

CBSE Class 12 Biology Question Paper 2025 with Solution PDF-Set 57-S-1 - Compartment



Question Paper with Solutions

Conducted by the Central Board of Secondary Education (CBSE)

Time Allowed: 3 hours

Maximum Marks: 70

General Instructions

- (i) This question paper contains **33** questions. All questions are **compulsory**.
- (ii) Question paper is divided into **five** sections – Sections **A, B, C, D and E**.
- (iii) **Section A** – questions number **1 to 16** are multiple choice type questions. Each question carries **1** mark.
- (iv) **Section B** – questions number **17 to 21** are very short answer type questions. Each question carries **2** marks.
- (v) **Section C** – questions number **22 to 28** are short answer type questions. Each question carries **3** marks.
- (vi) **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.
- (vii) **Section E** – questions number **31 to 33** are long answer type questions. Each question carries **5** marks.
- (viii) There is no overall choice. However, an internal choice has been provided in Sections B, D and E of the question paper. A candidate has to write answer for only **one** of the alternatives in such questions.
- (ix) Kindly note that there is a separate question paper for Visually Impaired candidates.
- (x) Wherever necessary, neat and properly labelled diagrams should be drawn.

Section A (16 marks)

Questions no. 1 to 16 are Multiple Choice Type Questions, carrying 1 mark each. Choose the best option.
 $16 \times 1 = 16$

1. Diseases like pneumonia and common cold are caused by pathogens. Choose the option that correctly indicates the difference between Pneumonia and Common cold : [1 mark]

- (A) Pneumonia is a communicable disease, whereas Common cold is a non-communicable disease.
- (B) Pneumonia is caused by a virus, while the Common cold is caused by bacteria.
- (C) Pneumonia pathogen infects alveoli of the lungs, whereas Common cold affects nose and respiratory passage but not the lungs.
- (D) Pneumonia cannot be prevented by vaccine, whereas Common cold can be prevented by vaccine.

Correct Answer: (C) Pneumonia pathogen infects alveoli of the lungs, whereas Common cold affects nose and respiratory passage but not the lungs.

Solution:

Concept:

- Pneumonia involves infection of the alveoli, the air sacs responsible for gaseous exchange in the lungs.
- The common cold, usually caused by rhinoviruses, affects the nose and respiratory passages but does not affect the lungs.

Step 1: Compare the sites of infection In pneumonia, alveoli become inflamed and may fill with fluid, interfering with breathing. In the common cold, infection remains in the nose and upper respiratory passages. Thus the anatomical distinction stated in option (C) agrees with the standard description.

Step 2: Reject the other comparisons Both illnesses are communicable, so (A) is false. The typical bacterial agents of pneumonia include *Streptococcus pneumoniae* and *Haemophilus influenzae*, whereas rhinoviruses cause the common cold; (B) reverses this comparison. Vaccines can prevent some forms of pneumonia, so the absolute claim in (D) is false.

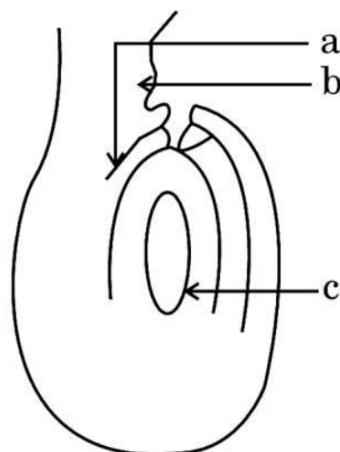
Step 3: Conclusion Pneumonia affects the alveoli; the common cold affects the nose and respiratory passages without involving the lungs. Hence, the correct option is (C).

Quick Tip to Solve: Use the site of infection as the deciding feature: alveoli indicate pneumonia, while nose and upper respiratory passages indicate the common cold.

2. Identify the various parts, 'a', 'b' and 'c', in the given diagram of ovule :

[1 mark]

Diagram of an ovule



- (A) a – Embryo sac, b – Inner integuments, c – Outer integuments
(B) a – Inner integuments, b – Nucellus, c – Chalazal end
(C) a – Hilum, b – Funicle, c – Embryo sac
(D) a – Mycophylar end, b – Hilum, c – Inner integuments

Correct Answer: (C) a – Hilum, b – Funicle, c – Embryo sac

Solution:

Concept:

- The funicle is the stalk attaching an ovule to the placenta; the hilum is the junction between the ovule body and funicle.
- The embryo sac is the female gametophyte located within the nucellus of the ovule.

Step 1: Trace the two attachment labels Label a points to the junction where the ovule body joins its stalk, identifying the hilum. Label b points to the stalk itself, identifying the funicle. Distinguish the joining point from the elongated supporting structure rather than treating both as the same part.

Step 2: Identify the internal oval Label c points to the oval structure within the ovule, the embryo sac. It does not point to either integument or the chalazal end. Options (A), (B) and (D) therefore assign incorrect structures to the labelled positions; only (C) identifies all the parts together.

Step 3: Conclusion The parts are a: hilum, b: funicle and c: embryo sac. Hence, the correct option is (C).

Quick Tip to Solve: First identify the central embryo sac at c, then distinguish the stalk (funicle) from its point of attachment (hilum).

3. Which of the following statements are true in respect of chorionic villi in humans ?

- (i) It appears after implantation of human embryo in the uterus.
- (ii) It becomes interdigitated with cervical tissue of female reproductive tract.
- (iii) It increases the surface area for exchange of materials.
- (iv) It develops from the inner cell mass of blastocyst.

[1 mark]

- (A) (i) and (ii)
- (B) (ii) and (iii)
- (C) (i) and (iv)
- (D) (i) and (iii)

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

Solution:

Concept:

- After implantation, finger-like chorionic villi develop from the trophoblast of the blastocyst.
- Chorionic villi interdigitate with uterine tissue and increase the exchange surface of the developing placenta.

Step 1: Assess statements (i) and (iii) Statement (i) is true: villi appear after implantation of the embryo in the uterine endometrium. Statement (iii) is also true: their finger-like projections increase the area available for exchange of nutrients, respiratory gases and wastes between maternal and foetal systems.

Step 2: Assess statements (ii) and (iv) Statement (ii) is false because the villi interdigitate with uterine tissue, not cervical tissue. Statement (iv) is false because villi arise from the trophoblast, whereas the inner cell mass gives rise to the embryo. Consequently, each option containing (ii) or (iv) must be rejected.

Step 3: Conclusion Only statements (i) and (iii) are true. Hence, the correct option is (D).

Quick Tip to Solve: Link chorionic villi with trophoblast and uterine endometrium; inner cell mass and cervical tissue are the distractors here.

4. A man with a certain disease marries a normal woman. They have four children (three daughters and one son). All the daughters suffer from their father's disease but the son is not affected. Which of the following mode of inheritance do you suggest for this disease ? [1 mark]

- (A) Autosome Linked Recessive
- (B) Sex-linked Dominant
- (C) Autosome Linked Dominant
- (D) Sex-linked Recessive

Correct Answer: (B) Sex-linked Dominant

Solution:

Concept:

- A father passes his X chromosome to every daughter and his Y chromosome to every son.
- An X-linked dominant disease allele is expressed even when a female has only one copy of that allele.

Step 1: Represent the suggested parental cross Let X^D carry the dominant disease allele and X^d carry the normal allele. The affected father is X^DY and the normal mother is X^dX^d . Every daughter receives X^D from her father, giving X^DX^d , and is affected.

Step 2: Explain why the son is unaffected Each son receives the paternal Y chromosome and the normal maternal X^d , giving X^dY . An X-linked recessive allele from an affected father and a normal non-carrier mother would instead produce carrier daughters. Autosomal inheritance does not specifically associate paternal transmission with every daughter while excluding sons; the suggested pattern is X-linked dominant.

Step 3: Conclusion The distribution is characteristic of sex-linked (X-linked) dominant inheritance. Hence, the correct option is (B).

Quick Tip to Solve: For an affected father, track his X to all daughters and his Y to all sons; affected daughters indicate dominance.

5. The chronological order of evolution of modern man from man-like primates is given below. Choose the option that indicates the evolution of man in correct order from early to recent times : [1 mark]

(A) Australopithecines → Ramapithecus → Homo habilis → Homo erectus → Homo sapiens

(B) Ramapithecus → Australopithecines → Homo habilis → Homo erectus → Homo sapiens

(C) Ramapithecus → Homo habilis → Australopithecines → Homo erectus → Homo sapiens

(D) Australopithecines → Homo habilis → Homo sapiens → Ramapithecus → Homo erectus

Correct Answer: (B) Ramapithecus → Australopithecines → Homo habilis → Homo erectus → Homo sapiens

Solution:

Concept:

- The textbook chronological sequence places *Ramapithecus* before Australopithecines and the species of *Homo*.
- Within the given *Homo* species, *Homo habilis* precedes *Homo erectus*, followed by *Homo sapiens*.

Step 1: Place the earlier forms first *Ramapithecus* existed much earlier than Australopithecines in the textbook account. Therefore any listed sequence putting Australopithecines before *Ramapithecus*, as in (A) and (D), has the early stages in the wrong order.

Step 2: Order the later hominins After Australopithecines comes *Homo habilis*, followed by *Homo erectus* and then *Homo sapiens*. Option (C) incorrectly places *Homo habilis* before Australopithecines. Option (D) also places *Homo sapiens* before earlier forms. Option (B) alone preserves the requested early-to-recent sequence throughout.

Step 3: Conclusion The sequence is *Ramapithecus*, Australopithecines, *Homo habilis*, *Homo erectus*, then *Homo sapiens*. Hence, the correct option is (B).

Quick Tip to Solve: Remember the given textbook order as Ramapithecus, Australopithecines, habilis, erectus, sapiens; check both the first pair and the Homo sequence.

6. What would be the genotype of parents if the F_1 offspring have the phenotypes in 1 : 1 proportion ?

[1 mark]

(A) $Aa \times Aa$

(B) $AA \times AA$

(C) $Aa \times AA$

(D) $Aa \times aa$

Correct Answer: (D) $Aa \times aa$

Solution:

Concept:

- Under complete dominance, a heterozygote expresses the dominant phenotype while a homozygous recessive individual expresses the recessive phenotype.
- A monohybrid test cross between a heterozygote and a homozygous recessive parent gives equal

dominant and recessive phenotypes.

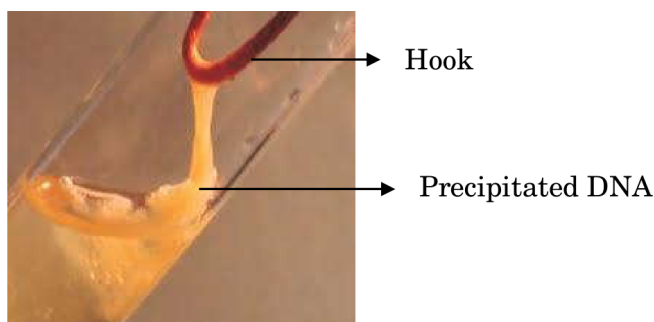
Step 1: Work out the test cross The heterozygous parent Aa forms gametes A and a in equal proportions, while the recessive parent aa forms only a gametes. Thus $Aa \times aa$ gives half Aa offspring and half aa offspring, corresponding to the two phenotypes in a 1 : 1 ratio.

Step 2: Check the remaining crosses $Aa \times Aa$ gives a 3 : 1 phenotypic ratio under complete dominance. Both $AA \times AA$ and $Aa \times AA$ produce only the dominant phenotype, although the latter produces two genotypes. A genotypic split is not enough: the question specifically requires two phenotypes in equal proportions.

Step 3: Conclusion The parents are $Aa \times aa$, giving dominant and recessive phenotypes in a 1 : 1 proportion. Hence, the correct option is (D).

Quick Tip to Solve: A phenotypic 1:1 ratio in a simple monohybrid cross points to a heterozygote crossed with the homozygous recessive tester.

7. Identify the material that helps in the precipitation of purified DNA during the process of isolation of DNA as shown in the given diagram. [1 mark]



- (A) Protease
- (B) Lysozyme
- (C) Cellulase
- (D) Chilled ethanol

Correct Answer: (D) Chilled ethanol

Solution:

Concept:

- Purified DNA can be precipitated by adding chilled ethanol to the aqueous preparation.
- Cell-wall digesting enzymes and protein-removing enzymes act during extraction and purification; they do not serve as the DNA precipitating agent.

Step 1: Identify the precipitation stage Addition of chilled ethanol precipitates purified DNA from solution. DNA becomes visible as fine threads that can be collected by spooling with a suitable rod or hook, consistent with the precipitated material shown in the diagram.

Step 2: Distinguish the roles of the enzymes Protease removes proteins, including proteins associated

with DNA. Lysozyme helps break bacterial cell walls, while cellulase digests cellulose-containing plant cell walls. These treatments help release or purify DNA before precipitation. Therefore options (A), (B) and (C) name useful extraction enzymes but do not answer which material precipitates the purified DNA.

