

CBSE Class 12 Biology Question Paper 2024 with Solution PDF-Set 57-S-2 - Compartment



Question Paper with Solutions

Conducted by the Central Board of Secondary Education (CBSE)

Time Allowed: 3 hours

Maximum Marks: 70

General Instructions

- (i) This question paper contains **33** questions. All questions are **compulsory**.
- (ii) Question paper is divided into **five** sections – Sections **A, B, C, D** and **E**.
- (iii) **Section A** – questions number **1** to **16** are multiple choice type questions. Each question carries **1** mark.
- (iv) **Section B** – questions number **17** to **21** are very short answer type questions. Each question carries **2** marks.
- (v) **Section C** – questions number **22** to **28** are short answer type questions. Each question carries **3** marks.
- (vi) **Section D** – questions number **29** and **30** are case-based questions. Each question carries **4** marks. Each question has subparts with internal choice in one of the subparts.
- (vii) **Section E** – questions number **31** to **33** are long answer type questions. Each question carries **5** marks.
- (viii) There is no overall choice. However, an internal choice has been provided in Sections B, C and D 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. $16 \times 1 = 16$

1. Estrogen is secreted by :

[1 mark]

- (A) Corpus luteum
- (B) Membrane granulosa of Graafian follicle
- (C) Pituitary gland
- (D) Germinal epithelium

Correct Answer: (B) Membrane granulosa of Graafian follicle

Solution:

Concept:

- Developing ovarian follicles secrete estrogens, which promote growth of the uterine endometrium during the proliferative phase.
- Granulosa cells of the mature Graafian follicle are an important source of estrogen; the corpus luteum is chiefly associated with progesterone secretion.

Step 1: Identify the follicular source The membrane granulosa forms the granulosa-cell layer of the Graafian follicle. These cells produce estrogen during follicular growth, so this tissue matches the usual NCERT association between the growing ovarian follicle and estrogen secretion.

Step 2: Compare the remaining tissues The corpus luteum mainly secretes progesterone, although it also secretes some estrogen. The pituitary secretes the gonadotropins FSH and LH that regulate ovarian activity, rather than estrogen. Germinal epithelium covers the ovary and is not the follicular estrogen-secreting layer. Thus membrane granulosa is the best answer intended among these choices.

Step 3: Conclusion Estrogen is secreted by the membrane granulosa of the Graafian follicle. Hence, the correct option is (B).

Quick Tip to Solve: Link the growing follicle with estrogen and the post-ovulatory corpus luteum chiefly with progesterone.

2. Long ribbon-like pollen grains are seen in some :

[1 mark]

- (A) Aquatic plants
- (B) Wind-pollinated grasses
- (C) Gymnosperms
- (D) Bird-pollinated flowers

Correct Answer: (A) Aquatic plants

Solution:

Concept:

- Hydrophily is the transfer of pollen through water, and occurs in a small number of flowering plants.
- In submerged marine seagrasses, long ribbon-like pollen grains are carried passively by water currents.

Step 1: Recall the aquatic adaptation In seagrasses such as *Zostera*, both the flowers and pollination are submerged. Their pollen grains are long and ribbon-like, allowing water currents to transport them until they contact the stigma. The question says some aquatic plants because not all aquatic plants are water-pollinated.

Step 2: Distinguish the other pollination modes Wind-pollinated grasses characteristically produce abundant, light, non-sticky pollen. Gymnosperms may have winged pollen adapted to wind transport. Bird-pollinated flowers transfer pollen through birds visiting their flowers. None of these is the standard example of long ribbon-like pollen associated with submerged water pollination.

Step 3: Conclusion Long ribbon-like pollen grains occur in some aquatic plants. Hence, the correct option is (A).

Quick Tip to Solve: Associate ribbon-like pollen with submerged seagrasses such as *Zostera*; aquatic habitat alone does not imply water pollination.

3. Which one of the following codons has dual function ?

[1 mark]

- (A) AUG
- (B) AUC
- (C) ACU
- (D) ACA

Correct Answer: (A) AUG

Solution:

Concept:

- A codon is a sequence of three nucleotides in mRNA that specifies an amino acid or a translation signal.
- AUG has a dual role: it codes for methionine and can act as the initiation codon for translation.

Step 1: Identify the two functions AUG specifies methionine when read as a sense codon. At the

appropriate initiation site on mRNA, it also establishes the start of protein synthesis and the reading frame. This combination of an amino-acid assignment and a start signal gives it the dual function asked for.

Step 2: Check the alternative codons AUC codes for isoleucine, whereas ACU and ACA both code for threonine in the standard genetic code. These three options do not have the usual initiation role assigned to AUG in the NCERT account. Do not confuse this dual function with degeneracy, in which several codons specify one amino acid.

Step 3: Conclusion AUG codes for methionine and functions as the initiation codon. Hence, the correct option is (A).

Quick Tip to Solve: For a dual-function codon, look for both an amino-acid assignment and a start signal: AUG provides both.

4. Which one of the following options gives the correct temperature condition and the mixture of the gaseous components that were used by S.L. Miller in 1953 to prove abiogenesis of life ? [1 mark]

- (A) CH_4 , H_2 , NO_2 and water vapour at 1800°C
- (B) CH_4 , H_2 , NH_3 and water vapour at 1800°C
- (C) CO_2 , H_2 , NH_3 and water vapour at 800°C
- (D) CH_4 , H_2 , NH_3 and water vapour at 800°C

Correct Answer: (D) CH_4 , H_2 , NH_3 and water vapour at 800°C

Solution:

Concept:

- Miller tested chemical evolution by simulating a reducing atmosphere containing methane, ammonia, hydrogen and water vapour.
- Electrical discharges supplied energy, and organic compounds including amino acids formed from inorganic starting materials.

Step 1: Match the experimental conditions The NCERT description of the 1953 experiment uses CH_4 , NH_3 , H_2 and water vapour in a closed flask at 800°C , with electric discharges. The gases represent the proposed primitive reducing atmosphere; the resulting amino acids support abiotic synthesis of organic molecules.

Step 2: Check gas identities and temperature Option (A) incorrectly substitutes NO_2 for ammonia and gives 1800°C . Option (B) has the correct gas mixture but the incorrect temperature. Option (C) substitutes CO_2 for methane. Option (D) alone matches both the listed gases and 800°C . The experiment produced organic molecules, not a living organism.

Step 3: Conclusion The required mixture is CH_4 , H_2 , NH_3 and water vapour at 800°C . Hence, the correct option is (D).

Quick Tip to Solve: Check both parts of this option: methane–ammonia–hydrogen–water vapour, then 800°C .

5. Amniocentesis is a technique that is used to :

[1 mark]

- (A) determine any disease of the heart
- (B) determine any genetic disorder of the foetus
- (C) determine any disorder of the brain
- (D) detect any abnormality in the bone formation

Correct Answer: (B) determine any genetic disorder of the foetus

Solution:

Concept:

- Amniocentesis is a prenatal diagnostic technique in which a small sample of amniotic fluid surrounding the foetus is obtained for analysis.
- Foetal cells in this fluid can be examined for chromosomal abnormalities and certain genetic disorders.

Step 1: Connect the sample with diagnosis The amniotic fluid contains cells shed by the developing foetus. Studying their chromosomes or appropriate biochemical and genetic features can identify certain inherited or chromosomal disorders before birth. Therefore the option referring to a genetic disorder of the foetus describes the intended diagnostic use.

Step 2: Compare the other proposed uses The technique is not a general test for any disease of the heart, any brain disorder, or every abnormality of bone formation. Those broad organ-based descriptions do not identify its characteristic prenatal genetic purpose. Although a genetic disorder may affect an organ or bones, the key feature tested here is examination of foetal genetic abnormalities.

Step 3: Conclusion Amniocentesis is used to determine genetic disorders of the foetus. Hence, the correct option is (B).

Quick Tip to Solve: Follow the sample: amniotic fluid contains foetal cells, so think of prenatal chromosomal or genetic diagnosis.

6. In humans, non-disjunction of the 21st pair of chromosomes leads to :

[1 mark]

- (A) Acquired Immune Deficiency Syndrome
- (B) Klinefelter's Syndrome
- (C) Turner's Syndrome
- (D) Down's Syndrome

Correct Answer: (D) Down's Syndrome

Solution:

Concept:

- Non-disjunction is the failure of chromosomes or sister chromatids to separate normally during cell division, producing cells with abnormal chromosome numbers.
- Down's syndrome is associated with trisomy 21: three copies of chromosome 21 instead of the usual pair.

Step 1: Trace the extra chromosome If chromosome 21 fails to segregate during gamete formation, a gamete may receive two copies instead of one. Fertilisation by a normal gamete then produces a zygote with three copies of chromosome 21 and usually 47 chromosomes in total. This aneuploid condition is trisomy 21.

Step 2: Distinguish the other conditions AIDS is an acquired infection caused by HIV, not chromosome non-disjunction. Klinefelter's syndrome usually has the sex-chromosome constitution 47, XXY, and Turner's syndrome has 45, X. These involve sex chromosomes, whereas the question specifically identifies autosome 21.

Step 3: Conclusion Non-disjunction involving chromosome 21 can cause trisomy 21, or Down's syndrome. Hence, the correct option is (D).

Quick Tip to Solve: Use the chromosome named in the question: chromosome 21 points to Down's syndrome; XXY and X concern sex chromosomes.

7. The most primitive ancestor of humans is :

[1 mark]

- (A) *Homo habilis*
- (B) *Australopithecus*
- (C) *Ramapithecus*
- (D) *Homo neanderthalensis*

Correct Answer: (C) *Ramapithecus*

Solution:

Concept:

- The NCERT account places the more man-like primate *Ramapithecus* earlier than *Australopithecus* and the listed members of *Homo*.
- To identify the most primitive form among the options, compare their relative places in the textbook sequence of human evolution.

Step 1: Identify the earliest listed form *Ramapithecus* is described with early primates living about 15 million years ago. It is therefore the earliest and most primitive form among the four choices in the evolutionary sequence used for this question.

Step 2: Order the later alternatives *Australopithecus* represents later early hominids; *Homo habilis* is the first human-like hominid described in this account. *Homo neanderthalensis* appeared much later still. Thus none of these three is as early as *Ramapithecus* within the given list. The comparison concerns the supplied options in the textbook account.

