

CBSE Class 12 Biology Question Paper 2026 with Solution PDF-Set 57-5-3

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. 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:

- Parturition is initiated by a neuroendocrine mechanism involving signals from the fully developed foetus and placenta.
- The foetal ejection reflex stimulates oxytocin release from the maternal posterior pituitary; oxytocin strengthens uterine contractions.

Step 1: Trace the reflex signal Signals from the mature foetus and placenta induce mild uterine contractions, called the foetal ejection reflex. This reflex acts on the mother's neuroendocrine system, causing her pituitary to release oxytocin into the circulation.

Step 2: Check the hormone and its source Oxytocin promotes stronger uterine contractions, which stimulate further oxytocin release in positive feedback. The foetal pituitary is not the source required here. Human chorionic gonadotropin and progesterone support pregnancy; neither is the hormone released by this reflex to intensify labour.

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

Quick Tip to Solve: Link the foetal ejection reflex to the mother's labour contractions: maternal pituitary releases oxytocin.

2. Match the IUDs in Column I with suitable example in Column II.

Column I	Column II
a. Non-medicated	i. Lippes loop
b. Copper releasing	ii. LNG-20
c. Hormone releasing	iii. Multiload 375

Options:

[1 mark]

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

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

Solution:

Concept:

- Intrauterine devices (IUDs) are classified as non-medicated, copper releasing or hormone releasing according to their active component.
- Lippes loop is non-medicated, Multiload 375 releases copper, and LNG-20 releases a progestogen.

Step 1: Match each device with its class Lippes loop contains neither a copper-releasing component nor a hormone preparation, so a matches i. Multiload 375 is a copper-releasing IUD, so b matches iii. LNG-20 is a hormone-releasing IUD, so c matches ii.

Step 2: Verify the complete combination Copper ions suppress sperm motility and fertilising capacity, whereas hormone-releasing devices make the uterus unsuitable for implantation and the cervix hostile to sperms. Option (A) misclassifies all three devices. Option (B) interchanges the copper and hormone examples, while option (D) incorrectly places LNG-20 in the non-medicated class.

Step 3: Conclusion The matching is a-i, b-iii, c-ii. Hence, the correct option is (C).

Quick Tip to Solve: Recognise LNG as levonorgestrel, a hormone; then pair Multiload 375 with copper and Lippes loop with non-medicated IUDs.

3. 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 flower colour is dominant over v for white flowers.

- A homozygous parent produces only one allele type in its gametes; a heterozygote expresses the dominant phenotype.

Step 1: Identify the parental gametes The violet parent has genotype VV , so all its gametes carry V . The white parent has genotype vv , so all its gametes carry v . Each offspring therefore receives one dominant allele and one recessive allele.

Step 2: Determine the offspring phenotype The cross is

$$VV \times vv \longrightarrow \text{all offspring } Vv.$$

Every heterozygous offspring expresses violet flowers because V is dominant. The 75% violet ratio belongs to $Vv \times Vv$, and 50% belongs to $Vv \times vv$. Neither cross is given here; 25% violet also cannot result from these homozygous parents.

Step 3: Conclusion All offspring are violet, giving 100% violet flowers. Hence, the correct option is (D).

Quick Tip to Solve: A cross between opposite homozygotes gives a uniform heterozygous generation; apply dominance only after writing its genotype.

4. 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 evolutionary account places active invertebrates around 500 million years ago, jawless fish around 350 million years ago, and seaweeds and a few plants around 320 million years ago.
- A larger value in millions of years ago denotes an earlier point in the evolutionary timeline.

Step 1: Associate the groups with the timeline In the textbook sequence used for this question, invertebrates, labelled (ii), come first. Jawless fish, labelled (iii), follow them. Seaweed, labelled (i), is placed after jawless fish in this account.

Step 2: Compare the listed orders Reading from the oldest time to the most recent gives $500 \rightarrow 350 \rightarrow 320$ million years ago. Options (A) and (B) put seaweed before invertebrates. Option (D) starts with invertebrates but places seaweed before jawless fish. These orders do not match the stated textbook timeline.

Step 3: Conclusion The sequence is invertebrates, jawless fish, seaweed: (ii), (iii), (i). Hence, the correct option is (C).

Quick Tip to Solve: Recall the NCERT sequence 500, 350, 320 million years ago; read larger ages first when arranging earliest to latest.

5. If a genetic disease is transferred from a phenotypically normal but carrier female to only some of the male progeny, the disease is: [1 mark]

- (A) autosomal dominant
- (B) autosomal recessive
- (C) sex-linked dominant
- (D) sex-linked recessive

Correct Answer: (D) sex-linked recessive

Solution:

Concept:

- In an X-linked recessive disorder, a heterozygous female can be phenotypically normal because the normal allele masks the recessive disease allele.
- A male has only one X chromosome and expresses a recessive disease allele carried on it; his X comes from his mother.

Step 1: Represent the carrier mother Let X^N carry the normal allele and X^d the recessive disease allele. A carrier female is $X^N X^d$. She produces eggs carrying either X^N or X^d in equal proportions, although she does not express the disorder.

Step 2: Follow transmission to sons A son receives a Y chromosome from his father. Sons receiving X^N from the mother are $X^N Y$, whereas sons receiving X^d are $X^d Y$ and affected. Thus only some sons inherit the disorder. A dominant disorder would generally be expressed by a female carrying its allele. Autosomal recessive inheritance can involve carriers but does not show this characteristic preference for male offspring.

Step 3: Conclusion The pattern indicates a sex-linked recessive disease. Hence, the correct option is (D).

Quick Tip to Solve: For a normal carrier mother with affected sons, track her two X chromosomes: a son cannot mask a recessive allele on his sole X.

6. 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 $G = C$ and $A = T$, where the letters denote the respective base counts or percentages.
- Each base pair contains two bases, so a DNA molecule with n base pairs contains $2n$ bases in all.

Step 1: Find the adenine percentage Guanine constitutes 30% of all bases, so cytosine also constitutes 30%. The percentage left for adenine and thymine together is

$$A + T = 100\% - 30\% - 30\% = 40\%.$$

Because adenine and thymine occur equally, adenine alone is 20%.

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

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

Option (A), 48, comes from taking 30% of the number of base pairs. Option (C), 96, is the guanine count, and option (D), 192, is the combined guanine and cytosine count. None of these is the adenine count.

Step 3: Conclusion The DNA molecule contains 64 adenine bases. Hence, the correct option is (B).

Quick Tip to Solve: First double the base-pair count to get total bases; then apply the adenine percentage found using $G = C$ and $A = T$.

7. A doctor identifies symptoms of nasal congestion, headache, sore throat, hoarseness and cough in a patient. The conclusion is that the patient is infected by a pathogen: [1 mark]

- (A) *Plasmodium*
- (B) Adenovirus
- (C) *Salmonella*
- (D) Rhinovirus

Correct Answer: (D) Rhinovirus

Solution:

Concept:

- Rhinoviruses cause the common cold, an infection of the nose and respiratory passage that does not involve the lungs.
- Its characteristic symptoms include nasal congestion and discharge, sore throat, hoarseness, cough and headache.

Step 1: Identify the symptom cluster The combined nasal and throat symptoms match the standard NCERT description of the common cold. The question gives the characteristic cluster of congestion, headache, sore throat, hoarseness and cough, rather than the features of a systemic or intestinal infection.

Step 2: Compare the possible pathogens Rhinovirus is the causative pathogen associated with this common-cold description. *Plasmodium* causes malaria, typically involving recurrent fever and chills. *Salmonella typhi* causes typhoid, associated with sustained fever and abdominal symptoms. Adenoviruses can cause respiratory illnesses, but rhinoviruses are the textbook match for the symptom set supplied here.

Step 3: Conclusion The patient is infected by Rhinovirus. Hence, the correct option is (D).

Quick Tip to Solve: Associate the NCERT cluster of nasal congestion, sore throat, hoarseness and cough with common cold and hence rhinovirus.

8. Which type of selection is industrial melanism observed in moth, *Biston betularia*? [1 mark]

- (A) Stabilising
- (B) Directional
- (C) Disruptive
- (D) Artificial

Correct Answer: (B) Directional

Solution:

Concept:

- Natural selection favours heritable variants that survive and reproduce better in a particular environment.
- Directional selection favours one extreme phenotype, shifting the population towards that variant.

Step 1: Identify the environmental advantage In polluted industrial areas, soot darkened tree trunks and lichens declined. Dark moths of *Biston betularia* were better camouflaged than light moths and were less easily detected by bird predators. They therefore survived and reproduced more successfully.

Step 2: Distinguish the types of selection The increase of the dark form represents a shift towards one extreme. Stabilising selection favours intermediate forms, whereas disruptive selection favours both extremes. Artificial selection requires deliberate human breeding; industrial melanism results from natural predation and environmental change.

