

CBSE Class 12 Biology Question Paper 2026 with Solution PDF-Set 57-5-1

Question Paper with Solutions

Conducted by the Central Board of Secondary Education (CBSE)



Time Allowed: 3 hours

Maximum Marks: 70

General Instructions

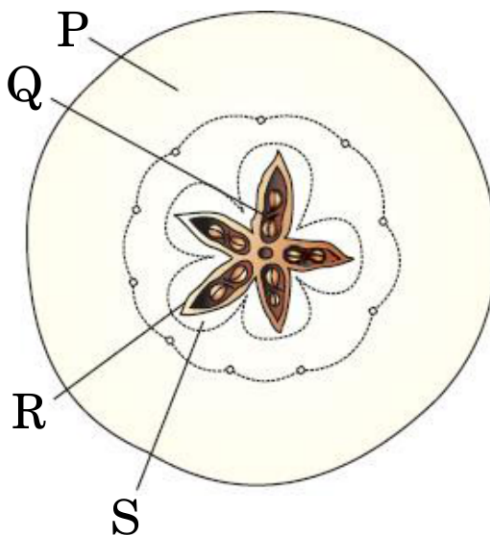
- (i) This question paper contains **33** questions. All questions are **compulsory**.
- (ii) Question paper is divided into **five** sections – Sections **A, B, C, D** and **E**.
- (iii) **Section A** – questions number **1** to **16** are Multiple Choice Type questions. Each question carries **1** 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. Identify the parts P, Q, R, S in the figure given below and select the option in the correct order.

[1 mark]



- (A) P - Seed, Q - Thalamus, R - Mesocarp, S - Endocarp
(B) P - Thalamus, Q - Seed, R - Endocarp, S - Mesocarp
(C) P - Seed, Q - Thalamus, R - Endocarp, S - Mesocarp
(D) P - Thalamus, Q - Seed, R - Mesocarp, S - Endocarp

Correct Answer: (B) P - Thalamus, Q - Seed, R - Endocarp, S - Mesocarp

Solution:

Concept:

- An apple is a false fruit: its fleshy thalamus contributes to the edible part, while the ovary forms the central fruit wall.
- Seeds develop from ovules. The endocarp is the innermost pericarp layer around the seed chambers; the mesocarp lies outside it.

Step 1: Identify the outer flesh and the seed P points to the broad outer fleshy region, which is the thalamus. Q points to a seed in the central core. Thus options (A) and (C), which interchange these two labels, are eliminated.

Step 2: Distinguish the two fruit-wall layers R points to the inner lining enclosing a seed chamber, the endocarp. S points to the region outside this lining, the mesocarp. Option (D) reverses R and S, so it does not match the labelled figure.

Step 3: Conclusion P = Thalamus, Q = Seed, R = Endocarp and S = Mesocarp. Hence, the correct option is (B).

Quick Tip to Solve: In an apple section, locate the broad thalamus first; then distinguish the inner endocarp from the mesocarp outside it.

2. The foetal ejection reflex in human triggers the release of _____ hormone from _____. Fill in the blanks by choosing right option. [1 mark]

- (A) oxytocin, foetal pituitary
- (B) oxytocin, maternal pituitary
- (C) human chorionic gonadotropin, placenta
- (D) progesterone, corpus luteum

Correct Answer: (B) oxytocin, maternal pituitary

Solution:

Concept:

- Signals from the fully developed foetus and placenta induce mild uterine contractions called the foetal ejection reflex.
- Oxytocin released from the maternal posterior pituitary stimulates stronger uterine contractions through positive feedback.

Step 1: Follow the parturition reflex The initial reflex stimulates oxytocin release in the mother. Oxytocin acts on her uterine muscle, causing stronger contractions. These contractions stimulate further oxytocin release until the baby is expelled.

Step 2: Check the hormone and its source The relevant pituitary is maternal, not foetal, eliminating (A). Human chorionic gonadotropin from the placenta and progesterone from the corpus luteum help support pregnancy; they are not the oxytocin response triggered by this reflex. Thus (C) and (D) do not fill the blanks correctly.

Step 3: Conclusion The blanks are oxytocin and maternal pituitary. Hence, the correct option is (B).

Quick Tip to Solve: Link foetal ejection reflex with maternal oxytocin: the foetus initiates the signal, but the mother's pituitary releases the hormone.

3. A DNA molecule is 160 base pairs long. It has 30% Guanine. How many Adenine bases are present in this DNA molecule? [1 mark]

- (A) 48
- (B) 64
- (C) 96
- (D) 192

Correct Answer: (B) 64

Solution:

Concept:

- In double-stranded DNA, Chargaff's rule gives $A = T$ and $G = C$, where the letters denote numbers or percentages of the corresponding bases.
- Each base pair contains two bases; hence a DNA molecule with n base pairs contains $2n$ bases altogether.

Step 1: Find the percentage of adenine Guanine accounts for 30%, so cytosine also accounts for 30%. The remaining 40% is shared equally between adenine and thymine.

$$A\% = \frac{100 - 30 - 30}{2} = 20\%.$$

Step 2: Convert the percentage into a base count The molecule contains $2 \times 160 = 320$ bases, counting both strands. Therefore,

$$N_A = \frac{20}{100} \times 320 = 64.$$

The value 48 is 30% of the number of base pairs and is not the adenine count. The value 96 counts guanine (or cytosine), and 192 counts guanine and cytosine together.

Step 3: Conclusion There are 64 adenine bases in the DNA molecule. Hence, the correct option is (B).

Quick Tip to Solve: Double the base-pair count before applying a base percentage; here adenine is half of the non-GC fraction.

4. In *Pisum sativum*, the flower colour may be violet (V) or white (v). What proportion of the offspring in a cross of 'VV' $\times$ 'vv' would be expected to be violet? [1 mark]

- (A) 25%
- (B) 50%
- (C) 75%
- (D) 100%

Correct Answer: (D) 100%

Solution:

Concept:

- In *Pisum sativum*, the allele *V* for violet flowers is dominant over the allele *v* for white flowers.
- A homozygous parent produces only one kind of gamete for this gene; a heterozygote expresses the dominant phenotype.

Step 1: Determine the parental gametes The violet parent has genotype *VV*, so each of its gametes carries *V*. The white parent has genotype *vv*, so each of its gametes carries *v*. There is only one possible combination when these gametes unite.

Step 2: Determine the offspring phenotype The cross *VV* $\times$ *vv* produces only *Vv* offspring. Every offspring therefore has the dominant allele and develops violet flowers. A 75% violet proportion belongs to *Vv* $\times$ *Vv*, while 50% belongs to *Vv* $\times$ *vv*; neither is the given cross. A 25% violet proportion is also incompatible with all offspring receiving *V*.

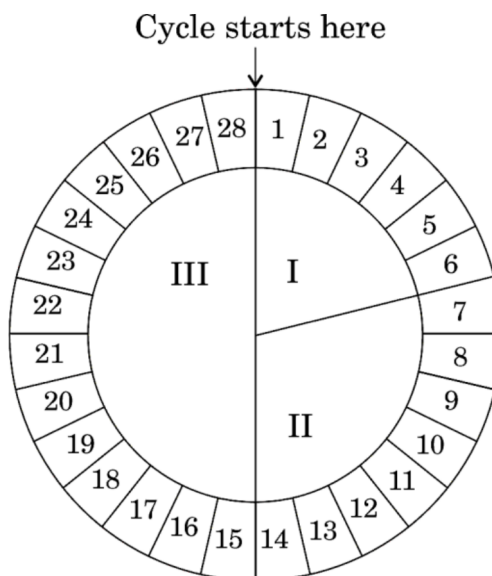
Step 3: Conclusion All offspring are heterozygous *Vv* and violet: the expected proportion is 100%. Hence, the correct option is (D).

Quick Tip to Solve: For a pure dominant crossed with a pure recessive, write the single gamete from each parent: all offspring have the same heterozygous genotype.

5. In a human female, menstrual cycle of 28 days is represented by the diagram given below.

Select the correct statement related with this diagram.

[1 mark]



- (A) Primary follicle of ovary matures into Graafian follicle in phase II.
- (B) The hormone secreted in large amounts in phase III is also responsible for maintaining pregnancy in human females.
- (C) Corpus luteum secretes progesterone in phase I, however it degenerates completely in phase III.
- (D) Both (A) and (B).

Correct Answer: (D) Both (A) and (B).

Solution:

Concept:

- During the follicular phase, ovarian follicles grow and a Graafian follicle matures; ovulation occurs around the middle of a typical 28-day cycle.
- During the luteal phase, the corpus luteum secretes progesterone, which maintains the endometrium and is essential for supporting pregnancy.

Step 1: Interpret phases II and III Phase II lies before mid-cycle ovulation and includes follicular maturation, so statement (A) is true. Phase III lies after ovulation and represents the luteal phase. Progesterone is secreted abundantly during this phase and helps maintain pregnancy, making statement (B) true.

Step 2: Test the corpus-luteum statement Statement (C) wrongly places corpus-luteum progesterone secretion in phase I. The corpus luteum develops after ovulation and is active during phase III. It regresses near the end of the cycle if fertilisation does not occur; it does not simply remain inactive throughout phase III. Since both (A) and (B) are valid, the combined option must be selected.

Step 3: Conclusion Follicular maturation in phase II and the pregnancy-supporting action of the phase III hormone are both correct. Hence, the correct option is (D).

Quick Tip to Solve: Use day 14 as the divider: follicle maturation precedes ovulation, while corpus-luteum progesterone secretion follows it.

6. Arrange the following in the correct sequence of their evolution and select the correct option:

(i) Seaweed

(ii) Invertebrates

(iii) Jawless fish

[1 mark]

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

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

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

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

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

Solution:

Concept:

- The NCERT account of the evolution of life forms places invertebrates before jawless fish, followed by seaweeds and a few plants in the stated sequence.
- Dates expressed as millions of years ago run from larger to smaller values when moving from earlier to later events.

Step 1: Recall the sequence in the evolutionary account Invertebrates were formed and active by about 500 million years ago. Jawless fish probably evolved around 350 million years ago. Seaweeds and a few plants existed probably around 320 million years ago in this textbook account. These dates place invertebrates first, jawless fish next and seaweed last among the listed entries.