Step 3: Conclusion Chilled ethanol is added to precipitate purified DNA. Hence, the correct option is (D).

Quick Tip to Solve: Associate DNA threads and spooling with chilled ethanol; associate lysozyme, cellulase and protease with earlier extraction steps.

8. Which of the following animals exhibit male heterogamety ?

(i) Fruit fly (ii) Fowl (iii) Human (iv) Honey bee

[1 mark]

- (A) (i) and (iii)
- (B) (ii) and (iv)
- (C) (ii) and (iii)
- (D) (i) and (iv)

Correct Answer: (A) (i) and (iii)

Solution:

Concept:

- Male heterogamety means that a male produces two kinds of gametes with respect to sex chromosomes.
- In the XX-XY system, females are XX and males are XY.

Step 1: Identify the male-heterogametic animals Fruit fly and human males are XY. They produce X-bearing and Y-bearing sperm, whereas XX females produce only X-bearing eggs.

Step 2: Exclude the other animals Fowl have female heterogamety: females are ZW and males are ZZ. Honey bees have haplodiploid sex determination; haploid males do not produce two sex-chromosome classes of sperm. Thus combinations including fowl or honey bee are unsuitable.

Step 3: Conclusion The animals are (i) fruit fly and (iii) human. Hence, the correct option is (A).

Quick Tip to Solve: Check which sex makes two sex-chromosome classes of gametes; do not confuse haplodiploidy with male heterogamety.

9. What would happen if in a gene encoding a polypeptide of 51 amino acids, codon present at 32 position (UAU) is mutated to UGA ? Select the option that indicates the polypeptide with correct number of amino acids formed after mutation. [1 mark]

- (A) A polypeptide of 50 amino acids will be formed.
(B) A polypeptide of 32 amino acids will be formed.
(C) Two polypeptides of 20 and 31 amino acids will be formed.
(D) A polypeptide of 31 amino acids will be formed.

Correct Answer: (D) A polypeptide of 31 amino acids will be formed.

Solution:

Concept:

- UAU encodes tyrosine, whereas UGA is a stop codon and encodes no amino acid.
- A nonsense mutation changes an amino-acid codon into a termination codon.

Step 1: Locate the new stop signal The codon at position 32 becomes UGA. Translation therefore adds amino acids for codons 1 through 31 and terminates when the ribosome reaches position 32.

Step 2: Count residues and reject alternatives The chain contains 32 minus 1, or 31, amino acids. No residue is added for the stop codon, so 32 is incorrect. The remaining downstream codons are not translated into a separate chain; neither 50 residues nor two polypeptides follows from this mutation.

Step 3: Conclusion A polypeptide of 31 amino acids is formed. Hence, the correct option is (D).

Quick Tip to Solve: When a coding position becomes a stop codon, count only the amino acids before that position.

10. Given below is Column A with a list of certain Assisted Reproductive Technologies (ART), and Column B, with the procedures followed during ART :

Column A (ART)	Column B (Procedures)
a. GIFT	i. Transfer of ovum from a donor into the fallopian tube of another female
b. ICSI	ii. Transfer of semen from the donor into the vagina of female
c. ZIFT	iii. Injecting sperms directly into the ovum
d. IUI	iv. Transfer of early embryos into the fallopian tube

Select the correct match :

[1 mark]

- (A) a-i, b-ii, c-iii, d-iv
(B) a-iv, b-i, c-ii, d-iii
(C) a-iv, b-iii, c-i, d-ii
(D) a-i, b-iii, c-iv, d-ii

Correct Answer: No fully correct printed option; (D) is intended, but IUI places semen into the uterus, not the vagina.

Solution:

Concept:

- GIFT transfers an ovum into a fallopian tube; ICSI injects a sperm directly into an ovum.
- ZIFT transfers a zygote or an early embryo into a fallopian tube; IUI introduces semen into the uterus.

Step 1: Match the three correctly stated procedures GIFT matches a-i, ICSI matches b-iii, and ZIFT matches c-iv. These three entries together occur only in option (D); the other options mismatch one or more of these procedures.

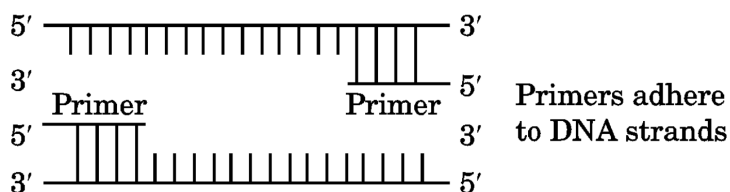
Step 2: Check the printed IUI entry Procedure ii states transfer of semen into the vagina. That describes vaginal artificial insemination, not intrauterine insemination (IUI), which requires placement into the uterus. Therefore d-ii is biologically incorrect as printed, and no option is fully correct. Option (D) is the intended answer by the other three matches, but its fourth match contains the printed error.

Step 3: Conclusion No option is fully correct as printed. Option (D), a-i, b-iii, c-iv, d-ii, is the intended match, with the correction that IUI places semen into the uterus.

Quick Tip to Solve: Use the anatomical destination: GIFT and ZIFT involve the fallopian tube, whereas the U in IUI denotes the uterus.

11. What is the process of binding a primer to the denatured strand called ?

[1 mark]



- (A) Denaturation
- (B) Annealing
- (C) Renaturation
- (D) Polymerisation

Correct Answer: (B) Annealing

Solution:

Concept:

- PCR uses successive stages of denaturation, primer annealing and extension.
- A primer binds a complementary sequence on a single-stranded DNA template by base pairing.

Step 1: Identify the stage shown The DNA strands have already separated. The short primers now adhere to complementary sequences on the denatured strands. This primer-template binding stage is annealing.

Step 2: Distinguish the other processes Denaturation separates the parental strands by breaking hydrogen bonds. Polymerisation extends the bound primer using DNA polymerase. Renaturation

refers to reassociation of complementary DNA strands; the specific PCR term for binding primers is annealing.

Step 3: Conclusion Binding of a primer to the denatured DNA strand is annealing. Hence, the correct option is (B).

Quick Tip to Solve: In PCR, remember the order: separate the strands, anneal the primers, then extend the new DNA.

12. Golden rice is a promising transgenic crop. When released for cultivation, it will help in : [1 mark]

- (A) Producing a petrol-like fuel from rice
- (B) Enrichment of Vitamin A
- (C) Pest resistance
- (D) Herbicide tolerance

Correct Answer: (B) Enrichment of Vitamin A

Solution:

Concept:

- Golden rice is a transgenic rice enriched with beta-carotene in the edible endosperm.
- Beta-carotene is a provitamin that the human body can convert into vitamin A.

Step 1: Relate the inserted trait to nutrition The engineered carotenoid pathway enables the rice grain to accumulate beta-carotene. Its consumption can help improve vitamin A intake and reduce the risk of vitamin A deficiency.

Step 2: Distinguish other transgenic traits Golden rice is an example of nutritional enhancement. Production of petrol-like fuel is not its purpose. Pest resistance and herbicide tolerance are separate crop traits and do not explain the golden-rice modification described here.

Step 3: Conclusion Golden rice helps in enrichment of vitamin A through its provitamin, beta-carotene. Hence, the correct option is (B).

Quick Tip to Solve: Associate the golden colour with beta-carotene, then connect beta-carotene to vitamin A.

13. Assertion (A) : In bioreactors, raw materials are biologically converted into desired products.

Reason (R) : In bioreactors, optimum growth conditions for microbes such as temperature, pH, substrate, salts, etc. are available. [1 mark]

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

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

Solution:

Concept:

- A bioreactor is a vessel supporting biological conversion of raw materials into specific products.
- Productive microbial growth requires controlled temperature, pH, nutrients and other suitable culture conditions.

Step 1: Evaluate the assertion The assertion is true. Microorganisms, cells or their enzymes use substrates supplied as raw materials and carry out biological reactions that form the desired product in the bioreactor.

Step 2: Evaluate the reason The reason is true. Bioreactors provide and regulate growth conditions such as temperature, pH, substrate supply and salts so that the culture can grow and function efficiently.

Step 3: Test the explanatory link These favourable conditions enable microbial activity and efficient conversion of substrates into products. The reason therefore explains how a bioreactor supports the biological conversion stated in the assertion; the choices with a false statement or no explanatory link are unsuitable.

Step 4: Conclusion Both Assertion and Reason are true, and Reason correctly explains Assertion. Hence, the correct option is (A).

Quick Tip to Solve: Link the controlled culture conditions directly to microbial activity and the conversion of substrate into product.

14. Assertion (A) : All the events starting from pollen landing on stigma till pollen tube entering the ovule are included in pollen-pistil interaction.

Reason (R) : Pollen-pistil interaction ensures that only suitable pollens germinate on the stigma.

[1 mark]

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

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

Solution:

Concept:

- Pollen-pistil interaction includes events from pollen deposition on the stigma to entry of the pollen tube into the ovule.
- Chemical recognition between pollen and pistil permits compatible pollen and rejects incompatible pollen.

Step 1: Evaluate the assertion The assertion is true. Pollen landing, recognition, germination and pollen-tube growth through the pistil up to the ovule belong to pollen-pistil interaction.

Step 2: Evaluate the reason The reason is also true. The pistil recognises suitable pollen and promotes its germination and tube growth, while unsuitable pollen is rejected by inhibition of germination or subsequent growth.

Step 3: Test whether the reason explains the definition The reason describes a selective function of pollen-pistil interaction. It does not explain the full scope or endpoints of the sequence defined in the assertion. Thus both statements are correct, but this function is not the explanation of the assertion; options claiming either statement is false are excluded.

Step 4: Conclusion Both Assertion and Reason are true, but Reason is not the correct explanation of Assertion. Hence, the correct option is (B).

Quick Tip to Solve: For assertion-reason questions, distinguish a process definition from a true statement describing only one of its functions.

15. Assertion (A) : DNA chemically is less reactive and structurally more stable when compared to RNA.

Reason (R) : DNA has 2'– OH group present at every nucleotide, which makes it more stable than RNA. [1 mark]

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

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

Solution:

Concept:

- DNA contains deoxyribose sugar, whereas RNA contains ribose sugar.
- The reactive hydroxyl group at the 2' carbon is present in RNA and absent from DNA.

Step 1: Judge Assertion (A) The assertion is true. DNA is chemically less reactive and structurally more stable than RNA. Its deoxyribose sugar lacks the reactive 2'-OH group; its double-stranded organisation also supports stability and repair.

Step 2: Judge Reason (R) The reason is false. DNA has hydrogen at the 2' carbon, not an OH group. RNA possesses the 2'-OH group, which increases its reactivity and makes it more liable to breakdown.

Step 3: Check the explanatory link Because the stated reason assigns the RNA sugar group to DNA, it cannot explain the true assertion. Options (A) and (B) incorrectly call the reason true, while (D) incorrectly calls the assertion false.

Step 4: Conclusion The assertion is true, but the reason is false. Hence, the correct option is (C).

Quick Tip to Solve: Associate ribose with the reactive 2-prime hydroxyl group; deoxyribose lacks it.

16. Assertion (A) : Competition is a type of interspecific interaction between two or more species when the resources necessary for them are limited and adversely affect them.

Reason (R) : Special adaptation may allow the competing species to coexist in the same geographical area. [1 mark]

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

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

Solution:

Concept:

- Interspecific competition is a $(-, -)$ interaction: competing species adversely affect one another.
- Resource partitioning can reduce competitive overlap and permit coexistence.

Step 1: Judge Assertion (A) The assertion is true. When two or more species use the same limiting resource, its use by one reduces availability to the other. Both competitors suffer a reduction in fitness relative to conditions without competition.

Step 2: Judge Reason (R) The reason is also true. Special adaptations, such as using different feeding sites or feeding at different times, can reduce resource overlap. This resource partitioning allows competing species to coexist in the same geographical area.

Step 3: Check the explanatory link The reason explains how coexistence becomes possible despite competition. It does not explain why competition arises or why the competitors adversely affect each other. Thus the two true statements do not have the explanation relationship required in option (A); (C) and (D) incorrectly declare one statement false.

Step 4: Conclusion Both statements are true, but the reason does not correctly explain the assertion. Hence, the correct option is (B).

Quick Tip to Solve: Separate the cause of competition from adaptations that reduce competition and permit coexistence.

Section B (10 marks)

17(a). How many meiotic divisions will a wheat plant undergo in order to produce 100 zygotes / 100 grains ? Calculate and give explanation. [2 marks]

Solution:

Concept:

- One microspore mother cell undergoes meiosis to produce four haploid microspores, each developing into a pollen grain.

- One megaspore mother cell undergoes meiosis to produce four megaspores; normally only one is functional and produces one embryo sac containing one egg.

Step 1: Count female-side meioses Each zygote forms by fertilisation of one egg. Thus 100 zygotes require 100 eggs in 100 embryo sacs. Since one functional embryo sac results from each megaspore mother cell, the female side requires 100 meiotic divisions. The other three megaspores of each tetrad degenerate.