Step 3: Conclusion Industrial melanism is an example of directional selection. Hence, the correct option is (B).

Quick Tip to Solve: When an environmental change favours one extreme phenotype, identify directional selection.

9. C-peptide of human insulin is:

[1 mark]

- (A) a part of mature insulin molecule.
- (B) responsible for formation of disulphide bridges.
- (C) removed during maturation of pro-insulin to insulin.
- (D) responsible for its biological activity.

Correct Answer: (C) removed during maturation of pro-insulin to insulin.

Solution:

Concept:

- Human insulin is initially synthesised as a precursor, pro-insulin, which contains a connecting segment called C-peptide.
- Mature insulin consists of the A and B polypeptide chains joined by disulphide bridges.

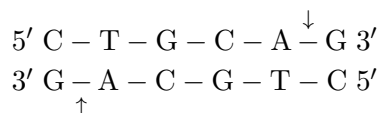
Step 1: Follow the maturation of pro-insulin During conversion of pro-insulin into mature insulin, the connecting C-peptide is removed by proteolytic processing. The A and B chains remain linked by disulphide bridges in the mature hormone.

Step 2: Check the other descriptions C-peptide is therefore not part of the mature insulin molecule, excluding (A). Disulphide bridges are bonds between cysteine residues; C-peptide itself is not the bridge-forming component described in (B). The biological action of mature insulin is exerted by the correctly folded A and B chains, not by a retained C-peptide, excluding (D).

Step 3: Conclusion C-peptide is removed during maturation of pro-insulin to insulin. Hence, the correct option is (C).

Quick Tip to Solve: Remember pro-insulin as A, B and connecting C; mature insulin retains A and B while C is removed.

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

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

Solution:

Concept:

- Restriction endonucleases cleave phosphodiester bonds at specific positions in their recognition sequences.
- Staggered cuts in the two antiparallel DNA strands produce fragments with complementary single-stranded sticky ends.

Step 1: Read each indicated cut separately On the upper strand, the downward arrow lies between A and G, so the two pieces are 5'-CTGCA and G-3'. On the lower strand, the upward arrow lies between G and A, giving 3'-G and ACGTC-5'. Do not reverse the lower strand: it is printed in the antiparallel direction.

Step 2: Match both strand fragments Only (D) places the upper break after the fifth nucleotide and the lower break after the first nucleotide. The cuts leave four-nucleotide, 3'-protruding sticky ends. Option (A) breaks the upper strand after the third base and the lower after the fifth; (B) breaks them after the second and fourth; (C) breaks both after the fourth. These positions disagree with the arrows.

Step 3: Conclusion The resultant fragments are those shown in option (D). Hence, the correct option is (D).

Quick Tip to Solve: Mark the cut on each printed strand independently, then compare both fragment lengths with every option.

11. 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:

- Introduction of alien species can threaten native biodiversity through predation, competition or other ecological effects.
- The Nile perch introduced into Lake Victoria is a classic example of biodiversity loss following alien species invasion.

Step 1: Recall the Lake Victoria example Nile perch was introduced into Lake Victoria in East Africa. Its predation contributed to the extinction of an ecologically unique assemblage of more than 200 species of native cichlid fish.

Step 2: Separate the similar examples African catfish is another introduced fish associated with threats to indigenous catfish in Indian rivers, but it is not the fish named in the Lake Victoria example. Catla and dogfish do not match the introduction and cichlid-extinction event described here. The location and affected fish group identify Nile perch specifically.

Step 3: Conclusion The fish was Nile perch. Hence, the correct option is (C).

Quick Tip to Solve: Pair Lake Victoria and cichlid extinction with Nile perch; distinguish this from African catfish in India.

12. Cattle or goats are never seen browsing on the weed, *Calotropis*. Select the correct option for the reason. [1 mark]

- (A) The plant produces highly poisonous tannins.
- (B) The plant produces quinine, which is bitter in taste.
- (C) The plant produces the poisonous chemical, cardiac glycoside.
- (D) The plant bears prickles.

Correct Answer: (C) The plant produces the poisonous chemical, cardiac glycoside.

Solution:

Concept:

- Plants possess physical and chemical defences that reduce damage by herbivores.
- *Calotropis* produces poisonous cardiac glycosides, which act as a chemical defence against browsing animals.

Step 1: Identify the defensive substance Cattle and goats avoid browsing on *Calotropis* because it produces the poisonous chemical cardiac glycoside. The presence of this toxin makes the plant

unsuitable as food and protects it from herbivory.

Step 2: Match the defence with the plant The example depends on a chemical toxin, not prickles, so (D) does not explain the observation. Although tannins and quinine are plant chemicals, neither is the specific chemical defence identified for *Calotropis* in this example. Thus (A) and (B) confuse different plant defensive substances.

Step 3: Conclusion *Calotropis* produces the poisonous chemical cardiac glycoside. Hence, the correct option is (C).

Quick Tip to Solve: Link *Calotropis* with cardiac glycosides; use thorns or prickles only for a physical defence.

13. 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 sequences repeated many times in the genome and constitutes a very large portion of human DNA.
- In the NCERT description, repetitive sequences do not have direct coding functions; their abundance and their coding role are separate properties.

Step 1: Judge the assertion The human genome contains extensive repetitive DNA. Thus 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 described as lacking direct coding functions. The reason is therefore true. This does not mean that all such DNA is biologically irrelevant; the statement concerns direct coding functions.

Step 3: Test the explanatory connection Lacking a direct coding function does not explain why a sequence occurs in many copies or why those copies occupy such a large fraction of the genome. The reason describes a property of repetitive DNA but does not account for its abundance. Option (A) wrongly asserts an explanatory link, while (C) and (D) wrongly label one statement false.

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: After judging both statements, ask whether the reason explains the abundance, rather than merely describing repetitive DNA.

14. 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 of the zygote produces blastomeres; an embryo with 8 to 16 blastomeres is called a morula.
- The morula develops into a blastocyst containing an outer trophoblast and an inner cell mass.

Step 1: Judge the assertion The solid embryonic mass formed at the 8- to 16-blastomere stage is termed the morula. The assertion gives this standard developmental definition and is true.

Step 2: Judge the reason As cell division continues, the morula transforms into a blastocyst, not into a trophoblast as a whole. Trophoblast is the outer layer of cells of the blastocyst; the inner cell mass is a distinct group that develops into the embryo. The reason confuses a whole developmental stage with one of its cell layers and is false.

Step 3: Select the appropriate relation A false reason cannot explain the true assertion. Options (A) and (B) incorrectly regard the reason as true, while (D) incorrectly rejects the assertion. The required combination is a true assertion with a false reason.

Step 4: Conclusion Assertion is true, but Reason is false. Hence, the correct option is (C).

Quick Tip to Solve: Keep the sequence morula to blastocyst clear; trophoblast names the blastocyst's outer cell layer.

15. 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 first requires disruption of the cell wall and membranes so that the cellular contents are released.
- The wall-digesting enzyme is selected according to the wall material: chitinase digests chitin, whereas cellulase digests cellulose.

Step 1: Evaluate the assertion Yeast is a fungus with a chitin-containing cell wall, so chitinase is used to break this barrier during DNA isolation. *Spirogyra* is a green alga with a cellulose-containing wall; its wall is treated with cellulase rather than chitinase. Thus, Assertion (A) is true.

Step 2: Evaluate the reason Chitin is a characteristic constituent of fungal cell walls. Yeast belongs to the fungi, so Reason (R) is also true.

Step 3: Test the explanatory link The presence of chitin in the yeast wall directly explains the use of chitinase. The different wall composition of *Spirogyra* explains why the same enzyme is not required there. Option (B) incorrectly denies this explanatory link, while (C) and (D) incorrectly declare one of the statements false.

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

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

16. Assertion (A): Besides curdling of milk, LAB also improves its nutritional quality by increasing Vitamin B₁₂.

Reason (R): LAB, when present in the stomach checks disease-causing microbes.

[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:

- Lactic acid bacteria (LAB) convert milk into curd and improve its nutritional quality by increasing vitamin B₁₂.
- LAB also help suppress disease-causing microbes; this protective effect is distinct from their nutritional contribution.

Step 1: Evaluate the assertion LAB grow in milk and produce acids that coagulate and partially digest milk proteins, forming curd. They also increase the vitamin B₁₂ content. Therefore, the assertion about curdling and improved nutritional quality is true.

Step 2: Evaluate the reason As stated in NCERT, LAB present in the stomach check disease-causing microbes. This beneficial protective role makes Reason (R) true.

Step 3: Examine whether the reason explains the assertion Suppression of harmful microbes does not explain why LAB increase the vitamin content of milk. The reason describes a separate benefit of LAB. Thus (A) is incorrect because there is no explanatory link, and (C) and (D) are incorrect because neither statement is false.

