of arguments, similarities in proteins and genes performing a given function among diverse organisms give clues to common ancestry. These biochemical similarities point to the same shared ancestry as structural similarities among diverse organisms. Man has bred selected plants and animals for agriculture horticulture, sport or security. Man has domesticated many wild animals and crops. This intensive breeding programme has created breeds that differ from other breeds (e.g., dogs) but still are of the same group. It is argued that if within hundreds of years, man could create new breeds, could not nature have done the same over millions of years.

**Important-**

**The host-parasite relationship provides evidences for evolution.** Ostrich and Rhea, two flightless birds placed in separate orders, are parasitized by an identical species of tapeworm and two identical species of feather mites. These parasites do not occur in any other bird. This similarity of parasites shows that the ostrich and Rhea have evolved from a common ancestor.

Relationship between the blood proteins indicating evolutionary inter-relationships is termed as serological relationship.

**Dollo's Law of Irreversibility :** A Belgian palaeotologist, L. Dollo, in 1893, stated that evolution is irreversible because the original environment in which evolution occurred cannot return.

**Cope's law :** Animals tend to increase in size during evolution. Evolution produced giant squids, giant clams giant reptiles (dinosaurs) and giant mammals, all to finally become extinct.

**Bergmann's Law :** German biologist, W. Bergmann, stated in 1847 that the individuals of warm-blooded animals inhabiting colder climates become larger on average than the individuals of the same species in warmer climates. The reason is that larger the body, lesser is surface area, and this conserves the body heat in cool climate.

**Allen's Law :** L.A. Allen in 1877 concluded that the warm-blooded animals living in cooler climates tend to have smaller extremities, such as legs, tail, pinnae and beak, to reduce heat loss.

**Gloger's Rule :**It states that population of species that occur in warm, humid climates are more heavily pigmented than those in cool, dry areas. Mass extinctions occurred many times in the earth's history. These may be due to the crash of a meteor or comet with earth (impact theory) or due to the drifting, coalescing and breaking apart of continents (continent movement theory).

The number of organisms in a population carrying a particular allele determines, the **allele frequency.**

A species exhibiting a gradual change in phenotypic characteristics throughout geographical range is referred to as a **cline.**

**Biopoiesis** the formation of living matter form nonliving material, especially in evolution.

Multiplicative speciation is called **cladogenesis.**

Replacement of one species by another without an increase in the number of its own species is called anagenesis. It is also called phyletic speciation. Example eohippus evolved into mesophippus while itself became extinct.

Population genetics is the study of alleles of genes in populations (often called demes), and the forces which maintain or change the frequencies of particular alleles and genotypes in populations. The total genetic stock of the population is its **gene pool.**

## 5. Adaptive Radiation

This 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.**

### 5.1 Evidences of Adaptive Radiation

**(1) Darwin Finches -** During his journey Darwin went to Galapagos islands. There he observed and 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 in the same island. All the varieties, he conjectured, evolved on the island itself. From the original seed-eating features, many other forms with a altered beaks arose, enabling them to become insectivorous and vegetarian finches. This 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. Darwin's finches represent one of the best example of this phenomenon.

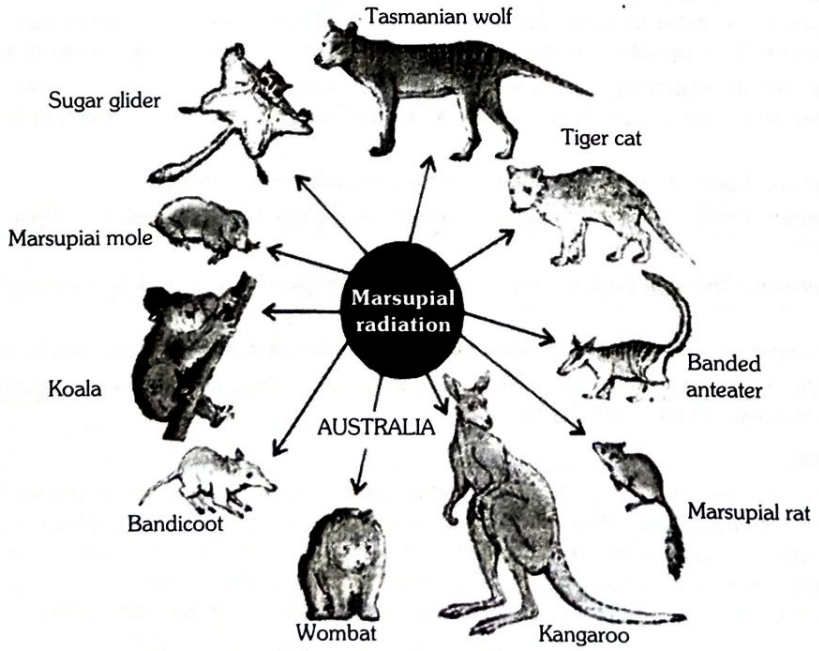
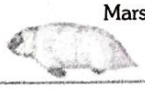
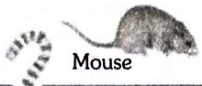
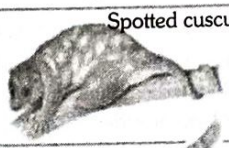
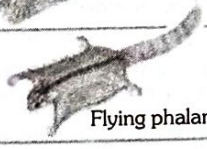
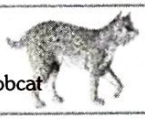



**Figure : –** Adaptive radiation of marsupials of Australia.

**(2) Australian Marsupials -** Another example is Australia marsupials. A number of marsupials, each different from the other evolved from an ancestral stock, but all within the Australian island continent. 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 Australian exhibit adaptive radiation in evolving into varieties of such placental mammals each of which appears to be 'similar' to a corresponding marsupial (e.g., placental wolf and Tasmanian wolf-marsupial).

| Niche | Placental Mammals | Australian Iarsupials |
|---|---|---|
| Burrower |  Mole |  Marsupial mole |
| Anteater |  Anbater |  Numbat (anteater) |
| Mouse |  Mouse |  Marsupial |
| Climber |  Lemur |  Spotted cuscus |
| Glides |  Flying squirrel |  Flying phalanger |
| Cat |  Bobcat |  Tasmanian "tiger cat" |
| Wolf |  Wolf |  Tasmanian wolf |

**Important-**

Fossil forests are known as 'fossil parks'. Many fossil parks have been found in India. These include:

About 50 million years old fossil forests in Mandla, Madhya Pradesh

About 100 million years old fossil forest in Rajmahal hills, Bihar.

About 200 million years old coal-forming fossil forest in Orissa.

National Fossil park, Tiruvakkarai in Tamilnadu.

Birbal Sahni institute of palaeontology, Lucknow has considerably contributed of the discovery and study of fossil parks. This institute has been named in honour of its founder, the famous botanist and paleontologist Prof. Birbal Sahni (1891-1949).

## 6. Theories of Evolution

From time to time, a number of hypotheses have been put forward to explain the mechanism by which very large number of species of animals and plants emerged on the face of this earth. However, most of these lacked scientific explanations and hence were discarded. In the following account, four modern theories have been put forward to explain the mode of evolution (origin of species). These are -

(1) Lamarck's theory of inheritance of acquired characters, or Lamarckism.
(2) Darwin's theory of natural selection, or Darwinism.
(3) Mutation theory
(4) Modern concept of evolution.

### 6.1 Lamarckism or inheritance of acquired characters

Lamarck's theory of evolution was published in 'Philosuphiezoologique' in the year 1809. It is popularly known as 'The inheritance of acquired characters in organisms'. It can be defined as 'The changes in structure or function of any organ acquired during the life-time of an individual in response to changes in the surrounding environment are inherited by its offsprings and keep on adding up over a period of time'. These changes lead to the origin of new species.

**(1) Lamarck theory has four propositions or assumptions.**

- **Internal Vital Force :** Living organisms and their parts tend to increases in size continuously due to internal forces of life.
- **Effect of Environment and new Needs :** Environment influences all types of organisms. A change in environment brings about changes in organisms. It gives rise to new needs. New needs of desire produce new structures and change habits of the organism.
- **Use and Disuse of Organs :** If an organ is used continuously and constantly, it will tend to become highly developed, whereas disuse results in its degeneration.
- **Inheritance of Acquired Characters :** Modifications which are acquired during the life time of an individual are inherited by its offspring, it means changes are cumulative over a period of time.

(2) **Evidences in favour of Lamarckism** - Lamarck gave the examples of Giraffes which in an attempt to forage leaves on all trees had to adapt by elongation of their necks. As they passed on this acquired character of elongated neck to succeeding generations, Giraffes, slowly, over the years, came to acquire long necks. Nobody believes this conjecture any more.

He put forward the theory of continuity of germplasm. According to Weismann, the characters influencing the germ cells are only inherited. There is a continuity of germplasm (protoplasm of somatic cells) is not transmitted to the next generation hence it does not carry characters to next generation. He removed the tail of mice continuously for about 22 generations and even the offsprings of 22$^{nd}$ generations had a tail as long as in the original parents.

(3) **Criticism of Lamarckism** - Lamarck's theory was subject to severe criticism. Two scientists Cuvier and Weismann were great critics of Lamarck. Some objections raised against Lamarckism are as follows:

- Though the tendency to increase in size has been shown in many forms, there are also instances where there is reduction in size. For example, trees that are primitive, are large in size, while the shrubs, herbs and grasses that evolved later are smaller in size.
- If new organs were to develop in response to a new need, then man should have developed wings by now.
- Changes acquired during the lifetime of an organism cannot be inherited by the offspring. For example, if a man loses his arm in war, he does not produce children without an arm. According to August Weismann, somatic changes acquired during the lifetime of the organisms are non- heritable, whereas, changes in the germplasm or reproductive cells are inheritable by the offspring.

  Weisman theory is known as the theory of continuity of germplasm. August Weismann in 1904, removed the tail of mice for about 22 generations. The offspring of the 22nd generation also had a tail as long as in the original parents.
- Mendel's law of inheritance also disproved Lamarck's theory.

(4) **Neo-Lamarckism** - A group of scientists has further studies Lamarck's theory and has supported its modified form, which is known as Neo-Lamarckism. A few of the Neo-Lamarckians are Spencer, Cope, Richard, Wells, Lawrence, Naegeli, Gadow, Dali, McDougall, etc. They suggested that if not all, some of the acquired characters are inherited to some extent. Neo-Lamarckism is modified form of Lamarckism which proposes that: Environment does influence an organism and change its heredity. At least some of the variations acquired by an individual can be passed on to the offspring. Internal vital force and appetency do not play any role in evolution. Only those variations are passed on to the offspring which also effect germ cells or where somatic cells give rise to germ cells.

The following examples support Neo-Lamarckism:

- The white mice which were reared at a high temperature (20°-30°C), were found to develop a longer body, a long tail and longer hindlimbs. This character was found to be transmitted to the offsprings generation after generation.
- Tower exposed some potato beetles to abnormal conditions of temperature and humidity at a stage when their reproductive organs were developing. The offsprings of these beetles showed colour variations and these were passed on to offsprings.

## 6.2 Darwinism or origin of species by natural selection or theory of natural selection

The author of 'The origin of species'. Charles Darwin was born on February 12, 1809 at Shrewsbury in England. In 1831, Darwin got an opportunity to travel by H.M.S. Beagle for a voyage of world exploration, planned by British Admiralty. During his voyage Darwin carefully noted the flora, fauna and geology of many little islands and collected numerous living and fossil specimens.

