6 Evolution

Fastrack Revision

- Evolutionary biology is the study of history of life forms on earth.
- The process of gradual modification of simpler forms into the present complex forms over millions of years is called evolution.
- **Origin of Life**
  - The universe is almost 20 billion years old.
  - Huge clusters of galaxies comprise the universe.
  - Galaxies contain stars and clouds of gas and dust.
  - A scientific theory called big bang theory explains that, the unimaginable large explosion created the universe.
  - As the universe expanded and cooled, the temperature came down and materials condensed under the influence of gravitation to form present day galaxy.

Knowledge BOOSTER

Our galaxy is called Milky Way formed 4.5 billion years back.

  - There was no atmosphere on early earth.
  - Water vapour, methane, carbon dioxide and ammonia released from molten mass covered the surface.
  - The UV rays from the sun broke up water into hydrogen and oxygen and the lighter H_2.
  - Oxygen combined with ammonia and methane to form water, CO_2 and others.
  - The ozone layer was formed. As it cooled, the water vapour fell as rain, to fill all the depressions and form oceans.
  - Life appeared 500 million years after the formation of earth, *i.e.*, almost 4 billion years back.
  - Different scientists had put different views about the origin of life.
- **Evolution of Life Forms-A Theory**
  - Conventional religious literature reveals about the theory of special creation based on three connotations:
    - All living organisms were created as such.
    - The diversity in all organisms always the same since creation and will be the same in future.
    - Earth is about 4000 years old.
  - All the ideas were challenged during 19^{th} century.
  - Charles Darwin concluded that existing living forms share similarities to varying degrees not only among themselves but also with life forms that existed millions of years ago.
  - Many life forms do not exist anymore because of extinctions of different life forms and there has been gradual evolution of life forms.
  - Darwin's theory of natural selection is based on the fact that those who are better fit in an environment, leaves more progeny than others and the progenies will survive more, hence are selected by the nature which he implied as mechanism of evolution.
  - Alfred Wallace stated that all the existing life forms share similarities and share some common ancestors which are present at different periods in the history of earth.
  - The geological history of earth closely correlates with the biological history of earth and a final conclusion is that earth is not thousand years old as was thought earlier but billions of years old.
- **Evidences for Evolution**
  - Evidences of evolution comes from Paleontological evidences.
  - Paleontology is the study of fossils.
  - Fossils are remains of hard parts of life forms lived in past but found in rocks or sediments.
  - Rocks from sediments and a cross section of earth's crust indicates the arrangement of sediments one over the other during the long history of earth.
  - Different aged rock sediments contain fossils of different life forms that probably died during the formation of the particular sediment which represent extinct organisms.
  - A study of fossils in different sedimentary layers indicates the geological period in which the organisms existed.
  - The study showed that life forms varied over time and certain life forms are restricted to certain geological time spans.
  - New forms of life have arisen at different times in the history of earth.
  - Comparative anatomy and morphology shows similarities and differences among organisms of today and those that existed years ago.
- **Homologous Organs**
  - The organs whose structure or origin is same but are functionally different.

    Example: (i) Vertebrate hearts or brains. (ii) In plants, the thorns and tendrils of *Bougainvillea* and *Cucurbita.* (iii) The forelimbs of whale, bats, cat and human share similarities in the pattern of forelimb bones.
  - All the animals have similar anatomical structure in their forelimb bones such as humerus, radius, ulna, carpals, metacarpals and phalanges.
  - Though the forelimbs have similar anatomical structure but they perform different functions.

- They have the same structure developed along different directions due to adaptations to different needs.
- Homology is based on divergent evolution and the structures are called homologous.
- Homology indicates common ancestry.

▶ **Analogous Organs**

- The organs whose structure or origin is not similar but functionally active are called **analogous organs**.
  Example: (i) The wings of bird and butterfly perform similar functions. (ii) Eyes of octopus and mammals. (iii) The flippers of penguins and dolphins. (iv) In plants, sweet potato and potato.
- Similarities in proteins and genes performing a given function among diverse organisms give clues to common ancestry.
- It is the similar habitat that has resulted in selection of similar adaptive features in different groups of organisms but towards the same function.
- Convergent evolution is the evolution where different structures develop similarly and results in analogous organs.

▶ **Natural Selection**

- It involves various observations supporting evolution.

▶ **Industrial Melanism**

- Before industrialisation, in Great Britain it was observed that there were more white-winged moths on trees than dark or melanised moth.
- After industrialisation, there were more dark-winged moths.
- Before industrialisation, almost white-coloured lichen covered the tree trunks and in that background the white-winged moths survived but the dark coloured moths were eaten by predators.
- During post industrialisation period, the tree trunks became dark due to industrial smoke and under such condition, the white-winged moths did not survive due to predators and 'the dark-winged moths' survived hence industrial melanism supports evolution by natural selection.

▶ **Antibiotic Resistant Bacteria**

- By employing antibiotics to bacterial colonies, the colonies sensitive to penicillin died, whereas the others that were resistant to penicillin survived.
- Probably the bacteria that survived underwent a chance mutation thereby possessing a gene that contributed to their resistance to the penicillin drug and hence selection by the nature, in course of time, was considered as fittest and established as new species.

▶ **Adaptive Radiation**

- The evolution of different species in a given geographical area starting from its original character and radiating to other geographical area is called **adaptive radiation**. **Example:** Finches in Galapagos Island.
- During Darwin's journey to Galapagos Island, he observed small black birds called Darwin's finches.
- The finches were diverse in their food habitats like original from seeds eating features to many other forms with altered beaks arose enabling them to become insectivorous and vegetarian finches.

▶ **Australian Marsupials**

- A number of marsupials, each different from the other evolved from an ancestral stock but all within the Australian continent.
- **Example:** Tasmanian wolf, tiger cat, marsupial rat, kangaroo, wombat, sugar glider, etc.

▶ **Placental Mammals**

- In Australia, adaptive radiation is exhibited where placental mammals are evolved into varieties each of which appears to be similar to a corresponding marsupial.
  Example: Placental wolf and Tasmanian wolf marsupial.

▶ **Biological Evolution**

The following theories have been put forward to explain the mode of evolution *i.e.*, origin of species.

▶ **Darwin's Theory of Evolution**

- The essence of Darwinian Theory about evolution is natural selection.
- Theory of natural selection states that individuals that are less adapted to the environment are eliminated and those better adapted by the nature are selected.
- The rate of appearance of new forms is linked to the life cycle or the lifespan.
- There must be a genetic basis for getting selected and to evolve.
- Some organisms are better adapted to survive in an otherwise hostile environment.
- Adaptive ability is inherited and it has genetic basis.
- Nature selects for fitness which is the end result of the ability to adapt and get selected by nature.
- Fitness is based on characteristics which are inherited.
- Branching descent and natural selection are the two key concepts of Darwinian Theory of Evolution.

▶ **Mechanism of Evolution**

- Evolution needs variations.
- Origin of variation and reason for speciation is inheritable factors influencing phenotype.
- Mendel explained the influence of inheritable factors on phenotype.
- Darwin mentioned that natural selection is the reason for evolution.
- Hugo de Vries based on his work on evening primrose believe that mutation causes evolution.
- Evolution for Darwin was gradual while de Vries believed that mutation caused speciation and hence called it saltation (single step large mutation).

▶ **Hardy-Weinberg Principle**

- Hardy-Weinberg principle is also called genetic equilibrium.
- Gene frequency remains constant from generation to generation and is stable, this is called genetic equilibrium.
- Sum total of allelic frequencies is 1 and individual frequencies can be named as p, q etc. hence, $p + q = 1$, where p and q represent the frequency of allele A and allele a.

- In diploids, the frequency of *AA* is p^2, *aa* is q^2 and of *Aa* is $2pq$. Hence, the formula is $p^2 + 2pq + q^2$. Which is a binomial expansion of $(p + q)^2$ which can be applied to any population to find out the gene frequency.
- When frequency measured differs from expected value, the difference indicates the extent of evolutionary change.