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

Quick Tip to Solve: Separate LAB's two benefits: vitamin enrichment improves nutrition, while checking pathogens provides protection.

Section B (10 marks)

17. State the role of thymus as a lymphoid organ. Name the cells that are released from it and mention their functions. [2 marks]

Solution:

Concept:

- Primary lymphoid organs provide the environment in which immature lymphocytes become antigen-sensitive, immunocompetent lymphocytes.
- The thymus is a primary lymphoid organ associated with the maturation of T-lymphocytes, which mediate cellular immune responses.

Step 1: State the role of the thymus The thymus provides a specialised microenvironment for the differentiation and maturation of immature T-lymphocytes. Their precursors arise in the bone marrow and enter the thymus, where they acquire immunocompetence. Mature T-lymphocytes are then released and populate secondary lymphoid organs, where contact with antigens initiates immune responses.

Step 2: Explain the functions of the released cells T-lymphocytes carry out cell-mediated immunity. Cytotoxic T-cells destroy virus-infected or abnormal body cells, and T-cell responses also participate in graft rejection. Helper T-cells assist other immune cells, including helping B-lymphocytes produce antibodies. T-cells do not themselves secrete antibodies; that is the function of plasma cells derived from B-lymphocytes.

Step 3: Conclusion The thymus matures and releases immunocompetent T-lymphocytes. These cells mediate cellular immunity and help coordinate other immune responses, including antibody production by B-cells.

Quick Tip to Solve: Link thymus with T-cell maturation, then distinguish direct cellular defence from the help T-cells give B-cells.

18(a). Explain the mutually rewarding relationship between Yucca plant and species of moth.

[2 marks]

Solution:

Concept:

- Mutualism is an interspecific interaction in which both participating species benefit, represented as (+, +).
- In the association between *Yucca* and its moth pollinator, plant reproduction is linked with the reproductive needs of the moth.

Step 1: Explain the benefit to the plant The female moth transfers pollen to the stigma of a *Yucca* flower while using the flower for egg laying. This pollination enables fertilisation and seed formation in the plant. The moth therefore provides the plant with the essential service of pollen transfer rather than merely visiting the flower without contributing to reproduction.

Step 2: Explain the benefit to the moth The moth lays its eggs in the locule of the flower's ovary, where the larvae subsequently hatch as the seeds begin developing. The developing seeds provide food for the larvae. The larvae consume only some seeds, leaving others to mature and reproduce the plant. Thus, the plant supplies both an egg-laying site and a food resource for the moth's offspring.

Step 3: Conclusion The relationship is mutually rewarding: *Yucca* gains pollination and seed production, while the moth gains a site for egg laying and developing seeds as larval food.

Quick Tip to Solve: Pair each partner with its reward: *Yucca* receives pollination; the moth receives an ovary for eggs and seeds for larvae.

OR

18(b). Pollination success will be reduced unless the orchid flower co-evolves with the pollinator. Explain. [2 marks]

Solution:

Concept:

- Co-evolution means that evolutionary changes in interacting species are associated with corresponding changes in their partners.
- Successful pollination requires a close match between the flower's attraction mechanism and the pollinator's recognition and behaviour.

Step 1: Describe the orchid's pollination mechanism In the Mediterranean orchid *Ophrys*, one petal resembles a female bee in size, colour and markings. A male bee is attracted to this resemblance and attempts pseudocopulation with the flower. During the attempt, pollen attaches to its body; when it visits another orchid flower, it transfers the pollen and brings about pollination.

Step 2: Explain why a matching evolutionary response is needed If the female bee's colour pattern or other recognised features change through evolution, the orchid's existing resemblance may no longer attract the male bee. Fewer male visits would mean less pollen transfer and reduced pollination success. The orchid must therefore evolve corresponding changes that maintain its resemblance to the female bee and continue to trigger the male's pollinating behaviour.

Step 3: Conclusion Orchid pollination depends on maintaining a close match with its pollinator. If the pollinator changes but the flower does not co-evolve, attraction and pollen transfer decline.

Quick Tip to Solve: Use the *Ophrys* example: changed female-bee appearance requires matching floral mimicry to keep male bees visiting.

19(a). Differentiate between grazing food chain and detritus food chain.

[2 marks]

Solution:

Concept:

- A food chain describes the transfer of food and energy through organisms linked by feeding relationships.
- The starting material distinguishes a grazing food chain from a detritus food chain: living producers in the former and dead organic matter in the latter.

Step 1: Compare their starting points A **grazing food chain** begins with living green plants, the producers that capture solar energy by photosynthesis. A **detritus food chain** begins with detritus, such as fallen leaves, dead organisms and organic wastes. Thus, their immediate sources of food are living plant material and dead organic material, respectively.

Step 2: Compare the first organisms using that food In a grazing food chain, herbivores feed directly on the producers and are subsequently eaten by carnivores; for example, grass → grasshopper → frog. In a detritus food chain, decomposers such as bacteria and fungi break down dead organic matter. Their extracellular enzymes digest it, and they absorb the resulting simpler nutrients. Detritivores also feed on detritus and aid its fragmentation.

Step 3: Conclusion Grazing food chains start with **living producers consumed by herbivores**, whereas detritus food chains start with **dead organic matter acted upon by decomposers and detritivores**.

Quick Tip to Solve: Compare the starting food first, then name the organisms that use it: green plants and herbivores versus detritus and decomposers.

OR

19(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 at successive trophic levels, with producers at the base.
- Such a simplified representation cannot show every feeding relationship or every ecological group in a natural ecosystem.

Step 1: Limitation 1: a species may occupy more than one trophic level An ecological pyramid does not account for the **same species belonging to two or more trophic levels**. For example, an omnivore acts as a primary consumer when eating plant material but as a higher-level consumer when eating another animal. Assigning that species to just one tier fails to express these different feeding roles.

Step 2: Limitation 2: food webs are not represented An ecological pyramid assumes a **simple food chain** and does not accommodate a food web. In nature, an organism may eat several kinds of food

and may itself be eaten by several predators. These interconnected chains provide multiple routes for the transfer of food and energy, whereas a pyramid shows a simplified sequence of trophic levels.

Step 3: Conclusion Two limitations are that ecological pyramids do not account for a species occupying multiple trophic levels and do not represent food webs.

Quick Tip to Solve: Recall two distinct omissions: one species can have several feeding roles, and real food chains are linked into food webs.

20. How do 'implants' act as an effective method of contraception in human females? Mention one advantage of implants over contraceptive pills. [2 marks]

Solution:

Concept:

- Hormonal contraceptive implants are placed under the skin and provide a sustained release of contraceptive hormones.
- Progestogens, alone or combined with oestrogens, can prevent conception by affecting ovulation, the uterine endometrium and cervical mucus.

Step 1: Explain how implants prevent conception Implants slowly release **progestogens, alone or in combination with oestrogens**. Their hormonal action inhibits ovulation, so an ovum is not released for fertilisation. They also alter the uterine endometrium to make implantation unsuitable and change the quality of cervical mucus, making sperm entry into the uterus difficult. These actions are similar to those of hormonal contraceptive pills.

Step 2: State the advantage over pills The contraceptive action of an implant lasts for a **much longer period** because the hormones are released gradually from the implanted preparation. Unlike oral contraceptive pills, it does not require the woman to remember a daily dose. This sustained action reduces dependence on daily adherence to a pill schedule.

Step 3: Conclusion Implants prevent conception through sustained hormonal action that inhibits ovulation and implantation and impedes sperm entry. Their advantage over pills is **longer-lasting protection without daily administration**.

Quick Tip to Solve: Link implants to the same hormonal actions as pills, then distinguish them by sustained release and freedom from daily dosing.

21(a). Explain any two methods of vectorless gene transfer. [2 marks]

Solution:

Concept:

- Vectorless gene transfer introduces foreign DNA directly into recipient cells without using a carrier vector such as a plasmid or a virus.
- Physical methods can bypass the barriers that normally prevent large DNA molecules from entering a cell.

Step 1: Method 1: microinjection In **microinjection**, recombinant DNA is injected directly into the nucleus of an animal cell using a very fine glass micropipette or microneedle. The cell is held in position while the DNA is delivered under microscopic control. Direct injection places the DNA inside the cell without depending on a biological vector to transport it across the cell membrane.

Step 2: Method 2: biolistics or the gene gun In **biolistics**, cells, particularly plant cells, are bombarded with high-velocity microparticles of gold or tungsten coated with DNA. The metal particles penetrate the cell wall and membrane and carry the foreign DNA into the cells. The introduced DNA can then become established in successfully transformed cells. Here the particles provide physical delivery, so no biological vector is required.