- In 1838, Darwin read an essay on 'The principles of populations' by R. Malthus (1798), who explained that the rate of reproduction was such that animal population increases many times more rapidly than the available food supply.
- The food supply increases in arithmetic ratio but the population increases in geometric ratio. With these observations, Darwin framed a reasonable theory of evolution.
- When Darwin was busy in giving shape to his findings, he received a manuscript 'On the Tendencies of variations to depart indefinitely from the original type' from Alfred Russel Wallace, in Malaya Archipelago who had taken observations almost identical to Darwin.
- Wallace had sent his manuscript for critical review. The paper contained complete details of the theory of 'Origin of species of proceedings of linnean Society in 1859. Finally, in 1859,
- Darwin published his observations and conclusions under the same 'Origin of species'. Darwin died on April 19, 1882 at the age of seventy three and was buried in Westminister Abbey near the grave of great Newton. Main features of the theory are-

  (1) **Overproduction or Enormous Fertility** - Living beings have an innate ability of producing their own progeny for the continuity of race. It has been observed that more individuals of each kind are produced than could possibly survive. Regardless of the rate of reproduction of a species, its number remains roughly constant under a fairly stable environment.

  (2) **Struggle for Existence** - According to Darwin, individuals multiply in geometric ratio whereas space and food remain almost constant. There is an intense competition and three-fold struggle to ensure living to obtain maximum amount of food and suitable land.

  (3) **Variations and Heredity** - The everlasting competition among the organisms has compelled them to change according to the conditions so that they can utilize the natural resources and can survive successfully. Therefore, it is difficult to find out any of the two individuals alike. Even the progeny of the same parents are not exactly alike in all respects. These differences are known as variations. Certain variations appeared in the parent generation and continue as heritable variations and form the raw material for evolution those which are helpful in the adaptations of an organism towards its surroundings would be passed on the next generation, while the others disappear.

**(4) Survival of the Fittest or Natural Selection -** During the struggle for existence only those individuals could survive which exhibit such variations that are proved to be more beneficial in facing the hardships and rigors of environment or which change to adapt themselves to the changing conditions. Those individuals or races which cannot tolerate these hardships stand no chance in the struggle for existence and are routed. It has been called natural selection by Darwin and survival of the fittest by Herbert spencer.

**(5) Origin of Species -** From above observations Darwin made certain conclusions and summarized them under the heading 'Origin of species by Natural selection' as follows: As a result of struggle for existence, variability and inheritance, the successive generations tend to become better adapted to their environment. These adaptations are preserved and accumulated in the individuals of the species and ultimately lead to the origin of new species form the old ones. The environment is ever changing and it leads to further changes and the appearance of new adaptations in the organisms. As natural selection continues, the latter descendants after several generations become markedly distinct from their ancestors. Further more, certain members of a population with one group of variations may become adapted to environment changes in one way, while others with a different set of variations may become adapted in a different way. As a result two or more species may arise from a signal ancestral species.

**(6) Evidence of support of Darwinism**

- **Rate of Reproduction :** Rate of reproduction is many times higher than the rate of survival in all organisms.
- **Limitation or Resources :** Food, space and other resources are limited.
- **Struggle for Existence :** Competition or struggle for existence is seen in all organisms.
- **Abundance of Variations :** Variations are so abundant in nature that no two individuals of a species are similar, not even the monozygotic twins (they possess some dissimilarity due to their environment).
- **Artificial Selection :** There is a close parallelism between natural selection and artificial selection. By controlled breeding and natural selection for several generations, many new varieties of plants and new species, races or breeds of domestic animals have been developed. If man can produce new varieties in a short time, nature with more time and vast resources can easily produce new species by selection.
- **Mimicry and Protective Coloration :** Mimicry and protective coloration as seen in certain animals can be achieved only by gradual changes occurring side by side both in the model and mimic occupying the same area.
- **Correlation between position on nectarines in flowers and length of proboscis of pollinating insects :** This relation between two different organisms can evolve gradually and can be explained by natural selection.

**(7) Evidence Against the Theory**

- Darwin failed to explain the exact cause of origin, types and inheritance of variations (can be explained by modern synthetic theory).
- Occurrence of vestigial organs cannot be explained by Darwinism (can be explained by Lamarckism up to some extent).
- Darwin explains the survival of fittest but not the arrival of the fittest (can be explained by mutation theory).

## 6.3 Mutation Theory

The term 'mutation' was introduced by Hugo de Vries, (1848-1935), a Dutch botanist, one of those three scientists who independently rediscovered Mendel's laws of heredity. Mutation theory was put forward by him in 1901. Hugo de vries based on his work on evening primrose (Oenotheralamarckiana) brought forth the idea of mutations –large difference arising suddenly in a population, he believed that it is mutation which causes evolution and not the minor variations (heritable) that Darwin talked about. Mutations are random and directionless while Darwinism variations are small and directional. Evolution for Darwin was gradual while deVries believed mutation caused speciation and hence called it saltation (single step large mutation).

**(1) The Salient Features of Mutation Theory are:**

- Mutations, sports or discontinuous variations are the raw material of evolution.
- Mutations appear all of a sudden. They become operational immediately.
- Unlike Darwin's continuous variations or fluctuations, mutations do not revolve around the mean or normal character of the species.
- The same type of mutations can appear in a number of individuals of a species.
- All mutations are inheritable.
- Mutations appear in all conceivable directions.
- Useful mutations are selected by nature. Lethal mutations are eliminated. However, useless and less harmful ones can persist in the progeny.
- Accumulation of variations produces new species. Sometimes a new species is produced from a single mutation.
- Evolution is a jerky and discontinuous process.

**(2) Advantages of Mutation Theory:**

- The mutation theory describes the importance of mutation in selective value of organisms.
- It explains the occurrence of evolutionary changes within short period in contrast to natural selection which describes slow and continuous variations.
- Mutation theory explains the absence of connecting links as no criteria against evolution but its possibility exist.
- Occurrence of mitosis in all possible directions removes the possibility of species disappearance by crossing.
- Induced mutations have given rise to new useful varieties.

### 6.4 Modern concept of evolution

The present concept of evolution is a modified form of the Darwin's theory of natural selection and often called Neo-Darwinism. According to it only genetic variations (mutations) are inherited and not all variations as held by Darwin. Thus modern concept of evolution is synthesis of Darwin's and Hugo de Vries theories. This is also called synthetic theory of evolution.

The synthetic theory of evolution is the result of their work of a number of scientists namely T. Dobzhansky, R.A. Fisher, J.B.S. Haldane, Sewall Wright, Ernst Mayer and G.L. Stebbins. Stebbins in his book process of organic evolution, discussed the synthetic theory. It concludes the basic and accessory factors.

**(1) Basic Factors**

- Gene mutation
- Change in chromosome Number and structure
- Genetic recombination
- Natural selection
- Reproductive isolation

**(2) Accessory Factors**

- Migration
- Hybridization

## 7. Mechanism of Evolution

Evolution is a change in a populations alleles and genotype from generation to generation. There are four basic mechanism by which evolution takes place. These include mutation, migration, genetic drift and natural selection.

### 7.1 Speciation

**(1) Formation of a new species from pre-existing species is called speciation, which may be of following types :**

- **Phyletic Speciation :**It is the formation of new species from pre-existing species but the parent species dies e.g., evolution of mesohippus from eohippus. Evolution of new species through change in single lineage is called anagenesis or phyletic evolution.
- **Gradual Speciation :**It is the slow transformation of an isolated population into new species through the accumulation of small continuous variation generation after generation. This is an example of adaptive radiation e.g., Darwin's finches. Formation of two species from a single ancestral species is called cladogenesis or divergent evolution.
- **Rapid or fast or Instant Speciation :** It occurs through mutation and polyploidy.

**(2) Patterns of speciation**

- **Allopatric Speciation :** Formation of new species occurring in different geographical areas is called allopatric speciation. It requires geographical isolation and is common among animals.
- **Sympatric Speciation :** Formation of new species occurring in same or overlapping geographical areas, is called sympatric speciation. It requires reproductive isolation and is common among plants.
- **Parapatric Speciation :** Two populations with adjacent geographical areas are called parapatric. It is an intermediate condition of allopatric and sympatric speciation and requires the reproductive isolation. It deals with the study of gene frequencies in a population and represents an application of Mendelian genetics into Darwinian natural selection.

The factors which influence speciations include Mutation, Migration, Natural Selection, Genetic Drift.

### 7.2 Mutation

It is sudden and heritable change in the organism. It is generally due to change in the base sequences of nucleic acid in the genome of an organism. Mutation may produce new allele which was not present earlier in the population.

**(1) Lederberg's replica plating experiment (1952) to demonstrate Mutation :**

This experiment was performed by J. Lederberg and E. Lederberg in 1952. J. Lederberg received Nobel prize in 1958 along with Beadle and Tatum. Lederberg prepared a master plate of several bacterial colonies on an agar plate. They developed exact replica of this master plate on a new agar plate with the help of wooden block and velvet disc. They tried to develop another replica on new agar plate having antibiotic penicillin (or streptomycin). They found that most of the bacterial colonies failed to grow (antibiotic sensitive strain) (antibiotic resistant strain). On the basis of above experiment and observation, Lederberg concluded that:

- Antibiotic does not induce the new mutation to occur.
- It selects only pre adaptive mutation i.e., it permitted the pre-existing mutation to express.
- It supports the natural selection (Theory of Darwin).
- **Reproductive Isolation** - It means 'inability to interbreed' and is separation of a large population into smaller units in order to Prevent the mating between 2 members of populations of 2 species and Promote the formation of new species. It along with natural selection provides direction to evolution. Any factor which reduces the chance of interspecific crosses is called isolating mechanism which may be of two types.

**(a) Premating isolation-** It is includes external barriers that prevent the interspecific crosses before mating hence called premating isolation e.g., Geographical isolation , Seasonal isolation, Mechanical isolation, Behavioural isolation

(b) **Postmating isolation** It includes internal barriers that reduce the chance of complete success of interspecific crosses after mating hence called postmating isolation e.g.,Gametic mortality, Zygotic mortality, Hybrid sterility, Hybrid breakdown.

## 7.3 Migration

The movement of individuals from one place to another is called migration. It can be a powerful agent of change because the members of two different populations may exchange genetic material.

## 7.4 Genetic Drift / Random Drift

In a small population, frequencies of particular allele may change drastically by chance alone. Such change in allele frequencies occurs randomly as if the frequencies were drifting and are thus known as genetic drift. It continues until genic combination is fixed and another is completely eliminated. Important features of genetic drift are-

- Sewall wright gave this term.
- It is random fluctuation in gene frequencies occurs by chance in small population from one generation to other.
- It acts in non-directional manner.
- It probably results from interbreeding in the populations.
- It causes elimination of certain alleles from the population and fixation of other alleles in the population.
- Loss of genetic variability is major effect of genetic drift.

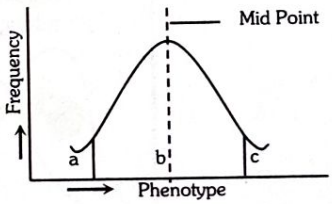
There are two special cases of genetic drift

(1) **Bottleneck effect (Stebbins)** : Any environmental condition which kills most of the members of population and only few survive causes bottleneck effect. Here, only chance determines the survival but not the adaptive value.

(2) **Founder effect (Mayr)** : If some members are separated from a population and start of develop a new population then these are called founders. The new population therefore has less genetic variation and reduced gene pool (the sum total of all the genes present in a mendelian population is called gene pool).

## 7.5 Natural Selection

It brings a change in gene frequencies and promotes adaptation as a product of evolution. Let us consider 3 types of individuals in a population. Smaller individuals (extreme phenotype), Medium individuals (average or normal), Larger individuals (extreme phenotype).




