CBSE Class 12 2025 Biology Question Paper (57/2/1) With Solutions

Time Allowed :3 Hour	**Maximum Marks :**70	**Total questions :**33

General Instructions

Read the following instructions very carefully and strictly follow them:

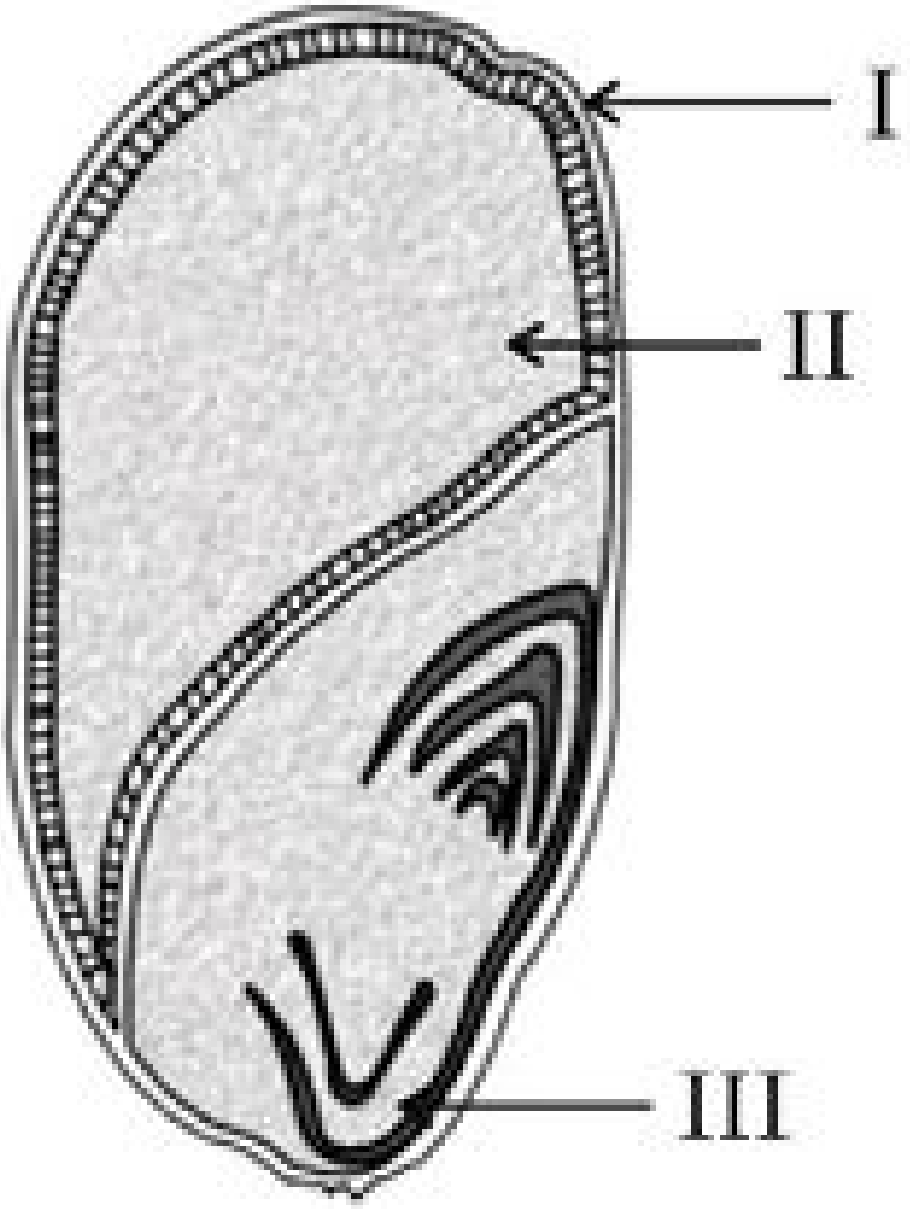
1. This question paper contains 33 questions. All questions are compulsory.
2. This question paper is divided into five sections Sections A, B, C, D and E.
3. In Section A Questions no. 1 to 16 are Multiple Choice type questions. Each question carries 1 mark.
4. In Section B Questions no. 17 to 21 are Very Short Answer type questions.Each question carries 2 marks.
5. In Section C Questions no. 22 to 28 are Short Answer type questions. Each question carries 3 marks.
6. In Section D Questions no. 29 and 30 are case study based questions. Each question carries 4 marks.
7. In Section E Questions no. 31 to 33 are Long Answer type questions. Each question carries 5 marks.
8. There is no overall choice given in the question paper. However, an internal choice has been provided in few questions in all the Sections except Section A.
9. Kindly note that there is a separate question paper for Visually Impaired candidates.
10. Use of calculators is not allowed.

SECTION A

Questions no. 1 to 16 are Multiple Choice Type Questions, carrying 1 mark each.

Choose the best option.

1. Given below is a diagram of T.S. of a monocot seed with parts I, II & III labelled :



Choose the option where parts I, II and III are identified correctly.

(A) I: Pericarp, II: Endosperm, III: Scutellum

(B) I: Pericarp, II: Endosperm, III: Coleorhiza

(C) I: Scutellum, II: Pericarp, III: Coleorhiza

(D) I: Coleorhiza, II: Scutellum, III: Pericarp

Correct Answer: (A) I: Pericarp, II: Endosperm, III: Scutellum

Solution:

Step 1: In the transverse section (T.S.) of a monocot seed, the outermost layer is the pericarp, which is labelled as I.

Step 2: The large starchy storage tissue inside is the endosperm, which is labelled as II.

Step 3: The structure at the bottom, protecting the embryonic shoot, is the scutellum, labelled as III.

Thus, the correct identification is I: Pericarp, II: Endosperm, III: Scutellum.

Quick Tip

In a monocot seed, the scutellum is a single cotyledon that absorbs nutrients from the endosperm during germination.

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2. The number of autosomes present in a human secondary spermatocyte

(A) 44

(B) 22

(C) 23

(D) 46

Correct Answer: (B) 22

Solution:

Step 1: A human secondary spermatocyte is a haploid cell formed after the first meiotic division during spermatogenesis.

Step 2: Humans have 46 chromosomes in total (diploid), with 44 autosomes and 2 sex chromosomes. In a haploid cell, the chromosome number is halved, so it has 23 chromosomes (22 autosomes + 1 sex chromosome).