Step 3: Conclusion Two vectorless methods are **microinjection**, which delivers DNA directly into an animal-cell nucleus, and **biolistics**, which delivers DNA on high-velocity gold or tungsten particles, especially into plant cells.

Quick Tip to Solve: Associate microinjection with a fine needle and the animal-cell nucleus; associate biolistics with DNA-coated gold or tungsten particles.

OR

21(b). Name the most commonly used bioreactor. List the advantages of the bioreactor. Also write the importance of sampling ports. [2 marks]

Solution:

Concept:

- A bioreactor provides controlled conditions for converting raw materials into useful biological products with the help of microorganisms, plant cells or animal cells.
- Product yield depends on maintaining suitable temperature, pH, nutrient supply, oxygen availability and mixing throughout the culture.

Step 1: Name the commonly used design The most commonly used bioreactor is the **stirred-tank bioreactor**. It is generally cylindrical with a curved base that facilitates mixing of the contents.

Step 2: State its advantages The stirrer mixes the culture uniformly and makes oxygen available throughout the vessel. Aeration supplies oxygen, while controls for temperature, pH and foam help maintain optimum growth conditions. Thus, the vessel supports the production of large quantities of the desired product under controlled conditions.

Step 3: Explain the sampling ports Sampling ports allow small volumes of culture to be withdrawn periodically for testing. Analysis of these samples helps monitor culture growth, nutrient consumption and product formation, so that conditions can be adjusted when required. Proper aseptic sampling also helps protect the bulk culture from contamination.

Step 4: Conclusion The stirred-tank bioreactor is the most commonly used design. Uniform mixing, oxygen supply and control of growth conditions support large-scale production; sampling ports permit periodic monitoring of the culture.

Quick Tip to Solve: Link the stirrer to mixing and oxygen distribution, and the sampling ports to withdrawing small samples for monitoring.

Section C (21 marks)

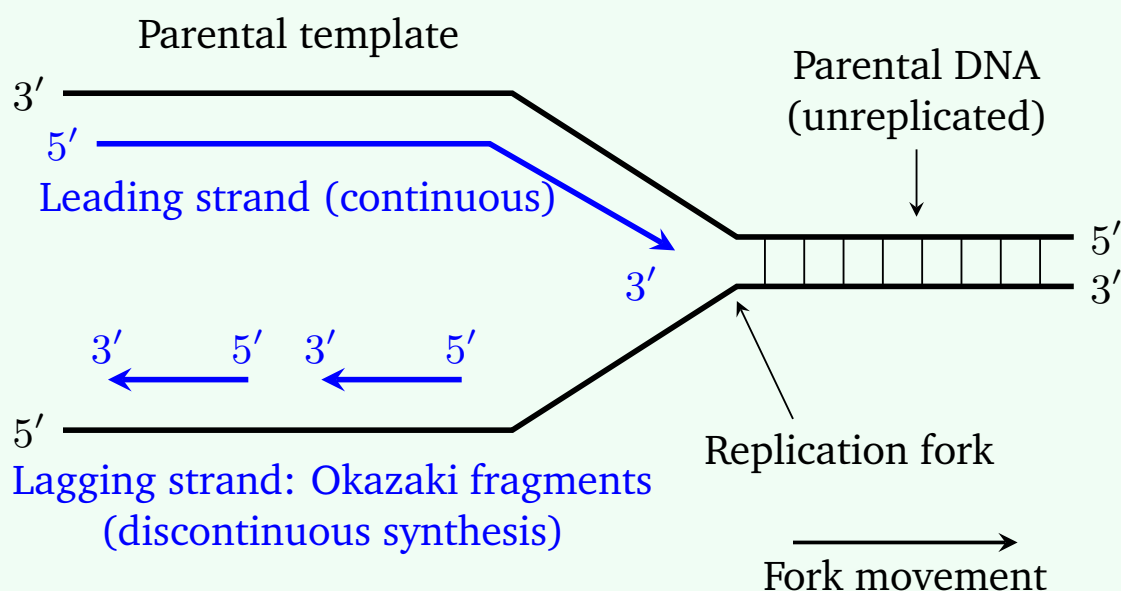
22. Draw a labelled diagram of a 'replicating fork' showing the polarity. Why does DNA replication occur within such 'fork'? [3 marks]

Solution:

Concept:

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

Step 1: Show the strands and their polarity The labelled replication fork below opens towards the right. The two black lines represent parental templates, and the arrows on the new strands indicate the direction of DNA synthesis. The parental duplex is locally unwound at the fork, making both template strands accessible for complementary base pairing.



Replication fork: all new DNA is synthesised in the 5' → 3' direction.

Step 2: Relate the polarity to strand synthesis On the template oriented 3' → 5' towards the moving fork, the leading strand is synthesised continuously in the same direction as fork movement. On the opposite template, synthesis proceeds discontinuously away from the fork as short Okazaki fragments. Each fragment is still synthesised 5' → 3'; DNA ligase subsequently joins the fragments to form a continuous daughter strand.

Step 3: Explain why replication uses 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 high amount of energy. Therefore, the DNA opens only in a small local region, forming a replication fork. Replication enzymes use the exposed templates in this region, and unwinding progresses as synthesis proceeds.

Step 4: Conclusion Replication occurs at a locally opened fork because complete simultaneous

separation of the long DNA molecule would be energetically very demanding. Both daughter strands grow $5' \rightarrow 3'$, continuously on one template and discontinuously on the other.

Quick Tip to Solve: Put a $3'$ end at every new-strand arrowhead: leading synthesis points towards the moving fork, while Okazaki-fragment synthesis points away from it.

23. 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 discourage self-pollination or self-fertilisation and favour the transfer of pollen to a genetically different plant of the same species.
- Continued self-pollination can cause inbreeding depression. Flowering plants use differences in timing, spatial separation and pollen-pistil recognition to promote outbreeding.

Step 1: Explain different times of pollen release and stigma receptivity Dichogamy: pollen release and stigma receptivity are not synchronised within the same flower. Either the pollen is released before its stigma becomes receptive, or the stigma is receptive before pollen release. Thus, the flower's own pollen is unavailable when its stigma can receive pollen, preventing autogamy and favouring pollen arriving from another flower.

Step 2: Explain spatial separation of anther and stigma Herkogamy: the anthers and stigma are positioned at different places in a flower so that pollen from its anthers cannot readily contact its own stigma. This physical separation prevents autogamy and promotes pollen transfer by a pollinating agent from another flower. Timing and spatial separation alone do not necessarily prevent transfer between different flowers on the same plant.

Step 3: Explain rejection of self-pollen Self-incompatibility: a genetically controlled mechanism recognises self-pollen and prevents it from fertilising the ovule. This occurs by inhibiting pollen germination on the stigma or pollen-tube growth in the pistil. Consequently, even if self-pollen is deposited, fertilisation requires compatible pollen from another plant, encouraging cross-pollination and outbreeding.

Step 4: Conclusion Three outbreeding devices are dichogamy, herkogamy and self-incompatibility. They respectively separate reproductive timing, prevent contact between a flower's anthers and stigma, and reject self-pollen, thereby favouring cross-pollination.

Quick Tip to Solve: Explain each device through its barrier: different time, different position, or genetic rejection of self-pollen.

24. Explain how the following microbes act as biocontrol agents:

(a) *Bacillus thuringiensis*

(b) Nucleopolyhedrovirus

[3 marks]

Solution:

Concept:

- Biological control uses living organisms or their products to suppress pests, reducing dependence on chemical pesticides.
- An effective biocontrol agent attacks its target pest while conserving beneficial organisms and ecological balance.

Step 1: (a) Explain the action of Bt *Bacillus thuringiensis* (Bt) produces insecticidal protein crystals during sporulation. Preparations of its spores and toxin are sprayed on vulnerable plants, such as brassicas and fruit trees, to control butterfly caterpillars. When a susceptible larva eats the treated leaves, the alkaline conditions in its gut convert the inactive protoxin into an active toxin. The toxin binds to the midgut epithelial cells and creates pores in their membranes, causing cell swelling and lysis. Damage to the gut kills the larva. Thus, Bt controls susceptible insect larvae by ingestion of its toxin; it does not act as a broad-spectrum chemical poison.

Step 2: (b) Explain the action of nucleopolyhedroviruses Nucleopolyhedroviruses are baculoviruses used to control insect pests and other arthropods. They infect susceptible pest hosts, multiply within them and cause disease and death. They are species-specific, narrow-spectrum insecticides, so they selectively suppress the target pest. They have no negative impacts on plants, mammals, birds, fish or even non-target insects. This is particularly valuable when beneficial insects must be conserved, and makes them useful in integrated pest management and ecologically sensitive areas.

Step 3: Conclusion Bt controls susceptible larvae through an insecticidal gut toxin, whereas nucleopolyhedroviruses control pests by host-specific viral infection. Both provide biological alternatives to chemical pest control.

