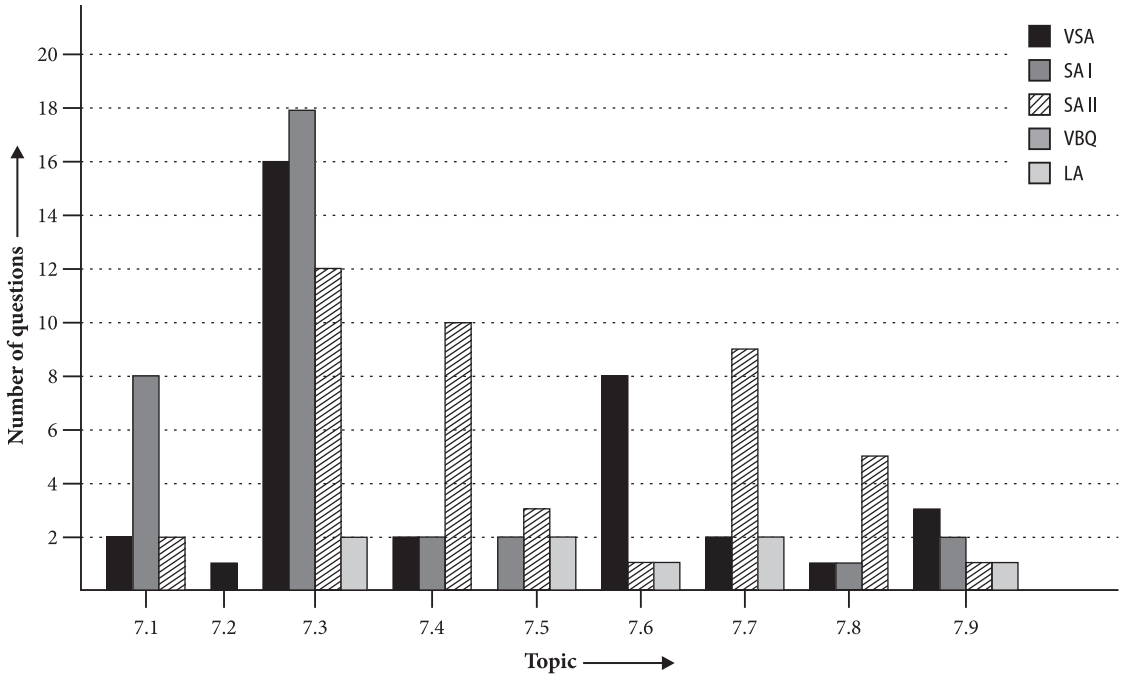
07 Evolution

Topicwise Analysis of Last 10 Years' CBSE Board Questions



- Maximum weightage is of *What are the Evidences for Evolution*?
- Maximum VSA, SAI and SAII type Questions were asked from *What are the Evidences for Evolution*?
- Maximum LA type questions were asked from *What are the evidences for Evolution?, Biological Evolution, Hardy-Weinberg Principle.*

QUICK RECAP

ORIGIN OF LIFE

Evolution (Gk. *e* - out, *volvere* - to roll) is unrolling or unfolding of nature that brings about an orderly change from one form or condition to another resulting in descendants becoming different from ancestors.

- Many theories were put forward to explain the origin of life.
- The origin of life is considered a unique trend in the history of universe.
- Most accepted theory to explain the origin of universe is the **Big-Bang theory** which was proposed by **Abbe Lemaitre** in 1931 according to which universe had an explosive beginning. Universe originated about 15 billion years ago by a big bang (thermonuclear explosion) of a dense entity. The universe expanded and hence the temperature came down. Hydrogen fused into progressively heavier atoms of different kinds of elements found today.
- **Panspermia theory** was proposed by Richter in 1865 according to which life came from outside in the form of spores.
- **Theory of spontaneous generation** believes that under certain conditions nonliving substances gave rise to living beings spontaneously. It was supported by many old scholars like **Thales**, **Anaximander**, **Aristotle**, **Plato**, **Epicurus**, etc. This theory was challenged by Francesco Redi, Spallanzani and Pasteur.
- **The modern hypothesis of origin of life was formulated by Haeckel.** This idea was elaborated in the chemical theory (in 1920s) by two workers independently : a Russian biochemist **A.I. Oparin** and an English biologist **J.B.S. Haldane.** It was summarised by Oparin in his book **"The Origin of Life"**.
- **Oparin and Haldane state that –**
  - Spontaneous generation of life under the present environmental conditions is not possible.
  - Earth's surface and atmosphere during the first billion years of its existence were radically different from today's conditions.
  - Earth's **initial atmosphere was a reducing one.**
- The Oparin-Haldane theory (also called **proto-biogenesis**) was experimentally supported by **Stanley Miller** in 1953**.**
- He created similar conditions in a laboratory scale. He created electric discharge in a closed flask containing CH_4, H_2, NH_3 and water vapour at 800°C. He observed formation of amino acids. In similar experiments others observed, formation of sugars, nitrogen bases, pigment and fats. With this limited evidence, the first part of the conjectured story, *i.e.,* chemical evolution was more or less accepted.
- The synthesis of carbohydrates, fats and amino acids and other complex organic substances probably occurred in sea, which had been described by Haldane as **'The hot dilute soup'. The formation of protein molecule is considered a land mark in the origin of life.**

Microsphere

The large organic molecules which were synthesised abiotically on primitive earth later came together, and due to intermolecular attraction, they formed large colloidal aggregates. Such water bound aggregates have been named **microspheres** by **Sydney Fox.**

Coacervate is an aggregate of macromolecules, such as proteins, lipids, and nucleic acids, that form a stable colloid unit with properties that resemble living matter.

- The first living organisms originated among organic molecules and in oxygen free atmosphere (reducing atmosphere). They were anaerobes capable of respiration in the absence of oxygen. They depended on the existing organic molecules for their nutrition and thus they were **heterotrophs.**
- When the supply of existing organic molecules was exhausted, some of the heterotrophs might have evolved into **autotrophs**.
- The prokaryotes gradually modified to adapt themselves according to new conditions. They developed a true nucleus and other specialised cell organelles. Thus free-living eukaryotic cell-like organisms originated in the ancient ocean, presumably about **1.5 billion years ago**.
- Primitive eukaryotes led to the evolution of protists, plants, fungi and animals. Life was present on earth about **3.9 billion years ago**.

THEORIES OF EVOLUTION

- To understand and explain the process of evolution various theories have been put forward by various scientists such as Lamarck, Darwin etc.

Neo-Lamarckism

- It is the modified form of Lamarckism supported by a number of scientists *viz* Spencer, Cope, Richard, Wells, Lawrence, Nageli, etc.

Lamarckism

First theory of evolution was proposed by **Jean Baptiste de Lamarck** in 1809 and was published in **'Philosophie Zoologique'**. It is popularly known as **'The Inheritance of Acquired Characters in Organisms'.** It can be defined as 'the changes in structure or function of any organ acquired during the life-time of an individual in response to changes in the surrounding environment which are inherited by its offspring and keep on adding up over a period of time'.

Assumptions of Lamarckism

(i) **Internal vital forces :** They lead to growth of living organisms.
(ii) **Effect of environment and new needs:** Changing environment gives rise to new needs in an individual.
(iii) **Use and disuse of organs :** Continuous use of an organ leads to its development and disuse results in degeneration.
(iv) **Inheritance of acquired characters:** Structural and functional changes acquired during lifetime of an individual are inherited by its offsprings which keep on accumulating and lead to origin of new species.

Evidences in favour of Lamarckism

- Disappearance of limbs in snake.
- Development of webbed toes in aquatic birds.
- Evolution of flightless birds from their flying ancestors.
- Reduction in mass of muscles of pinna in man, etc.

Evidences against Lamarckism

- Many times evolution shows reduction in size, *e.g.,* shrubs, herbs and grasses are smaller than trees although have evolved later.
- Experiments conducted by **August Weismann** discarded the law of inheritance of acquired characters. It proved that only characters affecting germ cells are inherited.

- According to it, the acquired characters which become incorporated in the germplasm are heritable and accumulate generation after generation resulting in the origin of new species.
- Neo-Lamarckism explains that germ cells may be affected by environment either directly or indirectly (*i.e.*, through somatic cells).

Modern Synthetic Theory

- **Dobzhansky (1937)** in his book '*Genetics and Origin of Species*' provided the initial basis of synthetic theory. 'Modern Synthetic Theory of Evolution' was designated by **Huxley in 1942.** According to synthetic theory there are five basic factors involved in the process of organic evolution.

I. Variations : Evolution occurs through the accumulation of genetic variations in the gene pool of population over long periods of time. The change in genes occurs in many ways such as mutations, genetic drift, gene migration, gene recombination and hybridisation.

(i) **Mutations :** Gene mutation is a random change in the base sequence of a gene.

Darwinism

- It is also known as **'Theory of Natural Selection'**.
- During his voyage by H.M.S. Beagle, Darwin sailed to the **Galapagos Islands** about 600 miles away from the west coast of South America. He observed that the common birds of Galapagos islands, the **finches**, were markedly different from the finches of main land and fossils of Galapagos islands are more similar to living species of South America. Here, Darwin found a living laboratory of evolution. The theory of natural selection was announced on June 30, 1858 by the English naturalist **Charles Darwin** (1809-1882) and **Alfred Russel Wallace** (1823-1913) in the paper **'Origin of Species by Means of Natural Selection'.**

Assumptions of Darwinism

(i)**Rapid multiplication :** All organisms possess enormous fertility and multiply in geometric ratios.
(ii)**Limited food and space :** Food and space remains almost constant. It affects survival of an individual.
(iii)**Struggle for existence :** Limited supply of food and space causes struggle for existence either between the individuals of same species, or different species or between organisms and environmental factors. Darwin emphasised on physical combat for the struggle for existence.
(iv)**Appearance of variations :** The everlasting struggle for existence compels organisms to change according to conditions in order to survive successfully. This produces variations among individuals.
(v)**Natural selection :** Organisms with favourable variations survive and are better adjusted to the changing environment. It has been called natural selection by Darwin and **survival of the fittest** by Herbert Spencer.
(vi) **Origin of species :** Useful variations keep on accumulating generation after generation and new species is formed.