Step 2: Count male-side meioses Each pollen grain delivers two male gametes into one embryo sac. One fuses with the egg and the other participates in triple fusion; they do not fertilise two separate eggs. Therefore, 100 pollen grains are needed. As one microspore mother cell gives four pollen grains, male meioses required are $100/4 = 25$.

Step 3: Add both contributions The total number of meiotic divisions in the wheat plant is

$$100 + 25 = 125.$$

This is the required count for forming the gametophytes that produce the 100 zygotes and hence 100 grains.

Step 4: Conclusion The wheat plant requires 125 meiotic divisions: 100 on the female side and 25 on the male side.

Quick Tip to Solve: Count one female meiosis per egg, but only one male meiosis per four pollen grains.

OR

17(b). How many pollen grains and ovules are likely to be formed in the anther and the ovary of an angiosperm bearing 35 microspore mother cells and 35 megaspore mother cells respectively ?

[2 marks]

Solution:

Concept:

- Microsporogenesis yields four microspores per microspore mother cell, and all four normally develop into pollen grains.
- In the usual angiosperm pattern, one megaspore per megaspore mother cell is functional and develops into the embryo sac within an ovule.

Step 1: Calculate pollen grains Each of the 35 microspore mother cells undergoes meiosis and forms a tetrad of four haploid microspores. All four normally survive and develop into pollen grains. Therefore,

$$\text{Pollen grains} = 35 \times 4 = 140.$$

The pollen grains may later divide mitotically to form the male gametophytes; this does not change their number.

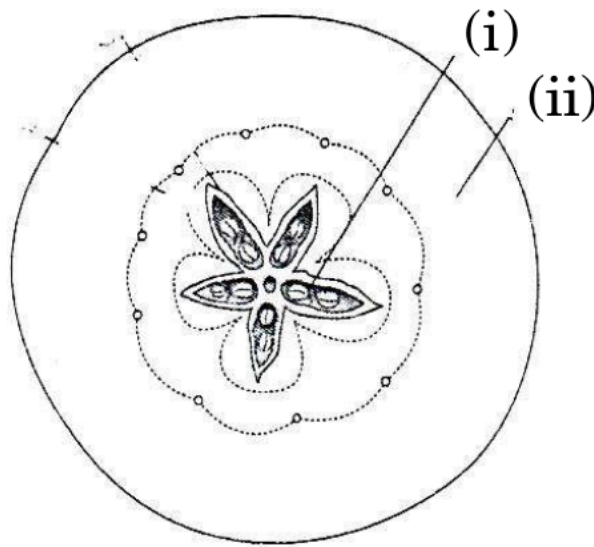
Step 2: Calculate ovules represented Each ovule normally contains one megaspore mother cell. Its meiosis produces four megaspores, of which three usually degenerate; the remaining one forms the

embryo sac. Thus the 35 megaspore mother cells represent 35 ovules, each potentially bearing one functional embryo sac. Ovules are structures containing these cells, rather than products of megaspore meiosis. Hence one must not multiply the ovule count by four.

Step 3: Conclusion The expected numbers are 140 pollen grains and 35 ovules.

Quick Tip to Solve: Multiply microspore mother cells by four; count one ovule for each megaspore mother cell.

18. Given below is a transverse sectional view of an apple. Label the following parts (i) and (ii) and write down their functions. [2 marks]



Solution:

Concept:

- An apple is a false fruit: the thalamus contributes most of its fleshy edible portion.
- After fertilisation an ovule develops into a seed, which contains the embryo.

Step 1: Identify part (i) and state its function Label (i) points to a seed in the central core. The seed contains the embryo of the next plant. Its seed coat protects the embryo, while stored reserves nourish it during early germination. Under suitable conditions the embryo develops into a seedling, allowing propagation of the plant.

Step 2: Identify part (ii) and state its function Label (ii) points to the fleshy thalamus, the enlarged floral receptacle surrounding the central core. It forms the major edible portion of the apple. Its fleshy tissue stores food and attracts fruit-eating animals, thereby helping dispersal of the seeds. Because this substantial fruit tissue develops from a floral part other than the ovary, apple is termed a false fruit.

Step 3: Conclusion (i) Seed: protects and nourishes the embryo and gives rise to a new plant. (ii) Fleshy thalamus: stores food, forms the edible portion and helps attract animals for seed dispersal.

Quick Tip to Solve: Trace the arrows carefully: the central seed differs from the broad fleshy thalamus around the core.

19(a). A couple believed that hospital authorities have exchanged babies and they have been given another baby by them. The wife is blood group 'A', her husband is blood group 'B' and the child is blood group 'O'.

(i) Could the baby be theirs ?

(ii) Justify your answer with the help of a cross.

[2 marks]

Solution:

Concept:

- The alleles I^A and I^B are codominant, whereas each is dominant over the recessive allele i .
- Group A can be $I^A I^A$ or $I^A i$; group B can be $I^B I^B$ or $I^B i$. Group O is always ii .

Step 1: (i) Check whether the child is possible Yes. A group O child must receive one recessive i allele from each parent. The mother can have genotype $I^A i$, and the father can have genotype $I^B i$. Their group A and B phenotypes therefore do not exclude a group O child. Both parents must be heterozygous for this outcome.

Step 2: (ii) Show the cross The parental cross and possible offspring are:

$$I^A i \times I^B i.$$

The mother produces gametes I^A, i , and the father produces gametes I^B, i .

	I^B	i
I^A	$I^A I^B$ (AB)	$I^A i$ (A)
i	$I^B i$ (B)	ii (O)

Each combination has probability $1/4$. Thus, a group O child is a normal possible outcome of this cross. Blood group compatibility alone cannot prove parentage or establish a hospital exchange.

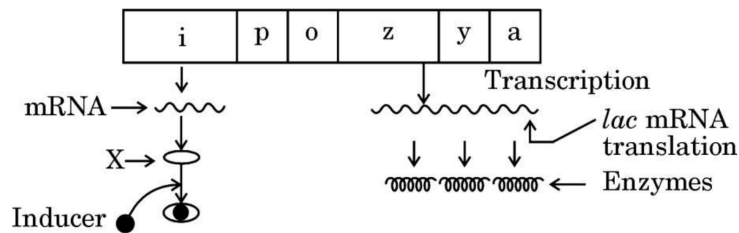
Step 3: Conclusion The baby could be theirs: heterozygous group A and group B parents can produce a group O (ii) child with probability 25%.

Quick Tip to Solve: Work backwards from group O: an ii child needs one i allele from each parent.

19(b)(i). Observe the diagram given below and answer the following questions.

Name the molecule 'X' synthesized by 'i' gene.

[0.5 marks]



Solution:

Concept:

- The regulatory *i* gene produces the repressor protein that controls access to the lac operator.
- An inducer binds the repressor and prevents it from blocking transcription.

Step 1: Identify the product of the regulatory gene The diagram shows the *i* gene being transcribed into mRNA and its message translated into molecule X. This regulatory product is the lac repressor protein; it is distinct from the enzymes encoded by the structural genes.

Step 2: Relate X to the inducer The inducer binds X in the diagram and inactivates it, allowing structural gene transcription. Therefore X is the repressor, rather than lactose, RNA polymerase or β -galactosidase.

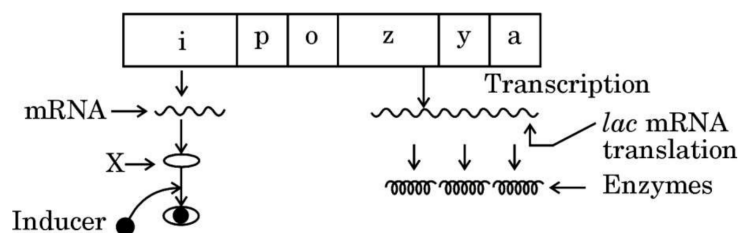
Step 3: Conclusion Molecule X is the lac repressor protein.

Quick Tip to Solve: Follow the arrow from *i*: its protein product is the repressor, not a lactose-metabolising enzyme.

19(b)(ii). Observe the diagram given below and answer the following questions.

Which one of the structural genes codes for β -galactosidase ?

[0.5 marks]



Solution:

Concept:

- The lac structural genes are *z*, *y* and *a*.
- The *z* gene encodes β -galactosidase, which hydrolyses lactose into glucose and galactose.

Step 1: Match the enzyme to its gene The structural gene *z*, also written *lacZ*, specifies the enzyme

β -galactosidase. It is the first structural gene after the operator in the arrangement shown.

Step 2: Distinguish the other gene products The y gene codes for permease, which facilitates entry of lactose, while a codes for transacetylase. The regulatory i gene produces the repressor. These products are different from the lactose-hydrolysing enzyme asked for here.

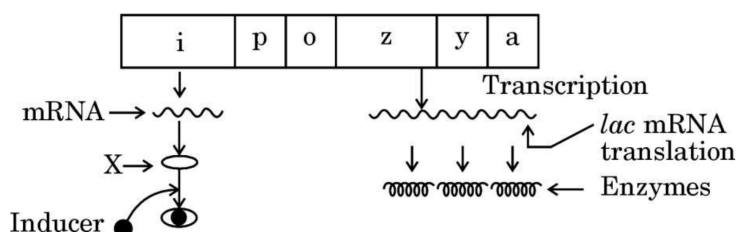
Step 3: Conclusion The z structural gene codes for β -galactosidase.

Quick Tip to Solve: Remember the lac gene sequence by pairing z with galactosidase, y with permease and a with transacetylase.

19(b)(iii). Observe the diagram given below and answer the following questions.

When will the transcription of this gene stop ?

[1 mark]



Solution:

Concept:

- The lac operon is inducible: lactose permits transcription by inactivating its repressor.
- An active repressor binds the operator and prevents RNA polymerase from transcribing the structural genes.

Step 1: Identify the condition for switching off Transcription stops when lactose, the inducer, is absent or has been used up. Without inducer binding, the repressor regains its active form. The condition is removal of the inducer, rather than production of additional structural enzymes.

Step 2: Explain the blocking mechanism The active repressor binds to the operator region of the operon. This blocks RNA polymerase from transcribing the structural genes z , y , a , so fresh lac mRNA is no longer synthesised. The regulatory i gene itself continues to produce repressor; it is transcription of the structural genes that is switched off.

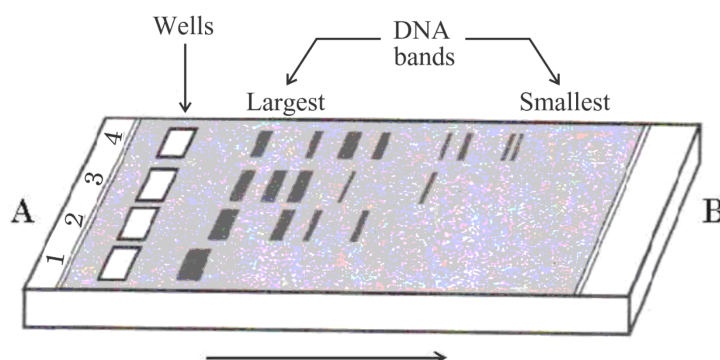
Step 3: Conclusion Transcription stops in the absence of lactose (inducer), when the active repressor binds the operator and blocks transcription of the structural genes.

Quick Tip to Solve: For switching off, state both the missing inducer and the repressor binding the operator.

20(a). Given below is the diagram representing the observation made for separating DNA fragments by gel electrophoresis. Observe the illustration and answer the questions that follow :

DNA fragments move in the direction A→B. Explain.

[1 mark]



Solution:

Concept:

- DNA has a net negative charge because of phosphate groups in its sugar-phosphate backbone.
- In an electric field, negatively charged DNA migrates towards the positive electrode, the anode.

Step 1: Identify the charge carried by the fragments The DNA fragments loaded into the wells carry negatively charged phosphate groups. Applying an electric field therefore makes them move away from the negative electrode near the wells; migration is due to electric attraction and repulsion, not gravity.

Step 2: Interpret A to B in the illustration The wells lie towards A, the cathode side, while B is the positive anode side. The fragments are attracted towards B, so their direction of motion is A to B. The agarose gel slows fragments according to size, but does not reverse their charge or their direction of migration.

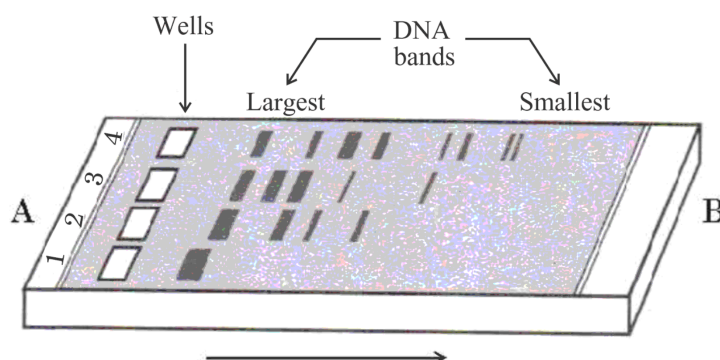
Step 3: Conclusion DNA moves from A to B because its negatively charged phosphate backbone is attracted towards the positive electrode (anode) at B.