Quick Tip to Solve: For Bt, link ingestion to alkaline activation and gut damage; for nucleopolyhedroviruses, stress host specificity and protection of beneficial insects.

25. 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 had their DNA manipulated to possess and express an additional foreign gene.
- The introduced gene allows researchers to study gene function, reproduce features of human diseases or obtain useful biological products.

Step 1: Study normal physiology and development Transgenic animals help scientists investigate how genes are regulated and how they affect normal body functions and development. For example,

an animal carrying an altered or additional gene involved in growth can reveal the biological role of that gene. By introducing a gene from another species and examining its expression and effects, researchers understand how genes contribute to the development and functioning of the body. This knowledge helps explain normal human physiology.

Step 2: Develop models of human disease Transgenic animals can be designed to show how particular genes contribute to disease. Models of human disorders such as cancer, cystic fibrosis and Alzheimer's disease enable scientists to study the mechanisms involved. Researchers can follow disease development in these models and investigate possible treatments, providing knowledge useful for human healthcare.

Step 3: Produce useful biological products Introducing a gene coding for a medically useful human protein can make a transgenic animal produce that protein. For example, transgenic animals can produce human alpha-1-antitrypsin, a protein used in treating emphysema. Such animals provide a means of obtaining valuable biological products for patients. The first transgenic cow, Rosie, produced milk enriched with human alpha-lactalbumin, illustrating production of a human protein in animal milk.

Step 4: Conclusion Three benefits are understanding normal physiology and development, creating models for human diseases and producing useful biological proteins.

Quick Tip to Solve: Organise three uses as normal function, disease models and useful proteins; give the purpose and a concrete example for each.

26. 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 organisation in which they occur.
- Its three major levels are variation in genes within a species, variation among species and variation among ecosystems.

Step 1: Explain genetic diversity Genetic diversity is the variation in genes within a single species, including differences among its populations over its geographical range. For example, populations of *Rauwolfia vomitoria* growing in different Himalayan ranges vary in the potency and concentration of the active chemical reserpine that they produce. These differences illustrate genetic variation within the same species, rather than the presence of different species. Such variation provides the basis for differences in traits among members of a species.

Step 2: Explain species diversity Species diversity is the variety of species present in a region. For example, the Western Ghats have a greater diversity of amphibian species than the Eastern Ghats. Here the comparison concerns the different amphibian species occurring in the two regions; it does not refer merely to the number of individuals of one species. A region containing a greater variety of species shows higher species diversity in this comparison.

Step 3: Explain ecological diversity Ecological diversity is the variety of ecosystems in a region,

with their different habitats, communities and ecological conditions. For example, India has deserts, rainforests, mangroves, coral reefs, wetlands, estuaries and alpine meadows. This range of ecosystems gives India greater ecological diversity than a country such as Norway. The comparison is between ecosystem types, rather than between genes or individual species.

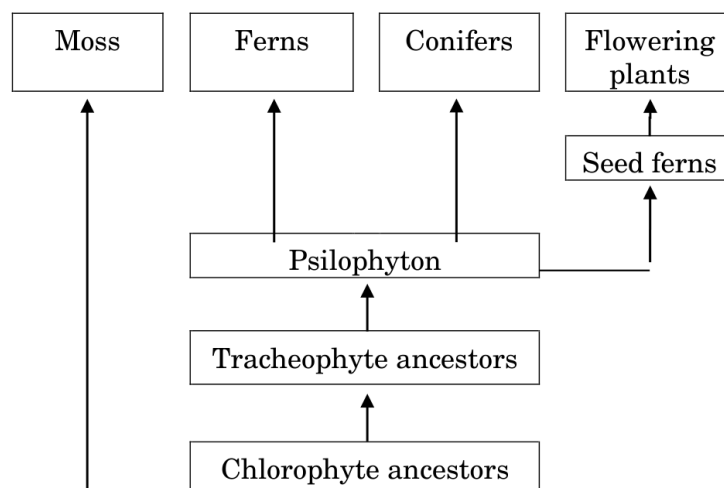
Step 4: Conclusion Genetic diversity is illustrated by variation in reserpine production within *Rauwolfia vomitoria*; species diversity by amphibian diversity in the Western Ghats; and ecological diversity by India's varied ecosystems.

Quick Tip to Solve: Classify each example by asking what varies: genes within one species, species in a region, or whole ecosystems.

27. 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:

- An evolutionary chart is read in the direction of its arrows, from an ancestral group towards its descendants.
- An immediate ancestor is the group directly below a descendant on its lineage; a common ancestor is shared when two lineages are traced backwards.

Step 1: (a) Trace the immediate ancestors of ferns and conifers Both the arrow ending at ferns and the arrow ending at conifers begin at Psilophyton. Thus Psilophyton is their immediate common ancestor in the given chart.

Step 2: (b) Find the nearest ancestor of flowering plants The arrow directly entering the flowering-plants box comes from seed ferns. Seed ferns are therefore the nearest ancestors of flowering plants shown here.

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

Step 4: (d) Follow the branches from Psilophyton Psilophyton leads directly to ferns and conifers, and also to seed ferns, which lead to flowering plants. It therefore provides common ancestry to ferns (pteridophytes), conifers (gymnosperms) and flowering plants (angiosperms).

Step 5: (e) Trace Psilophyton and seed ferns backwards Tracheophyte ancestors give rise to Psilophyton, whose branch then leads to seed ferns. Hence the ancestral group underlying both Psilophyton and seed ferns is the tracheophyte ancestors.

Step 6: (f) Trace mosses and tracheophytes backwards The moss lineage branches from the chlorophyte ancestors, and the tracheophyte lineage also rises from this basal group. Chlorophyte ancestors are therefore their common ancestors.

Step 7: Conclusion (a) Psilophyton; (b) seed ferns; (c) chlorophytes; (d) ferns, conifers and flowering plants; (e) tracheophyte ancestors; (f) chlorophyte ancestors.

Quick Tip to Solve: For “nearest ancestor”, follow just one incoming arrow; for common ancestry, trace both lineages backwards to their shared ancestral group.

28. Given below is an equation describing the growth pattern of a population:

$$dN/dt = rN$$

(a) Mention the type of growth model or growth pattern of the population described by the given equation.

(b) What does ‘r’ in the equation signify?

(c) Mention the type of growth curve that will be obtained if the population density (N) is plotted against time (t).

(d) According to you, will the resource availability be limited or unlimited for this type of growth in the given population?

[3 marks]

Solution:

Concept:

- In exponential growth, the instantaneous rate of increase of a population is proportional to its existing population density: $\frac{dN}{dt} = rN$.
- Here N is population density, t is time and r is the intrinsic rate of natural increase. For a population without migration, $r = b - d$, where b and d are per capita birth and death rates.

Step 1: (a) Identify the growth model The equation contains the population density multiplied by a constant per capita growth rate. It describes exponential growth. When $r > 0$, a larger population adds more individuals per unit time, so its absolute rate of increase keeps rising.

Step 2: (b) Interpret the parameter r The parameter r is the intrinsic rate of natural increase, also called the intrinsic rate of increase. It expresses the per capita net increase per unit time under the given conditions. It is the difference between per capita natality and mortality, $r = b - d$, when immigration and emigration are absent.

Step 3: (c) Identify the growth curve The solution of this growth equation is $N_t = N_0 e^{rt}$, where N_0 is the initial density and N_t is the density at time t . For a growing population with positive r , plotting density against time produces a J-shaped curve: the rise is initially slow and then becomes increasingly steep.

Step 4: (d) State the resource condition This model assumes unlimited resources, such as food and space, and favourable conditions for unrestricted growth. Resource limitation would introduce environmental resistance and prevent sustained exponential increase. The given equation has no carrying-capacity term to slow growth as density increases.

Step 5: Conclusion (a) Exponential growth; (b) r is the intrinsic rate of natural increase; (c) a J-shaped growth curve; (d) resources are assumed to be unlimited.

Quick Tip to Solve: Link rN with unrestricted growth and a J-shaped curve; a carrying-capacity factor signals logistic growth instead.

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:

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

Step 1: Apply the direction of RNA synthesis Since the growing RNA chain extends in the $5' \rightarrow 3'$ direction, RNA polymerase must move along and read its template in the opposite, $3' \rightarrow 5'$, direction.

Step 2: Identify the template for this transcription unit The DNA strand with $3' \rightarrow 5'$ polarity in the direction of transcription therefore serves as the template. The opposite strand has $5' \rightarrow 3'$ polarity in that direction and acts as the coding strand for this transcription unit; it cannot be read in that same direction to produce an antiparallel RNA by normal polymerase activity.

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

5' → 3', antiparallel to the template.

Quick Tip to Solve: Write the RNA arrow first, 5' → 3', then reverse it to obtain the template-reading direction.