Step 3: Conclusion The most primitive ancestor among the listed options is *Ramapithecus*. Hence, the correct option is (C).

Quick Tip to Solve: Arrange the given names from earlier to later in the NCERT account; *Ramapithecus* precedes *Australopithecus* and *Homo*.

8. The sequence that controls the copy number of linked DNA in the vector is termed :

[1 mark]

- (A) Selectable marker
- (B) Ori site
- (C) Palindromic sequence
- (D) Recognition site

Correct Answer: (B) Ori site

Solution:

Concept:

- A cloning vector carries foreign DNA and replicates inside a suitable host cell.
- The origin of replication (ori) is the DNA sequence from which replication starts; it also controls the copy number of linked DNA.

Step 1: Identify the replication control sequence When a DNA fragment is linked to a vector's ori, it can replicate along with the vector in the host. The properties of this origin determine how many copies of the linked DNA can be maintained in a cell. Thus, the feature asked about is associated with replication initiation.

Step 2: Distinguish the other vector features A selectable marker helps distinguish transformants from non-transformants; it does not set copy number. A palindromic sequence describes a sequence pattern, often found at restriction sites. A recognition site is where a specific restriction enzyme recognises DNA. Neither term names the vector's copy-number control sequence.

Step 3: Conclusion The sequence is the ori site, or origin of replication. Hence, the correct option is (B).

Quick Tip to Solve: Link the words “copy number” and “replication starts” to ori; link “selection of transformants” to a selectable marker.

9. Crystals of Bt toxin produced by some bacteria, do not kill the bacteria producing them because :

[1 mark]

- (A) bacteria are resistant to the toxin
- (B) toxin is immature
- (C) toxin is inactive
- (D) bacteria encloses 'toxin' in a special capsule

Correct Answer: (C) toxin is inactive

Solution:

Concept:

- *Bacillus thuringiensis* produces insecticidal proteins that occur as crystals containing inactive protoxins.
- Activation takes place in the susceptible insect gut, where the alkaline conditions solubilise the crystals and the protoxin is converted into its active form.

Step 1: Identify the form stored in the bacterium The crystalline protein produced by the bacterium is an inactive protoxin. It therefore does not exert the toxic action of the activated protein within the producing bacterial cell. Inactivity, rather than a protective capsule, accounts for the observation.

Step 2: Relate activation to the insect host After an insect ingests the crystals, the activated toxin binds to midgut epithelial cells and forms pores, causing swelling and cell lysis. “Immature” is not the precise biological state asked for; the stated explanation is an inactive protoxin. The alternatives asserting bacterial resistance or enclosure in a special capsule do not describe this mechanism.

Step 3: Conclusion Bt toxin does not kill its producer because it is present in an inactive form. Hence, the correct option is (C).

Quick Tip to Solve: Remember the sequence: inactive Bt protoxin in bacterial crystals, activation in the alkaline insect gut, then damage to midgut cells.

10. The population interaction where one species is harmed and the other is unaffected is : [1 mark]

- (A) Amensalism
- (B) Commensalism
- (C) Parasitism
- (D) Predation

Correct Answer: (A) Amensalism

Solution:

Concept:

- Population interactions are classified by the effects on the two species: benefit (+), harm (−), or no effect (0).
- Amensalism has the combination (−, 0): one species is harmed while the other remains unaffected.

Step 1: Translate the effects into signs The harmed species has a negative effect, while the unaffected species has a zero effect. The required combination is therefore (−, 0), irrespective of which species is listed first. No species is said to gain a benefit in the question.

Step 2: Compare the offered interactions Commensalism is (+, 0), because one species benefits and the other is unaffected. Parasitism and predation are both (+, −), because the parasite or predator benefits while its host or prey is harmed. Only amensalism combines harm to one species with no effect on the other.

Step 3: Conclusion The interaction is amensalism. Hence, the correct option is (A).

Quick Tip to Solve: Write the two signs first: (−, 0) means amensalism, whereas (+, 0) means commensalism.

11. The mosquito-borne disease in humans causing chronic inflammation of the lymphatic vessels is : [1 mark]

- (A) Elephantiasis
- (B) Ascariasis
- (C) Ringworm
- (D) Amoebiasis

Correct Answer: (A) Elephantiasis

Solution:

Concept:

- Filariasis, commonly called elephantiasis, is caused by filarial worms such as *Wuchereria bancrofti* and *Wuchereria malayi*.
- These parasites are transmitted through bites of infected female mosquitoes and cause chronic inflammation of lymphatic vessels.

Step 1: Match the affected organ and transmission route The two diagnostic clues are a mosquito vector and damage to lymphatic vessels. Filarial worms affect the lymphatic system, especially in the lower limbs, and can produce severe swelling. This combination identifies filariasis or elephantiasis.

Step 2: Exclude diseases with other causes and routes Ascariasis is an intestinal roundworm infection acquired by ingesting infective eggs, commonly through contaminated food or water. Ringworm is a fungal infection of tissues such as skin, scalp and nails. Amoebiasis is an intestinal infection caused by *Entamoeba histolytica* and spreads through contaminated food or water. These do not match mosquito-borne lymphatic inflammation.

Step 3: Conclusion The disease is elephantiasis. Hence, the correct option is (A).

Quick Tip to Solve: Pair “mosquito plus lymphatic vessels” with filariasis; mosquito transmission alone is not enough to identify the disease.

12. In plants, which one of the following helps in the absorption of phosphorus from soil ? [1 mark]

- (A) *Glomus*
- (B) *Rhizobium*
- (C) *Frankia*
- (D) *Anabaena*

Correct Answer: (A) *Glomus*

Solution:

Concept:

- Mycorrhiza is a symbiotic association between a fungus and plant roots; many fungi of the genus *Glomus* form such associations.
- The fungal partner absorbs phosphorus from the soil and passes it to the plant, while receiving organic food from the plant.

Step 1: Identify the nutrient-specific association The question specifically asks about phosphorus uptake. Mycorrhizal fungal hyphae explore the soil beyond the immediate root surface and improve the availability of this nutrient to their host plant. *Glomus* is the listed mycorrhizal fungus.

Step 2: Separate phosphorus uptake from nitrogen fixation *Rhizobium* is associated with nitrogen fixation in legume root nodules. *Frankia* forms nitrogen-fixing nodules in certain non-leguminous plants. *Anabaena* is a nitrogen-fixing cyanobacterium. These alternatives relate primarily to nitrogen enrichment, whereas the question describes the phosphorus-absorbing role of a mycorrhizal fungus.

Step 3: Conclusion *Glomus* helps plants absorb phosphorus from soil. Hence, the correct option is (A).

Quick Tip to Solve: For biofertiliser MCQs, associate phosphorus uptake with mycorrhiza and *Glomus*; associate the other three listed organisms with nitrogen fixation.

13. Assertion (A) : Biotechnology produces transgenic micro-organisms that act as microfactories for proteins.

Reason (R) : To produce proteins for human use like insulin, transgenic microorganisms can be developed. [1 mark]

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

Solution:

Concept:

- Recombinant DNA technology introduces a desired gene into a host microorganism so that the host can express the encoded protein.
- A transgenic microbial culture can produce useful proteins on a large scale and therefore functions as a biological microfactory.

Step 1: Evaluate the assertion The assertion is true. By carrying and expressing introduced genes, transgenic microorganisms synthesise desired proteins. Multiplication and culture of these cells allow the protein product to be obtained in substantial quantities, which is the basis of calling them microfactories.

Step 2: Evaluate the reason The reason is also true. Microorganisms can be genetically engineered to produce proteins needed for human use. Human insulin production using genetically modified bacteria is a standard application of recombinant DNA technology.

Step 3: Check the explanatory connection Production of a desired human-use protein such as insulin is precisely the useful manufacturing function performed by these engineered microorganisms. Thus,

the reason explains the microfactory role stated in the assertion. It is not an unrelated true fact, so the code for two true but unconnected statements does not apply.

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

Quick Tip to Solve: For “microfactory”, ask which product the engineered host manufactures; insulin provides the direct connection between these two statements.

14. Assertion (A) : Gross primary productivity is always less than net primary productivity.

Reason (R) : Rate of synthesis of organic matter by consumers is known as secondary productivity.

[1 mark]

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

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

Solution:

Concept:

- Gross primary productivity (GPP) is the total rate of organic matter production by producers during photosynthesis.
- Net primary productivity (NPP) is the organic matter remaining after respiratory loss: $NPP = GPP - R$, where R is the producers' respiration loss.
- Secondary productivity is the rate of formation of new organic matter by consumers.

Step 1: Evaluate the assertion using the productivity relation Producers use part of their photosynthetic production in respiration. Subtracting this loss gives NPP. Therefore, GPP is greater than NPP when respiration is positive, rather than less than it. The assertion reverses the relationship and is false.

Step 2: Evaluate the reason independently Consumers obtain organic food from other organisms and incorporate part of it into their own biomass. The rate of synthesis of new organic matter by these consumers is indeed secondary productivity. The reason gives the correct definition and is true.

Step 3: Select the appropriate truth-value code Since the assertion is false and the reason is true, neither code requiring both statements to be true can apply. The code for a true assertion and false reason also has the truth values reversed. A true definition of secondary productivity cannot make the incorrect GPP–NPP comparison valid.

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

Quick Tip to Solve: Remember “net = gross minus respiration” before comparing GPP and NPP; then assess consumer productivity as a separate definition.

15. Assertion (A) : Periodic abstinence is a method in which couples avoid coitus from day 10 to 17 of menstrual cycle.

Reason (R) : Periodic abstinence has limited effectiveness because menstrual cycles are not always regular. [1 mark]

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

Solution:

Concept:

- Periodic abstinence is a natural contraceptive method that avoids intercourse during the fertile period of the menstrual cycle.
- Ovulation occurs around the middle of a typical 28-day cycle; variation in its timing reduces the reliability of a fixed calendar estimate.

Step 1: Evaluate the assertion The assertion is true. In the standard NCERT description, couples avoid coitus from day 10 to day 17, when the chances of fertilisation are high. Avoiding intercourse during this fertile period reduces the possibility that viable sperm will meet the ovum.

