EVOLUTION

Evolutionary biology is the study of history of life forms on earth. To understand the changes in flora and fauna that have occurred over millions of years on earth we must have the understanding of origin of life, evolution of earth, evolution of stars and origin of the universe is necessary.

ORIGIN OF UNIVERSE

According to Big Bang Theory, Universe is almost 15-20 billion years old. A singular huge explosion, unimaginable in physical terms occurred. Universe expanded and temperature came down. Hydrogen and helium were formed some time later. The gases condensed under gravitation and formed galaxies of the present day universe. A huge cluster of galaxies comprises the universe. Galaxies contain stars and cloud of gases and dust. Our galaxy is Milky Way. **Stellar system and stars** were formed by spreading of original gaseous cloud into the space and divided into smaller and large masses.

According it's a part of Big Bang Theory: Solar system evolved around 4.5 to 5 billion years ago from a huge red hot gaseous cloud of free atoms with temperature of $5000^{o}C$ - $6000^{o}C$ called **Solar Nebula.** Due to condensation of Nebula, central mass formed Sun and peripheral ring of cloud continued rotating around central mass formed planets. Earth was supposed to have been formed about 4.5 billion years back. There was no atmosphere on early earth.

i. Life appeared 500 million years after the formation of earth *i.e.* almost four billion year back.

Universe is vast and earth itself is only a speck. The longest of all the construed and conjectured stories is the story of origin of life and evolution of earth and against the background of evolution of universe itself.

A unique event in the history of universe is origin of life. Stellar distances are measured in light years. The light started its journey millions of year back and from trillions of kilometres away and reaching our eyes now. However, when we see objects in our immediate surrounds we see them instantly and hence in the present time. Therefore, when we see stars we apparently are peeping into the past.

Theories of Origin of life

i. Theory of Special creation: It was supported by **Father Suarez**

This theory states that God created life in six days. This theory has three connotations:

(i) All living organisms were created as such.
(ii) Diversity was always the same since creation and will be the same in future also.
(iii) Earth is about 4000 years ago.

All these ideas were strongly challenged during nineteenth century mainly by Darwin. Special creation theory lacks scientific evidences, so it is not accepted.

i. Theory of spontaneous generation or abiogenesis:

According to this theory, life originated from decaying here and rotting matter like straw, mud etc. spontaneously. **Aristotle, Helmont, Anaximander** supported that life can arise from non-living things only.

i. Theory of biogenesis: It was supported by **Francisco Redi, Spallanzani** and **Louis Pasteur.**

According to this theory life arises from pre-existing life only. **Louis Pasteur**, a French scientist used **swan-necked** flasks to perform his experiment. Louis Pasteur by careful experimentation demonstrated that life come

only from pre-existing life. He showed the in pre-sterilised flasks, life did not come from killed yeast while in another flask open to air, new living organisms arose from 'killed yeast'. Spontaneous generation theory was dismissed once and for all. However, this did not answer how the first life form came on earth. He left flask for many days but no life appeared in broth. When swan neck was broken, life appeared in the broth of killed yeast.

i. **Cosmozoic theory:** It was proposed by **Richter.**
Early Greek thinkers thought units of life called **spores** were transferred to different planets including earth. and evolved in various forms.

i. **Theory of Panspermia:** This theory was proposed by **Arrhenius**
"Panspermia" is still a favourite idea for some astronomers. Primitive life or panspermia comes to earth from some other planets.

i. **Theory of catastrophism:** It was proposed by **George Cuvier.**
According to this theory, life on earth disappeared due to catastrophe and the destruction was followed by next more advanced creation.
Theory of Eternity of life: This theory was proposed by **Prayer**

According to it, different types of living beings have always existed on earth and shall continue to exist forever.

i. **Modern theory of origin of life or Oparin-Haldane chemosynthetic theory:** It was given by **Oparin of Russia and Haldane of England.**
It is the widely accepted theory. 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. Living things gave rise to other forms of life. It means **abiogenesis first, and biogenesis since. Oparin explained his theory in his book, "The origin of life".**

The entire process of origin of life has two phases:

i. **Chemical Evolution** (Formation of diverse organic molecules from inorganic constituents).Formation of biomolecules preceded the appearance of first cellular form of life.

i. **Atomic Phase**

Initial temperature of earth was 5000 to 6000^{o}C. Due to high temperature of earth C,O,H,N,P,S etc. were in atomic stage.

i. **Origin of simple inorganic molecules or compounds**

Atoms combined to from following molecules or compounds due to gradual cooling of earth. Simple molecules N_2, H_2 etc. were formed.

i. **Water and ammonia were probably first inorganic compounds of primitive earth.**

i. **Origin of simple organic compounds**

Nitrides and carbides reacted with water vapours to form the first organic compound **methane** and later on hydrogen cyanide was formed.

Superheated steam changed into hot water which came on the earth as rain and evaporated. This process continued and finally hot water oceans were formed. Ancient oceanic water contained large amounts of dissolved NH_3, CH_4, HCN, nitride, carbides and elements.

As earth surface cooled, molecules and minerals present in water bodies combined to form simple organic compounds like aldehyde, glycerol, fatty acid, amino acid, glucose, purine & pyrimidine.

Energy for this obtained from **heating of the earth, cosmic rays, lightening, volcanic eruptions and radioactive decay.**

Haldane proposed that these simple organic compounds gradually accumulated in the water bodies and finally a "**hot dilute soup"** or **"prebiotic soup"** or broth was formed.

Experimental proof of formation of simple organic compound

In 1953, S.L. Miller, an American scientist, under guidance of his teacher Urey of American performed simulation experiment to prove formation of simple organic compound.

He took, methane, ammonia, hydrogen in ratio 2 : 1 : 2 and water vapour at 800^{o}C in a sterilized apparatus providing similar conditions of primitive earth like high temperature, cooling, circulation and passing of electrical discharge. The experiment was continued for 18 days.

A number of simple organic compounds like amino acids, (Glycine, alanine, aspartic acid) Organic acid (Formic acid, acetic acid, lactic acid) Urea and hydrogen cyanide were formed. Neither purine nor pyrimidine were formed during their experiment.

i. In similar experiments other observed formation of sugars, nitrogen bases, pigments and fats.

Analyses of meteorite content also revealed similar process are occurring elsewhere in space. With this limited evidence, the first part of the conjectured story i.e. chemical evolution was more or less accepted.

i. Origin of large complex organic compound

Through chemical reaction and polymerization, simple organic compounds combined to form complex organic compound like carbohydrate, proteins, fats and nucleic acids were formed.

Experimental proof of formation of large complex organic compound + Coaservates.

S.W. Fox had demonstrated that when a mixture of 18-20 amino acids was heated to boiling point for several hours and then cooled, polypeptide chains called **proteinoids** were synthesized.

i. Biological Evolution

v) Origin of Protobionts: Two important Protobionts are **Coacervates** and **microspheres**.

Oparin (1924) observed that if a mixture of a large protein and a polysaccharide is shaken Coacervates form. They are formed of primarily proteins and polysaccharides, with some water, become separated from the surrounding aqueous solution. Oparin's coacervates also exhibit a simple form of metabolism. As these coacervates do not have lipid outer membrane and can not reproduce, they fail to fulfil the requirement as a candidate of probable precursors of life.

Microspheres form when mixture of artificially produced organic compounds is mixed with cool water. If the mixture contains lipids, the surface of the microspheres consists of a lipid bilayer, reminiscent to the lipid bilayer of cell membrane. Sydney Fox (1950) obtained portioned microspheres by heating a mixture of dry amino acids between 130^{o}C to 180^{o}C and later cooling them in water. They were about 1 to 2 µm in diameter, similar to the size and shape of coccoid bacteria. They could be induced to constrict in a process that superficially resembles budding in bacteria and fungi.

We have no idea about how the first self replicating metabolic capsule of life arose. They would have been giant molecules (RNA, protein, polysaccharides etc.) These capsules reproduced their molecules perhaps.

(i) Origin of primitive life (protocell or Eobionts) some microsphere having DNA and RNA evolved further developing lipoprotein membrane and enzymes mediated reaction, called protocells. Protocells in the ancient ocean represent the beginning of life and exhibited biosynthesis, replication, adaptation and nutrition.

(ii) **Origin of Prokaryote**

Protocells evolved into first true cells.

All life form were in water environment only.

The first cellular form was probably single celled, prokaryotes, anaerobes and chemoheterotrophs. Nucleic acid core consisted of naked DNA.

Chemoheterotrophs started absorbing nutritive organic compounds from the primitives seas for body building and energy.

(iii) **Origin of Chemoheterotrophs**

As the environment became cool, formation of new organic molecules stopped, resulting in food shortage for chemoheterotrophs. Food shortage was overcome by evolution of Chemoheterotrophs. Chemoheterotrophs started synthesizing their own organic food from inorganic compounds in the presence of chemical energy.

(iv) **Origin of photoautotrophs**

Some Chemoheterotrophs developed chlorophyll resulting in evolution of first photoautotrophs. First photoautotrophs did not use water as a raw material in photosynthesis and were anoxygenic. Later these started using the water as a reagent and O_2 was evolved in process of photosynthesis.

First oxygenic and aerobic photoautotrophs were cyanobacteria.

(v) **Effect of oxygen evolution**

Most of anaerobic organism got killed.

Methane oxidized forming CO_2 and water. CO_2 started to get utilized in photosynthesis.

$$CH_4 + 2O_4 \rightarrow CO_2 + 2H2O$$

Atmosphere of the earth became oxidizing.

Ammonia oxidized forming H_2O and N_2.

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

Ozone layer was also formed in the atmosphere.

$$2O_2 + O_2 \rightarrow 2O_3$$

(vi) **Origin of Eukaryotic cells (True nuclear cells)**

Oxygenic photosynthesis evolved sufficient oxygen in the primitive atmosphere, the prokaryotes gradually modified the adapt themselves according to new conditions They developed true nucleus and the other specialized cell organelles.

It is believed that free living eukaryotic cells like organism originated in the ancient about 2.0 billion years ago. Numerous types of algae, fungi protozoan and other invertebrates originated soon after.

This version of abiogenesis *i.e.* the first form of life arose slowly through evolutionary forces from non-living molecules is accepted by majority. However, once formed, how the first cellular forms of life could have evolved into complex biodiversity of today is fascinating story.

Evidences of Evolution

The important evidences in support of organic evolution are as follows:

1. Palaeontological Evidence

These evidences are based on the knowledge of fossils. The study of fossils is known as **palaeontology**

Fossils are remains of hard parts of life-forms found in rocks. Rocks form sediments and a cross-section of earth's crust indicates the arrangement of sediments one over the other during the long history of earth.

Most of fossils are found in sedimentary rocks. Different-aged rocks sediments contain fossils of different life-forms who probably died during formation of the particular sediment. They represent extinct organisms (e.g. Dinosaurs). A study of fossils in different sedimentary layers indicates the geological period in which they existed. The study showed that life-forms varied over time and certain life forms are restricted to certain geological time spans. Hence, new forms of life have arisen at different times in the history of earth.

Age of fossil can be determined by carbon 14 dating technique, radioactive clock method/Uranium lead method.

i. Most recent method is electron spin resonance method.

i. Distribution of fossil in different strata of rocks

The distribution of fossil indicates that early fossils present in bottom rocks are simple and older, however recent fossils found in upper layer of rocks are more complex. It shows that fossil form becomes more complex as we proceed from earliest to recent rocks.

ii. Number and nature of Fossils in Early Rocks: The rocks of early era contain less number of fossils than the rocks of later era and only fossils of simple marine invertebrates are in these rocks. It is due to the fact that the life first originated in sea as a simple form. So fossils were not in plenty in the beginning as they were in later stage.

iii. Disparity between the past and present forms of life: On the basis of fossils study, early organisms were very different from their modern forms. This proves that the organisms have been changing since their appearance, which supports that evolution has been taking place.

iv. Missing links

The fossil organisms which show characters of two different groups are called Missing Links. E.g. **Archaeopteryx:** Between reptiles and birds. Archaeopteryx is also called Lizard bird.

Evolutionary biology is the study of history and development of life forms on earth.

1. Morphological and Anatomical evidences

Comparative anatomy and morphology shows similarities and differences among organisms of today and those that existed years ago. The presence of such similarities indicates a common ancestry. Despite broad similarities, the organ systems of various groups have varied degree of specializations.

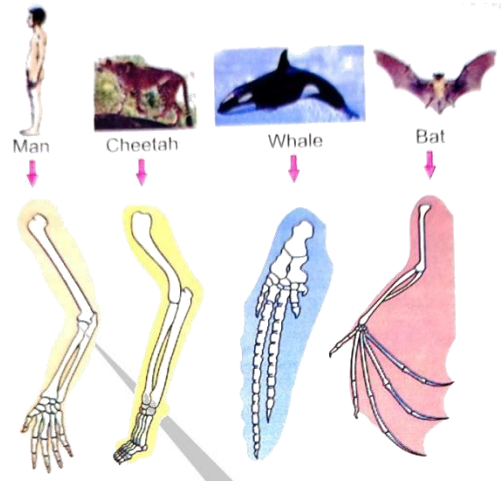
Homologous organs

The organs which are similar in origin and fundamental structure but different in appearance and functions are called **homologous organs.** Homology indicates common ancestry.

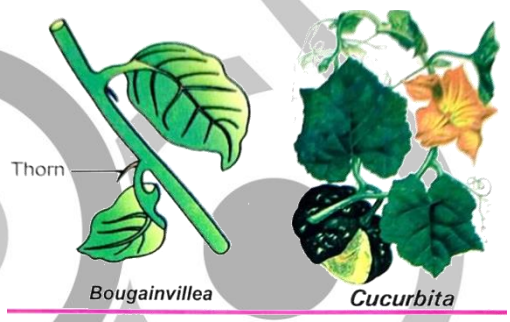
Organ which are different in appearance and function but similar in origin and basic structure are called homologous organ. They have same fundamental structure but performed different functions.

Examples:

i. Whales, bats, Cheetah and human (all mammals) share similarities in the pattern of bones of forelimbs through 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. When the same structures develop along different directions due to adaptations to different needs and environment, this is called **divergent evolution**.



