6 CHAPTER

Evolution

Level - 1 CORE SUBJECTIVE QUESTIONS

MULTIPLE CHOICE QUESTIONS (MCQs) (1 Mark)

1. Option (D) is correct
Explanation: Adaptive radiation is a process in which organisms diversify rapidly into a multitude of new forms, particularly when a change in the environment makes new resources available, creates new challenges, or opens new environmental niches. This process leads to the rapid divergence of traits among populations inhabiting a given geographical area, as these populations adapt to different niches.

2. Option (C) is correct
Explanation: Haeckel suggested that vertebrate embryos, including humans, show vestigial gill slits during development, functional only in fish but replaced by other structures in land vertebrates.

3. Option (D) is correct
Explanation: Homologous structures arise from a common ancestry and share a similar anatomical structure, even if they perform different functions. Convergent evolution, on the other hand, leads to analogous structures, where unrelated species evolve similar traits due to similar environmental pressures, not because of a shared ancestry.

4. Option (C) is correct
Explanation: In Hardy-Weinberg equilibrium, the frequencies of the genotypes can be calculated using the formula $p^2 + 2pq + q^2 = 1$, where p is the frequency of the dominant allele (A), and q is the frequency of the recessive allele (a).
Given:
- $p = 0.6$ (frequency of allele A)
- $q = 1 - p = 1 - 0.6 = 0.4$ (frequency of allele a)

The frequency of the heterozygous genotype (Aa) is given by pq.
$2pq = 2 \times 0.6 \times 0.4 = 0.48$

5. Option (B) is correct
Explanation: Homologous organs are structures found in different species that originate from a common ancestor but may serve different functions. This suggests divergent evolution, where species sharing a common lineage evolve and develop distinct characteristics, resulting in new species with varied traits while still maintaining similarities in their anatomical structures.

6. Option (B) is correct
Explanation: During the pre-industrialisation era in England, the environment was less polluted, and tree trunks were covered with light-coloured lichen. White-winged moths had better camouflage against the lighter background, while dark-winged moths stood out, making them more likely to be eaten by predators. As a result, natural selection favoured the survival of white-winged moths, leading to a decrease in the number of dark-winged moths.

7. Option (D) is correct
Explanation: In 1953, Stanley L. Miller conducted an experiment to simulate the conditions thought to be present on the early Earth, supporting the theory of chemical evolution. He used a mixture of methane (CH_4), hydrogen (H_2), ammonia (NH_3), and water vapour (H_2O) in a closed system, which was subjected to electrical sparks to mimic lightning, while the temperature was maintained around 800°C. This experiment led to the formation of organic compounds, such as amino acids, supporting the idea that life could have originated from simple chemical processes.

8. Option (B) is correct
Explanation: Louis Pasteur conducted experiments using swan-necked flasks to demonstrate that micro-organisms in the air, rather than spontaneous generation, were responsible for contamination. He utilised killed yeast to show that when the flask was sterilised and sealed, no microbial growth occurred, effectively disproving the theory of spontaneous generation.

9. Option (C) is correct
Explanation: Thick-shelled eggs allow for the protection of developing embryos in a terrestrial environment, providing a crucial adaptation for life on land after evolving from aquatic ancestors.

10. Option (C) is correct
Explanation: *Neanderthal* man is considered to be the closest extinct relatives of modern human beings. They started to evolve around 1,30,000 years ago. Modern humans and *Neanderthals* simultaneously branched out from a common ancestor, *Homo erectus*.

11. Option (C) is correct
Explanation: *Ramapithecus* is considered one of the earliest known ancestors of modern humans and is

thought to have lived approximately 4 to 6 million years ago. It exhibits traits that suggest a close relationship with later hominids.

12. Option (D) is correct
Explanation: The graph illustrates stabilising selection, where giraffes with medium neck lengths are favoured. Stabilising selection is a form of natural selection in evolution that supports average individuals within a population while decreasing the prevalence of extreme traits, such as very short or very long necks.