Step 2: Evaluate the reason The reason is also true. Menstrual cycles are not invariably regular, and ovulation may occur earlier or later than expected. Consequently, the fertile interval may extend beyond the days predicted by a fixed calendar rule, limiting the method's effectiveness.

Step 3: Test the explanatory link Irregular cycles explain a limitation of periodic abstinence, not why days 10–17 are selected. Those days are selected because they surround the expected time of ovulation. Thus (A) incorrectly claims an explanatory relationship, while (C) and (D) each incorrectly reject one true statement.

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

Quick Tip to Solve: Separate the reason for choosing the fertile days from the reason a calendar method can fail.

16. Assertion (A) : *Streptococcus pneumoniae* and *Haemophilus influenzae* are responsible for causing infectious diseases in human beings.

Reason (R) : A healthy person acquires the infection by inhaling the droplets/aerosols released by an infected person. [1 mark]

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

Solution:

Concept:

- Infectious diseases can spread from an infected individual to a healthy individual through transfer of pathogens.
- *Streptococcus pneumoniae* and *Haemophilus influenzae* are bacterial pathogens that cause pneumonia in human beings.

Step 1: Evaluate the assertion The assertion is true. These bacteria can infect the lungs and cause pneumonia, in which the alveoli become filled with fluid and breathing is impaired. Pneumonia caused by these pathogens is an infectious disease.

Step 2: Evaluate the reason The reason is true. An infected person releases pathogen-containing droplets or aerosols into the air. A healthy person may acquire the infection by inhaling them, allowing the bacteria to enter the respiratory tract.

Step 3: Relate transmission to infectiousness The reason describes how the pathogens pass from an infected person to a healthy person. It therefore explains the infectious nature of the disease referred to in the assertion. Option (B) misses this explanatory link; options (C) and (D) are incorrect because neither statement is false.

Step 4: Conclusion Both statements are true, and the reason explains the assertion by describing transmission of the infection. Hence, the correct option is (A).

Quick Tip to Solve: When an assertion calls a disease infectious, a reason describing its spread establishes the relevant link.

Section B (10 marks)

17. Why is making host cells 'competent' essential for rDNA technology ? Mention any two ways by which this can be achieved. [2 marks]

Solution:

Concept:

- Recombinant DNA must enter a living host cell so that it can be replicated and, where required, expressed.
- DNA is hydrophilic and cannot readily pass through the cell membrane; a competent host is able to take up foreign DNA.

Step 1: Explain the need for competence Simply mixing recombinant DNA with untreated host cells does not ensure that the DNA enters them. The cell membrane presents a barrier to the large, hydrophilic DNA molecule. Host cells must therefore be made capable of taking up the DNA, or the DNA must be delivered directly into them, before cloning or expression can occur.

Step 2: Describe chemical treatment followed by heat shock Treat bacterial cells with a suitable concentration of a divalent cation, such as calcium ions, which increases the efficiency with which DNA enters through pores in the cell wall. Incubate these competent cells with recombinant DNA on ice, expose them briefly to heat shock at 42°C, and then return them to ice. This enables uptake of recombinant DNA.

Step 3: Describe direct delivery by microinjection In microinjection, recombinant DNA is injected directly into the nucleus of an animal cell using a fine microscopic needle. This bypasses the membrane barrier and places the foreign DNA inside the host cell.

Step 4: Conclusion Competence or assisted delivery is essential for recombinant DNA to enter the host. Two suitable methods are calcium-ion treatment followed by heat shock in bacteria, and microinjection into animal cells.

Quick Tip to Solve: Pair each method with its host: calcium treatment and heat shock for bacteria, microinjection for animal cells.

18(a). Comment on the interaction between a fig tree and wasp. Mention the phenomenon that operates in their relationship. [2 marks]

Solution:

Concept:

- Mutualism is an interspecific interaction in which both participating species benefit, represented by (+, +).
- Co-evolution involves reciprocal evolutionary changes in interacting species, so that adaptations of one are matched by those of the other.

Step 1: Identify the benefits to the wasp A female fig wasp uses the fig inflorescence as a site for laying eggs. Some developing seeds provide food for the wasp larvae. The fig therefore supplies a

suitable place for reproduction and resources needed for larval development.

Step 2: Identify the benefit to the fig During egg laying, the wasp pollinates the fig flowers. This enables the fig to form seeds and reproduce. Although some seeds nourish wasp larvae, the plant gains the essential pollination service; therefore, the association benefits both partners and is mutualistic.

Step 3: State the evolutionary phenomenon The relationship shows co-evolution. Many fig species have a close, species-specific association with their pollinating wasps: the fig's floral features and the wasp's pollinating and egg-laying adaptations have evolved in relation to one another. Their reciprocal dependence explains the close matching of the two partners.

Step 4: Conclusion The fig tree and fig wasp show mutualism: the wasp obtains a breeding site and larval nourishment, while the fig is pollinated. The phenomenon operating in this specialised relationship is co-evolution.

Quick Tip to Solve: Name both levels: mutualism describes the benefits, whereas co-evolution explains the partners' matched adaptations.

OR

18(b). Explain “brood parasitism” with the help of an example.

[2 marks]

Solution:

Concept:

- Parasitism benefits the parasite while imposing a cost on the host, represented by (+, –).
- In brood parasitism, one bird species uses another bird's parental care to incubate its eggs and rear its young.

Step 1: Explain how brood parasitism works A brood-parasitic bird lays its eggs in the nest of a host bird instead of raising its offspring itself. The host incubates these eggs and feeds and protects the resulting young. The parasite saves the effort of parental care, while the host spends time and energy caring for unrelated offspring; its own reproductive success may consequently be reduced.

Step 2: Give the cuckoo and crow example The cuckoo or koel lays its eggs in the nest of a crow. The crow acts as the host and incubates the eggs and rears the young cuckoo along with, or at the expense of, its own brood. Thus the relationship concerns exploitation of parental care, rather than a parasite living inside the host's body.

Step 3: Explain the advantage of egg resemblance The parasite's eggs have evolved to resemble the host's eggs in colour and size. This mimicry reduces the chance that the host will detect and reject the foreign eggs, increasing the likelihood that the parasite's young will be successfully raised.

Step 4: Conclusion Brood parasitism is the laying of eggs in another bird's nest so that the host incubates them and raises the young. The cuckoo or koel parasitising the crow's nest is an example.

Quick Tip to Solve: In this example, identify the roles explicitly: cuckoo or koel is the brood parasite, and crow is the host.

19. State the cellular nature and functions of myometrium and endometrium.

[2 marks]

Solution:

Concept:

- The uterus has an outer perimetrium, a middle myometrium and an inner endometrium; the two inner layers have different tissues and functions.
- Muscular tissue produces force, whereas the glandular uterine lining prepares the uterus for pregnancy.

Step 1: Describe the myometrium The myometrium is the thick middle layer of the uterine wall, made of smooth muscle cells. These involuntary muscles undergo strong contractions during childbirth, helping to expel the fully developed foetus from the uterus.

Step 2: Describe the endometrium The endometrium is the inner glandular epithelial lining of the uterus. It undergoes cyclic changes during the menstrual cycle: it thickens and becomes richly vascular and secretory to receive the implanting blastocyst and support early embryonic development. If pregnancy does not occur, its superficial part breaks down and is shed during menstruation.

Step 3: Conclusion Myometrium: smooth muscle, responsible for forceful uterine contractions at parturition. Endometrium: glandular epithelial lining, undergoing cyclic changes and providing the site for implantation and early nourishment of the embryo.

Quick Tip to Solve: Associate “myo” with muscle and contraction; associate the inner endometrium with implantation and menstrual changes.

20. How do ‘implants’ act as an effective method of contraception in human females ? Mention their one advantage over contraceptive pills.

[2 marks]

Solution:

Concept:

- Hormonal contraceptives use progestogens alone or in combination with oestrogens to prevent pregnancy.
- An implant placed under the skin releases contraceptive hormones slowly, so its action continues for a long period.

Step 1: Explain how the implant prevents conception Implants release progestogens, alone or with oestrogens, into the body. Their hormonal action inhibits ovulation, makes the endometrium unsuitable for implantation and alters the cervical mucus so that it becomes less favourable for sperm entry. Thus they interfere with the release of the ovum and with the conditions needed for successful conception and implantation.

Step 2: Compare the implant with oral pills The slow, sustained release makes an implant effective for a prolonged period after insertion. Unlike contraceptive pills, it does not require the woman to remember a daily dose. This provides long-lasting contraception and reduces the chance of contraceptive failure caused by forgetting pills.

Step 3: Conclusion Implants provide sustained hormonal contraception by inhibiting ovulation

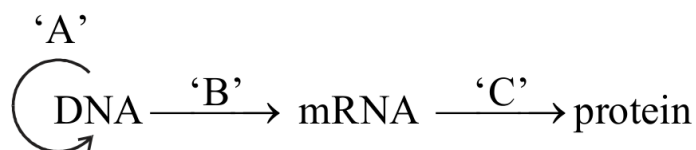
and implantation and making cervical mucus hostile to sperm entry. Their advantage over pills is prolonged action without daily dosing.

Quick Tip to Solve: State the hormonal mechanisms first, then give the implant-specific advantage: slow release avoids remembering a pill each day.

21. (a) Given below is a representation of the “Central dogma” :

Identify ‘A’, ‘B’ and ‘C’ in the above representation.

(b) What does the Central dogma state in molecular biology ? Write an example where it is not applicable. [2 marks]



Solution:

Concept:

- Replication copies DNA, transcription makes RNA from a DNA template and translation uses the information in mRNA to make a polypeptide.
- The usual direction of genetic information flow is DNA to RNA to protein. Retroviruses also transfer information from RNA to DNA.

Step 1: Identify the three labelled processes (a) A is DNA replication: the curved arrow returns to DNA, indicating that DNA produces a copy of itself. B is transcription, shown by the arrow from DNA to mRNA. C is translation, shown by the arrow from mRNA to protein; the mRNA nucleotide sequence specifies the amino-acid sequence of the polypeptide.

