Biology Question Paper with Solutions

Time Allowed :3 hours	**Maximum Marks :**70	**Total Questions :**33

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**: Sections **A, B, C, D, and E**.
3. **Section A** – questions number 1 to 16 are **multiple-choice type questions**. Each question carries 1 mark.
4. **Section B** – questions number 17 to 21 are **very short answer type questions**. Each question carries 2 marks.
5. **Section C** – questions number 22 to 28 are **short answer type questions**. Each question carries 3 marks.
6. **Section D** – questions number 29 and 30 are **case-based questions**. Each question carries 4 marks. Each question has subparts with **internal choice** in one of the subparts.
7. **Section E** – questions number 31 to 33 are **long answer type questions**. Each question carries 5 marks.
8. There is **no overall choice.** However, an internal choice has been provided in Sections **B, C, and D** of the question paper. A candidate has to write the answer for **only one of the alternatives** in such questions.
9. Kindly note that there is a separate question paper for **Visually Impaired candidates**.
10. Wherever necessary, **neat and properly labelled diagrams** should be drawn.

SECTION A

Question Nos. 1 to 16 are Multiple Choice Type Questions, carrying 1 mark each.

1. If the sequence of nitrogen bases of the coding strand in a transcription unit is 5'–ATGAATG–3', the sequence of bases in its RNA transcript would be:
Options:
(A) 5'–AUGAAUG–3'

(B) 5'–UACUUAC–3'
(C) 5'–CAUUCAU–3'
(D) 5'–GUAAUGA–3'

Correct Answer: (A) 5'–AUGAAUG–3'

Solution:

- In transcription, the coding strand's sequence directly determines the mRNA sequence, but with uracil (U) replacing thymine (T).
- Coding strand: 5'–ATGAATG–3'
- mRNA transcript: 5'–AUGAAUG–3'

Quick Tip

The RNA transcript is complementary to the template strand and identical to the coding strand, except uracil replaces thymine.

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2. How many base pairs will be there in 20 nucleosomes in a DNA double helix?
Options:
(A) 4000
(B) 40
(C) 20
(D) 2000

Correct Answer: (A) 4000

Solution:

- Each nucleosome consists of 200 base pairs of DNA.
- For 20 nucleosomes: $20 \times 200 = 4000$ base pairs.

Quick Tip

Nucleosomes are the fundamental units of chromatin, with DNA wrapped around histone proteins.

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3. A person with trisomy of 21st chromosome shows:
(i) Furrowed tongue
(ii) Characteristic palm crease
(iii) Rudimentary ovaries
(iv) Gynaecomastia

Select the correct option from the choices given below:
(A) (ii) and (iv)
(B) (i), (ii), and (iv)

(C) (ii) and (iii)
(D) (i) and (ii)

Correct Answer: (D) (i) and (ii)

Solution:

- Trisomy of chromosome 21 results in Down syndrome.
- Symptoms include furrowed tongue (i) and characteristic palm crease (ii).
- Other features vary and may include developmental delays.

Quick Tip

Down syndrome is caused by the presence of an extra copy of chromosome 21, leading to distinct physical and cognitive traits.

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4. Single step large mutation leading to speciation is also called:
Options:
(A) founder effect
(B) saltation
(C) branching descent
(D) natural selection

Correct Answer: (B) saltation

Solution:

- Saltation refers to a sudden, large-scale mutation that causes a significant evolutionary change.
- It contrasts with gradual evolution and leads to speciation.

Quick Tip

Saltation highlights the role of mutations in causing rapid evolutionary changes, bypassing gradualism.

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5. Identify the most appropriate technique depicted in the above diagram:
Options:
(A) IUT
(B) IUI
(C) ICSI
(D) ZIFT

Correct Answer: (C) ICSI

Solution:

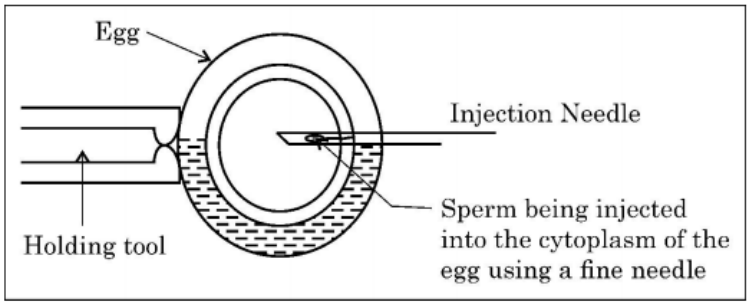

Figure 1: Sperm being injected into the cytoplasm of the egg using a fine needle.

- The diagram depicts Intracytoplasmic Sperm Injection (ICSI).
- Sperm is directly injected into the egg's cytoplasm using a fine needle.
- This method is used in cases of male infertility or low sperm count.

Quick Tip

ICSI is a specialized in-vitro fertilization (IVF) technique aiding in fertilization by injecting a single sperm into an egg.

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6. Match the following genes of the lac operon listed in column 'A' with their respective products listed in column 'B':

A: Gene	B: Products
a. 'i' gene	(i) β-galactosidase
b. 'z' gene	(ii) lac permease
c. 'a' gene	(iii) repressor
d. 'y' gene	(iv) transacetylase

Select the correct option:
(A) (i) (iii) (ii) (iv)
(B) (iii) (i) (ii) (iv)
(C) (iii) (i) (iv) (ii)
(D) (iii) (iv) (i) (ii)

Correct Answer: (C) (iii) (i) (iv) (ii)

Solution:

- The lac operon includes the following genes and their products:
  - **'i' gene:** Produces the repressor protein (iii).
  - **'z' gene:** Produces β-galactosidase (i), which breaks down lactose.
  - **'a' gene:** Produces transacetylase (iv).
  - **'y' gene:** Produces lac permease (ii), which facilitates lactose entry into the cell.

Quick Tip

The lac operon is an inducible operon that regulates lactose metabolism in prokaryotes.

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7. Which one of the following enzymes a fungal cell should be treated with to get the DNA along with other macromolecules released from it?
Options:
(A) Isozymes
(B) Cellulose
(C) Ribonuclease
(D) Chitinase

Correct Answer: (D) Chitinase

Solution:

- Fungal cells have a cell wall made of chitin.
- Chitinase is the enzyme that breaks down chitin, allowing the release of DNA and other macromolecules.

Quick Tip

Chitinase is commonly used in molecular biology to break down fungal cell walls and extract DNA.

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8. During biological treatment of sewage, the masses of bacteria held together by fungal filaments to form mesh-like structures are called:
Options:
(A) Primary sludge
(B) Flocs
(C) Activated sludge
(D) Anaerobic sludge

Correct Answer: (B) Flocs

Solution:

- During sewage treatment, bacteria and fungal filaments aggregate to form flocs.
- Flocs help in the breakdown of organic matter and are an essential part of biological treatment.

Quick Tip

Flocs are key in aerobic biological processes for treating wastewater.

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9. Which one of the following is not a characteristic feature of "humus" that is formed during decomposition of detritus?
Options:
(A) Amorphous, colloidal, dark-coloured substance
(B) Amorphous, colloidal, light-coloured substance
(C) High resistance to microbial action
(D) Colloidal substance

Correct Answer: (B) Amorphous, colloidal, light-coloured substance

Solution:

- Humus is an amorphous, colloidal, dark-coloured substance.
- It is resistant to microbial action and contributes to soil fertility.
- Light-coloured humus is not a characteristic feature.

Quick Tip

Humus is vital for maintaining soil structure and nutrient cycling.

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10. Interferons are proteins secreted by:
Options:
(A) RBC
(B) WBC
(C) Bacteria infected cell
(D) Virus infected cell

Correct Answer: (D) Virus infected cell

Solution:

- Interferons are proteins produced by cells in response to viral infections.
- They play a key role in the immune response by inhibiting viral replication and activating immune cells like natural killer cells.
- These proteins signal neighboring cells to heighten their antiviral defenses.

