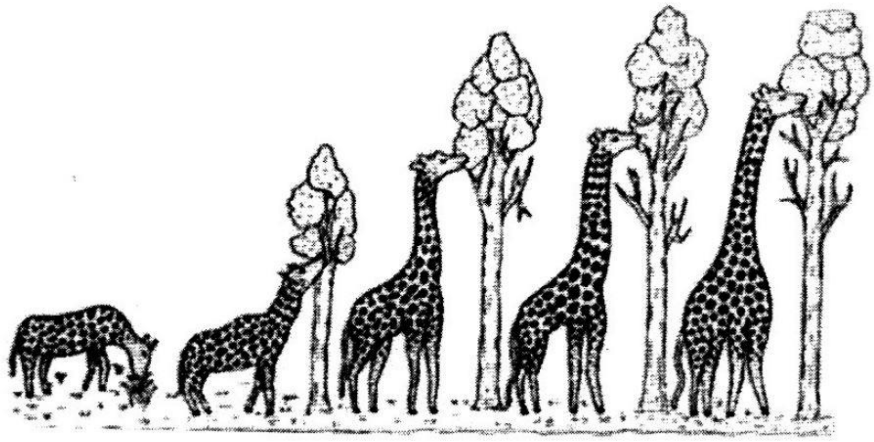
# Evolution

**1. Observe the picture given below. Name the naturalist and write the explanation given by him that evolution of life forms had occurred on the basis of this example.** (2024)



**Ans.** Name of the Naturalist – Lamarck

- Evolution of life forms driven by use and disuse of organs.

- He said Giraffes in an attempt to forage leaves on tall trees had to adapt by elongation of their necks.

- They passed on this acquired character of elongated neck to their succeeding generations and slowly over the years all the future generations had long necks.

**2. Explain the significance of the experiment carried out by S.L. Miller. Name the scientists whose hypothesis prompted him to carry out this experiment.**

(2024)

**Ans.**

• Miller experimentally showed formation of amino acids, and this proved theory of chemical evolution of life / formation of organic molecules from inorganic molecules.

• Oparin, Haldane

**3. How does meteorite analysis favour this hypothesis ?** (2024)

**Ans.** Analysis of meteorite content also revealed similar compounds indicating that similar processes are occurring in space.

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## Previous Years' CBSE Board Questions

### 6.1 Origin of Life

**MCQ**

**1.** The theory of evolution supported by the experiment conducted by Louis Pasteur is

(a) Spontaneous generation theory (b) Life comes only from pre-existing life

(c) Abiogenesis of life (d) Big bang theory.
**(2020)**

**2.** Louis Pasteur demonstrated that

(a) early life came from outer space (b) non-living chemicals produced living molecules

(c) life comes from pre-existing life (d) life originated spontaneously. **(2020)**

**VSA (1 mark)**

**3.** State the two principle outcomes of the experiments conducted by Louis Pasteur on origin of life.

**(2019)**

**4.** State two postulates of Oparin and Haldane with reference to origin of life.
**(AI 2017)**

**5.** Write the hypothetical proposals put forth by Oparin and Haldane.
**(Foreign 2015)**

**SA I (2 marks)**

**6.** What was proposed by Oparin and Haldane on origin of life? How did S.L. Miller's experiment support their proposal?
**(Foreign 2014)**

**SA II (3 marks)**

**7.** State Oparin and Haldane hypothesis. How did S.L. Miller experimentally prove it? Explain.

**(2020 C)**

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

## 6.3 What are the Evidences for Evolution?

**VSA (1 mark)**

**9.** Mention one example each from plants and animals exhibiting divergent evolution. **(2019)**

**10.** 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)**

**11.** Why are analogous structures a result of convergent evolution?
**(AI 2014)**

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

**SA I (2 marks)**

**13.** How is the study of fossils an evidence of evolution of life forms which have taken place on the earth? Explain giving two reasons.
**(2020)**

**14.** Wings of birds and wings of butterflies contribute to locomotion. Explain the type of evolution such organs are a result of.
**(2020)**

**15.** (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)**

**16.** 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

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(c) Wings of butterflies and birds

(d) Forelimbs of whales and mammals
**(Al 2015)**

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

**18.** Is sweet potato analogous or homologous to potato tuber? Give reasons to support your answer.

**(Delhi 2015C)**

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

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

**21.** 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)**

**22.** Explain how natural selection operates in nature by taking an example of white winged and dark winged moths of England.