Homologous organs in animals

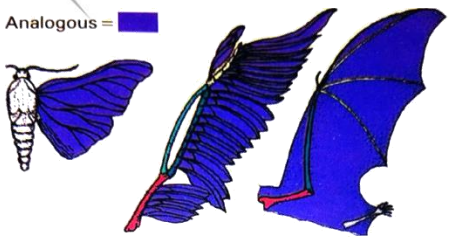


Homologous organs in plants

ii. Vertebrate hearts or brains.
iii. Mouth parts of insects
iv. Tendrils of cucurbits and thorns of Bougainvillea

2. Analogous organs

The organs which are different in origin and basic structure but are similar in appearance and function are called analogous organs. It is the similar habitat that has resulted in selection of similar adaptive features in different groups of organisms but towards the same function.



Wings of Insect, bird and bat

Examples:

i. Wings of birds and butterfly
ii. Flippers of penguins and dolphins
iii. Eye of octopus and mammals
iv. Sweet potato (root modification) and potato (stem modification)

HOMOLOGOUS ORGANS	ANALOGOUS ORGANS
They differ phenotypically.	The resemble phenotypically.
Internal structure is similar.	There is no similarity in internal structure
Development stages are similar.	Developmental stages are Quito different.
The organisms having homologous organs are phylogenetically related.	The organisms having analogous organs are phylogenetically unrelated.
Homologous organs show adaptation to different environments.	They show adaptation In response to similar environment.
They carry out different/similar functions.	They carry out similar function.
They develop in response to adaptive radiation or divergent evolution.	They develop in response to convergent evolution.

Examples:

(i) Trachea of insect and lungs of vertebrate
(ii) Flipper of seal fin of fish
(iii) Wings of birds and insect (butterfly)
(iv) Flippers of penguins and dolphins
(v) Eye of octopus and of mammals
(vi) Sting of honey bee and scorpion.
(vii) Sweet potato (root modification) and potato (stem modification)

3. Vestigial Organs

The organs which are non-functional or present in reduced form in the body and functional in their ancestors or related animals are called vestigial organs.

Vestigial organs are non-functional rudimentary organs of the body and are supposed to be functional in ancestors.

i. Vestigial organs in human beings: Nictitating membrane of eye, vermiform appendix, coccyx (caudal vertebrates), hairs on the body, canine teeth, wisdom teeth (3^{rd} molar), auricular muscles (muscles of the ear), nipples in males.

ii. Vestigial organ in other animals : Wings in flightless birds(Ostrich, Cassowary), vestiges of hind limb and pelvic girdle in python, vestigial 2^{nd} and 4^{th} digits of forelimbs and hind limbs of horse

4. Atavism or Reversion

The reappearance of ancestral characters which had either disappeared or were reduced is called Atavism. E.g. Presence of tail in children's, power of moving pinna, leaf of citrus plants.

Reappearance of ancestral characters is called Atavism or Reversion, e.g. Presence of tail in children, presence of long and thick hair on the body, power of moving pinna

5. Connecting link

The organisms which possess characters of two different groups are called connecting link.

Organisms having characters of two different taxonomic categories are called connecting link.

Examples:

i. **Euglena –** Between Plants and Animals, Proterospongia = Setween protocol Poriteza

ii. **Neopalina** - Between Annelida and Mollusca.

iii. **Peripatus** – Between Annelida and Arthropoda.

iv. **Balanoglossus** – Between Chordata and Non Chordata. Coela Canth

v. **Lobed fin fish (coelacanth), Protoperus** (Lung fish) is connecting link in between Pisces and Amphibians.

vi. **Duck billed platypus -** Between Mammals and reptiles.

6. **Study of individual organs:** There has been gradual evolution towards increased elaboration and efficiency.

i. Heart of vertebrates has changed from two chambered in fishes to four chambered in birds/mammals due to increased complexity in structure and functions in course of evolution.

ii. Similarly, the homologous structures shared in brain by different vertebrates are cerebellum, cerebrum, medulla, olfactory bulbs and optic lobes. There is progressive increase in size of different components.

Embryological evidences

1. **Similar early development**
   Similar early development (cleavage, blastulation and gastrulation) and transformation from one celled zygote to three-layered gastrula which further form similar structure in various animals. This shows their common ancestry.
2. **Similar invertebrate larvae**

   Annelids and mollusks possess a similar type of larva, trochophore. Larval resemblance points to a common ancestry.
3. **Similar vertebrate embryo**
   The early embryos of the vertebrates like fish, salamander, tortoise, chick, rabbit and human being resemble one another closely. They resemble in having similar form and structures like gill cleft, notochord, tail, eye and ear rudiments. Notochord is replaced by vertebral column. This similarity shows their common ancestry.
4. **Progressive Metamorphosis**

   Larvae of certain animals reveal the evolutionary relationship of adults with other animals e.g. frog is different from fish but the tadpole resembles fish in structure as well as mode of life. This shows that two animals had common ancestors but later diverged in evolutionary development.
5. **Retrogressive Metamorphosis**

   Certain animals undergo retrogressive metamorphosis so that the adults do not show true characteristics of the group to which they belong. The exact taxonomic position could be known only by the study of the larva e.g. Herdmania, Sacculina.
6. **Development of vertebrate organs**

   The development of certain organs such as heart, kidney and brains in vertebrates indicates their common ancestry. Four chamber heart of a bird or mammal is initially two chambered in embryo like fishes then becomes three chambered as found in amphibians and reptiles. Finally it becomes four chambered
7. **Temporary embryonic structures**

Embryos often possess structures which do not occur in adults. For example: bird embryo has tooth buds and gill clefts which are not found in the adult animals.

Teeth buds in embryos of birds reflects that their ancestors were reptiles. These teeth buds are temporary non functional embryonic structure.

8. Von Baer's law and Recapitulation theory/Biogenetic law:

It states that during embryonic development the generalized features (such as brain, spinal cord, axial skelton etc.) are common to all vertebrates appeared earlier than the special features (like hair in mammals only, features in birds only, limbs in quadrupeds only) which distinguish the various members of the group. Later this law was modified as the **biogenetic law** by **Ernst haeckel** which states that "**Ontogeny repeats Phylogeny**". It means that an organism repeats its ancestral history during its development.

Embryos of the vertebrate series exhibit many features that are not seen in adults. For example, all embryos of vertebrates develop a row of vestigial gill slits just behind the head. These gill slits are functional only in fishes. Gill slits also appear in the land vertebrates. It could mean that land vertebrates descended from fishes that had gill slits to help in aquatic respiration. Generalized features such as brain, spinal cord, axial skeleton and aortic arches are common to all vertebrates. Organisms that share common descent show embryological patterns on which they later build their adult patterns. This was first observed by von Baer. Ernst Haeckel reinterpreted Bear's law in the meant of the embryo/Life history of an organism) is recapitulation of phylogeny (development of race/the ancestral sequence). This is summarized as biogenetic law which states that ontogeny recapitulates phylogeny. However, this proposal was disproved on careful studies by von Baer as it was noted that the embryos do not pass through the adult stages of other animals. There are stages that related embryo do share.

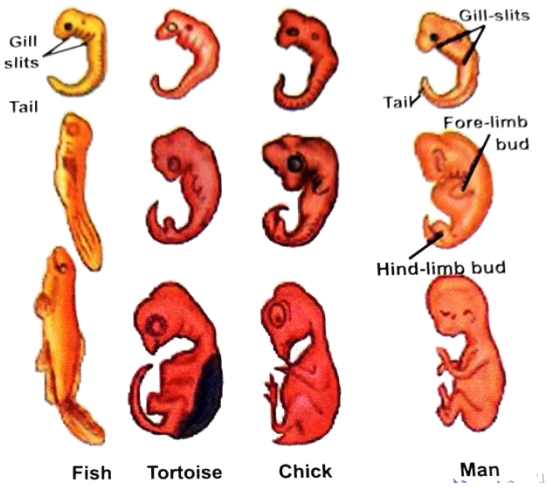
Examples of this phenomenon are also seen in plants.

For example –

(i) The Protonema, an early stage in the development of moss or fern gametophytes, resembles the filamentous green algae in structure, physiology and growth pattern. This suggests an algal ancestry of bryophytes and pteridophytes.

(ii) The gymnosperms have normally become independent of water in fertilisation. However, the primitive gymnosperms such as Cycas and Ginkgo have flagellated sperms and need water for fertilization just like the pteridophytes, their most likely ancestors.

(iii) The seedlings of acacia tree initially develop simple leaves, but the leaves that develop later are compound. Recapitulation has some value, although it is not a general phenomenon.



Example:

In the development of the frog a fish like tailed **Tadpole** larva is formed which swims with the tail and respires by the gills. This indicates that the frog has been evolved from a fish like ancestors.

Palaeontological evidence

It is based on the knowledge of fossils. Fossils. Fossils are remains of hard parts of life – forms found in rocks.

Rocks form sediments and a cross – section of earth's crust indicates the arrangement of sediments one over the other during the long history of earth.

- Most of fossils are found in sedimentary rocks.

Different – aged rock sediments contain fossils of different life – forms who probably died during formation of the particular sediment. Some of them appear similar to modern organisms. They represent extinct organisms (e.g., Dinosaurs). A study of fossils in different sedimentary layers indicates the geological period in which they existed. The study showed that life – forms varied over time and certain life forms are restricted to certain geological timespans. Hence, new forms of life have arisen at different times in the history of earth.

The study of fossils is known as palaeontology.

Charles Darwin was first to show that it provides direct evidence for organic evolution because it deals with actual animal which lived in the past.

Aquatic life forms can also get fossilised. The fossils which were formed at the bottom of water bodies became part of the sedimentary rocks. Such rocks came to the surface through upheavals in the crust of earth. We come across such fossils from exposed sedimentary rocks.

Fossil in which organic components of body is replaced by soil, minerals deposit is called petrified fossil. Such type of fossil consist of mostly hard parts of extinct animals.

Age of fossil can be determined by carbon 14 dating technique, radioactive clock method/Uranium lead method.

- Most recent method is electron spin resonance method.

Age of living tree can be computed by

- Carbon dating.
- Counting the number of growth rings at base of trunk if the tree shows secondary growth.

1. Distribution of fossil in different strata of rocks

The distribution of fossil indicates that early fossils present in bottom rocks are simple and older, however recent fossils found in upper layer of rocks are more complex and younger. It shows that fossil form becomes more and more complex as we proceed from earliest to recent rocks.

Simple organisms are ones which have simple morphology, anatomy, structure and functional organisation. They are considered to be primitive.

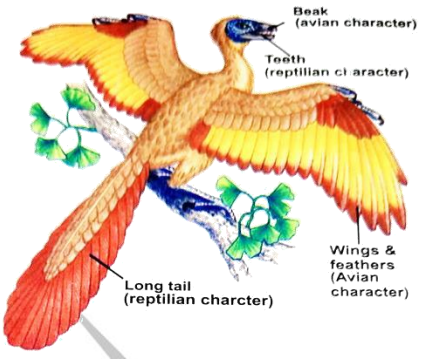
Complex organisms are the ones which have elaborate or complex morphology anatomy and functional organisation. They are more advance and have evolved from simple organisms.

2. Missing links

These are the fossils forms transitional between two groups (taxa) of organisms.

Archaeopteryx: Between reptiles and birds.

Archaeopteryx is also called lizard bird.



Archaeopteryx

Phylogeny of horse

- Phylogeny of horse was described by Othnies Marsh in 1879.

Name	Common Name	Height (in cm)	Molar
Eohippus (Hyracotherium)	Dawn horse	28 size of fox	Short crowned for browsing
Meshoippus	Intermediate horse	60	Short crowned for browsing
Merychippus	Ruminating horse	100	Long crowned for grazing
Pliohippus	Pliocene Horse	108	Long crowned for grazing
Equus	Modern Horse	150	Long crowned for grazing

The first fossil of the horse was found in north America, it was named Eohippus.

Important change during evolution of horse

Gradual increase in height (from 28 cm to 150 cm).

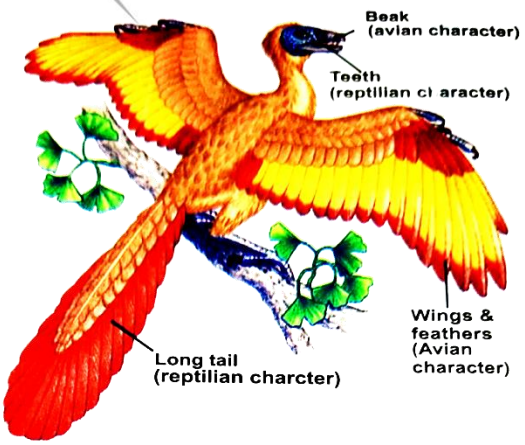
Reduction in number of functional digit (from 4 to 1)

Increase in size and complexity of crown of molars for chewing and grazing grass.

Lengthening of toes that are retained.

Lenghtening of limbs in general.

Enlargement of brain especially cerebral hemisphere.



Archaeopteryx

Geological time scale

In geological time scale the complete duration of earth is devised in following sequence Era – Period – Epoch

Fossils of different eras, periods and epochs show that higher complicated form originated from simpler form.

Ordovician period of palaeozoic era: Age of invertebrates, origin of fishes.

Devonian period of palaeozoic era: Age of fishes, origin of amphibians.

Carboniferous period of palaeozoic era: Age of amphibians, origin of reptiles.

Mesozoic era. Age of reptiles

Triassic period of Mesozoic era: Origin of dinosaurs and mammals.

Jurassic period of Mesozoic era: Dominant period of dinosaurs, origin of birds.

Cretaceous period of Mesozoic era: extinction of dinosaurs.

Recent epoch, quarternary period of coenozoic era; Age of man.

ERA	PERIOD	EPOCH
Coenozoic	Quaternary Tertiary	Recent pleistocene Miocene Oligocene Eocene Palaeocene
Mesozoic	Cretaceous Jurassic Triassic	
Palaeozoic	Permian Carboniferous Devonian Silurian Ordovician Cambrian	
Precambrian Or Proterozoic		

BRIEF ACCOUNT OF EVOLUTION

The first cellular forms of life appeared on earth about 2000 million years ago (mya). It is not clearly known that how non – cellular aggregates of giant macromolecules could evolve into cells with membranous envelop.

Some of these cells had the ability to release O_2. The reaction could have been similar to the light reaction in photosynthesis where water is split with the help of solar energy captured and channelized by appropriate light harvesting pigments.