▶ **Factors affecting Hardy- Weinberg Principle are:**

I. Gene flow

- The transfer of section of population to another place resulting in a change in gene frequencies in both old and new population is called **gene flow**.
- New genes and alleles are added to new population which are genetically different but can interbreed.

II. Genetic drift

- The random change in gene frequency that occurs only by chance is called **genetic drift**.
- Sometimes, the change in allelic frequency is so different in the new population, that they become a different species and the original drifted population becomes the founder, hence the effect is called **founder effect**.

III. Mutation

- The spontaneous change in the genetic makeup of an individual is called **mutation**.
- Pre-existing advantageous mutations when selected will result in observation of new phenotypes and over few generations this would result in speciation.

IV. Genetic recombination

- Exchange of genes between non-sister chromatids of homologous chromosomes during gametogenesis is called **genetic recombination**.
- Variation due to recombination during gametogenesis, or due to gene flow or genetic drift results in changed frequency of genes and alleles in future generation.

V. Natural selection

- The process by which better adapted individuals with useful variations are selected by nature and leave greater number of progenies is called **natural selection.**
- Natural selection can lead to:
  - **Stabilising selection:** Here, more individuals acquire mean character value *i.e.*, variation is much reduced.
  - **Directional change:** Here, more individuals acquire value other than the mean character value.
  - **Disruptive selection:** Here, more individuals acquire peripheral character value at both ends of the distribution curve.

▶ **Problems Based on Hardy-Weinberg Principle:**

Q. The frequency of two alleles in a gene pool is 0.15 *(A)* and 0.75 *(a)*. Assume that the population is in Hardy-Weinberg equilibrium.

(i) Calculate the percentage of heterozygous individuals in the population.

Sol. According to Hardy-Weinberg equilibrium equation, heterozygotes are represented by the 2pq term. Therefore, the number of heterozygous individuals (*Aa*) is equal to $2pq$ which equals $2 \times 0.15 \times 0.75 = 0.225 = 22.5\%$.

(ii) Calculate the percentage of homozygous recessives in the population.

Sol. The homozygous recessive individuals *(aa)* are represented by the q^2 term which equals $0.75 \times 0.75 = 0.5625 = 56.25\%$

▶ **A Brief Account of Evolution**

- About 2000 million years ago (mya), the first cellular forms of life appeared on earth.
- Some cellular forms had the ability to release O_2 and slowly single cell organisms became multicellular organisms.
- By the time of 500 mya, invertebrates were formed and active.
- Jawless fish probably evolved around 350 mya.
- Sea weeds and few plants existed probably around 320 mya.
- First organisms that invaded land were plants.
- Fish with stout and strong fins could move on land and go back to water which was about 350 mya.
- In 1938, a lobe finned fish caught in South Africa happened to be a *Coelacanth* which evolved into first amphibians that lived on both land and water and these were the ancestors of modern day frogs and salamanders.
- The amphibians evolved into reptiles that lay thick shelled eggs that do not dry up in sun.
- The modern day descendants of reptiles are the turtles, tortoises and crocodiles.
- In the next 200 million years or so, reptiles of different shapes and sizes dominated on earth.
- Giant ferns (pteridophytes) were present but they all fell to form coal deposits slowly.
- Some of the reptiles went back into water to evolve into fish like reptiles around 200 mya.
- The land reptiles were the dinosaurs and the biggest of them is *Tyrannosaurus rex* was about 20 feet in height and had huge fearsome dagger-like teeth.
- About 65 mya, the dinosaurs suddenly disappeared from the earth, some of them evolved into birds or might be killed by the climatic changes.
- The first mammals were like shrews and their fossils were small-sized.
- Mammals were viviparous and protected their unborn young inside the mother's body.
- Mammals dominated the earth when the population of reptiles came down.
- In South America, there were mammals resembling horse, hippopotamus, bear, rabbit, etc.
- Due to continental drift, when South America joined North America, these animals were overridden by North American fauna.
- Due to the same continental drift, pouched mammals of Australia survived because of lack of competition from any other mammal.
- Some mammals live wholly in water. **Examples:** Whales, dolphins, seals and sea cows.

▸ **Origin and Evolution of Man**

The stages of evolution of man are:

I. *Dryopithecus* and *Ramapithecus*:

- About 15 mya, primates called *Dryopithecus* and *Ramapithecus* were existing.
- They were hairy and walked like gorillas and chimpanzees.
- *Ramapithecus* was more man-like while *Dryopithecus* was more ape-like.
- Few fossils of man-like bones have been discovered in Ethiopia and Tanzania.
- These revealed hominid features leading to the belief that about 3-4 mya, man-like primates walked in eastern Africa.

II. *Australopithecus*

- About two mya, *Australopithecines* probably lived in East African grasslands.
- They hunted with stone, weapons etc. but essentially ate fruits.
- Some of the bones among the bones discovered were different.
- They were intermediate between apes and man.

III. *Homo habilis*

- The brain capacities were between 650-800cc.
- They probably did not eat meat.
- They were the makers of stone tools.

IV. *Homo erectus*

- About 1.5 mya, *Homo erectus* arose.
- *Homo erectus* had a large brain around 900cc.
- *Homo erectus* probably ate meat.

V. Neanderthal Man

- The Neanderthal man with a brain size of 1400cc lived in near east and central Asia between 1, 00,000-40,000 years back.
- They used hides to protect their body and buried their dead.

VI. *Homo sapiens* or Modern Man

- They arose in Africa and moved across continents and developed into distinct races.
- During ice age between 75,000-10,000 years ago, modern *Homo sapiens* arose.
- Pre-historic cave art developed about 18,000 years ago.
- Agriculture came around 10,000 years back and human settlements and civilisation started.

Practice Exercise

Multiple Choice Questions

Q 1. $(p+q)^2 = p^2 + 2pq + q^2 = 1$ represents an equation used in: *(NCERT EXEMPLAR)*

a. population genetics b. Mendelian genetics
c. biometrics d. molecular genetics

Q 2. Appearance of antibiotic-resistant bacteria is an example of: *(NCERT EXEMPLAR)*

a. adaptive radiation
b. transduction
c. pre-existing variation in the population
d. divergent evolution

Q 3. Fossils are generally found in: *(NCERT EXEMPLAR)*

a. sedimentary rocks b. igneous rocks
c. metamorphic rocks d. any type of rock

Q 4. Which type of selection is industrial melanism observed in moth, *Biston bitularia*? *(NCERT EXEMPLAR)*

a. Stabilising b. Directional
c. Disruptive d. Artificial

Q 5. Which of the following is an example for link species? *(NCERT EXEMPLAR)*

a. Lobe fish b. Dodo bird
c. Seaweed d. Chimpanzee

Q 6. Variations during mutations of meiotic recombinations are: *(NCERT EXEMPLAR)*

a. random and directionless
b. random and directional
c. random and small
d. random, small and directional

Q 7. One of the possible early source of energy was/were:

a. CO_2 b. chlorophyll
c. green plants d. UV rays and lightning

Q 8. The ship used by Charles Darwin during the sea voyages was:

a. H.M.S. Beagle b. H.S.M. Beagle
c. H.M.S. Eagle d. H.S.M. Eagle

Q 9. Fitness according to Darwin refers to:

a. number of species in a community
b. useful variation in population
c. strength of an individual
d. reproductive fitness of an organism

Q 10. Alfred Wallace worked in:

a. Galapagos Islands
b. Australian Island Continent
c. Malay Archipelago
d. None of the above

Q 11. The theory of natural selection was given by:

a. Lamarck b. Alfred Wallace
c. Charles Darwin d. Oparin and Haldane

Q 12. Identify the option that gives the correct type of evolution exhibited by the two animals shown, living in the same habitat in Australia. *(CBSE 2023)*

Mouse Marsupial Mouse

a. Convergent evolution b. Disruptive selection
c. Divergent evolution d. Homologous ancestry

