

CBSE Class 12 Biology Question Paper 2011 with Solution PDF-Set 57/1/1

Question Paper with Solutions

Conducted by the Central Board of Secondary Education (CBSE)



Time Allowed: 3 hours

Maximum Marks: 70

General Instructions

- (i) All questions are compulsory.
- (ii) This question paper consists of four Sections A, B, C and D. Section A contains 8 questions of one mark each, Section B is of 10 questions of two marks each, Section C is of 9 questions of three marks each and Section D is of 3 questions of five marks each.
- (iii) There is no overall choice. However, an internal choice has been provided in one question of 2 marks, one question of 3 marks and all the three questions of 5 marks weightage. A student has to attempt only one of the alternatives in such questions.
- (iv) Wherever necessary, the diagrams drawn should be neat and properly labelled.

Section A (8 marks)

1. Name the type of cell division that takes place in the zygote of an organism exhibiting haplontic life cycle. [1 mark]

Solution:

Concept:

- A haplontic life cycle has a haploid vegetative phase; the zygote is its only diploid stage.
- Meiosis reduces the chromosome number from diploid $2n$ to haploid n .

Step 1: Identify the diploid stage Fusion of two haploid gametes produces a diploid zygote. In a haplontic organism, this zygote does not develop into a multicellular diploid plant body.

Step 2: Restore the haploid phase The zygote undergoes reduction division to produce haploid cells or spores. These develop by mitosis into the haploid organism; ordinary mitosis of the zygote would retain the diploid chromosome number.

Step 3: Conclusion The zygote undergoes meiosis, specifically zygotic meiosis.

Quick Tip to Solve: Link haplontic life cycles with zygotic meiosis: the zygote must restore the haploid phase.

2. Write the scientific name of the microbe used for fermenting malted cereals and fruit juices. [1 mark]

Solution:

Concept:

- Fermentation converts sugars into ethanol and carbon dioxide in the absence of oxygen.
- Brewer's yeast is used in fermenting malted cereals and fruit juices.

Step 1: Identify the organism The microbe used is brewer's yeast, a unicellular fungus. It utilises fermentable sugars present in the prepared cereal material or fruit juice.

Step 2: State its scientific name Its binomial name is *Saccharomyces cerevisiae*. During alcoholic fermentation, its enzymes convert sugars into ethanol and carbon dioxide; the organism is identified by this scientific name rather than merely by the common name yeast.

Step 3: Conclusion The microbe is *Saccharomyces cerevisiae* (brewer's yeast).

Quick Tip to Solve: For cereal and fruit-juice alcoholic fermentation, recall brewer's yeast: *Saccharomyces cerevisiae*.

3. Write the unit used for measuring ozone thickness. [1 mark]

Solution:

Concept:

- Atmospheric ozone thickness refers to the total amount of ozone in a vertical column of air.

- The conventional unit for total-column ozone is the Dobson unit, abbreviated DU.

Step 1: Identify the measured quantity Ozone-layer thickness expresses the amount of ozone above a unit area, rather than the physical depth of a uniform layer at its atmospheric altitude.

Step 2: Specify the unit It is measured in Dobson units. One Dobson unit corresponds to a layer of pure ozone 0.01 mm thick when the ozone in the column is brought to standard temperature and pressure. This defines the column amount used for atmospheric ozone.

Step 3: Conclusion The unit is the Dobson unit (DU).

Quick Tip to Solve: Associate total ozone-column thickness with Dobson units, abbreviated DU.

4. Name the event during cell division cycle that results in the gain or loss of chromosome. [1 mark]

Solution:

Concept:

- Normal chromosome segregation distributes chromosomes equally to daughter cells.
- Failure of segregation can change the number of individual chromosomes, producing aneuploidy.

Step 1: Identify the faulty event During cell division, homologous chromosomes or sister chromatids may fail to separate properly at anaphase. They consequently pass together towards the same pole.

Step 2: Relate it to chromosome gain or loss The resulting daughter cells receive unequal chromosome complements: one may gain a chromosome while another loses one. The segregation failure is called nondisjunction; aneuploidy names the resulting numerical chromosome abnormality.

Step 3: Conclusion The event is nondisjunction, the failure of chromosomes or chromatids to segregate properly.

Quick Tip to Solve: Distinguish the event, nondisjunction, from its result, aneuploidy.

5. How can bacterial DNA be released from the bacterial cell for biotechnology experiments? [1 mark]

Solution:

Concept:

- DNA isolation begins by breaking open the cell so that its contents are released.
- Lysozyme digests the peptidoglycan cell wall of bacteria.

Step 1: Remove the bacterial cell wall Treat the bacterial cells with the enzyme lysozyme. Its action breaks down the peptidoglycan wall, removing the rigid protective barrier around the cell.

Step 2: Release the cellular contents Lysis of the treated cells, with disruption of the plasma membrane, releases the DNA into the extraction medium along with other cellular constituents. Subsequent purification removes RNA and proteins; those steps are distinct from the initial release of DNA.

Step 3: Conclusion Treat the bacterial cells with lysozyme to digest the cell wall and lyse the cells,

releasing their DNA.

Quick Tip to Solve: Match the wall-digesting enzyme to bacteria: lysozyme releases DNA by enabling cell lysis.

6. Write the importance of cryopreservation in conservation of biodiversity.

[1 mark]

Solution:

Concept:

- Cryopreservation stores living biological material at very low temperatures, commonly in liquid nitrogen at -196°C .
- It is an ex situ conservation method that preserves viable genetic resources outside natural habitats.

Step 1: Explain what is preserved Gametes, embryos, seeds and other suitable living tissues of threatened species can be stored by cryopreservation. Very low temperatures greatly reduce metabolic and degradative activity.

Step 2: Connect storage with conservation The preserved material retains viability for long periods and serves as a genetic resource. It can later be used for propagation or reproduction, helping conserve a species and its genetic diversity even when its natural population is threatened.

Step 3: Conclusion Cryopreservation preserves viable germplasm of threatened species for long periods, enabling future propagation and conservation of genetic diversity.

