

CBSE 12 Biology 2024 (57/2/2) Question Paper with Solutions

Time Allowed :3 hours	Maximum Marks :70	Total Questions :33
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General Instructions

Read the following instructions very carefully and strictly follow them:

1. This question paper contains 33 questions. All questions are compulsory.
2. The question paper is divided into **FIVE sections**: Section A, B, C, D, and E.
3. **Section A**: Questions 1 to 16 are multiple-choice type questions. Each question carries 1 mark.
4. **Section B**: Questions 17 to 21 are very short answer-type questions. Each question carries 2 marks.
5. **Section C**: Questions 22 to 28 are short answer-type questions. Each question carries 3 marks.
6. **Section D**: Questions 29 and 30 are case-based questions. Each question carries 4 marks and has subparts with internal choice in one of the subparts.
7. **Section E**: Questions 31 to 33 are long answer-type questions. Each question carries 5 marks.
8. There is no overall choice. However, **internal choice** has been provided in some questions in Section B, Section C, and Section D. A candidate has to attempt only one of the alternatives in such questions.
9. A separate question paper is available for **Visually Impaired candidates**.
10. Wherever necessary, neat and properly labeled diagrams should be drawn.

SECTION A

1. Homologous organs indicate:

- (A) Convergent Evolution
- (B) Divergent Evolution
- (C) Adaptive Radiation
- (D) Natural Selection

Correct Answer: (B) Divergent Evolution

Solution:

Understanding Homologous Organs.

Homologous organs are anatomical structures that originate from a common ancestor but may serve different functions in different species. These organs arise through inheritance from a shared evolutionary ancestor.

The Connection Between Homologous Organs and Divergent Evolution.

Divergent evolution occurs when organisms from a common ancestor adapt to distinct environmental conditions, leading to structural changes while maintaining underlying similarities.

Example of Homologous Organs.

A well-known example is the forelimb structure found in mammals, such as the human arm, the bat's wing, and the whale's flipper. While these limbs serve different functions, they share similar skeletal structures, illustrating their common evolutionary origin.

Homologous organs provide compelling evidence for divergent evolution, showcasing how species can evolve unique traits while preserving structural similarities.

Quick Tip

Divergent evolution leads to organisms developing specialized adaptations from a shared ancestral structure. Homologous organs are critical evidence of evolutionary changes over time, emphasizing the role of environmental pressures and survival strategies in shaping species.

2. A population is in genetic equilibrium/Hardy-Weinberg equilibrium for a gene with 2 alleles (dominant allele is 'A' and recessive allele 'a'). If the frequency of allele 'A' is 0.6, then the frequency of genotype 'Aa' is:

- (A) 0.21
- (B) 0.42
- (C) 0.48
- (D) 0.32

Correct Answer: (C) 0.48

Solution: Understanding the Hardy-Weinberg Equilibrium.

The Hardy-Weinberg principle explains a population in which allele frequencies remain unchanged, provided that no evolutionary forces such as natural selection, mutation, migration, or genetic drift are acting on it.

Using the Hardy-Weinberg Equation.

The Hardy-Weinberg equation is:

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

where:

p represents the frequency of the dominant allele A , and

q represents the frequency of the recessive allele a .

Given $p = 0.6$, we can determine q as follows:

$$q = 1 - p = 1 - 0.6 = 0.4$$

Calculating the Frequency of the Heterozygous Genotype.

The frequency of the heterozygous genotype Aa is calculated by:

$$2pq = 2(0.6)(0.4) = 0.48$$

Therefore, the frequency of the genotype Aa is 0.48.

Quick Tip

The Hardy-Weinberg equilibrium is an essential principle in population genetics. It aids in predicting genotype frequencies and understanding evolutionary changes by identifying when observed proportions differ from expected values.

3. In the double helical structure of DNA molecule, the strands are:

- (A) Identical and complementary
- (B) Identical and non-complementary
- (C) Anti-parallel and complementary
- (D) Anti-parallel and non-complementary

Correct Answer: (C) Anti-parallel and complementary

Solution:

Understanding the Structure of DNA.

DNA is a double-stranded molecule where each strand consists of nucleotides arranged in a specific sequence. These strands coil around each other to form a right-handed double helix.

Anti-parallel Orientation.

The two DNA strands run in opposite directions, with one strand oriented from 5' to 3', and the other running from 3' to 5'. This arrangement is known as anti-parallel.

Complementary Base Pairing.

The bases on the two strands pair in a specific manner: adenine (A) pairs with thymine (T), and guanine (G) pairs with cytosine (C), which ensures accurate replication during cell division.

The anti-parallel and complementary nature of the DNA strands ensures precise genetic replication and stability.

Quick Tip

The anti-parallel structure of DNA enables accurate base pairing and enzymatic activity during replication and transcription. This characteristic is essential for the faithful transfer of genetic information.

4. In a ‘transcription unit’, the ‘terminator’ is located towards the:

- (A) 3’ end of the template strand
- (B) 5’ end of the template strand
- (C) 5’ end of the coding strand
- (D) 3’ end of the coding strand

Correct Answer: (D) 3’ end of the coding strand

Solution:

Understanding Transcription.

Transcription is the process in which genetic information from DNA is transcribed into messenger RNA (mRNA). It consists of three main stages: initiation, elongation, and termination.

Function of the Terminator.

The terminator is a specific sequence of DNA that signals RNA polymerase to cease transcription. This prevents the synthesis of RNA from continuing and allows the newly created mRNA strand to detach from the DNA template strand.

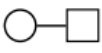
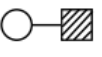
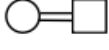
Position of the Terminator.

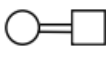
The terminator is located at the 3’ end of the coding strand. As RNA polymerase moves along the template strand in the 3’ to 5’ direction, it synthesizes the complementary mRNA in the 5’ to 3’ direction. The terminator sequence indicates the end of transcription at the 3’ end of the coding strand.

Therefore, the terminator sequence is located at the 3’ end of the coding strand, signaling the completion of RNA synthesis.

Quick Tip
The transcription process is tightly regulated to ensure only necessary genes are transcribed. The terminator sequence is vital for halting RNA synthesis at the appropriate point.

5. Which one of the following options denotes mating between relatives in human pedigree analysis?

- (A) 
- (B) 
- (C) 
- (D) 

Correct Answer: (D) 

Solution: Understanding Human Pedigree Analysis.

In pedigree charts, consanguineous mating (mating between relatives) is shown by a double line connecting the male and female individuals.

Identifying the Correct Symbol.