Quick Tip to Solve: First locate the wells: DNA runs from the negative end near the wells towards the positive anode.

20(b). Given below is the diagram representing the observation made for separating DNA fragments by gel electrophoresis. Observe the illustration and answer the questions that follow :

Name the matrix used and its role in gel electrophoresis.

[0.5 marks]



Solution:

Concept:

- Agarose is a natural polymer extracted from seaweeds and is used as the matrix for DNA gel electrophoresis.
- The gel acts as a molecular sieve, separating DNA fragments according to their size.

Step 1: Name the matrix The matrix is agarose gel. It forms a porous network through which DNA fragments travel when an electric field is applied. The fragments are placed in wells made in this gel before the current is switched on.

Step 2: Explain its separation role The pores offer greater resistance to larger DNA fragments. Smaller fragments pass more easily through the network and move farther towards the anode in a given time, while larger fragments remain nearer the wells. This size-dependent sieving produces the separate DNA bands shown in the illustration.

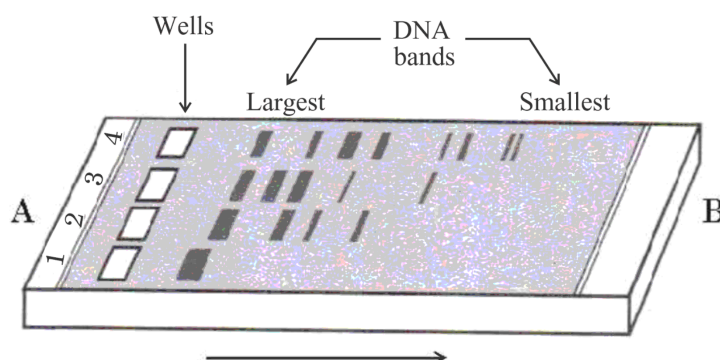
Step 3: Conclusion Agarose gel is used; it acts as a molecular sieve to separate DNA fragments by size, with smaller fragments migrating farther.

Quick Tip to Solve: Name the material and its role together: agarose is the matrix; molecular sieving separates sizes.

20(c). Given below is the diagram representing the observation made for separating DNA fragments by gel electrophoresis. Observe the illustration and answer the questions that follow :

Mention how the separated fragments can be visualized for further technical use.

[0.5 marks]



Solution:

Concept:

- DNA bands can be visualised by staining with ethidium bromide and exposing the gel to ultraviolet radiation.
- The stained fragments appear as bright orange bands, enabling the desired band to be identified.

Step 1: Make the separated DNA visible Stain the DNA with ethidium bromide and view the gel under ultraviolet light. Ethidium bromide associates with DNA and fluoresces, so the otherwise invisible DNA fragments appear as distinct bright orange bands.

Step 2: Connect visualisation to further use Identify the band containing the desired DNA fragment from its position in the gel. For subsequent technical use, the required band can be cut out and the DNA extracted from the gel by elution. Staining and ultraviolet illumination provide visualisation; elution is the later recovery step.

Step 3: Conclusion Stain with ethidium bromide and expose to UV radiation to see bright orange DNA bands; the desired fragment may then be recovered by elution.

Quick Tip to Solve: Use the sequence stain, UV, orange bands; mention elution only for recovery of the chosen fragment.

21(a)(i). Draw a pyramid of numbers where a large number of insects are feeding on the leaves of a tree. What is the shape of this pyramid ?

[1 mark]

Solution:

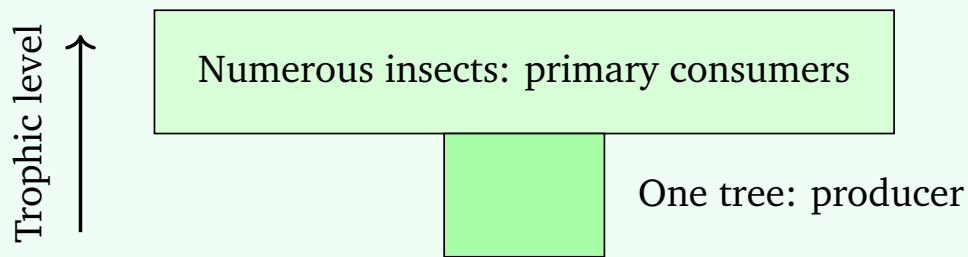
Concept:

- A pyramid of numbers represents the number of individual organisms at each trophic level.
- The width of a trophic-level band represents abundance, not the size or biomass of its members.

Step 1: Count the producer The producer in this example is a single large tree. Although it has many leaves and considerable biomass, it is counted as only one organism, so its band is narrow.

Step 2: Count the primary consumers A large number of herbivorous insects feed on the leaves of

that one tree. Their band is therefore wider than the producer band below it. The numbers increase from the producer to the primary-consumer level, giving an inverted arrangement.



Inverted pyramid of numbers for a tree and its insect consumers

Step 3: Conclusion The pyramid of numbers is inverted: one tree supports numerous insects.

Quick Tip to Solve: Count individuals, not leaves: all leaves belong to the same single producer.

21(a)(ii). Will the pyramid of energy also be of the same shape in this situation ? Give reason for your response. [1 mark]

Solution:

Concept:

- The pyramid of energy shows energy available at successive trophic levels per unit area per unit time.
- Energy transfer is inefficient: organisms use energy in metabolism and dissipate much of it as heat.

Step 1: Separate energy from organism numbers One large tree may support many small insects, so the pyramid of numbers can be inverted. This numerical relationship does not mean that the insects receive more energy than is available in the tree at the producer level.

Step 2: Follow energy transfer Only a fraction of the energy stored by the producer is transferred to insect consumers. Much is lost through respiration as heat, or remains in material that is not eaten or assimilated. Energy available at the next trophic level therefore decreases.

Step 3: Conclusion No. The pyramid of energy is always upright because energy decreases at each successive trophic level.

Quick Tip to Solve: For energy pyramids, compare energy transferred, rather than the number or size of organisms.

21(b)(i). What could be the reason for the fast rate of decomposition in the tropics ?

[1 mark]

Solution:

Concept:

- Decomposition is the breakdown of detritus by decomposers, including bacteria and fungi.
- Temperature and moisture strongly influence decomposer activity and the rate of decomposition.

Step 1: Identify the favourable tropical conditions Tropical regions generally provide warm temperatures and adequate moisture. These conditions favour the growth and metabolic activity of decomposer microorganisms in the detritus.

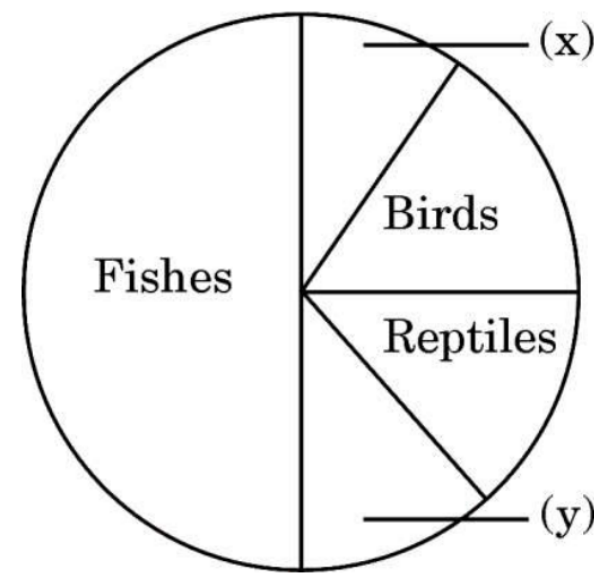
Step 2: Connect conditions with breakdown Active bacteria and fungi secrete enzymes that break complex organic matter into simpler substances. Warm, moist conditions accelerate this enzymatic breakdown compared with cold or dry conditions, where decomposer activity is restricted.

Step 3: Conclusion Warm temperatures and adequate moisture favour decomposer activity, causing rapid decomposition in the tropics.

Quick Tip to Solve: Link tropical warmth and moisture directly to the enzyme activity of decomposer microbes.

21(b)(ii). Identify 'x' and 'y' in the figure given below representing proportionate number of major vertebrate taxa.

[1 mark]



Solution:

Concept:

- The chart compares the relative numbers of species in the five major vertebrate taxa.
- The major vertebrate groups are fishes, amphibians, reptiles, birds and mammals.

Step 1: Read the labelled sectors Fishes occupy the large left half of the chart. Birds and reptiles are

already labelled in the right half. The remaining two sectors must therefore represent mammals and amphibians.

Step 2: Identify the two unlabelled groups The upper small sector marked x , between fishes and birds, represents mammals. The lower sector marked y , between reptiles and fishes, represents amphibians, following the relative species proportions shown in the standard vertebrate diversity chart.

Step 3: Conclusion x = Mammals; y = Amphibians.

Quick Tip to Solve: Locate x above the birds sector and y below reptiles before assigning the two missing taxa.

Section C (21 marks)

22. A woman has certain queries as listed below, before starting with contraceptive pills. Answer them.

(a) What do contraceptive pills contain ? Why are they considered as contraceptives ?

(b) What schedule should be followed for taking these pills ?

[3 marks]

Solution:

Concept:

- Oral contraceptive pills contain small doses of progestogens alone or a combination of progestogen and estrogen.
- Hormonal pills prevent conception by suppressing ovulation and producing changes that hinder fertilisation and implantation.

Step 1: (a) State the contents Contraceptive pills contain small doses of progestogens, either alone or combined with estrogen. These hormones alter the normal reproductive cycle in a controlled manner and are administered orally.

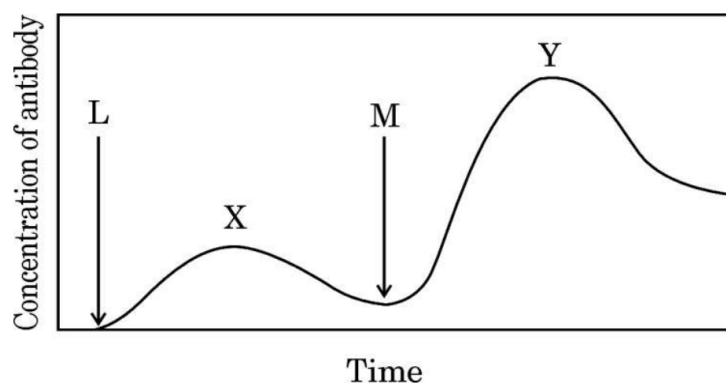
Step 2: (a) Explain the contraceptive action The pills inhibit ovulation, so an ovum is not normally released for fertilisation. They also alter the cervical mucus, making sperm entry into the female reproductive tract difficult, and modify the uterine endometrium so that implantation is inhibited. By preventing these essential steps leading to pregnancy, they act as contraceptives.

Step 3: (b) Describe the schedule One pill is taken daily for 21 days, starting within the first five days of the menstrual cycle. This is followed by a gap of seven days, during which menstruation occurs. The same daily 21-day course is then repeated after the seven-day interval, continuing the cyclic schedule for as long as contraception is required.

Step 4: Conclusion The pills contain progestogens alone or with estrogen; they inhibit ovulation and implantation and hinder sperm entry. Take one pill daily for 21 days, begin within the first five days of the cycle, then allow a seven-day gap and repeat.

Quick Tip to Solve: Remember the sequence: start within five days, take daily for 21 days, pause seven days, repeat.

23. The graph given below indicates the administration of the first (L) and second dose (M) of a vaccine. The corresponding response of the body is indicated by X and Y. Interpret the graph and explain the reason for such a response shown by the body. [3 marks]



Solution:

Concept:

- Vaccination induces active acquired immunity: exposure to an antigen activates antigen-specific lymphocytes and produces immunological memory.
- The primary response follows the first encounter; the secondary or anamnestic response follows a subsequent encounter with the same antigen.

Step 1: Interpret response X after dose L L represents the first vaccine dose. The vaccine antigen is encountered for the first time, so the body produces a primary immune response, X. There is a relatively long lag before antibody concentration rises because the few matching naive lymphocytes must first recognise the antigen, become activated and multiply. The antibody peak is relatively low and the concentration subsequently declines.

Step 2: Explain memory established by the first dose During the primary response, activated B lymphocytes form antibody-secreting plasma cells and long-lived memory B cells. Memory T cells are also generated. Although circulating antibody concentration falls after the first response, the antigen-specific memory cells remain in the body and preserve the ability to respond to that antigen.

Step 3: Interpret response Y after dose M M is the second dose or booster containing the same antigen. It activates the previously formed memory cells. Their rapid multiplication and differentiation give a secondary response, Y, with a shorter lag, a much higher antibody concentration and a more sustained response than X. Thus the graph demonstrates the specificity and memory of acquired immunity and explains why booster doses improve protection.