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

[1 mark]

Solution:

Concept:

- Eukaryotic primary transcripts, called heterogeneous nuclear RNA (hnRNA), contain both exons and introns.
- Splicing removes introns and joins exons to produce the correctly processed RNA sequence.

Step 1: Identify the parts of the primary transcript The hnRNA copied from a split gene includes intervening, non-coding introns as well as exons. It is therefore not yet the mature messenger RNA that can provide the correct message for protein synthesis.

Step 2: Explain the need for splicing During splicing, the introns are excised and the exons are joined in their proper order. Removing the intervening sequences preserves the required continuous message in the mature mRNA; simply retaining the unprocessed transcript would not supply the correctly assembled message.

Step 3: Conclusion hnRNA must undergo splicing to remove introns and join exons, forming the properly processed sequence of mature mRNA.

Quick Tip to Solve: Remember the two linked actions of splicing: introns are removed and exons are joined together.

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 requires processing to become functional messenger RNA; splicing is accompanied by modifications at its ends.
- The two end modifications are capping at the 5' end and tailing at the 3' end.

Step 1: Describe capping A modified guanosine nucleotide, the methyl guanosine triphosphate cap, is added at the 5' end of the transcript. This modification is called capping and helps protect the RNA and supports its use in translation.

Step 2: Describe tailing Adenylate residues, typically about 200–300, are added to the 3' end without a DNA template specifying each added residue. This process is called tailing or polyadenylation. The resulting poly(A) tail contributes to RNA stability and processing into functional mRNA.

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

Quick Tip to Solve: Pair each end with its modification: a guanosine cap at 5' and an adenylate tail at 3'.

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

[2 marks]

Solution:

Concept:

- During transcription of a particular transcription unit, RNA polymerase uses only one DNA strand as its template; the RNA sequence is complementary to that strand.
- The two DNA strands have complementary base sequences. Copying both strands of the same region would therefore produce RNAs with different but complementary sequences.

Step 1: Consider the information carried by two transcripts If both DNA strands were transcribed, each would specify a different RNA sequence. If the two RNAs were translated, they would generally specify different amino acid sequences and hence different polypeptides. The same DNA segment would thus appear to carry information for two different proteins, complicating the transfer of genetic information for that transcription unit.

Step 2: Consider pairing between the transcripts The two RNAs would be complementary because they were copied from complementary DNA strands. They could base-pair with one another to form double-stranded RNA. Such paired RNA would not function as the normal single-stranded mRNA template for translation, preventing the intended protein synthesis.

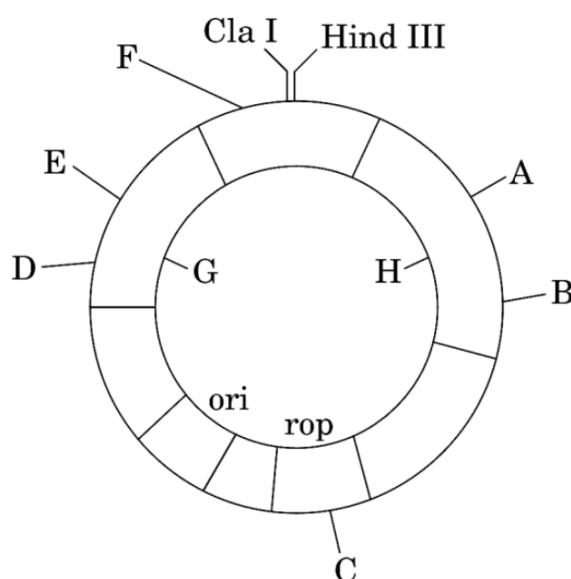
Step 3: Conclusion Only one strand of a given transcription unit is copied because transcribing both would produce different protein messages and complementary RNAs that could pair into double-stranded RNA, obstructing translation.

Quick Tip to Solve: Give two distinct consequences: different RNA messages, then complementary RNA pairing that prevents normal 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 a foreign DNA fragment into a host cell and enables that fragment to be copied.
- Plasmids and bacteriophages possess the ability to replicate in bacterial cells; DNA linked to them is replicated along with the vector.

Step 1: Relate replication to cloning Plasmids are extrachromosomal DNA molecules that can replicate independently of the bacterial chromosome. An inserted foreign DNA fragment becomes part of the plasmid and is therefore copied whenever the plasmid replicates.

Step 2: Apply the same principle to bacteriophages Bacteriophages introduce their genetic material into bacteria and multiply using the host machinery. Their multiplication can produce many copies of an inserted DNA fragment. Thus, both types of vector provide a means of amplifying the desired DNA in a bacterial host.

Step 3: Conclusion Plasmids and bacteriophages are used as cloning vectors because they can replicate within bacterial cells and thereby multiply the foreign DNA linked to them.

Quick Tip to Solve: For a vector question, connect its ability to replicate with the copying of the inserted foreign 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:

- In pBR322, the *rop* gene codes for a protein involved in regulation of plasmid replication and copy number.
- The origin of replication, *ori*, is the DNA sequence at which replication begins; a restriction site is a specific sequence recognised by a restriction endonuclease.

Step 1: Identify the requested gene Part (I) specifically asks for a gene. The *rop* gene encodes the Rop protein, which helps regulate plasmid replication and hence plasmid copy number. The nearby *ori* label denotes the origin of replication, rather than a protein-coding gene.

Step 2: Identify site C on the map Part (II) places site C in the region marked *rop*, at the lower part of the pBR322 map. This is the recognition site for PvuII. It must not be confused with PvuI, a different restriction site in the ampicillin-resistance region.

Step 3: Conclusion (I) The gene is *rop*. (II) Restriction site C is PvuII.

Quick Tip to Solve: Distinguish the *rop* gene from the *ori* sequence, and keep PvuII in the *rop* region separate from PvuI.

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

[1 mark]

Solution:

Concept:

- A selectable marker gives a host cell a detectable survival advantage, allowing transformed cells to be selected from untransformed cells.
- The two antibiotic-resistance markers in pBR322 confer resistance to ampicillin and tetracycline.

Step 1: Identify marker G The region labelled G on the left side of the vector is the ampicillin-resistance gene, amp^R . Bacteria with a functional copy of this marker can grow on medium containing ampicillin, whereas susceptible bacteria cannot.

Step 2: Identify marker H The region labelled H on the right side is the tetracycline-resistance gene, tet^R . It similarly permits selection using tetracycline. These genes are selectable markers because their resistance phenotypes reveal the presence of the corresponding functional vector sequences.

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

Quick Tip to Solve: On this pBR322 map, identify the left resistance region as amp^R and the right one as tet^R .

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

[2 marks]

Solution:

Concept:

- The selectable marker genes of pBR322 are amp^R and tet^R , which confer ampicillin and tetracycline resistance respectively.
- Each restriction endonuclease recognises its own DNA sequence. Inserting foreign DNA at a suitable site within a marker gene can disrupt the gene, causing insertional inactivation.

Step 1: Read the sites in the ampicillin-resistance gene The gene labelled G is amp^R . Its two indicated restriction sites are E, PvuI, and D, PstI. These sites lie in the ampicillin-resistance region on the left of the circular map. PvuI here is distinct from PvuII at site C in the *rop* region.

Step 2: Read the sites in the tetracycline-resistance gene The gene labelled H is tet^R . The two sites indicated along its right side are A, BamHI, and B, SalI. An insert at the BamHI site can inactivate tetracycline resistance while leaving ampicillin resistance available for selecting transformed cells. The requested pairs must therefore be grouped according to their marker gene, rather than listed as four unrelated enzymes.

Step 3: Conclusion In amp^R (G): PstI (D) and PvuI (E). In tet^R (H): BamHI (A) and SalI (B).

Quick Tip to Solve: Pair PstI and PvuI with ampicillin resistance, and BamHI and SalI with tetracycline resistance; PvuII belongs to the *rop* region.

Section E (15 marks)

31(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 follows one contrasting character. Each offspring receives one allele from each parent; the two alleles segregate during gamete formation.
- In complete dominance, the heterozygote resembles the dominant homozygote. In incomplete dominance, the heterozygote has an intermediate phenotype.

Step 1: Cross true-breeding pea plants Let P represent the allele for violet (purple) flowers and p the allele for white flowers. The violet allele is completely dominant over the white allele. Cross a true-breeding violet plant with a true-breeding white plant:

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

Thus, the recessive white trait is not expressed in the heterozygous first generation, although its allele is present.

Step 2: Self the pea hybrid to obtain the second generation Self-pollination of the F_1 hybrid gives $Pp \times Pp$. Each parent forms P and p gametes in equal proportions. Their random fusion gives:

	P	p
P	PP	Pp
p	Pp	pp

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 because P masks the expression of p . The reappearance of white flowers shows that the recessive allele was retained and segregated unchanged.