Option (D) accurately displays a double horizontal line between individuals, signifying consanguineous marriage. This is the standard notation used in human pedigree charts. Therefore, the correct answer is (D), as it properly indicates mating between relatives in human pedigree analysis.

Quick Tip

Consanguineous marriages in pedigree analysis increase the likelihood of genetic disorders due to the inheritance of recessive alleles. Look for the double line to identify such cases.

6. The vector for dengue fever is:

- (A) Female **Aedes** mosquito
- (B) Female **Anopheles** mosquito
- (C) Male **Aedes** mosquito
- (D) Female **Culex** mosquito

Correct Answer: (A) Female **Aedes** mosquito

Solution:

Understanding the Vector.

Dengue fever is mainly transmitted through the bite of an infected female **Aedes aegypti** mosquito. These mosquitoes are most active during the day, especially in the early morning and late afternoon.

The Role of the Female Mosquito.

Only female mosquitoes bite humans and animals to obtain blood, which is essential for the production of eggs. Male mosquitoes do not feed on blood.

Other Diseases Transmitted by Aedes Mosquitoes.

The same **Aedes** mosquitoes that transmit dengue fever are also responsible for spreading other diseases such as the Zika virus and chikungunya.

Therefore, the vector for dengue fever is the female **Aedes** mosquito.

Quick Tip

The **Aedes** mosquito is a significant vector for various viral diseases. Preventative measures include controlling mosquito populations and using protection like nets and repellents.

7. Which one of the following pairs is not correctly matched?

- (A) **Clostridium butylicum** – Butyric acid
- (B) **Trichoderma polysporum** – Cyclosporin A
- (C) **Monascus purpureus** – Citric Acid
- (D) **Streptococcus** – Streptokinase

Correct Answer: (C) **Monascus purpureus** – Citric Acid

Solution:

Review the Matches.

Clostridium butylicum produces butyric acid, which is used in the production of solvents and in fermentation processes.

Trichoderma polysporum produces cyclosporin A, a powerful immunosuppressive drug used in organ transplants.

Monascus purpureus produces statins, a class of drugs that lower cholesterol, not citric acid.

Streptococcus produces streptokinase, an enzyme that helps dissolve blood clots.

Monascus purpureus produces statins, not citric acid.

Quick Tip
Statins produced by Monascus purpureus lower cholesterol levels by inhibiting the enzyme HMG-CoA reductase, which plays a key role in cholesterol synthesis.

8. Which of the following is not required for PCR?

- (A) Restriction endonuclease
- (B) Taq Polymerase
- (C) Primer
- (D) DNA segment

Correct Answer: (A) Restriction endonuclease

Solution:

Key Components for PCR.

PCR (Polymerase Chain Reaction) requires three essential components:

Taq polymerase, which facilitates DNA amplification.

Primers to begin the DNA synthesis process.

DNA segments that serve as templates for amplification.

Function of Restriction Endonuclease.

Restriction endonuclease is used in genetic engineering to cut DNA at specific locations, but it is not necessary for PCR.

Therefore, restriction endonuclease is not needed for PCR.

Quick Tip

PCR amplifies DNA using the heat-stable enzyme Taq polymerase and does not require restriction enzymes, making it a quicker and more straightforward method for DNA analysis.

9. The pyramid of biomass in sea is generally inverted because in sea:

- (A) Biomass of fishes exceeds that of phytoplankton.
- (B) Number of phytoplanktons is more.
- (C) Number of phytoplanktons is less.
- (D) Large fishes feed on small fishes.

Correct Answer: (A) Biomass of fishes exceeds that of phytoplankton.

Solution: Understanding the Inverted Biomass Pyramid.

In most ecosystems, the biomass pyramid typically has a broad base of producers (e.g., plants) that support higher trophic levels. However, in marine ecosystems, the biomass of larger consumers, like fish, can exceed that of primary producers such as phytoplankton, resulting in an inverted pyramid.

Rapid Turnover of Phytoplankton.

Phytoplankton reproduce and turnover at a very high rate, meaning their biomass remains low despite their abundance. In contrast, large fish accumulate significant amounts of biomass.

Thus, the biomass of fish surpasses that of phytoplankton, leading to an inverted biomass pyramid.

Quick Tip

The inverted biomass pyramid in marine ecosystems highlights the rapid turnover and high productivity of phytoplankton, as well as the longer lifespans and larger biomass of marine animals.

10. In humans, the secondary oocyte completes meiotic division when:

- (A) It gets implanted in the uterine endometrium.
- (B) It is released from the matured Graafian follicle.
- (C) It is penetrated by the sperm cell.
- (D) Acrosomal enzymes break down the zona pellucida.

Correct Answer: (C) It is penetrated by the sperm cell.

Solution:

Conditions for Completing Meiosis.

The secondary oocyte is arrested in metaphase II of meiosis. It only completes meiosis II after fertilization, specifically upon sperm cell penetration.

Trigger for Meiotic Completion.

The entry of a sperm into the secondary oocyte initiates the completion of the second meiotic division, resulting in the formation of a mature ovum and a second polar body.

Thus, the secondary oocyte completes meiotic division upon sperm cell penetration.

Quick Tip

Sperm penetration triggers the final stages of oocyte maturation, which is essential for zygote formation and the start of embryonic development.

11. Match the items in Column I with those in Column II and select the correctly matched option from those given below:

Column I
Cross

- 1. Mendelian monohybrid
- 2. Mendelian dihybrid
- 3. Incomplete dominance
- 4. Test cross (monohybrid)

Column II
Phenotypic Ratio

- (i) 1 : 2 : 1 (F_2)
- (ii) 1 : 1
- (iii) 3 : 1 (F_2)
- (iv) 9 : 3 : 3 : 1 (F_2)

- (A) 1–(ii), 2–(iv), 3–(i), 4–(iii)

- (B) 1–(iii), 2–(i), 3–(iv), 4–(ii)
(C) 1–(iii), 2–(iv), 3–(i), 4–(ii)
(D) 1–(ii), 2–(i), 3–(iv), 4–(iii)

Correct Answer: (C) 1–(iii), 2–(iv), 3–(i), 4–(ii)

Solution:

Review the Columns.

A Mendelian monohybrid cross produces a 3 : 1 ratio in the F₂ generation.

A Mendelian dihybrid cross yields a 9 : 3 : 3 : 1 ratio in the F₂ generation.

Incomplete dominance results in a 1 : 2 : 1 ratio in the F₂ generation.

A test cross produces a 1 : 1 ratio.

The correct matches are (C) 1–(iii), 2–(iv), 3–(i), 4–(ii).