Step 3: Since the question asks for autosomes, we exclude the sex chromosome: 23 - 1 = 22 autosomes.

Thus, the number of autosomes in a human secondary spermatocyte is 22.

Quick Tip

A secondary spermatocyte is haploid, so it contains half the diploid number of chromosomes, with autosomes being all chromosomes except the sex chromosomes.

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3. A child with blood group A has the father with blood group B and the mother with blood group AB. Choose the option that gives the correct genotypes of father, mother and the child :

(A) Father: I^Ai, Mother: I^Bi, Child: I^Ai

(B) Father: I^AI^B, Mother: I^Ai, Child: I^AI^A

(C) Father: I^Bi, Mother: I^AI^B, Child: I^Ai

(D) Father: I^BI^B, Mother: I^AI^B, Child: I^AI^A

Correct Answer: (C) Father: I^Bi, Mother: I^AI^B, Child: I^Ai

Solution:

Step 1: Blood group A in the child means the genotype is I^AI^A or I^Ai.

Step 2: The father has blood group B (genotype I^BI^B or I^Bi) and the mother has blood group AB (genotype I^AI^B).

Step 3: For the child to have blood group A, they must inherit I^A from the mother (since the father cannot provide I^A) and either i or I^B from the father. Since the child's phenotype is A, the father must contribute i, making his genotype I^Bi, and the child's genotype I^Ai.

Thus, the correct genotypes are Father: I^Bi, Mother: I^AI^B, Child: I^Ai.

Quick Tip

In ABO blood group inheritance, a child with blood group A must inherit at least one I^A allele, which can come from a parent with blood group A or AB.

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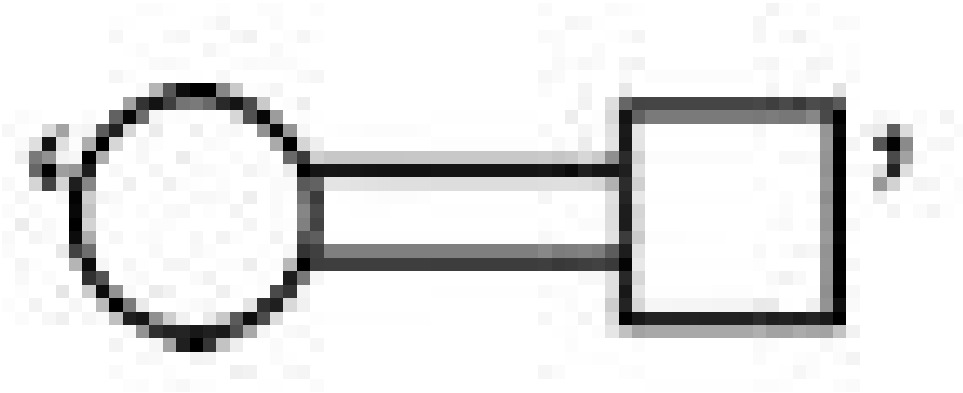
4. In a pedigree chart



represents :

(A) unrelated mating

(B) affected individuals

(C) mating between relatives (consanguineous mating)

(D) Non-identical twins

Correct Answer: (C) mating between relatives (consanguineous mating)

Solution:

Step 1: In a pedigree chart, a circle typically represents a female and a square represents a male.

Step 2: A horizontal line connecting them with a specific symbol, such as ⊜, indicates a consanguineous mating, meaning mating between relatives.

Step 3: This symbol does not represent unrelated mating, affected individuals, or twins.

Thus, the correct interpretation is mating between relatives (consanguineous mating).

Quick Tip

In pedigree charts, consanguineous mating is often indicated by a double line or specific notation between the symbols for male and female.

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5. Which one of the following options shows the correct evolutionary order of the plants mentioned below?

(i) Ferns (ii) Ginkgo (iii) Zosterophyllum (iv) Gnetales

Choose the correct option.

(A) (i), (iii), (ii), (iv)

(B) (iii), (i), (ii), (iv)

(C) (i), (ii), (iii), (iv)

(D) (iv), (ii), (i), (iii)

Correct Answer: (B) (iii), (i), (ii), (iv)

Solution:

Step 1: Zosterophyllum (iii) is one of the earliest land plants, appearing around 420 million years ago during the Silurian period.

Step 2: Ferns (i) evolved later, around 360 million years ago during the Devonian period.

Step 3: Ginkgo (ii) appeared around 270 million years ago in the Permian period, and Gnetales (iv) are more recent, evolving around 150 million years ago in the Mesozoic era.

Thus, the correct evolutionary order is (iii) Zosterophyllum, (i) Ferns, (ii) Ginkgo, (iv) Gnetales.

Quick Tip

When determining the evolutionary order of plants, consider their first appearance in the fossil record, from oldest to most recent.

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6. The phosphoester linkage in the nucleotides is between

(A) phosphate group and OH of 3'C of a nucleotide

(B) phosphate group and OH of 5'C of a nucleotide

(C) phosphate group and H of 3'C of a nucleotide

(D) phosphate group and H of 5'C of a nucleotide

Correct Answer: (B) phosphate group and OH of 5'C of a nucleotide

Solution:

Step 1: In a nucleotide, the phosphoester linkage forms the backbone of DNA or RNA by connecting nucleotides.

Step 2: This linkage occurs between the phosphate group of one nucleotide and the hydroxyl (OH) group on the 5' carbon of the sugar in the next nucleotide.

Step 3: The bond is not formed with the 3' carbon's OH in the backbone linkage, nor with a hydrogen atom.

Thus, the phosphoester linkage is between the phosphate group and the OH of 5'C of a nucleotide.

Quick Tip

The 5' to 3' directionality in DNA/RNA strands is due to the phosphoester linkage between the 5' phosphate and 3' OH of adjacent nucleotides.

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7. Given below is a heterogeneous RNA formed during Eukaryotic transcription:

How many introns and exons respectively are present in the hnRNA?

(A) 7, 7

(B) 8, 7

(C) 8, 8

(D) 7, 8

Correct Answer: (D) 7, 8

Solution:

Step 1: Heterogeneous nuclear RNA (hnRNA) in eukaryotes contains both exons (coding regions) and introns (non-coding regions) before processing into mature mRNA.

Step 2: The diagram $5' \sim\sim\sim\sim\sim 3'$ typically represents a sequence with alternating exons and introns. If the diagram implies 15 total segments (as a simplified representation), we interpret it as 8 exons (including the ends) and 7 introns (the segments between exons).