Step 3: Cross true-breeding *Antirrhinum* plants In *Antirrhinum* (snapdragon), use R and r for the flower-colour alleles: RR is red, rr is white and Rr is pink. Here the red allele is not completely dominant over the white allele.

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

The heterozygous plants express an intermediate flower colour, demonstrating incomplete dominance.

Step 4: Self the *Antirrhinum* hybrid and compare inheritance Selfing the pink F_1 plants gives $Rr \times Rr$.

Each hybrid produces equal proportions of R and r gametes:

	R	r
R	RR	Rr
r	Rr	rr

The F_2 genotypic ratio is $1 RR : 2 Rr : 1 rr$ and the phenotypic ratio is 1 red:2 pink:1 white. Unlike pea, each genotype has a distinct phenotype. Both crosses obey the law of segregation: alleles remain discrete and separate into different gametes. The recovery of red and white parental phenotypes in snapdragon also shows that the alleles have not permanently blended.

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. The genotypic ratio is 1 : 2 : 1 in both crosses.

Quick Tip to Solve: First write the common heterozygote cross and its 1 : 2 : 1 genotypes; then assign colours. Group the heterozygote with the dominant parent only in pea.

OR

31(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 result from an alteration in chromosome number or structure, or from mutation in a single gene.
- A chromosomal disorder affects the chromosome complement or chromosome structure; a Mendelian disorder is inherited according to the transmission pattern of the affected gene.

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. Numerical abnormalities can arise through failure of chromosomes to segregate properly during cell division. For example, Down's syndrome results from an additional copy of chromosome 21 (trisomy 21), so an affected individual has 47 chromosomes rather than the usual 46.

Step 2: Identify the basis of a Mendelian disorder A Mendelian disorder results from an alteration or mutation in a single gene and follows the inheritance pattern of that gene. For example, sickle-cell anaemia is an autosomal recessive disorder caused by a mutation in the gene for the beta-globin chain of haemoglobin. The chromosome number can remain normal; the defect lies in the sequence of the gene, rather than an extra or missing chromosome.

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

Quick Tip to Solve: Match each example to its level of change: trisomy 21 means an extra chromosome, while sickle-cell anaemia means a mutation in a single gene.

31(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 chromosomes or chromatids to segregate properly during cell division. It can produce gametes with an abnormal chromosome number.
- Aneuploidy is the gain or loss of one or more individual chromosomes. Loss of one sex chromosome produces monosomy X, rather than a change in a single gene.

Step 1: Identify the phenomenon and the disorder The phenomenon is **nondisjunction**, resulting in **aneuploidy**. For example, an abnormal gamete lacking a sex chromosome can fuse with a normal X-bearing gamete. The resulting zygote has only one X chromosome instead of a pair of sex chromosomes. This XO condition is called **Turner's syndrome**. The symbol O denotes the absence of a chromosome; it is not a separate chromosome.

Step 2: State the karyotype and its effects The karyotype is 45, X, commonly written 44 + XO: there are 44 autosomes and only one X chromosome, giving 45 chromosomes in total. The affected individual is phenotypically female. The ovaries are rudimentary or poorly developed, so the individual is sterile. Secondary sexual characters are poorly developed, including inadequate breast development, and menstruation is usually absent. Short stature and a webbed neck are additional characteristic features. These effects arise from the missing sex chromosome, not from the presence of an extra X or Y chromosome.

Step 3: Conclusion Nondisjunction produces aneuploidy, and the XO abnormality is **Turner's syndrome**, with karyotype 45, X (44 + XO). Affected females have rudimentary ovaries, sterility and poorly developed secondary sexual characters.

Quick Tip to Solve: Read XO as one X plus a missing sex chromosome: 44 autosomes plus 1 X gives 45 chromosomes and identifies Turner's syndrome.

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

[2 marks]

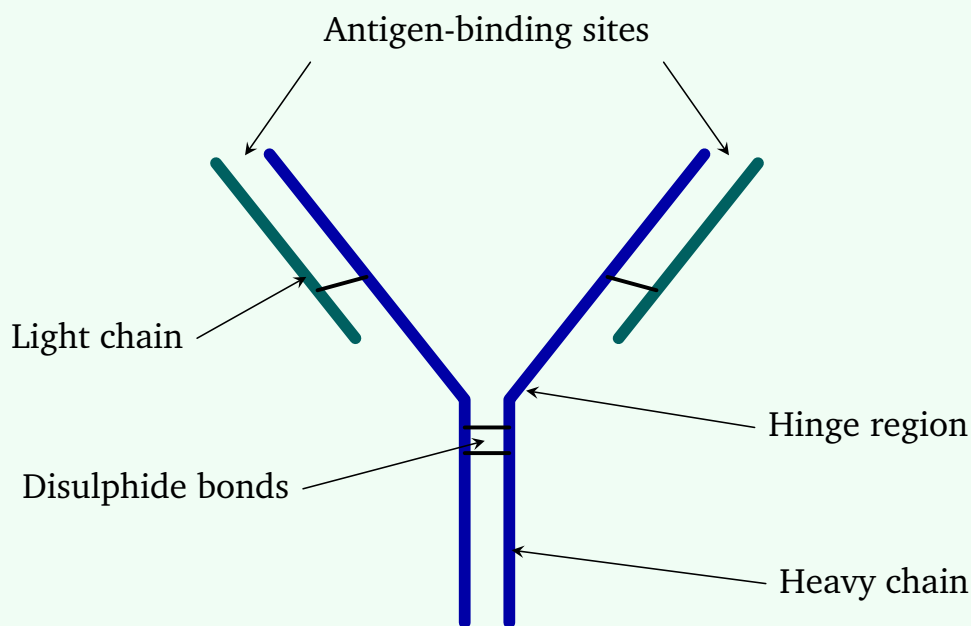
Solution:

Concept:

- An antibody is an immunoglobulin protein produced by plasma cells. Its basic molecule is Y-shaped and contains two identical heavy polypeptide chains and two identical light polypeptide chains, written H_2L_2 .
- Disulphide bonds join the chains. The tips of the two arms form antigen-binding sites, each involving a heavy chain and a light chain.

Step 1: Draw the four-chain structure Draw two long heavy chains forming the inner arms and the stem of the Y. Place one shorter light chain beside the outer side of each arm. Join the heavy chains to

one another near the hinge, and join each light chain to its adjacent heavy chain through disulphide bonds. The two arms bear identical antigen-binding sites.



Antibody molecule: two heavy chains and two light chains linked by disulphide bonds

Step 2: Label the main parts The labelled schematic identifies **heavy chain**, **light chain**, **disulphide bond** and **antigen-binding site**. The heavy chains continue into the lower stem, whereas the light chains are confined to the arms. The flexible hinge allows the arms to move while the paired chains remain linked.

Step 3: Conclusion The antibody has a Y-shaped H_2L_2 structure; four labelled parts are the heavy chain, light chain, disulphide bond and antigen-binding site.

Quick Tip to Solve: Draw the two long inner chains first, add the two short outer chains, and place each antigen-binding label at an arm tip.

32(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 mount a specific response and produce antibodies.
- Passive immunity is protection obtained by receiving ready-made antibodies from another source. The transferred antibodies act without requiring the recipient to first produce them.

Step 1: Compare the source of protection **Difference 1 – production of antibodies:** In active immunity, the individual's own B lymphocytes respond to an antigen and differentiate into antibody-secreting plasma cells. It can develop after infection or vaccination. In passive immunity, ready-made antibodies are transferred to the recipient, for example maternal antibodies passed to the baby or

antibodies injected as antiserum. Thus, the recipient supplies the immune response in active immunity, whereas another source supplies the antibodies in passive immunity.

Step 2: Compare the onset of protection **Difference 2 – speed:** Active immunity takes time to develop because antigen recognition, lymphocyte activation and antibody production must occur. Passive immunity acts immediately, or very rapidly after administration, because the specific antibodies are already available to bind their targets. This makes passive immunity useful when immediate protection is required.

Step 3: Compare duration and immunological memory **Difference 3 – persistence:** Active immunity is generally long-lasting and produces memory cells, enabling a faster and stronger response on subsequent exposure to the same antigen. Passive immunity is short-lived because the received antibodies are gradually broken down. Their transfer does not generate immunological memory in the recipient, so the protection fades as these antibodies disappear.

Step 4: Conclusion Active immunity uses self-produced antibodies, develops relatively slowly and is generally long-lasting with memory. Passive immunity uses transferred antibodies, provides rapid protection and is temporary without memory formation from the transfer.

Quick Tip to Solve: Compare the same three headings in both columns: who makes the antibodies, how fast protection begins, and how long it lasts with or without memory.