Quick Tip to Solve: For cryopreservation, connect long-term viable germplasm storage with future reproduction.

7. Mention the role of the codons AUG and UGA during protein synthesis.

[1 mark]

Solution:

Concept:

- The genetic code specifies both amino acids and signals that begin or end translation.
- AUG is the usual initiation codon; UGA is one of the termination codons of the standard genetic code.

Step 1: State the role of AUG AUG initiates translation by specifying the site at which synthesis of the polypeptide begins. It also codes for the amino acid methionine, including when it occurs within a coding sequence.

Step 2: State the role of UGA UGA acts as a stop codon. It does not specify an amino acid in the standard genetic code; it signals termination of translation and release of the completed polypeptide from the ribosome.

Step 3: Conclusion AUG initiates translation and codes for methionine; UGA signals termination of translation.

Quick Tip to Solve: Remember AUG as start plus methionine, and UGA as a translation stop signal.

8. Normally one embryo develops in one seed but when an orange seed is squeezed many embryos of different shapes and sizes are seen. Mention how it has happened. [1 mark]

Solution:

Concept:

- Polyembryony is the occurrence of more than one embryo in a single seed.
- In Citrus, maternal nucellar cells can develop into additional embryos by adventive embryony.

Step 1: Identify the phenomenon The presence of several embryos in one orange seed is called polyembryony. It does not mean that several seeds have fused together.

Step 2: Explain their origin Some diploid cells of the nucellus surrounding the embryo sac begin dividing and develop into embryos. These nucellar embryos grow alongside the normal embryo formed from the fertilised egg, producing several embryos within the same seed.

Step 3: Conclusion Orange shows polyembryony because nucellar cells develop into additional embryos beside the normal zygotic embryo.

Quick Tip to Solve: For Citrus polyembryony, name the nucellus as the source of the extra embryos.

Section B (20 marks)

9. How do histones acquire positive charge? [2 marks]

Solution:

Concept:

- Histones are basic proteins associated with DNA in eukaryotic chromatin.
- The basic amino acids lysine and arginine possess side groups that can carry positive charges.

Step 1: Identify the amino-acid composition Histones contain a high proportion of the basic amino-acid residues lysine and arginine. The charge on a protein depends on the ionisable groups present in its constituent amino acids; consequently, this enrichment makes histones basic proteins.

Step 2: Explain the positive charge At physiological pH, the basic side groups of lysine and arginine are predominantly protonated and positively charged. Their abundance gives histones a net positive charge. These positive charges attract the negatively charged phosphate groups of DNA, allowing DNA to associate with histone proteins and wrap around the histone octamer to form a nucleosome.

Step 3: Conclusion Histones acquire their positive charge from the abundant basic amino acids lysine and arginine, whose side groups are positively charged at physiological pH.

Quick Tip to Solve: Remember lysine and arginine for positive histones, and phosphate groups for negative DNA.

10. Why is CuT considered a good contraceptive device to space children?

[2 marks]

Solution:

Concept:

- CuT is a copper-releasing intrauterine device inserted into the uterus by a trained medical professional.
- A spacing method temporarily prevents pregnancy while allowing fertility to return after its removal.

Step 1: Explain how CuT prevents conception An intrauterine device increases phagocytosis of sperms within the uterus. In addition, the copper ions released by CuT suppress sperm motility and their fertilising capacity. These actions reduce the likelihood of fertilisation and make CuT an effective contraceptive.

Step 2: Relate its action to spacing children CuT provides sustained contraception after insertion and does not require an action at every sexual intercourse. Its effect is reversible: it can be removed by a trained healthcare professional when the couple wishes to have another child. It therefore allows the couple to delay the next pregnancy without undergoing permanent sterilisation.

Step 3: Conclusion CuT is suitable for spacing children because it provides effective, sustained and reversible contraception; copper ions impair sperm motility and fertilising capacity, and the device increases sperm phagocytosis.

Quick Tip to Solve: For a spacing device, connect the contraceptive mechanism with reversibility after removal.

11. Differentiate between albuminous and non-albuminous seeds, giving one example of each.

[2 marks]

Solution:

Concept:

- Endosperm is the nutritive tissue formed following triple fusion during double fertilisation.
- Seeds are classified as albuminous or non-albuminous according to whether endosperm persists at maturity.

Step 1: Describe albuminous seeds with an example Albuminous, or endospermic, seeds retain a portion of the endosperm in the mature seed because the developing embryo has not consumed it completely. This persistent tissue serves as a food reserve. Maize is an example of an albuminous seed.

Step 2: Contrast non-albuminous seeds with an example Non-albuminous, or non-endospermic, seeds have no persistent endosperm at maturity, as the developing embryo has consumed it during seed development. Reserve food is generally stored in the cotyledons instead. Pea is an example. Thus, the distinction concerns the mature seed; it does not mean that endosperm never formed in the non-albuminous seed.

Step 3: Conclusion Albuminous seeds retain endosperm at maturity, for example maize; non-albuminous seeds use up the endosperm during embryo development, for example pea.

Quick Tip to Solve: Compare endosperm at maturity: maize retains it, whereas pea uses it up during development.

12. Explain the process of RNA interference.

[2 marks]

Solution:

Concept:

- RNA interference (RNAi) is sequence-specific gene silencing that prevents expression of a target messenger RNA.
- Double-stranded RNA complementary to the target RNA initiates this cellular defence mechanism in eukaryotes.

Step 1: Produce the double-stranded RNA trigger Double-stranded RNA may originate from an RNA virus or from introduced genes that produce complementary sense and antisense RNA strands. When these complementary strands pair, they form double-stranded RNA corresponding to the target gene.

Step 2: Silence the complementary messenger RNA Cellular machinery processes the double-stranded RNA into short interfering RNAs. A guide strand directs an RNA-induced silencing complex to a messenger RNA with the complementary nucleotide sequence. The target messenger RNA is cleaved and degraded, preventing its translation into protein. Thus, expression of that particular gene is silenced without requiring removal of the gene from DNA.