Step 2: State the information flow and its exception (b) The central dogma, as represented here, states that genetic information flows from DNA to RNA and then to protein:



An exception to the usual DNA-to-RNA direction occurs in retroviruses such as HIV. Their RNA genome acts as a template for DNA synthesis by reverse transcriptase, a process called reverse transcription. This reverse information flow is RNA to DNA; it is not protein to RNA.

Step 3: Conclusion A: replication; B: transcription; C: translation. The usual flow is DNA to RNA to protein, whereas HIV shows reverse transcription from RNA to DNA.

Quick Tip to Solve: Read the start and end of each arrow: DNA to DNA is replication, DNA to RNA is transcription, and RNA to protein is translation.

Section C (21 marks)

22. (a) What is gene therapy ?

(b) Describe the procedure of such a therapy that could be a permanent cure for a genetic disease. Name the genetic disease. [3 marks]

Solution:

Concept:

- Gene therapy treats a genetic disorder by introducing a functional gene into the patient's cells to compensate for a defective gene.
- Adenosine deaminase (ADA) deficiency impairs immune function. Supplying a functional ADA gene enables cells to produce the missing enzyme.

Step 1: Define gene therapy (a) Gene therapy is a collection of methods used to correct a gene defect diagnosed in a child or an embryo. A normal, functional gene is delivered into the person's cells or tissues so that its product can take over the function of the defective gene and treat the disease.

Step 2: Identify the disease and explain conventional therapy (b) The genetic disease is ADA deficiency, caused by a defective or deleted gene for adenosine deaminase. In the conventional procedure, lymphocytes are isolated from the patient's blood and grown in culture. A functional ADA cDNA is introduced into these lymphocytes using a retroviral vector, and the genetically modified lymphocytes are returned to the patient. They can now produce ADA and help restore immune function. Since these lymphocytes do not live permanently, periodic infusions of modified cells are required.

Step 3: Explain how a permanent cure could be achieved For a potentially permanent cure, the functional ADA gene isolated from bone marrow cells is introduced into cells at an early embryonic stage. As the corrected embryonic cells multiply, their descendants inherit the functional gene and can continue producing ADA. Correcting the defect early in development can therefore provide a lasting source of the enzyme, unlike correction restricted to short-lived mature lymphocytes.

Step 4: Conclusion Gene therapy supplies a functional gene to compensate for a genetic defect. ADA deficiency could be permanently corrected by introducing the functional ADA gene into cells at an early embryonic stage.

Quick Tip to Solve: Distinguish the two procedures: corrected lymphocytes need repeated infusion, whereas introducing the ADA gene early in embryonic development could give a permanent cure.

23. Differentiate between the explanations given by Darwin and de Vries respectively on the mechanism of evolution. Write any three differences.

[3 marks]

Solution:

Concept:

- Darwin explained evolution through natural selection acting on heritable variations already present in a population.
- Hugo de Vries proposed the mutation theory after studying the evening primrose, *Oenothera lamarckiana*. He emphasised sudden heritable changes, called mutations.

Step 1: Difference 1: Nature and size of variations According to Darwin, the variations important for evolution are small and occur continuously among individuals. Natural selection preserves favourable heritable variations. According to de Vries, evolution is driven by mutations: large, sudden, discontinuous changes that appear in individuals and can be inherited.

Step 2: Difference 2: Direction of evolutionary change In the textbook comparison, Darwinian variations are described as small and directional: natural selection favours variations that improve survival and reproduction in the prevailing environment. De Vries described mutations as random and directionless; a mutation does not arise because the organism needs a particular adaptation. The directional outcome in Darwin's explanation is produced by selection, not by an organism consciously producing a useful change.

Step 3: Difference 3: Rate and mode of speciation Darwin viewed evolution as a gradual process in which favourable small variations accumulate over many generations, eventually producing new species. De Vries proposed that a new species could arise suddenly through a single large mutation. This single-step origin is called saltation.

Step 4: Conclusion The three contrasts are small continuous variations versus large discontinuous mutations; directional evolutionary change under selection versus random, directionless mutations; and gradual speciation versus sudden speciation by saltation.

Quick Tip to Solve: Compare the two theories under the same three headings: size of change, direction, and speed of speciation.

24. Differentiate between :

(a) Grazing food chain and Detritus food chain (Any three differences)

(b) Upright pyramid and Inverted pyramid (Any three differences)

[3 marks]

Solution:

Concept:

- A food chain represents transfer of food and energy through successive trophic levels. Its starting material distinguishes a grazing chain from a detritus chain.
- An ecological pyramid represents number, biomass or energy at successive trophic levels. Its width expresses the quantity represented, not the body size of an organism.

Step 1: (a) Grazing food chain and detritus food chain: three differences **Starting material:** A grazing food chain begins with living green plants or other photosynthetic producers. A detritus food chain begins with dead organic matter, such as fallen leaves, dead organisms and organic wastes.

First consumers: In a grazing food chain, herbivores feed directly on living producers. In a detritus food chain, decomposers such as bacteria and fungi, together with detritivores, utilise dead organic matter.

Entry of energy: The grazing chain receives energy through photosynthesis by its living producers. The detritus chain receives energy as chemical energy already stored in dead organic matter. Ultimately, this energy too is usually derived from photosynthesis; the detritus chain does not itself begin with capture of sunlight.

For example, grass → deer → tiger is a grazing chain, whereas leaf litter → earthworm → bird is a detritus-based chain.

Step 2: (b) Upright and inverted pyramids: three differences **Shape:** An upright pyramid has a broad producer base and becomes narrower towards higher trophic levels. An inverted pyramid has a narrow producer base and a broader level above it.

Relative quantities: In an upright pyramid, the represented quantity decreases from producers to successive consumers. In an inverted pyramid, a consumer level has a greater represented quantity than the producer level below it; for example, consumer biomass may exceed the standing biomass of producers.

Occurrence and examples: The pyramid of biomass in a grassland is upright because grasses have more standing biomass than the herbivores they support. The pyramid of biomass in many aquatic ecosystems is inverted because the small standing biomass of rapidly reproducing phytoplankton supports a larger biomass of zooplankton. Pyramids of number can also be inverted, as when one tree supports many insects. A pyramid of energy is always upright and can never be inverted, since usable energy is lost at every trophic transfer.

Step 3: Conclusion Grazing and detritus chains differ in their starting material, first consumers and route of energy entry. Upright and inverted pyramids differ in shape, relative trophic quantities and characteristic occurrence; energy pyramids are always upright.

Quick Tip to Solve: For an inverted aquatic biomass pyramid, compare standing biomass at one time; rapid phytoplankton turnover sustains consumers.

25. (a) Name the enzyme responsible for the transcription of tRNA.

(b) Draw a labelled diagram of an initiator tRNA charged with its respective amino acid.

(c) Explain the role of the initiator tRNA in initiation of protein synthesis.

[3 marks]

Solution:

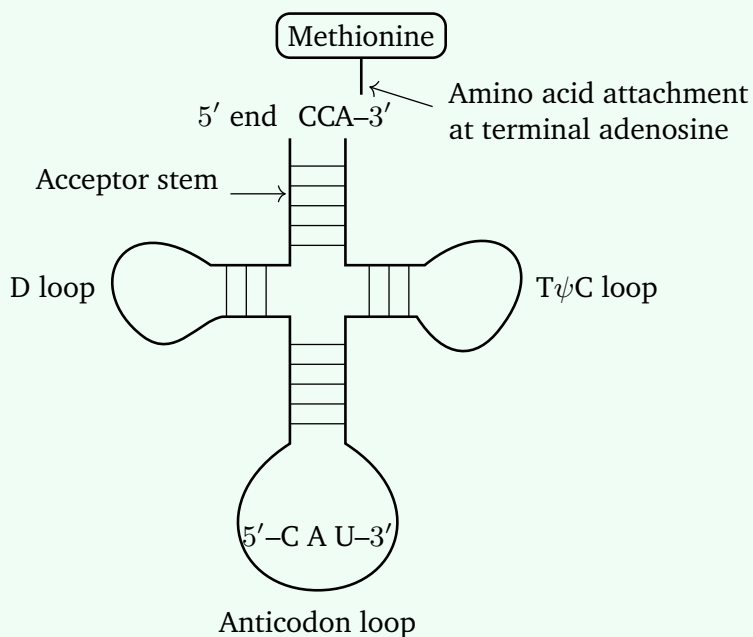
Concept:

- Transfer RNA (tRNA) acts as an adaptor: its anticodon recognises an mRNA codon while its acceptor end carries the corresponding amino acid.
- The initiator tRNA recognises the start codon 5'-AUG-3'. In the standard eukaryotic account, it

carries methionine.

Step 1: (a) Enzyme that transcribes tRNA In eukaryotic cells, **RNA polymerase III** transcribes tRNA genes. It also transcribes 5S rRNA and certain small RNAs. RNA polymerase I mainly transcribes the larger rRNAs, while RNA polymerase II transcribes the precursor of mRNA; thus neither is the expected enzyme for tRNA transcription here.

Step 2: (b) Charged initiator tRNA The labelled cloverleaf diagram shows initiator tRNA carrying **methionine** at its 3'-CCA acceptor end. The amino acid is attached to the terminal adenosine. The anticodon is 3'-UAC-5', equivalently 5'-CAU-3' as oriented in the diagram, complementary and antiparallel to the mRNA start codon 5'-AUG-3'. The opposite end of the RNA is its 5' end. Charging is catalysed by the appropriate aminoacyl-tRNA synthetase using ATP.



Charged initiator tRNA (schematic cloverleaf); methionine is attached at the terminal adenosine of the 3'-CCA end.

Step 3: (c) Role in initiation of protein synthesis The small ribosomal subunit associates with mRNA and the initiator tRNA. The initiator tRNA pairs its anticodon with the AUG start codon, positioning the first amino acid, methionine, and establishing the reading frame. The large ribosomal subunit then joins to form the initiation complex, with the initiator tRNA occupying the **P site**. The next aminoacyl-tRNA enters the A site according to the next codon; peptide-bond formation and elongation can then begin. Unlike elongator tRNAs, the initiator tRNA is placed directly in the P site at initiation.