Step 3: This matches the pattern of eukaryotic transcription where introns are removed, leaving exons in the mature mRNA.

Thus, the hnRNA has 7 introns and 8 exons.

Quick Tip

In eukaryotic hnRNA, introns are the non-coding regions between exons, and their number is typically one less than the number of exons in a linear sequence.

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8. Study the items of Column-I and those of Column-II:

Column-I	**Column-II**
(a) RNA polymerase I	**(i) 18s rRNA**
(b) RNA polymerase II	**(ii) SnRNAs**
(c) RNA polymerase III	**(iii) hnRNA**

Choose the option that correctly matches the items of Column-I with those of Column-II:

(A) (a)-(i), (b)-(ii), (c)-(iii)

(B) (a)-(iii), (b)-(ii), (c)-(i)

(C) (a)-(ii), (b)-(iii), (c)-(i)

(D) (a)-(i), (b)-(iii), (c)-(ii)

Correct Answer: (D) (a)-(i), (b)-(iii), (c)-(ii)

Solution:

Step 1: RNA polymerase I synthesizes ribosomal RNA, including 18s rRNA, so (a) matches with (i).

Step 2: RNA polymerase II synthesizes heterogeneous nuclear RNA (hnRNA), which is a precursor to mRNA, so (b) matches with (iii).

Step 3: RNA polymerase III synthesizes small nuclear RNAs (SnRNAs), so (c) matches with (ii).

Thus, the correct matching is (a)-(i), (b)-(iii), (c)-(ii).

Quick Tip

RNA polymerase I is responsible for rRNA, RNA polymerase II for mRNA precursors (hnRNA), and RNA polymerase III for small RNAs like SnRNAs.

9. For commercial and industrial production of citric acid, which one of the following microbes is used?

(A) Aspergillus niger

(B) Lactobacillus sp.

(C) Clostridium butyricum

(D) Saccharomyces cerevisiae

Correct Answer: (A) Aspergillus niger

Solution:

Step 1: Citric acid is widely produced industrially through microbial fermentation.

Step 2: Aspergillus niger, a filamentous fungus, is the most commonly used microbe for this purpose due to its ability to produce large amounts of citric acid under specific conditions.

Step 3: Other microbes like Lactobacillus, Clostridium, and Saccharomyces are used for different fermentation products, not citric acid.

Thus, Aspergillus niger is used for citric acid production.

Quick Tip

Aspergillus niger is preferred for citric acid production because it can efficiently convert sugars into citric acid under low pH conditions.

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10. If Meselson and Stahl's experiment is continued for 80 minutes (till III generation), what would be the ratio of DNA containing N^{15}/N^{15} : N^{15}/N^{14} : N^{14}/N^{14} in the medium?

(A) 1 : 1 : 0

(B) 1 : 1 : 3

(C) 0 : 1 : 8

(D) 1 : 4 : 0

Correct Answer: (C) 0 : 1 : 8

Solution:

Step 1: Meselson and Stahl's experiment demonstrates semi-conservative DNA replication. Initially, all DNA is N^{15}/N^{15} (heavy). After one generation in N^{14} medium, all DNA is hybrid (N^{15}/N^{14}).

Step 2: After the second generation (40 minutes, assuming 20 minutes per generation), half the DNA is N^{15}/N^{14} and half is N^{14}/N^{14} (1:1).

Step 3: After the third generation (80 minutes), the N^{15}/N^{14} DNA replicates to produce 2 N^{15}/N^{14} and 2 N^{14}/N^{14}, while the N^{14}/N^{14} DNA replicates to produce 4 N^{14}/N^{14}. Thus, the ratio is 0 N^{15}/N^{15} : 2 N^{15}/N^{14} : 6 N^{14}/N^{14}, which simplifies to 0:1:8 when considering relative proportions.

Thus, the ratio is $0 : 1 : 8$.

Quick Tip

In Meselson and Stahl's experiment, after each generation in N^{14} medium, the proportion of N^{14}/N^{14} DNA doubles, while N^{15}/N^{15} disappears after the first generation.

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11. Select the correct statement from the following biotechnological procedures:

(A) The polymerase enzyme joins the gene of interest and the vector DNA.

(B) Gel electrophoresis is used for amplification of a DNA segment.

(C) PCR is used for isolation and separation of the gene of interest.

(D) Plasmid DNA acts as vector to transfer the piece of DNA attached to it.

Correct Answer: (D) Plasmid DNA acts as vector to transfer the piece of DNA attached to it.

Solution:

Step 1: In biotechnology, a vector is a vehicle used to transfer a gene of interest into a host cell.

Step 2: Plasmid DNA is commonly used as a vector in genetic engineering to carry and transfer the desired DNA fragment into a host organism.

Step 3: The other options are incorrect: polymerase does not join DNA (ligase does), gel electrophoresis separates DNA, and PCR amplifies DNA, not isolates it.

Thus, the correct statement is that plasmid DNA acts as a vector to transfer the piece of DNA attached to it.

Quick Tip

Plasmids are widely used as vectors in genetic engineering because they can replicate independently in a host cell and carry foreign DNA.

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12. The decrease in the T-Lymphocytes count in human blood will finally result in

(A) decrease in antigens

(B) decrease in antibodies

(C) increase in antibodies

(D) increase in antigens

Correct Answer: (B) decrease in antibodies

Solution:

Step 1: T-Lymphocytes (T-cells) are a type of white blood cell critical for the immune response, particularly in helping B-cells produce antibodies.

Step 2: A decrease in T-Lymphocytes, such as in conditions like HIV/AIDS, impairs the immune system's ability to activate B-cells, leading to reduced antibody production.

Step 3: This does not directly affect antigen levels but reduces the body's ability to respond to antigens via antibodies.

Thus, a decrease in T-Lymphocytes results in a decrease in antibodies.

Quick Tip

T-Lymphocytes are essential for adaptive immunity, and their reduction, as seen in HIV, leads to a weakened immune response and lower antibody production.

Question numbers 13 to 16 consist of two statements — Assertion (A) and Reason (R). Answer these questions selecting the appropriate option given below:

(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): Corpus luteum secretes the hormone, progesterone.

Reason (R): Hormone Progesterone is essential for maintenance of the endometrium.

(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.

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

Solution:

Step 1: The corpus luteum, formed after ovulation, secretes progesterone, making Assertion (A) true.