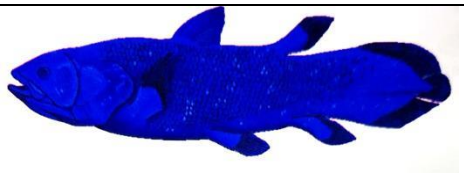
Multi – cellular forms were developed from single – celled organisms slowly.

Invertebrates were formed and active: about 500 mya.

Evolution of jawless fish: around 350 mya.

Existence of sea weeds and few plants: approx. 320 mya.

Presence of fish with stoued and strong fins (could move in land and go back to water): 350 mya.



A fish caught in South Africa in 1938 happened to be a Coelacanth (lobefins) which was thought to be extinct. Lobefins evolved into the first amphibians that lived on both land and water. There are no specimens of these leaf with us. However, these are considered as ancestors of modern day frogs and salamanders.

In the next 200 million years reptiles of different shapes and sizes dominated on earth. Giant ferns (pteridophytes) were present but they all fell to form coal deposits slowly.

The amphibians evolved into reptiles. They lay thickshelled eggs which do not dry up in sun unlike those o famphibians. Only their modern day descendants, the turles, tortoises and crocodiles are seen.

Evolution of fish like reptiles (lchthyosaurus): 200 mya.

(When some land reptiles when back into water).

Geological history of earth correlates with biological history of organisms.

Biggest dinasour (Land reptile): Tyrannosaurus rex (Height 20 ft, teeth – huge, fearsome, dagger like).

Reason for extinction of dinosaurs, can be killing due to climatic changes or most of them evolved into birds.

The first organisms that invaded land were plants. They were widespread on land when animals invaded land.

Evolution of life shows that life forms had a trend of moving from water to land.

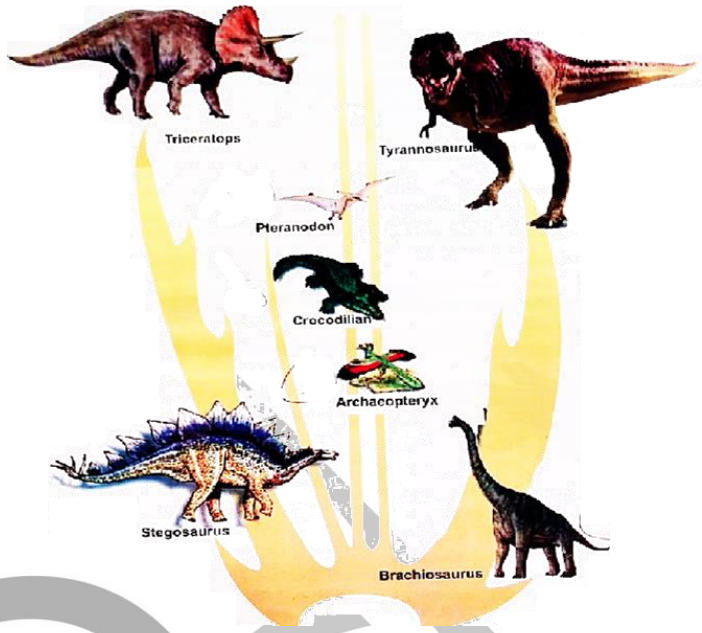
Sudden, abrupt and group specific extinctions have occurred in nature due to

(i) Over population of predators or competition from advanced descendants.
(ii) Genetic degeneration
(iii) Changes in environment like excessive cooling or warming, drought ore excessive raining
(iv) natural calamities like floods, volcanoes, earthquakes, epidemics, large meteorite hitting the earth etc.

Small sized reptiles of the era in which dinasours became extinct still exist today.

From a study of the history of life on earth through fossil records, it has been observed that large – scale loss of species like the one we are currently witnessing have also happened earlier, even before humans appeared on the scene. During the long period (> 3 billion years) since the origin and diversification of life on earth there were five episodes of mass extinction of species. The ‘Sixth Extinction’ presently in progress is different from the previous episodes. The different is in the rates; the current species extinction rates are estimated to be 100 to 1, 000 times faster than in the pre – human time and our activities are responsible for faster rates. Ecologists warn that if the present trends continue, nearly half of all the species on earth might be wiped out within the next 100 years.

The first mammals were like shrews. Their fossils are small sized. Mammals were viviparous and protected their unborn young inside the mother’s body.



Family trees of inosaurs and their living modern day counterpart organisms like crocodiles & birds

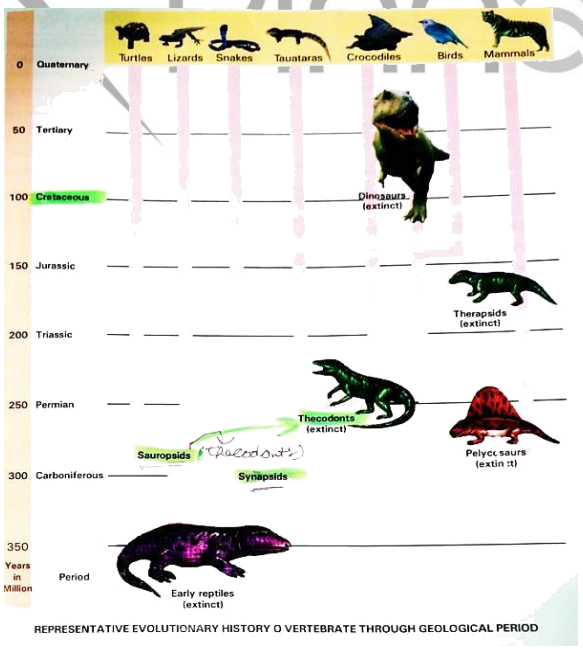
Viviparity is considered to be more evolved because the young ones are protected inside mother's body and are looked after they are born leading to more chances of survival.

Mammals were more intelligent in sensing and avoiding danger at least. Mammals took over this earth when reptiles came down. There were in South America mammals resembling horse, hippopotamus, bear, rabbit, etc.

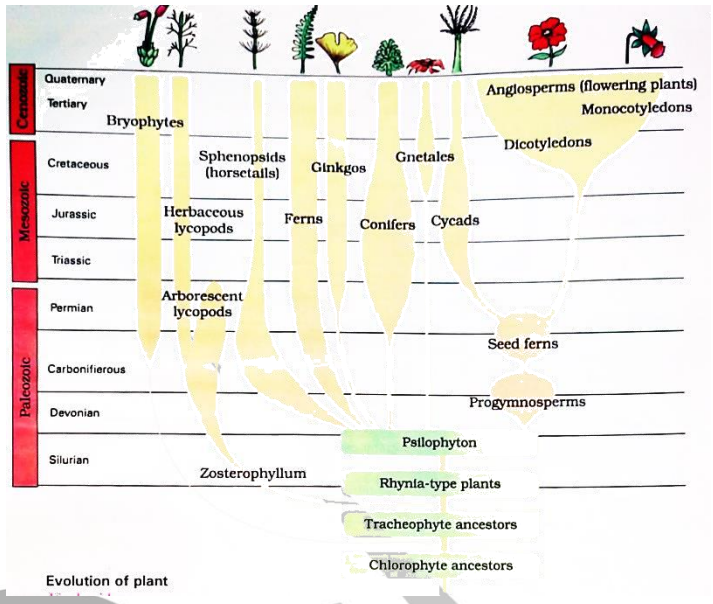
Due to continental drift, when South America joined North America. South American animals were overridden by North American fauna.

Due to the same continental drift pouched mammals of Australia survived because of lack of competition from any horse, elephant, dog, etc., are special stories of evolution.

The most successful story is the evolution of man with language skills and self – consciousness.



REPRESENTATIVE EVOLUTIONARY HISTORY O VERTEBRATE THROUGH GEOLOGICAL PERIOD



Evolution of plant

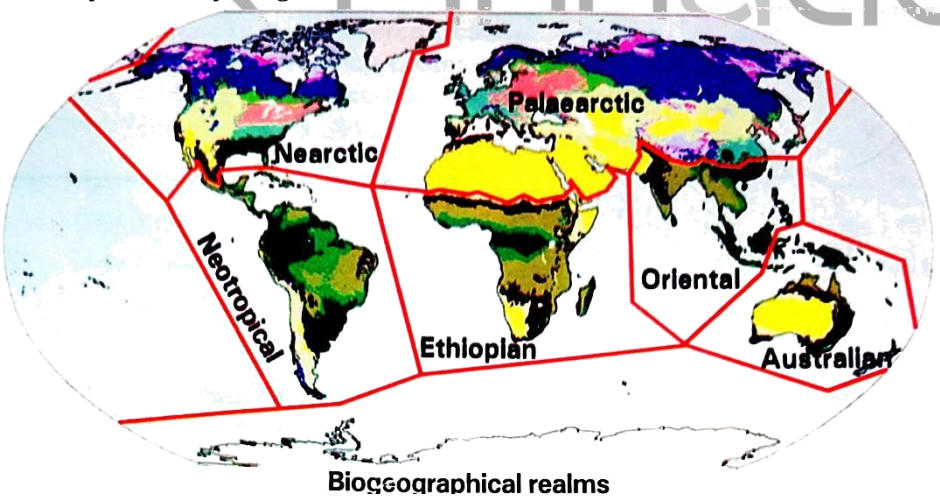
Biogeographical evidence

Biogeography is the study of patterns of distribution of animals and plants in different parts of the earth.

The earth has been divided into six major biogeographical regions called realms on the basis of distribution of plants and animals by Wallace.

i. Palaearctic
ii. Ethiopian
iii. Oriental
iv. Australian
v. Nearctic
vi. Neotropical

Continental drift theory: Given by Wagner.



Bioggographical realms

It is believed that millions of years ago all the continents were in the form of single land mass called **Pangaea.**

Due to various geological changes, huge land masses broke off and drifted apart from one another. As these land masses moved away they got separated from one another by seas and mountain like barriers.

These barriers prevented free movement of organisms among the continents.

As these land masses had different environmental condition, the plants and animals evolved differently.

Galapagos Islands

Galapagos Islands (**Living laboratory of evolution)** are a chain of 22 islands in the pacific ocean on the west coast of South America Charles Darwin visited these island on his ship (**H.M.S. Beagle**) in 1835.The flora and fauna of these islands resemble with those of South America mainland with which the Galapagos Islands were once connected. Birds of Galapagos Islands are now called Darwin's Finches and this name was given by **David Lack.** The diversity in the food habits produced different types of beaks among these finches.

1. Restricted distribution

When some unique organisms are confined in some part of the world it is called restricted distribution.

Example: Egg lying mammals and kangaroos are restricted in Australia Only. **Water** barrier, egg lying mammals and kangaroos remained confined to Australia and evolved along different lines by divergent evolution.

2. Discontinuous distribution

It is closely related species existing ate widely separated places.

Examples: Alligators present in **South-Eastern United States** and **eastern China** are somewhat different but they are related species of the same genus. The reason for the differences in alligators of two regions is long time geographical separation.

Magnolias, Tulips and Sassafras are now found naturally growing in the South eastern USA and in Eastern China.

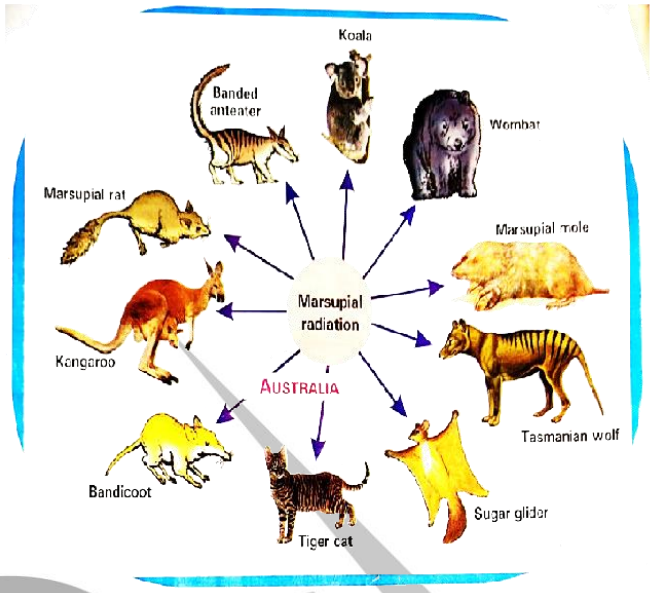
3. Adaptive radiation (Divergent evolution)

The process of evolution of the different species in a given geographical area starting from a point and literally radiating to other areas of geography or habit is called **adaptive radiation.** It is development of different functional structure from a common ancestor.

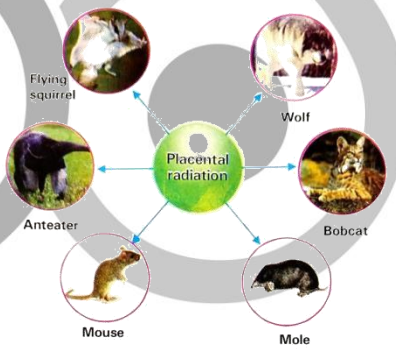
E.g. From the original seed-eating features, many other forms with altered beaks arose, enabling them to become insectivorous and vegetarian finches. Darwin's Finches of Galapagos Islands

Australian marsupial like Tasmanian wolf and Tasmanian cat, marsupial rat and marsupial mole.

Development of physical or geographical barriers between segment of populations of the same species is the most important precondition for adaptive radiation. Natural selection is driving force behind adaptive radiation.

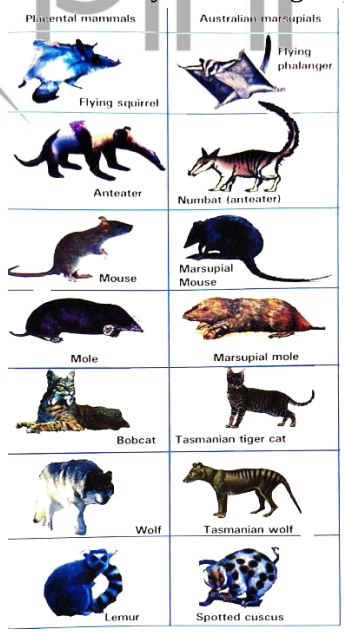


ADAPATIVE RADIATION OF MARSUPIALS OF AUSTRALIA



ADAPATIVE RADIATION OF PLACENTAL MAMMALS

4. **Adaptive convergence:** Formation of similar traits by unrelated groups of organisms.