**(NCERT Exemplar, Al 2014C)**

**SA II (3 marks)**

**23.** Industrial melanism in England after 1850 is an excellent example of Natural selection. Explain how?
**(2023)**

**24.** Analogous organs are a result of convergent evolution. Justify with the help of suitable example for each.
**(2020)**

**25.** "Appearance of melanised moths post-industriali-sation in England is a classic example of evolution by natural selection." Explain.
**(2019)**

**26.** (a) Differentiate between analogous and homologous structures.

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(b) Select and write analogous structures from the list given below:

(i) Wings of butterfly and birds

(ii) Vertebrate hearts

(iii) Tendrils of Bougainvillea and Cucurbita

(iv) Tubers of sweet potato and potato
**(2018)**

**27.** Differentiate between homology and analogy. Give one example of each.
**(Al 2016)**

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

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

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

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

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

**LA (5 marks)**

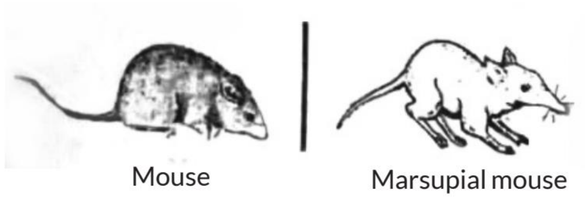
**33.** (a) Differentiate between analogy and homology giving one example each of plant and animal respectively.

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

## 6.4 What is Adaptive Radiation?

**MCQ**

**34.** Identify the option that gives the correct type of evolution exhibited by the two animals shown, living in the same habitat in Australia.

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(a) Convergent evolution (b) Disruptive selection

(c) Divergent evolution (d) Homologous ancestry
**(2023)**

**SA I (2 marks)**

**35.** (a) Identify any two marsupials from the list given below:

(i) Lemur, (ii) Spotted cuscus, (iii) Flying phalanger,

(iv) Bobcat, (v) Tasmanian wolf, (vi) Mole

(b) "Australian marsupials exhibit adaptive radiation". Justify the statement.
**(2020)**

**SA II (3 marks)**

**36.** (a) How did Darwin explain adaptive radiation?

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

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

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

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

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

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

**(Al 2014)**

**LA (5 marks)**

**41.** (a) How do the observations made during moth collection in pre- and post-industrialised era in England support evolution by natural selection?

(b) Explain the phenomenon that is well represented by Darwin's finches other than natural selection.
**(Delhi 2017)**

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## 6.5 Biological Evolution

**VSA (1 mark)**

**42.** How did Charles Darwin express 'fitness?
**(Delhi 2019)**

43. What role does an individual organism play as per Darwin's theory of natural selection?

**(Delhi 2017)**

**SA I (2 marks)**

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

**45.** 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)**

**46.** Charles Darwin during his famous sea voyage around the world in a ship (H.M.S. Beagle), concluded that there has been gradual evolution of life.

Answer the following questions:

(a) What is his theory known as? Explain the salient features of his theory.

(b) Name a scientist who arrived at a similar conclusion as that of Charles Darwin. **(2019)**

## 6.6 Mechanism of Evolution

**VSA (1 mark)**

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

**SA II (3 marks)**

**48.** (a) Darwin theory of Natural Selection is widely accepted but some limitations have been identified by modern biologists. Mention the limitations identified.

(b) Name and state the most accepted theory of evolution in modern times.