**Natural selection is of three types:**

- Stabilizing selection
- Directional selection.
- Disruptive selection

| S. No. | Character | Stabilizing selection | Directional selection | Disruptive selection |
|---|---|---|---|---|
| 1 | Phenotype favored | Medium phenotype | Only one extreme phenotype | Both extreme phenotypes |
| 2 | Condition of environment | Almost unchanged | Changes in one directions | Heterogeneous |
| 3 | Elimination | Both extreme phenotypes | Medium phenotype and one extreme phenotype | Medium phenotype |
| 4 | Peak produced | Only 1 peak in the center | Only 1 peak, at one side | 2 peaks' 1 on either side |
| 5 | Evolutionary change | Does not occur for e.g., latimeria (living fossil) | Occurs progressively, e.g., Industrial melanism, DDT resistance in mosquito etc. | Occurs but this type of selection is rare for e.g., British land snail. |

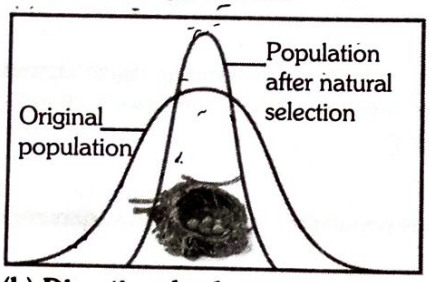
**Examples of Natural Selection**

- **Industrial melanism (Protective resemblance with surrounding)** : Phenomenon of replacement of light coloured peppered moth (Bistonbetularia) by dark melanic species (Bistoncarbonaria) is called industrial melanism. This had happened in England due to industrial smoke, originally reported by Ford and Fischer and then experimented by kettelewell. This is an example of natural selection, occurred due to gene mutation. This is a good evidence for evolution and tells how evolution has taken place before the human eyes.
- **DDT Resistance in Mosquito** : There were two types of mosquitoes;(a) More DDT sensitive (b) Less DDT resistant. When DDT was not used, former dominated over, later. When DDT introduced, DDT resistant mosquitoes survived because of competitive advantage.
- **Sickle Cell Disease** : This is an example of pleiotropy, sub-lethality, point mutation and natural selection. Gene for hemoglobin in homozygous dominant condition ($Hb^AHb^A$) produces normal hemoglobin and normal RBCs but there is a risk of malaria. Gene for homozygous recessive condition ($Hb^sHb^s$) produces sickle celled H band RBCs and the person dies because of lethal effect. Gene is heterozygous recessive condition ($Hb^AHb^S$) is called sickle cell trait and the person is

resistant to malaria infection because malarial parasite cannot complete its life cycle in affected RBCs. This condition is found in those areas of tropical Africa where malaria is common and heterozygous individuals survive because of competitive advantage.

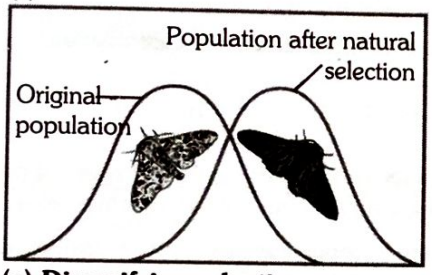
- **G-6 PD Deficiency :** Glucose-6-phosphate dehydrogenase enzyme is important in carbohydrate metabolism, hexose mono phosphate shunt and provides stability to RBCs. Deficiency of this enzyme is rare but has a malarial parasite cannot complete its life-cycle in affected RBCs.

**(a) Stabilizing selection**



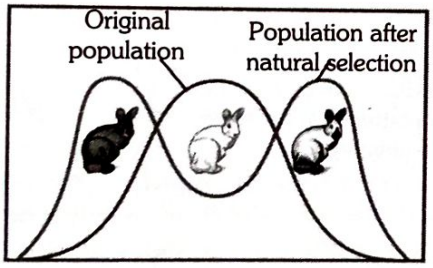

Robins typically lay four eggs, an example of stabilizing selection. Larger clutches may result in malnourished chicks, while smaller clutches may result in no viable offspring.

**(b) Directional selection**




Light-colored peppered moths are better camouflaged against a pristine environment; likewise, dark-colored peppered moths are better camouflaged against a sooty environment. Thus, as the Industrial Revolution progressed in nineteenth-century England, the color of the moth population shifted from light to dark, an example of directional selection.

**(c) Diversifying selection**




In a hypothetical population, gray and Himalayan (gray and white) rabbits are better able to blend with a rocky environment than white rabbits, resulting in diversifying selection,

## 7.6 Hardy Weinberg Law

- It was proposed by an English mathematician G.H. Hardy (1908) and German physician W. Weinberg (1909). According to this law "gene and genotype frequencies in a large and randomly mating mendelian population remain constant or stable under certain conditions." This type of genetic stability is called genetic equilibrium or Hardy Weinberg equilibrium.
- The evolutionary forces or agents or factors or processes that change the gene and genotype frequencies and effect the genetic equilibrium are:
  (a) Mutation
  (b) Migration
  (c) Selection
  (d) Recombinant
  (e) Genetic drift
- Absence of these factors means existence of genetic equilibrium and existence of genetic equilibrium means evolution is not taking place.
- Evolution is possible only when genetic equilibrium disturbs or upsets i.e., one or more such factors are operating.
- The relationship between gene and genotype frequencies can be expressed through following formula. $P+q=1$, $P^2+q^2+2pq=1$, where $p$ and $q$ are the two alleles in the same population. This is called Hardy Weinberg formula.

# 8. Origin and Evolution of Man

## 8.1 Introduction to Human Evolution

Probable Origin of man : Pliocene epoch of tertiary period of coenozoic era.
Place of Origin : Africa (probably Asia also).
Age of man :Holoecene or recent epoch
Most of the fossils of primitive man : From Africa.
Anthropology : Study of human evolution and culture.

## 8.2 Systematic Position

**Kingdom** : Animalia,
**Phylum** : Chordata,
**Group** : Craniata,
**Subphylum** : Vertebrata,
**Division** : Gnathostomata,
**Superclass** : Tetrapoda,
**Class** : Mammalia,
**Subclass** : Theria,
**Infraclass** : Eutheria,
**Order** : Primates,
**Suborder** : Anthropoidea,
**Infraorder** : Catarrhini,
**Superfamily** : Hominoidea,
**Family** : Hominidae,
**Genus** : Homo,
**Species** : Sapiens,
**Subspecies** : Sapiens

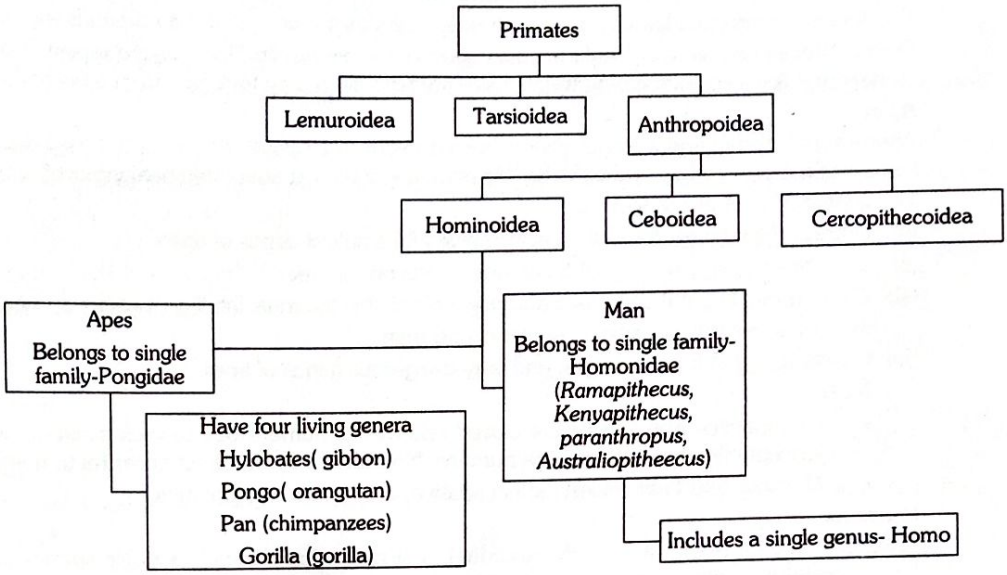



**Fig : Human Evolution**

## 8.3 Early Ideas on Human Ancestry

In 1863 T.A. Huxley made a scientific attempt to the prob man's origin in his book "Man's Place in Nature" and established that dur closest relatives are apes. Later, in 1871 Charles Darwin published his idea about man's ancestors in the book "The Descent of Man". He did not know any human fossil. His ideas were based entirely on the evidences from living men and primates. Darwin suggested that man, apes and monkeys have a common ancestor. Carolus Linnaeus, the Father of Taxonomy, placed man among the monkeys and apes. Linnaeus gave scientific name, the Homo sapiens, to man which means "man who is wise . Here, the word 'man' is used for both man and woman.

## 8.4 Similarities' between apes and man

A close relationship of apes with man is revealed by the following characters.

(i) Absence of a tail.
(ii) Relatively larger head, and longer neck and limbs.
(iii) Broadened chest due to flattening of sternum.
(iv) Smaller lumbar region due to reduced number of lumbar vertebrae.
(v) Relatively larger brain and cranial cavity; efficient memory.
(vi) Prominent browridges above the eyes.
(viii) Capability of communication by vocal means (sounds).
(ix) Highly developed facial musculature for expression of rage, surprise, pleasure and laughter by facial gestures.
(x) Tendency to live in pairs as couples, menstruation in females.

On basis of such a close resemblance between apes and man, it has been presumed that modern apes and man are 'cousins' descended from common ancestors.

## 8.5 Place of Origin of Man

Place of origin of man. The fossil evidence clearly indicates that origin of man occurred in Central Asia, China, Java and India (Shivalik Hills). It has been established that Dryopithecus is one of the oldest fossil which in turn evolved into apes and men.
For the sake of convenience, the origin and evolution of man can be studied in the following three major headings : prior to ape men, ape men including prehistoric man and true men including the living modern man. Morphological Changes involved in Evolution of Man.

The following main morphological changes occurred in the ancestors of modern man.

(1) Narrowing and elevation of nose.
(2) Formation of chin.
(3) Reduction of brow ridges.
(4) Flattening If face.
(5) Reduction in body hairs.
(6) Development of curves in the vertebral column for erect posture.
(7) Formation of bowl like pelvic girdle with broad ilia (pl. of ilium) in support of viscera
(8) Increase in height.
(9) Attainment of erect posture and bipedal locomotion.
(10) Enlargement and rounding of cranium.
(11) Increase in brain size and intelligence.
(12) Broadening of forehead and with vertical elevation.

## 8.6 Superfamily - Hominoids or Hominidea

The African anthropoid lineage, i.e. hominoids, includes the apes and the hominids (humans and their direct ancestors).

During Miocene epoch (23.5 million years ago), our super family-Hominoidae (apes) had more than 20 genera and 40 species. Many of these species went extinct and today these are represented by four genera of apes and one genus of humans.

**Apes**

Apes are rare today and no apes ever occurred in North or South America, but they were widespread in Asia and Africa. Apes have larger brain than monkey and lacks tail. Apes exhibit the most adaptable behaviour of any mammal except human beings.

The genera of apes are as follows

(i) Gibbon (*Hylobates*) It is the most primitive and smallest genus of apes.

(ii) Orangutan (*Simia* or *Pongo*) It can build nests on the trees.

(iii) Chimpanzee (*Pan*) It can make and use tools so it is the most intelligent genus among the apes.
Increasing complexity among primates and man.

(iv) Gorilla (*Gorilla*) It is the largest and very dangerous genus of apes.

**Note**

- Chimpanzee and Gorilla are closest relatives of humans due to their similarity in anatomy, body chemistry, behaviour and susceptibility to infection with humans. No modern ape is direct ancestral to humans.
- Humans and their closest extinct relatives are known as Hominins.

**Humans**

They belong to a single family (Hominoidae), a single genus (Homo), a single species (sapiens), a single sub-species (sapiens) and four races (Mongoloid, Negroid, Caucasoid and Australoid).

## 8.7 History of Human Evolution

The study of living and fossil primates (including monkey and man) shows that they has descended from a common ancestor and separated from the main stock during Oligocene period. The evolutionary history of man can be divided into following three steps only for the convenience of study.

Tree shrew like-animals were the ancestors of first primates.

Modern lemurs are found in Madagascar. The idriidri lemur is endangered.

The primitives are the only group of mammals having both binocular vision and grasping hands.

The first primates were prosimians (before monkeys).

Monkeys are day-active primates. They are the first primates with an opposable thumb. Monkeys first evolved in Africa.