Step 2: Match the events to their numbers Invertebrates are listed as (ii), jawless fish as (iii), and seaweed as (i). Options (A) and (B) incorrectly begin with seaweed. Option (D) puts seaweed between invertebrates and jawless fish, reversing the last two events in the stated NCERT sequence.

Step 3: Conclusion The sequence is Invertebrates → Jawless fish → Seaweed, or (ii), (iii), (i). Hence, the correct option is (C).

Quick Tip to Solve: Match these NCERT timeline entries to 500, 350 and 320 million years ago, then arrange the dates from older to younger.

7. *Monascus purpureus* is a yeast used commercially in the production of which one of the following?

[1 mark]

(A) Ethanol

(B) Streptokinase

(C) Citric acid

(D) Statins

Correct Answer: (D) Statins

Solution:

Concept:

- *Monascus purpureus* is used commercially to produce statins, which lower blood cholesterol.

- Statins act as competitive inhibitors of the enzyme responsible for cholesterol synthesis.

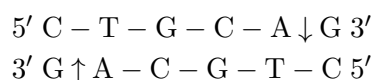
Step 1: Match the microorganism to its product The industrial product associated with *Monascus purpureus* is a statin. Its medical use follows from inhibition of cholesterol synthesis, which helps reduce the cholesterol level in blood.

Step 2: Eliminate the other microbial products Ethanol is commonly produced by brewer's yeast, *Saccharomyces cerevisiae*. Streptokinase, used as a clot buster, is obtained from *Streptococcus*. Citric acid is commercially produced using *Aspergillus niger*. These product-microbe pairs eliminate options (A), (B) and (C).

Step 3: Conclusion *Monascus purpureus* is used for commercial production of statins. Hence, the correct option is (D).

Quick Tip to Solve: Remember the linked trio: *Monascus*, statins and inhibition of cholesterol synthesis; match other products to their own microbes.

8. Given below is the restriction site of a restriction endonuclease Pst I and the cleavage sites on a DNA molecule.



Choose the option that gives the correct resultant fragments.

[1 mark]

- (A) $\begin{array}{cc} 5' \text{ C} - \text{T} - \text{G} & \text{C} - \text{A} - \text{G} 3' \\ 3' \text{ G} - \text{A} - \text{C} - \text{G} - \text{T} & \text{C} 5' \end{array}$
- (B) $\begin{array}{cc} 5' \text{ C} - \text{T} & \text{G} - \text{C} - \text{A} - \text{G} 3' \\ 3' \text{ G} - \text{A} - \text{C} - \text{G} & \text{T} - \text{C} 5' \end{array}$
- (C) $\begin{array}{cc} 5' \text{ C} - \text{T} - \text{G} - \text{C} & \text{A} - \text{G} 3' \\ 3' \text{ G} - \text{A} - \text{C} - \text{G} & \text{T} - \text{C} 5' \end{array}$
- (D) $\begin{array}{cc} 5' \text{ C} - \text{T} - \text{G} - \text{C} - \text{A} & \text{G} 3' \\ 3' \text{ G} & \text{A} - \text{C} - \text{G} - \text{T} - \text{C} 5' \end{array}$

Correct Answer: (D) $\begin{array}{cc} 5' \text{ C} - \text{T} - \text{G} - \text{C} - \text{A} & \text{G} 3' \\ 3' \text{ G} & \text{A} - \text{C} - \text{G} - \text{T} - \text{C} 5' \end{array}$

Solution:

Concept:

- Restriction endonucleases cleave phosphodiester bonds at specific positions within their DNA recognition sites.
- Staggered cuts in the two antiparallel DNA strands produce single-stranded cohesive, or sticky, ends; the base sequence itself remains unchanged.

Step 1: Locate each cut On the upper strand, Pst I cuts between the fifth base A and the sixth base G. The upper pieces are therefore 5'-CTGCA and G-3'. On the lower strand, it cuts between the first base G and the second base A, giving 3'-G and ACGTC-5'.

Step 2: Compare both strands with the options Option (D) preserves both cleavage positions. Option

(A) cuts the upper strand after its third base and the lower after its fifth; (B) cuts after the second and fourth; (C) cuts both after the fourth. None of these three matches the arrows. The correct staggered cleavage creates four-base overhangs at the 3' ends.

Step 3: Conclusion The upper strand separates as CTGCA and G, and the lower as G and ACGTC. Hence, the correct option is (D).

Quick Tip to Solve: Follow each arrow separately and count the bases before it: five on the upper strand, one on the lower.

9. Choose a correct option that shows an interaction in which one species benefits while the other is neither harmed nor benefitted. [1 mark]

- (A) Mycorrhizal associations between fungi and roots of higher plants
- (B) Sea anemone and clownfish
- (C) Abingdon tortoises and goats in the Galapagos Island
- (D) *Cuscuta* on hedge plants

Correct Answer: (B) Sea anemone and clownfish

Solution:

Concept:

- Commensalism is an interaction represented by (+, 0): one species benefits and the other is neither harmed nor benefited.
- Mutualism benefits both partners, competition harms both through resource limitation, and parasitism benefits one at the expense of the other.

Step 1: Identify the commensal pair The clownfish lives among the stinging tentacles of the sea anemone and gains protection from predators. In the NCERT example, the sea anemone derives no apparent benefit and suffers no harm from the association.

Step 2: Eliminate the other interactions Mycorrhiza is mutualism: the fungus supplies water and minerals, and the plant supplies organic food. Goats and Abingdon tortoises compete for vegetation. *Cuscuta* obtains nourishment from its host hedge plant and harms it, so that association is parasitism.

Step 3: Conclusion Sea anemone and clownfish show commensalism. Hence, the correct option is (B).

Quick Tip to Solve: Write the effect on each partner: clownfish gains protection (+), while the anemone is unaffected (0).

10. Transgenic animals have their genetic material manipulated. Select the correct option in reference to transgenic animals. [1 mark]

- (A) Foreign DNA and RNA are present in their cells.
- (B) Foreign RNA is present in all of their cells.
- (C) Foreign DNA is present in all of its cells.
- (D) Foreign RNA is present in some of its cells.

Correct Answer: (C) Foreign DNA is present in all of its cells.

Solution:

Concept:

- A transgenic animal carries foreign DNA introduced through genetic manipulation and incorporated into its genetic material.
- In the standard transgenic-animal model, introducing the transgene into an early embryonic cell allows it to be passed to descendant cells during development.

Step 1: Identify the introduced genetic material The defining introduced material is a DNA sequence, called a transgene. When the animal develops from a genetically modified early cell, the foreign DNA is retained in the cells derived from it. Thus the statement about foreign DNA throughout the animal is the intended description.

Step 2: Distinguish transgene presence from expression A transgene may be expressed only in particular tissues even though its DNA is present throughout the animal. Foreign RNA in all or some cells is not the defining feature, so (B) and (D) are unsuitable. Option (A) also incorrectly makes the presence of both foreign DNA and RNA a defining requirement.

Step 3: Conclusion Foreign DNA is present in all of its cells, as described by the standard transgenic-animal definition. Hence, the correct option is (C).

Quick Tip to Solve: Identify a transgenic animal by the introduced DNA; do not confuse its presence with tissue-specific RNA expression.

11. Select the odd option in the context of convergent evolution. [1 mark]

- (A) Eyes of Octopus and Mammals
- (B) Flippers of Penguins and Dolphins
- (C) Flying Squirrel and Flying Phalanger
- (D) Thorns of Bougainvillea and Tendrils of Cucurbita

Correct Answer: (D) Thorns of Bougainvillea and Tendrils of Cucurbita

Solution:

Concept:

- Convergent evolution produces similar functional adaptations independently in different evolutionary lineages.
- Homologous structures share a basic origin but can become modified for different functions; such

modification illustrates divergent evolution.

Step 1: Classify the similar adaptations The eyes of octopus and mammals are independently evolved camera-like eyes. Penguin and dolphin flippers are similar swimming adaptations. Flying squirrels and flying phalangers independently evolved gliding adaptations in placental and marsupial lineages. These are the convergent examples used here.

Step 2: Find the homologous pair Thorns of *Bougainvillea* and tendrils of *Cucurbita* are both modifications of the stem. Thorns provide protection, whereas tendrils assist climbing. Their common origin with different functions makes them homologous organs and an example of divergence, so this pair is the odd one.

Step 3: Conclusion Thorns of *Bougainvillea* and tendrils of *Cucurbita* illustrate divergent evolution. Hence, the correct option is (D).

Quick Tip to Solve: For the odd pair, ask whether the organs have the same origin: both thorn and tendril here are modified stems.

12. Which of the following fish led to the extinction of an ecologically unique assemblage of more than 200 species of cichlid fish in Lake Victoria of East Africa? [1 mark]

- (A) Catla Catla
- (B) Dogfish
- (C) Nile Perch
- (D) African Catfish

Correct Answer: (C) Nile Perch

Solution:

Concept:

- An alien species introduced into a new habitat may become invasive and threaten native biodiversity.
- An introduced predator can cause native prey populations to decline or disappear when local ecological relationships are disrupted.

Step 1: Recall the Lake Victoria example Nile perch was introduced into Lake Victoria in East Africa. Its predation on native fishes contributed to the extinction of an ecologically unique assemblage of more than 200 species of cichlid fish. The lake and the cichlids identify this specific NCERT example.

Step 2: Separate the other fish examples *Catla catla* is not the introduced predator associated with this Lake Victoria event, and dogfish is a marine cartilaginous fish. African catfish is a different invasive-fish example associated with threats to indigenous catfishes in India; it is not the fish named for the cichlid extinctions in Lake Victoria.

Step 3: Conclusion Nile perch caused the stated loss of cichlid diversity in Lake Victoria. Hence, the correct option is (C).

Quick Tip to Solve: Link Lake Victoria and cichlids to Nile perch; keep the African catfish example associated with India separate.

13. Assertion (A): The embryo with 8 to 16 blastomeres is called a morula.

Reason (R): The morula continues to divide and transform into trophoblast.

[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:

- Cleavage divides the zygote into progressively smaller cells called blastomeres; an embryo with 8 to 16 blastomeres is the morula.
- The morula develops into a blastocyst, whose cells become organised into an outer trophoblast and an inner cell mass.

Step 1: Judge the assertion The embryo containing 8 to 16 blastomeres is called a morula. This agrees with the standard sequence of early human embryonic development, so Assertion (A) is true.