Step 2: Progesterone prepares and maintains the endometrium for pregnancy, making Reason (R) true.

Step 3: Since progesterone from the corpus luteum directly supports the endometrium, (R) correctly explains (A).

Thus, both (A) and (R) are true, and (R) is the correct explanation of (A).

Quick Tip

Progesterone from the corpus luteum is crucial for maintaining pregnancy by supporting the endometrium until the placenta takes over.

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14. Assertion (A): The number of white winged moths decreased after industrialisation in England.

Reason (R): Effects of industrialisation were more marked in rural areas of England.

(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.

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

Solution:

Step 1: The number of white-winged moths decreased after industrialization in England due to industrial melanism, where darker moths were better camouflaged against soot-covered trees, making Assertion (A) true.

Step 2: The effects of industrialization, like soot deposition, were more pronounced in industrial urban areas, not rural areas, making Reason (R) false.

Step 3: Since (R) is incorrect, it cannot explain (A).

Thus, (A) is true, but (R) is false.

Quick Tip

Industrial melanism in moths is a classic example of natural selection, where pollution from industrialization favored darker moths in urban areas.

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15. Assertion (A): Streptococcus pneumoniae and Haemophilus influenzae are responsible for causing infectious disease in human beings.

Reason (R): A healthy person acquires the infection by inhaling the aerosols released by an infected person.

(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.

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

Solution:

Step 1: Streptococcus pneumoniae and Haemophilus influenzae are bacteria that cause diseases like pneumonia and meningitis in humans, making Assertion (A) true.

Step 2: These infections can indeed be acquired by inhaling aerosols from an infected person, making Reason (R) true.

Step 3: However, (R) only describes the mode of transmission, not why these bacteria cause disease (e.g., their pathogenicity), so it does not explain (A).
Thus, both (A) and (R) are true, but (R) is not the correct explanation of (A).

Quick Tip

Streptococcus pneumoniae and Haemophilus influenzae are transmitted via respiratory droplets, but their disease-causing ability depends on their virulence factors.

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16. Assertion (A): Restriction endonuclease recognises palindromic sequence in the DNA and cuts them.
Reason (R): Palindromic sequence has two unique recognition sites PstI and PvuI recognised by the restriction endonuclease.
(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.

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

Solution:
Step 1: Restriction endonucleases recognize specific palindromic sequences in DNA and cut them, making Assertion (A) true.
Step 2: A palindromic sequence is a DNA sequence that reads the same forward and backward on complementary strands, but it does not inherently have ”two unique recognition sites” like PstI and PvuI, which are specific restriction enzymes with their own recognition sequences, making Reason (R) false.
Step 3: Since (R) is incorrect, it cannot explain (A).
Thus, (A) is true, but (R) is false.

Quick Tip

Restriction endonucleases like PstI and PvuI each recognize specific palindromic sequences, but a single palindromic sequence is typically recognized by one enzyme, not two.

SECTION B

17. Student to attempt either option (A) or (B):

(A)

(i) Write two crucial changes, the seed undergoes while reaching maturity that enable them to be in a viable state until the onset of favourable conditions.

(ii) Name the oldest viable seed excavated from Arctic Tundra as per the records.

OR

(B)

(i) Pea flower produced seed sets. Give reason.

(ii) In case of Polyembryony, an embryo 'P' develops from a synergid and the embryo 'Q' develops from the nucellus. State the ploidy of embryo 'P' and 'Q'.

Solution:

Option (A):

Step 1: For (i), one crucial change is dehydration, where the seed loses water to enter a dormant state, preventing premature germination. Another change is the development of protective layers like the seed coat, which shields the embryo from environmental stress.

Step 2: For (ii), the oldest viable seed excavated from the Arctic Tundra is the Silene stenophylla, dated to about 32,000 years ago, which was successfully germinated.

OR

Option (B):

Step 1: For (i), pea flowers produce seed sets because they undergo self-pollination, as their flowers are cleistogamous (closed), ensuring pollen from the anther fertilizes the ovule within the same flower.

Step 2: For (ii), embryo 'P' (from synergid) is haploid (n) since synergids are part of the female gametophyte, while embryo 'Q' (from nucellus) is diploid (2n) as the nucellus is sporophytic tissue.

Quick Tip

In polyembryony, embryos can arise from different tissues with varying ploidy levels, such as haploid gametophytic cells (synergids) or diploid sporophytic cells (nucellus).

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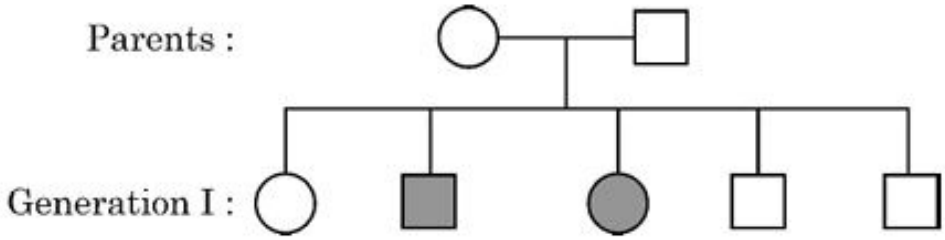
18. Study the given pedigree chart in which neither of the parents shows the trait but the trait is present in both male and female children.



Answer the following questions:

(a) Write the trait, also explain the inheritance of such trait in the progeny on the basis of given pedigree chart.

(b) Give one example of such trait in human beings.

Solution:

Step 1: For (a), the trait is recessive since neither parent shows the trait (they are carriers), but it appears in both male and female children. Both parents must be heterozygous (Aa), and the children with the trait are homozygous recessive (aa). The inheritance follows an autosomal recessive pattern, where the probability of the offspring inheriting the trait (aa) is 25% when both parents are carriers.

Step 2: For (b), an example of such a trait in humans is sickle cell anemia, which is an autosomal recessive disorder. Individuals must inherit two recessive alleles (ss) to express the trait, while carriers (Ss) do not show symptoms.

Thus, the trait is autosomal recessive, and sickle cell anemia is an example.

Quick Tip

In autosomal recessive inheritance, both parents must be carriers (heterozygous) for the trait to appear in the offspring, with a 25% chance for each child to be affected.

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19. Student to attempt either option (A) or (B).

(A) Describe any two situations where a medical doctor would recommend injection of pre-formed antibodies (antitoxins) into the body of a patient.