(c) Mention any two ways the limitations identified in Darwin's theory of evolution are explained in modern biology.
**(2023)**

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## 6.7 Hardy-Weinberg Principle

**VSA (1 mark)**

**49.** According to the Hardy-Weinberg principle, the allele frequency of a population remains constant. How do you interpret the change of frequency of alleles in a population? **(Al 2019)**

**SA I (2 marks)**

**50.** How would the gene flow or genetic drift affect the population in which either of them happens to take place?
**(Delhi 2019)**

**51.** With the help of an algebraic equation, how did Hardy-Weinberg explain that in a given population the frequency of occurrence of alleles of a gene is supposed to remain the same through generations?
**(2018)**

**SA II (3 marks)**

**52.** Hardy-Weinberg principle is stated in the following algebraic equation:

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

(a) State what do 'p' and 'q' denote in the equation.

(b) State Hardy-Weinberg principle as indicated in the equation.

(c) What would you interpret if the value of 1 in the equation gets deviated?
**(2020)**

**53.** Explain the Hardy-Weinberg principle with the help of an algebraic equation.
**(2019 C)**

**54.** How does the original drifted population become founders? Explain.
**(2019 C)**

**55.** Explain the three different ways in which the natural selection operates.
**(2019 C)**

**56.** $p^2 + 2pq + q^2 = 1$. Explain the algebraic equation on the basis of Hardy Weinberg's principle.

**(Delhi 2017)**

**57.** (a) Describe Hardy-Weinberg Principle.

(b) List any four factors which affect genetic equilibrium.

(c) Describe founder effect.
**(Foreign 2014)**

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**58.** Giving three reasons, write how Hardy-Weinberg equilibrium can be affected.

**(NCERT Exemplar, Al 2014C)**

**LA (5 marks)**

**59.** (a) How does the Hardy-Weinberg equation explain genetic equilibrium?

(b) Describe how this equilibrium is disturbed that may lead to founder effect.
**(Al 2019)**

## 6.9 Origin and Evolution of Man

**MCQ**

**60.** At which stage during evolution did human use hides to protect their bodies and buried their dead?

(a) Homo habilis

(b) Neanderthal man

(c) Java man

(d) Homo erectus
**(2023)**

**61.** Assertion (A): Homo sapiens have evolved from chimpanzee-like ancestors.

Reason (R) There is no difference between the two in the amino acid sequence of the protein Cytochrome-C.

(a) Both (A) and (R) are true and (R) is the correct explanation of (A).

(b) Both A and R are true and R is not the correct explanation of (A).

(c) (A) is true but R is false.

(d) (A) is false but (R) is true.

**VSA (1 mark)**

**62.** Write the names of the following:

(a) A 15 mya primate that was ape-like.
**(2023)**

(b) A 2 mya primate that lived in East African grasslands.
**(2018)**

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

**SA I (2 marks)**

**64.** Write two differences between Homo erectus and Homo habilis.
**(2/3, Delhi 2019)**

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

**SA II (3 marks)**

**66.** (a) Rearrange the following in the correct order of their appearance on earth between two million years and 40,000 years back.

Neanderthals, Australopithecus, Homo erectus and Homo habilis.

(b) Which one of the above

(i) had the largest brain size

(ii) ate fruits?
**(2020)**

**67.** Write the characteristics of Ramapithecus, Dryopithecus and Neanderthal man. **(AI 2017)**

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

**(3/5, Delhi 2014)**

## CBSE Sample Questions

### 6.3 What are the Evidences for Evolution?

**MCQ**

**1.** Evolutionary convergence is development of a

(a) common set of functions in groups of different ancestry

(b) dissimilar set of functions in closely related groups

(c) common set of structures in closely related groups

(d) dissimilar set of functions in unrelated groups.
**(2022-23)**

### 6.7 Hardy-Weinberg Principle

**SA II (3 marks)**

**2.** (a) How is Hardy-Weinberg's expression "$(p^2 + 2pq + q^2) = 1$"derived?

(b) List any two factors that can disturb the genetic equilibrium.
**(2022-23)**

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## Detailed SOLUTIONS

### Previous Years' CBSE Board Questions

**1.** (b): Louis Pasteur disapproved spontaneous generation theory and proved biogenesis, i.e., life comes from pre-existing life.