Step 4: Conclusion (a) RNA polymerase III transcribes tRNA in eukaryotes. (b) The initiator tRNA carries methionine at its 3'-CCA end and has the anticodon 3'-UAC-5'. (c) Its pairing with AUG positions the first amino acid in the ribosomal P site and establishes the reading frame.

Quick Tip to Solve: Label both functional ends: methionine at the 3'-CCA acceptor end and UAC at the anticodon loop; the initiator enters the P site.

26(a). (i) What are “biodiversity hotspot” regions ? Mention any two criteria used for determining any region as a “hotspot”.

(ii) Name any two hotspots of India.

[3 marks]

Solution:

Concept:

- Biodiversity hotspots are regions with exceptionally high species richness and a high degree of endemism that face serious threats to their natural habitats.
- An endemic species is naturally restricted to a particular geographical region; protecting that region protects species that cannot be conserved elsewhere in the wild.

Step 1: Define hotspots and state the criteria (i) A biodiversity hotspot is a region containing a particularly rich and distinctive assemblage of species, including many endemic species, and requiring urgent conservation. The two biodiversity criteria are **high species richness** (a large number of species in the region) and **a high degree of endemism** (many species confined to that region). Hotspots are also under severe threat from habitat loss, so conservation there can protect many threatened species at once. Under the formal hotspot criteria, a region must contain at least 1,500 endemic vascular plant species and must have lost at least 70% of its original natural vegetation.

Step 2: Identify two hotspots that include India (ii) Two examples are the **Western Ghats and Sri Lanka** hotspot and the **Himalaya** hotspot. The Indian Western Ghats form part of the first, and the Indian Himalayan region forms part of the second. Hotspot boundaries follow biodiversity patterns and can extend across national borders; the names therefore need not refer exclusively to Indian territory.

Step 3: Conclusion Biodiversity hotspots combine high species richness and high endemism with severe habitat threat. Two hotspots including Indian regions are Western Ghats and Sri Lanka, and Himalaya.

Quick Tip to Solve: Pair species richness with endemism when listing the biodiversity criteria, then give the complete names of two hotspots that include India.

OR

26(b). Explain giving three reasons, why tropics show greatest level of species diversity.

[3 marks]

Solution:

Concept:

- Species diversity generally increases from the poles towards the equator; tropical regions therefore support more species than temperate and polar regions.
- The tropical diversity gradient is explained by evolutionary time, climatic stability and the greater availability of solar energy for biological production.

Step 1: Explain the longer evolutionary history Tropical latitudes have remained relatively undisturbed for millions of years, whereas temperate regions experienced repeated glaciations. The long

uninterrupted evolutionary history of the tropics has provided more time for speciation and the accumulation of species. Repeated disturbances in temperate regions removed species and interrupted this process.

Step 2: Connect climatic stability with specialisation Tropical environments are less seasonal, relatively constant and more predictable than temperate environments. Such stable conditions promote niche specialisation: organisms can become adapted to particular resources or ways of life. This allows a greater variety of specialised species to coexist, contributing to high species richness.

Step 3: Relate solar energy to productivity Tropical regions receive more solar energy. This supports greater primary productivity through photosynthesis, increasing the biological energy and food available in the ecosystem. Greater productivity contributes indirectly to greater species diversity by supporting a wider variety of organisms and ecological interactions.

Step 4: Conclusion The three reasons are a longer relatively undisturbed evolutionary history, a stable and predictable climate favouring niche specialisation, and greater solar energy supporting higher productivity and indirectly greater diversity.

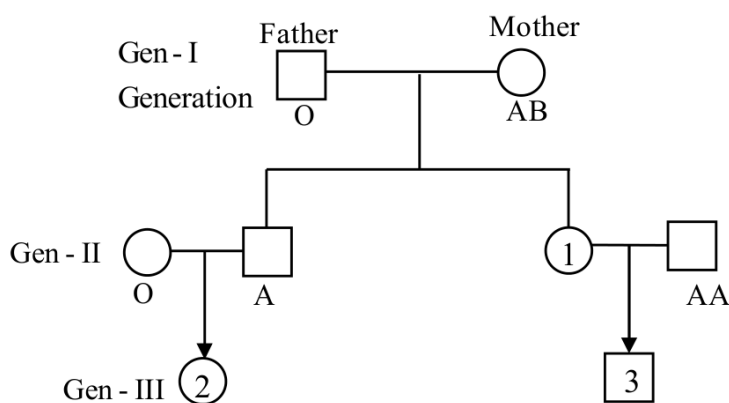
Quick Tip to Solve: Recall the three links: evolutionary time to speciation, climatic stability to niche specialisation, and solar energy to productivity.

27. Given below is the pedigree chart up to 3 generations (Generation I, Generation II, Generation III) of a family with respect to their blood groups.

(a) Mention the blood group along with the genotype of the offspring numbered '1' in Generation II.

(b) Write the possible blood groups along with their genotypes of the offsprings numbered '2' and '3' in Generation III.

[3 marks]



Solution:

Concept:

- ABO blood groups are controlled by the alleles I^A , I^B and i . Alleles I^A and I^B are codominant, and both are dominant over i .
- Group O has genotype ii , group AB has $I^A I^B$, group A has $I^A I^A$ or $I^A i$, and group B has $I^B I^B$ or $I^B i$.

Step 1: Determine the possibilities for individual 1 (a) The Generation I father is group O, ii , and the mother is group AB, $I^A I^B$. The father supplies only i gametes and the mother supplies I^A or I^B gametes. Thus,

$$ii \times I^A I^B \longrightarrow I^A i \text{ (A) or } I^B i \text{ (B)}.$$

Individual 1 can therefore have **group A with genotype $I^A i$** , or **group B with genotype $I^B i$** . The A blood group of her brother does not determine her own blood group; the two offspring represent separate fertilisation events.

Step 2: Cross the parents of individual 2 (b) The group A son in Generation II must be $I^A i$, since his group O father could only supply i . His partner is group O, ii . Their cross gives

$$I^A i \times ii \longrightarrow I^A i \text{ (A) or } ii \text{ (O)}.$$

Individual 2 can therefore be **A, $I^A i$** , or **O, ii** , each with probability $1/2$.

Step 3: Consider both possible genotypes of individual 1 The partner of individual 1 is labelled AA, meaning homozygous group A, $I^A I^A$. If individual 1 is $I^A i$, then

$$I^A i \times I^A I^A \longrightarrow I^A I^A \text{ or } I^A i,$$

both of which give group A. If individual 1 is $I^B i$, then

$$I^B i \times I^A I^A \longrightarrow I^A I^B \text{ (AB) or } I^A i \text{ (A)}.$$

Thus individual 3 can be **A with $I^A I^A$ or $I^A i$** , or **AB with $I^A I^B$** . Groups B and O are excluded because the father always contributes I^A .

Step 4: Conclusion Individual 1: A ($I^A i$) or B ($I^B i$). Individual 2: A ($I^A i$) or O (ii). Individual 3: A ($I^A I^A$ or $I^A i$) or AB ($I^A I^B$).

Quick Tip to Solve: Begin with the O parent, who must pass on i ; retain both possible genotypes for individual 1 before deriving the possibilities for individual 3.

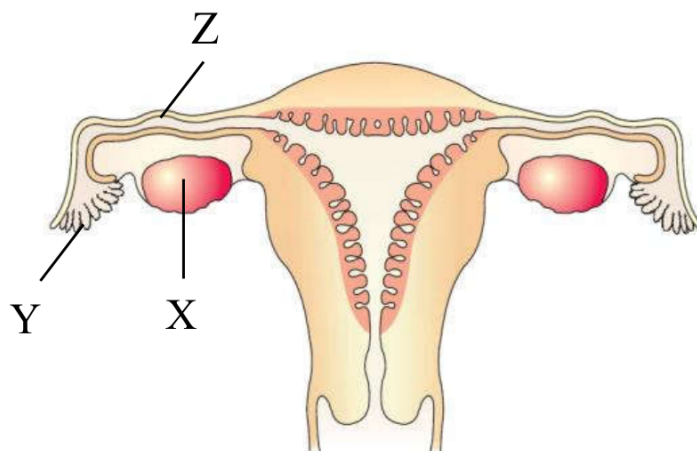
28. Given below is the diagram showing a part of the reproductive system of a human female.

(a) Identify 'Y' and write its function.

(b) Identify 'Z' and write the events that may occur here.

(c) Mention the stage at which the process of oogenesis temporarily gets arrested and name the cells thus formed in the 'X' of a baby girl at the time of her birth.

[3 marks]



Solution:

Concept:

- The ovary produces female gametes. The fimbriae of the oviduct collect the released secondary oocyte, and the oviduct transports it towards the uterus.
- Fertilisation normally occurs at the ampullary-isthmic junction of the oviduct; the resulting zygote undergoes cleavage during its passage towards the uterus.
- Oogenesis begins during foetal development. Primary oocytes remain arrested in prophase I of meiosis until their subsequent maturation after puberty.

Step 1: Identify Y and explain its function Y points to the finger-like fimbriae at the margin of the infundibulum, the funnel-shaped end of the fallopian tube. These projections help collect the secondary oocyte released by the ovary during ovulation and guide it into the oviduct.

Step 2: Identify Z and describe the events occurring there Z is the fallopian tube or oviduct. If sperm and the secondary oocyte reach its ampullary-isthmic junction simultaneously, fertilisation can occur there. The resulting zygote undergoes successive mitotic divisions called cleavage as it moves along the oviduct, producing blastomeres and then a morula. Implantation occurs later in the uterus, rather than in the oviduct.

Step 3: State the arrest stage in X at birth X is the ovary. During foetal life, oogonia enter meiosis I and become primary oocytes. In a baby girl at birth, these cells are temporarily arrested in prophase I, specifically its diplotene stage. Each primary oocyte becomes surrounded by granulosa cells to form a primary follicle. This first arrest must be distinguished from the metaphase II arrest of a secondary oocyte later in reproductive life.

Step 4: Conclusion (a) Y: fimbriae, which collect the ovulated secondary oocyte. (b) Z: oviduct, where fertilisation and early cleavage may occur. (c) X: ovary, containing primary oocytes arrested in prophase I of meiosis.