Step 2: Judge the reason The morula continues dividing and transforms into a blastocyst, not into a trophoblast. Trophoblast is the outer cell layer of the blastocyst; the inner cell mass lies inside and gives rise to the embryo. Reason (R) incorrectly identifies a part as the whole developmental stage and is false.

Step 3: Check the explanatory relationship A false reason cannot explain the true assertion. Options (A) and (B) require both statements to be true, while (D) requires the assertion to be false. All three are excluded by the independent judgments.

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

Quick Tip to Solve: Remember the sequence morula to blastocyst; trophoblast names the blastocyst outer layer, not the entire next stage.

14. Assertion (A): Repetitive sequences make up a very large portion of human genome.

Reason (R): Repetitive sequences do not have direct coding functions in the genome.

[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:

- Repetitive DNA consists of nucleotide sequences repeated many times in the genome; such sequences form a very large portion of the human genome.
- In the NCERT description, repetitive sequences have no direct coding functions, although they can help explain chromosome structure, dynamics and evolution.

Step 1: Judge the assertion The human genome contains a substantial amount of repetitive DNA, with repeated stretches occurring many times. Therefore, the statement that repetitive sequences make up a very large portion of the human genome is true.

Step 2: Judge the reason Repetitive sequences are generally described as lacking direct coding functions: they do not directly provide the coding information for proteins in the manner of protein-coding genes. This is the NCERT property stated by Reason (R), so the reason is also true.

Step 3: Test whether the reason explains the assertion The absence of direct coding function describes what these sequences do not code for. It does not explain why they occur in so many copies or occupy a large genomic fraction. A non-coding sequence need not be highly repeated. Thus the two statements are true, but the reason does not explain the assertion.

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

Quick Tip to Solve: Judge abundance and coding function separately: being non-coding alone does not explain a large number of repeat copies.

15. Assertion (A): Trichoderma species are free living fungi that are very common in the root ecosystems.

Reason (R): They are effective bio-control agents of several plant pathogens.

[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:

- *Trichoderma* species are free-living fungi commonly found in root ecosystems.
- An assertion and its reason may both be true without the reason explaining the assertion.

Step 1: Evaluate the assertion The assertion correctly describes the habitat and free-living nature of *Trichoderma*. These fungi are commonly present in the root ecosystem. Thus, Assertion (A) is true.

Step 2: Evaluate the reason *Trichoderma* species act against several plant pathogens and are useful biological control agents. Hence, Reason (R) is also true; options declaring either statement false are eliminated.

Step 3: Test the explanatory connection The reason states an agricultural use of these fungi. Being effective against plant pathogens does not explain why they are free-living or why they commonly occur in root ecosystems. Therefore, the two correct statements do not form the required explanation.

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 habitat from usefulness: a biocontrol role alone does not explain where a fungus lives.

16. Assertion (A): The use of chitinase enzyme is necessary for the separation of DNA from yeast cells but not in the case of *Spirogyra*.

Reason (R): Fungal cell wall is made up of fungal chitin.

[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:

- DNA isolation requires disruption of the cell wall and membranes to release the genetic material.
- Wall-digesting enzymes are chosen according to the wall composition: chitinase digests chitin, whereas cellulase digests cellulose.

Step 1: Evaluate the assertion Yeast is a fungus, and chitinase is used to break down its chitin-containing cell wall during DNA isolation. *Spirogyra* is an alga with a cellulosic wall, for which chitinase is not the appropriate wall-digesting enzyme. Thus, the assertion is true.

Step 2: Evaluate the reason Chitin is a characteristic component of fungal cell walls. Therefore, the statement that the fungal wall contains fungal chitin is true. The reason identifies the substrate upon which chitinase acts.

Step 3: Connect wall composition with enzyme choice The presence of chitin in yeast explains the use of chitinase, while the different wall composition of *Spirogyra* explains why that enzyme is not needed there. Thus, the reason explains the assertion. The choices calling either statement false, or denying this explanation, are unsuitable.

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

Quick Tip to Solve: Match each wall with its enzyme: fungal chitin with chitinase and algal cellulose with cellulase.

Section B (10 marks)

17(a). Mention the functions of each of the following:

(i) Tassels of Corn Cob

(ii) Scutellum

[2 marks]

Solution:

Concept:

- In wind-pollinated flowers, exposed receptive structures help intercept airborne pollen grains.
- The scutellum is the single, shield-shaped cotyledon of a grass embryo; it mediates the transfer of stored food to the growing embryo.

Step 1: State the function of the tassels of the corn cob The hair-like structures emerging from the corn cob represent the elongated styles and stigmas. They project outward and catch pollen grains carried by wind. Pollen received by the receptive stigma can germinate and form a pollen tube, enabling fertilisation of the ovule. Thus, their required function is to trap airborne pollen for pollination.

Step 2: State the function of the scutellum The scutellum lies between the embryo and the food-storing endosperm in a cereal grain such as maize. During germination, it absorbs soluble nutrients from the endosperm and transfers them to the growing embryonal axis. This supplies nourishment for early growth of the radicle and plumule before the seedling becomes independently photosynthetic.

Step 3: Conclusion (i) The tassels of the corn cob trap wind-borne pollen grains. (ii) The scutellum absorbs food from the endosperm and supplies it to the developing embryo during germination.

Quick Tip to Solve: Associate the exposed corn-cob hairs with pollen capture and the scutellum with food transfer from endosperm to embryo.

OR

17(b). Farmers prefer apomictic seeds over hybrid seeds. Give any two reasons.

[2 marks]

Solution:

Concept:

- Apomixis is seed formation without fertilisation; it is an asexual mode of reproduction that mimics sexual reproduction.
- Sexual reproduction in hybrid plants can produce segregation of characters in later generations, whereas apomictic reproduction can preserve the parental combination.

Step 1: Explain preservation of desirable hybrid traits Seeds collected from sexually reproducing hybrid plants can give progeny in which the hybrid characters segregate. Such progeny need not retain the same desirable combination or performance. If the hybrid reproduces apomictically, its embryos arise without fertilisation and the parental hybrid genotype is maintained. Farmers can therefore preserve the desired characters and hybrid vigour over successive seed generations.

Step 2: Explain the reduction in recurring seed cost Conventional hybrid seeds are expensive and generally have to be purchased again for the next crop to obtain the same hybrid performance. Apomictic seed production allows farmers to save seeds from their crop and sow them again while retaining the favourable parental traits. This avoids repeated purchase of costly hybrid seed and makes cultivation more economical.

Step 3: Conclusion Farmers prefer apomictic seeds because they preserve desirable hybrid characters without segregation and can be saved and reused, reducing the recurring expense of purchasing hybrid seeds.

Quick Tip to Solve: Give two distinct advantages: genetic stability of hybrid traits and the economic benefit of reusing saved seed.

18. Define the term ‘amniocentesis’. Why has the government imposed a statutory ban in spite of its importance in the medical field? [2 marks]

Solution:

Concept:

- Prenatal diagnostic tests can identify certain genetic and chromosomal disorders before birth.
- The medical value of a diagnostic method must be distinguished from its misuse for prenatal sex determination and sex selection.

Step 1: Define amniocentesis and state its medical use Amniocentesis is a prenatal diagnostic procedure in which a small sample of amniotic fluid surrounding the developing foetus is withdrawn. The foetal cells present in this fluid are examined, including analysis of their chromosomes, to detect certain chromosomal abnormalities and genetic disorders. Thus, the procedure can provide medically useful information about the health of the developing foetus.

Step 2: Explain why its misuse was banned Analysis of foetal chromosomes can also reveal the sex of the foetus. The technique was misused for prenatal sex determination followed by selective abortion of female foetuses, leading to female foeticide and an adverse sex ratio. The statutory ban addresses this misuse for sex determination and sex selection. It should not be understood as a ban on all legitimate prenatal diagnosis of genetic disorders.

Step 3: Conclusion Amniocentesis examines amniotic fluid and its foetal cells for prenatal diagnosis. Its misuse for prenatal sex determination was banned to prevent female foeticide and the resulting imbalance in the sex ratio.

Quick Tip to Solve: Link the definition to amniotic fluid and foetal cells, then distinguish disease diagnosis from misuse for sex selection.

19. Name the lymphoid organ that acts as a large reservoir of erythrocytes. Explain its role as a lymphoid organ. [2 marks]

Solution:

Concept:

- Secondary lymphoid organs provide sites where lymphocytes encounter antigens and become activated to produce an immune response.
- The spleen is a large, bean-shaped lymphoid organ containing lymphocytes and phagocytes, and acts as a reservoir of erythrocytes (red blood cells).

Step 1: Identify the organ The organ is the **spleen**. Its association with a large store of erythrocytes distinguishes it from other lymphoid organs such as the thymus and lymph nodes.

Step 2: Explain its immune function The spleen filters the blood and traps blood-borne microorganisms and other antigens. Its phagocytes engulf and destroy these microorganisms. Lymphocytes encounter the trapped antigens and become activated, initiating an immune response. Thus, the spleen serves as a secondary lymphoid organ as well as a reservoir of red blood cells.

Step 3: Conclusion The **spleen** is the erythrocyte reservoir. As a lymphoid organ, it traps blood-borne microorganisms and supports their removal by phagocytes and antigen-triggered lymphocyte responses.

Quick Tip to Solve: Link the spleen with filtering blood, and lymph nodes with filtering lymph; this identifies the correct secondary lymphoid organ.

20(a). Suggest how a virus-free healthy plant can be obtained from a diseased sugarcane plant. [2 marks]

Solution:

Concept:

- Meristem culture is the aseptic growth of a plant's apical or axillary meristem on a suitable nutrient medium to regenerate a complete plant.
- Even when a plant is infected with a virus, its apical and axillary meristematic regions can remain free of the virus. These regions therefore provide suitable explants for obtaining healthy plants.

Step 1: Select a virus-free meristem Excise a small apical or axillary meristem from the diseased sugarcane plant under sterile conditions. Use the meristematic region rather than an ordinary piece of infected stem or leaf, since the latter may carry the virus into the culture.

Step 2: Regenerate the plant in culture Place the excised meristem on a sterile nutrient medium containing minerals, a carbon source and suitable plant growth regulators. Maintain aseptic conditions and induce shoot and root development. The regenerated plantlet is hardened gradually and then transferred to soil, producing a healthy, virus-free sugarcane plant.