OR

(B) The symptoms of malaria do not appear immediately after the entry of sporozoites into the human body when bitten by female Anopheles mosquito. Explain why it happens.

Solution:

Option (A):

Step 1: One situation is when a patient is exposed to tetanus (e.g., through a deep puncture wound). A doctor injects tetanus antitoxins to neutralize the toxin produced by Clostridium tetani, providing immediate protection.

Step 2: Another situation is in the case of snakebite (e.g., a venomous snake like a cobra). Antivenom (pre-formed antibodies) is injected to neutralize the snake venom, preventing systemic damage.

OR

Option (B):

Step 1: Malaria symptoms do not appear immediately because the Plasmodium sporozoites injected by the Anopheles mosquito first travel to the liver, where they multiply into merozoites during the pre-erythrocytic stage (about 5–16 days).

Step 2: Only after this incubation period do merozoites enter the bloodstream, infect red blood cells, and cause symptoms like fever and chills as they multiply and rupture the cells. Thus, (A) includes tetanus and snakebite scenarios, while (B) explains the delayed onset of malaria due to the parasite's life cycle.

Quick Tip

Pre-formed antibodies (antitoxins) provide passive immunity for immediate protection, while malaria's delayed symptoms are due to the parasite's initial liver stage.

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20. Observe the given sequence of nitrogenous bases on a DNA fragment and answer the following questions:

5'	C	A	G	A	A	T	T	C	T	T	A	3'
3'	G	T	C	T	T	A	A	G	A	A	T	5'

(a) Name the restriction enzyme which can recognise the DNA sequence.

(b) Write the sequence after restriction enzyme cut the palindrome.

(c) Why are the ends generated after digestion called as 'Sticky Ends'?

Solution:

Step 1: For (a), the sequence 5'-GAATTC-3' (and its complement 3'-CTTAAG-5') is a palindrome recognized by the restriction enzyme EcoRI, which cuts between G and A.

Step 2: For (b), EcoRI cuts 5'-CAGAATTC TTA-3' into 5'-CAG-3' and 5'-AATTCTTA-3', and the complementary strand 3'-GTCTTAA GAA T-5' into 3'-GTC-5' and 3'-TTAAGAA T-5'. The resulting fragments are 5'-CAG-3' with 3'-GTC-5', and 5'-AATTCTTA-3' with 3'-TTAAGAA T-5'.

Step 3: For (c), the ends are called "Sticky Ends" because the cut by EcoRI leaves single-stranded overhangs (5'-AATT-3' on one fragment and 3'-TTAA-5' on the other), which can base-pair with complementary overhangs on other DNA fragments, facilitating ligation.

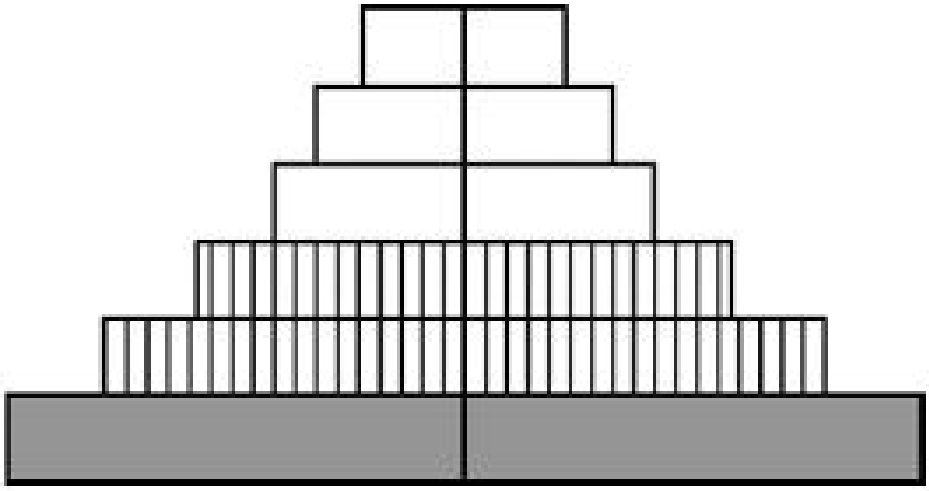
Thus, the enzyme is EcoRI, the fragments are as described, and the ends are sticky due to their overhanging sequences.

Quick Tip

Sticky ends are useful in genetic engineering because they allow precise joining of DNA fragments with complementary overhangs, such as those created by EcoRI.

21. Student to attempt either option (A) or (B).

(A) Identify the type of pyramid given below and write two identifying features of such a pyramid:



OR

(B)

(i) Construct an ideal pyramid of energy when 10,00,000 Joules of sunlight is available.

(ii) Mention the energy obtained by the fourth level of this pyramid.

Solution:

Option (A):

Step 1: The pyramid shown is an upright pyramid of energy, as it narrows progressively from the base (producers) to the top (higher trophic levels).

Step 2: Two identifying features are: (i) It always has a broad base representing the energy at the producer level, and (ii) Energy decreases at each successive trophic level due to the 10% energy transfer rule, reflecting energy loss as heat.

OR

Option (B):

Step 1: For (i), an ideal pyramid of energy with 10,00,000 J of sunlight (producers) follows the 10% rule. Primary consumers get 10% of 10,00,000 J = 1,00,000 J; secondary consumers get 10% of 1,00,000 J = 10,000 J; tertiary consumers (fourth level) get 10% of 10,000 J =

1,000 J. Thus, the pyramid is: Producers: 10,00,000 J, Primary Consumers: 1,00,000 J, Secondary Consumers: 10,000 J, Tertiary Consumers: 1,000 J.

Step 2: For (ii), the energy at the fourth level (tertiary consumers) is 1,000 J.

Thus, (A) identifies an upright pyramid of energy with its features, and (B) constructs the pyramid and specifies the fourth level's energy as 1,000 J.

Quick Tip

The pyramid of energy is always upright because energy transfer between trophic levels follows the 10% rule, with significant energy loss as heat at each step.

SECTION C

22. (a) A bilobed dithecous anther has 200 microspore mother cells per microsporangium. How many male gametophytes can be produced by this anther?
(b) Write the composition of intine and exine layers of a pollen grain.

Solution:

Step 1: For (a), a bilobed dithecous anther has 4 microsporangia (2 per lobe). Each microsporangium has 200 microspore mother cells (MMCs). Each MMC undergoes meiosis to produce 4 microspores, and each microspore develops into 1 male gametophyte (pollen grain). So, 200 MMCs produce $200 \times 4 = 800$ microspores per microsporangium. For 4 microsporangia, total microspores = $800 \times 4 = 3200$, which equals 3200 male gametophytes.