13. Option (A) is correct
Explanation: Convergent evolution occurs when unrelated species evolve similar traits or adaptations due to similar environmental pressures or habitats. In this case, the mouse and marsupial mouse, while belonging to different evolutionary lineages, have developed similar physical characteristics and behaviours to thrive in the same habitat in Australia.

14. Option (B) is correct
Explanation: *Neanderthal man*, who lived approximately 400,000 to 40,000 years ago, is known for using animal hides for clothing to protect themselves from harsh climates and for their burial practices.

ASSERTION-REASON QUESTIONS (1 Mark)

1. Option (A) is correct
Explanation: Gene flow increases genetic variation within a recipient population. When new alleles are introduced to this population, it can enhance its genetic diversity. Additionally, the removal of alleles from the donor population can also affect its allele frequency.

2. Option (A) is correct
Explanation: Darwin's theory of natural selection suggests that, given ideal conditions, even slow-growing species like elephants can reproduce and increase in population size over time. This is because, in the absence of limiting factors, populations can grow exponentially.

3. Option (C) is correct
Explanation: After industrialisation in England, the number of white-winged moths decreased significantly. This decline can be attributed to the phenomenon of industrial melanism, where darker-coloured moths had a better chance of survival against predators in polluted environments, leading to a decrease in the population of lighter-coloured moths. The effects of industrialisation were more marched in urban areas, not rural areas. Pollution and soot deposits were mainly present in cities leading to the darkening of tree trunks. Rural areas remained relatively unaffected where white moths could still blend in with the natural richen covered trees.

4. Option (C) is correct
Explanation: Adaptive ability has a genetic basis, as traits that enhance an organism's ability to survive and reproduce in a specific environment can be passed down through generations. Fitness, in evolutionary terms, refers to an organism's ability to survive and reproduce in its environment, and it is the result of adaptive abilities that have been selected for by natural selection.

VERY SHORT ANSWER TYPE QUESTIONS (2 Marks)

1. 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. In pre–sterilised flasks, life did not come from killed yeast, while in another flask open to air new living organisms arose from 'killed yeast'.
Conclusion: Dismissal of theory of spontaneous generation. Life arise from pre-existing life. Proved theory of biogenesis.

SHORT ANSWER TYPE QUESTIONS (3 Marks)

1. (i) Miller experimentally showed formation of amino acids and this proved theory of chemical evolution of life and formation of organic molecules from inorganic molecules.
• Oparin, Haldane prompted him to carry out this experiment.
(ii) Analysis of meteorite content also revealed similar compounds indicating that similar processes are occurring in space.

2. **(i)** The salient features of Darner's Theory of Natural election are:
(1) Organisms produce more offspring than can survive, leading to competition for resources.
(2) Individuals in a population show differences in traits due to genetic variations.
(3) Individuals with traits that provide an advantage in their environment are more likely to survive and reproduce.
(4) Favourable traits get passed on to the next generations, while less useful traits are eliminated over time.
(5) Over generations, small changes accumulate, leading to the evolution of new species.
(6) When variations become significant over time, new species may emerge due to adaptation and reproductive isolation.
(ii) Microbes divide fast with shorter life span and, variations can be observed in larger population within short time.

3. **(i)** Hardy – Weinberg Equilibrium
$p^2 + 2pq + q^2 = 1$

$AA + 2Aa + aa = 1$

Since frequency of grey snakes in the population $= 9\% = 9/100 = 0.09$

$q^2 = .09$

$q = 0.3$

Since $p + q = 1$

$p = 1 - q$

$p = 1 - 0.3$

$p = 0.7$

The frequency of homozygous dominant (AA) is equal to $P^2 = 0.49$

Or the % frequency of homozygous dominant = 49%

The frequency of heterozygous dominant (Aa) is equal to $2pq = 2 \times 0.7 \times 0.3 = 0.42$ Or % frequency of Aa = 42%

(ii) Natural selection

4. Certain features (like vestigial gill slits) develop during embryonic stages of all vertebrates (show common ancestry), but are absent in adults (except fishes).

Examples:

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

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

(3) The seedlings of Acacia tree initially develop simple leaves, but the leaves that develop later are compound.