Quick Tip

Understanding Mendelian and non-Mendelian inheritance ratios is crucial for analyzing genetic crosses. Different inheritance patterns lead to unique phenotypic ratios in offspring.

12. The functional megaspore of an angiosperm develops into:

- (A) Embryo sac
(B) Endosperm
(C) Embryo
(D) Ovule

Correct Answer: (A) Embryo sac

Solution: Definition of the Functional Megaspore.

The functional megaspore is the single surviving megaspore after meiosis within the plant's ovule. It is a haploid cell that will develop into the female gametophyte.

Development Process.

The functional megaspore undergoes multiple rounds of mitotic division, forming the embryo sac, which contains the egg cell and other critical structures necessary for fertilization.

The functional megaspore eventually develops into the embryo sac.

Quick Tip

The embryo sac in angiosperms plays a vital role in fertilization, as it houses the egg cell that merges with the sperm cell to form the zygote and begin seed development.

For Questions number 13 to 16, two statements are given — one labelled as Assertion (A) and the other labelled as Reason (R). Select the correct answer to these questions from the codes (A), (B), (C), and (D) as given below.

13. Assertion (A): Loss of biodiversity can occur due to overexploitation of resources.

Reason (R): Introduction of *Clarias gariepinus* in Indian rivers has led to a decline in native Indian fishes.

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

(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

(C) Assertion (A) is true, but Reason (R) is false.

(D) Assertion (A) is false, but Reason (R) is true.

Correct Answer: (B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

Solution: Examine Assertion (A).

Overexploitation of resources, the introduction of invasive species, and habitat destruction are major factors contributing to biodiversity loss.

Examine Reason (R).

Clarias gariepinus is an invasive species that competes with native fish, resulting in their decline and a loss of biodiversity in Indian rivers. However, this reason alone does not fully explain the broader issue of biodiversity loss caused by overexploitation.

(B) Both (A) and (R) are true, but (R) does not adequately explain (A).

Quick Tip

Invasive species like **Clarias gariepinus** disrupt ecosystems by outcompeting native species for resources, often leading to significant ecological changes.

14. Assertion (A): In genetic engineering, antibiotic genes are used as selectable markers.

Reason (R): Selectable markers help us to identify transformants from non-transformants.

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

(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

(C) Assertion (A) is true, but Reason (R) is false.

(D) Assertion (A) is false, but Reason (R) is true.

Correct Answer: (A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

Solution: Understanding Selectable Markers.

Selectable markers are genes that provide resistance to antibiotics, enabling researchers to differentiate between cells that have been successfully transformed and those that have not.

Examine the Reason (R).

Selectable markers help identify transformants by enabling them to survive under selective conditions, whereas non-transformants cannot.

(A) Both (A) and (R) are true, and (R) provides an explanation for (A).

Quick Tip

Selectable markers make it easier to identify successfully transformed cells, streamlining genetic engineering experiments and enhancing their efficiency.

15. Assertion (A): Virus-infected cells produce interferons.

Reason (R): Interferons can cause inflammation of virus-infected cells.

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

(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

(C) Assertion (A) is true, but Reason (R) is false.

(D) Assertion (A) is false, but Reason (R) is true.

Correct Answer: (C) Assertion (A) is true, but Reason (R) is false.

Solution: Understanding the Function of Interferons.

Interferons are proteins produced by cells infected with viruses. They help inhibit viral replication and bolster the immune response.

Inflammatory Response.

While interferons may play an indirect role in inflammation, their main function is in antiviral defense rather than inflammation.

(C) Assertion (A) is true, but (R) is false.

Quick Tip
Interferons are crucial in the immune defense against viral infections, signaling neighboring cells to activate protective mechanisms against viral replication.

16. Assertion (A): RNA is unstable and can mutate at a faster rate.

Reason (R): The presence of 2'–OH group in every nucleotide of RNA makes it labile and easily degradable.

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

(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

(C) Assertion (A) is true, but Reason (R) is false.

(D) Assertion (A) is false, but Reason (R) is true.

Correct Answer: (A) Both Assertion (A) and Reason (R) are true, and Reason (R) is the correct explanation of the Assertion (A).

Solution: Unstable nature of RNA.

RNA is more prone to degradation compared to DNA due to its single-stranded structure and the presence of the 2'–OH group.

Role of 2'–OH group.

The 2'–OH group makes RNA more susceptible to hydrolysis, contributing to its instability and short lifespan within cells.

(A) Both (A) and (R) are true, and (R) explains (A).

Quick Tip
RNA's instability is a key feature that allows it to carry temporary genetic instructions, while DNA remains the stable repository of genetic information in cells.

SECTION B

17. How is the rate of decomposition affected by the nature of detritus and temperature?

Solution: Nature of Detritus.

The decomposition rate is influenced by the chemical composition of detritus. Materials rich in nitrogen, proteins, and soluble compounds decompose quickly, while materials with high levels of lignin and cellulose decompose more slowly due to their resistance to microbial breakdown.

Impact of Temperature.

Temperature significantly affects the rate of decomposition. Warmer and more humid conditions promote decomposer activity (bacteria, fungi), speeding up the process. Conversely, low temperatures, particularly in dry environments, reduce microbial activity, slowing down decomposition.

Decomposition occurs more rapidly when detritus contains easily degradable substances and when the temperature is higher.

Quick Tip

The rate of decomposition is a vital process in ecosystems, recycling nutrients from dead organic matter back into the environment, which is essential for supporting plant and microbial life.

18. How is a restriction endonuclease named? Explain with the help of a suitable example.

Solution: Naming Convention.

Restriction endonucleases are named according to their bacterial origin. The naming system follows this format: the first letter of the genus, the first two letters of the species, a letter indicating the strain, and a Roman numeral denoting the order of discovery.

For example, **EcoRI**:

E stands for **Escherichia**,

co comes from **coli**,

R represents the strain,

I indicates the first enzyme discovered from this strain.

Restriction enzymes are named based on the bacterial strain from which they are isolated.

For instance, **EcoRI** is derived from **Escherichia coli**.

Quick Tip

Restriction enzymes are essential tools in molecular biology, allowing for precise DNA sequence cutting at specific sites, crucial for genetic manipulation and cloning.

19(a). Name any two copper-releasing intrauterine devices. State two reasons that make them effective contraceptives.

Solution: Examples of Copper IUDs.

Common examples of copper intrauterine devices (IUDs) include CuT and Cu7.

Mechanism of Action.