Evidences in favour of Darwinism

- Higher rate of reproduction in all organisms.
- Limitation of food, space and other resources.
- Struggle for existence is seen in all organisms.
- Abundance of variations among individuals of a population.
- Mimicry and protective colouration in certain animals.
- Correlation between position of nectaries in flowers and length of proboscis in pollinating insects.

Evidences against Darwinism

- Darwin did not differentiate between somatic and germinal variations and considered all variations as heritable.
- Occurrence of organisms that remained unchanged for several million years.
- Occurrence of discontinuous variations.
- Arrival of the fittest cannot be explained.
- The effect of use and disuse and the presence of vestigial organs cannot be explained.

Mutation Theory

- Mutation theory was put forward by **Hugo de Vries** in 1901.
- According to this theory new species originates due to discontinuous variations (mutations) which appear suddenly.

Postulates of Mutation Theory

- Mutations appear suddenly in a naturally breeding population and produce their effects immediately.
- Mutations are heritable and establish new species.
- Mutations are subjected to natural selection where mutants found unsuitable are destroyed.

Evidences in favour of Mutation Theory

- Mutations have genetic basis and are therefore heritable.
- It explains both progressive and retrogressive evolution.
- Mutations have given rise to new varieties, *e.g.*, Ancon sheep, hornless cattle, hairless cats, dogs, etc.

Evidences against Mutation Theory

- Natural mutations are not common.
- Most of the mutations are negative or retrogressive.
- Mutation does not explain development of mimicry, etc.
- Mutations are generally recessive.

The mutated gene may give rise to a new protein or may fail to produce any. This may change the phenotype (trait). Gene variation results in change in gene frequency.

(ii) **Genetic drift :** The theory of genetic drift was developed by geneticist **Sewall Wright** in 1930. It is also called as **Sewall Wright Effect** or **scattering of variability**. Genetic drift refers to **chance elimination** of the genes of certain traits, independent of gene's useful or harmful effect when a section of population migrates or dies of natural calamity. It alters the gene frequency of the remaining population. Hence genetic drift is a mechanism of evolution that acts in concert with natural selection to change species characteristics over time. Two important examples of genetic drift are bottleneck effect and founder effect.

- **Bottle neck phenomenon :** The yearly or seasonal phenomenon of cyclic fluctuation in population density causing periodic squeezing of some of the genes in a gene pool in random fashion is called bottle neck phenomenon.
- **Founder effect :** When a few individuals or a small group of individuals from some large population invades a new or isolated geographical region, they become the **founders**. These founders carry on a limited portion of the parental gene pool. The descendants of the founder isolates in new area and tend to have allele ratios similar to the founders rather than to the source population.

(iii) **Gene migration (Gene flow) :** If the migrating individuals interbreed with the members of local population, these may bring many new alleles into the local gene pool of the host population. This is called **gene migration**. This addition or removal of alleles when individuals enter or leave a population from another locality is called **gene flow**.

(iv) **Gene recombination :** It occurs due to the dual parentage, independent assortment of chromosomes, crossing over during meiosis, random fusion of gametes and formation of new alleles.

(v) **Hybridisation:** It is the crossing of organisms which are genetically different in one or more traits (characters). It helps in intermingling of genes of different groups of the same variety, species and sometimes different species.

II. Inheritance of variation : Organisms possessing hereditary characteristics that are helpful, either in the animal's environment or in some other environment, are favoured in the struggle for existence. Thus, the offspring are able to benefit from the advantageous characteristics of their parents.

III. Natural selection : It is **differential reproduction** which means some members of population have traits (genes) that enable them to grow up and reproduce at a higher rate and leave more surviving offsprings in the next generation than others, *i.e.,* they are selected by nature. Based upon different organism-environment relationships, following different kinds of natural selections have been recognised.

- **Stabilising selection or Balancing selection:** It acts in the absence of large scale environmental change or directional changes for long period. It favours an intermediate form and eliminates the extreme variants.
- **Directional selection or Progressive selection:** It produces a regular change within a population in one direction in respect to certain characteristics. It favours the phenotype which is non-average or extreme and then pushes the phenotype of the population in that direction.
- **Disruptive selection or Diversifying selection:** It is just the opposite of stabilising selection *i.e.*, the extremes have more adaptable phenotypes than the average ones. Consequently, the original population is disrupted into two or more separate groups that later evolve into new species. If disruptive selection results in many new species then it is termed as **adaptive radiation**. This kind of selection is rare.

Industrial melanism : Industrial melanism can be explained briefly as follows:

- The peppered moth existed in two strains (forms) : light coloured (white) and melanic (black).

- In the past, bark of trees were covered by whitish lichens, so white moths escaped unnoticed from predatory birds.
- After industrialisation, barks got covered by smoke, so the white moths were selectively picked up by birds.
- But black moths escaped unnoticed so they managed to survive, resulting in more population of black moths and less population of white moths.
- Thus, industrial melanism supports evolution by natural selection.

IV. Reproductive isolation : It refers to the mechanisms which check the populations of two different species from interbreeding. The reproductive isolation, thus preserves the integrity of a species by checking hybridisation. It may, however, lead to the origin of new species by accumulation of genetic variations in a population. Reproductive isolation, thus, lets evolution to occur.

V. Speciation : The population of a species separated by geographical and physiological barriers, accumulate different genetic differences due to mutations, recombination, hybridisation, genetic drift and natural selection. These populations, therefore, undergo morphological and genetic differentiation, and eventually reproductive isolation, forming new species.

EVIDENCES OF EVOLUTION

- **Homology** is the similarity between organs of different animals based on common ancestry or common embryonic origin and built on the same fundamental pattern, but perform varied functions and have different appearance. *E.g.,* the flipper of a seal, wing of a bat, forelimb of a mole, front leg of horse and the arm of a man look very different, perform different functions, but exhibit the same structural plan including same bones.
- Study of homologous structures illustrates the occurrence of **adaptive radiation (divergent evolution)**.
- Adaptive radiation represents evolution of new forms in several directions from the common ancestral type (divergence).
- The **analogous organs** have almost similar appearance and perform the same function but these develop in totally different groups and are totally different in their basic structure and developmental origin. *E.g.,* wing of a butterfly, bird, pterodactyl and bat serve the same purpose of uplifting the body in the air, but their basic structure is totally different.
- Study of analogous structures illustrates the occurrence of **convergent evolution**.
- Homology in the embryos of closely related vertebrates, indicates evolutionary relationship of the adult vertebrates.
- **Haeckel** formulated the "**Recapitulation theory or Biogenetic Law**" regarding this. This theory says that "**ontogeny recapitulates phylogeny**", *i.e.*, life history recapitulates evolutionary history. This means an organism repeats its ancestral history during its development. For example, in the development of frog a fish-like tailed larva is formed, which swims with the tail and respires by gills. This indicates that the frog has been evolved from a fish-like ancestor.
- Living organisms possessing characters of two different groups of organisms are known as the **connecting links**. Examples – Viruses : between non-living and living, *Euglena*: between plants and animals, *Peripatus* : between annelida and arthropoda, *Balanoglossus* : between non-chordates and chordates, *Chimaera* : between cartilaginous and bony fishes. They give a hint about evolution of one group from the other. On the other hand, fossils that show combined features of two groups are termed missing links, *e.g.*, *Archaeopteryx*.
- Similarities in the **biochemical composition, reactions and physiological activities** are the most convincing evidences of common ancestry. Aspects of biochemistry that indicate biochemical affinity are **metabolic processes, enzymes, hormones, blood and lymph, blood proteins, blood groups and molecular homology.**
- The direct evidence of organic evolution comes from the study of fossils. The term fossil refers

to the **petrified remains** or **impressions of organisms** that lived in past and got preserved in the sedimentary rocks. These include bones, teeth, shells and other hard parts of animal or plant body, and also impressions or imprints left by previous organisms in the soft mud or the moulds and casts of entire organisms.

- **Palaeontology** is the study of past life based on fossil records. Their study reveals the existence of life in past and illustrates the course of evolution of plants and animals.
- Fossils can be arranged in chronological sequence according to their age only when their correct age is determined. The age of fossils is determined by **radioactive dating technique**.
- Geological time is a chronological order or history of evolution based upon the study of fossils. It has been divided into **eras, periods and epochs**. The fossil studies have given evidences of several mass extinctions.

HARDY-WEINBERG PRINCIPLE

- The genetic equilibrium is defined as– "The relative frequencies of various kinds of genes in a large and randomly mating sexual panmictic population tend to remain constant from generation to generation in the absence of mutation, selection and gene flow." This is called **Hardy-Weinberg principle** or **Hardy-Weinberg equilibrium**.
- In a population at equilibrium, for a locus with two alleles, D and d having frequencies of p and q, respectively, the genotype frequencies are: DD = p^2, Dd = 2pq, and dd = q^2.
- The two formulae are :

$$\boxed{p^2 + 2pq + q^2 = 1, \quad p + q = 1}$$

where,

p = Frequency of the dominant allele in the population.

q = Frequency of the recessive allele in the population.

p^2 = Percentage of homozygous dominant individuals.

q2 = Percentage of homozygous recessive individuals.

2pq = Percentage of heterozygous individuals.

1 = Sum total of all the allelic frequencies.