Apes have larger brains than monkeys and do not have tails. The apes are not found in America.

Apes are direct ancestors of human beings.

## 8.8 Modern Apes

(1) Hominoid means both ape and man.

(2) Simian gap is a character of ape found between canine and incisor teeth.

(3) Modern apes are :

(i) Gibbon
(ii) Orangutan
} Asia

(iii) Gorilla
(iv) Chimpanzee
} Africa

(4) Gibbon is found from India to Indonesia and China while orangutan is found in Indonesia and Malaysia.

(5) Gibbon is called 'lesser ape' while orangutan, gorilla and chimpanzee are called "great apes"

(6) Gibbon is smallest, gorilla is largest and chimpanzee is most intelligent among modern apes.

(7) All modern apes have diploid chromosome no. as 48 (except gibbon 44).

(8) Chimpanzee is closest living evolutionary relative of man while gorilla is second closest relative.

(9) Blood protein of gorilla and chimpanzee are almost similar to that of man.

(10) The similarities and common origin of chromosomes no. and banding pattern, specially chromosomes no. III and IV.

(11) Modern ape and man are cousins and are descended from a common ancestor called proconsul.

(12) One important proconsul was Dryopithecus (from Africa) and other proconsul was shivapithecus (from Shivalik hills of India).

(13) Ramapithecus was our non-human primate ancestor. Its fossils (jaw bones and teeth only) was discovered by Lewis (1930) from Shivalik hills of India. It is now considered as a member of genus shivapithecus.

(14) Ramapithecus was more man-like while Dryopithecus was moe ape-like.

(15) Ramapithecus and Dryopithecus were hairy, walked like gorillas and chimpanzee were existing about 15 million years ago (mya).

**(I) Australopithecus (Ape man)**

The first hominid was discovered by Prof. Raymond Dart from Tuang (South Africa) in 1924.

It was fossil of skull of a 5-year old baby named Tuang baby.

Name Australopithecus means Australo = southern and pithecus = ape.

Face was prognathus (sloping).

Chin absent.

Eye brow ridges projected ever eye.

Man with ape brain.

First stood erect.

Ancestor of all humans of genus Homo and was missing link between ape and man.

Some species of Australopithecus were:

(a) A. africanus (African ape man/Tuang baby).

(b) A. afarensis (Lucy). This was almost a complete fossil of a female hominid discovered by Johanson from Ethiopia in 1974.

(c) A. robustus : Its old name was paranthropus; fossil of which was discovered by Robert Broom from Africa in 1938.

(d) A. boisei (nutcracker man) : Its old name was zinjanthropus; fossil of which was discovered by Leakey from Africa in 1959.

**(II) Prehistoric Man**

**Homo habilis (Handy man):**

Its fossil was discovered by Leakey from Africa in 1960.

Term 'habilis' means tool maker.

Oldest tool making man

Locomotion completely bipedal

Probably did not eat meat.

**Homo Erectus Erectus (Java man):**

Its old name was pithecanthropus, fossil of which was discovered by Dubois from java in 1891; renaming by **Meyer** (1950).

Lower jaw heavy with large teeth.

Meat eater; cannibal.

Lived in java, China and Africa.

**First use of fire.**

**Homo erectus pekinensis (Peking man):**

Its old name was sinanthropus; fossil of which was discovered by Pei and Davidson from China in 1924 and 1927; renaming by **Meyer** (1950).

Characters almost similar to that of java man except cranial capacity.

**Homo erectus ergaster (Turkana man / WT-15000):** Its fossil was discovered by Kimeu from Kenya.

**(III) Modern or wise man**

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

Its fossil was discovered by fuhlrott from Europian Neander valley of Germany in 1856.

Full brain man.

Speech center developed.

Social life started.

Cave dwellers.

Animal hides as clothes.

**Religious.**

Immortality of soul.

Ceremonial burial of dead bodies.

**(2) Homo sapiens fossils (Cro-magnon man):**

Its fossil was discovered by Mac gregor from Europian cromagnon rocks of France in 1868.

Direct / **recent ancestor** of man of today.

Face orthognathus type.

Chin present with moderate eye brow ridges.

Family life started.

Cloth users.

Acquainted with **art / painting.**

**Largest** cranial capacity.

First domesticated the dog.

**(3) Homo sapiens sapiens (Man of today)**

This ultraviolet man was originated about 11,000 years ago in the following around Caspian and Mediterranean seas with following important features :

Excellence in intelligence.

Locomotion bipedal with erect posture and hands.

Face orthognathus (erect).

Chin prominent with moderate eye brow ridges.

Vision stereoscopic /3-dimensional with rods and cones.

Foramen magnum shifted below the brain box.

Perfection in thumb opposability and the thumb can touch the tip of each finger.

Articulated speech (development of sound into speech).

**Summary of Human Evolution**

| Human | Common name | Epoch | Discovered by | Discovered in | Cranial capacity (approximately)* |
|---|---|---|---|---|---|
| A. africanus | African ape man | Pliocene | Raymond dart | Africa | 500 c.c. |
| Homo habilis | Skillfull man or handy man | Pleistocene | Leakey | Africa | 650-800 c.c. |
| Homo erectus erectus (Pithecanthropus) | Java man | Pleistocene | Dubois (1891) | Java | 900 c.c. |
| H. erectus pekinesis (sinanthropus) | Peking man | Pleistocene | Pei and Davidson (1924 and 1927) | China | 1075 c.c. |
| Homo sapiens neanderthalensis | Neanderthal man | Pleistocene | Fuhlrott (1856) | Germany | 1400 c.c. |
| Homo sapiens fossilis | Cro-magnon man | Recent | Mac gregor (1868) | France | 1500 c.c. |
| Homo sapiens sapiens | Man of today | Recent | - | - | 1350-1450 c.c. |

# 29. Evolution – Multiple Choice Questions

## 1. Origin of Life

1. Pasteur succeeded in disproving the spontaneous generation theory because
   (a) He was lucky
   (b) He was ingenious in drawing out the neck of the glass flasks so as to provide access to air but not to the micro-organism
   (c) Of the fact that the sample of yeast taken by him was dead
   (d) Of the clean surroundings of his laboratory
2. The complex organic compounds that may have first evolved in the direction of origin of life on earth, may have been
   (a) Proteins and amino acids
   (b) Proteins and nucleic acids
   (c) Urea and nucleic acids
   (d) Urea and amino acids
3. The scientist related with the over throw or the "Theory of spontaneous generation" and experiments with swan-necked flasks is
   (a) Von Helmont (b) Louis Pasteur
   (c) Miller (d) Haeckel
4. Abiogenesis means
   (a) Origin of life from non-living organisms
   (b) Origin of life from living organisms
   (c) Origin of viruses and microbes
   (d) None of these
5. About how long ago was the earth formed
   (a) 4.6 billion years ago (b) 10 billion years ago
   (c) 3.0 billion years ago (d) 20 billion years ago
6. There is no life on moon because there is no
   (a) Carbon (b) Nitrogen
   (c) Water (d) Silicates
7. According to Oparin, life originated as
   (a) Self reproduction (b) God's desire
   (c) Effect of sunlight on mud (d) None of these
8. The presence of salts (*NaCl* and others) in animal body fluid gives an inference that life originated in the
   (a) Salt solutions (b) Rain water
   (c) Primitive ocean (d) None of the above
9. Chemical theory of origin of life was given by

   **Or**

   Who proposed that the first form of life could have come frompri-existing non living organic molecules
   (a) Stanley Miller (b) Oparin and Haldane
   (c) Louis Pasteur (d) Spallanzani
10. Coacervates were experimentally produced by
    (a) Urey and Miller
    (b) Jacob and Monod
    (c) Fischer and Huxley
    (d) Sidney Fox and Oparin
11. Hot dilute soup was given by
    (a) Oparin (b) Haldane
    (c) Urey (d) None of these
12. Oparin-Haldane's view on the origin of life was first experimentally recognized by
    (a) Malthus (b) Plato
    (c) Louis Pasteur (d) Stanley L. Miller
13. 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
14. Viviparity is considered to be more evolved because
    (a) The young ones are left on their own
    (b) The young ones are protected by a thick shell
    (c) The young ones are protected inside the mother's body and are looked after they are born leading to more chances of survival
    (d) The embryo takes a long time to develop
15. In his classic experiment on the formation of amino acids, Stanley Miller passed an electric discharge in a mixture of

    **Or**

    Stanley Miller had put the oparin-Haldane theory to test in 1953 by creating in the laboratory, the probable condition of the primitive earth. In the experiment, simple amino acids were synthesized from which of the following mixture as observed after 18 days
    (a) Steam, $CH_4, H_2$ and $NH_3$
    (b) $CH_4, CO_2, O_2$ and $H_2$
    (c) $NH_3, O_2, H_2$ and steam
    (d) $CH_4, H_2, N_2$ and steam
16. The idea of Natural Selection as the fundamental process of evolutionary changes was reached
    (a) By Alfred Russel Wallace in 1901
    (b) Independently by Charles Darwin and Alfred Russel Wallace in 1859
    (c) Independently by Charles Darwin and Alfred Russel Wallace in 1900
    (d) By Charles Darwin in 1866
17. Type of nutrition in the primitive cells

    **Or**

    It is believed that the organisms first inhabited earth's surface were
    (a) Heterotrophic or holozoic
    (b) Heterophytic or holophytic
    (c) Saprophytic
    (d) Saprozoic
18. The prebiotic atmosphere of the earth was of a reducing nature. It was transformed into an oxidizing atmosphere of present day due to the emergence of
    (a) Cyanobacteria (b) Angiosperms
    (c) Photosynthetic bacteria (d) Eukaryotic algae
19. Life originated in
    (a) Precambrian era (b) Proterozoic era
    (c) Mesozoic era (d) Caenozoic era
20. First cell produced on earth is
    (a) Protobiont (b) Protozoa
    (c) Metazoa (d) None of these
21. Evolution of life shows that life forms had a trend of moving from
    (a) Land to water (b) Dryland to wet land
    (c) Frest water to sea water (d) Water to land
22. In 1953 S. L. Miller created primitive earth conditions in the laboratory and gave experimental evidence for origin of first form of life from pre-existing 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.
23. If you go back in the history approx. 4500 million years back when atmosphere was reducing the organism were
    (a) Autotroph, aerobic
    (b) Chemo-autotroph, anaerobic
    (c) Chemo-heterotroph, anaerobic
    (d) Heterotroph, anaerobic
24. Biogenetic law was put forward by
    (a) E. Haeckel (b) Charles Darwin
    (c) Karl von Bear (d) Lamarck

## 2. Organic Evolution and Speciation

**1.** The most accepted theory of organic evolution
(a) Natural selection theory (b) Phase theory
(c) Synthetic theory (d) Mutation theory

**2.** The greatest evolutionary change enabling the land vertebrates to be completely free from water, was the development of
(a) Four legs
(b) Lungs
(c) Shelled eggs and internal fertilization
(d) Four chambered heart

**3.** The cenozoic era is known as
(a) Age of mammals and modern flora
(b) Age of reptiles and gymnosperms
(c) Age of amphibia and lycopods
(d) Age of marine invertebrates

**4.** The principle that gives the geneticists a tool to determine when evolution is occurring is
(a) Chemiosmotic theory
(b) Hardy-Weinberg principle
(c) Malthusian principle
(d) Cloning theory

**5.** As per modern synthetic theory organic evolution depends upon
(a) Mutation, reproductive isolation and natural selection
(b) Gene recombination and natural selection
(c) Mutation and natural selection
(d) All of these

**6.** A species is produced by loss or disappearance of a few characters found in parents it is termed as
(a) Progressive species (b) Retrogressive species
(c) Successive species (d) Digressive species

**7.** The example of recapitulation theory is
(a) Embryonic membranes of reptiles
(b) Tadpole larva of frog
(c) Placenta of mammals
(d) Canine teeth of dog

**8.** Which of the following is related with reproductive isolation
(a) Genetic isolation (b) Temporal isolation
(c) Behavioural isolation (d) All of these