When more than one adaptive radiation appears to have occurred in isolated geographical area represent different habitat is called as **Convergent evolution.**

e.g. Australian marsupials and placental mammal show convergent evolutions.

Parallel evolution

Convergence in closely related species is termed as parallel evolution for example development of running habit in deer (2-toed) and horse (1-toed) with two vestigial splint bones.

Biochemical or Physiological evidence

Living beings exhibit a large degree of similarity in chemical constitution, biochemical reaction and body functions.

Functional macromolecules e.g. proteins as an enzymes hormones, receptors etc. involved in basic body functions remain the same in diverse groups of organisms. Evolution has occurred in them towards newer structure and functions e.g. antibodies in vertebrates.

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.

Molecular evidence

Similarity of organisms at the molecular level indicates phylogenetic relationship. The degree of similarity in the bases sequence in their nucleic acids, and amino acids sequence in their proteins are indicated. Human DNA differs in only 1.8% of its base pairs from chimpanzee DNA and there is no difference between the two in the amino acids sequence for the proteins cytochrome C. Similarity in the molecular structure of actin and tubulin proteins in all animal points to their common ancestry. A common genetic code is over whelming evidence that all organisms are related.

Evidence from taxonomy

Grading of animals in order of increasing complexity is an evidence of evolution, it show that complex form originated from simpler form.

Moreover, the natural system of classification is based upon similarity and such similarities of structures could be only due to an origin form common ancestor.

Evidences from plant and animal breeding

Man has developed different breeds of plants and animals for agriculture, horticulture, sport or security by **artificial selection**. During animal husbandry and plant breeding programmes, man created breeds that differ from other breeds (E.g. Dogs) but still are of the same group. If man could create new breeds within hundreds of years, nature has done the same over millions of years with vast resources by natural selection.

Difference between natural selection & artificial selection	
Natural selection	Artificial selection
Selection is carried out by nature.	Selection is carried out by human beings.
Only those traits are selected which have the best adaptive value in relation to a particular environment	Traits are selected by human beings for their requirement and economic value.

Slow process.	Fast process.

Phylogeny of horse

Phylogeny of horse described Othnies Marsh in 1879.

The first fossil of the horse was found in **North America** it was named **Eohippus.**

Important change during evolution of horse

Gradual increase in height (from 28 cm to 150 cm)

Reduction in number of functional digit (from 4 to 1)

Increase in size and complexity of crown of molars for chewing and grazing grass.

Lengthening of toes that are retained.

Lenghtening of limbs in general.

Enlargement of brain especially cerebral hemisphere.

Geological time scale

Brief Account Evolution

The first cellular forms of life appeared on earth about 2000 million years ago (mya).It is not clearly known that how non-cellular aggregates of giant macromolecules could evolve into cells with membranous envelop. Some of these cells had the liability to release O_2.The reaction could have been similar to the light reaction in photosynthesis where water is split with the help of solar energy captured and channelized by appropriate light harvesting pigments.

Multi-cellular forms were developed from single-celled organisms slowly.
Invertebrates were formed and active: about 500 mya.
Evolution of jawless fish: around 350 mya.
Existence of sea weeds and few plants: approx 320 mya.
Presence of fish with stout and strong fins (could move on land and go back to water): 350 mya.
In the next 200 million years reptiles of different shapes and sizes dominated on earth. Giants ferns (pteridophytes) were present but they all fell to form coal deposits slowly. The amphibians evolved into reptiles. They lay thick shelled eggs which do not dry up in sun unlike those of amphibians. Only their modern day descendents, the turtles, tor-roises and crocodiles are seen Evolution of fish like reptile (**Ichthosaurus):** 200 mya.(When some land reptiles went back into water).

Geological history of earth correlates with biological history of organisms.

Biggest dinasour (Land reptile): **Tyrannosauru rex** (Height 20 ft, teeth-huge, fearsome, dagger like).

Reason for extinction of dinosaurs can be killing due to climatic change or most of them evolved into birds.

The first organisms that invaded land were plants. They were widespread on land when animals invaded land.

Small size reptiles of the era in which dinasours become extinct still exit today.

The first mammals were like shrews. Their fossils are small sized. Mammals were viviparous and protected their unborn young inside the mother's body.

Mammals were more intelligent in sensing and avoiding danger at least. Mammals took over this earth when reptiles came down. There were in South America mammals resembling horse, hippopotamus, bear, rabbit, etc.

Due to continental drift, when South America joined North America, South American animals were overridden by North American fauna.

Due to the same continental drift pouched mammals of Australia Survived because of lack of competition from any other mammal. Some mammals live wholly in water for example, whales, dolphins, seals and sea cows. Evolution of horse, elephant, dog etc. are special stories of evolution.

The most successful story is the evolution of man with language skills and self-consciousness.

Theories of Evolution

i. Introduction

Lamarckism was proposed by French naturalist, Jean Baptiste de Lamarck in his famous book "Philosophic Zoologique".
It is the first theory of evolution and is also called "**Theory of inheritance of acquired character".**

ii. Postulates of Lamarckism

i. Effect of environment and new needs

Organisms are influenced by environment. Change in environment leads to the origin of new needs.

New needs / appetency produce new structures and change habits of the organism.

Internal vital forces tend to increase the size of body.

ii. Use and disuse of organ

If an organ is constantly used it would be better developed whereas disuse of an organ results in its degeneration. Examples in support of postulate use and disuse

i. Developed and strong biceps of black smith.

ii. Elongated limbless body of snake.

iii. Lengthening of neck of Giraffe.

iv. Vestigial organs of living animals

v. Webbed feet of swimming birds.

vi. Retractile claws in carnivorous.

vii. Cave dwellers lost their eye sight.

viii. Vestigeal wings in flightless bird.

ix. Emergent hydrophytes – show heterophylly.

x. Inheritance of acquired character

Changes which an organism acquires during its life time with changing environment are inherited.

xi. Speciation

New characters which are acquired in each generation are transmitted to next generation. It results in accumulation of new characters generation after generation. After a number of generation a new species get formed.

Lamarck gave the examples of Giraffes who in an attempt to forage leaves on tall 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 neck. Nobody believes this conjecture any more.

3. Criticism of Lamarckism

Lamarckism was criticised by German biologist August Weisman. He conducted an experiment on rats. He cut the tails of rat for many generations but no single rat was born without tail in any generation.

August Weisman proposed **theory of continuity of germplasm.** According to this theory, environment factors affects somatic cells only and do not affect germ cells, so acquired characters are not transmitted from one generation to the next, thus has no role in evolution. Later on, he also admitted that the germplasm may become modified to a certain extent by some environmental factors.

Mendel's Laws of inheritance also rejected Lamarckism.

Neo Lamarkism

According to present day knowledge, it is modification of Lamarkism as explained below :

Introduction: It was proposed by Charles Darwin Darwin, a British naturalist, travelled to various parts of the world on ship **H.M.S. Beagle** from 1831 to 1836. Alfred Wallace, a naturalist who worked in **Malay Archepelago** had also come to similar conclusions around same time.

Darwin was highly influnced by essay **"principle of population" by T.R. Malthus** and by Principle of Geology by Charles lyell.

Darwin published his observation and conclusion in a book entitled **on the origin of species by means by natural selection** in 1859.

Darwin and Wallace work was jointly published in proceeding of llnnean society of London in 1859.

2. Postulates of Darwinism

i. Enormous reprodutive capacity

Every living organism possesses enormous capacity of reproduction, so they produce many time more offspring in comparison to actual availability of resource.

The fact that theoretically population size will grow exponentially if everybody reproduced maximally and the fact that population sizes in reality are limited, means that there had been competition for resources

b. Limited food and space

Resources are very limited on earth, so each and every offspring born on earth cannot get share from the resources and ultimately dies, so limited food and space checks population growth.

c. Struggle for existence

In order to get share from available resource organism undergo massive struggle among themselves. This struggle is of 3 types :-

i. Intraspecific - between members of same species. When Darwin spoke of the struggle for existence and survival of the fittest in nature, he was convinced that interspecific competition is a potent force in organic evolution.

ii. Inter specific - between members of different species.

iii. Environmental struggle - between organism and environment.

d. Variations

Variations are differences among individuals. Any population has built-in variations which enable them to survive better in natural conditions. They would outbreed others that are less endowed ones.

Only some survived and grew at the cost of other that could not flourish. They novelty and brilliant insight of Darwin was that he asserted that Variations, which are heritable and which make resource utilisation better for few (adapted to habitat better) will enable only those to reproduce and leave more progeny.

Darwin believed that continuous and useful Variation constitute raw material for evolution. Variations are small directional and revolve around mean value.

e. Natural selection or survival of fittest

Darwin believed that nature selects only those individuals out of a population which are with useful continous Variations and best adapted to the environment while less fit or unfit individual are rejected by it.

Term **Natural Selection** was given by **Darwin** and term **Survival of fittest** by **Herbert Spencer.**

Evolution by natural selection would have started when cellular forms of life with differences in metabolic capability originated on earth.

The essence of Darwinism about evolution is natural selection.

Nature selects for fitness. Fitness according do Darwin refers ultimately and only to reproductive fitness. Those who better fit leave greater number of progeny and therefore will survive more and hence selected by nature. He called it natural selection.

Branching descent and **natural selection** are two key concepts of Darwinism.

Branching descent is the formation of different types species from a common ancestor due to occurrence of Variations and different adaptations of varing ecological niches .e.g. finches of Galapagos islands became different in shape and size of beaks, food habits etc.

Natural selection is the survival and preferential reproduction by those individuals which better adaptations to the existing environmental conditions.

Homology is accounted for by idea of branching descent.

i. Inheritance of useful variation

Darwin believed that individual selected by nature transfer their useful continuous variation to the next coming generation so that they found fit/suited to the environment. Hence for a period of time, over many generations, survivors will leave more progeny and there would be change in population characteristic and hence new forms appear to arise.

g. Speciation

Darwin belived that useful variation appear in each and every generation & get inherited.

After number of gereration useful variation becomes so prominent and distinct that new species are formed.

Natural selection is based on certain observations which are factual.

ii. Evidences in favour Darwinism

Entomophilly

Many pollinating insect possess proboscis length of which exactly matches with position of nectar.'

This can develop gradually through natural selection.

Mimicry

It is the resemblance of an arganism with another (ferocious, unpalatable) or a natural object so as to conceal itself for protection, or some other advantage like catching of prey, e.g., Praying mantis ,stick insect, leaf insect. The mimic must have envolved along with the model due to accumulation of useful variations.

Pedigree of some animals

Pedigree of horse, camels and elephents also supports the theory of natural selection.

Artificial selection

If within hundreds of years, man could create new breeds, nature could have done the same over million of tears.

iii. **Criticism of Darwinism**

Darwinism failed to explain

i. Cause of variation and sterility of hybrids.
ii. Inheritance of vestigial organ.
iii. Inheritance of over specialized organs like tusk antlers etc.
iv. Arrival of the fittest.
v. Difference between somatic & germinal variations.

Darwin himself said " I am convinced natural selectetion has been the most importantbut not the exclusive means of modification.

Mutation Theory of Evolution

i. Introduction

Mutation theory of evolution was proposed by **Hugo de Vries** in first decade of 20^{th} century in his book – **Species and varieties and their origin by mutation.**

Hugo de Vries performed experiment on plant – **Evening Primrose (*Oenothera lamarckiana*).**

He suggest from his experiment that new types of inherited characteristics may appear suddenly without any previous indication of their presence in the race.

ii. Main Theme of Mutation Theory

According to Hugo de Vries mutation is a process in which new species arises from pre existing marked inheritable variations

Mutations are not the minor, directional, small and heritable variations that Darwin talked about. Mutations are heritable, random and directionless. Mutation caused speciation and hence called saltation (single step large mutation).

So according to mutation theory, evolution is a **Jerky process** in which one species is formed, from another all of a sudden. Mutations are spontaneous and discontinuous variations called **Sports** by Darwin and **salutatory variations** by Bateson.

iii. Evidence in favour of mutation

Ancon sheep appeared from long legged sheep all of a sudden in a single generation.

Hornless cattle appeared from horned cattle all of a sudden.

Hairless cat appeared from haired cat all of a sudden.

Mutations have a genetic basis and are therefore inheritable.

iv. Evidence against mutation :

Mutations are mostly negative or retrogressive.

Rate of mutation is low as compared to phenomena like symbiosis and mimicry.

Oenothera lamarckiana was complex heterozygous plant with a number of chromosomal aberrations with mutants.

Population Genetics

In a given population the frequency of occurrence of alleles of a gene or a locus can be found out. This frequency is supposed to remain fixed and even remain the same through generations. **Hardy- Weinberg principle** stated it using algebraic equations. This principle says that allele frequencies in a population are stable and constant from generation to generation. The gene pool remains constant.

This is called **genetic equilibrium.** Sum total of all the allelic frequencies is 1.

Individual frequencies, for example, can be named p, q, etc. In a diploid, p and q represent the frequency of allele A and allele a. The frequency of AA individuals in a population is simply p^2. This is simply stated in

another ways, i.e., the probability that an allele A with a frequency of a p appears on both the chromosomes of diploid individual is simply the product of the probabilities, i.e. p^2. Similarly of aa is q^2, of Aa 2pq. Hence, $p^2 + 2pq + q^2 = 1$.

When frequency measured, differs from expected values, difference (direction) indicates the extent of evolutionary change. Disturbance in genetic equilibrium, or Hardy Weinberg equilibrium, i.e., change of frequency of alleles in population is interpreted as resulting in evolution.

Five factors that are known to affect Hardy Weinberg equilibrium are **gene migration are gene flow , Genetic drift, mutation, genetic recombination** and **natural selection.**

i. **Introduction**

Neo- Darwinism is the modern concept of evolution

Darwinism, the theory of natural selection has a wide acceptance. However, it has been criticised too, on the ground it could not explain how the variations arise. With progress in genetics, the sources of variation were explained and Darwin's theory was modified. Now, the most accepted theory of evolution is known as **SYNTHETIC THEORY OF EVOLUTION,** in which the origin of species is based on the interaction of genetic variation and natural selection.

ii. Variations

Variation is basis of evolution.