Step 4: Conclusion X is the slower, weaker primary immune response after L; Y is the faster, stronger and longer-lasting secondary response after M, caused by immunological memory.

Quick Tip to Solve: Compare the lag, peak height and duration of X and Y, then link all three differences to memory cells.

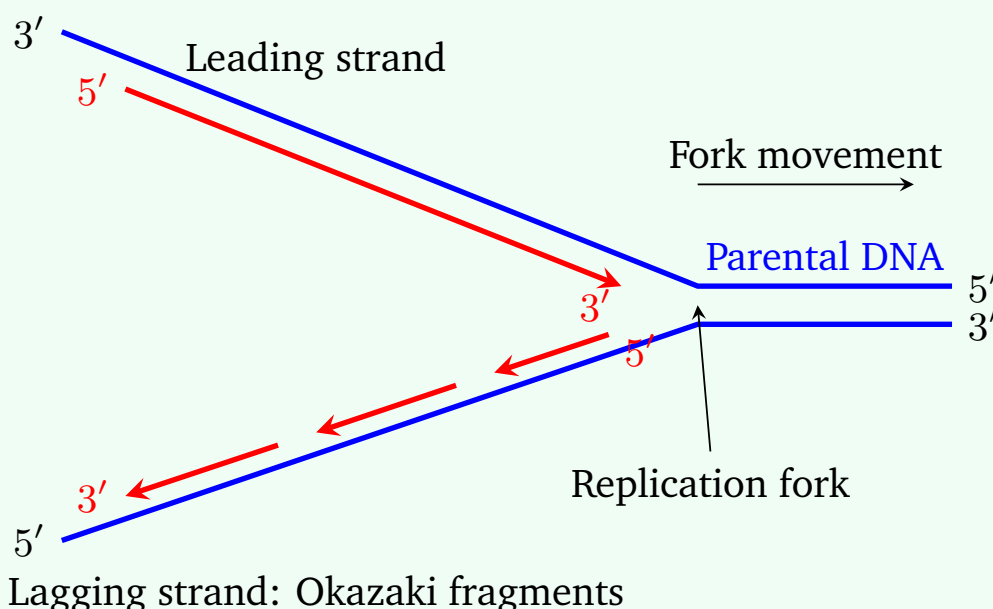
24. Draw a labelled schematic sketch of replication fork of DNA. Explain the role of any two enzymes involved in DNA replication. [3 marks]

Solution:

Concept:

- DNA replication is semiconservative: each daughter DNA molecule contains one parental strand and one newly synthesised strand.
- DNA polymerase extends a new DNA strand only in the $5' \rightarrow 3'$ direction; the antiparallel templates therefore give continuous and discontinuous synthesis.

Step 1: Label the replication fork The schematic shows the parental strands separating at the fork. The blue lines represent parental templates; red arrows represent newly synthesised DNA, with arrowheads at their growing $3'$ ends. The leading strand is made continuously towards the advancing fork. The lagging strand is made discontinuously as Okazaki fragments, each synthesised away from the fork. The two daughter strands are antiparallel to their respective templates.



DNA replication fork with parental templates and newly synthesised strands.

Step 2: Role of DNA-dependent DNA polymerase DNA-dependent DNA polymerase reads the parental DNA template and catalyses addition of complementary deoxyribonucleotides to the free $3'$ end of an existing primer. It makes phosphodiester bonds and extends each new strand only in the $5' \rightarrow 3'$ direction. Complementary base pairing ensures that the sequence of the template is copied accurately.

Step 3: Role of DNA ligase DNA ligase seals nicks in the sugar-phosphate backbone by forming phosphodiester bonds between adjacent DNA segments. After RNA primers on the lagging strand have been removed and replaced by DNA, ligase joins the Okazaki fragments into a continuous daughter strand. Thus polymerase synthesises the DNA whereas ligase completes the continuity of the backbone.

Step 4: Conclusion DNA polymerase synthesises complementary DNA in the $5' \rightarrow 3'$ direction; DNA ligase joins the discontinuously synthesised fragments of the lagging strand.

Quick Tip to Solve: Place 3-prime at each growing arrowhead; leading synthesis points towards the fork, while Okazaki synthesis points away.

25. A vector is genetically engineered with three features which facilitate gene-cloning within the host cell. List the three features and explain each one of them. [3 marks]

Solution:

Concept:

- A cloning vector carries foreign DNA into a suitable host and permits its propagation there.
- The three essential features are an origin of replication, a selectable marker and suitable cloning or recognition sites.

Step 1: Origin of replication (ori) The origin of replication is the DNA sequence from which replication starts. Foreign DNA linked to the vector is replicated along with it inside the host. The ori also influences the copy number of the linked DNA, so choosing an appropriate origin helps obtain the desired number of copies of the inserted gene.

Step 2: Selectable marker A selectable marker permits identification and selection of host cells that have taken up the vector, called transformants, from cells that have not. Antibiotic-resistance genes, such as those conferring ampicillin or tetracycline resistance, are common markers. On a suitable antibiotic-containing medium, cells carrying the resistance marker survive whereas non-transformants do not. Insertional inactivation of a marker can additionally help distinguish recombinant from non-recombinant transformants.

Step 3: Cloning sites or recognition sites The vector must have one or a few suitable recognition sites for restriction endonucleases, preferably a unique site for the chosen enzyme. Cutting at this site allows the foreign DNA to be inserted and joined by DNA ligase. A unique recognition site avoids cutting the vector into several fragments. The site should permit insertion without destroying functions essential for replication and maintenance of the recombinant vector.

Step 4: Conclusion The three features are ori for replication and copy-number control, a selectable marker for selecting transformants, and suitable unique restriction sites for insertion of foreign DNA.

Quick Tip to Solve: Remember ori, marker and cloning site by asking: how will DNA multiply, how will hosts be selected, and where will the insert join?

26. (a) Why do sportspersons often fall victim to cocaine addiction ? Name the plant from which this drug is derived. Also write down the mode of action of this drug.

(b) Name one drug and its harmful effect obtained from latex of Poppy plant. [3 marks]

Solution:

Concept:

- Cocaine is a powerful central nervous system stimulant; repeated use can cause dependence.
- Opioids act on opioid receptors and generally depress central nervous system activity.

Step 1: Explain attraction and source of cocaine (a) Sportspersons may misuse cocaine because its stimulant action produces temporary euphoria, increased energy and alertness, and a feeling of enhanced performance or reduced fatigue. Repeated misuse can lead to addiction; this perceived

benefit does not make it a safe aid to sport. Cocaine, also called coca alkaloid, is obtained from the coca plant, *Erythroxylum coca*.

Step 2: Explain its mode of action Cocaine interferes with the transport of the neurotransmitter dopamine. In particular, it inhibits dopamine reuptake at synapses, increasing its availability and prolonging stimulation of the reward pathway. This produces the characteristic sense of euphoria and contributes to compulsive repeated use.

Step 3: Identify a poppy-latex drug and its harm (b) Morphine is an opioid obtained from the latex of the poppy plant, *Papaver somniferum*. Its misuse can cause dependence and depress breathing by depressing the central nervous system. Heroin is prepared from morphine, but morphine itself is a direct example of a drug obtained from poppy latex.

Step 4: Conclusion Cocaine from *Erythroxylum coca* causes stimulant euphoria by interfering with dopamine transport. Morphine from poppy latex can cause dependence and respiratory depression.

Quick Tip to Solve: Link cocaine with coca, dopamine and stimulation; link morphine with poppy latex and depression of breathing.

27. (a) How does the Mediterranean orchid ‘Ophrys’ ensure its pollination by bees without offering any floral rewards ?

(b) Name the type of interaction seen in each of the following examples :

(i) *Ascaris* worms living in the intestine of humans.

(ii) Clown fish living amongst the tentacles of sea anemone.

[3 marks]

Solution:

Concept:

- Pollination transfers pollen from the anther to the stigma; floral signals can attract a pollinator even without nectar rewards.
- In parasitism one partner benefits while the other is harmed; in commensalism one benefits and the other is neither helped nor harmed.

Step 1: Explain sexual deceit in the orchid (a) One petal of the Mediterranean orchid *Ophrys* resembles a female bee in size, colour and markings. This resemblance attracts a male bee, which attempts to mate with the flower, a behaviour called pseudocopulation. The flower thus uses sexual deceit instead of providing a nectar or pollen reward.

Step 2: Connect the bee visits to pollen transfer During the male bee's attempt at pseudocopulation, pollen from the orchid becomes attached to its body. When the same bee visits another *Ophrys* flower and repeats the behaviour, it transfers the pollen to that flower's stigma. In this way the orchid achieves pollination without offering a floral reward.

Step 3: Classify the two interactions (b)(i) *Ascaris* in the human intestine shows parasitism: the worm obtains food and shelter, whereas the human host is harmed. (ii) The clown fish and sea anemone show commensalism in the standard textbook example: the fish gains protection from predators among the stinging tentacles, while the anemone is neither benefited nor harmed.

Step 4: Conclusion *Ophrys* uses sexual deceit and pseudocopulation to transfer pollen. The interactions are (i) parasitism and (ii) commensalism.

Quick Tip to Solve: For the interaction names, ask whether the second organism is harmed or unaffected after identifying the beneficiary.

28. Biotechnology has helped farmers to get pest-resistant cotton crops. Explain the technique adopted along with its mode of action. [3 marks]

Solution:

Concept:

- Genetic engineering introduces a useful gene into a crop so that the plant expresses the desired trait.
- Bt cotton expresses insecticidal proteins encoded by cry genes from *Bacillus thuringiensis*; the toxin acts after activation in a susceptible insect gut.

Step 1: Produce a transgenic cotton plant The technique is recombinant DNA technology or genetic engineering. Suitable insecticidal cry genes are isolated from the bacterium *Bacillus thuringiensis* (Bt), inserted into an appropriate vector, and introduced into cotton cells. Transformed cells are selected and regenerated into plants that express the Bt protein. For example, cryIAC and cryIIAb genes produce proteins effective against cotton bollworms.

Step 2: Activate the toxin inside the insect Bt toxin is produced in an inactive protoxin form, so the bacterium itself is not killed. When a susceptible bollworm larva feeds on the transgenic cotton tissue, it ingests the protein. The alkaline conditions of the insect gut solubilise the crystals and convert the inactive protoxin into the active toxin.

Step 3: Explain how the pest is killed The activated toxin binds to specific receptors on the surface of midgut epithelial cells. It forms pores in their membranes, causing cell swelling and lysis. Destruction of the gut epithelium kills the susceptible insect larva, thereby protecting the cotton crop. The action is selective because particular Bt toxins act against particular groups of insects.

Step 4: Conclusion Bt cotton is made by introducing Bt cry genes into cotton. The ingested toxin becomes active in the alkaline insect gut, damages midgut cells through pore formation and kills susceptible bollworms.

Quick Tip to Solve: Remember the sequence: cry gene transfer, toxin ingestion, alkaline activation, receptor binding, pores and gut-cell lysis.

Section D (8 marks)

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

29(a). Read the following passage and answer the questions that follow.

The chromosome number is fixed for all normal organisms leading to species specification, whereas any abnormality in the chromosome number of an organism results into abnormal individuals. Sometimes an error may occur during meiosis of cell cycle, where the sister chromatids fail to segregate, called non-disjunction, leading to the production of abnormal gametes with altered chromosome number. On fertilization, such gametes develop into abnormal individuals.

State what is aneuploidy.

[1 mark]

Solution:

Concept:

- A chromosome complement normally contains a characteristic number of each chromosome.
- Aneuploidy changes the number of particular chromosomes, rather than adding or removing complete chromosome sets.

Step 1: Define the chromosome-number change Aneuploidy is the gain or loss of one or more individual chromosomes from the normal chromosome complement. It commonly results from nondisjunction during cell division.

Step 2: Distinguish it from a whole-set change For a diploid organism, monosomy has $2n - 1$ chromosomes and trisomy has $2n + 1$ chromosomes. These illustrate aneuploidy because a particular chromosome is missing or extra; the change is not the addition of an entire haploid set.

Step 3: Conclusion Aneuploidy is an abnormal chromosome number caused by the loss or gain of one or more individual chromosomes.

Quick Tip to Solve: Use the words individual chromosomes in the definition to distinguish aneuploidy from a change in whole chromosome sets.

29(b). Read the following passage and answer the questions that follow.

The chromosome number is fixed for all normal organisms leading to species specification, whereas any abnormality in the chromosome number of an organism results into abnormal individuals. Sometimes an error may occur during meiosis of cell cycle, where the sister chromatids fail to segregate, called non-disjunction, leading to the production of abnormal gametes with altered chromosome number. On fertilization, such gametes develop into abnormal individuals.

A normal human sperm ($22 + Y$) fertilizes an ovum with karyotype ($22 + XX$). Name the disorder of the offspring thus produced and write any two symptoms of the disorder.