**9.** 'Genetic species concept' was given by
(a) Lamarck (b) Lotsy
(c) Ernst Mayr (d) Linnaeus

**10.** Which of the following variations are temporary and have nothing to do with the last or next generation
(a) Hereditary variations
(b) Discontinuous variations
(c) Environmental variations
(d) None of these

**11.** First mammals appeared in the period
(a) Triassic (b) Jurassic
(c) Cretaceous (d) Tertiary

**12.** Animal husbandry and plant breeding programmes are the examples of
(a) Reverse evolution (b) Artificial selection
(c) Mutation (d) Natural selection

**13.** Fossils are generally found in
(a) Sedimentary rocks (b) Igneous rocks
(c) Metamorphic rocks (d) Any type of rock

**14.** For the MN-blood group system, the frequencies of M and N alleles are 0.7 and 0.3 respectively. The expected frequency of MN-blood group bearing organism is likely to be
(a) 42% (b) 49%
(c) 9% (d) 58%

**15.** Variations during mutations of meiotic recombinations are
(a) Random and directionless
(b) Random and directional
(c) Small and directional
(d) Random, small and directional

**16.** A potential danger to a population that has been greatly reduced in number is the
(a) Hardy-Weinberg disequilibrium
(b) Tendency towards assortative mating
(c) Reduced gene flow
(d) Loss of genetic variability

**17.** When two related populations occupy geographically or spatially separate areas, they are called

**Or**

The organisms separated by geographical barriers are termed
(a) Allopatric population (b) Quantum population
(c) Saltational population (d) Parapatric population
(e) Sympatric population

**18.** There was no life in
(a) Azoic era (b) Mesozoic era
(c) Palaeozoic era (d) Cenozoic era

**19.** The origin of mammal like reptiles occurred in
(a) Triassic period (b) Permian period
(c) Jurassic period (d) Tertiary period

**20.** Recapitulation theory (Biogenetic law) explains "*Ontogeny repeats Phylogeny*". It was given by
(a) Lamarck (b) Haeckel
(c) Darwin (d) Robert Hooke

**21.** Which one of the following is not important for evolution
(a) Mutation (b) Recombination
(c) Genetic drift (d) Somatic variation

**22.** Which is not a pre-zygotic isolation mechanism
(a) Geographical isolation (b) Ecological isolation
(c) Seasonal isolation (d) Hybrid sterility

**23.** Inorganic evolution means
(a) Formation of molecules
(b) Formation of cell
(c) Evolution of new species
(d) Same as organic evolution

**24.** Most modern breeds of the domestic dog have evolved as a result of
(a) Natural selection (b) Artificial selection
(c) Sexual selection (d) Reproductive isolation

**25.** Geographic and reproductive isolation are most closely associated with
(a) Speciation (b) Extinction
(c) Over production (d) Competition
(e) Succession

**26.** Which one of the following scientists is not related with organic evolution
(a) Erasmus Darwin (b) Charles Darwin
(c) Darlington (d) T.R. Malthus

**27.** What is evolution
(a) Development of DNA from nucleotides
(b) Development of organism through time
(c) Development of a cell from chemicals
(d) None of these

**28.** The pioneers in the field of 'organic evolution' are
(a) Karl landsteiner, Hugo de Vries, Malthus
(b) Darwin, Hugo de Vries, Lamarck, Huxley
(c) Lamarck, Karl landsteiner, Malthus, deVries
(d) Darwin, Lamarck, Karl landsteiner, deVries

**29.** 'Ontogeny recapitulates phylogeny' is the brief definition of
(a) Darwinism (b) Mutation theory
(c) Biogenetic law (d) Abiogenesis

**30.** Amphibians were dominant during
(a) Carboniferous (b) Silurian
(c) Ordovician (d) Cambrian
(e) Jurassic

**31.** Which of the following were abundant in mesozoic era
(a) Mammals (b) Reptiles
(c) Insects (d) Fishes

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

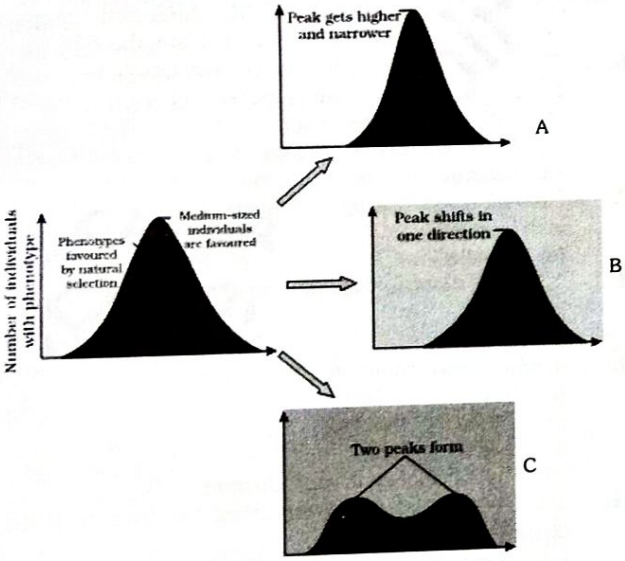
33. Which type of selection, explains industrial melanism observed in moth, Bistonbitularia
(a) Stabilising (b) Directional
(c) Disruptive (d) Artificial

34. Which of the following is an example for link species
(a) Lobe fish (b) Dodo bird
(c) Sea weed (d) Chimpanzee

35. Species is
(a) Population of individuals having same genotypes and phenotypes
(b) A group of individuals inhabiting a geographical area
(c) A group of interbreeding populations
(d) Population of one type

36. An isolated population of humans with approximately equal numbers of blue-eyed and brown-eyed individuals was decimated by an earthquake. Only a few brown-eyed people remained to form the next generation. This kind of change in the gene pool is called a
(a) Hardy-Weinberg equilibrium
(b) Blocked gene flow
(c) Bottleneck effect
(d) Founder effect

37. Following diagrammatic representation refers the natural selection on different traits. Choose the right option in which all the three graphs A, B and C are identified correctly




(a) A - Directional, B - Disruptive, C - Stabilising
(b) A - Stabilising, B - Disruptive, C - Directional
(c) A - Stabilising, B - Directional, C - Disruptive
(d) A - Directional, B - Stabilising, C – Disruptive

38. A selection that acts to eliminate one extreme from an aray of phenotypes is
(a) Disruptive (b) Directional
(c) Stabilizing (d) Coevolution

## 3. Evidences of Evolution

1. Haeckal's theory of recapitulation (Biogenetic law) means that
(a) All organisms start as an egg
(b) Life history of an animal reflects its evolutionary history
(c) Progeny of an organism resembles its parents
(d) Body parts once lost are regenerated

2. Which one of the following groups are not analogous organs
(a) Wings of birds and wings of butterfly
(b) Eye of octopus and eye of mammals
(c) Flippers of penguin and flippers of dolphin
(d) Thorns of bougainvilla and tendril of *Cucurbita*
(e) Tuberous root of sweet potato and stem tuber of potato

3. Connecting link between annelida and mollusca is
(a) Neopilina (b) Nautilus
(c) Glochidium larva (d) Veliger larva

4. Which one is not a true fossil
(a) Placoderm (b) Limulus
(c) Archeopteryx (d) Therapside

5. Occurrence of vestigeal organs is not explained by
(a) Theory of organic evolution
(b) Theory of special creation
(c) Scalanaturae
(d) Natural classification system

6. Fossil $X$ is older than fossil $Y$. Most evident answer is
(a) Fossil $Y$ has got some of the vestigial organs which are functional in $X$
(b) Fossil $Y$ has got homologous and analogous organs of fossil $X$
(c) Fossil $X$ is found in deeper sedimentation than $Y$
(d) Fossil $Y$ was found in better state than that of $X$

7. The rocks that contain fossil are
**Or**
The fossils are preserved in
(a) Metamorphic (b) Igneous
(c) Sedimentary (d) All the above

8. Which of the following is vestigeal organ in humans
(a) Ear pinna
(b) Nictitating membrane
(c) Mammary glands in males
(d) All of the above

9. Which is incorrect
(a) Wings of insects and birds are analogous
(b) Wings of insects and bats are analogous
(c) Wings of insects and birds are homologous
(d) Wings of bats and birds are homologous

10. Which of the following is the most evident source of evolution
(a) Fossils (b) Embryos
(c) Morphology (d) Vestigeal organs

11. The following structures shows that

(a) They have nothing to do with each other
(b) They are analogous
(c) They are vestigial structures
(d) They are homologous

12. The bones of forelimbs of whale, bat, cheetah and man are similar in structure, because
(a) One organism has given rise to another
(b) They share a common ancestor
(c) They perform the same function
(d) They have biochemical similarities

13. Which is basis of evolution
(a) Cell (b) Individual
(c) Population (d) Species

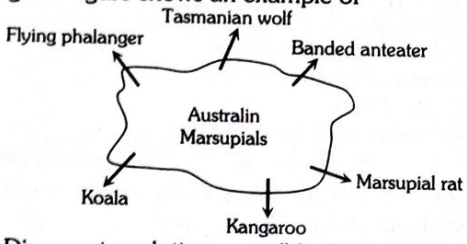
14. Vestigeal organs occur as
(a) Useless because of incomplete development
(b) Inefficient parts
(c) Fully developed but useless
(d) Analogous

15. Recapitulation theory forms
(a) Anatomical evidence (b) Taxonomical evidence
(c) Physiological evidence (d) Embryological evidence

16. Birds are evolved from
(a) Non-chordates (b) Reptiles
(c) Amphibians (d) Fishes

17. Which one of the following periods is largely associated with extinction of dinosaurs and the increase in flowering plants and reptiles
(a) Jurassic (b) Triassic
(c) Cretaceous (d) Permian

18. The given figure shows an example of

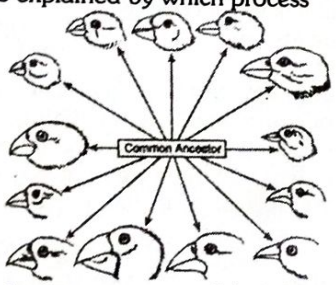



(a) Divergent evolution (b) Recapitulation
(c) Parallel evolution (d) Convergent evolution

19. Palaentological evidences for evolution refer to the
(a) Development of embryo (b) Homologous organs
(c) Fossils (d) Analogous organs

20. Appearance of antibiotic-resistance bacteria is an example of
(a) Adaptive radiation
(b) Transduction
(c) Pre-existing variation in the population
(d) Divergent evolution

21. The diversity within the wild bird species in the given figure can best be explained by which process




(a) Natural selection (b) Adaptive radiation
(c) Ecological succession (d) Both (a) and (b)

## 4. Lamarckism

1. Author of "*Philosophique Zoologique*" is
(a) Mendel (b) Darwin and Wallace
(c) Lamarck (d) Darwin

2. The idea of use and disuse of organs was given by
(a) Darwin (b) Lamarck
(c) Hugo de Vries (d) Morgan

3. Match the scientists listed under column 'I' with ideas listed Column 'II

| Column I | Column II |
|---|---|
| A. Darwin | i. Abiogenesis |
| B. Oparin | ii. Use and disuse of organs |
| C. Lamarck | iii. Continental drift theory |
| D. Wagner | iv. Evolution by natural selection |

(a) A-i, B-iv, C-ii, D-iii
(b) A-iv, B-i, C-ii, D-iii
(c) A-ii, B-iv, C-iii, D-i
(d) A-iv, B-iii, C-ii, D-i

4. Germplasm theory against Lamarck's principle, was given by

**Or**

Lamarck's acquired characters are not inherited and have no evolutionary value. This statement was given by
(a) Weismann (b) Darwin
(c) Lamarck (d) Hugo de Vries

5. Who was the first to discard the idea of fixity of species
(a) Jean Baptiste Lamarck (b) Charles Darwin
(c) Robert Hooke (d) William Harvey
(e) Stanley Cohen