It is generally belived that variations in population result in variable fitness. Other phenomenon like habitat fragmcntation and genetic drift may accentuate these variations leading to appearance of new species and hence evolution.

Evolution occurs though accumulation of gentic variation in in a population over long periods of time. Variations can occur due to mutations, recombinations, gene migration, genetic drift etc.

Mutations

These are permanent heritable changes in the genetic material of individuals.

Gene mutations produce new alleles. Sometimes new genes are also formed. Every gene can mutate though the frequency is low (one in million). Mutations resotre alleles that are removed by evolutionary agents.

By the "**Lederberg Replica Plating Experiment"** of Lederberg and Lederberg, they were able to show that there are mutations which are actually preadaptive. These kinds of mutations are regarded as beneficial mutations. The preadapted mutations express themselves only after exposure to the new environment to which the organisms are to adapt themselves.

The replica plating technique was performed on a culture of Escherichia coli in medium containing an antibiotic penicillin. The new colonies that did not grow were sensitive colonies that did some becteria grew and multiplied. This proved that mutations had occurred before the bacteria were exposed to penicillin. Thus mutations introduce new genes and alleles into the gene pool of a population.

The rate of appearance of new forms is linked to life cycle or life span. A colony of bacteria (Say A) growing on a given medium has built in variations in terms of ability to utilize a feed component. A change in medium composition would bring out only the part of population (say B) that can survive under new conditions. In due course of time this variant population outgrows the other and appears as new species. This would happen within days.

Fitness of B is better than A under new conditions. Nature selects for fitness. Fitness is based on characteristics which are inherited.

For the same thing to happen in a fish or fowl would take millions of years due to longer life span.

There must be a genetic basis for getting selection and to evolve. Some organisms are better adapted to survive in an otherwise hostile environment.

Adaptive ability is inherited and has a genetic basis.

Fitness is the end result of the ability to adapt and get selected by nature.

Recombinations

During meiosis, crossing over causes reshuffling of gene combinations which provides new combinations of existing genes and alleles. This is the essence of recombination.

It may bring together the alleles that arose at different times and places. Recombination can occur not only between genes but also within genes resulting in the formation of a new allele.

As it adds new alleles and combinations of alleles to the gene pool it is an agent of evolution.

Gene recombinations occur due to dual parentage, random union of gametes, chance separation of chromosomes and crossing over during gametogenesis.

Gene migration:

The movement of individuals from one place to another is called migration.

If the migrating individuals breeds within the new population the immigrants will add new alleles to the local genepool of the host population. This is called **gene migration.**

Gene frequencies change in the original as well as new population. New gene/alleles are added to the new population and are lost from the old population. Their would be gene flow if gene migration happens multiple times.

Migration, immigration or emigration results in unrestricted **geneflow** and diffusion of genes into populations.

If same change occur by chance it is called genetic drift.

Genetic drift

The random changes in the allele frequency occurring by chance alone are called, genetic drift. Drift is a binomial sampling error of the gene pool.

Alleles that form gene pool of the next generation are a sample of alleles from current generation.

Sampling errors(chances) often lead to the elimination of certain alleles and fixation of others, thus reducing genetic variability of the population.

There is **increase in inbreeding,** decrease in heterozygosity and increase in homozygosity.

Genetic drift can cause dramatic changes in allele frequencies in a population derived from small bands of colonisers, called **founders** to a new habitat.

Sometimes the change in allele frequency is so different in the new sample of population that they become a different species.

The original drifted population becomes **founders** and the effect is called founder effect.

Population crashes leading to drastic reduction in population size can cause change in allele frequencies.

The existing gene pool is limited, population crashes retard the ability of the population to re-establish its former richness. Such reduction in allele frequencies is called a **genetic bottleneck.**

Gentic bottleneck often prevents the species from reversing its path of extincton.

B. Natural selection

Examples of natural selection

i. Industrial Melanism: It was originally studied by Fisher and Ford in England. In a collection of month made in 1850s, i.e., before industrialisation set in, it was observed that there were more white- winged month on trees than dark- winged or melanised moths.

In a collection carried out from the same area, but after industrialisation, i.e., in 1920**,** there were more dark winged moths in the same area, i.e., the proportion was reversed.

The explanation put forth for this observation was that 'predators will spot a moth against a contrasting back ground. During post industrialisation period, the three trunks became dark due to industrial smoke and soots. Under this condition the white- winged moth did not survive due to predators, dark- winged or melanised moth survived. Before industrialisation set in, thick growth of almost white coloured lichen covered the trees – in that back-ground the white winged moth were picked out by predators.

Lichens can be used as industrial pollution indicators. They will not grow in areas that are polluted.

Moths that were able to camouflage themselves, i.e., in rural areas, the count of melanic moths was low. This showed that in a mixed population, those that can better- adapt, survive and increase in population, size.

No variant is completely wiped out.

In recent periods when soot emission has reduced (due to pollution control and use of electricity) both lichens and light variety of peppered moth have appeared in large number. Hence it is an excellent example of natural selection.

This reveals that evolution is apparently reversible.

ii. DDT resistance in mosquito :

Percentage of DDT sensitive mosquitoes was much higher than that of DDT resistant forms when DDT was initially used.

Due to presence of DDT in environment, natural selection operated and conditions became favourable to DDT resistant mosquitoes and their percentage became higher.

3. Sickle cell anemia :

Although gene of sickle cell anemia is lethal, yet its frequency is higher in African population.

This is due to heterozygous superiority

Individual having genotype $Hb^A Hb^A$ prone to malaria and those with genotype $Hb^s Hb^s$ suffer from sickle cell anemia.

Features of Natural Selection

Natural selection operates through **differential reproduction**, i.e. some members of population have traits (genes) which enable them to grow up and reproduce at a higher rate and leave more surviving offspring in the next generation than others.

If differential reproduction continues for many generation, the most successful individuals contribute more alleles to gene pool.

Depending upon the traits favoured in particular environment, a single species will come to have different types of populations in different places. It results in evolution.

In the modern view of evolution, natural selection is fundamentally a **creative force,** one that speards genetic variations.

Types of Natural Selection

Natural selection causes allele frequencies of a population to change. Depending upon which traits are favoured in a population it can produce three different results.

i. Stabilizing selection (normalizing selection) if both the smelliest and largest individuals contribute relatively fewer offspring to the next generation than those closer to average size do, then stabilizing selection is operating. Selection acts to eliminate both extremes from an array of phenotypes, the frequency

of the intermediate type which is already the most common, is increased. It reduces the variation but does not change mean value.

ii. **Directional selection (progressive selection) -** If individual at one extreme of the size distribution e.g. (the larger ones) contribute more offspring to the next generation then the other individuals do, tjen the mean size of individual in the population is operating.

Selection acts to eliminate one extreme from an array of phenotype, the genes determining this extreme become less frequent in the population. Example - The industrial melanism.

If directional selection operates for many generations, an evolutionary trend within the population results.

3. **Disruptive Selection (diversifying selection) -** When natural selection simultaneously favours individuals at both extremes of the distribution, disruptive selection is operating.
Selection acts to eliminate, rather than favour, the intermediate type. The individuals at both the extremes are favoured.

As a result we can see two peaks in the distribution of traits.

C. Reproductive isolation

Prevention of mating between two natural populations of the same of different species due to presence of barriers to interbreeding is called reproductive isolation.

i. **Speciation**

Formation of new species.

Allopatric speciation - speciation because of geographical isolation.

Sympatric speciation - A species development due to reproductive isolation and therefore , occuring in overlap ping of same area of geographical distribution as its sister species.

Human Evolution

Carolus Linnaeus called human 'homo sapiens' Homo sapiens' and placed them along with apes and monkeys.

T.H. Huxley tried to explain origin of human in his book **'Man's place in nature'**

Charles Darwin tired to explain ancestry of humans in his book **'The Descent of man'**

Mammals evolved 210-240 mya from synapsid reptiles & first mammals were shrew like insectivores.

Prosimian include lemurs, Loris and Tarsiers.

Simians include monkeys (New world and old world), apes and man.

Apes: There are four types of Apes:

i. Gibbon: Found in Asia. Smallest ape, most gentle, only ape found in india (Assam).

ii. Orangutan: Found in Asia. Makes nest over tree.

iii. Chimpanzee: Found in Africa. Most intelligent, nearest to human beings.

i. **Gorilla:** Found in Africa. Most ferrocious and dangerous ape.

Evidence for common Ancestry of great Apes and Man

Evidence from blood proteins:

Blood protein tests prove that man is most closely related to great apes (chimpanzee and Gorilla) and next closest, in order, are the old world monkeys, the new world monkeys and Tarsiers.

Evidence from blood groups:

In humans four blood groups A, B, AB and O occur. The blood groups A and B are found in apes but not in monkeys. This indicates that human beings are more closely related to apes than to monkeys.

Evidence from haemoglobin:

There is 99 percent haemoglobin in haemoglobin of man and gorilla. This suggests that the two are closely related.

Homology in chromosomes of Man and Greats apes

The banding pattern of individual human chromosomes is very similar to the banding pattern of corresponding chromosomes in apes.

The banding pattern of human chromosomes number 3 and 6 are compared with those of particular autosomes in the chimpanzee. It shows a common origin for man and chimpanzee. Total amount of DNA in human and apes is similar.

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

Primates called **Dryopithecus** (Proconsul) and **Ramapithecus** existed and chimpanzees. Dryopithecus is common ancestor of humans and apes that lived an arboreal life in Asia as well as Africa. Dryopithecus was more ape-like.

Ramapithecus (Kenyapithecusl Sivapithecus) was more man-like.

Few fossils of man-like bones have been discovered in Ethiopia and Tanzania. These revolved hominid features leading to the belief that about 3-4 mya, man-like primates walked in eastern Africa. They were probably not taller than 4 feet walked up right.

Two mya, **Australopithecines** probably lived in East African grasslands. Evidence shows they hunted with stone weapons but essentially ate fruit.

Some of bones among the bones discovered were different. This creature was called the first human-like being the hominid and was called ***Homo habilis*** (Stone tool maker, Handy man, nut craker/ Able man). The brain capacities were between 650-800 cc. They probably did not eat food.

In 1891 fossils discovered in Java revealed the next stage i.e. ***Homo erectus*** about 1.5 mya. *Homo erectus* had a large brain around 900 cc. *Homo erectus* probably ate meat, first man to use fire, lived in caves.

Types of Homo erectus

Homo erectus erectus (Java man)

Homo erectus pekinensis (Peking Man)

Homo erectus heidelbergensis (Heidelberg man)

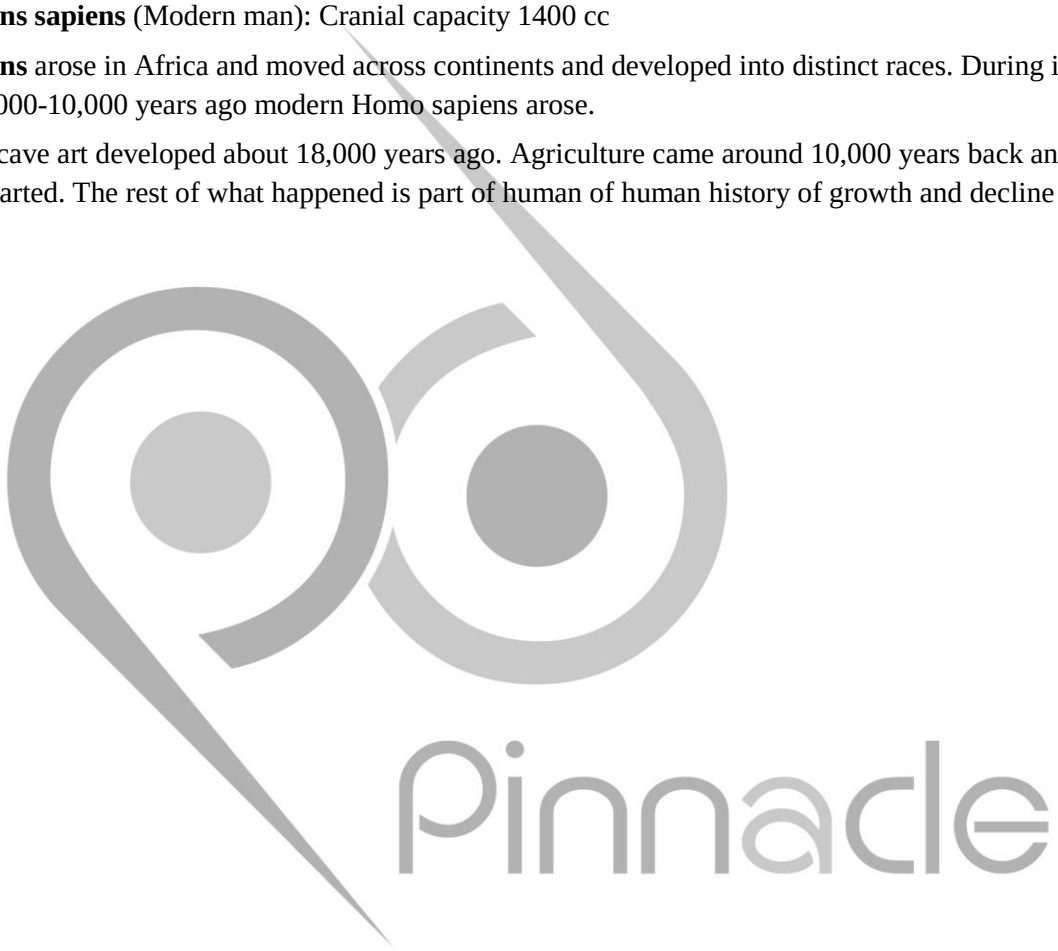
The Neanderthal man with a brain size of 1400cc lived 10000 to 40000 years ago in Europe, Asia and parts of Africa. They were with heavy eyebrows, short stature, retreating foreheads, large jaws with heavy teeth, stocky bodies, lumbering gait and stooped posture. They used hides to protect their body and buried their dead.

Homo sapiens fossilis (Cromagnon man) : Cranial capacity 1650 cc. Lived 11,000-50,000 years back. Chin present with strong laws. Cro-magnon man was cave dweller, hunter, and domesticated dogs, used stone spears and arrow heads, did some excellent cave paintings, used ivory ornaments and used animals skin for making garments. Considered as close relative and direct ancestors of man.