Step 2: For (b), the exine of a pollen grain is composed of sporopollenin, a tough, resistant polymer that protects the pollen. The intine is composed of cellulose and pectin, providing flexibility and support for pollen tube growth.

Thus, the anther produces 3200 male gametophytes, with the exine made of sporopollenin and intine made of cellulose and pectin.

Quick Tip

Each microspore mother cell in an anther produces 4 microspores via meiosis, and each microspore develops into a single male gametophyte (pollen grain).

23. (a) List two reasons that make copper releasing IUDs as effective contraceptives. (b) Explain how the intake of oral contraceptive pills prevent pregnancy in humans.

Solution:

Step 1: For (a), two reasons copper-releasing IUDs are effective contraceptives are: (i) Copper ions released by the IUD are toxic to sperm, reducing their motility and viability, thus preventing fertilization. (ii) The IUD causes a local inflammatory response in the uterus, creating an environment hostile to implantation of a fertilized egg.

Step 2: For (b), oral contraceptive pills contain synthetic hormones (estrogen and progesterone) that mimic pregnancy conditions. They inhibit the release of GnRH from the hypothalamus, preventing the secretion of FSH and LH from the pituitary, which stops ovulation. Additionally, they thicken cervical mucus, making it harder for sperm to reach the egg, and alter the uterine lining to prevent implantation.

Thus, copper IUDs prevent fertilization and implantation, while oral pills prevent ovulation and create barriers to fertilization.

Quick Tip

Copper IUDs work locally by affecting sperm and the uterine environment, while oral contraceptives act hormonally to suppress ovulation and alter reproductive conditions.

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24. Using a Punnett square workout the distribution of an autosomal phenotypic feature in the first filial generation after a cross between a homozygous female and a heterozygous male for a single locus.

Solution:

Step 1: For an autosomal trait at a single locus, let's assume the trait is controlled by alleles A (dominant) and a (recessive). A homozygous female could be AA or aa; a heterozygous male is Aa. Since the question doesn't specify dominance, let's assume the female is homozygous dominant (AA) for clarity.

Step 2: The cross is AA (female) × Aa (male). Using a Punnett square: Female gametes are

all A; male gametes are A or a. Offspring genotypes are AA (A from female, A from male) or AA (A from female, a from male). Phenotypically, all offspring are AA (100% dominant phenotype).

Step 3: If the female were homozygous recessive (aa), the cross would be aa × Aa. Offspring genotypes would be Aa (a from female, A from male) or aa (a from female, a from male), giving a 1:1 phenotypic ratio (50% dominant, 50% recessive). Since the question asks for a typical autosomal cross, the first scenario (all dominant) is more standard unless specified otherwise.

Thus, all offspring in the first filial generation show the dominant phenotype (100% AA).

Quick Tip

In a Punnett square for a single locus, a homozygous parent (AA or aa) paired with a heterozygous parent (Aa) results in either all dominant or a 1:1 phenotypic ratio, depending on the homozygous parent's genotype.

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25. How does the process of Natural Selection affect Hardy-Weinberg equilibrium? Explain with the help of graphs.

Solution:

Step 1: The Hardy-Weinberg equilibrium describes a population where allele and genotype frequencies remain constant over generations, assuming no evolutionary forces like natural selection, mutation, migration, or genetic drift.

Step 2: Natural selection disrupts this equilibrium by favoring certain alleles that confer a survival or reproductive advantage, changing allele frequencies over time. For example, if allele A is advantageous, its frequency increases, while the frequency of allele a decreases.

Step 3: Graphically, in Hardy-Weinberg equilibrium, allele frequencies (e.g., p for A and q for a) remain constant (straight lines over generations). Under natural selection, the frequency of the favored allele (p) increases exponentially, while the other (q) decreases, shown as diverging curves.

Thus, natural selection alters allele frequencies, disrupting Hardy-Weinberg equilibrium.

Quick Tip

Hardy-Weinberg equilibrium assumes no evolutionary forces, but natural selection drives adaptation by changing allele frequencies, often visible as diverging trends in graphs.

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26. Samples of blood and urine of a sportsperson are collected before any sports event for drug tests.

(a) Why there is a need to conduct such tests?

(b) Name the drugs the authorities usually look for.

(c) Write the generic names of two plants from which these drugs are obtained.

Solution:

Step 1: For (a), drug tests are conducted to ensure fair competition, as performance-enhancing drugs can give athletes an unfair advantage, violating sports ethics and regulations. They also protect athletes' health, as such drugs can have harmful side effects.

Step 2: For (b), authorities typically look for drugs like anabolic steroids (e.g., testosterone) and stimulants (e.g., amphetamines), which enhance performance by increasing muscle mass or alertness.

Step 3: For (c), two plants from which such drugs are derived include: (i) Cannabis (Cannabis sativa), which produces cannabinoids like THC, used as a stimulant, and (ii) Coca (Erythroxylum coca), which produces cocaine, a powerful stimulant.

Thus, tests ensure fairness and safety, targeting drugs like steroids and stimulants, often derived from plants like Cannabis and Coca.

Quick Tip

Performance-enhancing drugs are often plant-derived, and testing before events ensures compliance with anti-doping regulations in sports.

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27. (a) The insulin synthesised in our body is different from that synthesised by Eli

Lilly company using recombinant DNA technology. Differentiate between them.
(b) Why the insulin extracted from an animal source is not in use these days?

Solution:

Step 1: For (a), human insulin produced in the body is a 51-amino-acid protein hormone made by pancreatic beta cells, while Eli Lilly's insulin (e.g., Humulin) is synthesized using recombinant DNA technology in bacteria like E. coli, making it identical to human insulin but produced artificially. The difference lies in production: natural insulin is endogenous, while recombinant insulin is exogenous but structurally identical.

Step 2: For (b), insulin from animal sources (e.g., pigs or cows) is not widely used today because it differs slightly in amino acid sequence from human insulin, leading to potential immune reactions or allergies in some patients. Recombinant human insulin, being identical to human insulin, is safer and more effective.

Thus, recombinant insulin matches human insulin but is produced artificially, and animal insulin is avoided due to immunogenicity risks.

Quick Tip

Recombinant DNA technology allows production of human insulin in bacteria, avoiding the immunological issues associated with animal-derived insulin.