Q 13. **The phenomenon 'ontogeny repeats phylogeny' is explained by:**
a. Recapitulation theory b. Inheritance theory
c. Mutation theory d. Natural selection theory

Q 14. **Which of the following isotopes is used for finding the fossil age maximum about 35,0000 years?**
a. ^{238}U b. ^{14}C c. ^{3}H d. ^{206}Pb

Q 15. **The 'Devonian period' is considered to be as:**
a. age of fishes b. age of amphibians
c. age of reptiles d. age of mammals

Q 16. **Amphibians were dominant during ..... period.**
a. Carboniferous b. Silurian
c. Ordovician d. Cambrian

Q 17. **The primate which existed 15 mya was:**
a. *Homo habilis* b. *Australopithecus*
c. *Ramapithecus* d. *Homo erectus*

Q 18. **The extinct stone ancestor, who ate only fruits and hunted with stone weapons was:**
a. *Ramapithecus* b. *Australopithecus*
c. *Dryopithecus* d. *Homo erectus*

Q 19. **The brain capacity of *Homo erectus* was about:**
a. 650 cc b. 900 cc c. 1500 cc d. 1400 cc

Q 20. **At which stage during evolution did human use hides to protect their bodies and buried their dead?** *(CBSE 2023)*
a. *Homo habilis* b. Neanderthal man
c. Java man d. *Homo erectus*

Assertion & Reason Type Questions

Directions (Q.Nos. 21-28): *Each of the following questions consists of two statements, one is Assertion (A) and the other is Reason (R). Select the correct answer to these questions from the codes a, b, c and d as given below.*

a. Both Assertion and Reason are true and Reason is the correct explanation of Assertion.
b. Both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
c. Assertion is true but Reason is false.
d. Assertion is false but Reason is true.

Q 21. **Assertion (A): The first formed earth originally had reducing atmosphere.**
Reason (R): Hydrogen was abundant and there was no free oxygen.

Q 22. **Assertion (A): The first living organisms were heterotrophs.**
Reason (R): Hot dilute soup was formed in the ocean.

Q 23. **Assertion (A): Some babies are born with tail.**
Reason (R): Vestigial organs support the concept of organic evolution.

Q 24. **Assertion (A): Natural selection is the outcome of difference in survival and reproduction among individuals that show variation in one or more traits.**
Reason (R): Adaptive forms of a given trait tend to become more common while less adaptive ones become less common or disappear.

Q 25. **Assertion (A): Adaptive radiation results in cladogenesis.**
Reason (R): Adaptive radiation results in convergent evolution.

Q 26. **Assertion (A): Black coloured *Biston betularia* are abundant due to industrial pollution.**
Reason (R): Natural selection of darker forms occur in response to industrial pollution.

Q 27. **Assertion (A): Most common struggle for existence is intraspecific.**
Reason (R): All the members of a species have same food, shelter and mate.

Q 28. **Assertion (A): Interspecific struggle is not severe.**
Reason (R): In between the different species of animals, the fighting is severe for food and shelter only.

Answers

1. (a) population genetics
2. (c) pre-existing variation in the population
When a bacterial population encounters a particular antibiotic, those sensitive to it die. But some bacteria having mutations become resistant to antibiotics. Such resistant bacteria survive and multiply quickly as the competing bacteria have died. Soon the resistance providing genes become widespread and entire bacterial population become resistant. Appearance of antibodies resistant bacteria is example of pre-existing variation.
3. (a) sedimentary rocks
Fossils are the preserved remains of animals and plant life. Fossils are mostly found embedded in sedimentary rocks of the sedimentary rocks, most fossils occur in shale, limestone and sandstone.
4. (b) Directional
In directional selection, the population changes towards one particular direction. It means this type of selection favours small or large-sized individuals and more individuals of that type will be present in next generations. The mean size of the population changes, *e.g.*, evolution of DDT resistant mosquitoes.
5. (a) Lobe fish
6. (a) random and directionless
7. (d) UV rays and lightning
8. (a) H.M.S Beagle
9. (d) reproductive fitness of an organism
According to Darwin's theory fitness refers to the reproductive fitness of an organism because it describes the reproductive success of an individual

which is measured as the number of offsprings produce by an individual with respect to specific genotype or phenotype. Fitness theory of Darwin doesn't depend on strength of an organism to survive but the ability of an organism to pass on its genetic material to its offsprings.

10. (c) Malay Archipelago
Alfred Wallace worked in Malay Archipelago. He came to similar conclusions around the same time as Darwin. He played a pivotal role in developing the theory of natural selection. But over time, Charles Darwin became almost universally thought of as the father of evolution.
11. (c) Charles Darwin
12. (a) Convergent evolution
13. (a) Recapitulation theory
The theory of recapitulation is also called biogenetic law, and it is also called embryonic parallelism where it was expressed by a scientist Ernst Haeckel by a phrase called, 'Ontogeny is replaced by the phylogeny'.
14. (b) ^{14}C
15. (a) age of fishes
16. (a) Carboniferous
17. (c) *Ramapithecus*
Ramapithecus appeared about 15 million years ago in Pliocene epoch. Fossil of *Ramapithecus* was discovered by Edward Lewis (1932) from rocks of Shivalik Hills of India.
18. (b) *Australopithecus*
Australopithecus probably lived in East African grasslands about 2 million years ago. They hunted with stone weapons but essentially ate fruit. They were about 1.5 m high and their brain capacity was about 500 cc. They had bipedal locomotion and erect posture.
19. (b) 900 cc
Homo erectus had an average cranial capacity of about 1000 cc significantly larger than that of earlier hominids. In fact, in brain size certain *Homo erectus* individuals exceeded many modern humans of normal intelligence. *Homo erectus* had a cranial capacity greater than that of *Homo habilis*. The earliest remains show a cranial capacity of 850 cm, while the latest Javan specimens measure up to 1100 cm, overlapping that of *Homo sapiens*. The frontal bone is less sloped and the dental arcade smaller than the *Australopithecines*. The face is more orthognathic (less protrusive) than either the *Australopithecines* or *Homo habilis*, with large brow-ridges and less prominent zygomata (cheekbones).
20. (b) Neanderthal man
21. (a) Both Assertion and Reason are true and Reason is the correct explanation of Assertion.
The lightest atoms of nitrogen, carbon, etc, formed the primitive atmosphere. Hydrogen atoms were most numerous and most reactive in primitive atmosphere. Hydrogen atoms combined with all oxygen atoms to form water leaving no free oxygen. Thus, primitive atmosphere was reducing atmosphere (without free oxygen) unlike the present oxidising atmosphere (with free oxygen).
Formation of ozone layer is the consequence of modern oxidising atmosphere having plenty of free oxygen. As more oxygen accumulated in the atmosphere (due to photosynthesis) ozone began to appear in the top layers.
22. (b) Both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
23. (b) Both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
24. (a) Both Assertion and Reason are true and Reason is the correct explanation of Assertion.
25. (c) Assertion is true but Reason is false.
26. (a) Both Assertion and Reason are true and Reason is the correct of explanation of Assertion.
27. (a) Both Assertion and Reason are true and Reason is the correct of explanation of Assertion.
28. (a) Both Assertion and Reason are true and Reason is the correct of explanation of Assertion.

Case Study Based Questions

Case Study 1

Evolution of Life Forms

Darwin developed his ideas on descent with modification and the pressures of natural selection. A variety of evidence has been gathered supporting the theory of evolution. Fossil evidence shows the changes in lineages over millions of years, such as in hominids and horses. Studying anatomy allows scientists to identify homologous structures across diverse groups of related organisms, such as leg bones. Vestigial structures also offer clues to common ancestors. Using embryology, scientists can identify common ancestors through structures present only during development and not in the adult form. Biogeography offers further clues about evolutionary relationships. The presence of related organisms across continents indicates when these organisms may have evolved. For example, some flora and fauna of the Northern continents are similar across these landmasses but distinct from that of the Southern continents. Islands such as Australia and the Galapagos chain often have unique species that evolved after these landmasses separated from the mainland. Finally, molecular biology provides data supporting the theory of evolution.