Copper ions released by the IUD impair sperm motility, preventing them from fertilizing an egg. Additionally, the copper induces an inflammatory response in the uterine lining, making it hostile to both sperm and embryos.

Copper IUDs such as CuT and Cu7 are effective because they disrupt sperm movement and create an environment unfavorable for fertilization.

Quick Tip

Copper IUDs offer highly effective, long-term contraception, providing up to 10 years of protection without the use of hormones.

OR

19(b). Name any two outbreeding devices that flowering plants have developed and explain how they help in encouraging cross-pollination.

Solution: Examples of Outbreeding Mechanisms.

Two common outbreeding strategies in plants are dichogamy and self-incompatibility. Dichogamy involves the temporal separation of male and female reproductive phases, preventing self-pollination.

Self-incompatibility refers to genetic mechanisms that prevent self-pollen from fertilizing the ovule.

Role in Cross-Pollination.

Both of these mechanisms promote cross-pollination, which boosts genetic diversity and reduces the risk of inbreeding.

Outbreeding strategies like dichogamy and self-incompatibility ensure that plants undergo cross-pollination, fostering genetic diversity.

Quick Tip

Outbreeding mechanisms in plants are essential for maintaining genetic variation and reducing the likelihood of inbreeding depression, which can negatively affect the health of the plant population.

20. Although Haemophilia and sickle cell anemia are two blood-related Mendelian disorders, yet, they differ in their pattern of inheritance. State any two differences.

Solution: Understanding the Inheritance of Haemophilia.

Haemophilia is a sex-linked recessive disorder, primarily affecting males who have only one X chromosome.

Understanding the Inheritance of Sickle Cell Anemia.

Sickle cell anemia is an autosomal recessive disorder, meaning it equally affects both males and females, as it is inherited through autosomes, not sex chromosomes.

1. Haemophilia is a sex-linked recessive disorder, whereas sickle cell anemia is an autosomal recessive disorder.
2. Haemophilia primarily affects males, while sickle cell anemia affects both genders equally.

Quick Tip

To distinguish between sex-linked and autosomal disorders, check whether the condition is passed through sex chromosomes or autosomes, with autosomal disorders affecting both genders equally.

21. Identify A, B, C, and D in the following table:

Scientific name of the plant	Drug	Effect on the human body/human system
Papaver somniferum	A	Depressant/slows down body function
Cannabis sativa	Cannabinoids	B
Erythroxylum coca	C	D

Solution: Identify A.

Papaver somniferum is the source of morphine. Therefore, A = Morphine.

Identify B and C.

Cannabinoids influence the nervous system by slowing its activity. Thus, B = Nervous system depressant.

Erythroxylum coca is the source of cocaine. Therefore, C = Cocaine.

Identify D.

Cocaine is a stimulant that affects the central nervous system. Thus, D = Stimulant.

A = Morphine, B = Nervous system depressant, C = Cocaine, D = Stimulant.

Quick Tip
To identify drugs, link their scientific names to their common effects or uses in medicine or abuse. Understanding their biological actions aids in classification and therapeutic uses.

SECTION C

22. Predation is referred to as a detrimental interaction. Explain any three positive roles, supported by an example each, that a predator plays in an ecosystem.

Solution: Positive Effects of Predation.

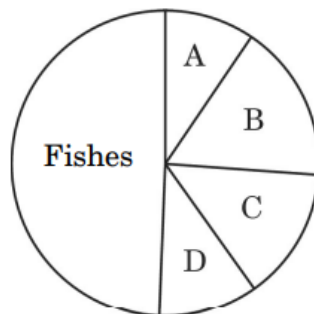
1. Controls prey populations: Predators help regulate the number of prey species, preventing overgrazing and resource depletion. Example: Tigers controlling the deer population in forests.
2. Promotes species diversity: By preying on dominant species, predators allow less dominant species to flourish. Example: Sea otters hunting sea urchins, which helps preserve kelp forests.
3. Eliminates weak and diseased individuals: Predators often target the weak, sick, or injured, contributing to the survival of the fittest. Example: Lions hunting injured or older antelopes.

Predators help regulate prey populations, promote species diversity, and eliminate weak individuals, all of which contribute to ecosystem balance.

Quick Tip

Predation plays a crucial role in ecology by maintaining population balance and supporting the stability of ecosystems.

- 23. Given below is a pie chart representing global diversity of vertebrates. (a) Redraw the pie chart identifying the groups 'A', 'B', 'C', and 'D' in their respective positions (b) Mention two examples of recently extinct animals.**



Solution: (a) Identifying the Groups in the Pie Chart.

The pie chart presents data on various groups of animals. The groups represented are as follows:

A = Amphibians

B = Reptiles

C = Birds

D = Mammals

Fish is already labeled on the chart, so it is not part of this identification task.

(b) Examples of Recently Extinct Animals.

The Passenger Pigeon is an example of a recently extinct species, having gone extinct in 1914 due to overhunting and habitat destruction.

The Tasmanian Tiger (also known as the Thylacine) is another recently extinct species, with its last known individual dying in captivity in 1936. Its extinction was caused by hunting and competition with introduced species.

Quick Tip

When studying biodiversity, it is helpful to connect each animal group with distinct traits and representative examples to understand the diversity within each category.

24(a). Differentiate between humoral immune response and cell-mediated immune response.

Solution:

The humoral immune response and the cell-mediated immune response are two key components of the adaptive immune system, each with distinct functions and mechanisms.

Humoral Immune Response: The humoral immune response involves the production of antibodies by B cells, which are a type of white blood cell.

These antibodies circulate in the bloodstream and bind to antigens on the surface of pathogens, such as bacteria and viruses, neutralizing them or marking them for destruction by other immune cells.

This response is particularly effective against extracellular pathogens, which exist outside cells, like bacteria in the bloodstream.

It also involves the activation of helper T cells, which support B cells in producing antibodies.

Cell-Mediated Immune Response:

The cell-mediated immune response primarily involves T cells, specifically cytotoxic T cells, which directly attack and destroy infected cells.

This response is crucial for dealing with intracellular pathogens, such as viruses, that hide inside host cells.

Helper T cells also play a role in stimulating cytotoxic T cells and macrophages.

Unlike the humoral response, which targets free-floating pathogens, the cell-mediated response targets and destroys infected cells.

Key Differences:

Target: Humoral immunity targets extracellular pathogens, while cell-mediated immunity targets intracellular pathogens.

Effector Cells: Humoral immunity involves B cells and antibodies, while cell-mediated immunity primarily involves T cells.