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28. (a) Draw a graph for a population whose population density has reached the carrying capacity.
(b) Out of the two population growth curves, which one is considered a more realistic for most populations? Why?
(c) Draw a growth curve where resources are not limiting for the growth of a population and give its equation.

Solution:

Step 1: For (a), a population at carrying capacity (K) follows a logistic growth curve, where growth slows as the population reaches K, leveling off. The graph below shows population size (N) over time, rising steeply at first, then plateauing at K.

Step 2: For (b), the logistic growth curve is more realistic for most populations because it accounts for limiting factors like resources and space, leading to a carrying capacity (K), unlike exponential growth, which assumes unlimited resources and is unsustainable in nature.
Step 3: For (c), when resources are not limiting, the population follows an exponential growth curve, which rises continuously. The equation for exponential growth is $N_t = N_0 e^{rt}$, where N_t is population size at time t, N_0 is initial population size, r is the growth rate, and e is the base of natural logarithms. The chart below represents this growth:

Quick Tip

Logistic growth reflects real-world constraints like carrying capacity, while exponential growth occurs only under ideal, unlimited conditions, as described by $N_t = N_0 e^{rt}$.

SECTION D

Question Nos.29 and 30 are case based questions.

29. Immunity in our body is of two types: (i) Innate immunity and (ii) acquired immunity. Innate immunity is a non-specific defence mechanism, whereas acquired immunity is pathogen-specific; it is called specific immunity too. Acquired immunity is characterised by memory. Antibodies are specific to antigens and there are different types of antibodies produced in our body: they are IgA, IgE, IgG and IgM. It shows primary response when it encounters the pathogen for the first time and secondary response during the subsequent encounters with the same Antigen/Pathogen.

(a) Name the two types of specialised cells which carry out the primary and secondary immune response.

(b) Why is the antibody-mediated immunity also called as humoral immune response?

Attempt either sub-part (c) or (d):

(c) The organ transplants are often rejected if taken from suitable compatible persons.

(i) Mention the characteristic of our immune system that is responsible for the graft rejection.

(ii) Name the type of immune response and the cell involved in it.

OR

(d) How is active immunity different from passive immunity?

Solution:

Step 1: For (a), the two types of specialized cells that carry out the primary and secondary immune responses are B-lymphocytes (B-cells), which produce antibodies, and T-lymphocytes (T-cells), which assist in coordinating the immune response and forming memory cells for faster secondary responses.

Step 2: For (b), antibody-mediated immunity is called humoral immunity because it involves antibodies produced by B-cells, which are dissolved in body fluids (historically called ”humors”) like blood and lymph, targeting extracellular pathogens.

Sub-part (c):

Step 3: For (c)(i), the characteristic of the immune system responsible for graft rejection is its ability to recognize foreign antigens, specifically the major histocompatibility complex (MHC) molecules on the donor organ, as non-self.

Step 4: For (c)(ii), the type of immune response is a cell-mediated immune response, and the cell involved is the cytotoxic T-cell (T-killer cell), which attacks the foreign graft cells.

OR

Sub-part (d):

Step 5: For (d), active immunity is developed by the body’s own immune system through exposure to a pathogen or vaccine, producing memory cells for long-term protection, while passive immunity involves the transfer of pre-formed antibodies (e.g., via mother’s milk or injections), providing immediate but temporary protection without memory cell formation. Thus, B- and T-cells drive immune responses, humoral immunity involves antibodies in body fluids, graft rejection is due to MHC recognition by cytotoxic T-cells, and active immunity differs from passive by involving self-generated, long-term immunity.

Quick Tip

Humoral immunity targets extracellular pathogens via antibodies, while cell-mediated immunity, involving T-cells, is crucial for rejecting grafts and fighting intracellular pathogens.

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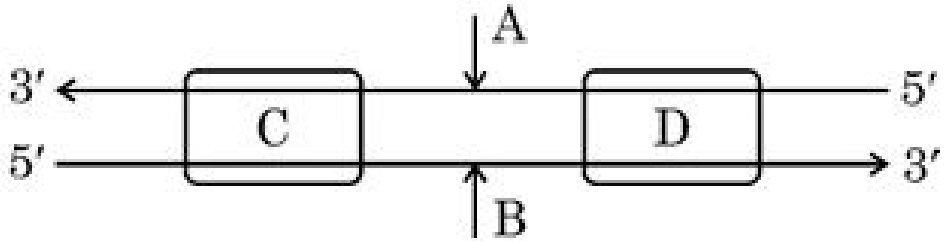
30. The process of copying the genetic information from one strand of DNA into RNA is termed as transcription. The principle of complementarity of bases governs the process of transcription, also except that uracil comes in place of thymine.

Study the complete transcription unit given below and answer the following questions:



(a) Name the main enzyme involved in the process of transcription.

(b) Identify coding strand and template strand of DNA in the transcription unit.

Attempt either sub-part (c) or (d):

(c) Identify (C) and (D) in the diagram, mention their significance in the process of transcription.

OR

(d) Describe the location of (C) and (D) in the transcription unit.

Solution:

Step 1: For (a), the main enzyme involved in transcription is RNA polymerase, which synthesizes RNA by reading the DNA template strand and adding complementary RNA nucleotides.

Step 2: For (b), in the transcription unit, the strand with 5’ to 3’ direction (bottom strand, B) is the coding strand, as it has the same sequence as the RNA (except T is replaced by U). The strand with 3’ to 5’ direction (top strand, A) is the template strand, as RNA polymerase reads it to synthesize RNA in the 5’ to 3’ direction.

Sub-part (c):

Step 3: For (c), (C) is the promoter region, where RNA polymerase binds to initiate transcription, and (D) is the terminator region, where transcription stops, signaling RNA polymerase to release the RNA and DNA. Their significance lies in defining the start and end of the transcription process.

Sub-part (d):

Step 4: For (d), (C) is located at the 5' end of the coding strand (or start of the transcription unit), serving as the promoter, and (D) is at the 3' end of the coding strand (or end of the transcription unit), acting as the terminator.

Thus, RNA polymerase drives transcription, the bottom strand (B) is coding and the top strand (A) is the template, with (C) and (D) as promoter and terminator, located at the start and end of the transcription unit, respectively.

Quick Tip

In transcription, the promoter (C) and terminator (D) are critical regulatory regions that control where RNA polymerase starts and stops synthesizing RNA.