## 5. Darwinism

1. Name of the ship in which Charles Darwin went for his expedition
(a) Siboga (b) Beagle
(c) Sea gull (d) Atlantic

2. According to the Neo–Darwinian theory, which of the following is responsible for the origin of new species
(a) Mutations
(b) Useful variations
(c) Mutations together with natural selection
(d) Hybridization

3. In forming the theory of evolution by natural selection, Darwin was greatly influenced by
(a) Mutations of Hugo de Vries
(b) Malthus idea of population control
(c) Environmental factors
(d) Lamarck acquired characters

4. The idea of "*survival of the fittest*" was given by
(a) Darwin (b) Herbert Spencer
(c) Malthus (d) Lyell

5. Main basis of Neo–Darwinism is

**Or**

Initiating force of evolution is
(a) Struggle for existence (b) Variations
(c) Survival of the fittest (d) Gene theory

6. There is more competition for survival between
(a) Same animals of same niche
(b) Different animals of same niche
(c) Same animals of different niche
(d) Different animals of different niche

7. Who gave the 'Theory of pangenesis'
(a) Lamarck (b) Wallace
(c) Haeckel (d) Darwin

8. "*Origin of Species*" was published in
(a) 1809 (b) 1858
(c) 1956 (d) 1859

9. In which case Darwin theory is wrong
(a) Arrival of the fittest
(b) Survival of the fittest
(c) Origin of species
(d) High efficiency of reproduction

10. The biologist who has been called the "Darwin of the 20th century", was
(a) Linnaeus (b) Ernst Mayr
(c) Diener (d) Whittaker

11. Which one 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

## 6. Evolution of Man

1. 'Peking man' is known as
(a) Australopithecus (b) Sinanthropus
(c) Pithecanthropus (d) Homo sapiens

2. Which of the following was not in the direction of evolution of human species
(a) Raised orbital ridges (b) Binocular vision
(c) Developed brain (d) Opposable thumb

3. The modern man differs from the apes in
(a) Protruding eyes (b) Spare body hair
(c) Wearing of clothes (d) Arms shorter than legs

4. The highest cranial capacity is/was present in
(a) Java man (b) Peking man
(c) Handy man (d) Modern man

5. Which of the following has the lowest cranial capacity
(a) Gorilla (b) Chimpanzee
(c) Modern man (d) Java ape man

6. *Pithecanthropus erectus* fossil was found in
(a) China (b) Japan
(c) Java (d) Texas

7. 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 → Homohabilis → Homo rectus → Homo sapiens
(d) Australopithecus → Ramapithecus → Homo rectus → Homo habilis → Homo sapiens

8. Which of the following was expert in making tools, weapons, paintings etc

**Or**

Who drew excellent pictures of animals in caves, made tools, curved ornaments from ivory stone arrows etc
(a) Java ape man (b) Peking man
(c) Cro-Magnon man (d) Rhodesian man

9. Cro-Magnon man was
(a) Herbivorous (b) Frugivorous
(c) Sanguivorous (d) Carnivorous

10. Which of the following stood erect first
(a) Java man (b) Peking man
(c) Australopithecus (d) Cro-Magnon man

11. The most recent and direct prehistoric ancestor of present man is
(a) Cro-Magnon (b) Preneanderthal
(c) Neanderthal (d) None of the above

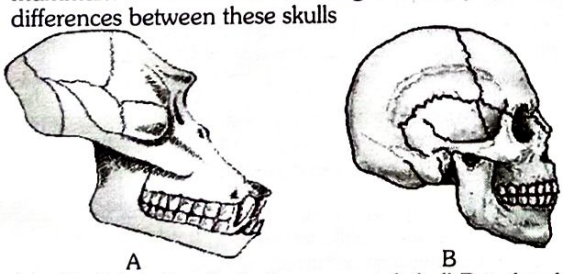
12. Which of the following is the most primitive ancestor of man

**Or**

The primate which existed 15 mya among these was
(a) Australopithecus (b) Ramapithecus
(c) Homo habilis (d) Homo neanderthalensis

13. The closest relative of modern man is considered to be
(a) Chimpanzee (b) Orangutan
(c) Apes (d) Gibbon

14. The given illustration shows the skull of two different mammals. Which of the following accurately describes the differences between these skulls



A B

(a) Skull A is the skull of an ape and skull B is the skull of human
(b) Skull A is of a primate and skull B is not of a primate
(c) Skull A has more brain capacity than skull B
(d) Skull A has more teeth than skull B

## 7. NEET

1. Which one of the following is incorrect about the characteristics of protobionts (coacervates and microspheres) as envisaged in the abiogenic origin of life) **[2008]**
(a) They were partially isolated from the surroundings
(b) They could maintain an internal environment
(c) They were able to reproduce
(d) They could separate combinations of molecules from the surrounding

2. The concept of chemical evolution is based on **[2007]**
(a) Crystallization of chemicals
(b) Interaction of water, air and clay under intense heat
(c) Effect of solar radiation on chemicals
(d) Possible origin of life by combination of chemicals under suitable environmental conditions

3. The four elements that make up 99% of all elements found in a living system are **[1994, 2008]**
(a) *H, O, C, N* (b) *C, H, O, S*
(c) *C, H, O, P* (d) *C, N, O, P*

4. Which one of the following is the correct sequence of chemical substances produced during the origin of life on the earth **[1996, 2004]**
(a) Water, amino acid, nucleic acid and enzyme
(b) Glucose, amino acid, nucleic acid and protein
(c) Amino acid, ammonium phosphate and nucleic acid
(d) Ammonia, amino acid, protein and nucleic acid

5. Some of the important evidences of organic evolution are **[2007]**
(a) Occurrence of homologous and vestigeal organs
(b) Occurrene of analogous and vestigeal organs
(c) Occurrence of homologous and analogous organs
(d) Occurrence of analogous organs only

6. Following are the two statements regarding the origin of life
(A) The earliest organisms that appeared on the earth were non-green and presumably anaerobes
(B) The first autotrophic organisms were the chemoautotrophs that never released oxygen of the above statements which one of the following option is correct **[2016]**
(a) (A) is correct but (B) is false
(b) (B) is correct but (A) is false
(c) Both (A) and (B) are correct
(d) Both (A) and (B) are false

7. Homeostasis is **[1991]**
(a) Disturbance in regulatory control
(b) Tendency to resist internal changes
(c) Plant and animal extracts used in homeopathy
(d) A tendency to change with change in environment

8. Which of the following was most likely to have been absent in free form in the primordial atmosphere at the time of origin of life **[1998, 1999, 2006, 2004, 2005, 2012]**
(a) $O_2$ (b) $CH_4$
(c) $H_2$ (d) $NH_3$

9. Which one of the following amino-acids was not found to be synthesized in Miller's experiment **[2006]**
(a) Glutamic acid (b) Alanine
(c) Glycine (d) Aspartic acid

10. Which one of the following experiments suggests that simplest living organisms could not have originated spontaneously from non-living matter **[2005]**
(a) Larvae could appear in decaying organic matter
(b) Microbes did not appear in stored meat
(c) Microbes appeared from unsterilized organic matter
(d) Meat was not spoiled, when heated and kept sealed in a vessel

11. Organisms which obtain energy by the oxidation of reduced inorganic compounds are called **[2002]**
(a) Saprozoic (b) Chemoautotrophs
(c) Photoautotrophs (d) Coproheterotroph

12. Species diversity generally increases as one proceeds from **[2006]**
(a) Low altitude to high altitude, and from low latitudes to high latitudes
(b) High altitude to low altitude, and from low latitudes to high latitudes
(c) High altitude to low altitude, and from high latitudes to low latitudes
(d) Low altitude to high altitude, and from high latitudes to low latitudes

13. Select the correct statement from the following **[2007]**
(a) Darwinian variations are small and directionless
(b) Fitness is the end result of the ability to adapt and gets selected by nature
(c) All mammals except whales and camels have seven cervical vertebrae
(d) Mutations are random and directional

**14.** Which one of the following is not a living fossil **[2006]**
(a) Archaeopteryx (b) Peripatus
(c) King crab (d) Sphenodon

**15.** Which era is dubbed as the age of prokaryotic microbes **[1995, 2012]**
(a) Phanerozoic (b) Proterozoic
(c) Precambrian (d) Archean

**16.** Evolution of different species in a given area starting from a point and spreading to other geographical areas is known as **[2012]**
(a) Adaptive radiation (b) Natural selection
(c) Migration (d) Divergent evolution

**17.** A population will not exist in Hardy-Weinberg equilibrium if **[2015]**
(a) There are no mutations
(b) There is no migration
(c) The population is large
(d) Individuals mate selectively

**18.** Correct sequence is **[1991]**
(a) Palaeozoic → Mesozoic → Coenozoic
(b) Mesozoic → Archaeozoic → Proterozoic
(c) Palaeozoic → Archaeozoic → Coenozoic
(d) Archaeozoic → Palaeozoic → Proterozoic

**19.** Jurassic period of the Mesozoic era is characterised by **[2006]**
(a) Dinosaurs become extinct and angiosperms appear
(b) Flowering plants and first dinosaurs appear
(c) Gymnosperms are dominant plants and first birds appear
(d) Radiation of reptiles and origin of mammal-like reptiles

**20.** The dinosaurs were maximum during the period of **[2002, 2013, 2015]**
(a) Jurassic (Mesozoic) (b) Triassic
(c) Cretaceous (d) Palaeocene

**21.** Animals living in colder region have shorter tail and ears as compared to the animals living in warmer regions. This phenomenon is called **[1996, 2009, 2010]**
(a) Bergman's law (b) Glober's law
(c) Allen's law (d) Jordan's law

**22.** Which one of the following sequences was proposed by Darwin and Wallace for organic evolution **[2003]**
(a) Variations, natural selection, overproduction, constancy of population size
(b) Overproduction, variations, constancy of population size, natural selection
(c) Variations, constancy of population size, overproduction, natural selection
(d) Overproduction, constancy of population size, variations, natural selection

**23.** In the developmental history of mammalian heart, it is observed that it passes through a two–chambered fish–like heart, three–chambered frog–like heart and finally four–chambered stage. To which hypothesis can this above cited statement be approximated **[1998, 2007]**
(a) Biogenetic law (b) Hardy Weinberg law
(c) Lamarck's principle (d) Mendelian principle

**24.** Indicate the completely correct statement about human races **[1994]**
(a) All human races can interbreed but most will produce infertile young ones
(b) Different human races cannot interbreed
(c) Some human races can interbreed
(d) All human races can interbreed and produce fertile offspring

**25.** The tendency of population to remain in genetic equilibrium may be disturbed by **[2013]**
(a) Lack of random mating (b) Random mating
(c) Lack of migration (d) Lack of mutations

**26.** Which one of the following statement is correct **[2007]**
(a) Stem cells are specialized cells
(b) There is no evidence of the existence of gills during embryogenesis of mammals
(c) All plant and animal cells are totipotent
(d) Ontogeny repeats phylogeny

**27.** Formation of which complex molecules was noticed by Urey and Miller when they subjected substances like $NH_3, CH_4, H_2O$ etc. to electric discharge **[1993, 2004]**
(a) Aquaregia (b) $H_2SO_4$
(c) $HCN$ (d) Amino acids

**28.** The presence of gill slits in the embryos of all vertebrates supports the theory of **[1995]**
(a) Recapitulation (b) Organic evolution
(c) Metamorphosis (d) Biogenesis

**29.** Evolution in which the animals of two different gene ecology show too much similarity with one another, as a result of adaptation is termed as **[1996, 2007, 2013]**
(a) Parallel evolution (b) Retrogressive evolution
(c) Progressive evolution (d) Convergent evolution

**30.** Mutations are mainly responsible for controlling **[1996,97]**
(a) Increasing population rate
(b) Maintaining genetic continuity
(c) Variation in organisms
(d) Extinction of organisms

**31.** One of the important consequences of geographical isolation is **[2007, 2008]**
(a) No change in the isolated fauna
(b) Preventing Speciation
(c) Speciation through reproductive isolation
(d) Random creation of new species