Quick Tip

Interferons are part of the body's innate immunity and are critical in controlling viral infections.

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11. Identify the correct labellings in the figure of a fertilised embryo sac of an angiosperm given below:
Options:
(A) A – zygote, B – degenerating synergids, C – degenerating antipodals, D – PEN

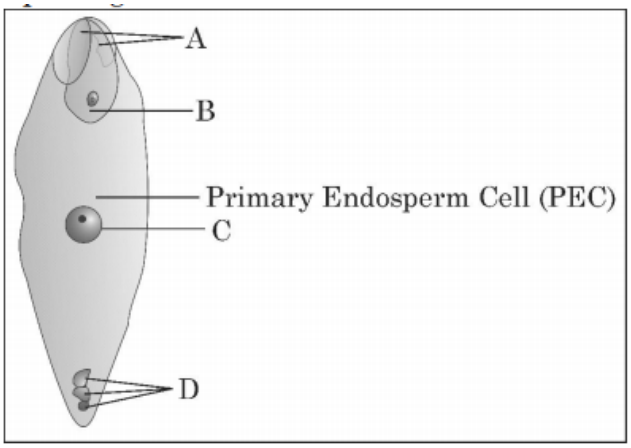

Figure 2: Diagram showing the labeled parts: A, B, Primary Endosperm Cell (PEC), C, and D.

(B) A – degenerating synergids, B – zygote, C – PEN, D – degenerating antipodals
(C) A – degenerating antipodals, B – PEN, C – degenerating synergids, D – zygote
(D) A – degenerating synergids, B – zygote, C – degenerating antipodals, D – PEN

Correct Answer: (B) A – degenerating synergids, B – zygote, C – PEN, D – degenerating antipodals

Solution:

- In the fertilized embryo sac:
  - A represents degenerating synergids as they are no longer needed post-fertilization.
  - B is the zygote, formed after the fusion of male and female gametes.
  - C is the Primary Endosperm Nucleus (PEN), which divides to form the endosperm, a nutritive tissue.
  - D shows degenerating antipodal cells that play no role after fertilization.

Quick Tip

In a fertilized embryo sac, the synergids and antipodal cells degenerate, while the zygote develops into the embryo and PEN forms the endosperm.

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12. Study the pedigree chart of a family showing the inheritance pattern of a certain disorder. Select the option that correctly identifies the nature of the trait depicted in the pedigree chart:
Options:
(A) Dominant X-linked
(B) Recessive X-linked
(C) Autosomal dominant
(D) Autosomal recessive

Correct Answer: (D) Autosomal recessive

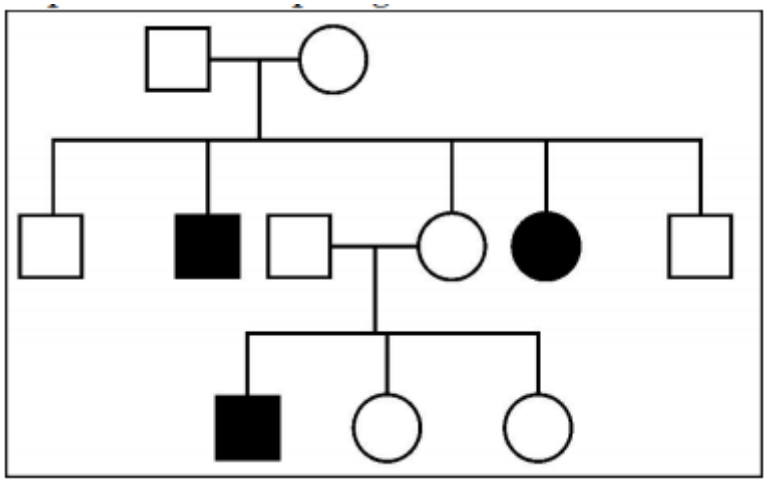

Figure 3: Pedigree chart depicting inheritance patterns.

Solution:

- The disorder is autosomal recessive based on the following observations:
  - The trait skips generations, as unaffected parents can pass the recessive allele to their offspring.
  - Both males and females are equally affected, indicating autosomal inheritance.
  - The condition appears only in individuals inheriting two copies of the recessive allele, one from each parent.
- This pattern eliminates options for X-linked or dominant inheritance, confirming autosomal recessive inheritance.

Quick Tip

Autosomal recessive traits require two copies of the defective gene for the disorder to manifest and can affect both genders equally.

Question numbers 13 to 16 consist of two statements — Assertion (A) and Reason (R). Answer these questions by selecting the appropriate option given below: Options:
(A) Both (A) and (R) are true and (R) is the correct explanation of (A).
(B) Both (A) and (R) are true, but (R) is not the correct explanation of (A).
(C) (A) is true, but (R) is false.
(D) (A) is false, but (R) is true.

13. Assertion (A): Communities that comprise of more species tend to be more stable.
Reason (R): A higher number of species results in less year-to-year variation in total biomass. Correct Answer: (A) Both (A) and (R) are true and (R) is the correct explanation of (A).
Solution:

- Species-rich communities show greater stability as they buffer against environmental fluctuations.
- Reason (R) explains Assertion (A), as a higher number of species ensures resource utilization efficiency and ecological balance, minimizing biomass variation.

Quick Tip

Communities with higher species diversity are more resilient to environmental changes and disturbances.

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14. Assertion (A): The sugar-phosphate backbone of two chains in DNA double helix shows anti-parallel polarity.
Reason (R): The phosphor-diester bonds in one strand go from a 3' carbon of one nucleotide to a 5' carbon of adjacent nucleotide, whereas those in complementary strand go vice versa. Correct Answer: (A) Both (A) and (R) are true and (R) is the correct explanation of (A).
Solution:

- DNA strands run anti-parallel, with one in 5' to 3' and the complementary strand in 3' to 5'.
- The phosphor-diester bond arrangement described in Reason (R) explains the anti-parallel polarity of DNA strands, confirming the explanation of Assertion (A).

Quick Tip

The anti-parallel arrangement of DNA strands is essential for complementary base pairing and replication.

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15. Assertion (A): In molecular diagnosis, single-stranded DNA or RNA tagged with radioactive molecule is called a probe.
Reason (R): A probe always searches and hybridizes with its complementary DNA in a clone of cells. Correct Answer: (A) Both (A) and (R) are true and (R) is the correct explanation of (A).
Solution:

- A probe is a labeled DNA or RNA strand used to identify specific sequences in molecular diagnostics.
- It hybridizes with its complementary DNA, supporting Reason (R) as the explanation for Assertion (A).

Quick Tip

Probes are key tools in molecular diagnostics for identifying specific genetic sequences.

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16. Assertion (A): AIDS is a syndrome caused by HIV.
Reason (R): HIV is a virus that damages the immune system with AIDS as its

genetic material. Correct Answer: (C) (A) is true, but (R) is false.
Solution:

- Assertion (A) is true because AIDS (Acquired ImmunoDeficiency Syndrome) is caused by HIV.
- Reason (R) is false as HIV is not genetic material; it is a virus containing RNA as its genetic material.

Quick Tip

HIV leads to AIDS by attacking the immune system, specifically targeting CD4+ T cells.

SECTION B

Short Answer Type Questions (Word Limit: 40 words)

17. Answer the questions based on the typical biogas plant diagram given below:

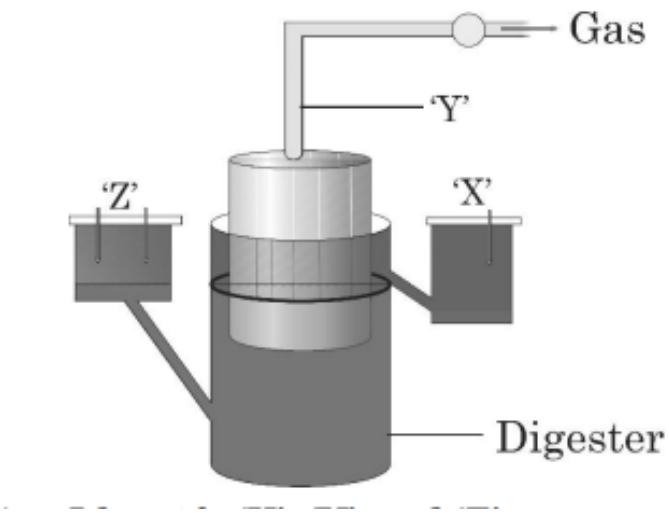

Figure 4: Biogas Plant Diagram showing parts 'X', 'Y', and 'Z'.