Step 3: Conclusion RNA interference silences a specific gene when double-stranded RNA triggers the recognition and degradation of its complementary mRNA, thereby preventing translation.

Quick Tip to Solve: Link the sequence in order: double-stranded RNA, complementary mRNA recognition, mRNA destruction, no protein.

13. List the key tools used in recombinant DNA technology.

[2 marks]

Solution:

Concept:

- Recombinant DNA technology joins a desired DNA fragment to a carrier DNA molecule and introduces it into a suitable host.
- The key tools are enzymes, cloning vectors and competent host organisms; each has a distinct role in producing recombinant DNA.

Step 1: Name the enzymes and their roles Restriction endonucleases cut DNA at specific recognition sequences, enabling the desired fragment and vector to be prepared with compatible ends. DNA ligase joins the DNA fragment to the vector by sealing the sugar-phosphate backbone. DNA polymerases synthesise DNA and are used, for example, to amplify the required DNA segment.

Step 2: Name the carrier and host A cloning vector, such as a plasmid or bacteriophage, carries the foreign DNA into the host and permits its replication. A competent host organism, commonly a suitable bacterial cell such as *Escherichia coli*, accepts the recombinant DNA and allows it to multiply or express the inserted gene.

Step 3: Conclusion The key tools are restriction enzymes and other DNA-processing enzymes, cloning vectors, and competent host organisms.

Quick Tip to Solve: Remember the roles in order: enzymes cut and join, vectors carry, and hosts multiply the recombinant DNA.

14. Name the two types of immune systems in a human body. Why are cell mediated and humoral immunities so called? [2 marks]

Solution:

Concept:

- Human immunity is of two main types: innate immunity, present from birth, and acquired immunity, developed after exposure to antigens.
- Cell-mediated and humoral immunity are the two major responses of acquired immunity, involving T lymphocytes and B lymphocytes respectively.

Step 1: Name the two immune systems The two types are innate immunity and acquired (adaptive) immunity. Innate immunity provides non-specific defence through barriers and other inborn mechanisms. Acquired immunity is antigen-specific and possesses memory, so a later encounter with the same antigen can produce a stronger response.

Step 2: Explain the names of the acquired responses Cell-mediated immunity is so called because T lymphocytes mediate the immune response through cells, for example against infected cells and transplanted tissue. Humoral immunity is so called because B lymphocytes produce antibodies, through plasma cells, that occur in body fluids or humours such as blood and lymph and act against antigens.

Step 3: Conclusion The two main types are innate and acquired immunity. T-cell action gives cell-mediated immunity, while antibodies in body fluids give humoral immunity.

Quick Tip to Solve: Keep the two classifications separate: innate/acquired are the main types; T-cell/antibody responses are branches of acquired immunity.

OR

14. Write the scientific names of the causal organisms of elephantiasis and ringworm in humans. Mention the body parts affected by them. [2 marks]

Solution:

Concept:

- Elephantiasis is a filarial worm infection that damages lymphatic vessels and interferes with lymph drainage.
- Ringworm is a fungal infection of superficial keratinised tissues; its name does not indicate a worm infection.

Step 1: Identify elephantiasis and the affected parts Elephantiasis is caused by the filarial worms *Wuchereria bancrofti* and *Wuchereria malayi* (the latter is also called *Brugia malayi*). They affect the lymphatic vessels, particularly those of the lower limbs. Chronic inflammation and obstruction of lymph flow cause marked swelling; genital organs may also be affected.

Step 2: Identify ringworm and the affected parts Ringworm is caused by fungi belonging to the

genera *Microsporum*, *Trichophyton* and *Epidermophyton*. These infect the skin, nails and scalp. The infection commonly produces dry, scaly lesions on skin, including the groin and regions between the toes.

Step 3: Conclusion Elephantiasis: *Wuchereria* species, affecting lymphatic vessels of limbs and genital organs. Ringworm: *Microsporum*, *Trichophyton* and *Epidermophyton*, affecting skin, nails and scalp.

Quick Tip to Solve: Link filarial worms to lymph vessels and swelling; link ringworm fungi to skin, nails and scalp.

15. Justify with the help of an example where a deliberate attempt by humans has led to the extinction of a particular species. [2 marks]

Solution:

Concept:

- Deliberate introduction of an alien species can cause the extinction of native species through predation or competition.
- A human action need not aim to exterminate the native species: an intentional introduction can nevertheless lead to its extinction.

Step 1: State the deliberate human action The Nile perch was deliberately introduced into Lake Victoria in East Africa. It is a large predatory fish introduced into a lake with a rich assemblage of native cichlid fishes. This is an example of human-mediated introduction of an alien species into a natural ecosystem.

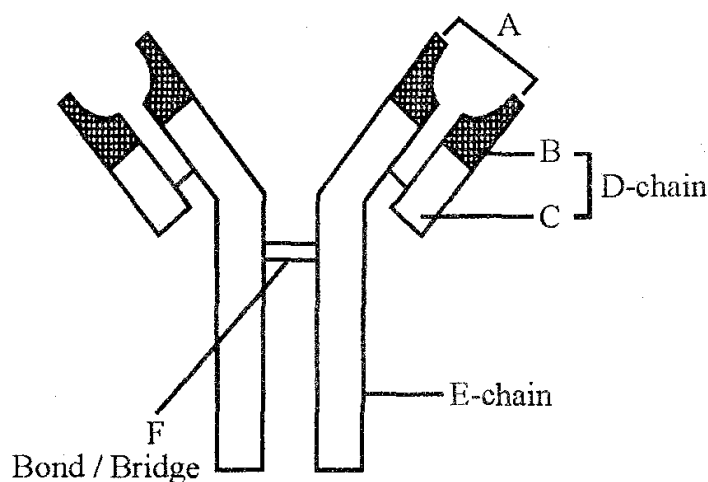
Step 2: Connect the introduction with extinction The introduced Nile perch preyed upon the native, ecologically unique cichlid fishes. Its establishment led to the extinction of more than 200 species of cichlids in the lake. Thus, a deliberate human introduction disrupted the existing community and caused loss of native biodiversity, illustrating how an intentional human action can produce species extinction.