[2 marks]

Solution:

Concept:

- Non-disjunction can produce an ovum with two X chromosomes instead of one; fertilisation changes the chromosome number of the zygote.

- Klinefelter syndrome is associated with an additional X chromosome in a male, giving the sex-chromosome complement XXY .

Step 1: Find the chromosome complement The sperm contributes 22 autosomes and a Y chromosome, while the ovum contributes 22 autosomes and two X chromosomes. Therefore,

$$(22 + Y) + (22 + XX) = 44 + XXY.$$

The offspring has 47 chromosomes, including three sex chromosomes. The presence of a Y chromosome makes the offspring male; the extra X produces Klinefelter syndrome rather than Turner syndrome, which involves loss of an X chromosome.

Step 2: State two characteristic symptoms The male has underdeveloped testes and is sterile because normal sperm formation is impaired. He also shows development of breasts, called gynaecomastia. These are characteristic effects of the abnormal sex-chromosome complement; the extra chromosome is a sex chromosome, not chromosome 21 as in Down syndrome.

Step 3: Conclusion The offspring has $44 + XXY$, i.e. Klinefelter syndrome. Two symptoms are underdeveloped testes with sterility and breast development (gynaecomastia).

Quick Tip to Solve: Add the autosomes and sex chromosomes separately before naming the syndrome.

29(c)(i). Read the following passage and answer the questions that follow.

The chromosome number is fixed for all normal organisms leading to species specification, whereas any abnormality in the chromosome number of an organism results into abnormal individuals. Sometimes an error may occur during meiosis of cell cycle, where the sister chromatids fail to segregate, called non-disjunction, leading to the production of abnormal gametes with altered chromosome number. On fertilization, such gametes develop into abnormal individuals.

What is meant by trisomy? Mention the chromosome number that shows trisomy in Down's syndrome.

[1 mark]

Solution:

Concept:

- Trisomy is an aneuploid condition involving an extra copy of one particular chromosome.
- Its chromosome number is $2n + 1$, where $2n$ is the normal diploid number.

Step 1: Define trisomy In trisomy, a homologous chromosome pair is represented by three copies instead of the normal two. The increase concerns one chromosome, not an entire extra chromosome set, so it differs from triploidy.

Step 2: Identify the chromosome Down syndrome results from trisomy of chromosome 21. Thus, chromosome 21 occurs in three copies; a typical affected individual has 47 chromosomes instead of 46.

Step 3: Conclusion Trisomy means the presence of one extra chromosome ($2n + 1$). Down syndrome shows trisomy of chromosome 21.

Quick Tip to Solve: Remember that 21 identifies the affected chromosome; 47 is the total chromosome count.

29(c)(ii). Read the following passage and answer the questions that follow.

The chromosome number is fixed for all normal organisms leading to species specification, whereas any abnormality in the chromosome number of an organism results into abnormal individuals. Sometimes an error may occur during meiosis of cell cycle, where the sister chromatids fail to segregate, called non-disjunction, leading to the production of abnormal gametes with altered chromosome number. On fertilization, such gametes develop into abnormal individuals.

Write any two symptoms of Down's syndrome.

[1 mark]

Solution:

Concept:

- Down syndrome is a chromosomal disorder associated with an extra copy of chromosome 21.
- Its effects include characteristic physical features and delayed mental development.

Step 1: Give a growth-related feature An individual with Down syndrome commonly has short stature. This describes reduced overall body height and is a recognised physical feature of the syndrome.

Step 2: Give a distinct physical feature The palm is broad and commonly bears a single transverse palmar crease. This is a second feature, separate from short stature. Other typical features can include a small round head and a partially open mouth with a protruding, furrowed tongue.

Step 3: Conclusion Two symptoms of Down syndrome are short stature and a broad palm with a characteristic single palmar crease.

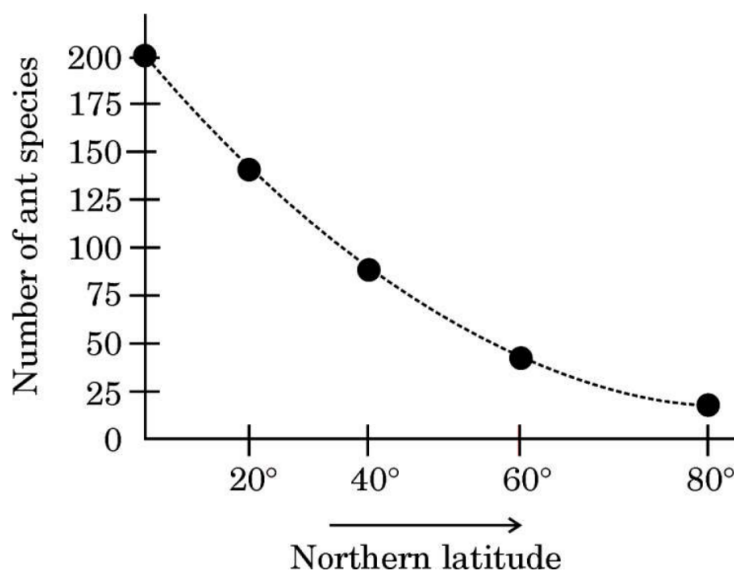
Quick Tip to Solve: Use two distinct textbook features, rather than repeating one feature in different words.

30(a). Biodiversity shows latitudinal and altitudinal gradients. There is little biodiversity at poles. It increases in temperate areas but reaches the maximum in tropics (latitudinal range of 23.5° N to 23.5° S). It is because the tropical rainforests have favourable environmental conditions not only for speciation, but also for supporting both variety and number of organisms. Harsh conditions exist in temperate areas during the cold season only. Number of vascular species is 118 – 236/0.1 ha in tropical forests and 21 – 48 species/0.1 ha in temperate forests. Their number would be 0.0 – 10.0 species/0.1 ha in arctic regions. Such a correlation occurs also in case of other taxonomic groups like ants, butterflies, birds, etc.

Based on the above information and graph, answer the following questions :

What does the graph depict ?

[1 mark]



Solution:

Concept:

- Species richness is the number of different species present in a region or community.
- A latitudinal gradient describes how species richness changes from the equator towards the poles.

Step 1: Read the axes The horizontal axis shows northern latitude and the vertical axis shows the number of ant species. The plotted values fall as northern latitude increases.

Step 2: Interpret the trend Ant species richness is greatest near the equator and declines towards higher northern latitudes. The graph therefore illustrates the latitudinal gradient in biodiversity, with greater richness in tropical regions than towards the poles.

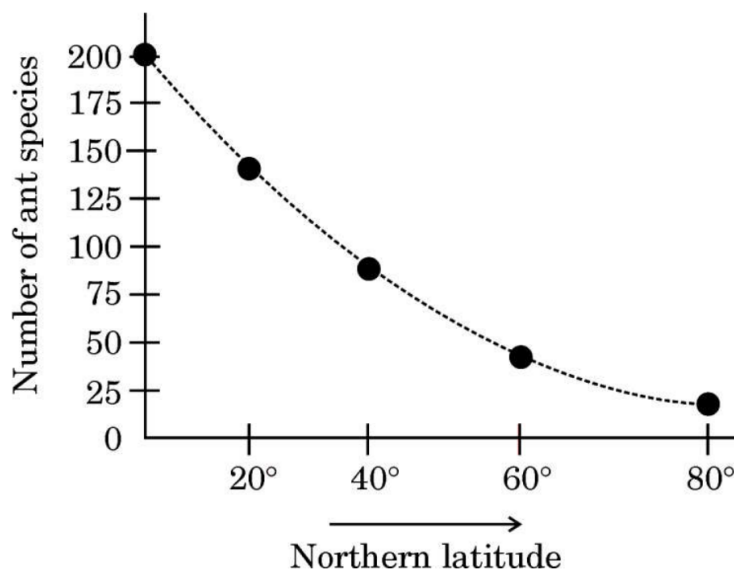
Step 3: Conclusion The graph depicts the latitudinal gradient of ant species richness: the number of species decreases from the equator towards the poles.

Quick Tip to Solve: Identify both axis variables before naming the biodiversity pattern shown by a graph.

30(b). Biodiversity shows latitudinal and altitudinal gradients. There is little biodiversity at poles. It increases in temperate areas but reaches the maximum in tropics (latitudinal range of 23.5° N to 23.5° S). It is because the tropical rainforests have favourable environmental conditions not only for speciation, but also for supporting both variety and number of organisms. Harsh conditions exist in temperate areas during the cold season only. Number of vascular species is 118 – 236/0.1 ha in tropical forests and 21 – 48 species/0.1 ha in temperate forests. Their number would be 0.0 – 10.0 species/0.1 ha in arctic regions. Such a correlation occurs also in case of other taxonomic groups like ants, butterflies, birds, etc.

Based on the above information and graph, answer the following questions :

With the help of graph, show the species-area relationship for a wide variety of taxa in a forest. Write an equation that shows this relationship on a logarithm scale. [2 marks]



Solution:

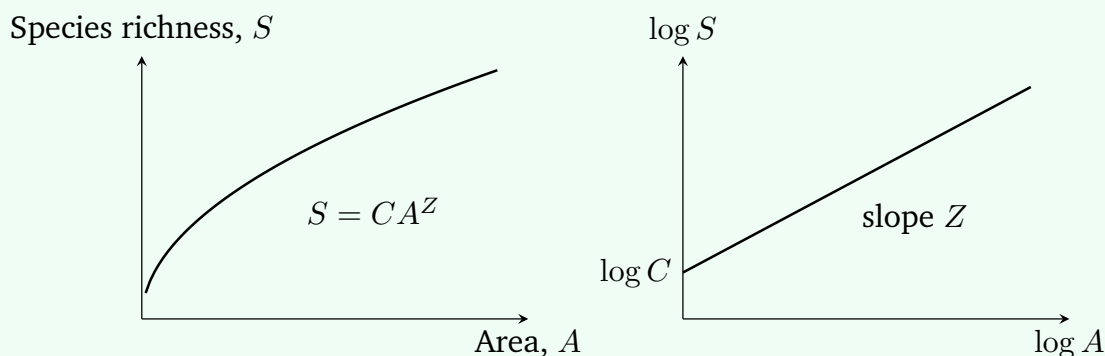
Concept:

- Within a region, species richness increases with the area explored, up to a limit.
- The relationship is $S = CA^Z$, where S is species richness, A is area, C is a constant and Z is the regression coefficient (slope on logarithmic axes).

Step 1: Represent the species-area relationship For a wide variety of taxa in a forest, increasing the area sampled includes more habitats and hence more species. On ordinary arithmetic axes the relation is a rising, concave-down curve, called a rectangular hyperbola in the textbook description. Its mathematical form is

$$S = CA^Z.$$

The curve below shows the general trend rather than measured values for a particular forest.



Species-area relationship on ordinary and logarithmic axes

Step 2: Convert to a logarithmic scale Taking logarithms of both sides gives

$$\log S = \log C + Z \log A.$$

Thus a plot of $\log S$ against $\log A$ is a straight line with slope Z and vertical intercept $\log C$. Within a region, Z is generally in the range 0.1 to 0.2 for a wide variety of taxa. The logarithmic plot makes the power relationship linear.

Step 3: Conclusion The species-area curve rises with area according to $S = CA^Z$. On a logarithmic scale, $\log S = \log C + Z \log A$, a straight line with slope Z .

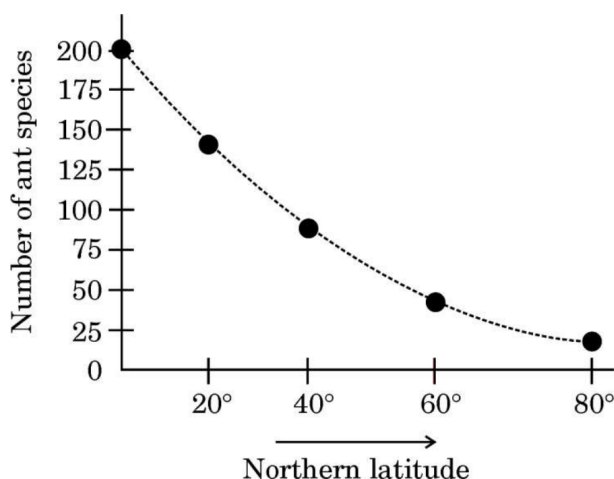
Quick Tip to Solve: For a power law, take logarithms to turn the exponent into the slope of a straight line.

30(c)(i). Biodiversity shows latitudinal and altitudinal gradients. There is little biodiversity at poles. It increases in temperate areas but reaches the maximum in tropics (latitudinal range of 23.5° N to 23.5° S). It is because the tropical rainforests have favourable environmental conditions not only for speciation, but also for supporting both variety and number of organisms. Harsh conditions exist in temperate areas during the cold season only. Number of vascular species is 118 – 236/0.1 ha in tropical forests and 21 – 48 species/0.1 ha in temperate forests. Their number would be 0.0 – 10.0 species/0.1 ha in arctic regions. Such a correlation occurs also in case of other taxonomic groups like ants, butterflies, birds, etc.