- Hardy-Weinberg's law describes a theoretical situation in which a population is undergoing no evolutionary change.
- Salient features of Hardy-Weinberg principle: (i) Random mating, (ii) Large population size, (iii) Biparental mode of reproduction, (iv) Homogeneous age structure.
- The gene frequency will remain static only in the absence of evolutionary forces like mutations, selection, genetic drift and migration.
- The basic timeline of a 4.6 billion year old Earth, with approximate dates:
  - 3.6 billion years of simple cells (prokaryotes),
  - 3.4 billion years of stromatolites demonstrating photosynthesis,
  - 2 billion years of complex cells (eukaryotes),
  - 1 billion year of multicellular life,
  - 600 million years of simple animals,
  - 570 million years of arthropods (ancestors of insects, arachnids and crustaceans),
  - 550 million years of complex animals,
  - 500 million years of fish and proto-amphibians,
  - 475 million years of land plants,
  - 400 million years of insects and seeds,
  - 360 million years of amphibians,
  - 300 million years of reptiles,
  - 200 million years of mammals,
  - 150 million years of birds,
  - 130 million years of flowers,
  - 65 million years since the dinosaurs died out,
  - 2.5 million years since the appearance of the genus *Homo*,
  - 25,000 years since the appearance of modern man.

HUMAN EVOLUTION

- Human evolution, or anthropogenesis, is the part of biological evolution concerning the emergence of *Homo sapiens* as a distinct species from other hominids, great apes and placental mammals.

Table : Summary of Human Phylogeny

	Name	Age of appearance	Cranial capacity (cm^3)	Food/Posture	Important features
1.	*Parapithecus*	40 million years, (Oligocene)	—	—	Has characters of tarsiers, and anthropoid called monkey ape, common ancester of man-ape-monkey.
2.	*Dryopithecus africanus* (Earliest fossil ape)	25 million years, (Miocene)	—	Soft fruits, leaves, knuckle walker	Muzzle and canines large, arms and legs equal-sized.
3.	*Ramapithecus* (earliest hominid fossil)	15 million years, (Miocene)	—	Seeds, nuts, semi-erect	Canines small, molars large, arboreal man like dentition.
4.	*Australopithecus africanus* (first ape-man)	5 million years, (Pliocene)	450	Essentially ate fruits, fully erect, 1.5 m.	Foramen magnum ventral, canines small, hunted small game.
5.	*Homo habilis* — (the first hominid tool maker)	2 million years, (Pleistocene) Early in Africa	650-800	Probably did not eat meat, fully erect	Canines small, earliest stone tools, hunted large game, Bipedal gait, cave-man led community life.
6.	*Homo erectus* - (the erect man) (java man)	1.5 million years, (Mid Pleistocene)	900	Probably ate meat 150-180 cm. tall	Thick, low forehead; brow ridges, used stone and bone tools, hunted big game.
7.	*Homo neanderthalensis* – (The Neanderthal man) (First civilized man)	100,000 to 40,000 years, (Pleistocene)	1400	Omnivorous, 1.5-1.66 m tall	Cave dweller, made flint flake tools, used hides as clothes, buried the dead, speech centres had developed, used syllabic language, prognathus face, chin absent.
8.	*Homo sapiens fossilis* – (the fossil modern man or Cro-Magnon man)	34,000 years Recent (Holocene)	1650	Omnivorous, 1.8m	Strong jaws with teeth close together, wisdom teeth, cave-dweller, paintings and carvings in caves, had art and culture, orthognathous face, broad pelvic basin, prominent chin.
9.	*Homo sapiens sapiens* – (the living modern man)	25,000 years (Holocene)	1300-1600	Omnivorous, 1.5-1.8m	Backbone with 4 curves; most intelligent; has art, culture, language.

Previous Years' CBSE Board Questions

7.1 Origin of Life

VSA (1 mark)

1. Write the hypothetical proposals put forth by Oparin and Haldane.

(*Foreign 2015*)

2. Name the scientist who disproved spontaneous generation theory.

(Delhi 2010)

SA I (2 marks)

3. What was proposed by Oparin and Haldane on origin of life? How did S.L. Miller's experiment support their proposal?

(Foreign 2014, Delhi 2011C)

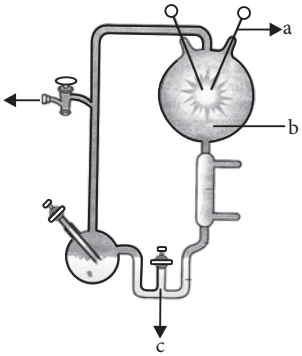
4. Mention the contribution of S.L. Miller's experiment on origin of life. *(AI 2013)*

5. Write the Oparin and Haldane's hypothesis about the origin of life on Earth. How does meteorite analysis favour this hypothesis?

(AI 2013)

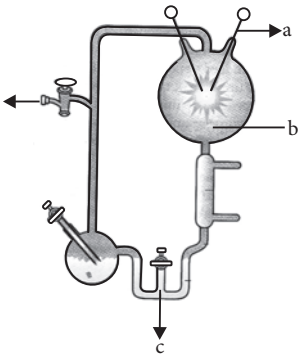
6. List the two main propositions of Oparin and Haldane. *(AI 2013)*

7. Name the scientist who has used the set-up shown. Write the purpose of 'a' in the set-up and the conclusion the scientist arrived at.



(Delhi 2013C)

8. The figure given represents Miller's apparatus used for his experiment. Name the chemicals found in the samples drawn from 'c'. How did this experiment support evolution?



(AI 2013C)

9. (a) Explain the theory of biogenesis.

(b) How did Miller demonstrate experimentally the chemical evolution that happened three billion years ago? *(Delhi 2010C)*

SA II (3 marks)

10. Describe the experiment that helped Louis Pasteur to dismiss the theory of spontaneous generation of life. *(Delhi 2016)*

11. State the theory of Biogenesis. How does Miller's experiment support this theory? *(Delhi 2012)*

7.2 Evolution of Life Forms-A Theory

VSA (1 mark)

12. How does 'fitness' of a population help in evolution?

(Delhi 2008C)

7.3 What are the Evidences for Evolution ?

VSA (1 mark)

13. State a reason for the increased population of dark coloured moths coinciding with the loss of lichens (on tree barks) during industrialisation period in England.

(Delhi 2015)

14. Why are analogous structures a result of convergent evolution?

(AI 2014)

15. Name the type of evolution that has resulted in the development of structures like wings of butterfly and bird. What are such structure called? *(Delhi 2014C)*

16. Identify the examples of convergent evolution from the following :
(a) Flippers of penguins and dolphins
(b) Eyes of octopus and mammals
(c) Vertebrate brains *(Delhi 2013)*

17. "Sweet potato tubers and potato tubers are the result of convergent evolution." Justify the statement. *(Delhi 2013)*

18. Identify the examples of homologous structures from the following.
(a) Vertebrate hearts
(b) Thorns in *Bougainvillea* and tendrils of *Cucurbita*.
(c) Food storage organs in sweet potato and potato. *(Delhi 2013)*

19. Write the similarity between the wing of a butterfly and the wing of a bat. What do you infer from the above with reference to evolution? *(Delhi 2012)*

20. State the significance of the study of fossils in evolution. *(Delhi 2012)*

21. State the significance of biochemical similarities amongst diverse organism in evolution. *(Delhi 2012)*

22. Comment on the similarity between the wing of a cockroach and the wing of a bird. What do you infer from the above, with reference to evolution? *(AI 2012)*

23. Explain convergent and divergent evolution with the help of one example of each. *(Delhi 2010)*

24. Mention the type of evolution that has brought the similarity as seen in potato tuber and sweet potato. *(Delhi 2009)*

25. Why are the wings of a butterfly and of a bat called analogous? *(Delhi 2009)*

26. Are the thorn of *Bougainvillea* and tendril of *Cucurbita* homologous or analogous? What type of evolution has brought such a similarity in them? *(Delhi 2009)*

27. Are the wing of a bird and the forelimb of a horse homologous or analogous? Name the type of evolution that explains the development of such structures. *(Foreign 2009)*

28. Name any two vertebrate body parts that are homologous to human forelimbs. *(AI 2008)*

SA I (2 marks)

29. (a) Select the homologous structures from the combinations given below :
(i) Forelimbs of whales and bats
(ii) Tuber of potato and sweet potato
(iii) Eyes of octopus and mammals
(iv) Thorns of *Bougainvillea* and tendrils of *Cucurbita*.
(b) State the kind of evolution they represent. *(AI 2015)*

30. Select two pairs from the following which exhibit divergent evolution. Give reasons for your answer.
(a) Forelimbs of cheetah and mammals.
(b) Flippers of dolphins and penguins.
(c) Wings of butterflies and birds.
(d) Forelimbs of whales and mammals. *(AI 2015)*

31. Explain divergent evolution with two examples. *(Foreign 2015)*

32. Is sweet potato analogous or homologous to potato tuber? Give reasons to support your answer. *(Delhi 2015C)*

33. Explain with the help of an example the type of evolution homology is based on. *(Delhi 2015C)*

34. State the evolutionary relationship giving reasons between the thorn of *Bougainvillea* and tendril of *Cucurbita*. *(AI 2015C)*

35. Identify the following pairs as homologous and analogous organs:
(a) Sweet potato and potato
(b) Eye of octopus and eye of mammals
(c) Thorns of *Bougainvillea* and tendrils of *Cucurbita*.
(d) Forelimbs of bat and whale. *(Delhi 2014)*

36. Explain how natural selection operates in nature by taking an example of white winged and dark winged moths of England. *(AI 2014C)*

37. Write about the ancestry and evolution of bat, horse and human on the basis of a comparative study of their forelimbs. What are these limbs categorised as? *(Delhi 2013 C)*

38. How does palaeontological evidences support evolution of organisms on earth? *(AI 2013C)*

39. What does the comparison between the eyes of octopus and those of mammals say about their ancestry and evolution? *(AI 2013C)*

40. In England, before industrialisation set in, there were more white winged moths than dark winged moths. However the number reversed in the same area when industrialisation set in. How does this observation support natural selection? *(AI 2013C, 2008C)*

41. Choose two pairs of homologous structures from the following and mention why they are so called :

(a) Hearts of humans and monkeys

(b) Eyes of octopus and mammals

(c) Thorns of *Bougainvillea* and tendrils of cucurbits

(d) Flippers of penguins and dolphins.