Step 3: Conclusion The deliberate introduction of Nile perch into Lake Victoria led to the extinction of more than 200 native cichlid fish species through predation.

Quick Tip to Solve: For this example, remember the chain: Lake Victoria, introduced Nile perch, predation, native cichlid extinctions.

16. Identify A, D, E and F in the diagram of an antibody molecule given below:

[2 marks]



Solution:

Concept:

- An antibody is a Y-shaped immunoglobulin made of two identical heavy polypeptide chains and two identical light polypeptide chains, commonly represented as H_2L_2 .
- The variable regions at the tips bind a specific antigen, while disulphide bonds join the chains and stabilise the molecule.

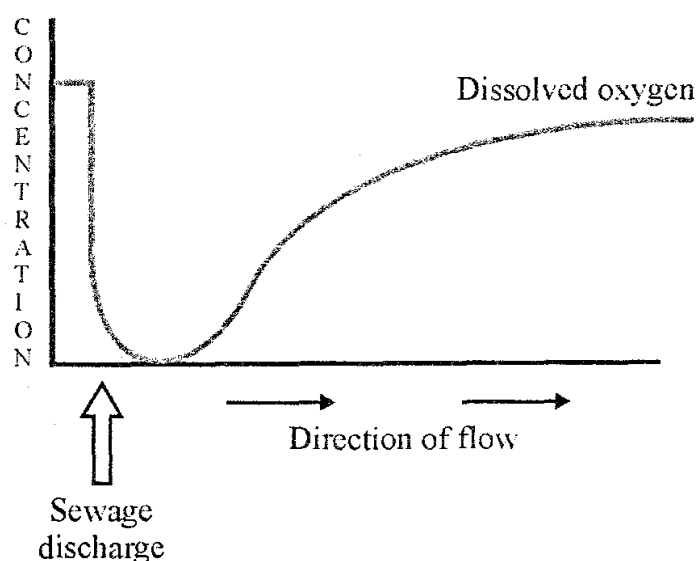
Step 1: Identify the binding site and the shorter chain A indicates the antigen-binding site at the tip of an arm. The variable portions of a heavy chain and a light chain together form this site, giving the antibody its antigen specificity. D indicates the light chain: the bracket spans the shorter, outer polypeptide, including its variable and constant regions.

Step 2: Identify the longer chain and the bridge E indicates the heavy chain, the longer polypeptide that extends from an arm down into the stem of the Y. F points to a disulphide bond or bridge joining the two heavy chains. These covalent sulphur-to-sulphur links help maintain the antibody's structure.

Step 3: Conclusion A: antigen-binding site; D: light chain; E: heavy chain; F: disulphide bond or bridge.

Quick Tip to Solve: Follow the full length of each chain: the short outer chain is light, whereas the chain continuing into the stem is heavy.

17. Study the graph given below. Explain how is oxygen concentration affected in the river when sewage is discharged into it. [2 marks]



Solution:

Concept:

- Dissolved oxygen is the oxygen available in water for respiration by aquatic organisms.
- Biochemical oxygen demand (BOD) measures the oxygen needed by aerobic microorganisms to decompose biodegradable organic matter; a greater organic load creates a greater oxygen demand.

Step 1: Explain the sharp fall after sewage enters Sewage adds abundant biodegradable organic material to the river. Aerobic decomposer microorganisms multiply and oxidise this material, consuming dissolved oxygen during respiration. The increased BOD causes oxygen concentration to fall rapidly just downstream of the sewage discharge, as shown by the descending curve. At its minimum, oxygen may be insufficient for fish and other oxygen-dependent aquatic animals.

Step 2: Explain recovery farther downstream As the river flows onward, much of the organic matter is decomposed and its concentration decreases. Microbial oxygen demand consequently falls. Oxygen entering the water from the atmosphere, aided by mixing, replenishes dissolved oxygen; photosynthesis can also contribute. The concentration therefore rises gradually farther downstream toward its earlier level, producing the recovery portion of the curve.

Step 3: Conclusion Dissolved oxygen first falls sharply because microbial decomposition of sewage consumes it, and then recovers downstream as the organic load and oxygen demand decrease and oxygen is replenished.

Quick Tip to Solve: Read the curve along the flow arrow: link the dip to microbial oxygen consumption and the rise to reduced demand and reaeration.

18. Explain how a hereditary disease can be corrected. Give an example of first successful attempt made towards correction of such diseases. [2 marks]

Solution:

Concept:

- Gene therapy introduces a functional normal gene into a patient's cells to compensate for a defective gene responsible for a hereditary disorder.
- Adenosine deaminase (ADA) is needed for normal immune function; its deficiency can cause severe combined immunodeficiency.

Step 1: Explain correction by gene therapy A normal, functional copy of the defective gene is delivered into suitable cells of the patient. Its expression supplies the missing or functional gene product and compensates for the inherited defect. The defective gene need not be physically removed for this functional correction to occur.

Step 2: Describe the first successful attempt The first clinical gene-therapy attempt was made in 1990 in a four-year-old girl with ADA deficiency. Her lymphocytes were removed from blood and grown in culture. A functional ADA cDNA was introduced into these cells using a retroviral vector, and the modified lymphocytes were returned to her. They could then produce ADA and improve immune function. Since these lymphocytes are not immortal, this treatment required periodic infusion of genetically modified cells rather than providing a permanent correction in all her cells.

Step 3: Conclusion A hereditary disease can be treated by gene therapy supplying a functional gene. The pioneering example was treatment of ADA deficiency in a four-year-old girl in 1990 using genetically modified lymphocytes.

Quick Tip to Solve: Remember the ADA sequence: isolate lymphocytes, culture them, introduce normal ADA cDNA, and return the corrected cells to the patient.