5.

Darwin's Evolution	de Vries Evolution
(i) Evolution was gradulal (stepwise).	Evolution occurred in single step (saltation).
(ii) Variations and natural selection occurs through a number of generations and are responsible for speciation.	Single step mutation causes speciation.
(iii) Variations are small and directional.	Mutationas are random and directionless.

6. **(i)** *Dryopithecus, Ramapithecus*

(ii) Time period : 2 million years ago

Place: East African grasslands.

(iii)

Homo habilis	*Homo erectus*
Brain capacity between 650 – 800 cc.	Brain capacity 900 cc.
Probably did not eat meat.	Probably ate meat.

7. **(i)** (1) Darwin's theory could not explain how the variations arose.

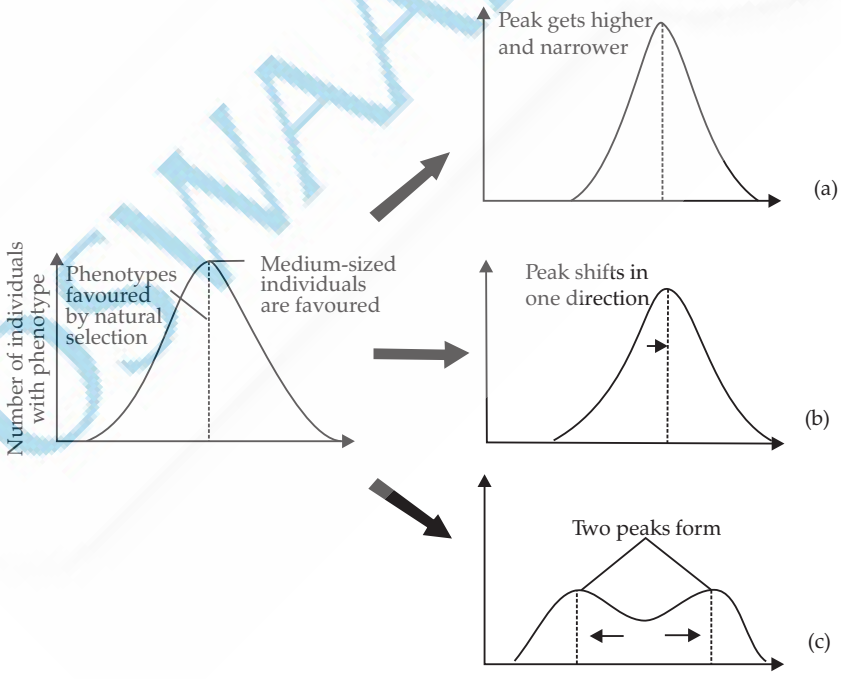
(2) Some traits (e.g. the development of wings or complex organs like the eye) are difficult to explain purely by gradual selection.

(ii) • Synthetic theory of evolution

• Origin of species is based on the interaction of genetic variation and natural selection.

(iii) Mutation, recombinants formed during meiosis/ crossing over /hybridisation /sexual reproduction.

8.



Operation of naturals selection on different traits (a) Stabilising (b) Directional and (c) Disruptive

9. Before industrialisation thick growth of almost white lichens covered tree trunks and walls, from the mixed population of white and black winged moths, white winged moth survived and increased in number due to camouflaging, dark coloured moth were picked out by predators and thus decreased in their numbers.

After industrialisation tree trunks became dark due to industrial smoke and soot. Due to absence of lichen, dark coloured moth survived and increased in number due to camouflaging, white winged moths were picked out by predators and thus decreased in their numbers.

LONG ANSWER TYPE QUESTIONS (5 Marks)

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

   (ii) S.L. Miller created electric discharge, in a closed flask containing CH_4, H_2, NH_3, and water vapour at 800°C. He observed formation of amino acids.

2. **(i)** A - No microbial growth would be observed since it was sterile and sealed.

   B - Microbial growth could potentially occur due to airborne contaminants reaching the nutrient media.

   C - Microbial growth from the initially spread culture would likely be observed, as the sealed environment would prevent external contaminants from entering.