(a) Identify 'X', 'Y', and 'Z'.
Solution: X: Slurry tank stores organic waste mixed with water. Y: Gas outlet releases methane-rich biogas. Z: Digester uses anaerobic bacteria to decompose organic material, producing biogas and nutrient-rich slurry for agricultural purposes.

Quick Tip

The digester is the heart of the biogas plant, where waste decomposes to produce methane-rich biogas and nutrient-packed slurry for farms.

(b) Why is dung preferred for the production of biogas?
Solution: Dung is rich in organic matter and cellulose, ideal for methanogenic bacteria. It is

affordable, abundant, and sustainable, producing renewable energy as biogas and nutrient-rich slurry, which serves as excellent manure for agricultural fields.

Quick Tip

Using dung for biogas not only produces clean energy but also minimizes methane emissions, contributing to sustainable waste management and climate change mitigation.

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18. If adenine is 31% in DNA, calculate the percentage of cytosine. Explain briefly.
Solution: Adenine pairs with thymine (31% each), totaling 62%. Cytosine and guanine share the remaining 38%. Therefore, cytosine is 19%, following Chargaff's rule, where purines (adenine, guanine) always pair with pyrimidines (thymine, cytosine).

Quick Tip

Chargaff's rule ensures complementary base pairing, maintaining DNA structure and accurate replication during cell division.

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19. (a) Why do farmers prefer apomictic seeds to hybrid seeds?
Solution: Farmers use apomictic seeds because they are genetically identical to the parent plant, ensuring trait stability. These seeds eliminate the need for annual purchases, reducing costs while preserving desirable traits across generations without genetic variability.

Quick Tip

Apomictic seeds ensure uniformity and cost savings, making them highly beneficial for farmers seeking trait stability across generations.

OR

(b) Mention one advantage and disadvantage of amniocentesis.
Solution:

- **Advantage:** Amniocentesis detects genetic or chromosomal disorders during pregnancy, helping in early diagnosis and medical intervention.
- **Disadvantage:** Misuse for sex determination risks female feticide, raising ethical concerns. Regulatory measures are crucial to prevent such exploitation of this diagnostic tool.

Quick Tip

Amniocentesis helps identify genetic disorders but must be regulated to avoid misuse for unethical practices like sex determination.

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20. Refer to the population growth curves shown below and answer:

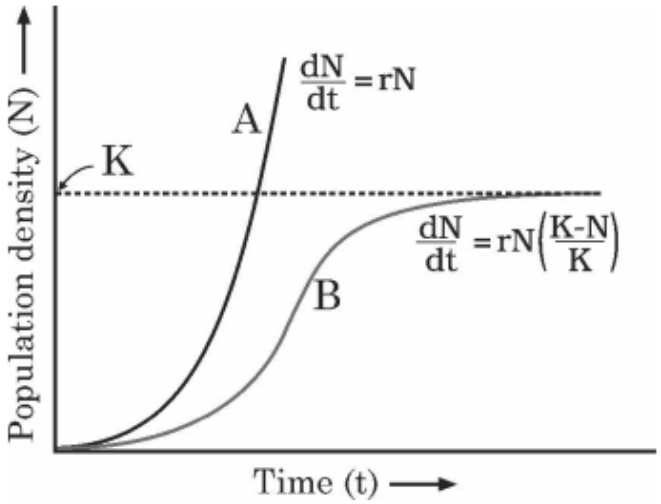

Figure 5: Population Growth Curves: Exponential (A) and Logistic (B). 'K' denotes carrying capacity.

(a) State the conditions for growth curve 'A' and growth curve 'B'.
Solution: Curve A depicts exponential growth with ideal conditions and unlimited resources. Curve B reflects logistic growth influenced by environmental resistance, resource limitations, and population regulation, ensuring sustainability within the environment's carrying capacity.

Quick Tip

Exponential growth occurs under ideal conditions, while logistic growth incorporates environmental limits, ensuring balance and sustainability.

(b) What does 'K' represent?
Solution: K represents the carrying capacity, the maximum population size sustainable by available resources, considering environmental factors. It determines population growth limits, balancing ecological resources and species survival.

Quick Tip

Carrying capacity (K) is crucial for maintaining population stability by balancing species survival with resource availability.

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21. Sequence:
5' – G↑A A T T C – 3'
3' – C T T A A↑G – 5'

(a) Name the restriction enzyme and type of sequence.
Solution:

- Enzyme: EcoRI cleaves the sequence at specific sites, recognizing G↑AATTC.

- Sequence: Palindromic, identical when read 5'-3' on one strand and 3'-5' on the complementary strand.

> Quick Tip
>
> Palindromic sequences are recognized by restriction enzymes, enabling specific DNA cutting for genetic engineering applications.

(b) Explain the arrows and the result.
Solution:

- Arrows mark EcoRI cleavage points, cutting between G and A.
- Result: Sticky ends are created, facilitating the attachment of complementary DNA fragments for cloning or ligation processes.

> Quick Tip
>
> Sticky ends enhance recombinant DNA technology by increasing the efficiency of foreign DNA integration into vectors.

SECTION C

22. (a) How is the grazing food chain different from the detritus food chain?

Solution: The grazing food chain begins with living producers like plants, transferring energy to herbivores and then to carnivores. The detritus food chain starts with decomposed organic matter, transferring energy to detritivores like earthworms and decomposers such as fungi and bacteria. Both food chains play essential roles in energy transfer, but the grazing food chain depends on photosynthesis, whereas the detritus food chain depends on organic waste decomposition. They interact, ensuring energy flow and nutrient recycling within ecosystems.

> Quick Tip
>
> Energy flow connects the grazing and detritus food chains, ensuring ecosystem balance and nutrient recycling.

(b) "The detritus food chain may be connected to the grazing food chain at some levels in an ecosystem." Give an example in support of the statement.

Solution: Dead plants and organic detritus are decomposed into nutrients by soil microorganisms. These nutrients are absorbed by plants, which serve as producers in the grazing food chain. Additionally, organisms like earthworms feed on detritus and are eaten by higher trophic-level organisms, linking the two chains. This interconnection emphasizes energy and nutrient flow, where waste materials are recycled into food chains, supporting ecosystem sustainability. The detritus food chain complements the grazing food chain by utilizing decomposed matter efficiently.

Quick Tip

The interconnection between food chains highlights the importance of decomposers in transferring energy and nutrients to primary and higher trophic levels.

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23. If the cells in the leaves of a maize plant contain 10 chromosomes each, write the number of chromosomes in its endosperm and zygote. Name and explain the process by which an endosperm and a zygote are formed in maize.

Solution: The endosperm contains 30 chromosomes (3n, triploid), while the zygote has 20 chromosomes (2n, diploid). These are formed through double fertilization, unique to angiosperms. One sperm nucleus fertilizes the egg cell, forming the diploid zygote. Simultaneously, another sperm nucleus fuses with two polar nuclei, forming the triploid endosperm. This process ensures both the development of the embryo and the formation of a nutrient-rich tissue (endosperm) for seed nourishment, vital for seed germination and plant growth.

Quick Tip

Double fertilization is critical for simultaneous zygote formation and nutrient-rich endosperm development, ensuring seed viability and germination success.

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24. (a) Why must a cell be made 'competent' in biotechnology experiments? How does calcium ion help in doing so?