Mechanism: Humoral immunity relies on antibodies to neutralize pathogens, whereas cell-mediated immunity involves direct killing of infected cells by cytotoxic T cells.

Quick Tip

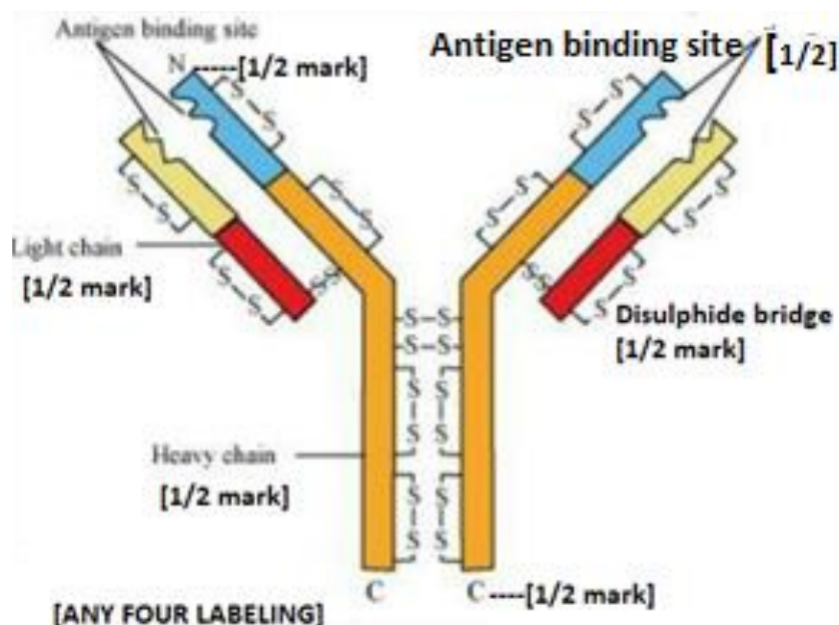
Humoral immunity primarily combats extracellular pathogens, whereas cell-mediated immunity is more effective against intracellular pathogens, such as viruses.

24(b). Draw a schematic diagram of an antibody molecule and label any four parts.

Solution: An antibody molecule is composed of two light chains and two heavy chains that together form a Y-shaped structure.

The diagram labels include: Antigen-binding site, Light chain, Heavy chain, and Disulfide bonds.

The diagram of the antibody molecule shows the antigen-binding sites, light and heavy chains, and disulfide bonds.



Quick Tip

Antibodies play a vital role in immune defense, with their variable regions enabling the recognition of a wide variety of antigens, which helps ensure specificity in immune responses.

25. Explain the mechanism of haplo-diploid pattern of sex determination with the help of a suitable example. Why is this pattern so called?

Solution:

Define Haplo-Diploid Pattern.

In a haplo-diploid system, males develop from unfertilized haploid eggs, while females develop from fertilized diploid eggs.

Example.

This pattern is observed in honeybees:

Haploid males (drones) are produced from unfertilized eggs.

Diploid females (workers and queens) are produced from fertilized eggs.

Reason for the Name.

The term haplo-diploid is used because it involves haploid males and diploid females.

In haplo-diploidy, males are haploid and females are diploid, as demonstrated in honeybees.

Quick Tip

Haplo-diploidy is an effective reproductive mechanism that leads to a division of labor in social insects, such as honeybees, creating specialized roles for reproductive and non-reproductive individuals.

OR

25.

T.S. Morgan and his colleagues worked with *Drosophila melanogaster* for their experiments. State the findings they arrived at and explain how.

Solution:

T.S. Morgan's Experimental Findings:

T.S. Morgan and his colleagues conducted studies on linkage and recombination in fruit flies (***Drosophila melanogaster***).

They discovered that certain genes are often inherited together because they are located on the same chromosome, leading to the concept of gene linkage.

Their experiments revealed that linked genes can undergo recombination during crossing over in meiosis, contributing to genetic variation.

They introduced the chromosomal theory of inheritance, which suggests that genes are arranged in a linear fashion on chromosomes, and that their relative distance affects the frequency of recombination.

Morgan's work also provided evidence for sex-linked inheritance, demonstrating that genes on sex chromosomes follow distinct inheritance patterns, as seen in his research on white-eyed mutants in ***Drosophila***.

How These Findings Were Made:

Morgan conducted breeding experiments with fruit flies, studying traits like eye color and wing shape over multiple generations.

He noticed deviations from Mendelian inheritance ratios when certain traits were inherited together, suggesting that they were linked on the same chromosome.

By examining recombination frequencies, Morgan and his team created genetic maps that placed genes based on crossover rates.

These observations were crucial in developing chromosome mapping techniques that are still used in contemporary genetics.

Quick Tip

T.S. Morgan's research with ***Drosophila melanogaster*** laid the groundwork for modern genetics. His discoveries on linkage, recombination, and chromosome mapping continue to be vital in understanding inheritance mechanisms.

26. "Human blood group (ABO group) inheritance is a good example of multiple

allelism and co-dominance.” Justify the statement.

Solution: Understanding Multiple Allelism.

The ABO blood group system is governed by three alleles: I^A , I^B , and i .

Each individual inherits two of these alleles, which determine their blood type.

Understanding Co-dominance.

I^A and I^B are co-dominant, meaning both alleles are fully expressed in individuals with the AB blood group.

Thus, ABO blood groups display multiple allelism (I^A , I^B , i) and co-dominance (I^A and I^B both expressed together in AB blood type).

Quick Tip

In co-dominance, both alleles equally contribute to the phenotype without blending, as seen in the AB blood type, where both I^A and I^B are simultaneously expressed.

27(a). Why is “in vitro fertilization (IVF)” so named? State its importance.

Solution: Meaning of IVF.

”In vitro” means ”in glass,” referring to fertilization occurring outside the body in a laboratory.

Importance.

IVF helps couples with infertility conceive.

It allows genetic screening of embryos to prevent genetic disorders.

IVF is named for its laboratory fertilization process and is important for treating infertility and genetic disorders.

Quick Tip

IVF is a breakthrough in reproductive technology, offering hope for couples facing infertility or genetic disorders, allowing for successful conception.

27(b). Distinguish between GIFT and ZIFT.

Solution:

GIFT (Gamete Intrafallopian Transfer): In GIFT, both the egg and sperm are collected from the couple and directly transferred into the fallopian tubes of the female.

Fertilization occurs naturally inside the fallopian tube, rather than in a laboratory dish.

This method is suitable for women with healthy fallopian tubes and is often used when both partners have fertility issues.