   (ii) It disproves the theory of spontaneous generation.
   - The lack of growth on the sterile, sealed plate (A) contradicts the idea of life spontaneously forming.

   (iii) Louis Pasteur's swan-necked flask experiment involved sealed and unsealed flasks containing broth to demonstrate that micro-organisms do not spontaneously generate but come from external sources, supporting the concept of biogenesis.

3. **(i)** Homozygous dominant (LL) individuals:
   360/1000 = 0.36 (or 36%)
   Heterozygous (Ll) individuals:
   150/1000 = 0.15 (or 15%)
   Homozygous recessive (ll) individuals:
   490/1000 = 0.49 (or 49%)

   (ii) If $p^2 = 0.36$
   $p = 0.6$
   if $q^2 = 0.49$
   $q = 0.7$

   (iii) For the population of rabbits to be in the Hardy Weinberg theorem,
   $p^2 + 2pq + q^2 = 1$
   Substituting the values $p = 0.6$ and $q = 0.7$
   $p^2 = 0.36$
   $q^2 = 0.49$
   $2pq = 2 \times 0.6 \times 0.7 = 0.84$
   So, from Hardy Weinberg theorem
   $= 0.36 + 0.84 + 0.49$
   $= 1.69$

Level - 2 ADVANCED COMPETENCY FOCUSED QUESTIONS

MULTIPLE CHOICE QUESTIONS (MCQs) (1 Mark)

1. Option (B) is correct
   Explanation: Homologous organs are structures that are similar in anatomy but may perform different functions in different organisms. Example: The forelimbs of humans, bats, whales, and cats all have the same basic bone structure but are used for different purposes (grasping, flying, swimming, walking). This similarity in structure despite different functions strongly supports divergent evolution and points to a common ancestry, which is a central idea in Darwin's theory of evolution.

2. Option (C) is correct
   Explanation: Fossils found in deeper rock layers are generally older, while those in upper layers are more recent. The presence of primitive horse fossils in deeper layers and more advanced species in upper layers shows a gradual change over time, which is a key concept in evolution. This supports the idea that organisms evolve over geological time, and fossil records can be used to trace evolutionary trends.

3. Option (C) is correct
   Explanation: Industrial melanism refers to the phenomenon observed in peppered moths during the Industrial Revolution in England. Before industrialisation, light-coloured moths were more common because they blended with lichen-covered trees. After industrialisation, pollution darkened tree bark, so dark-coloured moths had a survival advantage (better camouflage from predators). Over time, the frequency of dark-coloured moths increased — a classic case of directional natural selection, where one phenotype is favoured over another due to environmental changes.

4. Option (C) is correct
   Explanation: Darwin's finches, found on the Galápagos Islands, are a classic example of adaptive radiation. All the finches evolved from a common ancestor, but developed different beak shapes suited to their specific food sources (e.g., seeds, insects, cactus). This divergence in beak structure is a result of natural selection, where finches best adapted to their environment survived and reproduced.

5. Option (C) is correct
   Explanation: Genetic drift refers to random, chance-based changes in allele (gene) frequencies, especially in small populations. It is not guided by natural selection. Example: In a small isolated population, if

some individuals fail to reproduce by chance, certain alleles may disappear completely, even if they were neutral or beneficial.

6. Option (C) is correct
Explanation: This is a classic example of the bottleneck effect, a type of genetic drift. A random natural disaster (flood) drastically reduces the population size. The surviving beetles may not represent the genetic makeup of the original population. As a result, certain rare traits may become more common in the next generations — not due to selection, but due to chance survival.

ASSERTION-REASON QUESTIONS (1 Mark)

1. Option (B) is correct
Explanation: The assertion states that the genetic makeup (genotype) is a primary factor in determining the phenotype of a species while the reason focuses on the interaction between phenotype and environment affecting genetic makeup.

2. Option (A) is correct
Explanation: Assertion is true. Speciation — the formation of new species — often occurs when populations of a species become geographically isolated.
Reason is also true. Geographical isolation (like a mountain, river, or distance) prevents gene flow between the isolated groups. Over time, this leads to genetic divergence due to mutation, natural selection, and genetic drift.