Solution: Competency is necessary to enable cells to take up foreign DNA during transformation. Calcium ions neutralize the negative charges of DNA and the cell membrane, reducing repulsion between them. This creates favorable conditions for foreign DNA molecules to enter the cell. Competent cells are essential for successful genetic engineering experiments, where foreign DNA is introduced into host cells. This process is widely used in research, industry, and medicine for cloning, genetic modification, and protein production.

Quick Tip

Competent cells are a prerequisite for introducing recombinant DNA into host cells, aiding genetic transformation in biotechnology applications.

(b) State the role of "biolistic gun" in biotechnology experiments.

Solution: The biolistic gun or gene gun delivers DNA into plant cells by bombarding them with high-velocity microprojectiles coated with DNA. It is a vital tool in genetic engineering, enabling the transformation of plant cells that are otherwise difficult to modify. This technique is widely used in creating genetically modified crops, studying gene expression, and producing transgenic

plants. Its efficiency and versatility make it indispensable in agricultural and biotechnological research, especially for plants with thick cell walls.

Quick Tip

The biolistic gun is a vital tool for genetic engineering, widely used in plant biotechnology and transgenic research.

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25. (a) Why does DNA replication occur within a replication fork and not in its entire length simultaneously?

Solution: Replication occurs within the fork because DNA polymerase works in the 5' to 3' direction. Due to the antiparallel strands of DNA, one strand (leading) is synthesized continuously, while the other (lagging) is synthesized discontinuously using Okazaki fragments. This semi-discontinuous mechanism ensures accurate replication of both strands efficiently. If DNA replication happened simultaneously across the entire length, it would be inefficient and error-prone. The replication fork optimizes this process, ensuring proper sequence matching and error correction.

Quick Tip

Replication forks enable directional synthesis, ensuring accuracy in DNA replication by utilizing a semi-discontinuous mechanism.

(b) "DNA replication is continuous and discontinuous on the two strands within the replication fork." Explain with the help of a schematic representation.

Solution: DNA replication occurs in a semi-conservative manner, where the parental DNA strands serve as templates for the synthesis of new complementary strands. Due to the antiparallel nature of DNA and the unidirectional activity of DNA polymerase (5' to 3'), the two strands at the replication fork are synthesized differently:

- **Leading strand:** Synthesized continuously in the 5' to 3' direction, as it follows the replication fork movement.
- **Lagging strand:** Synthesized discontinuously in small fragments called Okazaki fragments, which are later joined by DNA ligase.

Schematic Representation:

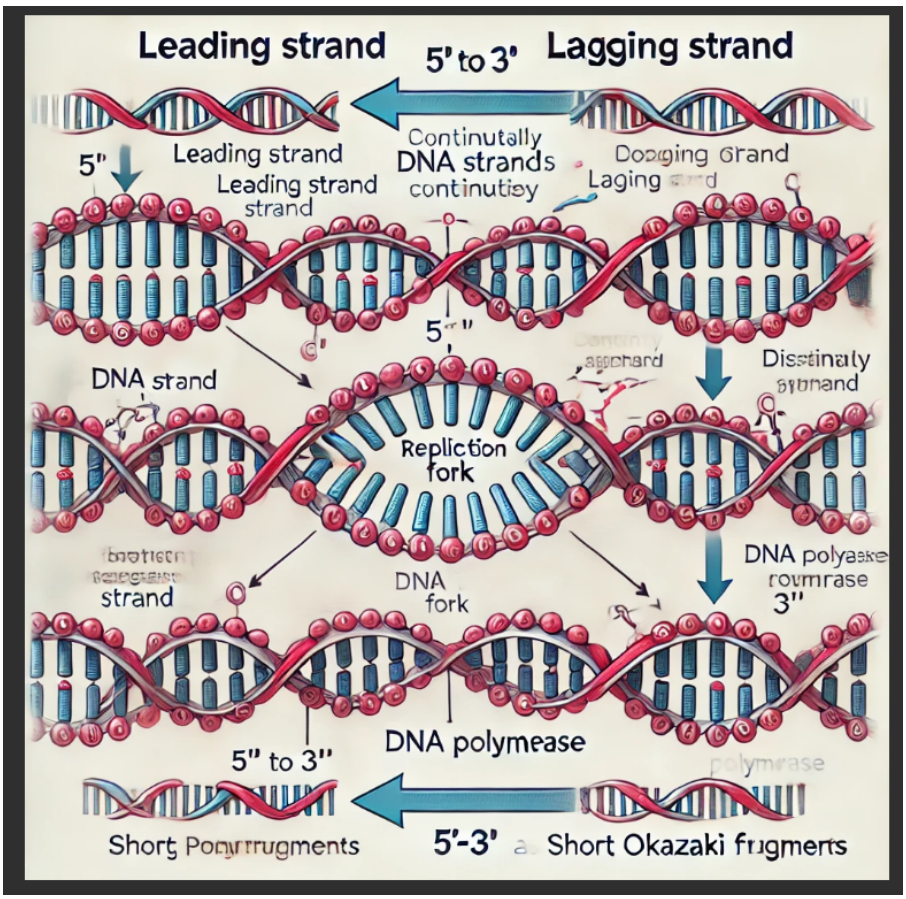

Figure 6: Schematic diagram of DNA replication showing the continuous synthesis of the leading strand and the discontinuous synthesis of the lagging strand with Okazaki fragments.

Quick Tip

Remember, the key difference lies in the directionality of synthesis: the leading strand is synthesized in one continuous stretch, while the lagging strand involves multiple short fragments.

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26. Expression of different genes for different traits may show dominance, incomplete dominance, or co-dominance. Write about expression of such genes with examples for one of the above modes.

Solution: Dominance: A dominant allele masks the expression of a recessive allele. For example, in pea plants, the allele for tallness (**T**) dominates over dwarfness (**t**). A heterozygous plant (**Tt**) will be tall.
Incomplete dominance: The heterozygous phenotype is an intermediate. Example: In snapdragons, crossing a red flower (**RR**) with white (**rr**) produces pink flowers (**Rr**).
Co-dominance: Both alleles are equally expressed. Example: In humans, **IA** and **IB** alleles are co-dominant, resulting in blood group **AB**.

Quick Tip

Gene expression patterns like dominance, incomplete dominance, and co-dominance reveal the diversity of inheritance in organisms.

27. (a) Tropical regions harbour more species than temperate regions. How have biologists tried to explain this in their own ways? Explain.

Solution: Tropical regions experience stable climates over millions of years, allowing uninterrupted evolution and speciation. High solar energy enhances productivity, providing abundant resources. Constant temperatures reduce the risk of species extinction due to extreme conditions. Longer growing seasons enable more generations, accelerating evolution. Absence of glaciation in the tropics prevented mass extinctions. Higher ecological niches support diverse species. These factors together explain why tropical ecosystems, like rainforests, support the greatest biodiversity on Earth compared to temperate regions.

Quick Tip

Tropical regions are biodiversity hotspots due to their long-term climate stability and high productivity.

OR

(b) (i) What does an ecological pyramid represent?

Solution: An ecological pyramid graphically represents the quantitative relationships of energy, biomass, or number of organisms at each trophic level in an ecosystem. Producers occupy the pyramid's base, supporting consumers above them. The structure depicts energy flow, biomass distribution, or organism abundance. Energy pyramids are always upright, reflecting energy loss at successive trophic levels. Biomass and number pyramids can be upright or inverted, depending on the ecosystem type. Ecological pyramids are critical for understanding energy transfer and ecosystem dynamics.

Quick Tip

Ecological pyramids visually illustrate the structure and function of ecosystems through energy, biomass, or number distributions.

(ii) The ecological pyramids may have an 'upright' or an 'inverted' shape. Justify with the help of suitable examples.

Solution: Upright pyramids occur in terrestrial ecosystems where energy flows from a large

producer base (e.g., plants in grasslands) to fewer herbivores and carnivores. Inverted pyramids are seen in aquatic ecosystems where producers like phytoplankton have lower biomass but support larger biomass consumers like fish. Upright biomass pyramids reflect higher productivity at the base, while inverted pyramids arise due to rapid phytoplankton turnover. Both pyramid types showcase energy and biomass flow, differing based on the ecosystem's unique dynamics.