ZIFT (Zygote Intrafallopian Transfer):

In ZIFT, eggs are fertilized outside the body (in vitro) before being transferred into the fallopian tubes.

The fertilized eggs, or zygotes, are placed in the fallopian tube where implantation and further development can occur.

ZIFT is often used when there are issues with the sperm or egg quality, and it provides a controlled environment for fertilization before transfer.

Key Differences:

1. Fertilization Location:

GIFT involves natural fertilization in the fallopian tube, while ZIFT involves in vitro fertilization (IVF) before the zygote is placed in the fallopian tube.

2. Suitability:

GIFT is suitable for women with open, healthy fallopian tubes, whereas ZIFT can be used when fertilization needs to occur outside the body due to male or female infertility issues.

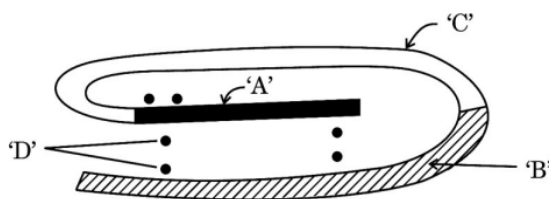
3. Procedure:

GIFT requires that both the egg and sperm be placed together in the fallopian tube, while ZIFT requires the zygote to be cultured in the lab before transfer.

Quick Tip
GIFT and ZIFT are both assisted reproductive techniques aimed at treating infertility, with the key difference being where fertilization occurs—inside the body (GIFT) or outside (ZIFT).

28. The diagram given below is a biomolecule needed for sugar metabolism in human

beings. (a) Name this biomolecule and mention whether it is in active state or inactive
(b) Identify the parts marked as 'A', 'B', 'C' and 'D'.



Solution:

(a) Name the Biomolecule.

The biomolecule shown in the diagram is insulin, which is in its active form. Insulin is a peptide hormone produced by the pancreas that plays a crucial role in regulating blood sugar levels. It is composed of two chains, an alpha chain and a beta chain, linked by disulfide bonds.

(b) Identify the Parts.

The different parts of the insulin molecule are labeled as follows:

A = Alpha Chain: This is one of the two polypeptide chains of insulin. It consists of 21 amino acids and is involved in the overall structure and function of the hormone.

B = Beta Chain: The second polypeptide chain, consisting of 30 amino acids. The beta chain, along with the alpha chain, makes up the full insulin molecule.

C = Disulfide Bond: These are covalent bonds formed between the cysteine residues of the alpha and beta chains, providing structural stability and maintaining the active form of the insulin molecule.

D = Connecting Peptide (C-peptide): This peptide connects the alpha and beta chains in the proinsulin form. It is removed during the conversion of proinsulin to active insulin, but it is sometimes measured in medical tests to assess insulin production.

Thus, the biomolecule is insulin, with the parts identified as:

A = Alpha chain

B = Beta chain

C = Disulfide bond

D = Connecting peptide (C-peptide).

Quick Tip

The labeled parts of insulin help to identify its structure and function, which are essential for understanding how it regulates blood glucose levels and its role in medical treatments for diabetes.

SECTION D

Questions No. 29 and 30 are case-based questions. Each question has 3 subparts with internal choice in one subpart.

Question 29: Read the following passage and answer the questions that follow.

In 1981, the health workers of United States of America had become aware of the increased frequency of Kaposi's sarcoma, cancer of the skin and blood vessels and another disease pneumocystis pneumonia, a respiratory infection caused by a protozoan. Both these diseases were very rare in the general population, but occurred frequently in more severely "immunosuppressed" individuals. This led to the recognition of the immune system disorder that was named Acquired Immune Deficiency Syndrome (AIDS).

In 1983, virologists working in the USA and France had identified a causative agent for 'AIDS', now known as Human Immunodeficiency Virus (HIV). 'HIV' follows a set path to attack the human body to cause the disease.

29(a) Name the group of cells the HIV attacks after gaining entry into the human body and write the various events that occur within this cell.

Solution: Identify the target cells.

HIV primarily attacks CD4+ T-lymphocytes (helper T cells).

Events occurring within the cell.

1. HIV binds to CD4 receptors on the surface of T cells.
2. Viral RNA enters the cell and is reverse transcribed into DNA.
3. The viral DNA integrates into the host genome.
4. New viral particles are synthesized and released, destroying the T cell.

HIV targets CD4+ T-lymphocytes, integrates its DNA, and destroys the cell to produce new viruses.

Quick Tip

CD4+ T cells play a critical role in immunity; their destruction leads to immune system failure in AIDS.
--

29(b) Write the expanded form of the diagnostic test used for detecting AIDS. Write the possible treatment available for the disease at present.

Solution: Name the diagnostic test.

- Expanded form: Enzyme-Linked Immunosorbent Assay (ELISA).

Current treatment.

Antiretroviral therapy (ART) is the primary treatment, using drugs like reverse transcriptase inhibitors and protease inhibitors to suppress viral load.

The diagnostic test is ELISA, and treatment involves antiretroviral therapy (ART).

Quick Tip

Early diagnosis through ELISA and adherence to ART can significantly improve the quality of life for AIDS patients.

29(c) Mention any two steps suggested by WHO for preventing the spread of this disease.

Solution: Preventive measures.

1. Promoting the use of condoms to prevent transmission through sexual contact.
2. Ensuring safe blood transfusions and use of sterilized needles.

WHO recommends safe sexual practices and sterilized medical procedures to prevent AIDS.

Quick Tip
Prevention strategies like education and awareness are key to reducing HIV spread.

OR

29(c) “A patient suffering from AIDS does not die of this disease but from some other infection.” Justify the statement.

Solution:

Effect of AIDS on the Immune System.

AIDS weakens the immune system by targeting and destroying CD4+ T-lymphocytes, leaving the body more susceptible to opportunistic infections.

Primary Cause of Death.

Patients typically do not die from the virus itself, but rather from secondary infections such as tuberculosis, pneumonia, or certain cancers.

Individuals with AIDS often die due to secondary infections or complications resulting from a weakened immune system.

Quick Tip
Regular monitoring to prevent opportunistic infections can help improve the life expectancy of patients with AIDS.

Question 30: Read the following passage and answer the questions that follow.

Spermatogenesis is an important primary sex characteristic in humans and all other vertebrates. The process is coordinated and controlled under the influence of hormones. It starts with the onset of puberty in humans and thereafter continues. The primordial cells within the embryonic testis which differentiate into spermatogonia are the precursors of the sperms. These are located at the outer walls of the seminiferous tubules where the process of spermatogenesis proceeds.