Step 3: Conclusion Obtain a virus-free sugarcane plant by **meristem culture**: isolate its virus-free apical or axillary meristem and grow it aseptically into a complete plant.

Quick Tip to Solve: For a virus-infected parent plant, specify the apical or axillary meristem as the explant; merely saying tissue culture misses the crucial selection step.

20(b). In order to force bacteria to take up the recombinant DNA, they must be made competent. Explain how it can be achieved. [2 marks]

Solution:

Concept:

- DNA is a hydrophilic molecule and cannot readily pass through the bacterial cell membrane. Bacteria must therefore be made competent to take up recombinant DNA.
- Treatment with a suitable concentration of divalent cations, such as calcium ions, increases the efficiency with which DNA enters the bacterial cells.

Step 1: Treat the bacterial cells Treat the bacteria with a specific concentration of calcium ions, commonly supplied by calcium chloride. This treatment makes the cells competent and facilitates DNA entry through pores in the cell wall and associated membrane barrier.

Step 2: Apply the ice and heat-shock sequence Incubate the competent cells with the recombinant DNA on ice. Briefly expose the mixture to 42 °C to give a heat shock, and then place it back on ice. This ice–heat shock–ice sequence enables the bacteria to take up recombinant DNA from the surrounding medium.

Step 3: Conclusion Make the bacteria competent by treatment with calcium ions, then incubate them with recombinant DNA on ice, heat-shock briefly at 42 °C, and return them to ice.

Quick Tip to Solve: Remember the sequence: calcium treatment, DNA plus cells on ice, brief heat shock at 42 degrees Celsius, then ice again.

21(a). Differentiate between grazing food chain and detritus food chain. [2 marks]

Solution:

Concept:

- A food chain traces the transfer of food and energy through successive feeding relationships in an ecosystem.
- Grazing and detritus food chains differ primarily in the material from which they begin and in the organisms that first use that material.

Step 1: Compare the starting material and first consumers A **grazing food chain** starts with living green plants or other photosynthetic producers. Herbivores feed on these producers, and carnivores feed on the herbivores. A **detritus food chain** starts with dead organic matter, such as fallen leaves and animal remains. Decomposers, principally bacteria and fungi, utilise this material; detritivores also feed on and fragment detritus.

Step 2: Compare the source of energy and give examples The grazing pathway begins with energy newly captured from sunlight by producers; for example, grass → grasshopper → frog. The detritus pathway begins with chemical energy already stored in dead organic matter; for example, dead leaves → earthworm → bird. Its starting material is therefore non-living rather than a living producer.

Step 3: Conclusion Grazing food chains begin with **living producers and herbivores**, whereas detritus food chains begin with **dead organic matter and its decomposers or detritivores**.

Quick Tip to Solve: Check the first link: living grass indicates a grazing chain, while fallen leaves or dead remains indicate a detritus chain.

OR

21(b). Ecological pyramids are widely accepted but they still have some limitations. Write any two limitations. [2 marks]

Solution:

Concept:

- Ecological pyramids represent the number, biomass or energy of organisms arranged in successive trophic levels.
- A simple pyramid represents a single feeding sequence, so it cannot fully represent the feeding relationships of a natural ecosystem.

Step 1: Identify the omission of food webs An ecological pyramid assumes a simple food chain and does not accommodate a food web. In nature, food chains are interconnected: a consumer may eat organisms from different food chains and may itself be eaten by several consumers. These multiple feeding links cannot be represented by the single linear sequence of trophic levels in a pyramid.

Step 2: Identify the omission of saprophytes Saprophytes, or decomposers, are not given a place in ecological pyramids, although they perform a vital role in ecosystems. They break down dead organic matter and wastes originating from all trophic levels and release inorganic nutrients for reuse by producers. Their omission leaves this essential decomposition and nutrient recycling pathway unrepresented.

Step 3: Conclusion Two limitations are that ecological pyramids do not accommodate food webs and do not give a place to saprophytes despite their vital role in the ecosystem.

Quick Tip to Solve: For two distinct limitations, name the missing network (food web) and the missing functional group (saprophytes), explaining each briefly.

Section C (21 marks)

22. List any three outbreeding devices that flowering plants have developed for cross-pollination and explain how they help to encourage cross-pollination. [3 marks]

Solution:

Concept:

- Outbreeding devices reduce self-pollination and favour the transfer of pollen between flowers of different plants of the same species.

- Cross-pollination is encouraged by differences in the timing or position of reproductive structures and by genetic rejection of self-pollen.

Step 1: Explain non-synchronous maturation Dichogamy is the condition in which pollen release from the anther and stigma receptivity of the same flower are not synchronised. The anthers may release pollen before the stigma becomes receptive, or the stigma may be receptive before pollen release. Thus, the flower cannot readily pollinate itself, and a receptive stigma can receive pollen from another flower whose anthers are releasing pollen at that time.

Step 2: Explain spatial separation Herkogamy is the positioning of the anther and stigma at different places in the flower so that its pollen cannot easily come into contact with its own stigma. This spatial barrier prevents autogamy and encourages a pollinating agent to bring pollen from another flower. Unlike dichogamy, this mechanism depends on position rather than the time of maturation.

Step 3: Explain self-incompatibility Self-incompatibility is a genetic mechanism that prevents self-pollen from fertilising the ovules. The pistil recognises self-pollen and inhibits its germination on the stigma or the growth of its pollen tube through the pistil. Therefore, even if self-pollen reaches the stigma, it is rejected, while compatible pollen from another plant can achieve fertilisation.

Step 4: Conclusion Three outbreeding devices are dichogamy (different timing), herkogamy (spatial separation) and self-incompatibility (genetic rejection of self-pollen). The first two prevent autogamy; self-incompatibility prevents fertilisation by self-pollen.

Quick Tip to Solve: Remember timing, position and recognition: explain how each creates a barrier to self-pollination or self-fertilisation.

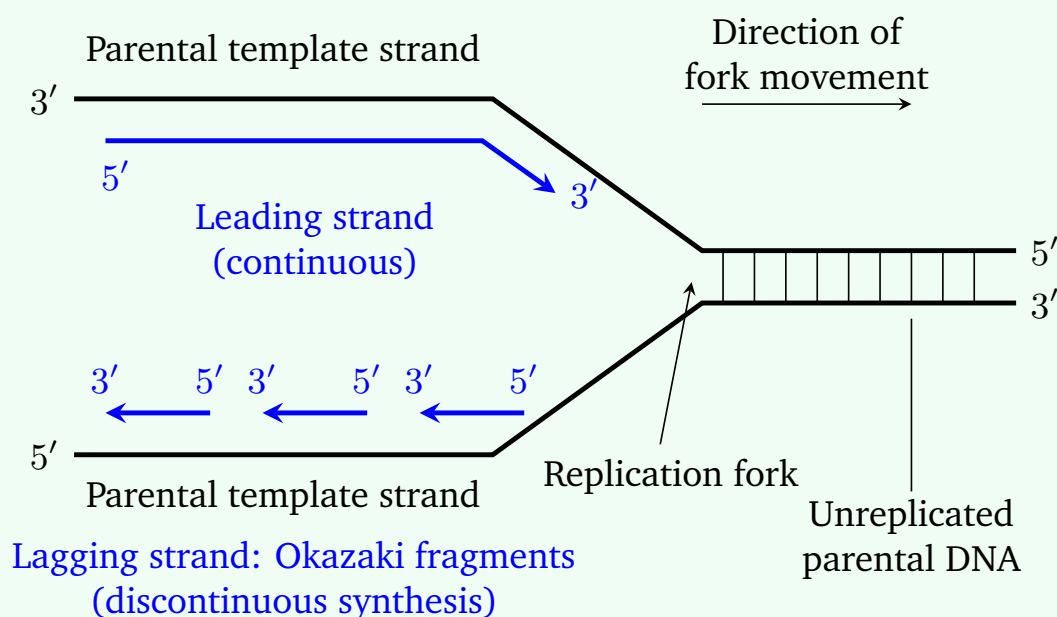
23. Draw a labelled diagram of a ‘replicating fork’ showing the polarity. Why does DNA replication occur within such ‘fork’? [3 marks]

Solution:

Concept:

- DNA replication is semiconservative: each daughter DNA molecule contains one parental strand and one newly synthesised strand.
- DNA-dependent DNA polymerase adds nucleotides only to the free 3' end, so every new strand grows in the 5' → 3' direction.
- The two parental strands are antiparallel, and their local separation forms a Y-shaped replication fork.

Step 1: Draw and read the replication fork The labelled diagram shows parental strands opening at a fork that moves to the right. Black lines are parental template strands; blue lines are newly synthesised DNA. The polarity is marked at the ends. The leading strand is synthesised continuously towards the advancing fork, using the parental template running 3' → 5' in that direction.



Replication fork showing strand polarity and directions of daughter-strand synthesis.

Step 2: Explain synthesis on the second template On the other parental template, synthesis still proceeds only $5' \rightarrow 3'$, but it runs away from the advancing fork. This produces short Okazaki fragments, forming the lagging strand. After primer removal and replacement with DNA, DNA ligase joins the fragments to form a continuous daughter strand. The arrows on the blue strands indicate the direction of new DNA synthesis.

Step 3: Explain why replication is localised to a fork The two strands of a long DNA molecule cannot be separated along their entire length at once because this would require a very large amount of energy. Instead, the DNA duplex opens locally, forming a small region called a replication fork. The exposed parental strands act as templates there, and progressive unwinding makes further template available as replication proceeds.

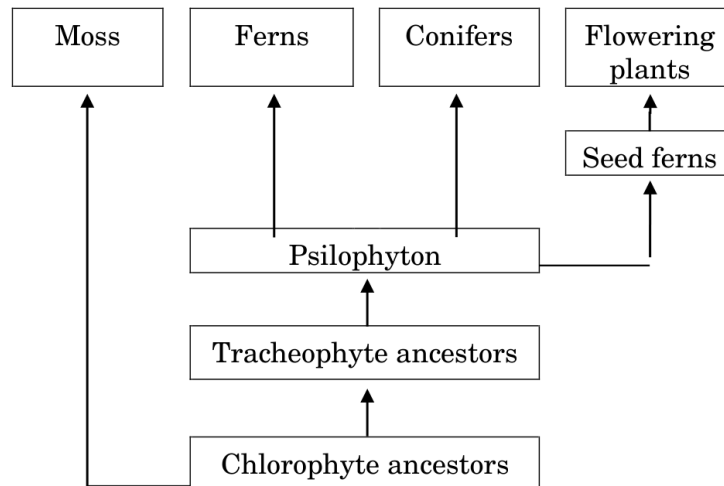
Step 4: Conclusion DNA replication occurs at a locally opened replication fork because separating the entire DNA molecule at once would be energetically prohibitive. Both daughter strands grow $5' \rightarrow 3'$: the leading strand continuously and the lagging strand discontinuously.