**2.** (c): Louis Pasteur demonstrate that life comes only from pre-existing life.

**3.** Louis Pasteur disapproved abiogenesis (spontaneous generation) and put forth the theory of biogenesis, which states that life originated from pre-existing life.

**4.** Two postulates of Oparin and Haldane with reference to origin of life are:

(i) The first form of life could have come from pre-existing, non-living organic molecules (e.g., RNA, protein, etc.) and that formation of life was preceded by chemical evolution.

(ii) The primitive atmosphere was of reducing type, i.e., containing gases like $CH_4$, $NH_3$, etc. The earth had high temperature and volcanic storms. There was no free oxygen.

**5.** 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.

**6.** 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's experiment supported chemical evolution of life. He created laboratory conditions similar to primitive earth. He used mixture of methane, ammonia, hydrogen and water in an air tight apparatus and passed electrical discharge 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.

**7.** Refer to answer 6.

**8.** 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 micro-organisms that might be present in

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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 micro-organisms for fermentation or putrefaction was the air and the organisms did not arise from the nutrient media.

**9.** Forelimbs of whales and bats and thorns of Bougainvillea and tendrils of Cucurbita exhibit divergent evolution.

**10.** 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.

**11.** Analogous structures 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 (butterfly) and wings of bird show convergent evolution, both have similar function but different basic structure.

**12.** Wings of birds and wings of butterfly are analogous as they share a common function, i.e., locomotion but would not have the same structure as the convergent evolution creates analogous structures that have similar function.

**13.** 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.

In support of it two evidences are given below:

(i) The rocks of early era contain less number of fossils than the rocks of later era due to the fact that life first originated in sea as a simple form.

(ii) Missing links or fossil organisms show characters of two different groups, e.g., Archaeopteryx is considered as link between reptiles and birds.

**14.** Refer to answer 12.

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

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

**16.** 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.

**17.** 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.

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

**19.** Homology is based on divergent evolution. It indicates common ancestry. Homologous organs have the same fundamental structures 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.

**20.** 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. Thus, homology indicates common ancestry and relationship between different groups. Difference in appearance is due to divergent evolution, i.e., the ancestors migrated to different habitats and organs became modified in adaptations to new requirements.

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**21.** 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.

**22.** 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.

**23.** In England after 1850s, an interesting observation explains the natural selection. Due to industrial smoke and soot the pale tree trunks became more and more blackened. As a result, the light-winged 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 winged or melanic moth. 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.

**24.** The organs which have similar functions but are different in their structural details and origin are called analogous organs. The analagous structures are the result of convergent evolution.

For example, the wings of an insect are analagous to wings of a bird. It is due to the fact that the basic structure of the wings of the insect is different from the wings of bird. However, their function is similar.

**25.** Refer to answer 22.

**26.** (a) Differences between analogous and homologous structures are as follows:

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| | Analogous structures | Homologous structures |
|---|---|---|
| (i) | They show superficial resemblance but their internal structure is quite different. | They differ morphologically but they have similar internal structure. |
| (ii) | They develop in unrelated organisms. | They develop in related organisms. |
| (iii) | They have similar functions. | They perform different functions. |
| (iv) | Analogous organs show convergent evolution. | Homologous organs show adaptive radiation (divergent evolution). |
| (v) | Example : Stings of honey bee and scorpion. | Example : Vertebrate forelimbs. |

(b) (i) In the given list, wings of butterfly and birds show analog as the basic structure of the wings of the insects is different from the wings of birds, however, their function is similar.

(ii) Vertebrate hearts show structural homology.

(iii) Thorns (not tendrils) of Bougainvillea and tendrils of Cucurbita both arise in the axillary position thus, show homology.

(iv) Tuber of sweet potato (root modification) and potato (stem modification) also show analogy.

**27.** The differences between homology and analogy are as follows:

| | Homology | Analogy |
|---|---|---|
| (i) | It 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. | It 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. |

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**28.** Difference between divergent evolution and convergent evolution are as follows:

| | 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. |

**29.** 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 and stings of honeybee and scorpion.

**30.** The organs which have similar functions but are different in their structural details and origin are called analogous organs. The analagous structures are the result of convergent evolution.