SECTION E

31. Student to attempt either option (A) or (B).

(A)

(i) Describe the process of megasporogenesis in an angiosperm.

(ii) Draw a diagram of a mature embryo sac of the angiosperm. Label its any four parts.

OR

(B) The reproductive cycle in the female primates is called menstrual cycle. The first menstruation begins at puberty.

Answer the following questions:

(i) Name the four phases of menstrual cycle in a proper sequence.

(ii) How long does the menstrual phase last in a menstrual cycle?

(iii) When and why hormones estrogen and progesterone reach their peak levels respectively, in the menstrual cycle?

(iv) Give the significance of LH surge.

Solution:

Option (A):

Step 1: For (i), megasporogenesis in an angiosperm is the process of forming megaspores in the ovule. It begins with a diploid megaspore mother cell (MMC) in the nucellus of the ovule. The MMC undergoes meiosis to produce four haploid megaspores. Typically, three megaspores degenerate, and one functional megaspore survives, which then develops into the embryo sac through megagametogenesis.

Step 2: For (ii), a mature embryo sac (female gametophyte) of an angiosperm is a 7-celled, 8-nucleate structure. It consists of: (1) the egg apparatus at the micropylar end with one egg cell and two synergids, (2) three antipodal cells at the chalazal end, (3) a large central cell with two polar nuclei, and (4) the overall sac surrounded by the integuments of the ovule. The diagram would show an oval structure with these labeled parts: egg cell, synergids, central cell, and antipodal cells.

OR

Option (B):

Step 3: For (i), the four phases of the menstrual cycle in sequence are: (1) menstrual phase, (2) follicular phase, (3) ovulatory phase, and (4) luteal phase.

Step 4: For (ii), the menstrual phase typically lasts 3 to 5 days, during which the uterine lining sheds if no pregnancy occurs.

Step 5: For (iii), estrogen peaks during the late follicular phase (around day 12–14) to stimulate the growth of the uterine lining and trigger the LH surge, while progesterone peaks during the luteal phase (around day 21) to maintain the endometrium for potential pregnancy.

Step 6: For (iv), the LH surge, occurring around day 14, triggers ovulation by causing the mature follicle to rupture and release the egg, a critical step for reproduction.

Thus, (A) describes megasporogenesis and the embryo sac structure, while (B) details the menstrual cycle phases, their duration, hormone peaks, and the role of the LH surge.

Quick Tip

Megasporogenesis produces the megaspore that develops into the embryo sac, while the menstrual cycle's hormonal peaks, like the LH surge, are key for ovulation and pregnancy preparation.

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32. Student to attempt either option (A) or (B).

(A)

(i) Explain how is a bacterial cell made 'competent' to take up recombinant DNA from the medium.

(ii) Explain the steps of amplification of gene of interest using PCR technique.

OR

(B)

(i) What are transgenic animals?

(ii) Why are these animals being produced? Explain any four reasons.

Solution:

Option (A):

Step 1: For (i), a bacterial cell is made 'competent' to take up recombinant DNA by treating it with calcium chloride ($CaCl_2$) and subjecting it to a heat shock. The $CaCl_2$ makes the cell membrane permeable by interacting with the negative charges on the membrane, and the heat shock (42°C for a brief period) creates a temperature gradient that allows the DNA to enter the cell through transient pores.

Step 2: For (ii), PCR (Polymerase Chain Reaction) amplifies a gene of interest in three steps per cycle: (1) Denaturation at 94–95°C to separate the DNA strands, (2) Annealing at 50–60°C to allow primers to bind to the target DNA, and (3) Extension at 72°C where Taq polymerase adds nucleotides to synthesize new DNA strands. This cycle repeats 25–30 times to exponentially amplify the gene.

OR

Option (B):

Step 3: For (i), transgenic animals are organisms that have had a foreign gene (transgene) inserted into their genome using genetic engineering techniques, resulting in the expression of a new trait.

Step 4: For (ii), transgenic animals are produced for four reasons: (1) To study gene function and regulation in a living organism, (2) To produce pharmaceuticals, like human proteins (e.g., insulin) in their milk, (3) To improve agricultural traits, such as disease resistance or growth rates in livestock, and (4) To model human diseases for research, like creating mice models for cancer studies.

Thus, (A) explains bacterial competence and PCR steps, while (B) defines transgenic animals and provides reasons for their production.

Quick Tip

Making bacteria competent involves chemical and thermal treatments, while transgenic animals are valuable for research, medicine, and agriculture due to their modified genomes.

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33. Student to attempt either option (A) or (B).

(A)

(i) Explain giving three reasons why tropics show greatest levels of species diversity.

(ii) Draw a graph showing species-area relationship. Name the naturalist who studied such relationship. Write the observation made by him.

OR

(B)

(i) The world is facing the accelerated rate of species extinctions due to human activities. Explain any three major causes of biodiversity losses.

(ii) Describe 'Ex situ' approach for conserving biodiversity. Give any two examples.

Solution:

Option (A):

Step 1: For (i), tropics show the greatest species diversity because:

1. They have a stable climate with less seasonal variation, allowing uninterrupted evolutionary processes.
2. High solar energy and moisture contribute to high productivity, supporting a wide variety of species.
3. Tropical regions have existed for a longer period without glaciation, giving more time for species diversification.

Step 2: For (ii), the species-area relationship graph shows a rectangular hyperbola when plotted on a standard scale, and a straight line on a log scale. Alexander von Humboldt studied this relationship and observed that species richness increases with area but only up to a limit. His equation is $S = CA^Z$, where S is species richness, A is area, C is a constant, and Z ranges between 0.1 to 0.2 for small areas.

OR

Option (B):

Step 3: For (i), three major causes of biodiversity losses are:
1. Habitat loss and fragmentation: Deforestation and urbanization destroy habitats.
2. Over-exploitation: Excessive hunting, fishing, and harvesting reduce populations.
3. Introduction of alien species: Non-native species may outcompete or prey on native species, disrupting ecosystems.

Step 4: For (ii), 'Ex situ' conservation involves conserving biodiversity outside its natural habitat. Examples include:
1. Gene banks (e.g., seed banks)
2. Zoological parks and botanical gardens

These methods help preserve genetic material and endangered species.

Quick Tip

Tropical diversity is due to stable climate and productivity. Ex situ methods protect species off-site, while habitat destruction is a leading cause of extinction.