Q 1. Which living organisms evolved first during evolutionary order?
a. Amphibians b. Marine
c. Reptiles d. Vertebrates

Q 2. Which word is proper for the similarity in their morphology, anatomy and embryology?
a. Analogous organs b. Vestigial organs
c. Homologous organs d. None of these

Q 3. Which of the following is/ are an example of homologous organs?
a. Wings of insects, birds and bats.
b. The thorns and tendrils of *Bougainvillea* and *Cucurbita.*
c. The forelimbs of higher vertebrates.
d. Both b. and c.

Q 4. The organs which are superficially similar but anatomically dissimilar doing similar functions are called .....
a. Analogous organs.
b. Homologous organs.
c. Vestigial organs.
d. None of the above.

Q 5. Which of the following is an example of analogous organs?
a. Vermiform appendix.
b. Nictitating membrane and ear muscles.
c. Both a. and b.
d. The thorns and tendrils of *Bougainvillea* and *Cucurbita.*

Answers

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

Case Study 2

Hardy-Weinberg Principle

As per Hardy–Weinberg Principle, "Allele and genotype frequencies in a population will remain constant from generation to generation in the absence of other evolutionary influences. These influences include mate choice, mutation, selection, genetic drift, gene flow and meiotic drive".

The gene pool remains a constant. The total genes and their alleles in a population make the gene pool. Sum total of all the allelic frequencies is 1.

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

When frequency differs from expected values, the difference (direction) indicates the degree of evolutionary change. Thus, disturbance in Hardy-Weinberg Equilibrium would then be said to result in evolution.

Factors that affect Hardy-Weinberg Equilibrium are Gene Migration or Gene Flow, Genetic Drift, Mutation, Genetic Recombination and Natural Selection.

Q 1. What is the importance of Hardy-Weinberg law?
a. Evolution b. Gene pool
c. Genetics d. Genetic variation

Q 2. The sum total of genes present in a Mendelian population is called:
a. gene pool b. gene frequency
c. genetic variation d. genetics

Q 3. How many years ago the earth was originated?
a. 6000 b. 5500
c. 5000 d. 6500

Q 4. Random genetic drifts in a population are a result of:
a. small size of population.
b. major genetic differences in individuals.
c. interspecific hybridisation.
d. slower rate of mutation.

Q 5. Match the columns and find out the correct option from the following:

S.No.	Column I		Column II
(i)	Genetic drift	(p)	The gene frequencies are found to fluctuate purely by chance.
(ii)	Gene flow	(q)	The genes of one population are transferred into another population.
(iii)	Gene frequency	(r)	It refers to the ratio of a gene in a gene pool.
(iv)	Gene pool	(s)	It is the sum total of genes present in a Mendelian population.

a. (i-q), (ii-r), (iii-p), (iv-s)
b. (i-r), (ii-s), (iii-q), (iv-p)
c. (i-p), (ii-q), (iii-r), (iv-s)
d. (i-s), (ii-p), (iii-r), (iv-q)

Answers

1. (a) **2.** (a) **3.** (c) **4.** (a) **5.** (c)

Case Study 3

Origin of Life

The universe is about 20 billion years old. The earth was formed about 4.5 billion years ago. The atmosphere was not present on early earth. The earth was covered with water vapour, methane, carbon dioxide and ammonia. The UV rays from the sun split water into hydrogen and oxygen. The oxygen reacted with ammonia and methane to form water, carbon dioxide and other gases. When the earth cooled down further, water vapour fell as rain, to form oceans. Life appeared on earth about 4 billion years back. Various theories are given for the origin of life on Earth like Theory of Abiogenesis, Biogenesis, Panspermia, Spontaneous Generation and Oparin and Haldane theory etc.

Read the given passage carefully and give the answer of the following questions:

Q 1. "The world has been evolved and not been created. Non-living substances have reacted to form organic compounds which developed into colloidal systems". Find out the theory proposed in the statements.

Ans. Theory of Organic Evolution has been proposed in the statement.

Q 2. Who cleared that interaction of chemical substances initiated origin of life in the past?

Ans. Haeckel cleared that interaction of chemical substances initiated origin of life in the past.

Q 3. In the beginning, how much was the temperature of the earth?

Ans. 5000°C to 6000°C was the temperature of the earth in the beginning.

OR

Which chemical is first formed in the earth?

Ans. Ammonia and methane.

Case Study 4

Adaptive Radiation

The process of evolution of many varieties from a single variety of organism in a given geographical area is called adaptive radiation. It happens within a short span of time.

Darwin's observation on finches of the Galapagos Islands showed interesting insights. Finches of that island show a wide variety, in terms of types of beaks, suited to different eating habits. Darwin proposed that all the varieties evolved on the island itself. From the original seed-eating features, many other forms (with altered beaks) arose. This shows adaptive radiation.

Another example of adaptive radiation is seen in Australian marsupials. Different types of marsupials evolved from one ancestral stock, within the Australian island continent. Placental mammals in Australia also exhibit adaptive radiation.

Read the given passage carefully and give the answer of the following questions:

Q 1. Adaptive radiation is nothing but divergence. What causes divergent evolution?

Ans. The divergent evolution is caused by:
(i) need for food (ii) isolation
(iii) absence of enemies.

Q 2. How many types of adaptive radiation are there?

Ans. Three types of adaptive radiations are there.

OR

Give an example of adaptive radiation.

Ans. Australian marsupials.

Q 3. What is the other name of de Vries theory?

Ans. The other name of de Vries theory is Theory of mutation.

Very Short Answer Type Questions

Q 1. State the two principal outcomes of the experiments conducted by Louis Pasteur on origin of life. *(CBSE 2019)*

Ans. Louis Pasteur by careful experimentation demonstrated that:
(i) Life comes only from pre-existing life.
(ii) In pre-sterilised flasks, life did not come from killed yeast while in another flask open to the air, new organisms arose from killed yeast.

Q 2. What did Louis Pasteur's experiment on 'killed yeast' demonstrate? Name the theory that got disproved on the basis of his experiment.

Ans. Louis Pasteur demonstrated that life comes only from pre-existing life. The theory of spontaneous generation was disproved on the basis of his experiment.

Q 3. Write the hypothetical proposals put forth by Oparin and Haldane.

OR

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

Ans. Oparin and Haldane proposed that life originated from pre-existing non-organic molecules and the diverse organic molecules were formed from these inorganic constituents by chemical evolution *i.e.*, formation of life was preceded by chemical evolution.

Q 4. State the significance of the study of fossils in evolution.

Ans. Fossils represent extinct organisms. The significance of their study in evolution are:
(i) They show life forms restricted to certain geological time spans existing in the past.
(ii) They show ancestry of present day organisms.
(iii) They are connecting links between two groups of organisms. (Any one)

Q 5. The microscopic pollen grains of the past are obtained as fossils. Mention the characteristic of the pollen grains that makes it happen. *(CBSE 2015, 17)*

Ans. Exine, the outermost hard layer is chemically composed of sporopollenin, which is highly resistant to high temperature, strong acids, alkali and enzymes.

Q 6. Are flippers of penguin and dolphin homologous or analogous? What type of evolution has brought such a similarity in them?

Ans. The flippers of penguin and dolphin are analogous. Convergent evolution brought similarity in them.

Q 7. Are the wings of a bird and the forelimb of a horse homologous or analogous? Name the type of evolution that explains the development of such structures.

Ans. They are homologous organs. Divergent evolution explains the development of such structures.

Q 8. What is "fitness of an individual" according to Darwin?

Ans. According to Darwin, "fitness of an individual" is the ability of an organism to survive and pass on its genes to future generations.

Q 9. 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.

Ans. The reason is natural selection or survival of the fittest.

Q 10. According to de Vries what is saltation? *(CBSE 2017)*

Ans. According to de Vries, saltation is single step large mutation.