**32.** Allopatric speciation is due to **[1990, 2011]**
(a) Mutation
(b) Geographical separation of populations
(c) Migration of member of a species form one to other populations
(d) Hybridization between closely related species

**33.** Two or more species occupying identical or overlapping areas are known as **[1990, 1994, 1996, 2005, 2012]**
(a) Sympatric species (b) Allopatric species
(c) Sibling species (d) Polytypic species

**34.** A species is taxonomically **[1994]**
(a) A group of evolutionary related populations
(b) A population with common characteristics as evolutionary base of variation
(c) A fundamental unit in the phylogenetic history of organisms
(d) A basic category to which most taxonomic information is attached

**35.** Geologically one of the following eras is known as "*Golden age of Reptiles*" or "*Golden age of Dinosaurs*" **[1994, 1996, 2000, 2002, 2003, 2004, 2005, 2008, 2010]**
(a) Mesozoic (b) Cenozoic
(c) Palaeozoic (d) None of the above

**36.** Random genetic drift in a population probably results from **[2002, 2003]**
(a) Large population size
(b) Highly genetically variable individuals
(c) Interbreeding within small isolated population
(d) Constant low mutation rate

**37.** In a random mating population in equilibrium, which of the following brings about a change in gene frequency in a non-directional manner **[2003]**
(a) Migration (b) Mutations
(c) Random drift (d) Selection

**38.** Genetic drift operates only in **[1998]**
(a) Island populations (b) Smaller populations
(c) Larger populations (d) Mendelian populations

**39.** The frequency of an allele in an isolated population may change due to **[1992, 2001]**
(a) Gene flow (b) Mutation
(c) Genetic drift (d) Natural selection

**40.** Among the following sets of examples for divergent evolution, select the incorrect option **[2018]**
(a) Eye of octopus, bat and man
(b) Brain of bat, man and cheetah
(c) Heart of bat, man and cheetah
(d) Forelimbs of man, bat and cheetah

**41.** Which one of the following pairs is correctly matched **[1995]**
(a) Streamlined body –Aquatic adaptation
(b) Excessive perspiration–Xeric adaptation
(c) Parasitism–Intra-specific relationship
(d) Uricotelism–Aquatic habitat

**42.** Which one of the following options gives one correct example each of convergent evolution and divergent evolution **[2012]**

| | Convergent evolution | Divergent evolution |
|---|---|---|
| (a) | Eyes of octopus and mammals | Bones of forelimbs of vertebrates |
| (b) | Thorns of Bougainvillia and tendrils of *Cucurbita* | Wings of butterflies and birds |
| (c) | Bones of forelimbs of vertebrates | Wings of butterfly and birds |
| (d) | Thorns of Bougainvillia and tendrils of *Cucurbita* | Eyes of Octopus and mammals |

**43.** Parallelism is **[1990, 2007]**
(a) Adaptive divergence in evolution
(b) Adaptive convergence of widely different species in evolution
(c) Adaptive convergence of closely related species in evolution
(d) None of these

**44.** Two zoogeographical regions separated by high mountain ranges are **[1995]**
(a) Palaearctic and Oriental
(b) Oriental and Australian
(c) Nearctic and Palaearctic
(d) Neotropical and Ethiopian

**45.** Which one of the following is a pair of homologus organs **[1994]**
(a) Lungs of rabbit and gills of rohu
(b) Wing of bat and wing of butterfly
(c) Pectoral fin of rohu and the forelimb of horse
(d) Wing of grasshopper and wing of crow

**46.** Which is connecting link between Reptiles and Aves **[1990, 1993, 1999, 2005.2006, 2009]**
(a) Archaeopteryx (b) Peripatus
(c) Ornithorynchus (d) Loligo

**47.** Two organs which are similar in structure and origin, but not necessarily in function are called **[1992, 1995, 1997, 1998, 2000, 2003, 2004, 2005]**

**Or**

The organs of different species that are related to each other through common descent though becomes functionally different are called
(a) Homologous (b) Analogous
(c) Apocrine (d) None of these

**48.** Which of the following is not vestigeal in human **[2000, 2002, 2004]**
(a) Coccyx (b) Nail
(c) Third molar (d) Abdomen

**49.** Presence of gills in the tadpole of frog indicates that **[2004]**
(a) Frogs will have gills in future
(b) Frogs evolved from gilled ancestors
(c) Fishes were amphibious in the past
(d) Fishes evolved from frog-like ancestors

**50.** The eye of octopus and eye of cat show different patterns of structure, yet they perform similar function. This is an example of **[2013]**
(a) Analogous organs that have evolved due to divergent evolution
(b) Homologous organs that have evolved due to convergent evolution
(c) Homologous organs that have evolved due to divergent evolution
(d) Analogous organs that have evolved due to convergent evolution

**51.** Analogous structures are a result of **[2005, 2016]**
(a) Divergent evolution (b) Convergent evolution
(c) Shared ancestry (d) Stabilizing selection

**52.** Given below are four statements (A-D) each with one or two blanks. Select the option which correctly fills up the blanks in two statements

**Statements :**
(A) Wings of butterfly and birds look alike and are the results of ___(i)___ , evolution.
(B) Miller showed that $CH_4$ , $H_2$ , $NH_3$ and ___(i)___, when exposed to electric discharge in a flask resulted in formation of ___(ii)___.
(C) Vermiform appendix is a ___(i)___organ and an ___(ii)___evidence of evolution.
(D) According to Darwin evolution took place due to ___(i)___and ___(ii)___of the fittest. **[2010]**

**Options :**
(a) (D) – (i) Small variations, (ii) Survival
(A) – (i) Convergent
(b) (A) – (i) Convergent,
(B) – (i) Oxygen, (ii) nucleosides
(c) (B) – (i) Water vapour, (ii) Amino acids
(C) – (i) Rudimentary, (ii) Anatomical
(d) (C) – (i) Vestigial, (ii) Anatomical
(D) – (i) Mutations, (ii) Multiplication

**53.** Evolutionary convergence is characterized by **[1997]**
(a) Development of characteristics by random mating
(b) Replacement of common characteristics in different group
(c) Development of dissimilar characteristics in closely related groups
(d) Development of a common set of characteristics in group of different ancestry

**54.** The humming bird, hawk and the humming moth illustrate **[1988]**
(a) Adaptive radiation (b) Homology
(c) Convergent evolution (d) Divergent evolution

**55.** Which one of the following in birds, indicates their reptilian ancestry **[2000, 2008]**
(a) Two special chambers crop and gizzard in their digestive tract
(b) Eggs with a calcareous shell
(c) Scales on their hind limbs
(d) Four chambered heart

**56.** What is common to whale, seal and shark **[2007]**
(a) Seasonal migration (b) Thick subcutaneous fat
(c) Convergent evolution (d) Homoeothermy

**57.** Tendril of *Cucurbita* & throns of *Bougainvillea* are **[2007, 2008, 2011]**
(a) Vestigial organ (b) Analogous organ
(c) Homologous organ (d) None of these

**58.** The earliest fossil form in the phylogeny of horse is **[1994]**
(a) Merychippus (b) Eohippus
(c) Equus (d) Mesohippus

**59.** Peripatus is known as a connecting link, because it has the characters of both **[1995, 2002, 2003, 2005, 2006, 2009, 2012]**
(a) Aves and Fishes
(b) Reptiles and Birds
(c) Fishes and Amphibians
(d) Arthropoda and Annelids

**60.** Convergent evolution is illustrated by **[2003]**
(a) Dogfish and whale
(b) Rat and dog
(c) Bacterium and protozoan
(d) Starfish and cuttle fish

**61.** Age of fossils in the past was generally determined by radio-carbon method and other methods involving radioactive elements found in the rocks. More precise methods, which were used recently and led to the revision of the evolutionary periods for different groups of organisms, includes **[2004, 2007]**
(a) Electron spin resonance (ESR) and fossil DNA
(b) Study of carbohydrates/proteins in rocks
(c) Study of carbohydrates/proteins in fossils
(d) Study of conditions of fossilization

**62.** Variation in gene frequencies within populations can occur by chance rather than by natural selection. This is referred to as **[2013]**

**Or**

Random unidirectional change in allele frequencies that occur by chance in all population and especially in small populations is known as **[2013]**

(a) Genetic load (b) Genetic flow
(c) Genetic drift (d) Random mating

**63.** Forelimbs of cat, lizard used in walking; forelimbs of whale used in swimming and forelimbs of bats used in flying are an example of **[2014]**

(a) Homologous organs (b) Convergent evolution
(c) Analogous organs (d) Adaptive radiation

**64.** The wings of a bird and the wings of an insect are **[2015]**

(a) Analogous structures and represent convergent evolution
(b) Phylogenetic structures and represent divergent evolution
(c) Homologous structures and represent convergent evolution
(d) Homologous structures and represent divergent evolution

**65.** Industrial melanism as observed in peppered moth proves that **[2007]**

(a) The true black melanic forms arise by a recurring random mutation
(b) The melanic form of the moth has no selective advantage over lighter form in industrial area
(c) The lighter-form moth has no selective advantage either in polluted industrial area or non-polluted area
(d) Melanism is a pollution-generated feature

**66.** According to Hugo de Vries, the mechanism of evolution is **[2018]**

(a) Minor mutations
(b) Phenotypic variations
(c) Saltation
(d) Multiple step mutations

**67.** Which one of the following evidences does not favour the Lamarckian concept of inheritance of acquired characters **[1994, 2000, 2003]**

(a) Melanization in peppered moth in industrial areas
(b) Presence of webbed toes in acquatic birds
(c) Lack of pigment in cave–dwelling animals
(d) Absence of limbs in snakes

**68.** In the case of peppered moth (*Biston betularia*) the black-coloured from became dominant over the light-coloured form in England during industrial revolution. This is an example of **[1998, 1999, 2001, 2002, 2006, 2009]**

(a) Natural selection whereby the darker forms were selected
(b) Appearance of the darker coloured individuals due of very poor sunlight
(c) Protective mimicry
(d) Inheritance of darker colour character acquired due to the darker environment

**69.** Darwin's Finches are an excellent example of **[2008, 2010, 2015]**

(a) Brood parasitism (b) Connecting links
(c) Adaptive radiation (d) Seasonal migration

**70.** What is the most important factor for the success of animal population **[1997]**

(a) Natality (b) Unlimited food
(c) Adaptability (d) Interspecies activity

**71.** Darwin in his 'Natural Selection Theory' did not believe in any role of which one of the following in organic evolution **[2003]**

(a) Discontinuous variations
(b) Parasites, predators and natural enemies
(c) Survival of the fittest
(d) Struggle for existence

**72.** Industrial melanism is an example of **[2003, 2009]**

(a) Defensive adaptation of skin against ultraviolet radiations
(b) Drug resistance
(c) Darkening of skin due to smoke from industries
(d) Protective resemblance with the surrounding

**73.** Darwin's finches discovered from the Galapagos island provide evidence infavour of **[2004, 2007, 2009]**

(a) Camouflage
(b) Mimicry
(c) Biogeographical evidence of evolution
(d) Seasonal migration

**74.** The finch species of Galapagos island are grouped according to their food sources. Which of the following is not a finch food **[2013]**

(a) Carrion (b) Insects
(c) Tree buds (d) Seeds

**75.** The diversity in the type of beaks of finches adapted of different feeding habits on the Galapagos islands as observed by Darwin, provides evidence for **[1998]**

(a) Origin of species by natural selection
(b) Intraspecific variations
(c) Intraspecific competition
(d) Interspecific competition

**76.** One of the following phenomena supports Darwin's concept of natural selection in organic evolution **[2005]**

(a) Development of transgenic animals
(b) Production of 'Dolly', the sheep by cloning
(c) Prevalence of pesticide resistant insects
(d) Development of organs from 'stem cells' for organ transplantation

**77.** According to Darwin, the organic evolution is due to **[2013]**

(a) Reduced feeding efficiency in one species due to the presence of interfering species
(b) Intraspecific competition
(c) Interspecific competition
(d) Competition within closely related species