Section C (27 marks)

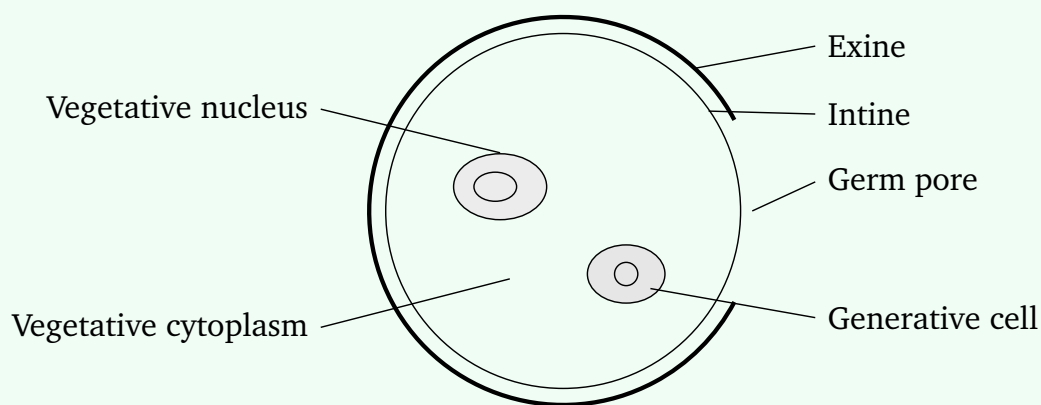
19. Draw a diagram of a male gametophyte of an angiosperm. Label any four parts. Why is sporopollenin considered the most resistant organic material? [3 marks]

Solution:

Concept:

- The pollen grain represents the male gametophyte of an angiosperm. In its commonly shed two-celled stage it contains a large vegetative cell and a smaller generative cell.
- The pollen wall has a tough outer exine, made of sporopollenin, and an inner intine. Germ pores are regions where sporopollenin is absent.

Step 1: Draw and label the male gametophyte The diagram shows a two-celled pollen grain. The outer exine, inner intine, germ pore, vegetative nucleus and generative cell are labelled. The large vegetative cell has abundant cytoplasm and an irregular nucleus; the smaller generative cell lies in its cytoplasm and later divides to form two male gametes.



Two-celled angiosperm pollen grain

Step 2: Explain the exceptional resistance of sporopollenin Sporopollenin withstands high temperatures and the action of strong acids and alkalis. No enzyme that degrades it is known. Its chemical stability protects the pollen contents against harsh environmental conditions and helps pollen grains remain preserved as fossils for very long periods. This combination of physical and chemical resistance explains its description as the most resistant organic material.

Step 3: Conclusion A pollen grain is the male gametophyte, with exine, intine, a vegetative cell and a generative cell. Sporopollenin in the exine is exceptionally resistant to heat, strong acids, alkalis and enzymatic degradation.

Quick Tip to Solve: Label the two wall layers and the two cellular components, and show a gap in exine for the germ pore.

20. How are dominance, codominance and incomplete dominance patterns of inheritance different from each other? [3 marks]

Solution:

Concept:

- Dominance describes the relationship between two alleles of a gene in a heterozygote. The key comparison is whether one allele, both alleles, or an intermediate phenotype is expressed.
- Alleles retain their identities during inheritance in all three patterns. An intermediate phenotype does not mean that the alleles permanently blend.

Step 1: Complete dominance In complete dominance, the heterozygote has the same phenotype as the homozygous dominant individual; the recessive allele is masked. For example, in pea plants, tall TT and tall Tt have the same tall phenotype, whereas tt is dwarf. A cross between two heterozygotes gives a phenotypic ratio of 3 : 1, although the genotypic ratio is 1 : 2 : 1.

Step 2: Codominance In codominance, both alleles express their effects fully in the heterozygote. For example, in the human ABO blood group system, $I^A I^B$ produces both A and B antigens on red blood cells, giving blood group AB. The heterozygote therefore shows both parental features distinctly,

rather than an intermediate antigen.

Step 3: Incomplete dominance In incomplete dominance, neither allele is completely dominant, and the heterozygote has a phenotype intermediate between the two homozygotes. For example, crossing red-flowered RR and white-flowered rr snapdragons produces pink-flowered Rr offspring. Selfing the pink plants gives red, pink and white flowers in the phenotypic ratio 1 : 2 : 1, matching the genotypic ratio.

Step 4: Conclusion Complete dominance gives the heterozygote the dominant parental phenotype; codominance gives simultaneous expression of both alleles; incomplete dominance gives an intermediate heterozygous phenotype.

Quick Tip to Solve: Compare the heterozygote first: tall, AB and pink illustrate dominance, codominance and incomplete dominance respectively.

21. The base sequence in one of the strands of DNA is TAGCATGAT.

(i) Give the base sequence of its complementary strand.

(ii) How are these base pairs held together in a DNA molecule?

(iii) Explain the base complementarity rules. Name the scientist who framed this rule.

[3 marks]

Solution:

Concept:

- In double-stranded DNA, adenine (A) pairs with thymine (T), and guanine (G) pairs with cytosine (C). Complementary strands run antiparallel to one another.
- Hydrogen bonds join complementary bases across the two strands: two bonds in an A–T pair and three bonds in a G–C pair.

Step 1: (i) Write the complementary sequence Replace each base by its specific partner without changing the order of the positions: T by A, A by T, G by C and C by G. The paired sequences are

Given strand: TAGCATGAT

Complement: ATCGTACTA.

Thus the complementary sequence is ATCGTACTA when read opposite the strand as written. If the given strand is written from 5' to 3', this complementary line runs from 3' to 5'.

Step 2: (ii) State what holds the base pairs together The bases of the two DNA strands are held together by hydrogen bonds. Adenine forms two hydrogen bonds with thymine, whereas guanine forms three hydrogen bonds with cytosine. These interstrand bonds differ from the phosphodiester bonds that join successive nucleotides within each strand.