Q 11. Mention how is mutation theory of Hugo de Vries different from Darwin's theory of natural selection. *(CBSE 2015)*

Ans. According to Hugo de Vries, new species arise due to single step large mutation whereas according to Darwin, evolution occurs gradually by the method of natural selection.

Q 12. What is paleontology?

Ans. The systematic and scientific study of fossils is called paleontology.

Q 13. Rearrange the human activities mentioned below as per the order in which they developed after the modern *Homo sapiens* came into existence during ice age:

(i) Human settlement
(ii) Pre-historic cave art
(iii) Agriculture

Ans. The order of activities is as follows:

(i) Pre-historic cave art
(ii) Agriculture
(iii) Human settlement

Q 14. 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?

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

Q 15. What does Hardy-Weinberg equation $p^2 + 2pq + q^2 = 1$ convey?

Ans. Hardy-Weinberg equation conveys genetic equilibrium, *i.e.*, sum total of all allelic frequencies is 1.

Q 16. What is gene migration? *(CBSE 2016)*

Ans. When a section of population migrates, it results in addition of new genes or alleles to one population and their loss to another population. This is called gene migration.

Q 17. Define genetic drift. *(CBSE 2017)*

Ans. A sudden change in gene frequency by chance alone rather than by natural selection is called genetic drift.

Q 18. In a certain population, the frequency of three genotypes is as follows:

Genotype	BB	Bb	bb
Frequency	22%	62%	16%

What is the likely frequency of B and b alleles? *(NCERT EXEMPLER)*

Ans. **Frequency of B allele:** all of BB + 1/2 of Bb = 22 + 31 = 53%
Frequency of b allele: all of bb + 1/2 of Bb = 16 + 31 = 47%

Q 19. What is the foundar effect? *(NCERT EXEMPLAR)*

Ans. Founder effect is the phenomenon that occurs when a small group of organism becomes isolated from a larger population and becomes so genetically different from the original population that they become a new population together.

Q 20. Write the names of the following: *(CBSE 2018)*

(i) A 15 mya primate that was ape-like
(ii) A 2 mya primate that lived in East African grasslands

Ans. (i) *Dryopithecus*
(ii) *Australopithecines / Australopithecus / Homo habilis*

Q 21. Write the probable differences in eating habits of *Homo habilis* and *Homo erectus*.

Ans. *Homo habilis* did not eat meat. They were vegetarian. On the other hand, *Homo erectus* ate meat. They were meat eater.

Q 22. What are the brain capacities of *Homo habilis* and Neanderthal man?

Ans. The capacity of brain of *Homo habilis* is 650-800cc and Neanderthal man is 1400cc.

Short Answer Type Questions

Q 1. Write the Oparin and Haldane's hypothesis about the origin of life on Earth. How does meteorite analysis favour this hypothesis?

Ans. Oparin and Haldane's hypothesis stated that life originated from pre-existing non-living organic molecules (*e.g.*, RNA, protein, etc.). When the meteorites were analysed, it was observed that presence of similar compounds was confirmed which conclude that similar process is going on elsewhere in the space.

Q 2. Mention the contribution of S.L. Miller's experiments on Origin of Life.

Ans. S.L. Miller created an environment in laboratory similar to the one that existed before life originated. In a closed flask containing CH_4, H_2, NH_3 and water vapour at 800°C, electric discharge was created. The conditions were similar to those in primitive atmosphere. After a week, they observed presence of amino acids and complex molecules like sugars, nitrogen bases, pigments and fats in the flask. This provided experimental evidence for the theory of chemical origin.

Q 3. Convergent evolution and divergent evolution are the two concepts explaining organic evolution. Explain each one with the help of an example.

OR

Differentiate between divergent and convergent evolution. Give examples of each.

Ans. Convergent Evolution: When more than one adaptive radiation appeared to have occurred in an isolated geographical area and two or more groups of unrelated animals resemble each other for similar mode of life or habitat, it is called convergent evolution, *e.g.*, Australian marsupials, placental mammals.

Divergent Evolution: In some animals, the same structures developed along different directions due to adaptations to different needs. This is known as divergent evolution. For example, forelimbs of whales, bats, cheetah and human perform different functions but have similar anatomical structure with similar bones arranged in similar segments.

COMMON ERROR

Students forget to mention examples in both types of evolution or interchange them by mistake.

Q 4. Abingdon tortoise in Galapagos islands become extinct within a decade on introduction of goats in the island. Explain giving reason. *(CBSE 2023)*

Ans. The Abingdon tortoise in Galapagos islands become extinct within a decade only after goats were introduced on the islands. It is an example of competitive exclusion. It happened due to greater browsing efficiency of the goats.

Q 5. Branching descent and natural selection are the two key concepts of Darwinian Theory of Evolution. Explain each concept with the help of a suitable example.

Ans. Branching Descent: In it, different species descending from the common ancestor get adapted in different habitats, *e.g.*, Darwin's finches—varieties of finches arose from grain eaters; Australian marsupials evolved from common marsupial.

Natural Selection: It is a process in which heritable variations enable better survival of the species to reproduce in large numbers, *e.g.*, white moth surviving before the industrial revolution and black moth surviving after industrial revolution, long-necked giraffe survived the evolution process; DDT-resistant mosquitoes survive.

Q 6. Explain adaptive radiation with the help of a suitable example. *(CBSE 2016)*

Ans. Adaptive Radiation: It is the evolutionary process in which different species starting from a common point in a geographical area radiate to other geographical areas. **Examples:** Darwin's finches.

(i) Darwin observed many varieties of finches in the same island.

(ii) All varieties had evolved from original seed-eating finches.

(iii) With alteration in beaks, some became insectivorous and some vegetarian.

Q 7. (i) Identify any two marsupials from the list given below:

(a) Lemur **(b) Spotted calicos**
(c) Flying phalanger **(d) Bobcat**
(e) Tasmanian wolf **(f) Mole**

(ii) "Australian marsupials exhibit adaptive radiation." Justify the statement. *(CBSE 2015)*

Ans. (i) Flying phalanger and Tasmanian wolf

(ii) Australian marsupials exhibit adaptive radiation as they differ from each other and are evolved from an ancestral stock which all fall within the Australian island continent.

Q 8. "Post-Industrialisation, the population of melanised moth increased in England at the expense of white-winged moths." Provide explanations. *(CBSE 2015)*

Ans. Pre-industrialisation period had more white-winged moth against grey lichens on tree trunks. During industrialisation, large amount of soot and smoke deposited on tree trunks, making the bark dark. Against the dark background, white moths could easily be preyed upon. Melanised moth could camouflage against dark bark. This natural selection increased their number.

Q 9. (i) Rearrange the following in an ascending order of evolutionary tree: reptiles, salamanders, lobefins, frogs.

(ii) Name two reproductive characters that probably make reptiles more successful than amphibians.

Ans. (i) The ascending order is:
Lobefins, frogs, salamanders, reptiles.

TiP

Learn the evolutionary tree in proper order for providing correct arrangement.

(ii) Reptiles are more successful than amphibians as:
(a) reptiles lay eggs on land.
(b) reptiles lay thick shelled eggs which do not dry up in sun unlike those of amphibians.

Q 10. Protein synthesis machinery revolves around RNA but in the course of evolution, it was replaced by DNA. Justify. *(CBSE 2015)*

Ans. Since RNA was unstable and prone to mutations, DNA evolved from RNA with chemical modifications that makes it more stable. DNA has double-stranded nature and has complementary strands. These further resist changes by evolving a process of repair.

Q 11. What is speciation? List any two events leading to speciation. *(CBSE 2016)*

Ans. The process involving formation of new species from the existing species is called speciation.
Two events leading to speciation are:

(i) Interbreeding among different populations or species.
(ii) Migration.