Homo sapiens sapiens (Modern man): Cranial capacity 1400 cc

Homo sapiens arose in Africa and moved across continents and developed into distinct races. During ice age between 75,000-10,000 years ago modern Homo sapiens arose.

Pre-historic cave art developed about 18,000 years ago. Agriculture came around 10,000 years back and human settlement started. The rest of what happened is part of human of human history of growth and decline of civilisations.



EXERCISE - 1

1. Origin of life from non – living organisms is known as _____ and was first refuted by _____.
   (a) Biogenesis ; Spallanzani
   (b) Abiogenesis ; Louis Pasteur
   (c) Abiogenesis; Francesco Redi
   (d) Abiogenesis ; Arrhenius
2. Which of the following scientist is related to panspermia theory of origin of life stating that organism existed throughout the universe and their spores etc. Could freely travel through outer space?
   (a) Anaximander
   (b) Von Helmont
   (c) Spallanzani
   (d) Arrhenius
3. Abiogenesis means
   (a) Origin of life from non – living material
   (b) Origin of life from living organisms
   (c) Origin of viruses and microbes
   (d) None of these
4. Mark the correct statement
   (a) Arrhenius stated that air carried micro – organism
   (b) Father Suarez approved of the view of special creation
   (c) Pasteur did his experiment on flesh
   (d) Redi put forward the theory of special creation
5. Life came out of decaying & rotting matter like straw, mud etc is the basis of
   (a) Theory of spontaneous generation
   (b) Idea of panspermia
   (c) Version of abiogenesis
   (d) Chemical evolution
6. Swan – necked flask experiment was done by
   (a) Aristotle
   (b) Louis Pasteur
   (c) Robert Koch
   (d) Francesco Redi
7. The theory of spontaneous generation of abiogenesis was disproved by
   (a) A.I. Oparin
   (b) Sidney Fox
   (c) A.R. Wallace
   (d) Louis Pasteur
8. Theory of catastrophism was supported by
   (a) Louis Pasteur
   (b) A.I. Oparin
   (c) Cuvier
   (d) Haldane
9. The correct match is

i. Theory of chemosynthesis	a. Cuvier
ii. Theory of abiogenesis	b. Saurez
iii. Special Creation theory	c. Von Helmont
iv. Catastrophe theory	d. A.I. Oparin theory

   (a) I – a, ii – b, iii – c, iv – d
   (b) I – b, ii – c, iii – d, iv – a
   (c) I – c, ii – d, iii – a, iv – b
   (d) I – d, ii – c, iii – b, iv – a
10. Origin of life took place in water under certain conditions. The scientists have obtained cell like structure which are known as
    (a) Protobiont
    (b) Eobionts
    (c) Prokaryotes
    (d) Eukaryotes
11. The concept of chemical evolution is based on
    (a) Crystallization of chemicals
    (b) Effect of solar radiation on chemicals
    (c) Interaction of water, air and clay under intense heat
    (d) Possible origin of life by combination of chemical under suitable environmental conditions
12. How has the free O_2 been released into the earth's atmosphere whereas there was no free O_2 at the time of origin of life?
    (a) By catabolic activity of animals
    (b) By photosynthetic activity
    (c) By heating of the earth
    (d) None fo the above
13. Hot dilute soup was given by
    (a) Oparin
    (b) Haldane
    (c) Urey
    (d) None of mode
14. Which of the following was the first type of mode of nutrition which developed in the Eobionts or the first living structure?
    (a) Chemoheterotroph
    (b) Chemoautotroph
    (c) Photoautotroph

(d) Phytotroph

15. Gases found in primitive atomosphere were
(a) CH_4, NH_3, H_2, H_2O (vapour form)
(b) CH_3, NH_3, CO_2, H_2O
(c) CH_4, H_2O, CO_2
(d) CH_4, O_2, CO_2

16. Coacervates for colloidal aggregates formed on primitive earth was so called by
(a) Miller
(b) Sydney fox
(c) Oparin
(d) Haldane

17. Formation of diverse organic molecules was proceeded by chemical evolution has been proved by
(a) Theory of panspermia
(b) Evolution of varied life forms
(c) Origin of life from rotting matter life straw
(d) S.L. Miller's experiment is 1953

18. Which of the following conditions are not needed for biogenesis?
(a) Self replicating molecules
(b) Occurrence of mutations
(c) Partial isolation from general environment
(d) Absence of mutation

19. In the Miller's experiment, methane, ammonia, hydrogen and water vapour were circulated in air tight apparatus and electrical discharge was provided from electrodes at 800 ℃. On analysis, the following amino acids were found except one. Mark it
(a) Alanine
(b) Glycine
(c) Valine
(d) Aspartic acid

20. Miller synthesized simple amino acids from one of the following mixture in his experiment
(a) H_2, O_2, N_2 and water vapour
(b) CH_4 , NH_3, H_2 and water vapour
(c) H_2, O_2, N_2 and water vapour
(d) CH_4, NH_3 HCN and water vapour

21. The first cellular form of life
(a) Arose non – living molecules
(b) Was a multicellular aquatic form
(c) Was a unicellular terrestrial form
(d) Arose around 4600 mya

22. The spark – discharge apparatus to test chemical evolution of life was designed
(a) Oparin and Haldane
(b) Miller and Urey
(c) Jacob and Monad
(d) Dixon and Jolley

23. Synthesis of amino acids to prove that amino acids formed in primitive ocean was experimentally proved by
(a) Sydney Fox
(b) Oparin
(c) Haldane
(d) Stanley Miller

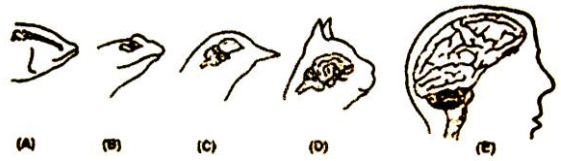
24. Whales, Bats, Cheetah and Human share similarities in the pattern of bone of forelimbs. Their forelimbs are _____structures favours _____evolution
(a) Homologous, divergent
(b) Analagous, convergent
(c) Homoplastic, divergent
(d) Analogous, parallel

25. Find the odd one out
(a) Thorns and tendrils of Bougainvillea and Cucurbita, respectively
(b) Brain of Fish, Frog and Human
(c) Heart of Crocodile and lung fish
(d) Tendrils of Smilex and Passiflora

26. Choose the odd one in each category and then select the correct option:
a. Wings in kiwi, auricular muscles, molars in man vestigcal
b. Sting of honey bee and scorpion, legs of insects, flippers of penguins and dolphins
c. Vestiges of hindlimb in Python, presence of tail in children, power of moving pinna
(a) Auricular muscles, flippers of penguins and dolphins, power of moving pinna
(b) Molars in man, legs of insects, vestiges of hindlimb in Python.
(c) Molars in man, sting of honey bee, vestiges of hindlimb in Python
(d) Wings in kiwi, legs of insects, presence of tail in children

27. Heart is two chambered in pisces and four chambered in mammals. This suggests
(a) Comparative anatomy and evolutionary trend
(b) Comparative physiology and evolutionary convergence
(c) Comparative embryology and evolutionary convergence

(d) Comparative morphology and evolutionary convergence

28. 

In the above diagram, the development of brain in different vertebrates exhibit

(a) Homology with increasing structural and functional complexity
(b) Analogy with increasing structural and functional complexity
(c) Analogy with increasing structural complexity and decreasing functional complexity
(d) Homology with increasing structural complexity and decreasing functional complexity

29. Evolution of different life forms is
(a) Abrupt with different variations
(b) Gradual with different variations
(c) Static with different variations
(d) First abrupt then gradual with variations

30. Which of the following evidence is better to understand the process of organic evolution?
(a) Homologous and analogous organs
(b) Homologous and vestigial organs
(c) Atavism and analogous organs
(d) Connecting links and analogous organs

31. Which is a correct different between homologous & analogous organs?

Character	Homologous	Analogous
(a) Internal Organisation	Different	same
(b) Function	same	different
(c) Origin	similar	dissimilar
(d) Evolution	convergent	divergent

32. Mark the correct match
(a) Mouth parts of insects – Analogous organs
(b) Sting of honey Bee and of scorpion – Homologous organs
(c) Balanoglossus - Connecting link
(d) Presence of Pinna - Vestigeal organ

33. What is true about homologous or homologous organs?
(a) Development of different structures due to adaptations to similar needs
(b) Homology indicates common ancestry
(c) Homologous organs show the development of different structures evolving from a common form
(d) Both (b) & (c)

34. Choose the examples of analogous organs
a. Mouth parts of cockroach and mosquito
b. Heart of man and heart of pigeon
c. Wings of crow and butterfly
d. Forelimb of human and chimpanzee
e. Eye of octopus and that of cat
(a) a, c & e
(b) b, c & d
(c) a & c
(d) c & e

35. A comparative study of embryos of different vertebrate groups suggests
a. Close relationship of development patterns in vertebrates
b. Embryos of closely related groups or with common ancestory are more similar
c. Basic structure formed first and specialised structures appear later
d. Adults forms of organisms are advanced versions of embryos of organisms of lower hierarchy
(a) a, b, c & d
(b) a, b & c
(c) b, c & d
(d) a & b

36. Which of following best express recapitulation theory?
(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

37. Which of the following is a temporary embryonic structure?
(a) Kidney in the tadpole of frog
(b) Hair in whale embryo
(c) Hair in human embryo
(d) Kidney in whale embryo

38. Haeckel's biogenetic law of recapitulation theory states that
(a) Life history of an animal reflects evolutionary history of the same
(b) Progeny resembles parents
(c) mutations are acquired characters

(d) All organisms begin their life from zygote

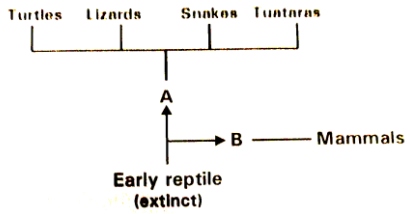
39. A person discovered an organism but not able to assign proper taxonomic position. Which according to you can help him to assign a systemic position?
(a) Study of its biogeography
(b) Study of its internal morphology
(c) Study of its some Vestigeal characters
(d) Study of its developmental stages

40. Appearance of teeth in the embryos of birds is an example of _____
(a) Vestigeal organs
(b) Embryological evidence
(c) Atavism
(d) Speciation

41. The oldest surviving rocks, about 4.3 billion years old contain
(a) Traces of life
(b) No definite trace of life
(c) Fossils of cyanobacteria
(d) Carbonates

42. An examination of fossils and other materials indicates that
(a) Life has been in existence since the beginning of the earth
(b) Life appears to have been in existence for more than three billion years
(c) Life may not have existed on earth until about two billion years ago
(d) Life was transported on the earth from some other planets

43. Palaenotogical evidences suggest
a. New life forms arisen a different times on earth
b. Life forms aired over time
c. Certain life forms are restricted to certain geographical area
d. Different rock sediments contain different life forms
e. Fossils in different sedimentary layer indicate geological period of their existence
(a) a, b, c, d, e
(b) b, c, d, e
(c) a, b, c, d
(d) a, b, d, e



44. The ancestral reptiles giving rise to reptiles and mammals representing at A and B respectively are
(a) Therapsids and sauropsids
(b) Synapsids and Therapsids
(c) Sauropsids and Synapsids
(d) Therapsids and pelycosaurids

45. Animals that evolved into first amphibians are likely to be
(a) Jawless fishes
(b) Salamanders
(c) Toad fishes
(d) Lobefins

46. Select the incorrect match of event and its time span of occurrence

Event	Time span of occurrence
(a) Invertebrates formed and became active	500 myA
(b) Reptiles dominated earth	50 my A
(c) Dinosaurs disappeared from earth	65 myA
(d) Amphibians dominated	350 myA

47. Refer the given statements and select the correct ones
i. Carbon dating can only be done for dead organisms
ii. Fossils found in the upper layers are complex as compared to the ones present in deeper layer.
iii. Number of growth rings at base of the tree trunk helps in estimating age of a living tree.
iv. Study of fossils is called Palaeontology
(a) I, ii, iii and iv
(b) ii and iv
(c) I, iii and iv
(d) none of these

48. ___(i) ____are remains of hard parts of life forms found in ____(ii)____. Latter form sediments which arrange one over the other during the long history of earth. The study of (i) indicate the ___(iii) ____period in which certain organisms were present. This evidence

is called _____(iv)____. What are (i) – (iv) respectively?
(a) Fossil, oil, geographical, embryological
(b) Fossil, rock, geographical, embryological
(c) Fossil, rock, geological, Palaenotogical
(d) Fossil, ice, geological, morphological

49. How many of these are living, descendants of a sauropsids ancestor?
Python, Frog, Chameleon, Crocodiles, Darwin's finches, Tiger, Turtles, Elephant, Pteranodon, Parrot
(a) 8
(b) 9
(c) 6
(d) 7

50. Choose the incorrect pair of an organism and its description
(a) Archeopteryx – Had toothed beak
(b) Tyrannosaurus – Had dagger like teeth
(c) Latimeria – Lobefins evolved into first amphibians
(d) ichthyosaurus – Evolved from an aquatic ancestors

51. What statements is true about extinction of dinosaurs?
(a) They disappeared from earth around 200 mya
(b) Some dinosaurs evolved into birds
(c) Climatic changes had no role in their extinction most probably
(d) Both (a) and (b)

52. A series of fossils in the phylogeny of an animal were obtained and the scientist proposed its change in feeding from browsing to grazing. What change was observed in the fossils?
(a) Reduction in the size of canines
(b) Increase in size and complexity of molars
(c) Decrease in size and complexity of molars
(d) Increase in the size of canines

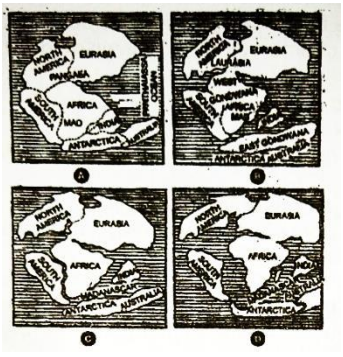
53. Ancestors of mammals appear to have diverged from the common reptilian ancestor (for all reptiles, brids and mammals) around which period
(a) Carboniferous
(b) Permian
(c) Triassic
(d) Jurassic

54. What is correct sequence of periods of palaeozoicera is descending order in geological time scale?
(a) Cambrian → Devonian → Ordovician → Silurian → Carboniferous → Permian
(b) Cambrian → Ordovician → Silurian → Devonian → Carboniferous →Permian
(c) Permian → Carboniferous → Devonian → Silurian → Ordovician → Cambrian
(d) Permian → Carboniferous → Silurian → Ordovician → Cambrian → Devonian

55. The existing lines that diverged from Thecodont ancestors include
(a) Crocodiles and dinosours
(b) Crocodiles and snakes
(c) Dinosours and birds
(d) Crocodiles and birds

56. Which of the following statement is incorrect regarding vertebrates evolution?
(a) Reptiles arose along many independent lines
(b) Amphibians could not survive exclusively on land because their eggs used to dry up in sun
(c) Lobe fins evolved into first amphibians
(d) Some of the amphibians came on land and went back in water to evolve into animals like lchthyosaurs

57. Survival of pouched mammals in Australia can attributed to
(a) Continental drift
(b) Ice age
(c) Continental elevation
(d) Presence of placentals on mainland

58. 