(Delhi 2012C)

42. Divergent evolution leads to homolgous structures. Explain with the help of an example. *(AI 2011C)*

43. Convergent evolution leads to analogous structures. Explain with the help of an example. *(AI 2011C)*

44. Why are thorn of *Bougainvillea* and tendrils of *Cucurbita* called homologous? What does this homology indicate? *(AI 2011C)*

45. What is divergent evolution? Explain taking an example of plants. *(Delhi 2008)*

SA II (3 marks)

46. Differentiate between homology and analogy. Give one example of each. *(AI 2016)*

47. Differentiate between divergent and convergent evolution. Give one example of each. *(AI 2016)*

48. Explain convergent evolution with the help of two examples. *(Foreign 2015)*

49. What are analogous structures? How are they different from homologous structures? Provide one example for each. *(Foreign 2015)*

50. How did industrialisation play a role in natural selection of light and dark coloured moth in England? *(Delhi 2015C)*

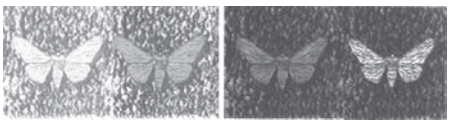
51. How does the study of fossils support evolution? Explain. *(AI 2015C)*

52. Explain convergent evolution taking one example for plants. *(Delhi 2012C)*

53. How does industrial melanism support Darwin's theory of natural selection? Explain. *(AI 2012C)*

54. Convergent evolution and divergent evolution are the two concepts explaining organic evolution. Explain each one with the help of an example. *(Foreign 2011)*

55.



(a) (b)

What do these pictures 'a' and 'b' illustrate with reference to evolution? Explain. *(Foreign 2009)*

56. Explain taking one example of vertebrate anatomy that evolution of life forms has occurred on earth. *(AI 2009C)*

57. The study of

(a) Fossils of dinosaurs

(b) Forelimbs of cheetah, bat, whale and human

(c) Thorns of *Bougainvillea* and tendril of *Cucurbita*.

Show that evolution of life forms has indeed taken place on earth. Explain. *(AI 2008C)*

LA (5 marks)

58. (a) Differentiate between analogy and homology giving one example each of plant and animal respectively.

(b) How are they considered as an evidence in support of evolution? *(Delhi 2016)*

59. (a) Anthropogenic actions have caused evolution of species. Explain with the help of two examples.

(b) Differentiate between divergent and convergent evolution. *(Delhi 2008C)*

7.4 What is Adaptive Radiation?

VSA (1 mark)

60. Write the term used for resemblance of varieties of placental mammals to corresponding marsupials in Australia.

(1/2, Delhi 2013C)

61. Name the placental mammals corresponding to the Australian 'Spotted cuscus' and Tasmanian 'tiger cat' which have evolved as a result of convergent evolution. *(AI 2008C)*

SA I (2 marks)

62. How do Darwin's finches illustrate adaptive radiation? *(AI 2008)*

63. What is adaptive radiation? How did Darwin explain this process of evolution?

(Delhi 2008C)

SA II (3 marks)

64. (a) How did Darwin explain adaptive radiation?

(b) Give another example exhibiting adaptive radiation. *(3/5, Delhi 2016)*

65. Explain adaptive radiation with the help of a suitable example. *(Delhi 2015)*

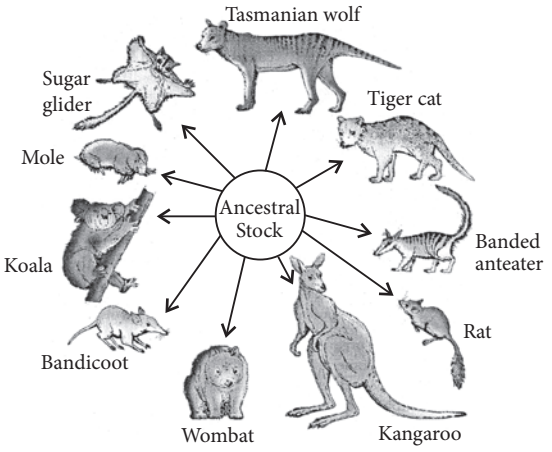
66. What is adaptive radiation? When can adaptive radiation be referred to as convergent evolution? Give an example. *(Delhi 2015)*

67. Explain the interpretation of Charles Darwin when he observed a variety of small black birds on Galapagos Islands. *(Delhi 2015)*

68. (a) Explain adaptive radiation with the help of a suitable example.

(b) Cite an example where more than one adaptive radiation have occurred in an isolated geographical area. Name the type of a evolution your example depict and state why it is so named. *(AI 2014)*

69. Name and explain the evolutionary concept represented in the illustration given below:



(AI 2012)

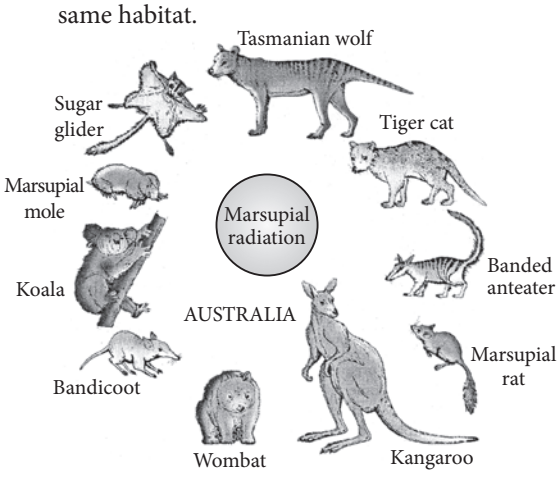
70. Australian marsupials and placental mammals are suitable examples of adaptive radiation and convergent evolution. Explain giving reasons.

(AI 2010C)

71. (a) Mention the specific geographical region where these organisms are found.

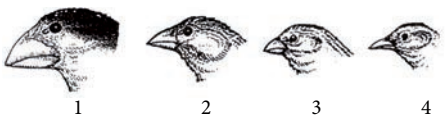
(b) Name and explain the phenomenon that has resulted in the evolution of such diverse species in the region.

(c) Explain giving reasons the existence of placental wolf and Tasmanian wolf sharing the same habitat.



(Delhi 2009)

72.



(a) Write your observations on the variations seen in the Darwin's finches shown above.

(b) How did Darwin explain the existence of different varieties of finches on Galapagos Islands? *(AI 2009)*

73. Darwin observed a variety of beaks in small black birds inhabiting Galapagos Islands. Explain what conclusions did he draw and how. *(AI 2009C)*

7.5 Biological Evolution

SA I (2 marks)

74. Name the scientist who influenced Darwin and how? *(2/5, Delhi 2016)*

75. Explain Darwinian theory of evolution with the help of one suitable example. State the two key concept of the theory. *(2/5, Delhi 2014)*

SA II (3 marks)

76. Branching descent and natural selection are the two key concepts of Darwinian theory of evolution. Explain each concept with the help of suitable example. *(AI 2011)*

77. Fitness is the end result of the ability to adapt and get selected by nature. Explain with suitable example. *(Delhi 2010)*

78. (a) Natural selection operates when nature selects for fitness. Explain.

(b) The rate of appearance of new forms is linked to the life span of an organism. Explain with the help of a suitable example. *(Delhi 2010)*

79. "Nature selects for fitness". Explain with suitable example. *(3/5, AI 2009C)*

80. How does Darwin's theory of natural selection explain the appearance of new forms of life on earth? *(AI 2008)*

7.6 Mechanism of Evolution

VSA (1 mark)

81. According to De-Vries what is saltation? *(Delhi 2016, 2014C)*

82. Write the basis of origin of variations in organisms as described by Hugo de Vries. *(AI 2013C)*

83. Mention how is mutation theory of Hugo de Vries different from Darwin's theory of natural selection. *(Foreign 2011)*

84. List the two characteristics of mutation that help in explaining evolution. *(Delhi 2011C)*

85. Mention the key concepts about the mechanism of biological evolution/speciation according to (a) de Vries and (b) Darwin. *(Delhi 2010C)*

86. Mention what caused evolution according to de Vries. *(AI 2009C)*

87. What causes speciation according to Hugo de Vries? *(Delhi 2008)*

SA II (3 marks)

88. Describe the mechanism of evolution as explained by Hugo de Vries. *(AI 2012C)*

LA (5 marks)

89. (a) Explain the salient features of Hugo de Vries theory of mutation.