Q 12. 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? *(CBSE 2018)*

Ans. In a population of diploid organisms, if frequency of allele $A = p$ and frequency of allele $a = q$ then, expected genotype frequency under random mating are:

$AA = p^2$ (for the AA homozygotes)
$aa = q^2$ (for the aa homozygotes)
$Aa = 2pq$ (for the Aa heterozygotes)

In absence of selection, mutation, genetic drift or other forces, allelic frequency p and q are constant through generation.
Therefore, $p^2 + 2pq + q^2 = 1$.

COMMON ERROR
Students do not learn the equation properly and miss out the proper explanation of the principle.

Q 13. How would the gene flow or genetic drift affect the population in which either of them happens to take place? *(CBSE 2019)*

Ans. Gene flow (gene migration multiple times) affects the population by changing allele frequency in both old and new populations thereby, altering the Hardy-Weinberg equilibrium.
Genetic drift is a sudden change in the frequency of genes and their alleles within a gene pool of a population over a very short duration of time. A population experiencing such a phenomenon will not obey Hardy-Weinberg principle. Genetic drift can occur due to natural or artificial selection alike.

Q 14. Gene flow occurs through generations. Gene flow can occur across language barriers in humans. If we have a technique of measuring specific allele frequencies in different population of the world, can we not predict human migratory patterns in pre-history and history? Do you agree or disagree? Provide explanation to your answer. *(NCERT EXEMPLAR)*

Ans. Yes, I agree. Gene flow occurs through generations. By studying specific allele frequencies, we can predict the human migratory patterns in pre-history and history. Studies have used specific genes/chromosomes/ mitochondrial DNA to trace the evolutionary history and migratory patterns of humans. The project is known as the Human Genographics Project.

Q 15. State and explain the factors affecting allele frequency in populations. *(NCERT EXEMPLAR)*

Ans. The factors affecting allele frequency in populations are:

(i) Gene migration or gene flow: 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.

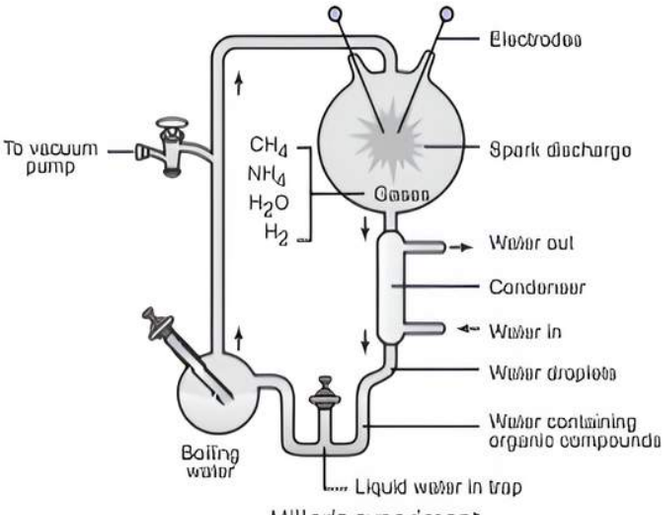
(ii) Genetic drift: If the same change occurs by chance, it is called genetic drift. Sometimes the change in allele frequency is so different in the new sample of population that they become a different species. The original drifted population becomes founders and the effect is called **founder effect**.

(iii) Mutation: Microbial experiments show that pre-existing advantageous mutations when selected will result in observation of new phenotypes. Over few generations, this would result in speciation. Natural selection is a process in which heritable variations enabling better survival are enabled to reproduce and leave greater number of progeny.

Long Answer Type-I Questions

Q 1. State the theory of biogenesis. How does Miller's experiment support this theory?

Ans. The theory of biogenesis states that a living organism arises from other living organisms.



Miller's experiment

Experimental evidence of chemical evolution/ Miller's experiment:
Experiment was performed by S.L. Miller and H.C. Urey in 1953.
Experimental set-up: In a closed flask containing CH_4, H_2, NH_3 and water vapour at 800°C, electric discharge was created. The conditions were similar to those in primitive atmosphere.
Observations: After a week, they observed presence of amino acids and complex molecules like sugars, nitrogen bases, pigments and fats in the flask.

Conclusions:

(i) It provides experimental evidence for the theory of chemical origin.

(ii) It showed that the first non-cellular form of life was created about 3 billion years ago.

(iii) It showed that non-cellular biomolecules exist in the form of DNA, RNA, polysaccharides and proteins.

Q 2. (i) Differentiate between analogous and homologous structures.

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

(a) Wings of butterfly and birds

(b) Vertebrate hearts

(c) Tendrils of *Bougainvillea* and *Cucurbita*

(d) Tubers of sweet potato and potato

(CBSE 2018)

Ans. (i) Analogous structures are anatomically not similar though perform similar functions and are a result of convergent evolution.
Homologous structures are anatomically similar (but perform different functions) and are a result of divergent evolution.

(ii) (a) Wings of butterfly and birds (d) Tubers of sweet potato and potato are analogous structures.

Q 3. What type of organs eye of an octopus and that of a human called? Give another example from the animal group and one from the plants of such organs. Name and explain the evolutionary process they exhibit.

Ans. These organs are called analogous organs.
Another example from animal group is flippers of penguins and dolphins or eye of octopus and mammals in plants. These organs can be seen in sweet potato (root modification) and potato (stem modification). They are anatomically dissimilar structure though they perform similar functions.
This type of evolution is called convergent evolution.

Q 4. How do fossils help us in understanding the evolutionary history?

Ans. There are paleontological evidences about fossils which help to understand the evolutionary history.

(i) The study of fossils is called paleontology. Fossils are the remains or impressions of past organisms preserved in sedimentary rocks or other media.

(ii) Different-aged rock sediments in earth's crust indicate the presence of fossils of different life forms which died during the sediment formation.

(iii) A variety of fossils ranging from the modern organisms to extinct organisms can be observed.

(iv) By studying the different sedimentary layers, the geological time period in which the organism existed, can be predicted.

Q 5. Since the origin of life on earth, there were five episodes of mass extinction of species.

(i) How is the 'Sixth Extinction', presently in progress, different from the previous episodes?

(ii) Who is mainly responsible for the 'Sixth Extinction'?

(iii) List any four points that can help to overcome this disaster.

Ans. (i) The current species extinction rates (Sixth Extinction) are estimated to be 100-1000 times faster than in the pre-human times (previous episodes).

(ii) Human activities are mainly responsible for the sixth extinction.

(iii) This disaster can be overcome in the following ways:

(a) Preventing habitat loss and fragmentation

(b) Checking overexploitation

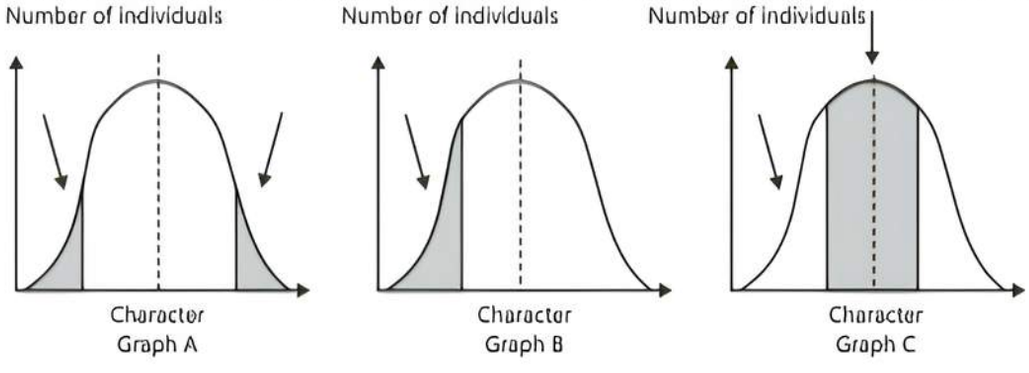
(c) Preventing alien species invasion

(d) Preventing co-extinction

(e) Conservation/Preservation of species.

(Any four)

Q 6. The graphs below show three types of natural selection. The shaded areas marked with arrows show the individuals in the population which are not selected. The dotted vertical lines show the statistical means.