3. Option (A) is correct
Explanation: Assertion is true. Homologous organs support divergent evolution, where related organisms evolve different adaptations from a common ancestor.
Reason is also true. Homologous organs share a common structural design but have different functions (e.g., human hand, whale flipper, bat wing).

4. Option (D) is correct
Explanation: Assertion is false. Genetic drift is more significant in small populations, not large ones. In small populations, random events can cause big shifts in allele frequencies.
Reason is true. In large populations, the effect of random changes (genetic drift) is buffered or stabilised, so allele frequencies remain relatively steady over time.

5. Option (D) is correct
Explanation: Assertion is false. Analogous organs do not suggest common ancestry. Instead, they are the result of convergent evolution, where unrelated organisms evolve similar traits independently due to similar environmental pressures.
Reason is true. Analogous organs have similar functions but different structural origins and anatomy.

6. Option (A) is correct
Explanation: Assertion is true. Industrial melanism is a classic example of natural selection where environmental changes influenced survival and reproduction.
Reason is also true. In polluted environments during the Industrial Revolution, dark-coloured moths were better camouflaged on soot-darkened tree bark, so they avoided predators and survived more than light-coloured moths.

VERY SHORT ANSWER TYPE QUESTIONS (2 Marks)

1. CH_4, H_2O, H_2, NH_3
   - The experimental setup does not have a source of electric sparks/energy that could provide the energy necessary to initiate chemical reactions among the gases and form various organic molecules.

2. No
   - The scenario violates the rule of 'no gene flow/ migration' from the Hardy-Weinberg law.

3. **(i)** Birds with intermediate beak sizes have a feeding advantage, driving the population towards increased intermediate sizes due to their higher survival and reproductive success, reducing extremes.
   (ii) Stabilising selection.

4. The age of the fossil samples in the order of oldest to youngest is –
Sample B > Sample A > Sample C.
The depth of a fossil sample can indicate its age because new sediment layers settle on top of existing ones, compressing and solidifying them. Older layers and fossils are found at greater depths than younger ones.

5. False
Genetic flow involves the movement of individuals and their genes between populations, actively influencing genetic diversity, whereas genetic drift is a random process that can lead to changes in allele frequencies within populations, often leading to a decline in genetic diversity.

6. **(i)** *Australopithecus* evolved in East African grasslands.
(ii) Java man -*Homo erectus*.

SHORT ANSWER TYPE QUESTIONS (3 Marks)

1. The observation can be explained using the concept of natural selection:
   (i) Environmental Change:In industrial areas, pollution causes tree trunks to become dark due to soot deposition.

(ii) Selective Advantage:Dark-coloured moths blend better with the darkened bark, making them less visible to predators, while light-coloured moths are more easily spotted and eaten.

(iii) Survival and Reproduction:As a result, dark-coloured moths survive and reproduce more, increasing their population over time. This is an example of directional natural selection, where the environment favours one phenotype over another.

2. The decreasing effectiveness of antibiotics in livestock is a real-life example of evolution through natural selection:

(i) Selection Pressure:Frequent use of antibiotics creates a selection pressure on bacterial populations.

(ii) Survival of Resistant Bacteria:Some bacteria may have mutations that make them resistant to the antibiotic. These resistant bacteria survive the treatment while the non-resistant ones die.

(iii) Evolution of Resistance:The resistant bacteria multiply and pass on their resistance genes to future generations, leading to the evolution of antibiotic-resistant strains. Over time, the antibiotics become less effective.

3. Preserving endangered species in gene banks or through cryopreservation plays a crucial role in evolution and biodiversity conservation in the following ways:

(i) Conservation of Genetic Diversity:It helps store the genetic material (DNA, seeds, gametes) of endangered species, which preserves their genetic variability — a key raw material for evolution.

(ii) Support for Future Evolution:These preserved genes can be used in the future to reintroduce lost traits or help species adapt to changing environments, thus supporting the evolutionary potential of species.