Step 3: (iii) Explain complementarity and name the scientist A purine always pairs with a pyrimidine: A pairs specifically with T, and G specifically with C. Hence, in double-stranded DNA, $A = T$ and $G = C$, so $A + G = T + C$. These relationships are known as Chargaff's rules and were formulated by Erwin Chargaff. They explain why the sequence of one DNA strand determines the sequence of the other; they do not require the amount of A to equal the amount of G.

Step 4: Conclusion (i) ATCGTACTA is complementary to TAGCATGAT. (ii) A–T and G–C pairs have two and three hydrogen bonds respectively. (iii) Erwin Chargaff's rules give $A = T$ and $G = C$ in double-stranded DNA.

Quick Tip to Solve: Write each complementary base directly beneath its partner, and remember that the second strand runs antiparallel.

22. (a) Sickle celled anaemia in humans is a result of point mutation. Explain.

(b) Write the genotypes of both the parents who have produced a sickle celled anaemic offspring.

[3 marks]

Solution:

Concept:

- A point mutation is a change at a single nucleotide position in a gene; a base substitution can alter a codon and hence one amino acid in a protein.
- Sickle-cell anaemia is an autosomal recessive disorder. Let Hb^A denote the normal allele and Hb^S the sickle-cell allele.

Step 1: (a) Identify the molecular change In the gene encoding the beta chain of haemoglobin, a single base-pair substitution changes the coding-DNA triplet from GAG to GTG. Consequently, the corresponding mRNA codon changes from GAG to GUG. Glutamic acid is therefore replaced by valine at the sixth amino-acid position of the beta-globin chain. Since a change at just one nucleotide position causes this amino-acid substitution, the disorder is an example of point mutation.

Step 2: Explain the consequence for red blood cells The altered haemoglobin, HbS, tends to polymerise under low oxygen tension. This distorts normally biconcave red blood cells into sickle-shaped cells. Such cells are fragile and are destroyed more rapidly, producing anaemia; their abnormal shape can also obstruct small blood vessels.

Step 3: (b) Give the parental genotypes The expected carrier-parent cross is $Hb^A Hb^S \times Hb^A Hb^S$. Each parent can contribute an Hb^S allele, giving an affected child with genotype $Hb^S Hb^S$. This cross produces normal homozygotes, carriers and affected homozygotes in the ratio 1 : 2 : 1, so the probability of an affected child in each pregnancy is $1/4$. Strictly, an affected child establishes that both parents carry Hb^S ; if a parent is themselves affected, $Hb^A Hb^S \times Hb^S Hb^S$ or $Hb^S Hb^S \times Hb^S Hb^S$ can also produce an affected child.

Step 4: Conclusion A single base substitution causes the sixth beta-globin residue to change from glutamic acid to valine. The standard parental genotypes are $Hb^A Hb^S$ and $Hb^A Hb^S$, yielding an affected $Hb^S Hb^S$ offspring.

Quick Tip to Solve: Keep DNA GTG distinct from mRNA GUG, and show that each parent supplies one sickle-cell allele.

23. What is inbreeding depression and how is it caused in organisms? Write any two advantages of inbreeding. [3 marks]

Solution:

Concept:

- Inbreeding is mating between closely related individuals within the same breed, usually continued for several generations.
- Inbreeding increases homozygosity: identical alleles are increasingly brought together, exposing both desirable and harmful recessive traits.

Step 1: Define inbreeding depression Inbreeding depression is the reduction in fertility and productivity, and often in vigour or survival, caused by continued close inbreeding. Thus, prolonged mating among close relatives can reduce the performance of the resulting stock rather than improve it.

Step 2: Explain how it arises Closely related individuals are more likely to carry the same alleles inherited from common ancestors. Repeated mating among them increases homozygosity and reduces heterozygosity in their offspring. Harmful recessive alleles that were masked in heterozygotes can consequently occur in the homozygous state and be expressed. Their expression impairs fitness, fertility and productivity, producing inbreeding depression.

Step 3: State two advantages of controlled inbreeding First, increased homozygosity helps establish pure lines and fix desirable characteristics, allowing useful traits of superior animals to be maintained consistently in a breed. Second, inbreeding exposes harmful recessive alleles in homozygotes. Breeders can identify individuals expressing these defects and eliminate them from the breeding programme. Thus, with careful selection, inbreeding helps purify the stock by removing deleterious recessive alleles.

Step 4: Conclusion Inbreeding depression is reduced fertility and productivity due to increased homozygosity and expression of harmful recessives. Two benefits of controlled inbreeding are establishing pure lines with fixed desirable traits and exposing deleterious recessives for elimination by selection.

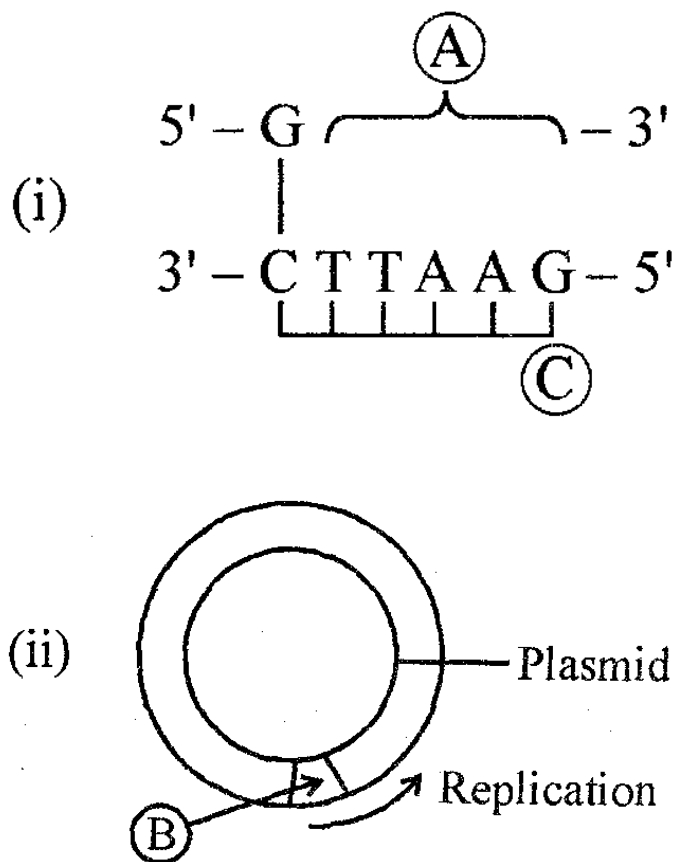
Quick Tip to Solve: Link both the disadvantage and the benefits to increased homozygosity, then explain the role of selection.