(b) How is Darwin's theory of natural selection different from it? Explain. *(Delhi 2011)*

7.7 Hardy-Weinberg Principle

VSA (1 mark)

90. How does a population become 'founders' of a new species? *(AI 2012C)*

91. According to Hardy-Weinberg's principle the allele frequency of a population remains constant. How do you interpret the change of frequency of alleles in a population? *(AI 2009)*

SA II (3 marks)

92. What does the following equation represent? Explain.

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

(AI 2015, 2011C)

93. Describe the three different ways by which natural selection can affect the frequency of a heritable trait in a population. *(Foreign 2014, AI 2011C)*

94. (a) Describe Hardy-Weinberg Principle.
(b) List any four factors which affect genetic equilibrium.
(c) Describe founder effect. *(Foreign 2014)*

95. Giving three reasons, write how Hardy-Weinberg equilibrium can be affected. *(AI 2014C)*

96. (a) How does the Hardy-Weinberg's expression ($p^2 + 2pq + q^2 = 1$) explain that genetic equilibrium is maintained in a population?
(b) List any two factors that can disturb the genetic equilibrium. *(AI 2010)*

97. (a) How did Hardy-Weinberg explain that allelic frequencies in a population are stable and are constant from generation to generation?
(b) Why does genetic equilibrium get disturbed in a population? Give reason. *(AI 2008C)*

98. How is genetic drift different from gene migration? Explain *(AI 2008C)*

LA (5 marks)

99. How does the process of natural selection affect Hardy-Weinberg equilibrium? Explain. List the other four factors that disturb the equilibrium. *(AI 2013)*

100. How does the shift in Hardy-Weinberg equation lead to founder affect? Explain. (Delhi 2011C)

7.8 A Brief Account of Evolution

VSA (1 mark)

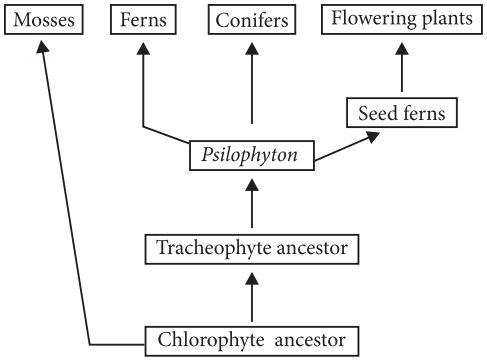
101. Coelacanth was caught in 1938 in South Africa. Why it is very significant in the evolutionary history of vertebrates? *(AI 2010C)*

SA I (2 marks)

102. Rearrange the following in increasing order of evolution :
Gnetales; Ferns; *Zosterophyllum; Ginkgo* *(AI 2014C)*

SA II (3 marks)

103. Study the schematic representation of evolutionary history of plant forms given below and mention :



(a) The plant form Ferns and Conifers are most related to.
(b) The nearest ancestors of flowering plants.
(c) The most primitive group of plants.
(d) Common ancestry of *Psilophyton* provides to.
(e) The common ancestor of *Psilophyton* and seed ferns.
(f) The common ancestors of mosses and tracheophytes. *(Delhi 2012C)*

104. Discovery of lobefins is considered very significant by evolutionary biologists. Explain. *(Delhi 2009C)*

105. (a) Rearrange the following in an ascending order of evolutionary tree:
reptiles, salmander, lobefins, frogs
(b) Name two reproductive characters that probably make reptiles more successful than amphibians. *(AI 2009C)*

7.9 Origin and Evolution of Man

VSA (1 mark)

106. Write the probable differences in eating habits of *Homo habilis* and *Homo erectus*. *(AI 2016)*

107. Name the common ancestor of the great apes and man. *(AI 2011)*

108.
1.5 mya – Java man
Homo habilis – more man like
2 mya – *Australopithecus* – hunted with stones

Study the ladder of human evolution given above and answer the following questions.

(a) Where did *Australopithecus* evolve?

(b) Write the scientific name of Java man.

(Delhi 2010C)

SA I (2 marks)

109. Name the first human like hominid. Mention his food habit and brain capacity. *(AI 2015C)*

110. Name the ancestors of a man based on the features given below :

(a) Human like, meat-eater with 900 cc brain, lived in Java.

(b) More human with brain size 1400 cc, lived in Central Asia, used hides and buried their dead.

(c) Human like, vegetarian, with brain capacity between 650 cc and 800 cc.

(d) Man like primate, that existed about 15 mya. Fossils found in Tanzania.

(AI 2013C)

SA II (3 marks)

111. Mention any three characteristics of Neanderthal man that lived in near East and Central Asia.

(3/5, Delhi 2014)

LA (5 marks)

112. (a) Name the primates that lived about 15 million years ago. List their characteristic features.

(b) (i) Where was the first man-like animal found?

(ii) When did modern *Homo sapiens* appear on this planet? *(Delhi 2011)*

Detailed Solutions

1. Hypothetical proposals given by Oparin and Haldane :
(i) Life originated spontaneously from pre-existing non-living organic molecules.
(ii) Formation of life was preceded by chemical evolution.

2. Louis Pasteur disproved spontaneous generation theory and proved biogenesis.

3. Oparin of Russia and Haldane of England proposed that the first form of life could have originated from pre-existing non-living organic molecules (*e.g.* RNA, protein, etc.) and that formation of life was preceded by chemical evolution. *i.e.*, formation of diverse organic molecules from inorganic constituents.
The Oparin-Haldane theory (also called chemical theory or naturalistic theory) was experimentally supported by Stanley Miller. Miller created laboratory conditions similar to primitive earth. Miller used mixture of methane, ammonia, hydrogen and water in an air tight apparatus and passed electrical discharged from electrodes at 800 °C. He passed the mixture through a condenser. He circulated the gases in same way for about a week and then analysed the contents. Formation of simple organic compounds supported chemical evolution of life.

4. Miller's experiment supported chemical evolution of life. He experimentally showed formation of complex organic molecules from simple inorganic compounds. In a closed flask, he circulated mixture of four gases (H_2, CH_4, NH_4 and water vapour) and passed electric current through it at 800°C. Formation of some amino acids, proved that organic compounds were basis of life.

5. Oparin and Haldane proposed that life originates from pre-existing non-living organic molecules, such as RNA, proteins etc. and formation of life was preceded by chemical evolution. Meteroite analysis confirmed presence of similar compounds elsewhere in space, maintaining that, life had reached earth in form of spores from other heavenly bodies.

6. *Refer to answer 3.*

7. Stanley Miller had used the set up shown. In the figure 'a' represents electrodes, used for simulation of lightning. From the experiment, Miller concluded that complex organic molecules were formed from simple inorganic molecules.

8. Sample drawn from 'c' contained simple organic compounds containing amino acids like alanine, glycine and aspartic acid. This experiment proved chemical evolution of life. Miller proved that organic compounds were basis of life and organic compounds were formed from simple inorganic compounds.

9. (a) Louis Pasteur disapproved abiogenesis (spontaneous generation) and put forth the Theory of biogenesis, which states that life originated from pre-existing life. He took broth in a long necked flask and then he bent its neck (swan neck). He boiled the broth in this flask to kill any microorganisms that might be present in it. This flask was kept for months but, no life appeared, as the germ laden dust particles in the air were trapped by the curved neck of the flask that served as filter. If the swan neck was broken off, the broth developed colonies of moulds and bacteria. Thus, he showed that the source of the microorganisms for fermentation or putrefaction was the air and the organisms did not arise from the nutrient media.
(b) Stanley Miller (1953), designed an apparatus for simulating conditions prevalent on earth at the time of abiogenic evolution of organic substances. The apparatus had a spark chamber with two electrodes (for simulation of lightning), a flask for boiling (simulation for evaporation and circulation) and a condenser. A control apparatus was also prepared but without electrodes in the spark chamber. Miller used a mixture of methane, ammonia, hydrogen and water in this apparatus. The mixture was exposed to electric discharges, followed by condensation. It was continued for one week. The experiment was repeated a number of times. The products were extracted and identified through chromatography. He found a large number of simple organic compounds including some amino acids such as alanine, glycine and aspartic aid. Miller proved that organic compounds were basis of life and organic compounds were formed from simple inorganic compounds.

10. *Refer to answer 9 (a).*

11. Theory of biogenesis states that life originated from pre-existing forms. *Refer to answer 9 (b).*

12. The fittest organisms, *i.e.,* the organism with beneficial variations, survives and adapts to ever changing harsh environmental condition. Therefore, fit bettter in an environment, produce more progeny and therefore will survive and hence are selected by the nature.

13. During industrialisation period in England, in the industrial areas, sulphur dioxide pollution from the burning of coal killed the lichens growing on the trees, exposing the darker bark which was further darkened by falling smoke particles. So, white moths were selectively picked up by birds and black moths escaped unnoticed and managed to survive resulting in more population of black moth than white moth.

14. Analogous organs are a result of convergent evolution. Convergent evolution is development of similar adaptive functional structures in unrelated group of organisms. *e.g.,* wings of an insect and wings of bird show convergent evolution, both have similar function but different basic structure.

15. *Refer to answer 14.*

16. (a) Flippers of penguins and dolphins and (b) eyes of octopus and mammals are analogous organs showing convergent evolution.

17. Sweet potato tubers (root modification) and potato tubers (stem modification) shows convergent evolution as both have different structure but perform similar function of storing food. Thus, these structures are analogous.

18. (a) Vertebrate hearts and (b) thorns of *Bougainvillea* and tendrils of *Cucurbita* are homologous organs, indicating common ancestry.

19. Wing of butterfly and wing of bat are analogous organs as they perform similar function of flying but have different origin and structures. Wings of butterfly are composed to chitinous membranes while wings of bat are composed of bony skeleton. This infer that they represent convergent evolution.

20. Fossils are remains of organisms of the past buried in different strata of the earth. The study of fossils helps in understanding about the past life.
(i) The fossil records have helped in reconstructing the phylogeny of many organisms *e.g.*, of horse, elephant and man.
(ii) Fossils also indicate the connecting links between two groups of organisms e.g. Archaeopteryx shows features of both reptiles and birds.

21. Similarities in proteins and genes performing a given function among diverse organisms give clues to common ancestry. Biochemical similarities point to the same shared ancestry as structural similarities among diverse organisms and hence show common ancestry and evolution of different groups of organisms.

22. Wing of a cockroach and wing of bird are analogous organs as they have different basic structure but perform same function, and thus show convergent evolution.

23. Divergent evolution is development of different functional structures from a common ancestral form. It represents adaptive radiation. Homologous organs show adaptive radiation or divergent evolution *E.g.*, Darwin's finches of the Galapagos islands. They had common ancestors but now have different types of modified beaks according to their food habits.
Convergent evolution is development of similar adaptive functional structures in unrelated groups of organisms. It is called adaptive convergence or convergent evolution. *E.g.*, wings of insect, bird and bat.