The transition from figure A to D showed
a. Earth was originally a single land mass
b. continental drift has occurred
c. Drifting resulted in phenomenon's of restriction. discontinuous distribution and adaptive radiation

d. drifting caused similar geography and different flora and fauna of various realms

(a) a, b, c & d
(b) a, b & c
(c) a, b & d
(d) a & d

59. Continents drift explains
(a) Mass extinction
(b) Distribution of fossils on earth
(c) Geographical upheavals
(d) All of these are correct

60. Which of the following is incorrect regarding mammalian evolution?
(a) When reptiles came down, mammals dominated earth
(b) North American mammals resembling horse, hippopotamus, bear, rabbit etc. were overridden by South American fauna
(c) First mammals were shrew like and their fossils were small sized
(d) Some mammals could adapt to live completely in water

61. What advantage do the mammals have over the reptiles?
(a) Mammals produce more offspring
(b) Mammals are larger in size
(c) Mammals protect their unborn inside the mother's body
(d) Mammals were less sensitive in sensing danger

62. Which of the following does not show adaptive convergence?
(a) Bobcat and Tasmanian tiger cat
(b) Lemur and spotted cuscus
(c) Flying phalanger and sugar glider
(d) Anteater and numbat

63. Find the correct match for the following animals showing convergent evolution
(a) Lemur and Tasmanian wolf
(b) Flying squirrel and Spotted cuscus
(c) Anteater and Numbat
(d) Bob cat and Marsupial mole

64. The small black birds noticed by Darwin on Galapagos Islands were originally
(a) Seed eating
(b) Insectivorous
(c) Piscivorous
(d) Herbivorous

65. Ancestors of lizards, birds and crocodiles were
(a) Thecodont s
(b) Synapsids
(c) Sauropsids
(d) Pelycosaurs

66. Tasmanian wolf and Sugar glider show
(a) Divergent evolution
(b) Convergent
(c) Adaptive radiation
(d) Both a and c

67. Which of the following statement is incorrect?
(a) Flying phalanger and flying squirrel are able to glide from tree to tree
(b) Numbat and anteater feed on ants
(c) Lemur and spotted cuscus are arboreal
(d) Bandicoot and wombat showed adaptive convergence

68. An incorrect pair is:
(a) Parallel evolution – Running habit in deer and horse
(b) Convergent evolution – Australian marsupials
(c) Divergent evolution – Placental mammals
(d) Adaptive radiation – Darwin's finches

69. Oxyhemoglobin crystals of vertebrates show relationship among vertebrates and are used as evidences from
(a) Cytology
(b) Biochemistry & physiology
(c) Taxonomy
(d) Genetics

70. Which one of the following similarities among vertebrates is the example of Biochemical evidence?
(a) Auricles and ventricles of heart
(b) Blood proteins and molecules of cell
(c) Morula and blastula formation
(d) Homologous organs.

71. The blood proteins of a peacock are closely related with which amniote?
(a) Crocodile
(b) Archaeopteryx
(c) Parrot
(d) Dinosaur

EXERCISE - 2

1. Study of the history of life forms on the earth is known as
   (a) Evolution
   (b) Evolutionary biology
   (c) Palaeobiology
   (d) Anthropology
2. When we are looking at starts which of the following statement do you find, is true?
   (a) We are apparently peeping into past
   (b) We are apparently peeping into future
   (c) We are looking into present
   (d) We are able to directly differentiate between present and past
3. The origin of universe dates back to almost
   (a) 4.5 billion years
   (b) 4000 million years
   (c) 20 billion years
   (d) 3.5 billion years
4. What is not true about big band theory?
   (a) It talks about single huge explosion
   (b) Expansion of universe and decrease in temperature
   (c) Formation of galaxies by expansion of gases
   (d) Formation of hydrogen and helium
5. Which of the following was there in primitive earth?
   (a) Ammonia and oxygen
   (b) Well develop ozone
   (c) Molecular oxygen
   (d) Hydrogen and methane
6. Early earth had
   a. No oxidising atmosphere
   b. Water vapours, methane, CO_2 and ammonia
   c. No free oxygen
   d. Free hydrogen
   (a) + , + , + , +
   (b) +, +, - , +
   (c) - , + , + , +
   (d) - , + , - , +
7. Origin of life occurred
   (a) Around 4 bya
   (b) 500 mya after the formation of earth
   (c) at the same time as the formation of earth
   (d) Both a & b
8. During primitive times, oceans contained (I) fishes (II) algae (III) water (IV) ammonia, methane and minerals
   (a) I and II
   (b) II and III
   (c) I and IV
   (d) III and IV
9. "Life has come from preexisting life" has been experimentally proved in
   (a) Theory of spontaneous generation
   (b) Theory of given by Greeks
   (c) Theory given by Oparin and Haldane
   (d) Theory given by L. Pasteur
10. First form of the life came from
    (a) Preexisting non living organic molecules
    (b) Cosmic dust of galaxies
    (c) Preexisting living organic molecules
    (d) Combination of various gases in early atomosphere
11. According to Oparin and Haldane formation of life was preceded by chemical evolution as
    (a) Diverse inorganic molecules are formed from organic molecules
    (b) Diverse inorganic molecules are formed from simple organic molecule
    (c) Diverse organic molecules are formed from inorganic molecules
    (d) All of these
12. Miller performed his experiment with
    (a) CH_4, H_2, NH_3 and water vapours at 1800°C
    (b) CH_4, H_2, NH_3 and water vapours at 800°C
    (c) CO_2, H_2, NH_3 and CO_2 vapours at 800°C
    (d) CO_2, CH_4, NH_3 and H_2 vapours at 1600°C
13. The end product obtained in Miller and Urey experiment was
    (a) Amino acid
    (b) Sugars
    (c) N – bases
    (d) Pigments
14. Analysis of meteorite content provide evidence for
    (a) No indication of life
    (b) Similar processes of biological evolution on earth and other planets
    (c) Similar process of chemical evolution for life has also occurred some where else
    (d) No new life could be possible on the earth
15. First cellular forms of life have originated in
    (a) Air
    (b) Soil

(c) Rocks
(d) Water

16. What is not true about connotations of special creation theory?
(a) All living beings are created as such
(b) No change in present and past forms
(c) Earth is 4000 years old
(d) Based ON Scientific proofs

17. According to Charles Darwin observations
a. Similarities exist of varying degree between present forms as well past forms
b. There is no change in diversity between present and past forms
c. New forms of life arose at different time periods
d. There has been abrupt evolution of life forms
The correct statements are
(a) a & b
(b) b & c
(c) a & c
(d) b & d

18. Mechanism of evolution implies
(a) Natural selection
(b) Biological selection
(c) Species selection
(d) Both a & b

19. The wings of a bird and the wings of an insect are
(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

20. Fossils are
(a) Remains of life forms is rocks
(b) Remains of hard parts of life form in rocks
(c) Remains of soft parts of life forms in rocks
(d) Both a & c

21. Different aged rock sediments suggest that
(a) Fossils of different life forms existed during different periods
(b) fossils of similar life forms that existed during different periods
(c) Living and non living life forms
(d) All of the above

22. Which of the following statements are true for paleontological evidences?
a. These are evidences gathered from fossils
b. New forms of life have arisen at different geological life spans
c. Life forms varied over the time with few exceptions
d. rocks of different age contain fossils of different life forms
(a) a, b, c & d
(b) a, b & c
(c) b, c & d
(d) a, b & d

23. Comparative anatomy and morphology show
(a) Similarities and differences amongst present forms only
(b) Similarities & differences amongst past forms only
(c) similarities and differences amongst past as well as present forms
(d) similarities and differences amongst past and extinct forms

24. Similarities in the patterns of bones of forelimbs of different vertebrates give reference for
(a) Paleontological evidences
(b) Biogeographical evidences
(c) Evidences from comparative anatomy & physiology
(d) Evidences from taxonomy

25. Homology indicate
(a) Common ancestory
(b) Different ancestory
(c) Common physiology
(d) Different anatomy

26. Which of the following pairs show homology?
a. Limbs of cheetah and whale
b. Throns of Bougainvillea and tendrils of Cucurbita
c. Wings of butterfly and pigeon
(a) a & b
(b) b & c
(c) a & c
(d) a, b & c

27. Homologous organs suggest
(a) Same strucutre developed along different directions due to differential adaptations
(b) same structure developed along different directions due to similar adaptations
(c) Different structure developed along different directions due to similar adaptations

(d) different structure developed along different directions due to differential adaptations

28. Homologous organs indicate
(a) Convergent evolution due to same needs
(b) Divergent evolution due to different needs
(c) Divergent evolution due to similar needs
(d) Convergent evolution due to different needs

29. Common ancestory is shown by
(a) Analogy
(b) Parallelism
(c) Homology
(d) Both a & b

30. Structures which are not anatomically similar but perform similar function are
(a) Homologous structure
(b) Analogous strucutre
(c) Vestigeal structure
(d) Both b & c

31. Flippers of penguins and fins of dog fish indicate analogy and help in understanding how
(a) Similar habitat has resulted in selection of similar adaptive feature
(b) Chance mutations can result in parallel evolution
(c) Divergent evolution or adaptive radiation occurs
(d) Similar structures evolve for divergent functions

32. Which of the following is not a correct match?
(a) Octopus eye & mammalian eye – Analogy
(b) Similarity in proteins - Homology
(c) Flipper of Penguins & Dolphins – Convergence
(d) Sweet potato and potato – Homology

33. Which of the following appeared later when the earth cooled down to temperature below 100℃?
(a) Lithosphere
(b) Atmosphere
(c) Stratosphere
(d) Hydrosphere

34. Abiogenesis stand for
(a) Life originates spontaneously from lifeless matter
(b) Life originates from pre – existing life
(c) Life originates by the super power of God
(d) Life originates through pan sperms

35. Mark the correct statement
(a) Darwin disapproved theory of special creation
(b) Father Saurez discarded the view of special creation
(c) Pasteur did his experiment on flesh
(d) Redi put forward the theory of special creation

36. Origin of life on earth through accidental invasion by primitive life forms as spores and microbes, probably existing throughout universe, is called
(a) Panspermia theory of Arrhenius
(b) Catalysm proposed by Cuvier
(c) Protobiogenesis theory by Haeckel
(d) Chemobiological theory by Oparin and Haldane

37. In the ancient atmosphere free C, N_2 and O_2 were not present because
(a) Of the large amount of H_2 and high temperature
(b) C would have combined with H to form CH_4
(c) Any free oxygen would have combined with hydrogen and carbon to form water CO_2
(d) All of these

38. Which of these is a true statement?
(a) The primitive atmosphere was an oxidizing one and today's is a reducing one, making photosynthesis possible
(b) The primitive atmosphere had 20% oxygen, just like it is today
(c) The reducing primitive atmosphere contributed to the origin of life, and the oxidizing one today would hinder it
(d) It took so long for prokaryote evolution because the primitive atomosphere screened out the ultraviolet radiation from the sun

39. The best theory which explains the origin of life and is based upon experiments
(a) Oparin Haldane theory
(b) Catastrophism
(c) Abiogenesis
(d) Biogenesis

40. The correct sequence for the manufacture of the molecules on the primitive earth is
(a) NH_3, protein, amino acids and nucleic acid
(b) NH_3, H_2 O, nucleic acid and protein
(c) NH_3, H_2 O, nucleic acid, protein, H_2 O
(d) Carbohydrates, H_2 O, NH_3 and amino acids

41. According to chemosynthetic generation theory, the sequence of origin of life may be considered as
(a) Amino acids, nucleoproteins, chlorophyll

(b) Chlorophyll, DNA, glycogen
(c) Nucleic acids, amino acids, chlorophyll
(d) Chlorophyll, nucleic acids, amino acids

42. The energy source for the creation of the first organic compounds came from
(a) Electric discharge
(b) UV light
(c) High temperature
(d) All of these

43. What happened to NH_3 present in primary atomosphere during its conversion to secondary atmosphere during its conversion to secondary atomosphere?
(a) Its concentration increased due to excessive formation of oxygen
(b) Most of it got oxidized to nitrogen oxides
(c) Got oxidized to N_2 and water
(d) Was absorbed by photo autotrophs

44. The major requirement for promoting polymerisation is
(a) Adequate source of energy
(b) Removal of water from the surface of reactant
(c) Oxidising atomosphere
(d) Both a and b

45. First eukaryotic cell probably acquired energy from
(a) Aerobic cellular respiration
(b) ATP in its environment
(c) Anaerobic cellular respiration
(d) ATP captured from prokaryotes

46. The first enzymes were
(a) Proteinaceous
(b) RNA molecules
(c) Inorganic
(d) Lipids

47. The category of molecules produced by the Miller – Urey experiments was
(a) Organic monomers
(b) Inorganic monomers
(c) Organic polymers
(d) Inorganic polymers

48. Which of the following mode of nutrition is most primitive?
(a) Chemoautotroph
(b) Chemoheterotroph
(c) Anaerobic photoautotroph
(d) Aerobic photoautotroph