24. (a) Identify (A) and (B) illustrations in the following:

(b) Write the term given to (A) and (C) and why?

(c) Expand PCR. Mention its importance in biotechnology.

[3 marks]

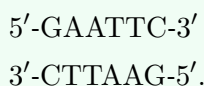


Solution:

Concept:

- Complementary DNA bases pair specifically: adenine with thymine and guanine with cytosine. The strands are antiparallel, so their directions must be tracked when reading a sequence.
- The origin of replication, ori, is the DNA sequence from which replication starts; a plasmid vector must contain an origin so that it can replicate in a host.
- PCR amplifies a selected DNA segment using primers, a thermostable DNA polymerase and repeated cycles of strand separation and DNA synthesis.

Step 1: (a) Identify A and B A is the missing sequence AATTC in the upper strand. By base complementarity, the complete duplex is



B is the origin of replication, ori, of the plasmid. It is the DNA sequence at which plasmid replication starts. DNA inserted into a suitable plasmid is copied along with the plasmid from this origin in a host

cell.

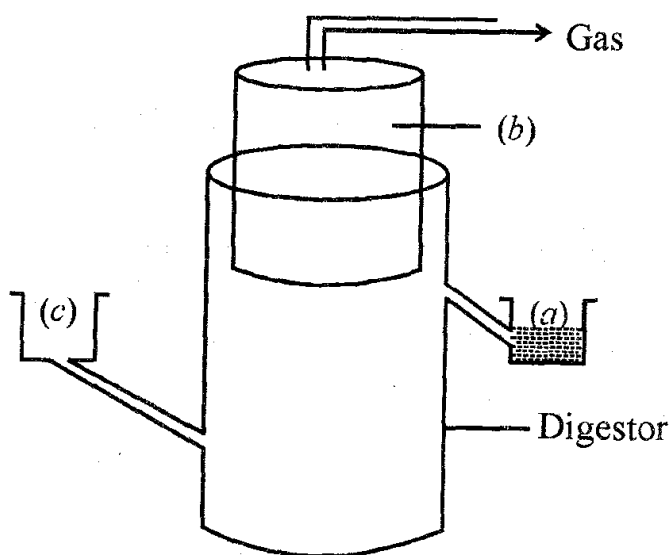
Step 2: (b) Name the sequence pattern and explain it The complete upper sequence containing A and the lower sequence indicated by C form a palindromic nucleotide sequence. A DNA palindrome reads the same on the two complementary strands when both are read in the same direction, namely from 5' to 3'. The upper strand reads GAATTC from left to right; the lower strand also reads GAATTC when read from right to left, its 5'-to-3' direction. It does not mean that one strand reads identically in both directions. This particular palindrome is the recognition sequence of the restriction endonuclease EcoRI.

Step 3: (c) Expand PCR and give its importance PCR stands for Polymerase Chain Reaction. It produces many copies of a specific DNA segment in vitro, starting from a very small amount of DNA. Repeated cycles of denaturation, primer annealing and extension by a thermostable DNA polymerase amplify the sequence bounded by the primers. PCR therefore supplies sufficient copies of a desired gene or DNA fragment for cloning and subsequent analysis, and is also useful in detecting specific pathogen or genetic sequences.

Step 4: Conclusion A is AATTC and B is the origin of replication. The completed duplex is a DNA palindrome because both strands read GAATTC in the 5'-to-3' direction. PCR means Polymerase Chain Reaction and amplifies a selected DNA segment.

Quick Tip to Solve: Fill A by complementary base pairing, then read the bottom strand right to left to recognise the palindrome.

25. The diagram above is that of a typical biogas plant. Explain the sequence of events occurring in a biogas plant. Identify a, b and c. [3 marks]



Solution:

Concept:

- Biogas is produced by anaerobic microbial digestion of organic matter such as cattle dung; methanogens, including Methanobacterium, generate methane.
- The floating gas holder collects the gas, while the digested slurry is removed and used as manure.

Step 1: Prepare and feed the slurry Cattle dung is mixed with water to form a slurry. This is fed through the inlet tank and inlet pipe into the underground digester. The closed digester provides an oxygen-free environment for anaerobic decomposition of the dung and other organic material.

Step 2: Digest the organic matter and collect gas Anaerobic microbes break down complex organic substances into simpler compounds. Methanogenic bacteria act on the products of this decomposition and produce biogas, chiefly methane, with carbon dioxide and hydrogen. The gas accumulates under the floating metal gas holder. As gas accumulates, the holder rises; gas is drawn through the outlet pipe for cooking or lighting.

Step 3: Remove spent slurry and identify the labels Addition of fresh slurry displaces digested slurry through the outlet into the collecting tank. This spent slurry is rich in nutrients and is used as manure. In the printed diagram, (a) is the outlet tank containing spent slurry, (b) is the floating gas holder or gas-collecting metal cover, and (c) is the inlet or mixing tank for dung slurry.

Step 4: Conclusion Dung slurry undergoes anaerobic digestion and methane production; biogas is collected for fuel and spent slurry is used as manure. Labels: (a) spent-slurry outlet tank, (b) floating gas holder, and (c) dung-slurry inlet tank.

Quick Tip to Solve: Trace the lower inlet pipe into the digester, then locate the raised gas holder and the opposite overflow outlet.