OR

32(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, also called elephantiasis, is a parasitic disease in which filarial worms principally affect the lymphatic system.
- The lymphatic vessels normally return tissue fluid to the blood. Inflammation and obstruction of these vessels cause persistent accumulation of fluid and swelling.

Step 1: (I) Name the causative worms The two species are *Wuchereria bancrofti* and *Wuchereria malayi*. These are filarial nematodes whose adult forms live in the lymphatic vessels of the infected person.

Step 2: (II) Describe the effects on the body The worms cause slowly developing, chronic inflammation of the organs in which they live for many years, usually the lymphatic vessels of the lower limbs. Damage to lymphatic drainage produces severe swelling and enlargement of the affected limbs, giving the characteristic appearance called elephantiasis. The genital organs may also be affected, resulting in gross deformities. Thus, the major damage follows prolonged inflammation and impaired drainage of lymph rather than a brief, local skin reaction.

Step 3: (III) Explain transmission The disease spreads through the bite of an infected female mosquito,

commonly *Culex*. A mosquito acquires microfilariae when it feeds on an infected person. These develop into infective larvae inside the mosquito. During a later bite, the mosquito transmits the infective larvae to another person; they enter the body and ultimately develop in the lymphatic system. The mosquito therefore acts as the vector carrying the parasite between human hosts.

Step 4: Conclusion *Wuchereria bancrofti* and *Wuchereria malayi* cause chronic lymphatic inflammation, elephantiasis of the limbs and possible genital deformity. Transmission occurs through the bite of an infected female mosquito.

Quick Tip to Solve: Link the three demands in order: two worm species, damage to lymphatic drainage, and transmission by an infected female mosquito.

32(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:

- Innate defence includes local inflammatory responses and protective proteins released by body cells.
- A substance's source is the cell that releases it; its role is the protective effect it produces in the body.

Step 1: (I) State the source and role of histamine Histamine is released by mast cells in tissues; basophils can also release it. It mediates the local inflammatory response by dilating small blood vessels and increasing their permeability. This allows fluid and defence components to reach the affected tissue and helps the recruitment of white blood cells to the site of infection or injury. Histamine therefore supports local defence through inflammation; it does not itself act as an antibody or directly kill all pathogens.

Step 2: (II) State the source and role of interferons Interferons are proteins secreted by virus-infected cells. They act on nearby uninfected cells and induce an antiviral state that inhibits viral replication, thereby protecting these cells from viral infection. This limits the spread of the virus from an infected cell to neighbouring cells and forms a cytokine barrier of innate immunity.

Step 3: Conclusion Histamine from mast cells promotes local inflammation and the arrival of defence components. Interferons from virus-infected cells protect neighbouring uninfected cells by inhibiting viral replication.

Quick Tip to Solve: Pair each mediator with its source and action: mast cell–histamine–inflammation; virus-infected cell–interferon–antiviral protection.

33(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 near the ampullary-isthmic junction of the fallopian tube.
- Cleavage consists of successive mitotic divisions of the zygote. The resulting embryo becomes a blastocyst, which implants in the uterine endometrium.

Step 1: Bring the gametes together During insemination, semen is released into the vagina. Motile sperms pass through the cervix and uterus into the fallopian tube. Meanwhile, ovulation releases a secondary oocyte from the ovary; the fimbriae help collect it into the oviduct. Fertilisation can take place only if the sperm and the secondary oocyte reach the fertilisation site at the same time.

Step 2: Permit entry of one sperm A sperm contacts the zona pellucida surrounding the secondary oocyte. Enzymes released from its acrosome help it penetrate the coverings and reach the oocyte plasma membrane. Fusion of the sperm and oocyte membranes allows sperm entry. This induces changes in the zona pellucida that prevent entry of additional sperms, thereby preventing polyspermy and ensuring that only one sperm fertilises the oocyte.

Step 3: Complete meiosis and form the zygote Sperm entry induces the secondary oocyte to complete its second meiotic division. This unequal division produces a large haploid ovum and a small second polar body. The haploid sperm nucleus and ovum nucleus fuse, restoring the diploid chromosome number and forming the zygote. In humans, the two gametes contribute 23 chromosomes each, so the zygote contains 46 chromosomes.

Step 4: Follow cleavage to blastocyst formation As the zygote moves through the oviduct towards the uterus, it undergoes mitotic cleavage to produce 2, 4, 8 and then 16 cells called blastomeres. The embryo with 8–16 blastomeres is the morula. The morula continues dividing as it enters the uterus and develops into a blastocyst. Its blastomeres become arranged into an outer trophoblast layer and an inner cell mass attached to the trophoblast. The inner cell mass develops into the embryo proper.

Step 5: Implant the blastocyst in the uterus The blastocyst is freed from the zona pellucida, and its trophoblast attaches to the endometrium, the lining of the uterus. The uterine cells divide rapidly and cover the blastocyst, embedding it within the endometrium. This embedding is called implantation and marks the establishment of pregnancy. Thus, the embryo develops initially in the oviduct but becomes attached to the maternal uterine tissue at the blastocyst stage.

Step 6: Conclusion Fertilisation forms a diploid zygote in the fallopian tube. Cleavage produces a morula and then a blastocyst, whose trophoblast attaches to the uterine endometrium and brings about implantation.

Quick Tip to Solve: Keep the sites and stages in order: fertilisation in the oviduct, zygote, cleavage, morula, blastocyst, and implantation in the uterine endometrium.

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

hCG; LH; FSH; Relaxin.

[1 mark]

Solution:

Concept:

- The sequence follows follicular development and ovulation, followed by establishment of pregnancy and its later stages.
- FSH and LH are pituitary gonadotropins; hCG is a pregnancy hormone, while relaxin is associated with the later phase of pregnancy in the NCERT sequence.

Step 1: Place the hormones acting before conception Follicle-stimulating hormone (FSH) promotes ovarian follicular growth. The subsequent luteinising hormone (LH) surge induces ovulation and formation of the corpus luteum. Thus, FSH precedes the ovulatory LH surge in the sequence leading to pregnancy.

Step 2: Place the pregnancy hormones After implantation, the developing placental tissue secretes human chorionic gonadotropin (hCG), which supports the corpus luteum. Relaxin is placed later, during the later phase of pregnancy. The sequence therefore runs from follicular development through ovulation to early and then late pregnancy.

Step 3: Conclusion The required sequence is $\boxed{\text{FSH} \rightarrow \text{LH} \rightarrow \text{hCG} \rightarrow \text{Relaxin}}$.

Quick Tip to Solve: Associate the order with four events: follicle growth, ovulation, corpus-luteum support in pregnancy, and preparation for childbirth.

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

[4 marks]

Solution:

Concept:

- FSH and LH are gonadotropins of the anterior pituitary. They control ovarian follicular development, ovulation and formation of the corpus luteum before pregnancy is established.
- After implantation, hCG supports the corpus luteum in early pregnancy; relaxin helps prepare the maternal birth passage for childbirth.

Step 1: State the source and functions of FSH Follicle-stimulating hormone (FSH) is secreted by the anterior lobe of the pituitary gland. In the ovarian cycle leading to conception, it stimulates the growth and maturation of ovarian follicles. It also promotes oestrogen secretion by the developing follicles. Thus, FSH helps prepare a mature follicle containing the oocyte before ovulation; it is not a hormone secreted by the placenta.

Step 2: State the source and functions of LH Luteinising hormone (LH) is also secreted by the anterior pituitary. The mid-cycle LH surge induces rupture of the mature Graafian follicle and release of the secondary oocyte, that is, ovulation. LH also promotes the transformation of the ruptured follicle into the corpus luteum and stimulates its progesterone secretion. Progesterone maintains the uterine

endometrium in a condition suitable for implantation and pregnancy.

Step 3: State the source and functions of hCG Human chorionic gonadotropin (hCG) is secreted by the trophoblast of the developing embryo and subsequently by the placenta. Its main early-pregnancy function is to maintain the corpus luteum and sustain its secretion of progesterone. This prevents degeneration of the corpus luteum and the resulting breakdown of the endometrium, thereby supporting continuation of early pregnancy until placental hormone production is sufficient.

Step 4: State the source and functions of relaxin Relaxin is secreted by the ovary, particularly the corpus luteum, during pregnancy; in the NCERT account it is associated with the later phase of pregnancy. It helps relax the pelvic ligaments and pubic symphysis and promotes softening of the cervix. These changes make the birth passage more accommodating and facilitate delivery of the baby.

Step 5: Conclusion FSH and LH originate in the anterior pituitary and promote follicular growth and ovulation/corpus-luteum formation, respectively. Placental hCG maintains the corpus luteum in early pregnancy, while ovarian relaxin helps prepare the pelvic region and cervix for childbirth.

Quick Tip to Solve: Pair FSH with follicular growth, LH with ovulation, hCG with corpus-luteum maintenance, and relaxin with preparation for delivery; then attach the source to each function.