For example, the wings of an insect are analagous to wings of a bird. It is due to the fact that the basic structure of the wings of the insect is different from the wings of bird.

However, their function is similar.

For differences between analogous and homologous organs, refer to answer 26 (a).

**31.** Refer to answer 22.

**32.** 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. 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

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has been concluded that evolution has taken place from simple to complex in a gradual manner.

**33.** (a) Refer to answer 27.

(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.

**34.** (a)

**35.** (a) (ii) Spotted cuscus, (iii) Flying phalanger and (v) Tasmanian wolf are Australian marsupials.

(b) 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. Australian marsupials exhibit adaptive radiation because a number of marsupials, each different from the other evolved from an ancestral stock, but all within the Australian island continent.

**36.** (a) 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 examples 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.

(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.

**37.** Refer to answer 36 (a).

**38.** 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, 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).

Placental mammals in Australia exhibit adaptive radiation in evolving into varieties of such placental mammals each of which appears to be similar to a

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corresponding marsupial, e.g., placental wolf and Tasmanian wolf-marsupial. Hence, Placental mammals show convergent evolution.

**39.** 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.

**40.** (a) Refer to answer 36 (a).

(b) Australian marsupials and placental mammals. Placental mammals in Australia evolve into varieties of placental mammals each of which appears to be similar to a corresponding marsupial. As similar adaptive functional structures develop in unrelated group of organisms so, it is called adaptive convergence or convergent evolution.

**41.** (a) 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 exists in two strains: white-winged moth and dark-winged moth (melanised). Before industrialisation, bark of trees was covered by whitish lichens, so white moths escaped unnoticed from predatory birds.

Due to industrial smoke and soot, the pale tree trunks became more and more blackened. As a result, the white 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 white 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.

(b) Darwin's finches of the Galapagos islands represent adaptive radiation. Adaptive radiation (divergent evolution) is the evolution from a common ancestral form to a number of different forms. Darwin's finches had a common ancestor but now have different types of modified beaks according to their food

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habits. As the original population of finches increased in size it spreaded out from its centre of origin to exploit new habitats and food sources. After some time, it resulted in evolution of a number of populations, each adapted to its particular habitat. Eventually these populations differed from each other sufficiently to become new species.

Darwin differentiated thirteen species of finches and grouped them into six main types : -

(i) Large ground finches.

(ii) Cactus ground finches feeding on cacti.

(iii) Vegetarian tree finches.

(iv) Insectivorous tree finches.

(v) Warbler finches.

(vi) Tool-using or Woodpecker finches.

**42.** According to Charles Darwin, nature selects for fitness. One must remember that fitness is based on characteristics which are inherited. Hence, there must be a genetic basis for getting selected and to evolve. Fitness is the end result of the ability to adapt and get selected by nature.

**43.** According to Darwin, fitness (reproductive fitness) of an individual affect's evolution of species. An individual organism who better fits in an environment leave more progeny than others. This organism will survive more and hence gets selected by nature. He called this as natural selection and implied it as a mechanism of evolution.

**44.** 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. Malthus on human population growth influenced him.

**45.** 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 ingene frequencies in the population and gave direction to evolution. Two key concepts of Darwinian theory of evolution are branching descent and natural selection.

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**46.** (a) The theory is known as Darwin's theory of natural selection. The salient features of this theory are as follow:

(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.

(b) Alfred Wallace arrived at similar conclusion as that of Charle's Darwin.

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

**48.** (a) Limitations of Darwin's theory of natural selection are as follows:

(i) Occurrence of discontinuous variations. This theory fails to explain the cause of sudden changes of the body. The main limitation was lack of the knowledge of heredity.

(ii) Arrival of the fittest,

(iii) presence of vestigial organs,

(iv) over specialisation of some organs,

(v) degeneration of certain organs that cannot be explained.

(b) Synthetic theory or Neo-Darwinism is the most accepted theory of evolution in modern times. According to this theory, the origin of new species is based on the interaction of genetic variations and natural selection.