Quick Tip to Solve: Mark parental strands antiparallel first; then place every new-strand arrow towards its own 3-prime end, including each Okazaki fragment.

24. Study the given chart showing evolution of plants. Answer the following questions:

- (a) Identify the plant which acts as an immediate ancestor of both ferns and conifers.
- (b) Name the nearest ancestors of flowering plants.
- (c) Name the most primitive group of plants.
- (d) Psilophyton provides common ancestry to which classes?
- (e) Name the common ancestor of psilophyton and seed ferns.
- (f) Name the common ancestor of mosses and tracheophytes.

[3 marks]



Solution:

Concept:

- In the given evolutionary chart, an arrow runs from an ancestral group towards its descendants. Trace arrows backwards to identify ancestry.
- An immediate ancestor is the group directly below a descendant on its connecting branch; a common ancestor lies on the ancestral paths of both groups.

Step 1: (a) Trace the branches of ferns and conifers The arrows leading directly to both ferns and conifers arise from *Psilophyton*. Therefore, *Psilophyton* is their immediate ancestor in the chart.

Step 2: (b) Identify the group just below flowering plants The arrow entering the flowering-plants box comes from seed ferns. Thus, seed ferns are the nearest ancestors of flowering plants in this chart.

Step 3: (c) Read the basal ancestral group Chlorophyte ancestors occupy the base of the chart and give rise to the other lineages shown. Hence, chlorophytes, the green-algal group, are the most primitive group represented.

Step 4: (d) Follow all branches from Psilophyton *Psilophyton* provides common ancestry to the fern and seed-plant lineages: ferns, conifers and seed ferns. The seed-fern branch subsequently leads to flowering plants, so flowering plants also share this ancestry.

Step 5: (e) Trace the ancestral stock of Psilophyton and seed ferns Tracheophyte ancestors give rise to *Psilophyton*, from which the seed-fern branch emerges. Thus, the ancestral group below these two in the chart is the tracheophyte ancestors.

Step 6: (f) Locate the split towards mosses and tracheophytes One branch from the chlorophyte

ancestors leads to mosses, while the upward branch leads to the tracheophyte ancestors. Chlorophyte ancestors are therefore the common ancestors of mosses and tracheophytes.

Step 7: Conclusion (a) *Psilophyton*; (b) seed ferns; (c) chlorophytes; (d) ferns and the seed-plant lineages, including conifers and seed ferns (and their flowering-plant descendants); (e) tracheophyte ancestors; (f) chlorophyte ancestors.

Quick Tip to Solve: For each pair, trace its arrows backwards to the shared ancestral branch; for a nearest ancestor, stop at the first connected box.

25. Mention a product of human welfare obtained with the help of each one of the following:

- (a) *Saccharomyces cerevisiae*
- (b) *Propionibacterium shermanii*
- (c) *Aspergillus niger*
- (d) *Trichoderma polysporum*
- (e) *Acetobacter aceti*
- (f) *Streptococcus*

[3 marks]

Solution:

Concept:

- Microorganisms are grown under controlled conditions to obtain useful products, including fermented foods, organic acids, enzymes and medicines.
- Identify each microbe by its characteristic industrial product. Different microbes perform different biochemical conversions, even when both are used in food processing.

Step 1: (a) Match *Saccharomyces cerevisiae* with its fermentation product *Saccharomyces cerevisiae*, commonly called brewer's yeast, produces ethanol by fermenting sugars. It is used in the manufacture of alcoholic beverages such as beer and wine.

Step 2: (b) Match *Propionibacterium shermanii* with cheese production *Propionibacterium shermanii* is used in the production of Swiss cheese. The large holes in this cheese develop because the bacterium releases a large amount of carbon dioxide during production.

Step 3: (c) Identify the organic acid from *Aspergillus niger* *Aspergillus niger*, a fungus, is used for industrial production of citric acid. Citric acid is a useful organic acid employed in foods and beverages.

Step 4: (d) Identify the medicinal product from *Trichoderma polysporum* *Trichoderma polysporum* produces cyclosporin A. This compound is used as an immunosuppressive agent in organ-transplant patients, helping reduce immune rejection of the transplanted organ.

Step 5: (e) Identify the acid produced by *Acetobacter aceti* *Acetobacter aceti* is used to produce acetic acid by oxidation of ethanol. This activity is used in the manufacture of vinegar.

Step 6: (f) Identify the enzyme obtained from *Streptococcus* *Streptococcus* produces streptokinase. This enzyme is used as a clot buster to help remove blood clots in patients who have suffered myocardial infarction.

Step 7: Conclusion The products are: (a) ethanol; (b) Swiss cheese; (c) citric acid; (d) cyclosporin A; (e) acetic acid; and (f) streptokinase.

Quick Tip to Solve: Keep the two acid producers distinct: *Aspergillus niger* gives citric acid, whereas *Acetobacter aceti* gives acetic acid.

26. Transgenic animals are produced by man. Explain any three ways in which such animals can be beneficial to humans. [3 marks]

Solution:

Concept:

- Transgenic animals have their DNA manipulated so that they possess and express an additional, introduced gene. The resulting change in gene expression can be used to investigate biological processes or produce useful substances.
- A useful application must explain both the role of the transgenic animal and the benefit obtained by humans. Three distinct applications are described below.

Step 1: Explain their use in studying normal physiology and development Transgenic animals help scientists investigate how genes are regulated and how they affect normal body functions and development. Introducing a gene or altering its expression allows its effect on a biological process to be studied. For example, studying genes involved in growth factors helps reveal how these factors influence growth and development. This improves understanding of normal human physiology.

Step 2: Explain their use as models of human disease Animals can be made transgenic to carry genes associated with particular human diseases and to develop relevant disease features. They then serve as models for examining how the disease arises and for testing possible treatments before their use in humans. Transgenic models have been developed for diseases such as cancer, cystic fibrosis and Alzheimer's disease.

Step 3: Explain their use in producing biological products A gene encoding a useful human protein can be introduced into an animal so that the animal produces that protein, for example in its milk. The protein can then be collected and purified for medical use. Transgenic animals have been used to produce human alpha-1-antitrypsin, a protein used in treating emphysema. Thus, they provide a means of obtaining valuable therapeutic biological products.

Step 4: Conclusion Three benefits of transgenic animals are understanding normal physiology and development, studying human diseases and testing treatments, and producing useful therapeutic proteins such as human alpha-1-antitrypsin.

Quick Tip to Solve: For each application, connect the introduced gene to a practical benefit: study normal function, model a disease, or produce a useful protein.

27. Explain Gause's 'Competitive Exclusion Principle' with the help of a suitable example. [3 marks]

Solution:

Concept:

- Interspecific competition occurs when individuals of different species depend on the same limiting resource, such as food or space.
- An ecological niche describes how a species uses resources and functions in its environment. Complete overlap in the use of a limiting resource can lead to competitive exclusion.

Step 1: State Gause's competitive exclusion principle Two closely related species competing for the same limiting resources cannot coexist indefinitely in the same niche. Under these conditions, the competitively inferior species is eventually eliminated from that habitat by the superior competitor. The principle applies when resources are limiting; mere presence of two species in the same habitat does not necessarily cause exclusion.

Step 2: Explain the barnacle example Connell's experiments on the rocky sea coasts of Scotland showed that the larger, competitively superior barnacle *Balanus* dominates the intertidal area and excludes the smaller barnacle *Chthamalus* from that zone. Both require suitable space for attachment. Competition for this limited space prevents *Chthamalus* from occupying the area dominated by *Balanus*.

Step 3: Connect the example to the principle When the superior competitor is removed experimentally, the smaller barnacle can occupy an area from which it was previously excluded. Thus, competition restricts its distribution. Exclusion here means loss from the contested habitat, not necessarily extinction of the species everywhere.

Step 4: Conclusion Gause's principle predicts the exclusion of an inferior competitor when two species depend on the same limiting resources; exclusion of *Chthamalus* by *Balanus* illustrates it.

Quick Tip to Solve: State the limiting-resource condition, then name the superior competitor and the species it excludes in your example.

28. Explain the level of biodiversity at genetic, species and ecological levels with the help of one example each. [3 marks]

Solution:

Concept:

- Biodiversity is the variety of living organisms and the biological systems of which they are a part. It is considered at genetic, species and ecological levels.
- The three levels distinguish variation within one species, variation among species and variation among ecosystems, respectively.

Step 1: Explain genetic diversity with an example Genetic diversity is the variation in genes within a species, including differences among its individuals and populations. For example, populations of the medicinal plant *Rauwolfia vomitoria* growing in different Himalayan ranges vary in the potency and concentration of the active chemical reserpine that they produce. The plants belong to the same

species, so these differences illustrate diversity at the genetic level rather than differences between species.

Step 2: Explain species diversity with an example Species diversity is the variety of species found in an area; species richness is the number of different species present. For example, the Western Ghats have greater amphibian species diversity than the Eastern Ghats. This comparison concerns the variety of amphibian species in the two regions, rather than genetic differences among individuals of a single amphibian species.

Step 3: Explain ecological diversity with an example Ecological diversity is the variety of ecosystems in a geographical region. India has deserts, rain forests, mangroves, coral reefs, wetlands, estuaries and alpine meadows. These ecosystems differ in their physical conditions and biological communities. Their variety illustrates diversity at the ecosystem level.

Step 4: Conclusion Genetic diversity is variation within a species, species diversity is the variety of species in an area, and ecological diversity is the variety of ecosystems in a region.

Quick Tip to Solve: Match each example to its scale: one species for genetic diversity, different species for species diversity, and habitats or ecosystems for ecological diversity.