Quick Tip

The shape of ecological pyramids depends on the ecosystem's structure and energy or biomass flow.

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28. Identify a, b, c, d, e, and f in the table given below:

Sl. No.	Organism	Bioactive Molecule	Use
1	*Monascus purpureus*	Statins	Lowers blood cholesterol
2	*Streptomyces*	Antibiotic	Treats infections
3	*Trichoderma polysporum*	Cyclosporin A	Immunosuppressant
4	*Penicillium notatum*	Penicillin	Kills bacteria
5	*Aspergillus niger*	Citric acid	Food additive
6	*Lactobacillus*	Lactic acid	Used in food preservation

Solution: Bioactive molecules have diverse medical and industrial uses. Statins from *Monascus purpureus* lower cholesterol, reducing cardiovascular risks. Cyclosporin A from *Trichoderma polysporum* suppresses immune responses, vital for organ transplants. Penicillin, an antibiotic from *Penicillium notatum*, combats bacterial infections. Citric acid from *Aspergillus niger* serves as a food preservative and additive. Lactic acid from *Lactobacillus* aids food preservation. These microorganisms' bioactive molecules highlight their significance in medicine, agriculture, and industry.

Quick Tip

Microorganisms produce bioactive molecules vital for medical, industrial, and agricultural applications.

SECTION D

Q. No. 29 and 30 are case-based questions. Each question has 3 sub-questions with internal choice in one sub-question:

29. Read the following passage and answer the questions that follow:
"Mosquitoes are drastically affecting human health in almost all developing tropical countries. Different species of mosquitoes cause fatal diseases, leading to loss of life or reduced productivity. Consequently, the health index of these countries suffers."

(a) Name the form in which *Plasmodium* gains entry into (1) human body (2) the female *Anopheles* body.

Solution:

- (1) Sporozoite – The infective stage that enters the human body.
- (2) Gametocytes – The stage that enters the mosquito during a blood meal.

Quick Tip

The sporozoite stage of *Plasmodium* infects humans, while gametocytes ensure parasite transmission to mosquitoes.

(b) Why do the symptoms of malaria not appear in a person immediately after being bitten by an infected female *Anopheles*? Give one reason. Explain when and how the symptoms of the disease would appear.

Solution:

- The sporozoites take time to multiply in liver cells and then infect red blood cells, leading to symptoms.
- Symptoms like fever, chills, and sweating appear after the parasites rupture red blood cells.

Quick Tip

The incubation period of malaria allows the parasites to develop in liver cells before causing symptoms.

OR

(b) Explain the events which occur within a female *Anopheles* mosquito after it has sucked blood from a malaria patient.

Solution:

- Gametocytes of *Plasmodium* enter the mosquito's gut with the blood meal.
- In the gut, gametocytes develop into gametes, fuse to form zygotes, and subsequently develop into sporozoites.
- The sporozoites migrate to the mosquito's salivary glands, preparing it to infect another host.

Quick Tip

Plasmodium undergoes sexual reproduction inside the mosquito, continuing its life cycle.

(c) Name a species of mosquito other than female *Anopheles* and the disease, for which it carries the pathogen.

Solution:

- Mosquito: *Aedes aegypti*.
- Disease: Dengue or Zika virus.

Quick Tip

Aedes aegypti spreads diseases like Dengue, Zika, and Chikungunya, showcasing vector-specific disease transmission.

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30. In a human female, the reproductive phase starts on the onset of puberty and ceases around middle age. Study the graph given below regarding the menstrual cycle and answer the questions that follow:

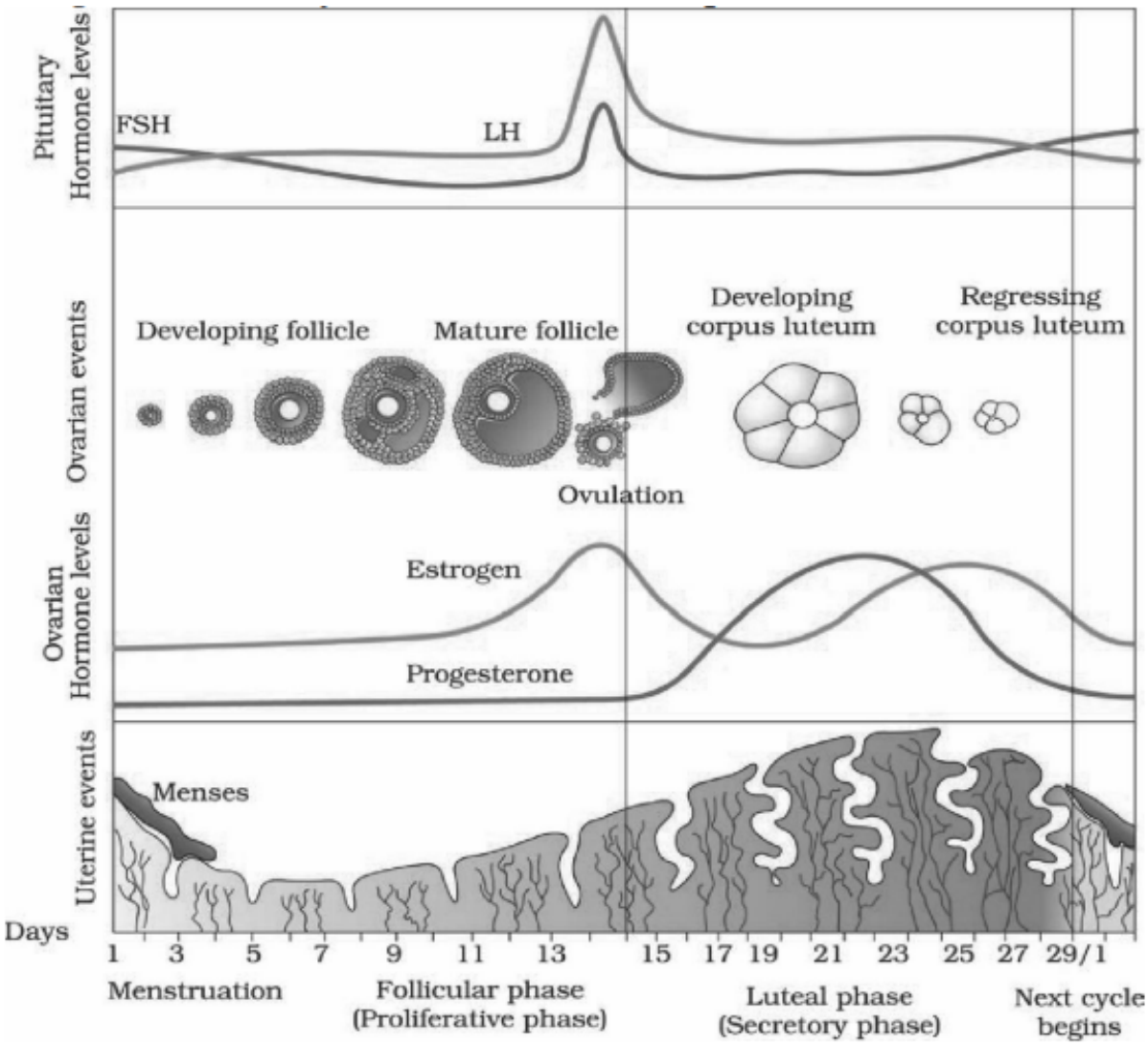

Figure 7: Hormonal regulation and events during the menstrual cycle.

(a) Name the hormones and their source organ, which are responsible for the menstrual cycle at puberty.

Solution:

- Hormones: Follicle Stimulating Hormone (FSH) and Luteinising Hormone (LH).
- Source organ: Pituitary gland.

Quick Tip

FSH and LH regulate ovarian follicle development and ovulation during the menstrual cycle.

(b) For successful pregnancy, at what phase of the menstrual cycle an early embryo (up to 3 blastomeres) should be implanted in the Uterus (IUT) of a human female who has opted for Assisted Reproductive Technology (ART)? Support your answer

with a reason.