24. *Refer to answer 17.*

25. *Refer to answer 19.*

26. Thorn of *Bougainvillea* and tendril of *Cucurbita* are homologous organs. They both arise from axillary position but they perform different functions. Thorns provide protection and tendrils provide support. They have anatomical similarity but differ functionally. Divergent evolution has brought such a similarity in them.

27. Wing of bird and the forelimb of horse are homologous organs, as both have same fundamental structures but have different functions *i.e.*, for flying in bird and in horse for running. Homology indicates common ancestry and shows divergent evolution.

28. Forelimbs of whale and wings of birds are homologous to human's forelimbs.

29. (a) (i) Forelimbs of whales and bats and (iv) thorns of *Bougainvillea* and tendrils of *Curcurbita* are homologous organs.

(b) These structures represent divergent evolution, indicating common ancestry, having same fundamental structure but different function.

30. The organs which exhibit divergent evolution are:

(a) Forelimbs of cheetah and mammals

(d) Forelimbs of whales and mammals

Whales, cheetah, bat and human (all mammals) share similarities in the pattern of bones of forelimbs. Though these forelimbs perform different functions in these animals, they have similar anatomical structure *i.e.*, all of them have humerus, radius, ulna, carpals, metacarpals and phalanges in their forelimbs. Hence, in these animals, the same structure developed along different directions due to adaptations to different needs. This is divergent evolution and these structures are homologous.

31. Divergent evolution is development of different functional structures from a common ancestral form. It represents adaptive radiation. Homologous organs show adaptive radiation. *E.g.*, Darwin's finches of the Galapagos islands. They had common ancestors but now have different types of modified beaks according to their food habits. Locomotion in mammals is also an example of divergent evolution, as forelimbs of cheetah, whale, bat and man have same structural plan but different functions.

32. *Refer to answer 17*.

33. Homology is based on divergent evolution. It indicates common ancestry. Homologous organs have the same fundamental structure but are different in functions. These organs follow the same basic plan of organisation during their development. But in the adult condition, these organs are modified to perform different functions as an adaptation to different environments. Examples : The forelimbs of man, cheetah, whale and bat have the same basic structural plan. But have different shapes and functions.

34. *Refer to answer 26*.

35. Homologous organs : (c) Thorns of *Bougainvillea* and tendrils of *Cucurbita*, (d) forelimbs of bat and whale.

Analogous organs: (a) Sweet potato and potato, (b) eye of Octopus and eye of mammals.

36. Natural selection is the process by which those organisms that are best suited to their environment and are able to reproduce well in changed environmental conditions, survive. One of the most striking examples, which demonstrates the action of natural selection in the wild is the case of peppered moth, *Biston betularia* that lives in all parts of England.

Due to industrial smoke and soot the pale tree trunks became more and more blackened. As a result, the light moths stood out in contrast to its background, increasing the possibility of being easily detected and eaten by their predators, such as birds, in much greater number than the dark melanic variety. Decrease in the number of light winged moths and increase in the number of dark variety was the ultimate result. Therefore, evolution favoured the dark winged melanic moths to reproduce more successfully for their adaptation in the polluted areas of England. Evolution of darker form in response to industrial pollution is known as industrial melanism.

37. Comparative study of forelimbs of bat, horse and human shows common ancestry or common embryonic origin. Bat, horse and human share similarities in the pattern of bones of forelimbs, as they have similar anatomical structure—humerus, radius, ulna, carpals, metacarpals, and phalanges, but perform different functions, (in bat for flying, running in horse and walking in humans). These limbs are categorised as homologous organs as same structure developed along different directions due to adaptations to different needs.

38. Palaeontology is the study of past life based on fossil records. Their study reveals the type of life forms in past and illustrates the course of evolution of plants and animals.

The distribution of fossils in the rocks of different ages fully supports the concept of evolution.

It shows that wing forms became more and more complex as we proceed from earliest to recent. From the fossil records it has been concluded that evolution has taken place from simple to complex in a gradual manner.

39. Eyes of octopus and mammals are analogous organs, which represent convergent evolution, *i.e.*, development of similar adaptive functional structures in unrelated group of organisms. These organs have different structure but perform similar functions.

40. *Refer to answer 36.*

41. (a) Vertebrate hearts *i.e.,* hearts of humans and monkeys and (b) thorns of *Bougainvillea* and tendrils of cucurbits are homologous organs, as they have same structure but perform different functions.

42. Divergent evolution is development of different functional structures from common ancestral form, as the ancestors migrated to different habitats and organs became modified in adaptations to new requirements. *i.e.*, homologous organs. Different mouth parts of some insects. The mouth parts of cockroach, honey bee, mosquito and butterfly have the same fundamental part. In each of these insects, the mouth parts comprise labrum, a pair of mandibles and two pairs of maxillae, but they have different functions to perform, keeping in view their different feeding habits. The mouth parts in cockroach are adapted for biting and chewing. In honey-bee for chewing and lapping, in mosquito for piercing and sucking, in house-fly for sponging and in butterfly for siphoning.

43. Convergent evolution is development of similar adaptive functional structure in unrelated groups of organisms, resulting in analogous organs in unrelated organisms, which have similar functions but different developmental patterns. *E.g.*, the wings of bee, bird and bat.

44. Thorns of *Bougainvillea* and tendrils of *Cucurbita* are homologous organs, as both arise in the axillary position but are modified for different functions. Thorns for protection and tendrils as support for climbing. Thus, homology indicates common ancestry and relationship between different groups. Difference in appearance are due to divergent evolution *i.e.,* the ancestors migrated to different habitats and organs became modified in adaptations to new requirements.

45. When lineages split and evolve along separate adaptive pathways showing increased morphological differences in a given biospace, it is called as divergent evolution. Thorns of *Bougainvillea* and tendrils of *Passiflora* are modified branches and are axillary in position. It means axillary branches in *Bougainvillea* are modified into thorns for protection from burrowing animals and in *Passiflora* into tendrils for climbing. Presence of homologous organs in different groups confirms that difference in appearance is due to divergent evolution, *i.e.,* the ancestors migrated to different habitats and organs became modified in adaptation to new requirements.

46. The differences between homology and analogy are as follows :

	Homology	**Analogy**
(i)	Homology is the similarity between organs of different animals based on common ancestry or common embryonic origin and built on same fundamental pattern, but perform varied functions and have different appearance.	Analogy is almost similar appearance of organs performing similar function but develop in totally different groups and have totally different basic structure and developmental origin.
(ii)	It illustrates divergent evolution.	It illustrates convergent evolution.
(iii)	*E.g.,*thorns of *Bougainvillea* and tendrils of *Cucurbita*.	*E.g.,*Sweet potato and potato.

47. Difference between divergent evolution and convergent evolution.

	Divergent Evolution	**Convergent evolution**
(i)	Development of different functional structures from a common ancestral form.	Development of similar adaptive functional structures in unrelated groups of organisms.
(ii)	Homologous organs show divergent evolution.	Analogous organs show convergent evolution.
(iii)	Examples: Darwin's finches, Australian Marsupials, locomotion in mammals.	Examples: Australian Marsupials and placental mammals, various aquatic vertebrates and wings of insect, bird and bat.

48. *Refer to answers* 43 and 47.

49. Difference between analogous structures and homologous structures.

	Analogous structures	**Homologous structures**
(i)	They show superficial resemblance.	They differ morphologically.
(ii)	Their internal structure is quite different.	They have similar internal structure.
(iii)	They develop in unrelated organisms.	They develop in related organisms.
(iv)	Stages in the development are different.	Stages in the development are similar.
(v)	They have similar functions.	They perform different functions.
(vi)	They have dissimilar development pattern.	They have similar development pattern.
(vii)	Analogous organs show convergent evolution.	Homologous organs show adaptive radiation (divergent evolution).
(viii)	Example wings of insects and wings of birds.	Example : vertebrate forelimbs.

50. *Refer to answer 36.*

51. Fossils refer to the petrified remains or impressions of organisms that lived in past and got preserved in the sedimentary rocks. These include bones, teeth, shells and other hard parts of animal or plant body, and also any impressions or imprints left by previous organisms in the soft mud or the moulds and casts of entire organisms. *Also refer to answer 38.*

52. Convergent evolution refers to the development of similar adaptive functional structures in unrelated group of organisms. It is also called adaptive convergence. *E.g.*, The cladode of *Ruscus* are analogous to leaves of other plants. Both look alike and perform the same function of photosynthesis but are different in origin.

53. *Refer to answer 36.*

54. *Refer to answer 47.*

55. In picture 'a' the light-coloured species is well adapted to the lighter background of the lichen covered trunks of trees. Here it is not seen by the predatory birds. In contrast, the dark winged moths are quite visible against the lighter background hence, are spotted and picked by the predatory birds. In the industrial areas, as in picture 'b' sulphur dioxide pollution from the burning of coal killed the lichens growing on the trees, exposing the darker bark, which was further darkened by the falling smoke particles. Against a dark background, the light-coloured moths are conspicuous and are picked up by the predatory birds. For the survival, nature has favoured the dark-coloured melanic species from the light-coloured species. The former has a much better chance of survival under the new conditions created by pollution.

56. Study of comparative anatomy and morphology shows similarity and differences among organisms of today and those that existed millions of years ago. These informations give a clue to whether a common ancestor was shared or not. Development of many vertebrate organs (*e.g.*, heart, brain, kidney) indicate the possible path of evolution as well as the common ancestry of vertebrates. For example, during its development, the heart of a mammal or bird is initially two-chambered (as in fishes), then three-chambered (as in amphibians and some reptiles) and ultimately four-chambered. It clearly shows that birds and mammals have originated from fishes through amphibians and reptiles.