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

The process of copying genetic information from template strand of DNA into RNA is called transcription. It is mediated by RNA polymerase. Transcription takes place in the nucleus of eukaryotic cells. In transcription, only a segment of DNA and only one of the strands is copied into RNA. [4 marks]

29(a). Why is the strand of DNA with $3' \rightarrow 5'$ polarity transcribed and not the other strand of $5' \rightarrow 3'$ polarity? [1 mark]

Solution:

Concept:

- DNA-dependent RNA polymerase synthesises an RNA chain only in the $5' \rightarrow 3'$ direction by adding nucleotides to its free $3'$ end.
- The RNA strand and the DNA template used to synthesise it are complementary and antiparallel.

Step 1: Apply the direction of RNA synthesis Because RNA polymerase extends the RNA only at its $3'$ end, it must read the DNA template in the opposite direction, $3' \rightarrow 5'$, while making RNA in the $5' \rightarrow 3'$ direction.

Step 2: Identify the strand used in this transcription unit The strand with $3' \rightarrow 5'$ polarity in the direction of transcription can therefore serve as the template. The opposite strand, with $5' \rightarrow 3'$ polarity in that direction, is the coding strand and is not copied in this transcription unit.

Step 3: Conclusion The $3' \rightarrow 5'$ DNA strand is transcribed because RNA polymerase synthesises RNA

only $5' \rightarrow 3'$, antiparallel to its template.

Quick Tip to Solve: Write the RNA arrow first as $5' \rightarrow 3'$; the template arrow must run in the opposite direction.

29(b)(i). Why is hnRNA required to undergo splicing?

[1 mark]

Solution:

Concept:

- The primary RNA transcript in eukaryotes is heterogeneous nuclear RNA (hnRNA), containing both exons and introns.
- Splicing removes introns and joins the exons to form a continuous sequence in the processed RNA.

Step 1: Identify the need for processing hnRNA contains intervening non-coding sequences called introns between the expressed sequences called exons. Therefore, the primary transcript cannot be used directly as the functional mRNA for synthesis of the intended protein.

Step 2: Explain the role of splicing During splicing, the introns are removed and the exons are joined in their proper order. This creates the correctly arranged expressed sequence needed in mature mRNA for translation; introns are not simply retained and translated with the exons.

Step 3: Conclusion hnRNA requires splicing to remove introns and join exons, producing the continuous expressed sequence needed for functional mRNA.

Quick Tip to Solve: Link the need directly to introns: hnRNA contains them, so splicing removes them and joins the exons.

OR

29(b)(ii). Mention the two additional processes which hnRNA needs to undergo after splicing to become functional.

[1 mark]

Solution:

Concept:

- Eukaryotic hnRNA undergoes processing to form mature mRNA. Besides splicing, this processing includes modification of its two ends.
- Capping modifies the $5'$ end, whereas tailing modifies the $3'$ end; these modifications help stabilise the RNA and support its use in protein synthesis.

Step 1: Describe capping at the five-prime end In capping, a methyl guanosine triphosphate cap is added to the $5'$ end of hnRNA. This specialised end modification helps protect the transcript and supports recognition during translation.

Step 2: Describe tailing at the three-prime end In tailing, approximately 200–300 adenylate residues are added to the $3'$ end in a template-independent manner. This forms the poly-A tail. Together with splicing and capping, it contributes to formation of mature, functional mRNA.

Step 3: Conclusion The two additional processes are **capping** at the 5' end and **tailing (polyadenylation)** at the 3' end.

Quick Tip to Solve: Remember the end-specific pair: a cap goes on 5', and the poly-A tail goes on 3'.

29(c). Why is only one strand of the DNA transcribed? Give two reasons.

[2 marks]

Solution:

Concept:

- During transcription of a transcription unit, only one DNA strand acts as the template. The RNA sequence is complementary to this strand.
- The two DNA strands are complementary and therefore carry different base sequences when read in the same direction. Messenger RNA must remain single-stranded to be translated by ribosomes.

Step 1: Consider the information in the two transcripts If both strands of the same DNA region were transcribed, their different base sequences would produce RNAs with different codon sequences. These RNAs could specify different polypeptides. Thus, the same DNA segment would encode two different proteins, complicating the transfer of genetic information.

Step 2: Consider pairing between the transcripts The two RNA molecules would be complementary to each other because they were copied from complementary DNA strands. They could associate by base pairing to form double-stranded RNA. This would prevent the messenger RNA from being translated normally, since translation requires an accessible single-stranded mRNA template.

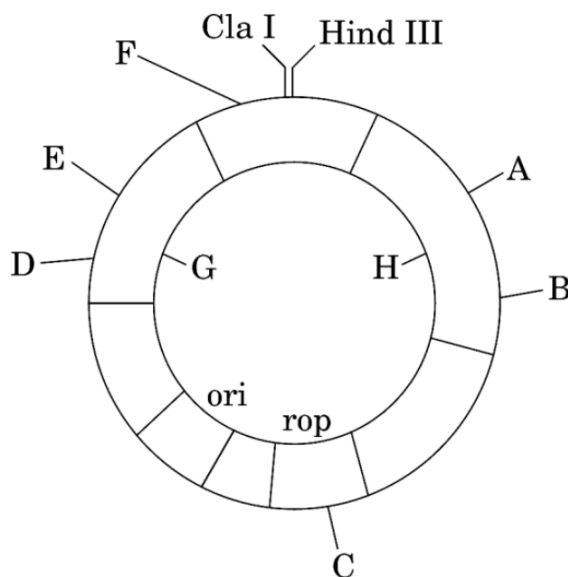
Step 3: Conclusion Only one strand is transcribed for a given transcription unit to avoid (i) producing two different protein messages from the same DNA region and (ii) forming complementary RNAs that pair into double-stranded RNA and prevent translation.

Quick Tip to Solve: State the two consequences separately: different codons would specify different proteins, and complementary transcripts would pair and block translation.

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

We know that plasmids and bacteriophages are the most commonly used vectors in biotechnology experiments. If we can link an alien piece of DNA to the plasmid DNA, the alien DNA can be multiplied equal to the copy number of the plasmid. Engineered vectors are used these days. Study the diagram of the *E. coli* cloning vector pBR322 and answer the questions that follow:

[4 marks]



30(a). Why are plasmids and bacteriophages used as cloning vectors?

[1 mark]

Solution:

Concept:

- A cloning vector carries foreign DNA into a host and enables that DNA to be multiplied.
- Plasmids and bacteriophages replicate within bacterial cells independently of the bacterial chromosomal replication cycle.

Step 1: Identify their ability to multiply Plasmids are extrachromosomal DNA molecules capable of autonomous replication. Bacteriophages infect bacteria and multiply their genetic material inside the host, often producing many copies.

Step 2: Relate vector replication to the insert When a foreign DNA fragment is linked to vector DNA, it is replicated along with the vector inside the host. Thus a small amount of inserted DNA can be amplified into many identical copies.

Step 3: Conclusion Plasmids and bacteriophages are used as cloning vectors because they replicate in bacterial hosts and multiply the foreign DNA attached to them.

Quick Tip to Solve: Connect the vector's capacity for replication directly to amplification of the inserted DNA.

30(b)(i). Identify:

(I) The gene in the cloning vector that controls the copy number of the vector.

(II) The restriction site – C in the ‘rop’ gene.

[1 mark]

Solution:

Concept:

- The origin of replication, *ori*, is the DNA sequence where replication begins and is responsible for controlling the copy number of linked DNA.
- Restriction sites are specific DNA sequences recognised by restriction endonucleases; their names identify the enzymes that cut there.

Step 1: Identify the copy-number control sequence For part (I), identify *ori*, the origin of replication. Any DNA linked to this sequence can replicate within the host, and the origin determines the number of copies maintained. Although the question calls it a gene, *ori* is specifically a replication-origin sequence.

Step 2: Read the site labelled C In the standard pBR322 map, the restriction site labelled C in the *rop* region is PvuII. The *rop* gene codes for a protein involved in regulating plasmid replication; it should be distinguished from the origin sequence itself.

Step 3: Conclusion (I) *ori* (origin of replication); (II) C is the PvuII restriction site.

Quick Tip to Solve: Associate *ori* with initiation and copy number; locate PvuII in the *rop* region of pBR322.

OR

30(b)(ii). Identify and name two selectable markers shown in the diagram.

[1 mark]

Solution:

Concept:

- A selectable marker helps distinguish transformed bacteria from bacteria that have not received the vector.
- The two antibiotic-resistance genes of pBR322 confer resistance to ampicillin and tetracycline.

Step 1: Identify marker G G is the ampicillin-resistance gene, amp^R , on the left side of the plasmid map. Bacteria carrying a functional copy of this marker can grow on a medium containing ampicillin.

Step 2: Identify marker H H is the tetracycline-resistance gene, tet^R , on the right side of the plasmid map. It permits growth in the presence of tetracycline. Antibiotic-sensitive non-transformants fail to grow on the corresponding selective medium.

Step 3: Conclusion G is amp^R , the ampicillin-resistance marker, and H is tet^R , the tetracycline-resistance marker.

Quick Tip to Solve: On this pBR322 map, identify the left marker as ampicillin resistance and the right marker as tetracycline resistance.

30(c). Name the two restriction sites each in the two genes you have identified as selectable markers.

[2 marks]

Solution:

Concept:

- pBR322 contains two selectable markers: the ampicillin-resistance gene, amp^R , and the tetracycline-resistance gene, tet^R .
- A restriction site within a marker gene can be used for insertion of foreign DNA. Inserting DNA there can disrupt that marker, causing insertional inactivation.

Step 1: Locate sites in the ampicillin-resistance gene The gene labelled G is amp^R . Its two restriction sites are PvuI and PstI. In the supplied map these correspond to E (PvuI) and D (PstI), respectively. They lie in the ampicillin-resistance region on the left of the plasmid.

Step 2: Locate sites in the tetracycline-resistance gene The gene labelled H is tet^R . Its two indicated restriction sites are BamHI and SalI, corresponding to A and B, respectively. These lie in the tetracycline-resistance region on the right. Disruption of this gene by insertion at a suitable site eliminates tetracycline resistance while the ampicillin marker can remain functional.

Step 3: Conclusion amp^R : PvuI (E) and PstI (D).

tet^R : BamHI (A) and SalI (B).

Quick Tip to Solve: Keep PvuI in the ampicillin marker distinct from PvuII in the *rop* region; associate BamHI with tetracycline-marker inactivation.