30(a) State the site of action of FSH in the testes and describe its action thereafter.

Solution: Location of FSH Action.

Follicle Stimulating Hormone (FSH) targets Sertoli cells within the seminiferous tubules.

Action of FSH.

FSH stimulates Sertoli cells to produce androgen-binding proteins, which aid in maintaining high concentrations of testosterone in the seminiferous tubules.

Additionally, Sertoli cells provide nourishment and structural support to developing spermatocytes, enabling their maturation into sperm cells.

FSH acts on Sertoli cells, enhancing their ability to support spermatogenesis.

Quick Tip

FSH plays a key role in sperm development within the testes by promoting the function of Sertoli cells.

OR

30(a) Describe the role of LH in the process of spermatogenesis.

Solution: Function of LH.

Luteinizing Hormone (LH) activates Leydig cells in the testes.

Leydig cells are responsible for producing testosterone, which plays a vital role in spermatogenesis by supporting sperm maturation.

LH stimulates Leydig cells to produce testosterone, which regulates the process of spermatogenesis.

Quick Tip

Testosterone, produced by Leydig cells, is essential for both the progression and maintenance of spermatogenesis.

30(b) Name the cells and their products which undergo:

(i) Mitosis and Differentiation

(ii) Meiosis I and Meiosis II during the process of spermatogenesis.

Solution: Cells Involved in Mitosis and Differentiation.

Spermatogonia undergo mitosis to produce primary spermatocytes.

Cells Involved in Meiosis.

Primary spermatocytes undergo Meiosis I, resulting in secondary spermatocytes.

Secondary spermatocytes then undergo Meiosis II to produce spermatids.

Mitosis generates primary spermatocytes, while meiosis results in the formation of spermatids.

Quick Tip

The process of mitosis and meiosis ensures the generation of haploid spermatids from diploid spermatogonia.

30(c) Name the accessory ducts that the sperms travel through from seminiferous tubules to reach the epididymis.**Solution:**

Accessory Ducts in the Male Reproductive System: The male reproductive system has several accessory ducts that facilitate the transportation and maturation of sperm. These ducts play a crucial role in moving sperm from the seminiferous tubules, where sperm is produced, to the epididymis for storage and further maturation. The key accessory ducts are:

1. Rete Testis:

The rete testis is a network of tubules located within the testes. It serves as the primary passageway for sperm from the seminiferous tubules to the vasa efferentia. The sperm move from the seminiferous tubules into the rete testis, where they begin their journey to the next duct in the system.

2. Vasa Efferentia:

The vasa efferentia are small tubes that connect the rete testis to the epididymis. These ducts transport sperm from the rete testis to the epididymis, where the sperm will mature and gain motility. The vasa efferentia help in the concentration of sperm as they move through the ducts.

Pathway of Sperm Movement: - Sperm are produced in the seminiferous tubules of the

testes. From there, they move into the rete testis, where they pass through a network of tubules. - Next, the sperm enter the vasa efferentia, which leads them to the epididymis. - The epididymis is the site where sperm mature and gain the ability to swim, which is essential for fertilization.

These ducts are essential for the proper functioning of the male reproductive system as they facilitate the movement, concentration, and maturation of sperm.

Quick Tip

The accessory ducts, including the rete testis and vasa efferentia, are integral to the transport and maturation of sperm from the seminiferous tubules to the epididymis. Proper functioning of these ducts ensures that sperm are stored and ready for fertilization.

SECTION E

31(a)(i) Why should a cell be made competent to take up an alien DNA? How can a bacterial cell be made competent using calcium ions? Explain.

Solution:

Importance of Competence.

Competent cells have the ability to absorb foreign DNA during the process of genetic transformation.

Role of Calcium Ions.

Bacterial cells are treated with calcium chloride to induce competence.

The calcium ions cause the formation of pores in the bacterial cell wall, which facilitates the entry of foreign DNA.

For transformation to occur, cells need to be competent. Treating bacterial cells with calcium chloride makes their cell walls permeable to DNA.

Quick Tip

Competence is a key step in genetic engineering, allowing foreign DNA to be introduced into cells.

31(a)(ii) (1) State the importance of gel electrophoresis in biotechnology.

Solution:

The Role of Gel Electrophoresis in Biotechnology:

Gel electrophoresis is an essential technique in biotechnology that is primarily used for analyzing DNA, RNA, and proteins.

It plays a key role in various applications such as DNA fingerprinting, genetic mapping, and molecular cloning.

This method is commonly used in fields like forensic science, disease diagnosis, and recombinant DNA technology.

Gel electrophoresis works by separating and purifying biomolecules according to their size and charge, which allows for detailed analysis and further experimentation.

Quick Tip

Gel electrophoresis is a powerful tool for separating biomolecules, helping researchers analyze DNA, RNA, and proteins based on their size and charge. It's essential in many biotechnological applications, such as genetic fingerprinting and molecular diagnostics.

31(a)(ii) (2) Explain the principle on which this technique works.

Principle of Gel Electrophoresis:

Gel electrophoresis works on the principle that charged molecules migrate through a gel matrix under the influence of an electric field.

Negatively charged DNA or RNA molecules move towards the positively charged anode, with smaller molecules moving faster than larger ones.

The separation occurs due to molecular sieving, where the gel acts as a filter, allowing smaller molecules to pass through more easily.

31(a)(ii) (3) Mention why ethidium bromide is used in this technique.

Role of Ethidium Bromide in Gel Electrophoresis:

Ethidium bromide (EtBr) is a fluorescent dye used to stain DNA and RNA in gel electrophoresis.

It intercalates between the base pairs of nucleic acids, allowing visualization under UV light. EtBr makes it easier to detect DNA fragments after separation, aiding in analysis and documentation.

Quick Tip

Gel electrophoresis is a vital technique in molecular biology. Ethidium bromide is commonly used for visualization, but safer alternatives like SYBR Green are also available to reduce toxicity.

OR

(b) Bt cotton , the genetically modified crop, has greatly helped the cotton farmers to increase their crop yield.

(I) How was Bt cotton plant made resistant to bollworm? Explain.

Solution:

Incorporating the Bt Gene.

A gene from **Bacillus thuringiensis** (Bt), responsible for producing Cry proteins toxic to bollworms, is introduced into cotton plants.

Production of Bt Toxin.

The genetically modified Bt cotton produces Cry proteins that are activated in the alkaline environment of the bollworm's gut, leading to their death.

Bt cotton produces Cry proteins that are toxic to bollworms, preventing infestation.