57. (i) Fossils of dinosaurs - Dinosaurs are organisms that existed in the past but are now extinct. The 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.

(ii) Forelimbs of cheetah, bat, whale and human are homologous organs as they share similarities in the pattern of bones, though these perform different functions. This shows divergent evolution.

(iii) Thorns of *Bougainvillea* and tendrils of *Cucurbita* are also homologous structures as they both arise from axillary position but in *Bougainvillea*

it helps in prolection but in *Cucurbita* it helps in support. Homology shows divergent evolution.

58. (a) The differences between homology and analogy are as follows :

	Homology	**Analogy**
(i)	Homology is the similarity between organs of different animals based on common ancestry or common embryonic origin and built on same fundamental pattern, but perform varied functions and have different appearance.	Analogy is almost similar appearance of organs performing similar function but develop in totally different groups and have totally different basic structure and developmental origin.
(ii)	It illustrates divergent evolution.	It illustrates convergent evolution.
(iii)	Thorns of *Bougainvillea* and tendrils of *Cucurbita* are examples of homology. They are axillary in position but perform different functions.	The tendrils of grape vine and pea are examples of analogy. Tendrils of pea are leaf modifications whereas in grape vine it is modification of terminal bud.
(iv)	The fore-limbs of man, cheetah, structural plan consisting of humerus, radio-ulna, carpals, metacarpals and digits. The fore-limbs of all these vertebrates are similar in structure and arrangement but have different shapes and functions. In man they are used for grasping, in cheetah for running, in whale for swimming and in bat for flying.	The wings of butterfly and bird serve the same purpose of flying, have superficial resemblance, but their basic structure is totally different.

(b) Both homologous and analogous organs provide concrete evidence in support of evolution. Homology, (similarity between organs of different animals) indicates common ancestry, or common embryonic origin. Analogy shows that evolution of similar adaptive features in different groups of organisms is due to similar habitat.

59. (a) Evolution is not a directed process in the sense of determinism. It is a stochastic process based on chance events in nature and chance mutations in the organisms. Anthropogenic actions also leads to evolution. *E.g.*

(i) Excess use of herbicides, pesticides, etc. has resulted in selection of resistant varieties.

(ii) Resistant varieties of microbes develop against which, antibiotics are applied.

(b) *Refer to answer 47.*

60. Adaptive radiation.

61. Placental mammal Lemur corresponds to Spotted cuscus and Bobcat corresponds to Tasmanian tiger cat.

62. Process of evolution of different species in a given geographical area starting from a point and literally radiating to other areas of geography (habitats) is called adaptive radiation. Darwin's finches represent one of the best example of this phenomenon, as many varieties of finches were observed to be present in the same island. All the varieties, evolved on the island itself from the original seed-eating finches that lead to various modifications in the finches according to their food habits. This evolution in finches enabled the birds to become insectivorous, vegetarian, wood pecking, ground feeding etc.

63. *Refer to answer 62.*

64. (a) *Refer to answer 62.*

(b) Another example is Australian marsupials. A number of marsupials, each different from the other evolved from an ancestral stock, but all within the Australian island continent.

65. *Refer to answer 62.*

66. The process of evolution of different species in a given geographical area starting from a point and literally radiating to other areas of geography (habitats) is called adaptive radiation *e.g.*, Darwin's finches. Adaptive radiation can be referred to as convergent evolution, when more than one adaptive

radiation appeared to have occurred in an isolated geographical area (representing different habitats). *E.g.*, A number of marsupials, each different from the other evolved from an ancestral stock, but all within the Australian island continent.

67. During his journey, Darwin went to Galapagos island, where he observed amazing diversity of small black birds called Darwin's Finches. From original seed-eating birds, many different varieties, with altered beaks arose, such as insectivorous finches, vegetarian finches, etc. Birds of Galapagos Islands influenced Darwin to think about evolutionary change. He reasoned that after originating from common ancestral seed eating stock, the finches must have radiated to different habitats and undergone adaptive changes in their beaks which enable them to become insectivorous, vegetarian, etc. This process of evolution of different varieties of Darwin finches in a given geographical area is called adaptive radiation.

68. (a) *Refer to answer 62.*

(b) A number of marsupials, each different from the other evolved from an ancestral stock, but all within Australian island continent. As similar adaptive functional structures develop in unrelated group of organisms so, it is called adaptive convergence or convergent evolution.

69. Given illustration represents adaptive radiation of Australian marsupials within Australian island continent. A number of marsupials, each different from the other evolved from an ancestral stock, but all within Australian island continent. This pattern occurs when organisms coming from different stocks evolve similar features and adapt to the same habitat. This is also referred to as convergent evolution.

70. *Refer to answer 66.*

71. (a) These organisms are founds in Australian island continent. *Refer to answer 68 (b).*

(b) *Refer to answer 69.*

(c) Existence of placental wolf and Tasmanian wolf sharing the same habitat is because of convergent evolution.

72. (a) Darwin finches show variations in the shape of their beaks. During the process of evolution, they have evolved from seed eating finches to vegetarian insectivorous finches, etc.

(b) *Refer to answer 62.*

73. *Refer to answer 67.*

74. Darwin was influenced by a book 'An Essay On The Principles of Populations' by Thomas Malthus. In this, he discussed that there are 'positive checks' that control geometrically growing population. Darwin noticed the conflict between resources of population and its continued reproductive pressure. Darwin considered that like humans, competition exist among all living things. Thus, work of T.R. Matlhus on human population growth influenced him.

75. Darwinian theory of evolution is based on Natural Selection. For example, resistance of insects to pesticides, when DDT was introduced, it was found to be highly effective against mosquitoes, flies and other insects. However, within a few years, populations of mosquitoes and flies were found to be mostly resistant to it. Other pesticides have also caused development of resistant forms. DDT did not give resistance to mosquitoes but acted as an environmental factor that resulted in natural selection. DDT brought about a change in gene frequencies in the population and gave direction to evolution.

Two key concepts of Darwinian theory of evolution are Branching descent and Natural Selection.

76. Branching descent and natural selection are two key concepts of Darwinism. Branching descent refers to convergent evolution. When more than one adaptive radiation appeared to have occurred in an isolated geographical area (representing different habitats) it is referred to as convergent evolution. *E.g.*, Australian marsupials and placental mammals show convergent evolution. *Also refer to answer 36.*

77. Nature selects for fitness which is the end result of the ability of an organism to adapt and get selected by the nature. For example, a colony of bacteria (say A) growing on a given medium has built-in variation in terms of ability to utilise a feed component. A change in the medium composition would bring out only that part of the population (say B) that can survive under the new conditions. In due course of time this variant population outgrows the others and appears as new species.

78. (a) During the struggle for existence, only those individuals could survive which exhibit variations that are more beneficial in facing the

hardships and rigours of environment or which change to adapt themselves to the changing environmental conditions.
Only the fittest organism survive in changed environmental condition and those unfit are destroyed.

During the evolution of reptiles, giant reptiles, the dinosaurs etc., appeared. Majority of them were herbivorous, but due to certain climatic changes, the vegetation disappeared and, therefore, most of them became extinct. However, small animals who could change their feeding habits from herbivorous to carnivorous diet survived, because they could easily get adapted to the changed environment. These, therefore, survived and reproduced successfully and hence were selected by nature.
(b) The rate of appearance of new forms is linked to the life cycle or the life span. Microbes that divide fast have the ability to multiply and become millions of individuals within hours. A colony of bacteria (say A) growing on a given medium has built-in variation in terms of ability to utilise a feed component. A change in the medium composition would bring out only that part of the population (say B) that can survive under the new conditions. In due course of time this variant population outgrows the others and appears as new species. This would happen within a few days. For the same thing to happen in a fish or fowl, it would take million of years as life span of these animals are in years.

79. *Refer to answer 78.*

80. The theory of natural selection is based on the following factors :
(i) Rapid multiplication among organisms leads to population growth.
(ii) Limited environmental resources such as food and space leads to struggle for existence.
(iii) Due to variation, some individuals would adust better than others.
(iv) Variations cause natural selection or survival of the fittest.
(v) Inheritance of useful variation leads to formation of new species.

81. Saltation is single step large mutation that causes species formation, thus causing evolution.

82. According to de Veries, mutations are the basis of origin of variations in organisms.

83. According to Hugo de Vries, mutations are sudden and heritable variations which causes evolution, hence called it saltation (single step large mutations). While Darwin's theory of natural selection states that speciation is due to accumulation of small, directional, and heritable variations, and is a gradual process.

84. According to mutation theory of evolution:
(i) Mutations are random, inheritable and appear in all conceivable directions.
(ii) Same type of mutations can appear in number of individuals of a species.

85. Hugo de Vries gave mutation theory to explain biological evolution. According to this theory, mutations are large and discontinuous variations (mutations) which appear suddenly and are heritable. Two key concept of Darwin theory of evolution are branching descent and natural selection.

86. *Refer to answer 82.*

87. *Refer to answer 82.*

88. Hugo de Vries (1901), on the basis of his experiment on *O. lamarkiana* put forward mutation theory to explain the mechanism of evolution. According to him, mutation causes species formation (and hence called it saltation) and thus evolution. These mutations are random and directionless.
Salient features of the mutation theory are
(i) Mutations are discontinuous variations and the raw material of evolution.
(ii) Mutations appear all of a sudden. They become operational immediately.
(iii) Unlike Darwin's continuous variations or fluctuations, mutations do not revolve around the mean or normal character of the species.
(iv) The same type of mutations can appear in a number of individuals of a species.
(v) All mutations are inheritable.
(vi) Mutations appear in all conceivable directions.
(vii) Useful mutations are selected by nature. Lethal mutations are eliminated. However, useless and less harmful ones can persist in the progeny.
(viii)Accumulation of variations produce new species. Sometimes a new species is produced from a single mutation.
(ix) Evolution is a jerky and discontinuous process.