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(c) (i) Darwinism believes in the selection of individuals on the basis of accumulation of variations while according to Neo-Darwinism variations accumulate in the gene pool and not in the individual.

(ii) Darwinism does not believe in isolation. Neo-Darwinism incorporates isolation as an essential component of evolution.

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

**50.** Gene flow or gene migration 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 in a population.

Genetic drift refers to a change in the population of alleles in the gene pool. It occurs by eliminating or fixing certain alleles in the population randomly and by chance. These affect population by changing the allelic frequency in both old and new population that become a different species.

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

The gene pool, i.e., total genes and their alleles in a population remains a 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 organism, '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 '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' '2pq'.

Hence, $p^2 + 2pq + q^2 = 1$. This is a binomial expansion of $(p + q)^2$. When the measured frequency 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.

**52.** (a) In a diploid organism, 'p' and 'q' represent frequency of allele 'A' and allele 'a' respectively.

(b) Hardy-Weinberg equilibrium states that there is a balance in the frequency of alleles from generation to generation within a large population over a period of

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time assuming that: (i) mating is random; (ii) there is no natural selection; (iii) there is no migration; (iv) there is no mutation. He also stated that sum of all allelic frequency is 1.

(c) If value of 1 in the equation deviates, this indicates changing gene frequencies that would imply evolution is in progress.

**53.** Hardy-Weinberg equilibrium states that there is a balance in the frequency of alleles from generation to generation within a large population over a period of time assuming that: (i) mating is random; (ii) there is no natural selection; (iii) there is no migration; (iv) there is no mutation. He also stated that sum of all allelic frequency is 1. In such a stable population, for a gene with two alleles, A (dominant) and a (recessive), the frequency of both allele is denoted as p and q respectively. Then the frequencies of the three possible genotypes (AA, Aa, and aa) can be expressed by the equation:

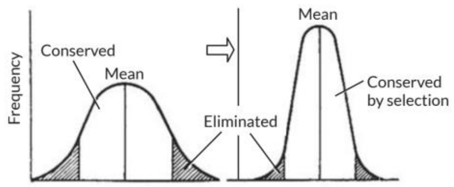
$p^2 + 2pq + q^2 = 1.$

where $p^2$ = frequency of AA (homozygous dominant) individuals, $2pq$ = frequency of Aa (heterozygous) individuals, and $q^2$ = frequency of aa (homozygous recessive) individuals.

**54.** When a few individuals or a small group of individuals from a large population invades a new or isolated geographical region, these become the founders. 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 distinctively different (genotypically and phenotypically) from the parent population. Formation of different genotypes in new settlement is called founder effect.

**55.** Based upon different organism-environment relationships, natural selections operate in following three types:

(i) 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:

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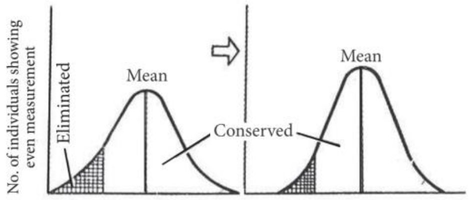
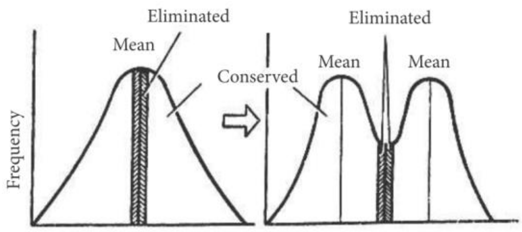
(ii) Directional selection or Progressive selection: It favours the phenotype which is extreme and then pushes the distribution curve of the phenotype, of the population, in that one particular direction. Graph representing directional selection can be represented as:




(iii) 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:




**56.** In a stable population as per the Hardy Weinberg Principle, for a gene with two alleles, 'A' (dominant) and 'a' (recessive), the frequency of both allele is denoted as p and q respectively. Then the frequencies of the three possible genotypes: (AA, Aa and aa) can be expressed by the equation

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

where $p^2$ = frequency of AA (homozygous dominant) individuals, $2pq$ = frequency of Aa (heterozygous) individuals, and $q^2$ = frequency of aa (homozygous recessive) individuals.