49. Cyanobacteria are
(a) Most primitive organisms
(b) Virus infecting blue green algae
(c) First oxygenic photosynthetic organisms
(d) First anoxygenic photosynthetic organism

50. What is the supportive evidence for evolution from comparative embryology?
(a) All plant seeds look alike
(b) All embryos arise from the union of egg and sperm
(c) Different species have different embryos
(d) Different species develop along the pattern set by their common ancestor

51. Presence of gill slits in the embryos of all vertebrates supports the theory of
(a) Organic evolution
(b) Biogenesis
(c) Metamorphosis
(d) Recapitulation

52. Taxonomic position of a certain animal could only be determined through its larva as the adult showed highly simplified strucutre. The animal is showing
(a) Progressive metamorphosis
(b) Retrogressive metamorphosis
(c) Disruptive selection
(d) Both a and c

53. Comparative study of vertebrate organs favours which of the following
(a) Morphological and Anatomical evidences
(b) Paleontological evidences
(c) Biochemical evidences
(d) Biogeographical evidences

54. Analogous structures are the result of
(a) Divergent evolution
(b) Convergent evolution
(c) Adaptive convergence
(d) Both b and c

55. Which of the following is different from others?
(a) Flippers of penguins and dolphins
(b) Sweet potato and potato
(c) Eye of octopus and mammals
(d) Thorn of Bougainvillea and Tendrils of Cucurbita

56. Similarity in vertebrate hearts or brains indicate
(a) Common ancestory
(b) Similar habitat
(c) Similar habits
(d) All of these

57. Which statement about homologous traits is correct?

(a) Homologous traits are having common ancestory
(b) Homologous traits show divergent evolution
(c) Forelimbs of horse and man
(d) All of the above

58. Which of the following sets include analogous organ only?
(a) Wings of butterfly, sparrow and bat
(b) Legs of Locusta and house life, grass hopper and bat
(c) Hands of man, monkey and kangaroo
(d) Mandibles of cockroach, mosquito and honey bee

59. Beign all mammals, whale, dolphins, bat, monkey and horse some common characters but they also show conspicuous differences. This is due to phenomenon of
(a) Normalisation
(b) Parallel evolution
(c) Convergence
(d) Divergence

60. Flippers of dolphin and fins of penguins indicate analogy and help in understanding how
(a) Similar habitat has resulted in selection of similar adaptive feature
(b) Chance mutations can result in parallel evolution
(c) Divergent evolution or adaptive radiation occurs
(d) Similar structures evolve for divergent functions

61. Tasmanian wolf is a marsupial while wolf is a placental mammal. This shows
(a) Convergent evolution
(b) Divergent evolution
(c) Parallelism
(d) Inheritance of acquired characters

62. "In animals structure of different origin developed along similar directions due to adaptation to similar needs. This is _____ and these structures are _____." Complete the statement by using correct option
(a) Divergent evolution, homologous
(b) Parallel evolution, homoplastic
(c) Adaptive radiation, analogous
(d) Convergent evolution, analogous

63. Which of the following gives the correct evidence from connecting link?
(a) Ornithorhynchus – between amphibia and reptiles
(b) Balanoglossus – between protozoa and porifera
(c) Neopilina – between Mollusca and Echinodermata
(d) Peripatus – between annelids and arthropoda

64. Identify the correct statements pertaining to connecting links
a. Neopilina is connecting link between Annelida and Arthropoda
b. Peripatus is connecting link between Annelida and Mollusca
c. Latimeria is connecting link between pisces and amphibia
d. Tyrannosaurus is connecting link between reptiles and birds
(a) a, b & c
(b) c only
(c) a, b, & d
(d) d only

65. Connecting links occur between reptiles & birds and also between reptiles & mammals. This indicates
(a) Evolution of mammals from birds
(b) Evolution of reptiles from brids
(c) Evolution of reptiles from mammals
(d) Common ancestory of reptiles, brids & mammals

66. Appearance of ancestral character, such as tail in new born baby, thick hair, gill slits etc. is known as
(a) Homologous
(b) Analogous
(c) Vestigial
(d) Atavism

67. Which of the following is most sensitive and accurate method for dating the fossils
(a) Carbon strontium method
(b) Carbon dating method
(c) Electron spin resonance method
(d) Stratification method

68. Which will be true in sedimentary rocks?
(a) Upper strata older and lower younger
(b) Upper strata younger and lower older
(c) There is no stratification
(d) None of the above

69. Fossil remains of Archaeopteryx indicates that
(a) It was a flying reptile from Triassic

(b) It was a flying reptile from Permian
(c) Reptiles gave rise to birds during Permian
(d) Reptiles gave rise to birds during Jurassic

70. Which of the following group of structures shows its degenerative or non functional trait during course of evolution in man?
(a) Coccyx, vermiform appendix and ear muscles
(b) Wisdom tooth, canines and plica circulars
(c) Hairs, ear ossicles and vermiform appendix
(d) Pinna muscles, hairs and nails

71. Baby born with huge body hair and tail is the example of
(a) Phylogeny
(b) Ontogeny
(c) Atavism
(d) Analogy

72. Which one of the following set of muscles is the example of vestigial organs?
(a) Pinna muscles, appendicular muscles, body muscles
(b) Auricular muscles, abdominal muscles, eye muscles
(c) Nictitating muscles, pinna muscles, body muscles
(d) None of these

73. Certain group of organisms are most likely to be dominant in Paleozoic era. These include
(a) Fishes
(b) Amphibians
(c) Invertebrates
(d) All the above groups

74. Which animal group dominated in palaeozoic era?
(a) Reptiles
(b) Fishes
(c) Birds
(d) Mammals

75. Devonian period is age of
(a) Fishes
(b) Amphibians
(c) Reptiles
(d) Mammals

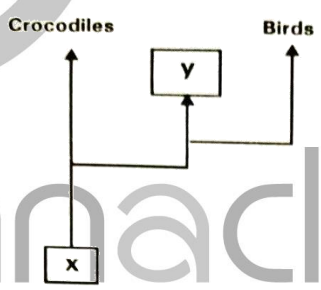
76. Mammals arose from reptiles in
(a) Jurassic period of Mesozoic era
(b) Triassic period of Mesozoic era
(c) Cretaceous period of Mesozoic era
(d) Carboniferous age

77. Given below is a series of steps during evolution of vertebrates. Identify the correct chronological sequence in which they occur
a. Early reptiles gave rise to sauropsids
b. Dinosaurs developed from thecodonts
c. Turtles evolved from sauropsids
(a) a – b – c
(b) a – c – b
(c) c – b – a
(d) b – a – c

78. Identify the incorrect statement
(a) Latimeria is connecting link between fishes and amphibians
(b) Some and reptiles evolved into fish like reptiles around 200 mya were Tyrannosaurus
(c) Jawless fish evolved about 350 mya
(d) None of these

79. In horse there has been an adaptation of reduction of toes from 5 to 1 on each foot, which is long and covered by a hoof. This toe is
(a) 1st
(b) 2nd
(c) 4th
(d) 3rd

80. Identify x and y



(a) Therapsids and mammals
(b) Therapsids an dinosaurs
(c) Sauropsids and Therapsids
(d) Thecodonts and dinosaurs

81. Evolution of horse from Hyracotherium involved
(a) Lengthening of limbs and increase in size
(b) Progressive loss of digits and lengthening of retained digits
(c) Increased complexity of molars
(d) All of the above

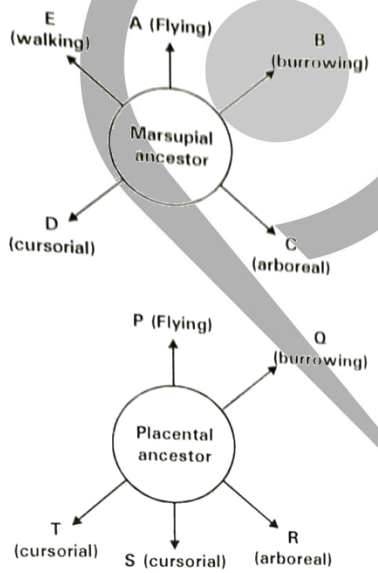
82. Most primitive fossil of horse is
(a) Equus
(b) Merychippus
(c) Meshoippus
(d) Eohippus

83. Which of the following is supposed to be biggest known fossils of reptiles?
(a) Stegosaurus
(b) Tyrannosaurus
(c) Pteranodon
(d) Brachiosaurus

84. The cretaceous period of Mesozoic era when dinosaurs became extinct occurred approximately
(a) 800 million yrs ago
(b) 280 million yrs ago
(c) 65 million yrs ago
(d) 550 million yrs ago

85. Convergent evolution is illustrated by
(a) Dogfish and whale
(b) rat and dog
(c) Bacterium and protozoan
(d) Starfish and cuttle fish

86. Study the following figures showing evolution of life forms A to E & P to T and identify correct statements



a. A and D show divergent evolution.
b. D and S show convergent evolution.
c. B and C show convergent evolution.
d. A, P and R show divergent evolution.
(a) a and b
(b) a and c
(c) a only
(d) d only

87. Due to continental drift
(a) North American fauna was overridden by South American fauna
(b) South American fauna was overridden by North American fauna
(c) South African fauna was overridden by North African fauna
(d) North African fauna was overridden by South African fauna

88. When more than one adaptive radiation appeared to have occurred in an isolated geographical area representing different habitat it is called
(a) Convergent evolution
(b) Adaptive radiation
(c) Natural selection
(d) Saltation

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

90. The name Galapagos islands has been given on the basis of occurrence of
(a) Black coloured lava
(b) Giant tortoises
(c) Giant iguanas
(d) All of these

91. Two geographical regions separated by high mountains are
(a) Oriental and Australian
(b) Palearctic and oriental
(c) Nearctic and palaearctic
(d) Neotropical and Ethiopian

92. Tulips & magnolias are examples of –
(a) Discontinuous distribution
(b) Parallel evolution
(c) Industrial mealnism
(d) Island fauna

93. Which of the following examples support the biogeographical evidences?
(a) Formation of various realms
(b) Restricted distribution of marsupials
(c) Darwin finches of Galapagos islands
(d) All of the above

94. Let in a scene of Jurassic period, dinosaurs roam in carboniferous forest, eating plants and being eaten by lions and tigers. Then above scene is FALSE because
(a) All dinosaurs were carnivorous
(b) Dinosaurs were aquatic, not found in forest
(c) Lions and tigers had not evolved by that time
(d) Lion and tigers were eliminated by dinosaurs

95. Evidence in favour of evolution can be obtained from
(a) Morphology and comparative anatomy
(b) Embryology and paleontology
(c) Taxonomy and biochemistry
(d) All of the above

96. Which of the following structures is a solid proof of organic evolution?
(a) Wings of bird and rats
(b) Jointed legs in arthropods and mammals
(c) Gill clefts in vertebrate embryos
(d) Excretory organs of earthworm and cockroach

97. In recent years, DNA sequence of mt – DNA & Y – chromosomes were considered for study of human evolution because they
(a) Can be studied from samples of fossil remains
(b) Are small & thus easy to study
(c) ARE uniparental in origin & do not take part in recombination
(d) Their structure is known in greater detail.

In the following questions, a statement of assertion (A) is followed by a statement of reason (R).
(A) If both Assertion and Reason are true and the reason is the correct explanation of the assertion, then mark 1
(B) If both Assertion and Reason are true but the reason is not the correct explanation of the assertion, then mark 2.
(C) If Assertion is true statement but Reason is false, then mark 3.
(D) If both Assertion and Reason are false, then mark 4.

98. A: Primitive atomosphere was having no free oxygen.
R: The primitive atomosphere was reducing in nature.

99. A: Each Coacervates is composed of macro molecules.
R: It was first living cell.

100. A: Protocell represented the beginning of life.
R: Protocell gave rise to prokaryotes.

101. A: It was cyanobacteria – like organism which in ancient time added oxygen to the atmosphere…
R: Cyanobacteria were oxygenic photoautotrophs.

102. A: After appearance of oxygen in the atmosphere, CH_3 and NH_3 began to disappear.
R: Oxygen is involved in forming ozone layers.

ANSWER KEY

EXERCISE – 1

Ques.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Ans.	c	d	a	b	a	b	d	c	d	a
Ques.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.
Ans.	d	b	b	a	a	c	d	d	c	b
Ques.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.
Ans.	a	b	d	a	d	b	a	a	b	b
Ques.	31.	32.	33.	34.	35.	36.	37.	38.	39.	40.
Ans.	c	c	d	d	b	b	b	a	d	b
Ques.	41.	42.	43.	44.	45.	46.	47.	48.	49.	50.
Ans.	b	b	a	c	d	b	b	c	c	d
Ques.	51.	52.	53.	54.	55.	56.	57.	58.	59.	60.
Ans.	b	b	a	c	d	d	a	b	d	b
Ques.	61.	62.	63.	64.	65.	66.	67.	68.	69.	70.
Ans.	c	c	c	a	c	d	d	b	b	b
Ques.	71.									
Ans.	c									

EXERCISE – 2

Ques.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Ans.	b	a	c	c	d	a	d	d	d	a
Ques.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.
Ans.	c	b	a	c	d	d	c	a	a	b
Ques.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.
Ans.	a	a	c	c	a	a	a	b	c	b
Ques.	31.	32.	33.	34.	35.	36.	37.	38.	39.	40.
Ans.	a	d	d	a	a	a	d	c	a	b
Ques.	41.	42.	43.	44.	45.	46.	47.	48.	49.	50.
Ans.	a	d	c	d	a	b	a	b	c	d
Ques.	51.	52.	53.	54.	55.	56.	57.	58.	59.	60.
Ans.	d	b	a	d	d	a	d	a	d	a
Ques.	61.	62.	63.	64.	65.	66.	67.	68.	69.	70.
Ans.	a	d	d	b	d	d	c	b	d	a
Ques.	71.	72.	73.	74.	75.	76.	77.	78.	79.	80.
Ans.	c	d	d	b	a	b	b	b	d	d
Ques.	81.	82.	83.	84.	85.	86.	87.	88.	89.	90.
Ans.	d	d	d	c	a	a	b	a	a	b
Ques.	91.	92.	93.	94.	95.	96.	97.	98.	99.	100.
Ans.	b	a	d	c	d	c	c	b	c	a
Ques.	101.	102.								
Ans.	a	b								