Quick Tip to Solve: Link the labels to their positions: finger-like fringe = fimbriae; connecting tube = oviduct; oval gonad = ovary. At birth, remember primary oocyte and prophase I together.

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.

A senior student, sneezing very badly, with watery eyes and having difficulty in breathing was brought to the school medical room by his fellow friends. The medical room nurse enquired as to what had happened. One of the students said “after the football match we all were sweating profusely, one of our friends sprayed deodorant on us. Soon after the deodorant was sprayed on the senior boy, the symptoms appeared.”

[4 marks]

29(a). What are the symptoms seen in the student indicative of ? Elaborate.

[1 mark]

Solution:

Concept:

- Allergy is an exaggerated immune response to certain substances in the environment, called allergens.
- Allergic reactions can cause sneezing, watery eyes and difficulty in breathing; IgE antibodies are associated with such responses.

Step 1: Relate the symptoms to the exposure The boy developed sneezing, watery eyes and breathing difficulty soon after deodorant was sprayed. This combination and timing indicate an allergic response to a component of the spray.

Step 2: Explain the exaggerated response The component acts as an allergen in a sensitive individual and provokes an excessive immune reaction. Other students need not develop the same symptoms because sensitivity to a particular allergen differs between individuals.

Step 3: Conclusion The symptoms are indicative of allergy: an exaggerated immune response to an environmental allergen, here a component of the deodorant spray.

Quick Tip to Solve: Connect the immediate onset after spraying with the typical allergy symptoms, then define allergy using the words exaggerated immune response.

29(b). State how the cause of such responses can be confirmed.

[1 mark]

Solution:

Concept:

- An allergen is the substance that triggers an exaggerated immune response in a sensitive person.
- Allergy testing identifies the particular allergen by examining the response to very small quantities of suspected substances under medical supervision.

Step 1: Test the suspected allergens A doctor can expose the individual to, or inject, very small doses of suspected allergens separately as part of a controlled allergy test. In this case, the possible allergens include components of the deodorant.

Step 2: Observe the specific reaction The responses are observed for evidence of an allergic reaction, such as a local skin response. A response to a particular test substance helps identify it as the cause; the history of symptoms following exposure supports this interpretation.

Step 3: Conclusion The cause can be confirmed by medically supervised testing with very small doses of possible allergens and observing which substance produces an allergic response.

Quick Tip to Solve: State both parts of the confirmation method: test tiny doses of suspected allergens and observe the resulting allergic response.

29(c)(i). Name the cells in our body and the chemicals produced by them that are responsible for such reactions. Name any two drugs used to reduce these symptoms. [2 marks]

Solution:

Concept:

- Allergic responses involve IgE antibodies and mast cells. Contact with the relevant allergen can trigger release of chemical mediators from sensitised mast cells.
- Histamine and serotonin are mediators associated with allergic symptoms. Drugs can reduce symptoms by opposing mediator effects or suppressing inflammation.

Step 1: Name the cells and their mediators The cells are mast cells. They release histamine and serotonin during an allergic reaction. These mediators contribute to the local inflammatory response and symptoms such as sneezing, watery eyes and breathing difficulty. The allergen initiates the reaction, whereas the mediators released by the cells produce its effects.

Step 2: Name two drugs that reduce symptoms Antihistamines and steroids are two accepted drug groups. Antihistamines reduce the effects of histamine, while steroids suppress the inflammatory response. Both address the allergic response; they should not be confused with antibiotics, which act against susceptible bacteria and do not specifically counter this allergy.

Step 3: Conclusion Mast cells release histamine and serotonin. Two drugs used to reduce these symptoms are antihistamines and steroids.

Quick Tip to Solve: Keep the answer in three linked pairs: mast cells; histamine and serotonin; antihistamines and steroids. Name the cell before its chemicals.

OR

29(c)(ii). 'In recent times there is a rise in such reactions amongst urban human population.' Do you agree ? Give three reasons in support of your answer. [2 marks]

Solution:

Concept:

- Allergy is excessive immune sensitivity to an environmental substance. Both the person's immune responsiveness and exposure to triggering substances influence allergic reactions.

- NCERT relates the increased occurrence of allergies in urban populations to modern lifestyles, greater sensitivity to allergens and the protected environment provided early in life.

Step 1: State agreement and the lifestyle reason Yes. First, modern urban lifestyles are associated with lowered immunity and greater sensitivity to allergens, as described in NCERT. Consequently, exposure to a substance that is harmless to many people may provoke an exaggerated response in a susceptible person.

Step 2: Explain the protected childhood environment Second, children brought up in highly protected environments have less early exposure to diverse environmental microbes. This can limit normal immune conditioning and favour allergic sensitivity. This explains why the protected environment provided during early life is relevant to the rise of allergies.

Step 3: Relate urban exposure to allergic reactions Third, urban environments increase contact with airborne pollutants and potential allergens, including chemicals in sprays and other products. In susceptible individuals, greater exposure to such triggers can provoke allergic symptoms; in the passage, deodorant spray is the immediate suspected trigger.

Step 4: Conclusion Yes. Three supporting reasons are modern lifestyle-related changes in immunity and sensitivity, a highly protected early-life environment, and increased urban exposure to pollutants and potential allergens.

Quick Tip to Solve: Organise the three reasons as lifestyle, childhood environment and present-day exposure; connect each one explicitly to allergic sensitivity or triggering.

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

Restriction endonuclease was isolated for the first time by W. Arber in 1962, in bacteria. DNA, the genetic material can be manipulated by addition or substitution of the desired gene by using a specific restriction endonuclease resulting in rDNA. This is one of the major steps in biotechnology. [4 marks]

30(a). Name the first isolated restriction endonuclease. Why are restriction endonucleases so called ? [1 mark]

Solution:

Concept:

- Restriction enzymes are bacterial enzymes that recognise specific DNA sequences and cleave foreign DNA, thereby restricting its multiplication.
- An endonuclease cuts phosphodiester bonds within a DNA molecule, whereas an exonuclease removes nucleotides from its ends.

Step 1: Identify the first isolated enzyme The first restriction endonuclease isolated and characterised was Hind II. It recognises a specific sequence of six base pairs in DNA and cuts at that site.

Step 2: Explain both parts of the name These enzymes are called restriction enzymes because they restrict the growth of invading bacteriophages by cutting their DNA. They are endonucleases because they make cuts at specific internal sites in DNA rather than progressively removing nucleotides from the ends.

Step 3: Conclusion Hind II was the first isolated restriction endonuclease. The name describes

restriction of foreign DNA through cleavage at internal recognition sites.

Quick Tip to Solve: Split the name into restriction (limits phage growth) and endonuclease (cuts within DNA).

30(b). Write the palindrome recognised by EcoRI.

[1 mark]

Solution:

Concept:

- A DNA palindrome has the same base sequence when both complementary strands are read in the same direction, from 5' to 3'.
- EcoRI recognises a particular six-base-pair sequence in double-stranded DNA; the two strands are complementary and antiparallel.

Step 1: Write the recognition site and its complement The EcoRI recognition palindrome is



Adenine pairs with thymine and guanine pairs with cytosine, giving the lower complementary strand.

Step 2: Check the direction of reading Read the upper strand from left to right and the lower strand from right to left. Both readings run from 5' to 3' and give GAATTC, confirming that this is a DNA palindrome. Reading both lines left to right would compare opposite directions and would miss this property.

Step 3: Conclusion EcoRI recognises 5'-GAATTC-3', paired with 3'-CTTAAG-5'.

Quick Tip to Solve: Always mark both strand ends; a DNA palindrome is checked by reading each strand from 5' to 3'.

30(c)(i). How does restriction endonuclease function ? Explain.

[2 marks]

Solution:

Concept:

- Restriction endonucleases recognise specific short base sequences, generally palindromic sequences, in double-stranded DNA.
- They cleave phosphodiester bonds in the sugar-phosphate backbone of both strands at defined positions, producing DNA fragments.

Step 1: Recognise and bind the target sequence A restriction endonuclease checks the length of the DNA sequence. When it encounters its specific recognition sequence, it binds to the DNA at that site. In a palindromic recognition sequence, the two strands give the same base sequence when each is read in the 5' to 3' direction.

Step 2: Cut the two DNA strands The enzyme cuts phosphodiester bonds at characteristic positions on the two strands. For example, EcoRI cuts between G and A in each strand of its GAATTC

recognition sequence. Its staggered cuts leave short, single-stranded 5' overhangs called sticky ends. These complementary ends can hydrogen-bond with ends produced by the same enzyme on another DNA molecule; DNA ligase then seals the backbone to form recombinant DNA. Other restriction endonucleases can make straight cuts that produce blunt ends.

Step 3: Conclusion A restriction endonuclease binds its specific DNA recognition site and cleaves the two sugar-phosphate backbones at defined positions, generating fragments with sticky or blunt ends.

Quick Tip to Solve: Describe recognition, binding and backbone cleavage in order; distinguish the cutting enzyme from DNA ligase, which joins fragments.

OR

30(c)(ii). Write the convention for naming a restriction endonuclease with the help of an example.

[2 marks]

Solution:

Concept:

- A restriction endonuclease is named after the bacterial organism and strain from which it was isolated.
- A Roman numeral at the end of the name indicates the order in which enzymes were isolated from that strain.

Step 1: Decode the organism and strain In the example EcoRI, the first letter E comes from the genus *Escherichia*. The next two letters, co, come from the species *coli*. Together, Eco therefore identifies *Escherichia coli*. The following letter R identifies the bacterial strain, RY13, from which this enzyme was isolated. The genus initial is written as a capital letter and the two species letters as lower-case letters.

Step 2: Decode the order of isolation The final Roman numeral I indicates that EcoRI was the first restriction endonuclease isolated from that particular strain. If more than one enzyme is isolated from the same strain, Roman numerals distinguish their order of isolation. The numeral does not indicate the number of DNA strands cut or the number of bases in the recognition sequence.

Step 3: Conclusion EcoRI means E from *Escherichia*, co from *coli*, R from strain RY13, and I for the first enzyme isolated from that strain.

Quick Tip to Solve: Parse EcoRI as E | co | R | I: genus, species, strain, then Roman-numeral order of isolation.

Section E (15 marks)

31(a). (i) Absence of lactose in the culture medium affects the expression of lac operon in *E. coli*. Why and how ? Explain.