Solution:

- Phase: Luteal phase (Day 15–28).
- Reason: The endometrium is thick and rich in blood supply during this phase, suitable for embryo implantation and nourishment.

Quick Tip

The luteal phase ensures optimal uterine conditions for embryo implantation due to high progesterone levels.

(c) Name the hormone and its source organ responsible for the events occurring during the proliferative phase of the menstrual cycle. Explain the event.

Solution:

- Hormone: Estrogen.
- Source organ: Ovaries (developing follicles).
- Event: Estrogen repairs and thickens the uterine lining, preparing it for potential implantation.

Quick Tip

Estrogen is essential for regenerating the uterine lining during the proliferative phase of the menstrual cycle.

OR

Why does menstruation only occur if the released ovum is not fertilised? Explain.

Solution:

- If the ovum is not fertilised, the corpus luteum degenerates, reducing progesterone levels.
- This hormonal drop leads to the breakdown and shedding of the uterine lining as menstrual blood.

Quick Tip

Menstruation is triggered by the absence of fertilisation, causing hormonal changes that lead to uterine lining shedding.

SECTION E

31. Natural selection operates in different ways in nature.

31.

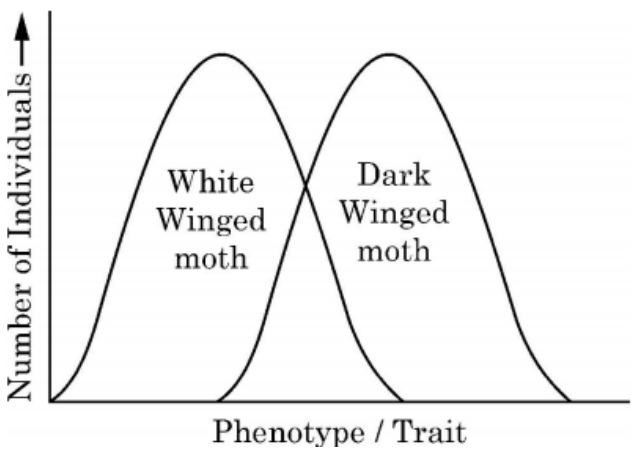

Figure 8: Phenotype distribution of White and Dark Winged Moths.

(a)

(i) Identify the type of natural selection depicted in the graph above.

Solution:

The graph depicts **Directional Selection**, which occurs when one extreme phenotype is favored over others due to environmental pressures. Key points:

- **Definition:** Directional selection shifts population traits toward one extreme, favoring individuals with advantageous traits.
- **Example:** During industrial melanism, darker moths had better camouflage in polluted environments, increasing survival and reproduction rates.
- **Impact:** Over time, populations evolve, favoring traits that enhance adaptability to specific environments.

Directional selection contrasts with:

1. **Stabilizing Selection:** Maintains traits within a specific range.
2. **Disruptive Selection:** Favors extreme phenotypes over intermediate ones.

Quick Tip

Directional selection shifts the population's traits toward one extreme due to environmental pressures.

(ii) In England after industrialisation, the population of dark-winged moths were more favoured than white-winged moths. Explain.

Solution:

Industrialization in England caused significant changes in the environment:

- **Pre-industrialization:** Tree barks were light-colored, allowing white-winged moths to blend in and avoid predators.
- **Post-industrialization:** Pollution darkened tree barks with soot, making white-winged moths more visible and vulnerable to predation.

- **Survival of Dark-Winged Moths:** Dark-winged moths became better camouflaged, leading to higher survival and reproduction rates.

This phenomenon, called **Industrial Melanism**, is a classic example of directional selection where environmental changes shift population traits.

Quick Tip

Camouflage increases an organism's chances of survival in changing environments.

(iii) Anthropogenic action can enhance the rate of evolution. Explain with the help of an example.
Solution:
Human activities create strong selective pressures that accelerate evolution. Examples include:

- **Antibiotic Resistance:** Overuse of antibiotics leads to the survival and reproduction of resistant bacterial strains, making infections harder to treat.
- **Pesticide Resistance:** Pests evolve resistance to pesticides, reducing their effectiveness over time.
- **Industrial Melanism:** Pollution caused by industrialization favored darker phenotypes in species like the peppered moth.
- **Climate Change:** Rapid environmental shifts force species to adapt quickly, leading to observable evolutionary changes.

These examples demonstrate how anthropogenic actions influence evolution, emphasizing the importance of sustainable practices to reduce their impact on biodiversity.

Quick Tip

Anthropogenic factors, such as industrial pollution and excessive use of antibiotics, accelerate evolutionary changes.

OR (b) (i) Why did Hershey and Chase use ^{35}S and ^{32}P in their experiment? Explain.
Solution:
Hershey and Chase used radioactive isotopes to distinguish between proteins and DNA:

- **^{35}S:** Labeled the sulfur in proteins, as proteins contain sulfur but no phosphorus.
- **^{32}P:** Labeled the phosphorus in DNA, as DNA contains phosphorus but no sulfur.

Their experiment showed that only **^{32}P** (DNA) entered bacterial cells during infection, while **^{35}S** (protein) remained outside. This conclusively demonstrated that DNA is the genetic material.

Quick Tip

Radioactive isotopes are key tools for distinguishing between macromolecules in molecular biology experiments.

(ii) State the importance of (1) blending and (2) centrifugation in their experiment.
Solution:
Blending and centrifugation were critical in the Hershey-Chase experiment:

- **Blending:** Dislodged phage protein coats from the bacterial surface, ensuring only internalized materials remained with the bacteria.
- **Centrifugation:** Separated bacterial cells (pellet) from phage protein coats (supernatant), allowing accurate measurement of radioactivity.

These methods confirmed that ^{32}P (DNA) entered bacterial cells, while ^{35}S (protein) remained outside, proving DNA as the hereditary material.

Quick Tip

Blending and centrifugation ensured separation of phage protein and DNA for accurate experimental results.

(iii) Write the conclusion they arrived at the end of their experiment.
Solution:
Hershey and Chase concluded that **DNA, not protein,** is the genetic material responsible for heredity.

- **Observation:** ^{32}P (DNA) entered bacterial cells during phage infection, while ^{35}S (protein) remained outside.
- **Impact:** This finding shifted the focus of molecular biology research toward DNA's structure and role in heredity, paving the way for key discoveries like the double-helix structure.

Quick Tip

Hershey and Chase demonstrated conclusively that DNA, not protein, is the hereditary material in cells.

32. (a)

(i) Describe the events of spermatogenesis with the help of a schematic diagram.
Solution:

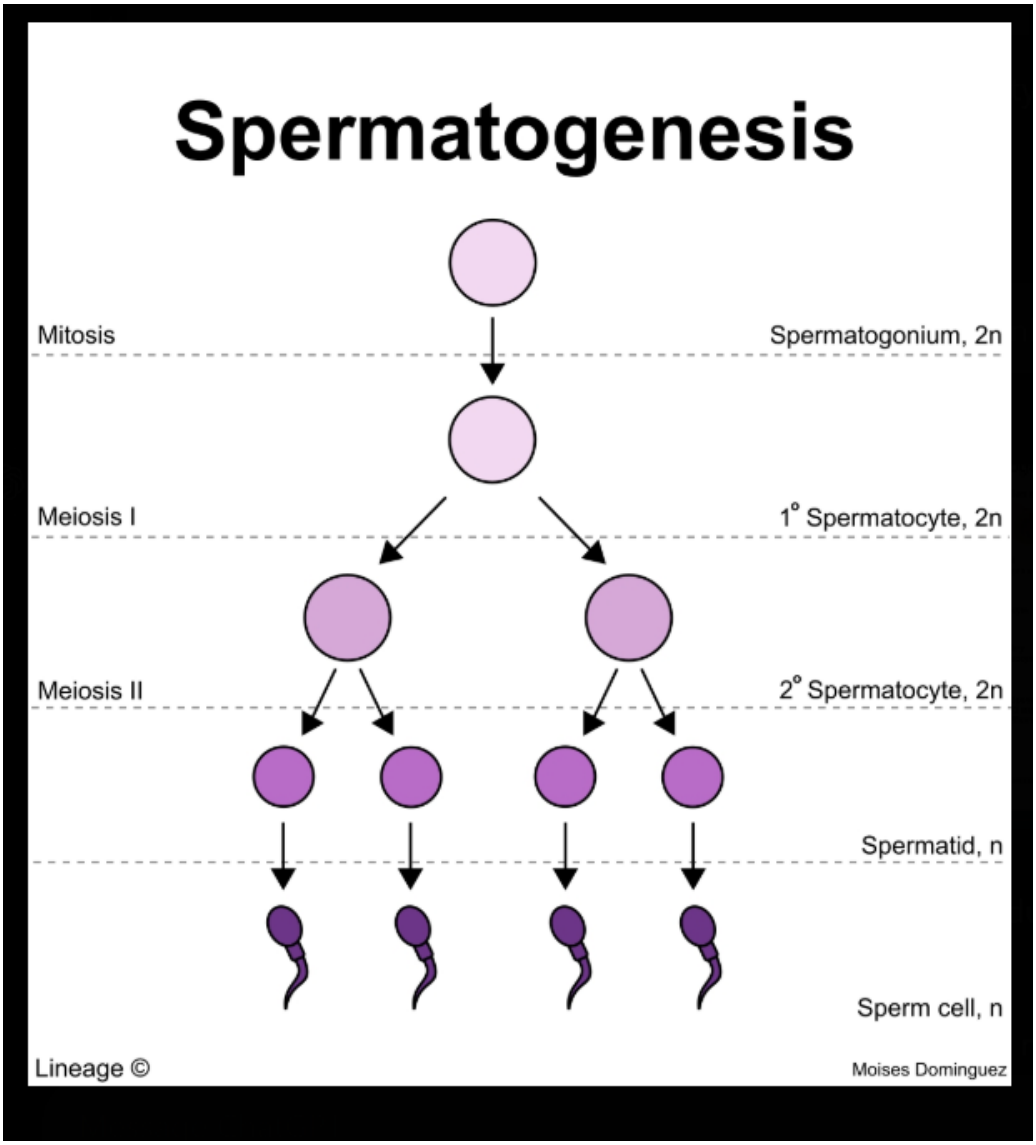

Figure 9: Schematic diagram showing the process of spermatogenesis.

Spermatogenesis occurs in the seminiferous tubules of the testes and involves the production of haploid sperm cells from diploid spermatogonia. The process includes three main phases:

- **Multiplication Phase:** Diploid spermatogonia (stem cells) undergo mitosis to increase their number. Some spermatogonia differentiate into primary spermatocytes.
- **Growth Phase:** The primary spermatocytes grow in size and prepare for meiosis.
- **Maturation Phase:** Primary spermatocytes undergo meiosis I to form two haploid secondary spermatocytes. These then undergo meiosis II, producing four haploid spermatids.

Spermatids undergo **spermiogenesis**, transforming into mature spermatozoa. Sertoli cells provide structural and nutritional support throughout this process. The entire cycle takes approximately 64–74 days in humans.

Quick Tip

Spermatogenesis ensures the production of haploid sperm cells essential for sexual reproduction.

(ii) Explain the role of hormones in spermatogenesis.
Solution:
Hormonal regulation is crucial for spermatogenesis. The process involves the following hormones:

- **GnRH (Gonadotropin-Releasing Hormone):** Secreted by the hypothalamus, it stimulates the anterior pituitary to release FSH and LH.
- **FSH (Follicle-Stimulating Hormone):** Acts on Sertoli cells to promote spermatogenesis and produce androgen-binding protein (ABP), which maintains high testosterone levels in the seminiferous tubules.
- **LH (Luteinizing Hormone):** Stimulates Leydig cells in the testes to produce testosterone.
- **Testosterone:** Essential for the maturation of sperm cells and feedback regulation of GnRH, FSH, and LH levels.
- **Inhibin:** Secreted by Sertoli cells, it specifically regulates FSH secretion to maintain hormonal balance.
- **Prolactin:** Enhances the sensitivity of Leydig cells to LH, indirectly supporting testosterone production.

Disruptions in these hormonal levels can impair sperm production and lead to infertility. Hormonal therapies can help restore balance and normal spermatogenesis.

Quick Tip

Hormonal regulation is crucial for the proper initiation and maintenance of spermatogenesis.

(b) OR

(i) Show the development of a megaspore mother cell up to the formation of a mature embryo sac in flowering plants with the help of labelled diagrams only.
Solution:

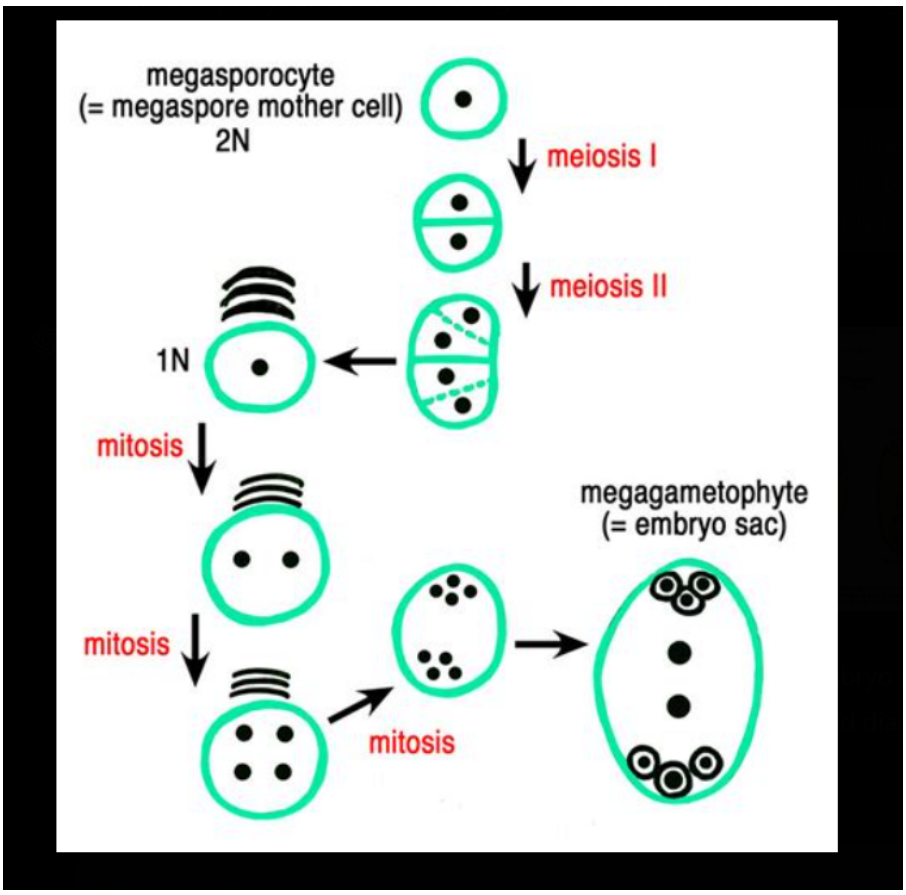

Figure 10: Development of a megaspore mother cell into a mature embryo sac.

The development involves the differentiation of a diploid megaspore mother cell (MMC) within the ovule. It undergoes meiosis to form four haploid megaspores, of which only one survives. The surviving megaspore undergoes three mitotic divisions, forming an eight-nucleate, seven-celled embryo sac.

Quick Tip

The development of the embryo sac is essential for fertilization in flowering plants.

(ii) How does geitonogamy differ from xenogamy?
Solution:
Geitonogamy: - Transfer of pollen between flowers of the same plant. - Functionally resembles cross-pollination but involves the same genotype.
Xenogamy: - Transfer of pollen from one plant to another plant of the same species. - Promotes genetic diversity through true cross-pollination.