(iii) Revival and Research:Preserved material can aid in repopulation efforts, research, and maintaining ecological balance, which is essential for sustaining biodiversity on Earth.

4. The development of drug-resistant strains of HIV or TB is a real-life example of "survival of the fittest," a key principle of Darwinian evolution:

(i) Variation in the Population:Within a population of viruses or bacteria, some strains may carry mutations that make them resistant to a specific drug.

(ii) Selective Pressure:When the drug is administered, sensitive strains are killed, but resistant strains survive and continue to multiply.

(iii) Survival and Dominance of the Fittest:These resistant strains are considered the "fittest" in that drug environment. Over time, they become more common, showing how the population evolves to withstand treatment.

CASE BASED QUESTIONS (4 Mark)

1. (i) Given is bb = $q^2 = 0.4$.
To determine q, which is the frequency of the recessive allele in the population, simply take the square root of q^2 which works out to be 0.632
(i.e. $0.632 \times 0.632 = 0.4$).
So, q = 0.63

(ii) As we know that p + q = 1,
then p must be 1 - 0.63 = 0.37.
The percentage of beetles in the population that are heterozygous would be 2pq.
2 (0.37) (0.63) = 0.47

(iii) **(a)** Given is BB = $p^2 = (0.37)^2 = 0.14$

OR

(iv) As, 1500 is the total population
40% is red population,
Hence the number of beetles with red colour will be
$1500 \times 0.4 = 600$
If total population is 1500 and red is 600 then black would be 1500 – 600 = 900.

2. (i) Option (B) is correct
Explanation: Stabilising selection favours the intermediate trait, in this case, the intermediate wing colour, over the extremes (very bright or very dull colours). It results in a higher survival and reproduction rate for individuals with traits near the population mean.

(ii) Option (B) is correct
Explanation: In a darker environment, butterflies with duller wing colours would be better camouflaged, reducing their visibility to predators. Over time, the population may shift toward dull-winged individuals for increased survival.

(iii) Option (B) is correct
Explanation: Directional selection occurs when one extreme of a trait is favoured over others, leading to a shift in the population's trait distribution. In this case, the shift is towards duller wing colours for better camouflage in a darker environment.

(iv) Option (C) is correct
Explanation: Butterflies with brighter wing colours would be more easily spotted by predators, which would reduce their long-term survivability despite potentially increased mating success.

3. (i) Frequency of DD = $p^2 = 250/1000 = 0.25$
$p = 0.5$
Therefore, $q = 1 - p = 1 - 0.5 = 0.5$
Frequency of $dd = q^2 = 0.25$
Frequency of D$d = 2pq = 2 \times 0.5 \times 0.5 = 0.5$

(ii) Stabilising evolution

- The DD genotype (extreme drought resistance) and the dd genotype (poor drought resistance) are not favoured due to their disadvantages under varying water availability. The Dd genotype (intermediate drought resistance) has the highest fitness and is favoured, leading to a peak in the middle of the graph.

(iii) (a) Directional evolution

- Due to the increased drought periods, the selective pressure will favour genotypes with better drought resistance (like DD and possibly Dd), reducing the frequency of the dd genotype, leading to a directional shift towards the D allele.

OR

(b) Fitness refers to the outcome of an organism's adaptation, where its ability to produce offspring with advantageous traits for survival and reproduction is enhanced.

- Natural selection is a mechanism by which heritable traits that confer greater success in a given environment become more prevalent over generations, illustrating the process through which advantageous traits are favoured and passed on. In essence, fitness is the consequence/result of successful adaptation, while natural selection is the dynamic process that drives the persistence of adaptive traits in a population over time.

LONG ANSWER TYPE QUESTIONS (5 Marks)

1. Natural selection is the process by which organisms with traits better suited to their environment survive, reproduce, and pass on those traits to the next generation. The case of industrial melanism in peppered moths is a classic example that illustrates this concept.

Example of Industrial Melanism:

Before Industrialisation:In unpolluted areas, light-coloured peppered moths were more common. They could easily camouflage against the lichen-covered tree trunks. Dark-coloured moths were easily seen and eaten by birds.