**78.** Industrial melanism is an example of **[2015]**

(a) Natural selection (b) Mutation
(c) Goldstein (d) Mendel

**79.** The extinct human who lived 1,00,000 to 40,000 years ago, in Europe, Asia and parts of Africa, with short stature, heavy eyebrows, retreating fore heads, large jaws with heavy teeth, stocky bodies a lumbering gait and stooped posture was **[2012]**

(a) Homo habilis (b) Neanderthal human
(c) Cro–magnon humans (d) Ramapithecus

**80.** Which one of the following statements is correct **[1998]**

(a) *Homo erectus* is the ancestor of man
(b) Cro-magnon man's fossil has been found in Ethiopia
(c) Australopithecus is the real ancestor of modern man
(d) Neanderthal man is the direct ancestor of *Homo sapiens*

**81.** Which of the following is the correct order of evolutionary history of man **[2001]**

(a) *Peking man, heidel berg man, neanderthal, cro-magnon*
(b) *Peking man, homosapiens, cro-magnon, neanderthal*
(c) *Peking man, neanderthal, homosapiens, heidelberg,*
(d) *Peking man, cro-magnon, homosapiens, Neanderthal*

**82.** During evolution of man many changes have taken place in his ancestral characters. Which one of the following is an unsignificant change **[1994, 1996, 2000]**

(a) Change of diet from hard tough fruits and roots into soft food
(b) Qualitative improvement in the structure of hands skills for making tools
(c) Disappearance of tail
(d) Improvement in speech for communication and social behaviour

83. Among the human ancestors the brain size was more than 1000 CC in [2007]
(a) Homo neanderthalensis (b) Homo erectus
(c) Ramapithecus (d) Homo babilis

84. Common origin of man and chimpanzee is best shown by [1997]
(a) Dental formula (b) Cranial capacity
(c) Binocular vision (d) Chromosome number

85. Which of the following had the smallest brain capacity [2015]
(a) Homosapiens
(b) Homo neanderthalensis
(c) Homo habilis
(d) Homo erectus

86. The age of the fossil of Dryopithecus on the geological time scale is [1998]
(a) $75\times10^6$ years back (b) $25\times10^6$ years back
(c) $2.5\times10^6$ years back (d) $50\times10^6$ years back

87. There are two opposing views about origin of modern man. According to one view Homo erectus in Asia were the ancestors of modern man. A study of variation of DNA however suggested African origin of modern man. What kind of observation on DNA variation could suggest this [2005]
(a) Greater variation in Asia than in Africa
(b) Greater variation in Africa than in Asia
(c) Similar variation in Africa and Asia
(d) Variation only in Asia and no variation in Africa

88. What kind of evidence suggested that man is more closely related with chimpanzee than with other hominoid apes [2004]
(a) Evidence from fossil remains, and the fossil mitochosomes, DNA alone
(b) Evidence from DNA extracted from sex chromosomes, autosomes and mitochondria
(c) Evidence from DNA from sex chromosomes only
(d) Comparison of chromosomes morphology only

89. What was the most significant trend in the evolution of modern man (*Homo sapiens*) from his ancestors [2012]
(a) Shortening of jaws
(b) Binocular vision
(c) Increasing cranial capacity
(d) Upright posture

90. Which one of the following is direct ancestor of modern man [1996]
(a) Australopithecus (b) Ramapithecus
(c) Homo erectus (d) Homo habilis

91. In recent years, DNA sequences (nucleotide sequence) of *mt*-DNA and *Y* chromosomes were considered for the study of human evolution, because [2003]
(a) They can be studied from the samples of fossil remains
(b) They are small, and therefore, easy to study
(c) They are uniparental in origin and do not take part in recombination
(d) Their structure is known in greater detail

92. Which one of the following statements is correct regarding evolution of mankind [1997]
(a) Neanderthal man and Cro-Magnon man were living at the same time
(b) Australopithecus was living in Australia
(c) *Homo erectus* is preceded by *Homo habilis*
(d) None of these

93. Adaptive radiation refers to [2007]
(a) Adaptations due to Geographical isolation
(b) Evolution of different species from a common ancestor
(c) Migration of members of a species to different geographical areas
(d) Power of adaptation in an individual to a variety of environments

## 8. AIIMS

1. Occurrence of endemic species in South America and Australia is due to [2010]
(a) Extinction of these species from other regions
(b) Continental separation
(c) Absence of terrestrial route to these places
(d) Retrogressive evolution

2. Adaptation of a species is its [2001]
(a) Ecdysis (b) Metamorphosis
(c) Acquired character (d) Hereditary character

3. Hardy and weinberg principle explains [2010]
(a) Genetic equilibrium (b) Non random mating
(c) Evolutionary force (d) All of the above

4. Most primitive living mammals which provide an evidence of organic evolution from geographical distribution are found in [1998]
(a) China (b) India
(c) Australia (d) Africa

5. What does the term 'reproductive isolation' refers to [2010]
(a) An individual is unable to fertilise itself
(b) Genes are not exchanged between two populations
(c) Individuals from two population never mate
(d) Individuals from two populations never produce offsprings

6. What is correct [2011]
(a) Natural selection is responsible for extinction of dinosaurs
(b) Lion and Leopard have convergent evolution
(c) *Homo habilus* and *Homo erectus* are closely related
(d) *Bistonbetularia* shows cryptic camouflage

7. Below are listed some pairs of characters. The homologous pair is [2010]
(a) Forelimbs of dog and camel
(b) Insect wing and bat wing
(c) Feathers of birds and fins of fish
(d) Lens of vertebrate and arthropod

8. Which one is not a vestigeal organ in man [1992]
(a) Vermiform appendix (b) Plica semilunaris
(c) Ear muscles (d) Malleus

9. Organs that have different embryonic origin but perform similar functions are [1992]
(a) Homologous organs (b) Analogous organs
(c) Vestigeal organs (d) Atavism

10. Appearance of ancestral characters in the new borns, such as tail, monstral face, gill slits, multiple mammae etc. are known as [2008]

**Or**

Presence of tail in a child is an example of [2004]
(a) Homologous (b) Analogous
(c) Atavism (d) Vestigeal

11. Which is a vestigeal organ of python [2009]
(a) Nose (b) Hind limbs
(c) Scales (d) Teeth

12. Wings of pigeon, mosquito and bat show [1999]
(a) Atavism (b) Mutation
(c) Divergent evolution (d) Convergent evolution

13. The scientists regarded as Neo–Lamarckist are [1993]
(a) August Weismann and T.H. Morgan
(b) Hardy Weinberg
(c) Correns, Tshermak and Hugo de Vries
(d) Kammerer and Mc Dougall

14. Who is related with 'Galapagos Island' [1998]
(a) Malthus (b) Darwin
(c) Wallace (d) Lamarck

15. "Darwin's finches" refers to [1993]
(a) Fossils of birds collected by Darwin at Galapagos islands
(b) A type of birds present on Galapagos islands
(c) Migratory birds collected by Darwin at Galapagos islands
(d) Fossils of reptiles collected by Darwin at Galapagos island

**16.** If Darwin's theory of pangenesis shows similarity with theory of inheritance of acquired characters then what shall be correct according to it **[2010]**
(a) Useful organs become strong and developed while useless organs become extinct. These organs help in struggle for survival
(b) Size of organs increase with ageing
(c) Development of organs is due to willpower
(d) There should be some physical basis of inheritance

**17.** Appearance of dark-coloured peppered moths among the light-coloured ones as a result of increased industrial pollution is an example of **[2010]**
(a) Disruptive selection (b) Stabilising selection
(c) Directional selection (d) None of the above

**18.** If mating is random, population is large and mutation does not occur; then gene frequencies of population from generation to generation remain constant. This was put forwarded by **[1993]**
(a) Lederberg (b) Wallace
(c) Hardy Weinberg (d) Haeckel

**19.** Match the scientists and their contributions in the field of evolution **[2010]**

| Name of the Scientist | | Contributions | |
|---|---|---|---|
| A. | Charles Darwin | 1. | Mutation theory |
| B. | Lamarck | 2. | Germ plasm theory |
| C. | Hugo de Vries | 3. | Philosophie Zoologique |
| D. | Ernst Haeckel | 4. | The Origin of species |
| E. | August Weismann | 5. | Biogenetic law |
| | | 6. | Essay on population |

(a) A – 4, B – 3, C – 1, D – 5, E – 2
(b) A – 4, B – 3, C – 5, D – 1, E – 6
(c) A – 4, B – 4, C – 5, D – 3, E – 1
(d) A – 2, B – 3, C – 1, D – 5, E – 2
(e) A – 3, B – 4, C – 1, D – 5, E – 2

**20.** Largest cranial capacity was found in **[2001]**
(a) Neanderthal man (b) Cro-Magnon man
(c) Java ape man (d) Peking man

**21.** The early stage human embryo distinctly possesses **[2003]**
(a) Gills (b) Gill slits
(c) External ear (Pinna) (d) Eye brows

**22.** The extinct human ancestor, who ate only fruits and hunted with stone weapons was **[2012]**
(a) Ramapithecus (b) Australopithecus
(c) Dryopithecus (d) Homo erectus

**23.** Which of the following was the transitional stage (connective link) between apes and humans **[2000]**
(a) Homo habilis
(b) Homo erectus
(c) Australopithecus ramidus
(d) Australopithecus africanus

## 9. Assertion and Reason

**1.** Assertion : *Ginkgo biloba* is a living fossil.
Reason : Organism which have persisted and remain unchanged for the past several million years while their relative disappeared.

**2.** Assertion : Natural selection is the outcome of difference in survival and reproduction among individuals that show variation in one or more traits.
Reason : Adaptive forms of a given trait tend to become more common; less adaptive ones become less common or disappear.

**3.** Assertion : From evolutionary point of view, human gestation period is believed to be shortening.
Reason : One major evolutionary trend in humans has been the larger head undergoing relatively faster growth rate in the foetal stage.

**4.** Assertion : New world and old world monkeys are alike.
Reason : Old world monkeys are closer to man.

**5.** Assertion : Chimpanzee is the closest relative of present day humans.
Reason : The banding pattern in the autosome number 3 and 6 are remarkably similar.

**6.** Assertion : Cro-magnon man has more intelligence than the man of present time.
Reason : He is regarded as most recent ancestor of today's man.

**7.** Assertion : Darwin's finches show a variety of beaks suited for eating large seeds, flying insects and cactus seeds.
Reason : Ancestral seed-eating stock of Darwin's finches radiated out from South American mainland to different geographical areas of the Galapagos Islands, where they found competitor-free new habitats.

**8.** Assertion : Comparative biochemistry provides a strong evidence in favour of common ancestry of living beings.
Reason : Genetic code is universal.

**9.** Assertion : We have lost all the direct evidences of origin of life.
Reason : The person responsible to protect the evidences were not skilled.

**10.** Assertion : Leaf butterfly and stick insect show mimicry to dodge their enemies.
Reason : Mimicry is a method to acquire body colour blinding with the surroundings.

**11.** Assertion : Coacervates are believed to be the precursors of life.
Reason : Coacervates were self-duplicating aggregates of proteins surrounded by lipid molecules.

**12.** Assertion : The theory of survival of the fittest is widely misunderstood.
Reason : Evolution does not always increase the chances of a species survival and species do not survive when such chances happen rapidly.

**13.** Assertion : Most evolutionary trees place information about the pattern of relationship among organisms on the vertical axis and information about time on the horizontal axis.
Reason : An evolutionary tree depicts the pattern of relationships among parents and their offsprings.

**14.** Assertion : Mutations cause evolution.
Reason : Ancon sheep and hornless cattle are developed by inducing mutation.

**15.** Assertion : Human ancestors never used their tails and so the tails expressing gene has disappeared in them.
Reason : Lamarck's theory of evolution is popularly called theory of continuity of germ plasm.

**16.** Assertion : Primitive atmosphere was formed by the lightest atoms.
Reason : The primitive atmosphere was reducing in nature.