Quick Tip

Geitonogamy involves the same plant, while xenogamy promotes cross-pollination for genetic diversity.

(iii) Name the type of flowers that are invariably autogamous.
Solution:
Cleistogamous flowers are invariably autogamous. These flowers do not open, ensuring self-pollination and guaranteeing reproductive success, even in unfavorable environmental conditions.

> Quick Tip
>
> Cleistogamous flowers ensure self-pollination, even in the absence of pollinators.

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33. (a)

(i) Draw a schematic diagram of the cloning vector pBR322 and label:

- (1) BamHI site
- (2) Gene for ampicillin resistance
- (3) Ori
- (4) Rop gene

Solution:

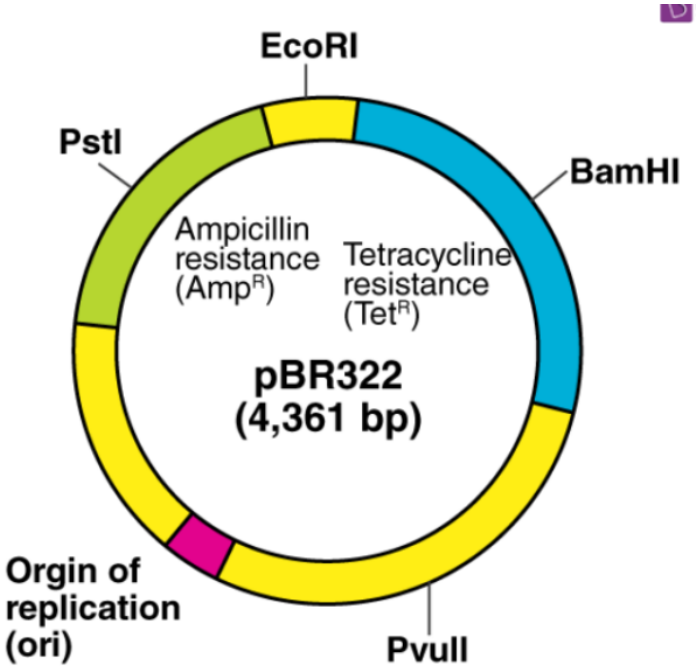

Figure 11: Schematic diagram of the cloning vector pBR322 with labeled components: BamHI site, Ampicillin resistance gene, Ori, and Rop gene.

The pBR322 vector is a widely used plasmid in genetic engineering. Key features include: - **BamHI site:** A restriction site for inserting foreign DNA. - **Ampicillin resistance gene:** Enables selection of transformed cells that can grow in the presence of ampicillin. - **Ori (Origin**

of replication): Ensures plasmid replication within the host cells. - **Rop gene:** Regulates plasmid copy number for stable cloning.
These components make pBR322 an efficient and versatile vector for molecular cloning, simplifying the process of inserting and propagating foreign DNA in host cells.

Quick Tip

pBR322 is one of the first widely used cloning vectors in genetic engineering.

(ii) State the role of 'rop' gene.
Solution:
The **rop gene** in pBR322 regulates plasmid replication, maintaining a low copy number for stable maintenance. Key functions include:
- **Preventing host cell burden:** High plasmid copy numbers can stress the host cell, reducing its growth and efficiency.
- **Modulating replication:** Rop regulates RNA molecules involved in plasmid replication, ensuring balance.
This gene is critical for maintaining the integrity of inserted foreign DNA during cloning experiments.

Quick Tip

The rop gene ensures controlled plasmid replication, essential for stable cloning.

(iii) A cloning vector does not have a selectable marker. How will it affect the process of cloning?
Solution:
Selectable markers are essential for identifying recombinant cells. Without them:
1. **Increased complexity:** Alternative methods like PCR or sequencing would be needed, increasing cost and time.
2. **Higher error rate:** Non-recombinant cells may outgrow recombinant ones, complicating the process.
3. **Importance of markers:** Antibiotic resistance genes, for example, enable easy identification by allowing only transformed cells to grow.
Their absence significantly complicates the cloning workflow and reduces efficiency.

Quick Tip

Selectable markers simplify the identification of recombinant DNA in host cells.

(iv) Why is insertional inactivation preferred over the use of selectable markers in cloning vectors?
Solution:
Insertional inactivation involves disrupting a functional gene by inserting foreign DNA, providing a clear visual distinction between recombinant and non-recombinant colonies. Advantages include:

1. **Biosafety:** Avoids the use of antibiotic resistance genes, reducing environmental risks.
2. **Simpler identification:** Recombinant colonies can be visually identified (e.g., by loss of color).
3. **Cost-effectiveness:** Reduces reliance on antibiotics and additional screening steps.
This method is efficient and environmentally friendly, making it a preferred choice in modern cloning practices.

> Quick Tip
>
> Insertional inactivation is a biosafe and effective method for identifying recombinant DNA.

(b) OR

(i) Name the nematode (scientific name) that infects the roots of tobacco plant and reduces its yield.
Solution:
The nematode is **Meloidogyne incognita**, commonly known as the root-knot nematode.
Key Details:

- It infects the roots of tobacco plants, causing the formation of characteristic root knots or galls.
- These galls disrupt the root structure, leading to reduced water and nutrient absorption.
- Infected plants exhibit stunted growth, wilting, and significantly reduced yields.

Management Practices:

- Crop rotation with non-host plants to break the nematode life cycle.
- Application of nematicides to control nematode populations.
- Development and use of nematode-resistant plant varieties.

> Quick Tip
>
> Meloidogyne incognita causes root knot disease, significantly reducing crop yield.

(ii) Name the vector that is used to introduce nematode-specific genes into the host plant (tobacco).
Solution:
The vector used is **Agrobacterium tumefaciens**.
Key Features:

- **Ti Plasmid:** The bacterium contains a tumor-inducing (Ti) plasmid, modified to include nematode-specific genes for safe transfer.
- **RNAi Technology:** The introduced genes produce double-stranded RNA, which triggers RNA interference (RNAi) to silence critical nematode genes.

- **Eco-friendly Protection:** Transgenic tobacco plants resist nematode infestation without the need for chemical pesticides.

Applications:

- Agrobacterium-mediated gene transfer is widely used to create transgenic plants with improved traits, such as pest and disease resistance.

> Quick Tip
>
> Agrobacterium tumefaciens is a natural genetic engineer widely used in transgenic research.

(iii) How do sense and anti-sense RNAs function?
Solution:
Key Definitions:

- **Sense RNA:** This strand corresponds to the coding sequence of a gene. It acts as a template for protein synthesis during translation.
- **Anti-sense RNA:** This strand is complementary to the sense RNA. It binds to sense RNA, forming a double-stranded RNA complex, which blocks translation by ribosomes.

RNA Interference (RNAi):

- RNAi is a gene silencing mechanism where double-stranded RNA prevents the expression of a specific gene.
- RNAi technology is widely used in plants to control pests, pathogens, and undesirable traits.

Example: In transgenic tobacco, anti-sense RNA silences essential genes in nematodes, preventing their survival and reproduction.

> Quick Tip
>
> Sense and anti-sense RNAs regulate gene expression through RNA interference mechanisms.

(iv) Why could parasite not survive in a transgenic tobacco plant?
Solution:
Transgenic tobacco plants produce **double-stranded RNA (dsRNA)** that targets essential genes in nematodes.
Key Mechanisms:

- **RNA Interference (RNAi):** The dsRNA produced by the plant is absorbed by the nematode, where it triggers RNAi, silencing critical genes required for survival and reproduction.
- **Gene Silencing:** Without the expression of vital genes, the nematode cannot perform necessary cellular processes, leading to its death.

- **Eco-friendly Approach:** Unlike chemical pesticides, this method is specific to nematodes, leaving beneficial soil organisms unharmed.

Advantages:

- Protects crops effectively.
- Reduces reliance on chemical pesticides.
- Promotes sustainable agriculture.

Quick Tip

RNA interference effectively controls parasitic infections in transgenic crops.