89. (a) *Refer to answer 88.*

(b) Difference between Hugo de Vries' mutation theory and Darwinian's theory are as follows :

	Darwin's theory	**Hugo de Vries mutation theory**
(i)	According to Darwin, all the living cells produce minute particles or pangenes which pass into germ cells for transmission to the offspring.	Only those variations are transferred to the offspring which originate in germ cells or in the cells which form germ cells.
(ii)	Organisms produce more offspring than the available food and space so that a struggle for existence ensures amongst them.	The theory believes in the struggle for existence.
(iii)	Variations appear automatically.	Variations appear due to change in genetic make up.
(iv)	It is based on the origin and selection of continuous variations.	The theory is based on discontinuous variations.
(v)	Evolution is a continuous process, the direction of which is governed by nature.	Evolution is a jerky process, the direction of which is unpredictable though ultimately it is governed by nature.

90. When a few individuals or a small group of individuals from some large population invades a new or isolated geographical region, they may have different genotype frequencies from that of parent population, hence these become the founders or founder members.

91. Change of frequency of alleles in a population will result in natural selection leading to the evolution.

92. The given equation represents Hardy-Weinberg equation.

Hardy-Weinberg's principle says that allele frequencies in a population are stable and is constant from generation to generation. The gene pool (total genes and their alleles in a population) remains constant. This is called genetic equilibrium.

Hardy and Weinberg stated it using an algebraic equation.

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** respectively. The frequency of AA individuals in a population is simply p^2. The probability that an allele A with frequency of p appear on both the chromosomes of a diploid individual is simply the product of the probabilities, *i.e.*, p^2. Similarly of aa is q^2, of Aa is 2pq. Hence, $p^2 + 2pq + q^2 = 1$. This is a binomial expansion of $(p + q)^2$.

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

93. Based upon different organism-environment relationships, following these different kinds of selection process have been recognised:

(a) Stabilising selection or Balancing selection: It favours the average or normal phenotypes and eliminates the extreme variants, that fall towards both ends of the bell-shaped curve of variability for the distribution of measurements of phenotypic traits.

(b) Directional selection or Progressive selection: It favours the phenotype which is extreme and then distribution curve of the population is pushed in that direction.

(c) Disruptive selection or Diversifying selection: The extremes have more adaptable phenotypes than the average ones. Consequently, the original population is disrupted into two more separate groups that later evolve into new species.

94. (a) *Refer to answer 92.*

(b) Factors affecting genetic equilibrium are gene flow, mutation, natural selection and genetic recombination.

(c) When a few individuals or a small group of individuals from a large population invades a new or

isolated geographical region, they may have different genotype frequencies from the population parent. These become the founders or founder members.
These founders carry on a limited portion of the parental gene pool. Their gene pool may contain certain alleles in a very low frequency or may lack a few alleles. As a result of the loss of genetic variation the new population may be distincively different (genotypically and phenotypically) from the parent population. Formation of different genotype in new settlement is called founder effect.

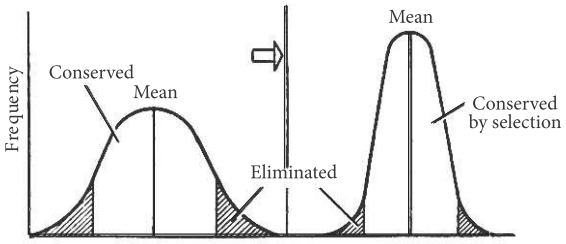
95. Hardy-Weinberg equilibrium can be effected by following ways:
(a) Gene flow : It refers to the movement of alleles from one population to another as a result of interbreeding between members of the two populations. It causes continual interchange of alleles between organisms.
(b) Genetic drift : It refers to a change in the population of alleles in the gene pool. It is random and occurs only by chance.
(c) Genetic recombination : Crossing over during meiosis is a major source of genetic variation within population. Alleles of parental linkage groups separate and new associations of alleles are formed in the gamete cells. Offspring formed from these gametes showing 'new' combination of characteristics are called recombinants.

96. (a) *Refer to answer 92.*
(b) The major factors known to disturb Hardy-Weinberg equilibrium are as follows :
(i) Gene migration or gene flow.
(ii) Mutation.

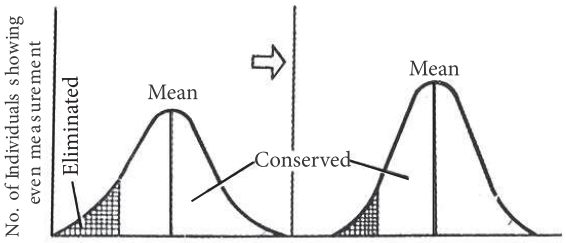
97. (a) *Refer to answer 92.*
(b) When migration of a section of population to another place and population occurs, gene frequencies change in the original as well as in the new population. New genes/alleles are added to the new population and these are lost from the old population. There would be a gene flow if this gene migration happens multiple times. If the same change occurs by chance, it is called genetic drift. Sometimes the change in allele frequency is so different in the new sample of population that they become a different species. Thus, genetic equilibrium in a population gets disturbed.

98. Genetic drift refers to the random fluctuations in the gene frequencies in a small population, generation after generation purely by chance.
Gene migration is the change in gene frequency in the original population and the new population, when a section of population migrate to another place or is added to a new population.

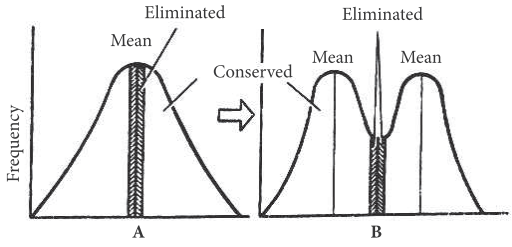
99. Based upon different organism-environment relationships, following different kinds of natural selections have been recognised.
(a) Stabilising selection or Balancing selection: It favours the average or normal phenotypes and eliminates the extreme variants, that fall towards both ends of the bell-shaped curve. The bell shaped curve for the distribution of measurement of the phenotypic trait produced by stabilising selection can be represented by the following figure:



(b) Directional selection or Progressive selection: It favours the phenotype which is extreme and then pushes the distribution curve of the phenotype, of the population, in that direction. Graph representing directional selection can be represented as:



(c) Disruptive selection or Diversifying selection: The extremes have more adaptable phenotypes than the average ones. Consequently, the original population is disrupted into two more separate groups that later evolve into new species. Graph representing disruptive selection can be represented as:



Factors that effect the equilibrium are :

(i) Genetic drift : It refers to the elimination of genes of certain traits when a section of population migrates or dies of natural calamity. It alters the gene frequency of the remaining population.

(ii) Mutations : Gene mutation is a random change in the base sequence of a gene. It occurs by substitution, addition or deletion of one or more base. This ultimately affects the allele's frequency in the population. The mutated gene may give rise to a new protein or may fail to produce any. This may change the phenotype (trait).

(iii) Gene flow : The phenomenon of addition or removal of alleles when individuals enter or leave a population is called gene flow. If interspecific hybrids are fertile these may lead to formation of new species hence disturbing genetic equilibrium.

(iv) Gene recombination : Since it adds new alleles and combination of alleles to the gene pool it is an important process during evolution which causes variations.

100. Flow of genes between two populations alters the gene frequency. Sometimes the change in allele frequency is so different in new population that they become a different species. The original drifted population becomes founders.

When a few individuals or a small group of individuals from some large population invades a new or isolated geographical region, carry on a limited portion of the parental gene pool. Their gene pool may contain certain alleles in a very low frequency or may lack a few alleles. The descendants of the founder will tend to have ratios similar to the founders rather than the source population. Formation of different genotype in new settlement is called founder effect.

101. Coelacanth is considered to be the missing link between fishes and the first four-limbed animals (amphibians). These were the ancestors of modern day frogs and salamanders.

102. *Zosterophyllum* → Ferns → *Ginkgo* → *Gnetales.*

103. (a)*Psilophyton*, (b) Seed ferns, (c) Chlorophyte ancestor, (d) Ferns, conifers and seed ferns, (e) Tracheophyte ancestor, (f) Chlorophyte ancestor.

104. Discovery of lobefins is significant for evolution because lobefins (called coelacanth) evolved into the first amphibians that lived on both land and water. These were ancestors of modern day frogs and salamanders. The amphibians evolved into reptiles. They lay thick-shelled eggs which do not dry up in sun unlike those of amphibians.

105. (a) Lobefins → Frogs → Salamander → Reptiles

(b) Reptiles were more successful than amphibians because : (i) They lay thick shelled eggs which do not dry up in sun unlike those of amphibians.

(ii) Internal fertilisation.

106. *Homo habilis* and *Homo erectus* were omnivores. *Homo erectus* perhaps used to eat cooked meat or food because he was the first prehistoric man to make use of fire for cooking whereas *Homo habilis* used to eat raw food.

107. *Dryopithecus africanus* is the common ancestor of great apes and man.

108. (a) East Africa, (b) *Homo erectus*.

109. *Homo habilis* were first human like hominid. They probably did not eat meat and their brain capacities were between 650-800 cc.

110. (a) *Homo erectus*, (b) *Homo sapines neanderthalensis*, (c) *Homo habilis*, (d) *Ramapithecus*

111. Characteristics of Neanderthal man:

(i) They possess a brain capacity of 1400 cc.

(ii) They walked upright and had low brows, receding jaws and high domed heads.

(iii) They used hides to protect their body and bury their dead.

112. (a) *Dryopithecus* and *Ramapithecus* appeared about 14-15 million years ago.

(b) (i) *Homo habilis* were first man like animal and were discovered in East Africa.

(ii) Modern *Homo sapiens* appeared about 75,000-10,000 years ago in holocene epoch.