Quick Tip

Genetic engineering allows crops to produce proteins that specifically target pests, helping to reduce the reliance on chemical pesticides.

(b)(ii) Describe the mechanism that leads to the death of bollworms feeding on Bt cotton plants.

Solution:

Consumption of Bt Toxin.

Bollworms consume Cry proteins from Bt cotton.

Activation of the Toxin.

In the bollworm's alkaline gut, Cry proteins become activated and bind to specific receptors.

Damage to Gut Lining.

Once activated, the toxins form pores in the gut lining, leading to leakage. This causes the bollworm to starve and eventually die.

Bt toxins damage the gut lining of bollworms, resulting in their death.

Quick Tip

Bt crops offer targeted pest control by using proteins that specifically kill harmful pests while preserving beneficial organisms.

32(a)(i) Explain the process of double fertilization in an angiosperm starting from the germination of pollen grains on the stigma, mentioning the ploidy of the end products formed at the end. State the role of synergids during the course of the process.

Solution: Germination of pollen grains.

Pollen grains germinate on the stigma, forming a pollen tube carrying two male gametes.

Entry into ovule.

The pollen tube enters the ovule through the micropyle and discharges the male gametes.

Double fertilization.

One male gamete fuses with the egg cell, forming a diploid zygote.

The second male gamete fuses with the two polar nuclei, forming a triploid primary endosperm nucleus.

Step 4: Role of synergids.

Synergids guide the pollen tube to the egg cell and help in the process of fertilization.

Double fertilization results in a diploid zygote and triploid endosperm, facilitated by synergids.

Quick Tip
Double fertilization is a unique process in angiosperms that ensures the formation of both an embryo and a nutritive tissue for seed development.

32(a)(iI) Why does the development of endosperm precede that of the embryo?

Solution: Function of endosperm.

Endosperm provides nutrients to the developing embryo.

Sequence of development.

The embryo develops only after the endosperm is formed, ensuring a steady nutrient supply.

Endosperm formation precedes embryo development to provide essential nutrients.

Quick Tip
Endosperm ensures the embryo receives necessary nutrients during seed development.

OR

32(b)(i) Mention the site where fertilization of the ovum occurs in a human female.

Explain the process of fertilization and mention how polyspermy is prevented.

Solution: Site of fertilization.

Fertilization occurs in the ampullary region of the fallopian tube.

Process of fertilization.

Sperm penetrates the ovum's protective layers, leading to the fusion of male and female nuclei.

Prevention of polyspermy.

The cortical reaction alters the zona pellucida, preventing additional sperm from entering the ovum.

Fertilization occurs in the fallopian tube, and polyspermy is prevented by the cortical reaction.

Quick Tip
Polyspermy prevention is crucial for ensuring the correct number of chromosomes in the zygote.

32(b)(ii) Name the embryonic stage that gets implanted in the uterus. Explain the process of implantation in a human female.

Solution: Embryonic stage.

The blastocyst stage implants in the uterine wall.

Process of implantation.

The blastocyst adheres to the endometrium.

Trophoblast cells invade the uterine lining, anchoring the embryo.

The blastocyst implants in the uterus through adhesion and invasion of the endometrium.

Quick Tip
Implantation is a critical step in early pregnancy, as it establishes a connection between the embryo and maternal blood supply.

33. (a) (i) State Mendel's law of independent assortment.

Solution:

Mendel's Law of Independent Assortment:

This law states that the inheritance of one trait does not affect the inheritance of another trait, as long as the genes for these traits are on different chromosomes.

As a result, during gamete formation, the alleles for different genes are distributed independently, leading to increased genetic variation.

Quick Tip

Mendel's Law of Independent Assortment highlights how genetic diversity is generated through the independent inheritance of traits located on separate chromosomes.

33. (a) (ii) Explain this law by taking the example of a cross between two heterozygous parents of pea plants with respect to flower colour and flower position using Punnett Square.

Dihybrid Cross in Pea Plants:

Consider a cross between two pea plants heterozygous for flower colour (P = purple, p = white) and flower position (A = axial, a = terminal).

The genotype of both parents is PpAa.

A Punnett Square for this dihybrid cross shows a 9:3:3:1 phenotypic ratio, confirming independent assortment.

	<i>PA</i>	<i>Pa</i>	<i>pA</i>	<i>pa</i>
<i>PA</i>	<i>PPAa</i>	<i>PPAa</i>	<i>PpAA</i>	<i>PpAa</i>
<i>Pa</i>	<i>PPAa</i>	<i>PPaa</i>	<i>PpAa</i>	<i>Ppaa</i>
<i>pA</i>	<i>PpAA</i>	<i>PpAa</i>	<i>ppAA</i>	<i>ppAa</i>
<i>pa</i>	<i>PpAa</i>	<i>Ppaa</i>	<i>ppAa</i>	<i>ppaa</i>

Phenotypic Ratio:

9 Purple-Axial

3 Purple-Terminal

3 White-Axial

1 White-Terminal

This confirms independent assortment, as the inheritance of flower colour does not affect the inheritance of flower position.

Quick Tip

Mendel's law of independent assortment explains how genetic traits are inherited independently. This law holds true for genes on different chromosomes but may not apply when genes are linked on the same chromosome.

OR

33. (b) Explain Griffith's experiment conducted in search of genetic material and write the conclusion he arrived at. How did Avery, MacLeod and McCarty establish the biochemical nature of the "Genetic Material" identified by Griffith?

Griffith's Experiment: In 1928, Frederick Griffith conducted experiments on *Streptococcus pneumoniae** bacteria to investigate genetic material.

He worked with two strains of bacteria:

The S (Smooth) strain – Virulent, causing pneumonia.

The R (Rough) strain – Non-virulent, harmless.

His experiment involved:

Injecting live S strain into mice → Mice died.

Injecting live R strain into mice → Mice survived.

Injecting heat-killed S strain into mice → Mice survived.

Injecting a mixture of heat-killed S strain and live R strain → Mice died.

This suggested that the R strain was transformed into the virulent S strain, leading to the concept of the Transformation Principle.

Avery, MacLeod, and McCarty's Contribution:

In 1944, Avery, MacLeod, and McCarty demonstrated that DNA is the genetic material.

They treated the heat-killed S strain extract with enzymes that degrade proteins, RNA, and DNA.

Transformation occurred when proteins and RNA were degraded, but it did not happen when DNA was degraded.

This provided evidence that DNA carries genetic information.

Quick Tip
Griffith's and Avery's experiments were instrumental in establishing DNA as the hereditary material, advancing our understanding of genetics and molecular biology.