**57.** (a) Refer to answer 53.

(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, these become the founders. 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 distinctively different (genotypically and phenotypically) from the parent population. Formation of different genotype in new settlement is called founder effect.

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**58.** Hardy-Weinberg equilibrium can be affected by following ways:

(i) 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.

(ii) Genetic drift: It refers to a change in the population of alleles in the gene pool. It is random and occurs only by chance.

(iii) 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.

**59.** (a) In a given population, one can find out the frequency of occurrence of alleles of a gene or a locus. This frequency is supposed to remain fixed and even remain the same through generations. Hardy-Weinberg principle stated it using algebraic equations which says that allele frequencies in a population are stable and is constant from generation to generation.

The gene pool, i.e., total genes and their alleles in a population remains a 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 organism, '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 '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' '2pq! Hence, $p^2+2pq + q^2 = 1$. This is a binomial expansion of $(p + q)^2$. When the measured frequency 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.

(b) When a few individuals or a small group of individuals called founders from some large population invade a new or isolated geographical region, they carry 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. This formation of different genotype in new settlement is called founder effect and is an important example of genetic drift in human population.

**60.** (b): Neanderthal man used hides to protect their bodies and buried their dead.

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**61.** (b)

**62.** (a) Dryopithecus was ape-like primate about 15 mya.

(b) Australopithecus lived in East African grasslands about 2 mya.

**63.** 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.

**64.** Differences between Homo erectus and Homo habilis are:

| | *Homo erectus* | *Homo habilis* |
|---|---|---|
| (i) | He was also known as "Erect man" who appeared about 1.7 million years ago in Middle Pleistocene. | He was also known as "Handy man" who lived in Africa about 2 million year ago. |
| (ii) | He had 900 c.c. brain capacity | He had 650-800 c.c. brain capacity. |

**65.** Homo habilis were first human like hominid. They were omnivores and their brain capacities were between 650-800 c.c.

**66.** (a) Australopithecus → Homo habilis → Homo erectus → Neanderthals

(b) (i) Neanderthals

(ii) Australopithecus

**67.** The characteristics of Ramapithecus are as follow:

(i) They were more man-like and perhaps walked like gorilla.

(ii) They lived on the tree tops but also walked on the ground.

(iii) Their jaws and teeth were like those of humans.

(iv) Small canines and large molars suggest that they ate hard nuts and seeds like modern man. The characteristics of Dryopithecus are as follows:

(i) They were more ape-like but had arms and legs of the same length.

(ii) Heels in their feet indicate their semi-erect posture.

(iii) They had large brain, large muzzle, large canines and were without browridges.

(iv) They were arboreal, knuckle-walker and ate soft fruits and leaves.

The characteristics of Neanderthal man are as follows:

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

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

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

(iv) They were adapted to cold environment.

**68.** The characteristics of Neanderthal man are as follows:

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

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

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

## CBSE Sample Questions

**1.** (a): Development of common set of characters in groups of different ancestry is called convergent evolution.

**2.** (a) Sum total of all the allele frequencies is 1. Let there be two alleles A and a in a population. The frequencies of alleles A and a are 'p' and 'q' respectively. The frequency of AA individuals in a population is $p^2$ and it can be explained that the probability that an allele A with frequency of p would appear on both the chromosomes of a diploid individual is simply the product of the probabilities, i.e., $p^2$.

Similarly, the frequency of aa is $q^2$ and that of Aa is 2pq.

$(p^2 + 2pq + q^2) = 1$, where $p^2$ represents the frequency of homozygous dominant genotype, 2pq represents the frequency of the heterozygous genotype and $q^2$ represents the frequency of the homozygous recessive.

(b) Factors that affect Hardy-Weinberg equilibrium are

(i) Gene migration or gene flow

(ii) Genetic drift

(iii) Mutation

(iv) Genetic recombination

(v) Natural Selection
**(Any two)**

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