Section E (15 marks)

31(a). Briefly explain the events of fertilisation and implantation in an adult human female. [5 marks]

Solution:

Concept:

- Fertilisation is the fusion of the haploid male and female gametes to form a diploid zygote; in humans it normally occurs at the ampullary-isthmic junction of the fallopian tube.
- Cleavage produces progressively smaller cells called blastomeres without a corresponding increase in the overall size of the early embryo.
- Implantation is the embedding of the blastocyst in the uterine endometrium, where the embryo obtains support for further development.

Step 1: Bring the gametes together During insemination, semen is released into the vagina. Motile sperms travel through the cervix and uterus into the fallopian tube. The secondary oocyte released at ovulation also reaches the ampullary-isthmic junction. Fertilisation can take place only when viable sperms and the oocyte are present there at the same time.

Step 2: Describe sperm entry and formation of the zygote A sperm contacts the zona pellucida surrounding the secondary oocyte. Enzymes released from its acrosome help it penetrate the egg coverings, and the sperm and oocyte plasma membranes fuse. Changes induced in the zona pellucida

prevent additional sperms from entering, thereby preventing polyspermy. Sperm entry induces the secondary oocyte to complete meiosis II, producing a haploid ovum and a second polar body. The male and female haploid nuclei fuse (syngamy), restoring the diploid chromosome number and forming the zygote.

Step 3: Follow cleavage to the blastocyst stage As the zygote moves through the oviduct towards the uterus, it undergoes successive mitotic cleavage divisions, producing 2, 4, 8 and then 16 blastomeres. The embryo with 8–16 blastomeres is called a morula. On entering the uterus it continues dividing and develops into a blastocyst. Its blastomeres become arranged into an outer trophoblast and an inner cell mass attached to the trophoblast; a fluid-filled cavity is present inside. The inner cell mass gives rise to the embryo.

Step 4: Explain attachment and implantation After the blastocyst is freed from the zona pellucida, its trophoblast attaches to the uterine endometrium. The uterine cells divide rapidly and cover the blastocyst, embedding it within the thick, vascular endometrium. This embedding, beginning about a week after fertilisation, is called implantation and leads to pregnancy. The trophoblast subsequently contributes to the chorionic villi that, together with maternal uterine tissue, form the placenta.

Step 5: Conclusion Fertilisation at the ampullary-isthmic junction produces a diploid zygote. Cleavage converts it into a morula and then a blastocyst, which attaches to and becomes embedded in the uterine endometrium during implantation.

Quick Tip to Solve: Keep the locations distinct: fertilisation occurs in the oviduct, whereas implantation occurs in the uterus. Recall the developmental order as zygote, morula, blastocyst, implantation.

OR

31(b)(i). Arrange the following hormones in sequence of their secretion in a pregnant woman:

hCG; LH; FSH; Relaxin.

[1 mark]

Solution:

Concept:

- FSH and LH are anterior pituitary hormones that regulate follicular maturation and ovulation before pregnancy is established.
- hCG is secreted after implantation, whereas relaxin is associated with the later phase of pregnancy in the NCERT account.

Step 1: Place the ovarian-cycle hormones first FSH promotes growth and maturation of ovarian follicles. The subsequent LH surge triggers ovulation and formation of the corpus luteum. Thus, in the reproductive sequence leading to pregnancy, FSH precedes LH.

Step 2: Place the pregnancy hormones next After fertilisation and implantation, hCG supports the corpus luteum during early pregnancy. Relaxin is secreted by the ovary in the later phase of pregnancy. Therefore hCG precedes relaxin in the expected sequence. The ordering includes the events leading to pregnancy; it does not imply that FSH and LH first appear only after conception.

Step 3: Conclusion The sequence is FSH → LH → hCG → Relaxin.

Quick Tip to Solve: Link the hormones to the stages: follicular growth, ovulation, early pregnancy support, and late pregnancy relaxation.

31(b)(ii). Mention the source and the functions of the above mentioned hormones.

[4 marks]

Solution:

Concept:

- FSH and LH are gonadotropins secreted by the anterior pituitary. Their actions on the ovary prepare for fertilisation and the establishment of pregnancy.
- During pregnancy, hCG supports the corpus luteum, while relaxin helps prepare the maternal pelvic region for childbirth. State the source and function of each hormone separately.

Step 1: Identify the source and action of FSH Follicle-stimulating hormone (FSH) is secreted by the **anterior pituitary**. It stimulates the growth and maturation of ovarian follicles and promotes oestrogen secretion by the developing follicles. These actions occur during the follicular phase of the cycle that precedes conception, preparing the follicle containing the oocyte for ovulation.

Step 2: Identify the source and action of LH Luteinising hormone (LH) is secreted by the **anterior pituitary**. The mid-cycle LH surge induces ovulation and the conversion of the ruptured Graafian follicle into the corpus luteum. LH supports the corpus luteum and its secretion of progesterone, which helps maintain the uterine endometrium for implantation. FSH and LH are normally suppressed during an established pregnancy by hormonal negative feedback; they do not initiate repeated ovarian cycles then.

Step 3: Identify the source and action of hCG Human chorionic gonadotropin (hCG) is secreted by the **trophoblast of the developing embryo and subsequently the placenta**. In early pregnancy it maintains the corpus luteum and thereby sustains its progesterone secretion. Progesterone maintains the endometrium and supports continuation of the pregnancy until placental hormone production is sufficient to support it.

Step 4: Identify the source and action of relaxin Relaxin is secreted by the **ovary, particularly the corpus luteum**, during pregnancy. It promotes relaxation of the pelvic ligaments and softening of the cervix, facilitating passage of the baby during childbirth. In the NCERT description, its secretion by the ovary is associated with the later phase of pregnancy.

Step 5: Conclusion FSH and LH originate in the anterior pituitary and control follicular development, ovulation and corpus-luteum formation. Placental hCG maintains the corpus luteum in early pregnancy, and ovarian relaxin facilitates childbirth by relaxing the pelvic ligaments and softening the cervix.

Quick Tip to Solve: Pair each hormone with a source and a target action: pituitary–follicle/ovulation, placenta–corpus luteum, and ovary–pelvic relaxation.

32(a). Work out separate monohybrid crosses up to F_2 generation between two pea plants and two *Antirrhinum* plants, both having contrasting traits with respect to the colour of the flower. Comment on the patterns of inheritance in the crosses carried out in such two cases. [5 marks]

Solution:

Concept:

- A monohybrid cross studies one pair of contrasting traits. The two alleles of a gene separate during gamete formation, so each gamete receives only one allele.
- In complete dominance, a heterozygote has the dominant parent's phenotype. In incomplete dominance, the heterozygote has an intermediate phenotype, although the alleles remain discrete.

Step 1: Cross pure violet and white pea plants In pea, let P represent the dominant allele for violet flowers and p the recessive allele for white flowers. Take true-breeding parents:

$$\begin{aligned}\text{Parents: } & PP \text{ (violet)} \times pp \text{ (white)} \\ \text{Gametes: } & P \qquad p \\ F_1 : & Pp \text{ (all violet).}\end{aligned}$$

The violet phenotype appears in every heterozygous offspring because P completely dominates p .

Step 2: Self the pea hybrids to obtain the second generation Self-pollination of the F_1 plants gives $Pp \times Pp$. Each parent produces P and p gametes in equal proportions. Their combinations are:

	P	p
P	PP	Pp
p	Pp	pp

Hence, the F_2 genotypic ratio is $1 PP : 2 Pp : 1 pp$, while the phenotypic ratio is 3 violet : 1 white. Both PP and Pp are violet, whereas only pp is white. The recessive trait reappears because the alleles segregate rather than blend.

Step 3: Cross pure red and white snapdragon plants In *Antirrhinum* (snapdragon), use R and r for the alleles associated with red and white flower colour. Neither allele completely dominates the other:

$$\begin{aligned}\text{Parents: } & RR \text{ (red)} \times rr \text{ (white)} \\ \text{Gametes: } & R \qquad r \\ F_1 : & Rr \text{ (all pink).}\end{aligned}$$

The heterozygote has an intermediate flower colour, so this cross shows incomplete dominance.

Step 4: Self the pink hybrids and compare the patterns Self-pollination gives $Rr \times Rr$. Both parents form R and r gametes in equal proportions:

	R	r
R	RR	Rr
r	Rr	rr

The F_2 genotypic ratio is $1 RR : 2 Rr : 1 rr$. As all three genotypes have distinct phenotypes, the

phenotypic ratio is also 1 red : 2 pink : 1 white. The reappearance of red and white offspring proves that the parental alleles were not permanently blended in the pink hybrid. The law of segregation holds in both crosses; the difference lies in the expression of the heterozygote.

Step 5: Conclusion Pea shows complete dominance with an F_2 phenotypic ratio of 3 : 1. *Antirrhinum* shows incomplete dominance with an F_2 phenotypic ratio of 1 : 2 : 1. Both crosses give the same F_2 genotypic ratio, 1 : 2 : 1.

Quick Tip to Solve: Write the four genotype combinations first. Combine the two heterozygotes with the dominant homozygote only in pea; in snapdragon, count pink separately.

OR

32(b)(i). Answer the following questions:

How does a chromosomal disorder differ from a Mendelian disorder? Write one example for each.

[2 marks]

Solution:

Concept:

- Genetic disorders may arise from an abnormal chromosome number or structure, or from a mutation affecting a single gene.
- A Mendelian disorder follows a recognisable single-gene inheritance pattern, such as autosomal recessive or sex-linked recessive inheritance.

Step 1: Identify the basis of a chromosomal disorder A chromosomal disorder results from the absence, excess or abnormal arrangement of one or more chromosomes. Thus the defect concerns chromosome number or structure and may affect many genes together. For example, Down's syndrome is caused by an extra copy of chromosome 21 (trisomy 21); an affected individual typically has 47 chromosomes instead of 46.

Step 2: Identify the basis of a Mendelian disorder A Mendelian disorder results from an alteration or mutation in a single gene and is transmitted according to the inheritance of its alleles. The chromosome number can remain normal. For example, sickle-cell anaemia is an autosomal recessive Mendelian disorder caused by a mutation in the gene encoding the β -globin chain of haemoglobin. Two disease alleles produce the affected condition, while a heterozygote carries one normal and one mutant allele.