Based on the above information and graph, answer the following questions :

Explain the correlation between latitudinal gradient and number of plant species.

[1 mark]



Solution:

Concept:

- Species richness is the number of species in a given area. Latitude measures angular distance north or south of the equator.
- The latitudinal diversity gradient relates increasing distance from the equator to decreasing species richness.

Step 1: State the relationship The number of plant species generally decreases as latitude increases from the equator towards either pole. Conversely, plant species richness increases on moving from polar regions towards the tropics.

Step 2: Use the supplied evidence Tropical forests contain 118–236 vascular plant species per 0.1 ha, compared with 21–48 in temperate forests and 0–10 in arctic regions. These figures compare equal areas, so they demonstrate a gradient in species richness rather than an effect of sampling a larger area.

Step 3: Conclusion Plant species richness is greatest in the tropics and declines towards the poles; it is negatively correlated with increasing absolute latitude.

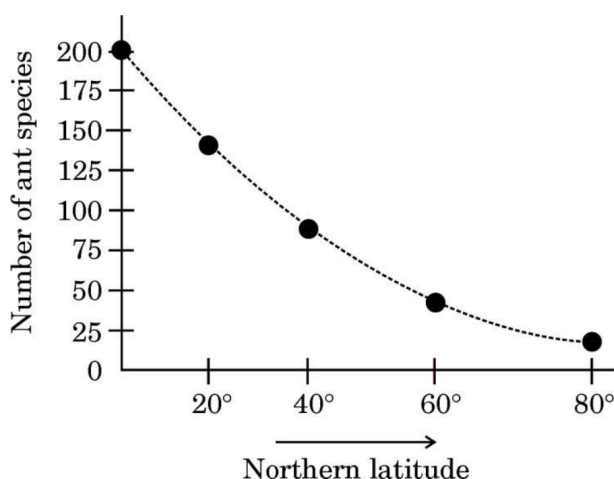
Quick Tip to Solve: Compare equal areas and describe the direction from equator to poles, not simply north to south.

OR

30(c)(ii). Biodiversity shows latitudinal and altitudinal gradients. There is little biodiversity at poles. It increases in temperate areas but reaches the maximum in tropics (latitudinal range of 23.5° N to 23.5° S). It is because the tropical rainforests have favourable environmental conditions not only for speciation, but also for supporting both variety and number of organisms. Harsh conditions exist in temperate areas during the cold season only. Number of vascular species is 118 – 236/0.1 ha in tropical forests and 21 – 48 species/0.1 ha in temperate forests. Their number would be 0.0 – 10.0 species/0.1 ha in arctic regions. Such a correlation occurs also in case of other taxonomic groups like ants, butterflies, birds, etc.

Based on the above information and graph, answer the following questions :

Tropics are considered to be more stable where species continue to flourish and evolve undisturbed for millions of years. Give any two reasons. [1 mark]



Solution:

Concept:

- Long periods without major climatic disturbance allow species to persist and diversify.
- A relatively constant environment favours niche specialisation and coexistence of species.

Step 1: Long evolutionary history Tropical regions have remained relatively undisturbed for millions of years, unlike temperate regions repeatedly affected by glaciations. This has provided a longer uninterrupted period for speciation and accumulation of species.

Step 2: Relatively constant climate Tropical environments are less seasonal, relatively more constant and predictable. Their stable climate favours niche specialisation, allowing many species to flourish together and continue evolving over long periods.

Step 3: Conclusion Two reasons are the long history without repeated glaciations and the relatively constant, less seasonal and predictable tropical climate.

Quick Tip to Solve: Give one historical reason and one climatic reason to keep the two explanations distinct.

Section E (15 marks)

31(a). (i) Identify the disease in which the body cells of the patient lose the property of contact inhibition. State its possible causes (any three). Also name any two methods to detect and to diagnose this disease.

(ii) Your classmate complains of headache and cough. The doctor confirms that he is suffering from pneumonia and not common cold, on the basis of certain symptoms. List these symptoms and write any two precautions to be followed to prevent the spread of this disease. [5 marks]

Solution:

Concept:

- Normal cells show contact inhibition: contact with neighbouring cells restrains further proliferation. Cancer cells lose this control and divide uncontrollably.
- Carcinogens can transform normal cells into cancerous cells. Pneumonia is an infection of the lungs in which the alveoli may fill with fluid, impairing gas exchange.

Step 1: (i) Identify the disease The disease is cancer. Loss of contact inhibition permits cells to proliferate even when they touch surrounding cells, producing an abnormal mass of cells called a tumour. Malignant tumour cells can invade neighbouring tissues and spread to distant sites.

Step 2: (i) State three possible causes Three possible cancer-causing agents are: (1) ionising radiation, such as X-rays or gamma rays; (2) chemical carcinogens, such as those present in tobacco smoke; and (3) oncogenic viruses, which can introduce or activate cancer-promoting genetic changes. These agents can disrupt the normal regulation of cell growth and division.

Step 3: (i) Give two detection and diagnostic methods 1. Biopsy followed by histopathological examination: a small piece of suspected tissue is removed and examined microscopically for cancerous changes. 2. Computed tomography (CT): X-rays produce cross-sectional images that help locate

abnormal internal growths and assess their extent.

Step 4: (ii) List symptoms suggesting pneumonia In addition to headache and cough, pneumonia commonly causes fever and chills. Infection of the alveoli causes fluid accumulation and breathing difficulty. In severe cases, the lips and fingernails may become grey to bluish because oxygen supply is reduced. These lung-related signs distinguish it from the usual common cold, which mainly affects the nose and upper respiratory passages.

Step 5: (ii) State two precautions against spread 1. Cover the nose and mouth while coughing or sneezing, preferably with a tissue that is disposed of properly, to reduce the release of infectious respiratory droplets. 2. Avoid close contact with infected persons and do not share their drinking glasses or eating utensils, since droplets and contaminated articles can transmit the infection.

Step 6: Conclusion (i) Cancer; causes include ionising radiation, tobacco-smoke carcinogens and oncogenic viruses; biopsy with histopathology and CT help detect and diagnose it. (ii) Pneumonia causes fever, chills and breathing difficulty, with grey-bluish lips and nails in severe cases. Practise cough hygiene and avoid close contact or sharing utensils with an infected person.

Quick Tip to Solve: Link contact inhibition to cancer; link alveolar fluid and breathing difficulty to pneumonia rather than common cold.

OR

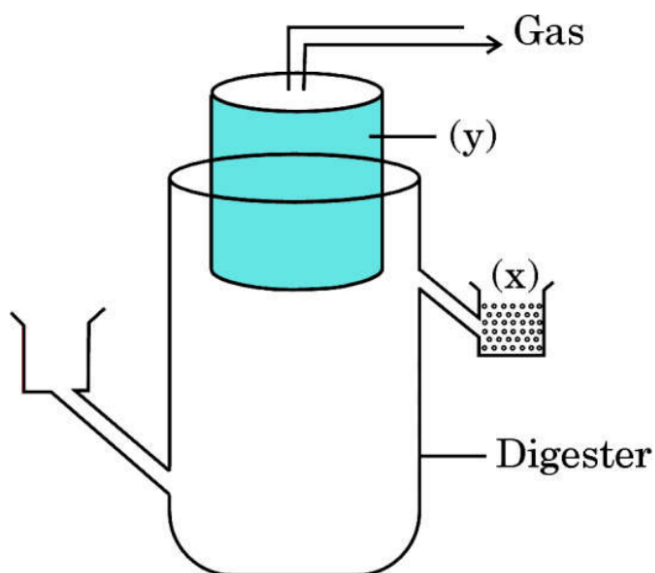
31(b). Study the diagram of a typical biogas plant and answer the following questions :

(i) Identify 'x' and 'y'.

(ii) Write three components of biogas. Name one microorganism which is involved in biogas production.

(iii) Name two institutes which developed the technology of biogas production in India.

[5 marks]



Solution:

Concept:

- Biogas is produced by anaerobic microbial digestion of organic wastes such as cattle dung. Methanogens produce methane under oxygen-free conditions.
- A typical biogas plant has a digester, a floating gas holder to collect biogas, and an outlet for spent slurry that can be used as manure.

Step 1: (i) Identify x The label x points to the spent slurry emerging through the side outlet. It is the digested slurry left after anaerobic breakdown of organic matter. It is rich in nutrients and can be used as manure in agricultural fields. Thus, the outlet supplies a useful fertiliser while allowing the plant to receive more dung slurry through the inlet.

Step 2: (i) Identify y The label y points to the floating gas holder, also called the floating cover. It collects the biogas produced in the digester and rises as gas accumulates. Gas is taken out through the pipe connected to its upper portion for use as fuel. The larger chamber below is the digester, which is already labelled in the question.

Step 3: (ii) State the components and microorganism Three components of biogas are methane (CH_4), carbon dioxide (CO_2), and hydrogen (H_2). Methane is the major combustible constituent. One microorganism involved is *Methanobacterium*, a methanogen that grows anaerobically and contributes to methane production during digestion of cattle-dung slurry. Methanogens are also found in the rumen of cattle, explaining their presence in dung used as the inoculum.

Step 4: (iii) Name the institutes The technology for biogas production in India was developed mainly through the efforts of the Indian Agricultural Research Institute (IARI) and the Khadi and Village Industries Commission (KVIC). These are the two institutions associated with development of this technology in the standard account of biogas production. Biogas plants provide a useful way of converting locally available organic waste into fuel and manure.

Step 5: Conclusion x is spent slurry and y is the floating gas holder. Biogas contains methane, carbon dioxide and hydrogen; *Methanobacterium* participates in its production. The two institutions are IARI and KVIC.

Quick Tip to Solve: Follow the outlet pipe to identify spent slurry; the upper cylinder connected to the gas pipe is the floating gas holder.

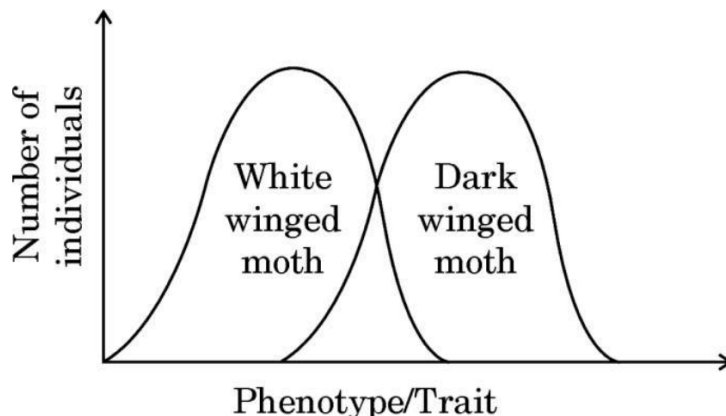
32(a). (i) Natural selection operates in different ways in nature.

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

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

(ii) State Hugo de Vries' theory of mutation. How is it different from Darwin's theory of natural selection ?

[5 marks]



Solution:

Concept:

- Natural selection favours heritable variants that survive and reproduce more successfully in a particular environment. A change in the environment can change which variant has this advantage.
- Directional selection favours one extreme phenotype and shifts the population distribution towards it. Mutation theory emphasises sudden heritable changes, whereas Darwin emphasised gradual accumulation of favourable small variations.

Step 1: (i)(I) Explain industrial melanism Before industrialisation, tree trunks in England were lighter and covered with lichens. White-winged moths blended with this background, whereas dark-winged moths were more conspicuous to predatory birds. After industrialisation, soot darkened tree trunks and pollution reduced the lichens. Dark-winged moths then became better camouflaged, while white-winged moths stood out and were more readily eaten by birds. Consequently, dark moths survived and reproduced more successfully, increasing their frequency in the population. The environment selected an existing heritable colour variant; the moths did not deliberately change their colour.

Step 2: (i)(II) Identify the selection in the graph The graph shows directional selection. The distribution shifts from the white-winged phenotype towards the dark-winged phenotype because the changed environment favours the darker extreme. It is not stabilising selection, which favours the intermediate phenotype, nor disruptive selection, which favours both extremes over intermediates.

Step 3: (ii) State Hugo de Vries' mutation theory From his work on the evening primrose, *Oenothera lamarckiana*, Hugo de Vries proposed that evolution and the origin of new species occur through mutations: sudden, heritable, discontinuous changes. He regarded mutations as random and directionless and proposed that speciation could occur by a single large change, called saltation.

Step 4: (ii) Compare it with Darwin's view Darwin's theory explains evolution by natural selection acting on small heritable variations. Individuals with favourable variations leave more offspring,

so these variations accumulate over many generations and evolutionary change is gradual. In contrast, de Vries emphasised sudden, large mutations and discontinuous change rather than the slow accumulation of small variations. Thus, Darwinian evolution is gradual in this comparison, whereas de Vries' saltation is a sudden change leading to a new form.