(ii) Write any two ways in which the gene expression is regulated in eukaryotes.

[5 marks]

Solution:

Concept:

- The lac operon is an inducible system in which a repressor controls transcription of the structural genes needed for lactose metabolism.
- The regulatory gene *i* produces the repressor; the operator is the DNA site to which the active repressor binds. Lactose acts as the inducer in the NCERT description.
- Eukaryotic gene expression can be controlled at several stages between DNA transcription and protein synthesis.

Step 1: (i) Identify why lactose absence switches the operon off Lactose is the substrate whose utilisation requires the products of the lac structural genes. In its absence, the bacterium does not need to produce these enzymes in large amounts. More directly, no inducer is available to bind to and inactivate the repressor. The regulatory gene *i* is expressed constitutively, so repressor protein is present even when lactose is absent from the medium.

Step 2: Trace the repressor's effect on transcription Without the inducer, the repressor remains active and binds to the operator region of the operon. This blocks RNA polymerase from effectively transcribing the structural genes *z*, *y* and *a*. Thus the operon is repressed, or switched off, and appreciable synthesis of its polycistronic mRNA does not occur.

The *z* gene encodes β -galactosidase, which hydrolyses lactose; *y* encodes permease, which increases entry of lactose into the cell; and *a* encodes transacetylase. Their induced synthesis therefore does not take place without lactose. This regulation avoids unnecessary enzyme synthesis. If lactose becomes available, the inducer inactivates the repressor so it cannot occupy the operator, allowing transcription to proceed.

Step 3: (ii) Explain two control levels in eukaryotes **Transcriptional regulation:** Expression is controlled by regulating the formation of the primary RNA transcript. Regulatory proteins influence transcription initiation, so the amount of RNA produced from a particular gene changes.

Processing-level regulation: After transcription, processing of the primary transcript, particularly splicing, is regulated. Introns must be removed and exons joined to form mature mRNA. Control of this processing determines which mature transcript becomes available for subsequent protein synthesis. These are two distinct stages: making the primary transcript and processing that transcript.

Step 4: Conclusion In the absence of lactose, the active repressor binds the operator and represses transcription of the lac structural genes. In eukaryotes, gene expression can be regulated at the transcriptional level and at the RNA-processing level.

Quick Tip to Solve: Trace the switch in order: no lactose, active repressor, occupied operator, blocked transcription. For eukaryotes, name the stage and explain what is controlled there.

- 31(b).** (i) By taking two suitable traits in a pea plant, work out a dihybrid cross up to F_2 generation.
 (ii) State the Mendel's law derived from such a cross only. [5 marks]

Solution:

Concept:

- A dihybrid cross follows the inheritance of two contrasting pairs of traits simultaneously. Choose seed shape and seed colour in pea plants.
- Let R denote round seeds and r wrinkled seeds; let Y denote yellow seeds and y green seeds. Round and yellow are dominant over wrinkled and green, respectively.
- During gamete formation, the two alleles of a gene segregate; for these independently assorting genes, either allele of one pair can accompany either allele of the other pair.

Step 1: (i) Cross the pure-breeding parents Take a homozygous round, yellow-seeded pea plant and a homozygous wrinkled, green-seeded pea plant. Their parental cross is

$$RRYY \times rryy.$$

The first parent produces only RY gametes and the second produces only ry gametes. Fertilisation therefore produces a uniform first filial generation:

$$F_1 : RrYy \text{ (all round and yellow).}$$

Both dominant traits appear because each offspring has at least one dominant allele for each character.

Step 2: Self the dihybrid and list its gametes Self-pollinate the F_1 plants to obtain the F_2 generation:

$$RrYy \times RrYy.$$

Each parent produces four types of gametes, RY , Ry , rY and ry , in equal proportions of $1/4$. The allele for seed shape segregates independently of the allele for seed colour, so all four combinations are possible in both pollen and ovules.

Step 3: Work out the second filial generation Combining the four male and four female gamete types gives the following Punnett square; each cell represents an equally probable fertilisation combination.

	RY	Ry	rY	ry
RY	$RRYY$	$RRYy$	$RrYY$	$RrYy$
Ry	$RRYy$	$RRyy$	$RrYy$	$Rryy$
rY	$RrYY$	$RrYy$	$rrYY$	$rrYy$
ry	$RrYy$	$Rryy$	$rrYy$	$rryy$

A dash in $R-$ or $Y-$ below means that the second allele may be dominant or recessive. Grouping the

sixteen combinations by phenotype gives:

Phenotype	Genotype class	Proportion
Round yellow	$R-Y-$	9/16
Round green	$R-yy$	3/16
Wrinkled yellow	$rrY-$	3/16
Wrinkled green	$rryy$	1/16

Round green and wrinkled yellow are new combinations compared with the original parents, showing that the two pairs of traits have recombined.

Step 4: (ii) State the law demonstrated by this cross **Mendel's law of independent assortment:** When two pairs of traits are combined in a hybrid, segregation of one pair of characters is independent of the other pair of characters. Thus inheritance of seed shape does not determine inheritance of seed colour in this cross. This law applies to independently assorting genes, such as the gene pairs considered here.

Step 5: Conclusion The parental cross $RRYY \times rryy$ gives all $RrYy$ round-yellow F_1 plants. Selfing gives the F_2 phenotypic ratio 9 : 3 : 3 : 1 for round yellow, round green, wrinkled yellow and wrinkled green, respectively, demonstrating the law of independent assortment.

Quick Tip to Solve: First write all four gametes of $RrYy$: RY, Ry, rY, ry . Fill the four-by-four square, then classify each cell by the presence or absence of dominant R and Y .

32(a). Describe the process of wastewater (sewage) treatment under the following heads :

(i) Primary treatment

(ii) Secondary treatment

[5 marks]

Solution:

Concept:

- Primary treatment physically removes floating and suspended solids from sewage by filtration and sedimentation.
- Secondary treatment uses microorganisms to remove biodegradable organic matter. Biochemical oxygen demand (BOD) measures the oxygen required by microorganisms to oxidise the organic matter in a water sample; a fall in BOD indicates reduced organic pollution.
- Aerobic microbes treat the liquid effluent, whereas anaerobic microbes digest the separated sludge and generate biogas.

Step 1: (i) Remove solids by primary treatment Pass sewage through a series of filters to remove floating debris. Allow it to undergo sedimentation so that grit, including soil and small pebbles, settles. Floating and suspended materials are thus removed by physical processes. All the solids that settle form the primary sludge; the liquid above it is the primary effluent. Transfer this effluent to the secondary treatment stage, because dissolved and fine organic matter remains after physical separation.

Step 2: (ii) Grow aerobic microbes in aeration tanks Pass the primary effluent into large aeration

tanks. Mechanically agitate it and pump air into it. Oxygen supports vigorous growth of useful aerobic microbes, which form flocs: masses of bacteria associated with fungal filaments in mesh-like structures. These microbes consume a major portion of the organic matter in the effluent. As the amount of biodegradable organic matter falls, the BOD is significantly reduced. Treatment continues until this reduction has occurred.

Step 3: Settle and recycle the activated sludge Transfer the treated effluent to a settling tank. The bacterial flocs settle to form activated sludge. Pump a small part of this activated sludge back into the aeration tank as an inoculum, supplying an active microbial population for treatment of incoming sewage. The remaining major part is sent to large anaerobic sludge digesters.

Step 4: Digest the sludge and release treated effluent In the sludge digesters, anaerobic bacteria digest the bacteria and fungi present in the sludge. During digestion, gases such as methane, hydrogen sulphide and carbon dioxide are produced; together these form biogas, which can be used as a fuel. The effluent from the secondary treatment plant has a much lower BOD and is generally released into natural water bodies after treatment. Sludge digestion and treatment of the liquid effluent are distinct operations within the overall process.

Step 5: Conclusion Primary treatment separates solids physically into primary sludge and effluent. Secondary treatment biologically reduces the organic load and BOD of the effluent, produces activated sludge, and includes anaerobic digestion of the excess sludge with biogas formation.

Quick Tip to Solve: Keep the sequence clear: filtration and sedimentation, aeration and floc formation, activated-sludge settling, then sludge digestion. Only a small part of activated sludge returns as inoculum.

OR

32(b). (i) Explain the sequence of events occurring in a biogas plant.

(ii) Write the components of biogas.

(iii) Write any three advantages of using cow dung as the raw material.

[5 marks]

Solution:

Concept:

- Biogas is a mixture of gases, predominantly methane, produced by microbial breakdown of organic matter under anaerobic conditions.
- Methanogens such as *Methanobacterium* occur in the rumen of cattle and in cattle dung. Dung supplies both organic material and a microbial inoculum for a biogas plant.
- A biogas plant converts an organic waste into useful fuel while leaving a spent slurry that can be used as manure.

Step 1: (i) Feed the slurry and allow anaerobic digestion Mix cattle dung with water to form a slurry and feed it into the digester tank of the biogas plant through the inlet. The digester provides anaerobic conditions. Microorganisms break down the complex organic matter in the slurry, and methanogenic activity produces methane-rich biogas. Cow dung already contains methanogens derived from the cattle digestive tract, helping to establish the microbial population needed for this process.

Step 2: Collect gas and remove the spent slurry The gas accumulates in the gas holder above the slurry. In a floating-cover plant, the cover rises as more gas is produced. An outlet pipe carries the gas to nearby houses, where it can be used for cooking and lighting. Digested or spent slurry is removed through another outlet and used as fertiliser. Addition of fresh slurry and removal of spent slurry allow the plant to continue operating.

Step 3: (ii) State the components of biogas Biogas consists mainly of methane (CH_4), together with carbon dioxide (CO_2) and hydrogen (H_2); small amounts of hydrogen sulphide (H_2S) may also occur. Methane is the principal combustible component responsible for its value as a fuel.

Step 4: (iii) Explain three advantages of using cow dung **1. It provides suitable microorganisms and substrate:** Cow dung is rich in methanogens and contains organic matter, including undigested plant material, that supports microbial digestion and biogas production.

2. It is readily available and economical: In cattle-rearing rural areas, dung is an abundant, inexpensive waste material. Using it provides a useful fuel while recycling locally available waste.