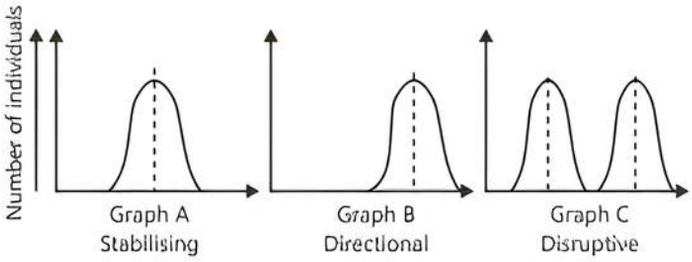
(i) What names are given to the types of selection shown in graphs A, B and C?

(ii) After the selection has operated for several generations in the above populations indicated as Graph A, B and C, graphically illustrate the probable results. *(CBSE SQP 2023-24)*

Ans. (i) A-Stabilising; B-Directional; C-Disruptive;

(ii) Graph A – Stabilising

Graph B — Directional
Graph C — Disruptive



Q 7. (i) Darwin's theory of natural selection is widely accepted but some limitations have been identified by modern biologists. Mention the limitations identified.

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

(iii) Mention any two limitations identified in Darwin's theory of evolution as explained in modern biology. *(CBSE 2023)*

Ans. (i) **Limitations of Darwin's Theory of Evolution:**

(a) The theory of evolution could not explain how and where variations have arisen.

(b) It also could not explain how the variations are inherited.

(ii) **Synthetic Theory of Evolution:**

The most accepted theory of evolution is the synthetic theory of evolution or Neo-Darwinism, also called the modern concept.

According to this theory, the origin of new species is based on the interaction of genetic variations and natural selection. It recognises various factors like gene mutations, changes in chromosome number and structures, genetic recombination, natural selection, and reproductive isolation.

(iii) The following are two limitations identified in Darwin's theory of evolution that have been explained in modern biology.

(a) **Lack of knowledge about the source of variation:** Darwin's theory did not explain the source of variation that is necessary for natural selection to operate. And also he did not understand the mechanism behind inheritance and genetic variation.

(b) **Incomplete understanding of inheritance:** Darwin did not have a complete understanding of how traits are inherited from one generation to the next.

Q 8. (i) How does the Hardy–Weinberg's expression ($p^2 + 2pq + q^2 = 1$) explain that genetic equilibrium is maintained in a population?

(ii) List any two factors that can disturb the genetic equilibrium. *(CBSE 2017)*

Ans. (i) Hardy-Weinberg's expression explains the following:

(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 individual in a population is p^2 and it can be explained that 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, the frequency '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 represents the frequency of the homozygous recessive.

(b) **Genetic equilibrium states the status of evolution:** (i) If there is some fluctuation or disturbance in genetic equilibrium or Hardy–Weinberg equilibrium, *i.e.*, change of frequencies of alleles in a population, then it can be predicted that evolution is in progress.

(ii) Factors that affect Hardy–Weinberg equilibrium:

(a) Gene migration or gene flow

(b) Genetic drift

(c) Mutation.

Q 9. Industrial melanism in England after 1850 is an excellent example of natural selection. Explain how? *(CBSE 2023)*

Ans. Industrial melanism in England after 1850 is an excellent example of natural selection. It is because, before industrialisation, the air quality of England was good due to which lichens were able to grow on tree barks. Lichens were white in colour. Hence, moths living on tree bark evolved with time to have a more white population due to less melanin production. This reduced the number of black moths in the population. This was an adaptation to hide from predators.

With time as industrialisation grew the air quality reduced. This eliminated the lichens from the region. Now the dark brown to black colour of tree bark was exposed. Due to this, the moth population evolved to have more melanin giving them black colour. This reduced the number of white moths in the population. This was an adaptation to hide from predators' attacks.

In short, evolving with the situation gave moths' population a benefit due to natural selection.

Q 10. Write the characteristics of *Ramapithecus*, *Dryopithecus* and Neanderthal man. *(CBSE 2017)*

Ans. Characteristics of *Ramapithecus*:

(i) It evolved around 15 mya.

(ii) More man-like, walked more erect, teeth like modern man.

Characteristics of *Dryopithecus*:

(i) It evolved around 25 mya.

(ii) Ape like, hairy arms and legs of same length, large brain, ate soft fruits and leaves, walked like gorillas and chimpanzees.

Characteristics of Neanderthal Man:

(i) It evolved around 1,00,000-40,000 year ago.

(ii) Fossils found in East and central Asia, brain size 1400 cc, used hides to protect body, buried their dead.

Q 11. (i) Write two differences between *Homo erectus* and *Homo habilis*.

(ii) Rearrange the following from early to late geologic periods:
Carboniferous, Silurian, Jurassic. *(CBSE 2019)*

Ans. (i)

Character	*Homo erectus*	*Homo habilis*
(a) Brain capacity	900 cc	650-800 cc
(b) Eating habit	They probably ate meat.	They probably did not eat meat.

(ii) The correct sequence from early to late geological period is :
Silurian period → Carboniferous period → Jurassic period.

COMMON ERROR

Students don't give difference in tabular form or do not explain the answer based on characters.

Long Answer Type-II Questions

Q 1. Explain the salient features of Hugo de Vries theory of mutation. How is Darwin's theory of natural selection different from it? Explain. *(CBSE 2011)*

Ans. Salient features of theory of Hugo de Vries are:

(i) Mutations cause evolution.

(ii) New species originate due to large mutations.

(iii) Evolution is a discontinuous process and not gradual.

(iv) Mutations are directionless.

(v) Mutations appear suddenly.

(vi) Mutations exhibit their effect immediately.

Difference between Darwin's theory of natural selection and Hugo de Vries theory of mutation:

S. No.	Basis of difference	Darwin's Theory of Natural Selection	Hugo de Vries Theory of Mutation
(i)	Evolutionary process	He believed that minor variations cause evolution. Darwinian variations are small and directional.	He believed that mutation causes evolution.
(ii)	Type	He believed evolution to be gradual.	He believed sudden mutations caused evolution.

Q 2. (i) How did Darwin explain adaptive radiation? Give another example exhibiting adaptive radiation.

(ii) Name the scientist who influenced Darwin and how? *(CBSE 2016)*

Ans. (i) During his journey, Darwin went to Galapagos Islands. There he observed an amazing diversity of creatures. Of particular interest were small black birds, later called Darwin's Finches which amazed him. He realised that there were many varieties of finches in the same island. All the varieties, he conjectured, evolved on the island itself. From the original seed-eating features, many other forms with altered beaks arose, enabling them to become insectivorous and vegetarian finches. This process of evolution of different species in a given geographical area starting from a point and literally radiating to other areas of geography (habitats) is called adaptive radiation. Darwin's finches represent one of the best examples of this phenomenon. Another example is Australian marsupials.

(ii) Thomas Malthus influenced Darwin. According to Malthus, population size grows exponentially (due to maximum reproduction). However, the population size remains limited due to limited natural resources which leads to competition.

Q 3. Mention Darwin's observations made on finches during his visit to Galapagos islands. Write the explanation given by Darwin on his observations. *(CBSE 2023)*

Ans. During his visit to the Galapagos Islands, Charles Darwin observed several species of finches. He noticed that each species had a unique beak shape, adapted for specific types of food sources. This led him to hypothesize that the finches had evolved from a common ancestor and that natural selection had played a role in shaping their beaks to suit their particular food sources.

Darwin observed that some finches had small beaks suited for eating insects, while others had larger beaks for cracking seeds or nuts. He also noted that the beak size and shape varied among different islands in the Galapagos archipelago. This suggested to Darwin that the finches had diverged into separate species over time, adapting to the specific environmental conditions on each island.

Darwin's explanation for these observations was that over time, random genetic mutations occurred within the finch population. These mutations provided advantages to individuals with certain characteristics, allowing them to survive and reproduce more successfully than others. This process of natural selection gradually led to the development of different finch species with unique beak shapes suited to different types of food sources.