Step 5: Conclusion Soot-darkened trunks favoured camouflaged dark moths through differential survival and reproduction. The graph depicts directional selection. De Vries emphasised sudden mutations and saltation, while Darwin emphasised gradual accumulation of favourable small variations through natural selection.

Quick Tip to Solve: A shift of the whole curve towards one extreme indicates directional selection; connect the shift to camouflage and differential reproduction.

OR

32(b). (i) (I) Why did Hershey and Chase use ^{35}S and ^{32}P in their experiments ? Explain.

(II) Write the conclusion they reached at the end of the experiment.

(ii) Draw a clover leaf-like structure of tRNA showing the following :

(I) Tyrosine attached to the amino acid site.

(II) Anticodon for this amino acid in its correct site (codon for tyrosine is UAC).

[5 marks]

Solution:

Concept:

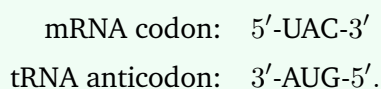
- A radioactive tracer distinguishes the two possible hereditary substances: DNA contains phosphorus in its phosphate backbone, whereas proteins can contain sulphur in cysteine and methionine.
- During bacteriophage infection, the material that enters the bacterium and directs production of new phages is the genetic material.
- tRNA has an amino acid attachment site at its 3'-CCA end and an anticodon loop that recognises a complementary, antiparallel mRNA codon.

Step 1: (i)(I) Explain the choice of radioactive isotopes Hershey and Chase grew one batch of bacteriophages in a medium containing radioactive ^{35}S . Sulphur occurs in the amino acids cysteine and methionine of proteins but is absent from DNA. Thus ^{35}S labelled the phage protein coat selectively. They grew another batch in a medium containing radioactive ^{32}P . DNA contains phosphorus in its sugar-phosphate backbone, whereas the phage coat proteins do not contain phosphorus. Hence ^{32}P labelled phage DNA selectively. Using separate batches allowed the fate of DNA and protein to be followed independently during infection of *E. coli*.

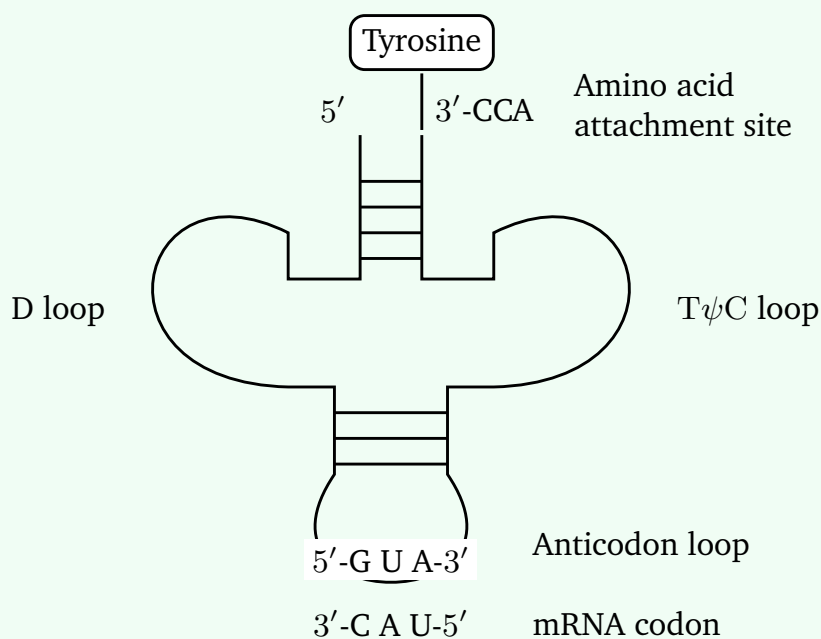
Step 2: (i)(II) State the experimental evidence and conclusion After the labelled phages infected bacteria, blending detached the phage coats and centrifugation separated the bacterial pellet from the supernatant. With ^{35}S -labelled phages, radioactivity remained mainly in the supernatant with the detached protein coats. With ^{32}P -labelled phages, radioactivity was found in the bacterial pellet, showing that phage DNA had entered the cells. DNA directed the formation of progeny phages. They therefore concluded that DNA, rather than the protein coat, is the genetic material of the

bacteriophage.

Step 3: (ii) Locate tyrosine and its anticodon on tRNA Tyrosine is attached to the terminal adenosine of the 3'-CCA amino acid acceptor end. The anticodon is situated in the anticodon loop, opposite the acceptor stem in the cloverleaf representation. For the given tyrosine codon, pairing is



Thus the anticodon is AUG when written antiparallel to the given codon; when written in the conventional 5'-to-3' direction it is GUA. The drawing labels both polarity and the attachment site so that these two representations are unambiguous.



Cloverleaf tRNA carrying tyrosine, with the anticodon shown antiparallel to the UAC codon.

Step 4: Conclusion ^{35}S traces phage protein and ^{32}P traces DNA; the experiment established DNA as the phage genetic material. Tyrosine attaches at the tRNA 3'-CCA end, and its anticodon pairs as 3'-AUG-5' with 5'-UAC-3'.

Quick Tip to Solve: Write codon and anticodon on separate antiparallel lines before labelling the tRNA; attach the amino acid to the 3'-CCA end, never to the anticodon loop.

33(a). (i) Draw a diagram of an enlarged view of transverse section (T.S.) of one microsporangium of an angiosperm and label the following parts :

(I) Tapetum

(II) Middle layers

(III) Endothecium

(IV) Microspore mother cell

(ii) Write the function of Tapetum.

(iii) Explain the following giving reasons :

(I) Pollen grains are well-preserved as fossils.

(II) Pollen tablets are in use by people these days.

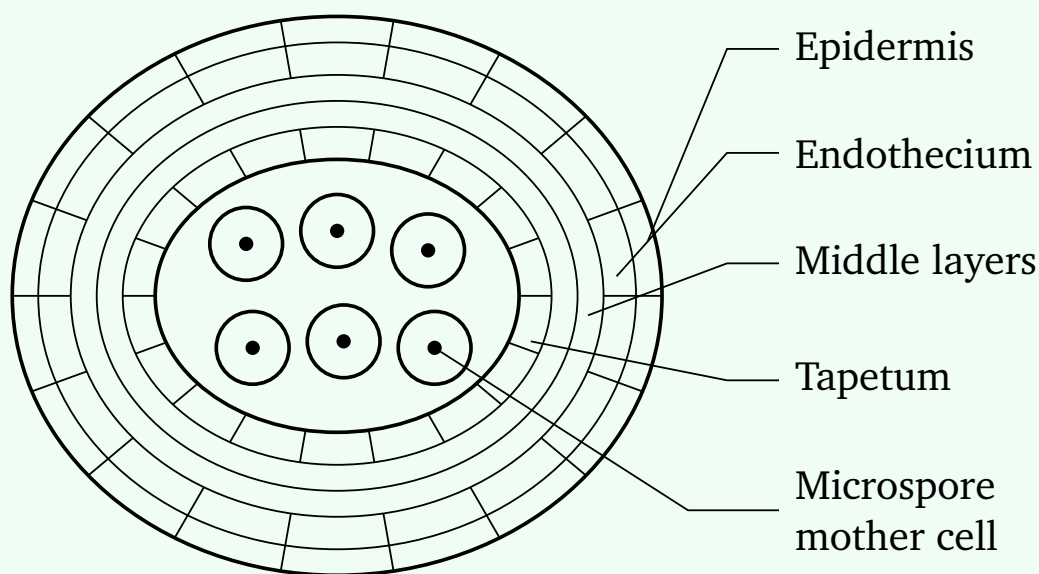
[5 marks]

Solution:

Concept:

- A microsporangium is surrounded by four wall layers: epidermis, endothecium, middle layers and tapetum, from outside towards the centre.
- The central sporogenous tissue differentiates into diploid microspore mother cells. Each mother cell undergoes meiosis to form a tetrad of haploid microspores.
- The tapetum nourishes developing pollen grains; the pollen exine contains the highly resistant substance sporopollenin.

Step 1: (i) Enlarged T.S. of one microsporangium The labelled diagram shows a young microsporangium containing microspore mother cells. The tapetum is the innermost wall layer, immediately surrounding the sporogenous tissue. Outside it lie the middle layers, endothecium and epidermis. The central cells shown are microspore mother cells, not mature pollen grains.



Enlarged T.S. of a young microsporangium (schematic)

Step 2: (ii) Function of tapetum The tapetum supplies nourishment to developing microspores and pollen grains. Its cells have dense cytoplasm and usually more than one nucleus, supporting their active nutritive role during pollen development.

Step 3: (iii)(I) Preservation of pollen grains as fossils The outer pollen wall, the exine, is made of sporopollenin, one of the most resistant organic materials known. It withstands high temperatures and strong acids and alkalis. No enzyme that degrades sporopollenin is known. Therefore, the exine resists decomposition over long periods, allowing pollen grains to remain well preserved as fossils even after softer tissues have decayed.

Step 4: (iii)(II) Use of pollen tablets Pollen grains are rich in nutrients. They are therefore marketed as pollen tablets and syrups and consumed as food supplements. Their use is based on their nutritive content; pollen consumption has also been claimed to improve the performance of athletes and race horses.

Step 5: Conclusion The diagram identifies the required wall layers and microspore mother cells. Tapetum nourishes developing pollen; sporopollenin explains fossil preservation, while the nutrient richness of pollen explains its use in food supplements.

Quick Tip to Solve: Remember the outside-to-inside order as epidermis, endothecium, middle layers, tapetum; place mother cells inside the tapetum.

OR

33(b)(i). Where does spermatogenesis occur in human testes ? Describe the process of spermatogenesis up to the formation of spermatozoa.

[3 marks]

Solution:

Concept:

- Spermatogenesis forms haploid spermatozoa from diploid spermatogonia in the seminiferous tubules of testes, beginning at puberty.
- Mitosis maintains the spermatogonial population; two meiotic divisions reduce chromosome number and produce spermatids. Spermiogenesis transforms spermatids into spermatozoa.

Step 1: Site and multiplication of germ cells Spermatogenesis occurs in the seminiferous tubules of the human testes. Spermatogonia situated near the inner wall of the tubules multiply by mitotic divisions. Each spermatogonium is diploid, with $2n = 46$ chromosomes. Some spermatogonia enlarge and differentiate into primary spermatocytes, which also have 46 chromosomes.

Step 2: Meiotic formation of spermatids Each primary spermatocyte undergoes meiosis I to form two equal, haploid secondary spermatocytes, each containing $n = 23$ chromosomes. The secondary spermatocytes undergo meiosis II to produce four equal haploid spermatids in total from each primary spermatocyte. The chromosome number remains 23 in each spermatid after the second meiotic division.

Step 3: Transformation into spermatozoa The spermatids transform into spermatozoa through spermiogenesis. Their nuclei condense, the acrosome and tail develop, and excess cytoplasm is shed, producing the specialised sperm structure. Sertoli cells provide nourishment and support to developing germ cells. The sperm heads remain embedded in Sertoli cells during development; mature

spermatozoa are subsequently released into the lumen of the seminiferous tubule by spermiation.

Step 4: Conclusion In the seminiferous tubules, spermatogonia form primary spermatocytes, which undergo meiosis I and II to produce haploid spermatids. Spermiogenesis then converts these spermatids into spermatozoa; one primary spermatocyte yields four spermatozoa.

Quick Tip to Solve: Track the sequence as 46 chromosomes in primary spermatocytes, then 23 in secondary spermatocytes, spermatids and spermatozoa.

33(b)(ii). Trace the path of movement of spermatozoa from the testes upto the ejaculatory duct.

[2 marks]

Solution:

Concept:

- Spermatozoa are released into the lumen of the seminiferous tubules of the testes and then pass through the male reproductive ducts.
- The accessory ducts conduct sperm; the vas deferens joins the duct of the seminal vesicle to form the ejaculatory duct.

Step 1: Trace the route within and out of the testis From the seminiferous tubules, spermatozoa enter the rete testis, a network of channels within the testis. They then pass through the vasa efferentia, which leave the testis and open into the epididymis situated along its posterior surface. Thus the sequence so far is seminiferous tubules, rete testis, vasa efferentia and epididymis.

Step 2: Continue to the ejaculatory duct The epididymis continues as the vas deferens. This duct ascends into the abdomen and loops over the urinary bladder. It receives the duct from the seminal vesicle, and the resulting common duct is the ejaculatory duct. The seminal vesicle is an accessory gland that adds secretion; sperm do not pass through the body of this gland.

Step 3: Conclusion The path is: seminiferous tubules of the testes → rete testis → vasa efferentia → epididymis → vas deferens → ejaculatory duct.

Quick Tip to Solve: Remember the order rete testis, vasa efferentia, epididymis, vas deferens; the seminal-vesicle duct joins the final duct rather than forming a sperm-storage stop.