3. The residue remains useful as manure: The spent dung slurry can be applied to fields as fertiliser. Thus the raw material yields biogas while retaining its value as an organic manure, instead of being directly burnt as dried dung cakes.

Step 5: Conclusion In a biogas plant, dung slurry undergoes anaerobic digestion, the methane-rich gas is collected and supplied through a pipe, and the spent slurry is used as manure. Cow dung is useful because it supplies microbes and organic matter, is inexpensive and readily available, and yields a valuable fertiliser residue.

Quick Tip to Solve: Describe biogas production in the order inlet slurry, anaerobic digester, gas holder and outlet slurry. For cow dung, remember inoculum and substrate, cheap availability, and useful manure residue.

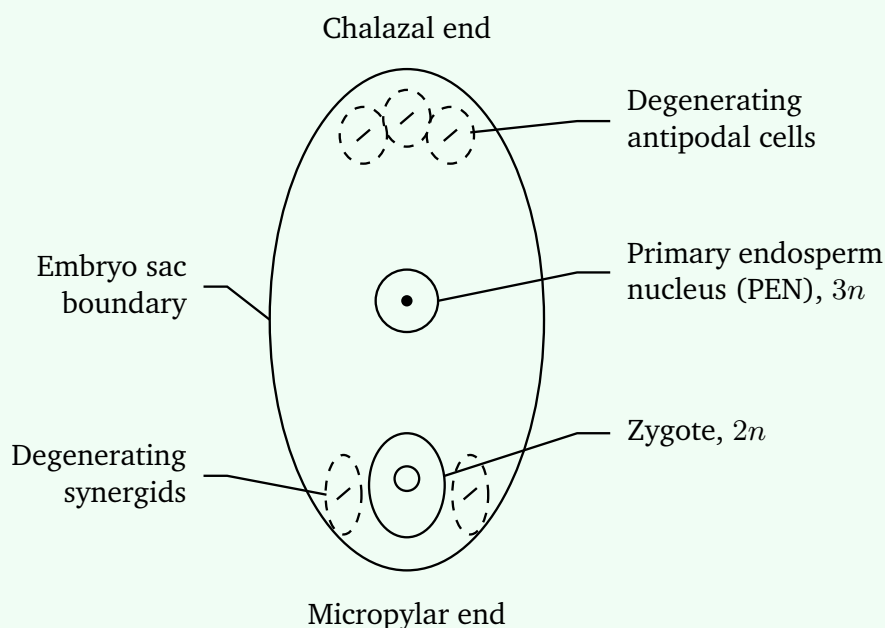
33(a). (i) Draw a labelled diagram of a fertilised embryo sac of an angiosperm. (label any four parts)
(ii) Explain double fertilisation in angiospermic plant. [5 marks]

Solution:

Concept:

- Double fertilisation in an angiosperm consists of two fusion events in the same embryo sac: syngamy and triple fusion.
- A haploid male gamete fuses with the haploid egg to form a diploid zygote, whereas the other male gamete fuses with the two polar nuclei to form the triploid primary endosperm nucleus.
- The zygote develops into the embryo; the primary endosperm cell develops into the endosperm, which nourishes the developing embryo. Here n denotes one set of chromosomes.

Step 1: (i) Draw the embryo sac after fertilisation The labelled diagram shows the stage just after double fertilisation. The egg has become the diploid zygote near the micropylar end, and the central cell contains the triploid primary endosperm nucleus. Synergids at the micropylar end and antipodal cells at the chalazal end degenerate. The zygote, primary endosperm nucleus, degenerating synergids and degenerating antipodal cells are labelled separately. The primary endosperm nucleus must not be shown as two unfused polar nuclei in a fertilised embryo sac.



Fertilised embryo sac immediately after double fertilisation (schematic).

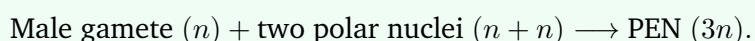
Step 2: (ii) Describe delivery of the male gametes After compatible pollination, a pollen grain germinates on the stigma. Its pollen tube grows through the style, reaches an ovule and usually enters through the micropyle. The tube enters one synergid through the filiform apparatus and releases two haploid male gametes into the embryo sac. These two male gametes participate in different fusion events.

Step 3: Explain syngamy One male gamete moves towards the egg cell. Their nuclei fuse, bringing together the paternal and maternal chromosome sets. This fusion is called syngamy and produces the diploid zygote:



The zygote subsequently develops into the embryo. It is located towards the micropylar end of the fertilised embryo sac.

Step 4: Explain triple fusion and its outcome The second male gamete moves into the large central cell and fuses with the two polar nuclei. Three haploid nuclear sets participate, so this event is called triple fusion. If the polar nuclei have already fused, the male gamete fuses with their diploid secondary nucleus. In either case, the product is the triploid primary endosperm nucleus (PEN):



The central cell containing the PEN is now the primary endosperm cell. It develops into the endosperm, the nutritive tissue supporting embryo development. Endosperm development generally precedes embryo development.

Step 5: Conclusion Double fertilisation comprises syngamy and triple fusion in the same embryo sac, producing a diploid zygote ($2n$) and a triploid primary endosperm nucleus ($3n$), respectively. It is a characteristic feature of flowering plants.

Quick Tip to Solve: For a fertilised embryo sac, replace the egg by a zygote and the polar nuclei by one PEN; remember the chromosome-set totals $n + n = 2n$ and $n + n + n = 3n$.

33(b). (i) Draw a labelled diagram of a cross-section of human seminiferous tubule. (label any four parts)

(ii) Explain the hormonal regulation of spermatogenesis.

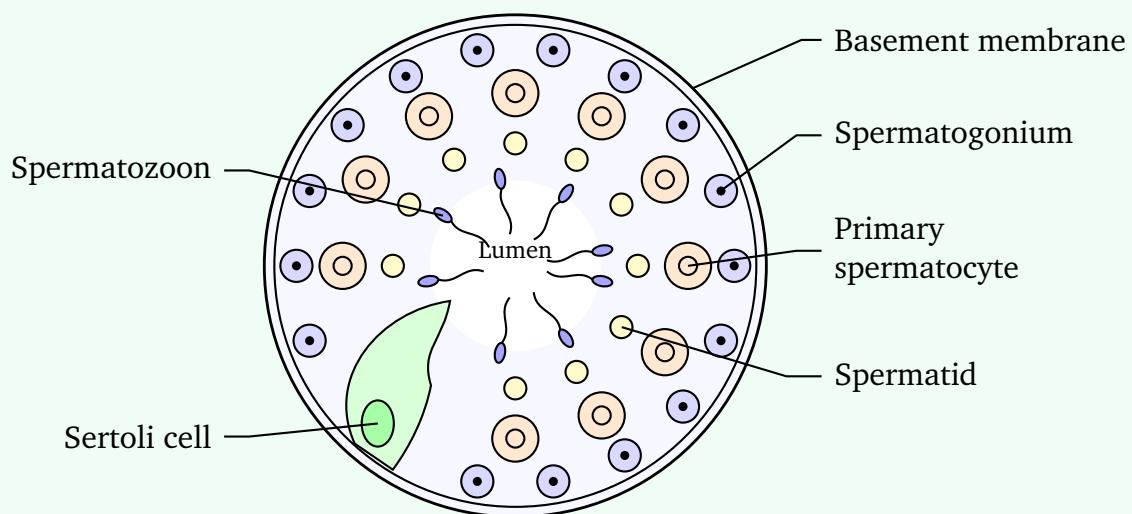
[5 marks]

Solution:

Concept:

- Spermatogenesis is the formation of haploid spermatozoa from diploid spermatogonia in the seminiferous tubules of the testes. Developing germ cells move from the basal region towards the lumen.
- Hypothalamic gonadotropin-releasing hormone (GnRH) controls the anterior pituitary gonadotropins, luteinising hormone (LH) and follicle-stimulating hormone (FSH).
- Leydig cells secrete androgens, whereas Sertoli cells support and nourish the developing germ cells. Their hormonal control coordinates sperm formation.

Step 1: (i) Draw and label the seminiferous tubule The cross-section below shows the basement membrane around the tubule and the central lumen. Spermatogonia lie near the basement membrane; primary spermatocytes lie farther inward. Later stages, including spermatids and spermatozoa, occur towards the lumen. Sertoli cells extend through the germinal epithelium and provide nourishment to developing germ cells. The labelled basement membrane, spermatogonia, primary spermatocytes, spermatids, spermatozoa, Sertoli cell and lumen identify more than the four parts requested. Leydig cells lie in the interstitial tissue outside the tubules.



Cross-section of a human seminiferous tubule (schematic).

Step 2: (ii) Initiate the hormonal signal at puberty At puberty, secretion of GnRH from the hypothalamus increases significantly. GnRH acts on the anterior pituitary and stimulates secretion of the two gonadotropins, LH and FSH. These hormones reach the testes through the blood and act on different target cells.

Step 3: Explain the action of LH on Leydig cells LH acts on the interstitial cells, also called Leydig cells, located between the seminiferous tubules. It stimulates the synthesis and secretion of androgens,

chiefly testosterone. Androgens, in turn, stimulate spermatogenesis in the seminiferous tubules, helping maintain the hormonal environment needed for sperm production.

Step 4: Explain the action of FSH on Sertoli cells FSH acts on the Sertoli cells within the seminiferous tubules and stimulates their secretion of factors that help in spermiogenesis. Spermiogenesis is the transformation of spermatids into spermatozoa. Sertoli cells also nourish the developing germ cells. Thus the androgen-producing Leydig cells and the supporting Sertoli cells have complementary roles in the production and maturation of sperm.

Step 5: Conclusion The labelled cross-section shows germ cells arranged from the basement membrane towards the lumen, with supporting Sertoli cells. Hormonal regulation follows GnRH stimulation of the anterior pituitary: LH stimulates Leydig cells to secrete androgens for spermatogenesis, while FSH stimulates Sertoli-cell factors that assist spermiogenesis.

Quick Tip to Solve: Remember the two targets separately: LH acts on Leydig cells; FSH acts on Sertoli cells. In the diagram, place spermatogonia near the outer boundary and spermatozoa next to the lumen.