During and after Industrialisation: Pollution caused tree bark to darken due to soot. Now, dark-coloured moths were better camouflaged, and light-coloured ones became more visible to predators. As a result, dark-coloured moths had a survival advantage and reproduced more.

Change in Population:Over generations, the moth population shifted from light to dark-coloured. This change in frequency of traits is an example of evolution by natural selection.

Support for Darwin's Theory:

Darwin proposed that individuals with favourable traits survive and pass those traits to offspring. In this case, camouflage (a favourable trait) increased the chances of survival and reproduction. The shift in moth coloration due to environmental change demonstrates "survival of the fittest" and supports Darwin's idea of adaptation and gradual evolution.

2. Evolution is driven by several mechanisms that introduce or alter genetic variation in a population. Three key mechanisms are genetic drift, gene flow, and mutation, each contributing uniquely to the evolutionary process.

(i) Genetic Drift: A random change in allele frequencies, especially in small populations. It can lead to loss or fixation of alleles by chance, reducing genetic diversity. Example: After a natural disaster (e.g., flood), only a few beetles survive randomly, not based on fitness. If survivors mostly have green shells, future generations may be predominantly green — not due to selection, but chance survival (bottleneck effect).

(ii) Gene Flow:Movement of alleles between populations through migration or interbreeding. It increases genetic variation, reduces differences between populations, and introduces new traits. Example:If individuals from one bird population migrate and breed with another, they may introduce new feather colour genes, increasing diversity in the recipient population.

(iii) Mutation:A permanent change in the DNA sequence. It is the original source of new genetic variation, which can be acted upon by natural selection. Example: In bacteria, a random mutation may lead to antibiotic resistance. If antibiotics are used, resistant bacteria survive and multiply — leading to evolution of resistant strains.

3. The rise of drug-resistant microbes and pesticide-resistant pests is a direct outcome of evolution by natural selection. It demonstrates how organisms evolve to survive in changing environments, particularly under human-induced pressures.

Relation to Evolution:

(i) Variation in Population: Within microbial or pest populations, some individuals may possess natural genetic mutations that make them resistant to drugs or pesticides.

(ii) Selective Pressure: When antibiotics or pesticides are used repeatedly, susceptible individuals die, but resistant ones survive and reproduce.

(iii) Survival of the Fittest: The resistant traits are passed on to the next generation, gradually making the population dominated by resistant forms. This illustrates Darwin's principle of natural selection – only the fittest survive and reproduce.

Strategies to Slow Down the Process:

(i) Rotational Use and Combination Treatments: Alternate or rotate drugs/pesticides to prevent prolonged exposure to one type. Use combination therapies (e.g., multiple antibiotics or pesticides) to reduce the chance of resistance developing.

(ii) Controlled and Judicious Use: Avoid overuse or misuse of antibiotics and pesticides. In medicine, follow the full prescribed course of treatment. In agriculture, apply Integrated Pest Management (IPM) techniques to reduce dependence on chemicals.

4. Speciation is the formation of new species from existing ones. Isolation — particularly reproductive isolation — plays a key role in this process. When populations of the same species become isolated, they can no longer interbreed. Over time, due to genetic divergence (caused by mutations, natural selection, and genetic drift), these populations evolve separately. Eventually, they become distinct species.

Types of Speciation:

(i) Allopatric Speciation: It occurs due to geographical isolation (e.g., mountains, rivers, distance).The separated populations evolve independently. Example: Darwin's finches on the Galápagos Islands evolved into different species due to geographic separation on different islands.

(ii) Sympatric Speciation: It occurs without geographical separation, within the same area. It happens due to behavioural, ecological, or genetic differences.Example: In plants, polyploidy (change in chromosome number) can cause instant reproductive isolation and new species formation.

Reproductive isolation is crucial because:

(i) It prevents gene flow between populations.

(ii) It ensures that genetic differences accumulate over time.

(iii) It leads to the development of distinct traits and eventually new species.

(iv) Without reproductive isolation, interbreeding would merge the gene pools, preventing speciation.