Overall, Darwin's observations of the finches played a crucial role in the development of his theory of evolution by natural selection.

Q 4. (i) Explain the process of natural selection that leads to speciation.

(ii) List the three different ways in which this process operates in nature. Explain any one of the processes.

Ans.

(i) The process of natural selection that leads to speciation is explained as follows:

(a) There has been gradual evolution of life forms with new forms arising at different periods of history.

(b) Any population has built-in variations in characteristics which adapt it better to environment.

(c) The characteristics which enable some populations or individuals to survive better in natural conditions (climate, food, physical factors) would out-breed others (Survival of the fittest).

(d) Those populations which are better fit (reproductively fit) in an environment will be selected by nature and will survive more (Natural selection).

(e) Adaptability is inherited and fitness is the end result of ability to adapt and get selected by nature.

(ii) The process of natural selection is based on the following factual observations:

(a) Limited natural resources.

(b) Stable population size except seasonal fluctuation.

(c) Varying characteristics of members of a population.

(d) Most of the variations are inherited.

Q 5. How does the process of natural selection affect Hardy-Weinberg equilibrium? Explain.

Ans. The process of natural selection affect Hardy–Weinberg equilibrium in the following ways:

(i) Gene migration or gene flow: When individuals migrate to another place or population, new genes or alleles are added to new population and are lost from old population, in turn, changing the frequencies. When gene migration occurs many times, it is called gene flow.

(ii) Genetic drift: Changes occurring in frequencies by chance is called genetic drift. Sometimes, due to changes in allele frequency in new population, some form a different species. This effect is called founder effect and the original drifted population is called founder.

(iii) Mutation: Advantageous mutations lead to new phenotypes and over few generations, result in speciation.

(iv) Genetic recombination: During gametogenesis, variations due to recombination result in new phenotypes.

(v) Natural selection: Heritable variations that enable survival of the fittest will leave greater number of progeny. Natural selection can have following three effects:

(a) Stabilisation: Larger number of individuals acquires mean character value so peak gets higher and narrower.

(b) Directional change: Large number of individuals acquires value other than mean character value so peak shifts in one direction.

(c) Disruption: Large number of individuals acquires peripheral character values at both ends of the distribution curve and hence two peaks are formed.

Q 6. (i) Name the primates that lived about 15 million years ago. List their characteristic features.

(ii) (a) Where was the first man-like animal found?

(b) Write the order in which Neanderthals, *Homo habilis* and *Homo erectus* appeared on Earth. State the brain capacity of each one of them.

(c) When did modern *Homo sapiens* appear on this planet?

Ans. (i) Primates called *Dryopithecus* and *Ramapithecus* lived 15 million years ago. Their characteristic features are:

(a) They were hairy and walked like gorillas and chimpanzees.

(b) *Ramapithecus* was more man-like.

(c) *Dryopithecus* was more ape-like.

(ii) (a) First man-like animal was found in Ethiopia and Tanzania.

(b) The order of appearance from the earliest to the latest is: *Homo habilis*, *Homo erectus*, Neanderthals. The brain capacity of *Homo habilis* is 650–800 cc, of *Homo erectus* is 900 cc and of Neanderthals is 1400 cc.

(c) Modern *Homo sapiens* appeared between 75,000–10,000 years ago.

TiP

Learn thoroughly the period of evolution of human ancestors or their time of origin along with their general features.

Chapter Test

Multiple Choice Questions

Q 1. Abiogenesis theory of origin supports:

a. spontaneous generation.
b. origin of life from blue-green algae.
c. origin of life is due to pre-existing organisms.
d. organic evolution is due to chemical reactions.

Q 2. According to one of the most widely accepted theories, earth's atmosphere before origin of life was:

a. oxidising.
b. oxidising along with H_2.
c. reducing with free O_2 in small amount.
d. reducing with oxygen absent in O_2 form.

Q 3. The preserved fossil remains of *Archaeopteryx* show that:

a. it was a flying reptile from the Permian period.
b. reptiles gave rise to birds during Jurassic period.
c. it was a flying reptile in the Triassic period.
d. reptiles gave rise to birds during Permian period.

Assertion and Reason Type Questions

Directions (Q.Nos. 4-5): *Each of the following questions consists of two statements, one is Assertion (A) and the other is Reason (R). Select the correct answer to these questions from the codes a, b, c and d as given below.*

a. Both Assertion and Reason are true and Reason is the correct explanation of Assertion.
b. Both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
c. Assertion is true but Reason is false.
d. Both Assertion and Reason are false.

Q 4. Assertion (A): Primitive atmosphere was formed by the light elements.
Reason (R): The primitive atmosphere was reducing in nature.

Q 5. Assertion (A): In disruptive selection, phenotypes move away from the average towards the ends of population distribution.
Reason (R): The selection pressure due to increased competition removes the average of the phenotypic distribution in the population.

Case Based Questions

Case Study 1

Q 6. Charles Darwin, an English naturalist and one of the most important biologists of 19th century made an extensive study of nature for over 20 years while on a voyage of world exploration on a famous ship H.M.S. Beagle. During this journey, he explored the fauna and flora of a number of continents and islands such as Galapagos islands. There he observed great variations among the organisms living there and called it "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'**.

(i) Charles Darwin was best known in the 19th century for:

a. creating the idea of evolution.
b. creating the idea of uniformitarianism.
c. aking the idea of evolution acceptable for scientists and the educated general public.
d. All of the above.

(ii) Charles Darwin's ideas concerning the causes of evolution were probably formulated in his mind:

a. while he was still a student at Cambridge University.
b. before he began his voyage of exploration around the world on H.M.S. Beagle.
c. during his voyage on H.M.S. Beagle, especially after he reached the Galapagos Islands.
d. during the late 1880's.

(iii) Charles Darwin concluded that the 13 species of finches on the Galapagos Islands:

a. were identical to 13 finch species in North-Western South America 600 miles to the east.
b. probably evolved from one ancestral South American species.
c. had all adapted to the same food sources.
d. Both b. and c.

(iv) Which of the following statements about Darwin is true?

a. He failed to convince the majority of biologists and other educated people in the late 19th century that life evolves.
b. He thought that the biggest and strongest animals are always at an advantage in natural selection.
c. His book 'On the Origin of Species' did not sell well and the biologists in his time did not take much notice of it.
d. None of the above

Case Study 2

Q 7. *Dryopithecus* and *Ramapithecus* existed around 15 mya. *Ramapithecus* was more man-like, while *Dryopithecus* was more ape-like. Man-like primates existed in Eastern Africa around 3 to 4 mya. *Australopithecines* probably lived in East African grasslands around 2 mya. *Homo habilis* is an example of *Australopithecines*. Scientists still differ if *Homo habilis* should be kept under *Australopithecines* or among hominids. Its brain was of 650-800 cc capacity. *Homo erectus* existed about 1.5 mya. Its brain's capacity was 900 cc. Neanderthal lives near East and central Asia between 1,00,000 to 40,000 years back. The brain capacity of Neanderthal was 1400 cc. Modern *Homo sapiens* arose in Africa between 75,000 to 10,000 years back.

Read the given passage carefully and give the answer of the following questions:

(i) Which characters of *Australopithecus* is like man?

(ii) What is the cranial capacity of modern man?

(iii) Which is the main race of human?

OR

How many races of humans are found?

Very Short Answer Type Questions

Q 8. Give the name of any two vertebrate's body parts that are homologous to human forelimbs.

Q 9. State the significance of study of fossils in evolution.

Q 10. Attempt giving a clear definition of the term species?

Short Answer Type Questions

Q 11. How did Darwin explain the adaptive radiation from his point of view?

Q 12. What is the study of fossils called? Write few points as to how the fossils throw light on past life.

Long Answer Type -I Question

Q 13. Define fossils. Give any two ways in which the study of fossils support biological evolution of an organism.

Long Answer Type -II Question

Q 14. (I) Natural selection operated when nature selects for fitness. Explain.

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