Step 3: Conclusion Chromosomal disorders involve abnormal chromosome number or structure, as in Down's syndrome. Mendelian disorders involve a single-gene mutation, as in sickle-cell anaemia.

Quick Tip to Solve: Contrast the level of the defect: a whole chromosome or chromosome segment versus a single gene, and pair each category with its own example.

32(b)(ii). Answer the following questions:

Name the phenomenon that leads to situations like 'XO' abnormality in humans. Also name this genetic disorder. How are individuals with an XO chromosomal abnormality affected? Write its symptoms as well as karyotype.

[3 marks]

Solution:

Concept:

- Nondisjunction is the failure of homologous chromosomes or sister chromatids to segregate properly during cell division; during gamete formation it can produce gametes with an abnormal chromosome number.
- Aneuploidy is the gain or loss of individual chromosomes. Loss of one sex chromosome gives monosomy X, represented as $45, X$ or XO.

Step 1: Identify the origin of the abnormality During meiosis, nondisjunction can produce a gamete lacking a sex chromosome. If this gamete fuses with a normal gamete carrying one X chromosome, the resulting zygote has only one X chromosome. Thus, nondisjunction is the underlying segregation error, and the resulting numerical abnormality is aneuploidy, specifically monosomy X. Here O denotes the absence of a second sex chromosome, not another type of chromosome.

Step 2: Name the disorder and give its karyotype This condition is Turner's syndrome. The individual has 44 autosomes and one X chromosome, so the total chromosome number is 45 rather than the usual 46. Its karyotype is $45, X$, also written as $44 + XO$.

Step 3: Describe the effects and symptoms Affected individuals are phenotypically female, but their ovaries are rudimentary and poorly developed. They are usually sterile, lack normal ovarian function, and show poorly developed secondary sexual characteristics, such as underdeveloped breasts. Menstruation is commonly absent. Short stature and a webbed neck are other characteristic features. These effects arise from the missing sex chromosome and must not be confused with the XXY constitution of Klinefelter's syndrome.

Step 4: Conclusion Nondisjunction leads to aneuploidy; XO is Turner's syndrome with karyotype $45, X$. The affected female typically has rudimentary ovaries, sterility and poorly developed secondary sexual characteristics.

Quick Tip to Solve: Read XO as one X plus a missing sex chromosome: $44 + 1 = 45$. Associate it with a sterile female and rudimentary ovaries.

33(a)(i). Draw the structure of an antibody molecule and label any four of its parts.

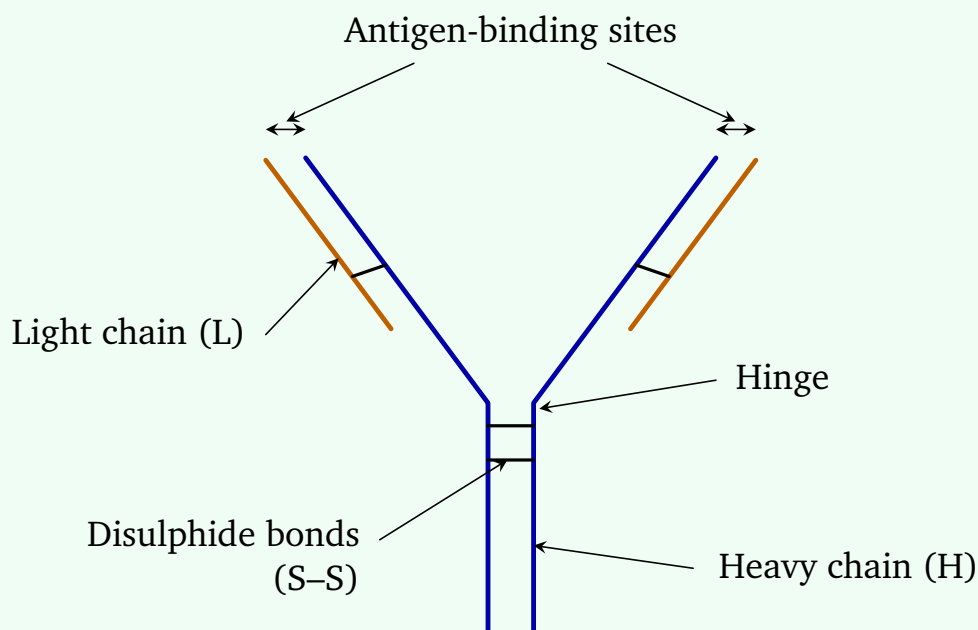
[2 marks]

Solution:

Concept:

- An antibody is an immunoglobulin produced by plasma cells derived from B lymphocytes. A typical antibody molecule has a Y-shaped structure.
- It contains two identical heavy polypeptide chains and two identical light polypeptide chains, represented as H_2L_2 . Disulphide bonds hold the chains together.

Step 1: Construct the four-chain arrangement Draw the two longer heavy chains forming the stem and the inner side of each arm of the Y. Place one shorter light chain alongside the outer side of each arm. Each light chain is joined to its neighbouring heavy chain by a disulphide bond; the two heavy chains are also linked by disulphide bonds near the hinge.



Typical antibody molecule showing the H_2L_2 arrangement

Step 2: Label the parts and locate the binding sites Label a heavy chain, a light chain, a disulphide bond and an antigen-binding site. The diagram labels these four parts explicitly. Each antigen-binding site is formed by the variable regions of one heavy chain and its adjacent light chain at an arm tip. A typical Y-shaped antibody therefore has two antigen-binding sites with the same specificity. The hinge permits flexibility of the arms.

Step 3: Conclusion The labelled antibody consists of two heavy chains and two light chains joined by disulphide bonds, with antigen-binding sites at the two arm tips.

Quick Tip to Solve: First draw two long inner chains and two short outer chains; then label H, L, an S–S link and a tip as an antigen-binding site.

33(a)(ii). Differentiate between active and passive immunity. Write any three differences. [3 marks]

Solution:

Concept:

- Active immunity develops when exposure to an antigen stimulates the individual's own immune system to produce a specific response.
- Passive immunity is protection obtained by receiving ready-made antibodies from another individual or an external source.

Step 1: Compare the source of antibodies **Active immunity:** The person's own B lymphocytes respond

to the antigen and differentiate into antibody-secreting plasma cells. This occurs after an infection or vaccination.

Passive immunity: The person receives preformed antibodies rather than producing them as the basis of the acquired protection. Examples include maternal antibodies reaching the baby through the placenta or colostrum, and injection of an antibody preparation such as an antitoxin.

Step 2: Compare the speed of protection Active immunity: The primary response develops relatively slowly because antigen recognition, lymphocyte multiplication and differentiation take time. It therefore has an initial lag period.

Passive immunity: Protection is immediate because functional antibodies are already available. This is useful when rapid protection is required after a dangerous exposure.

Step 3: Compare duration and immunological memory Active immunity: Protection is generally long-lasting because the response generates memory cells. On later exposure to the same antigen, these cells produce a faster and stronger secondary response.

Passive immunity: Protection is temporary because the transferred antibodies are gradually broken down. Their transfer does not generate antigen-specific memory cells in the recipient, so it does not provide a memory-based secondary response.

Step 4: Conclusion The three differences are antibody source (self-produced versus received), onset (delayed versus immediate) and persistence with memory (generally long-lasting with memory versus temporary without induced memory).

Quick Tip to Solve: Compare the same three headings for both types: who makes the antibodies, how quickly protection starts, and whether memory remains.

OR

33(b)(i). (I) Write the scientific names of the two species of filarial worms causing filariasis.

(II) How do they affect the body of infected persons?

(III) How does the disease spread?

[3 marks]

Solution:

Concept:

- Filariasis is a parasitic disease caused by filarial nematodes that mainly affect the lymphatic vessels in humans.
- The disease is vector-borne: a female mosquito carries the parasite from an infected person to another person during blood feeding.

Step 1: (I) Identify the two filarial worms The two species are *Wuchereria bancrofti* and *Wuchereria malayi*. The latter is also known as *Brugia malayi*. Write the genus with an initial capital and the species name in lower case; both words of a scientific name are italicised.

Step 2: (II) Explain their effects on the body The worms live for many years, usually in the lymphatic vessels of the lower limbs. Their presence causes chronic inflammation and obstruction of lymph flow. Lymph drainage is impaired, producing persistent swelling and enlargement of the affected

body parts, especially the legs. This condition is called elephantiasis. The genital organs may also be affected, resulting in gross deformities.

Step 3: (III) Describe transmission A female mosquito takes up microfilariae while feeding on the blood of an infected person. These develop into infective larvae inside the mosquito. When the infected mosquito subsequently bites a healthy person, the larvae enter the person's body and can establish infection in the lymphatic system. Thus the bite of an infected female mosquito spreads the disease; ordinary physical contact with a patient does not transmit it.

Step 4: Conclusion *W. bancrofti* and *W. malayi* cause filariasis, with chronic lymphatic inflammation, swelling and deformity; infected female mosquitoes transmit the parasites.

Quick Tip to Solve: Link the three answers in order: two *Wuchereria* species, blocked lymph vessels and elephantiasis, then the infected female mosquito vector.

33(b)(ii). Mention the source and the role of the following in providing defence against infection in the human body:

(I) Histamine

(II) Interferons

[2 marks]

Solution:

Concept:

- Defence molecules may promote a local inflammatory response or protect cells against viral multiplication.
- The source of a defence molecule is the cell that releases it; its role describes how it helps the body respond to a threat.

Step 1: (I) Histamine: source and role Histamine is released mainly by mast cells in tissues. It acts as a mediator of inflammation: it dilates nearby blood vessels and increases capillary permeability. This helps fluid and defence components reach the affected tissue and supports the local inflammatory response. Histamine release also accounts for many symptoms of an allergic reaction, so its role should be distinguished from that of an antiviral protein.

Step 2: (II) Interferons: source and role Interferons are proteins secreted by virus-infected cells. They act on nearby uninfected cells and induce an antiviral state, helping protect those cells from viral infection by inhibiting viral replication. This limits the spread of the virus from infected cells to surrounding cells. They form a cytokine barrier of innate immunity.

Step 3: Conclusion Histamine from mast cells promotes inflammation; interferons from virus-infected cells protect nearby uninfected cells against viral infection.

Quick Tip to Solve: Pair each source with its action: mast cells–histamine–inflammation; virus-infected cells–interferons–antiviral protection of neighbouring cells.