26. How can crop varieties be made disease resistant to overcome food crisis in India? Explain. Name one disease resistant variety in India of:

(a) Wheat to leaf and stripe rust

(b) Brassica to white rust

[3 marks]

Solution:

Concept:

- Disease resistance is the inherited ability of a plant to prevent or restrict infection and disease development by a pathogen.
- Breeding combines resistance genes from a suitable parent with desirable yield and quality traits; selection and testing identify a stable resistant variety.

Step 1: Select parents and make crosses Screen available germplasm for resistance to the disease concerned and select a resistant parent. Cross this plant with a cultivated variety that has high yield and other desirable agricultural characters. Hybridisation brings the resistance genes and useful crop characters together in the progeny.

Step 2: Select and test resistant progeny Grow the progeny, expose or screen them for the pathogen,

and select plants that combine disease resistance with high yield and quality. Continue selection and self-pollination over successive generations to obtain stable lines. Test the selected lines for resistance, yield and adaptation before their release for cultivation. When useful natural resistance is unavailable, mutation breeding can generate variation from which resistant mutants are selected. Resistant crops reduce disease losses and help increase the available food supply.

Step 3: Give the named Indian varieties (a) Himgiri is a wheat variety resistant to leaf and stripe rust. (b) Pusa Swarnim, also called Karan Rai, is a Brassica variety resistant to white rust. These examples illustrate the use of specific inherited resistance against particular diseases.

Step 4: Conclusion Disease-resistant crops are developed by selecting resistant parents, hybridising, selecting resistant progeny and testing stable lines. The required examples are Himgiri wheat and Pusa Swarnim (Karan Rai) Brassica.

Quick Tip to Solve: Remember the matching pairs: Himgiri with wheat rusts, and Pusa Swarnim with white rust of Brassica.

OR

26. Write the source and the effect on the human body of the following drugs:

(i) Morphine

(ii) Cocaine

(iii) Marijuana

[3 marks]

Solution:

Concept:

- Plant-derived drugs act on specific receptors or signalling pathways in the nervous system and alter normal physiological functions.
- Opioids depress central nervous system activity, cocaine stimulates it, and cannabinoids characteristically affect the cardiovascular system as well as perception.

Step 1: Morphine: source and effect Morphine is an opioid alkaloid obtained from the latex of the poppy plant, *Papaver somniferum*. It binds to opioid receptors in the central nervous system. It acts as a powerful analgesic and sedative, relieving severe pain and depressing body functions. Thus, its characteristic action is central nervous system depression, rather than stimulation.

Step 2: Cocaine: source and effect Cocaine is obtained from the coca plant, *Erythroxylum coca*, native to South America. It interferes with the transport of the neurotransmitter dopamine, thereby enhancing its action. Cocaine is a potent central nervous system stimulant: it produces a sense of euphoria and increased energy. Excessive dosage can produce hallucinations and serious disturbances in normal nervous and cardiovascular functioning.

Step 3: Marijuana: source and effect Marijuana is prepared from the leaves, flowers and flowering tops of *Cannabis sativa*. Its active cannabinoids interact with cannabinoid receptors, found principally in the brain. It alters mood, perception and coordination and has characteristic effects on the cardiovascular system, including an increase in heart rate. Marijuana therefore belongs to the

cannabinoid group of drugs.

Step 4: Conclusion Morphine comes from *Papaver somniferum* and is an analgesic and depressant; cocaine comes from *Erythroxylum coca* and is a stimulant; marijuana comes from *Cannabis sativa* and affects perception and cardiovascular function.

Quick Tip to Solve: Pair each plant with its characteristic effect: poppy with depression, coca with stimulation, and cannabis with cardiovascular effects.

27. Name the type of interaction seen in each of the following examples:

- (i) *Ascaris* worms living in the intestine of human
- (ii) Wasp pollinating fig inflorescence
- (iii) Clown fish living among the tentacles of sea-anemone
- (iv) Mycorrhizae living on the roots of higher plants
- (v) Orchid growing on a branch of a mango tree
- (vi) Disappearance of smaller barnacles when *Balanus* dominated in the Coast of Scotland. [3 marks]

Solution:

Concept:

- Population interactions are identified by their effect on the two species: benefit (+), harm (–), or no significant effect (0).
- Mutualism benefits both partners; commensalism benefits one while the other is unaffected. A parasite benefits at the host's expense, whereas competition reduces access to a shared limiting resource.

Step 1: (i) *Ascaris* and (ii) fig wasp (i) **Parasitism** (+, –): *Ascaris* obtains food and shelter in the human intestine, while the human host is harmed through loss of nutrients and illness.

(ii) **Mutualism** (+, +): the wasp pollinates the fig inflorescence, enabling seed formation. The fig provides the wasp a site for egg laying and nourishment for its developing young.

Step 2: (iii) Clown fish and (iv) mycorrhiza (iii) **Commensalism** (+, 0): the clown fish obtains protection from predators among the sea-anemone's stinging tentacles; the anemone is not significantly benefited or harmed in this textbook example.

(iv) **Mutualism** (+, +): the fungus improves the plant's uptake of water and mineral nutrients, especially phosphorus, while receiving carbohydrates from the plant.

Step 3: (v) Orchid and (vi) barnacles (v) **Commensalism** (+, 0): the epiphytic orchid receives physical support and better exposure to light on the mango branch. It does not draw food from the mango tree, which remains unaffected.

(vi) **Interspecific competition**: *Balanus* excludes the smaller barnacles from the occupied habitat by competing for limited space. Their disappearance is competitive exclusion, not evidence of predation or parasitism.

Step 4: Conclusion (i) Parasitism; (ii) mutualism; (iii) commensalism; (iv) mutualism; (v) commensalism; (vi) interspecific competition (competitive exclusion).

Quick Tip to Solve: Ask whether each partner gains, loses or stays unaffected; physical support alone does not make an orchid a parasite.

Section D (15 marks)

28. (a) Draw a labelled diagram of the human female reproductive system.

(b) Enumerate the events in the ovary of a human female during:

(i) Follicular phase

(ii) Luteal phase of menstrual cycle

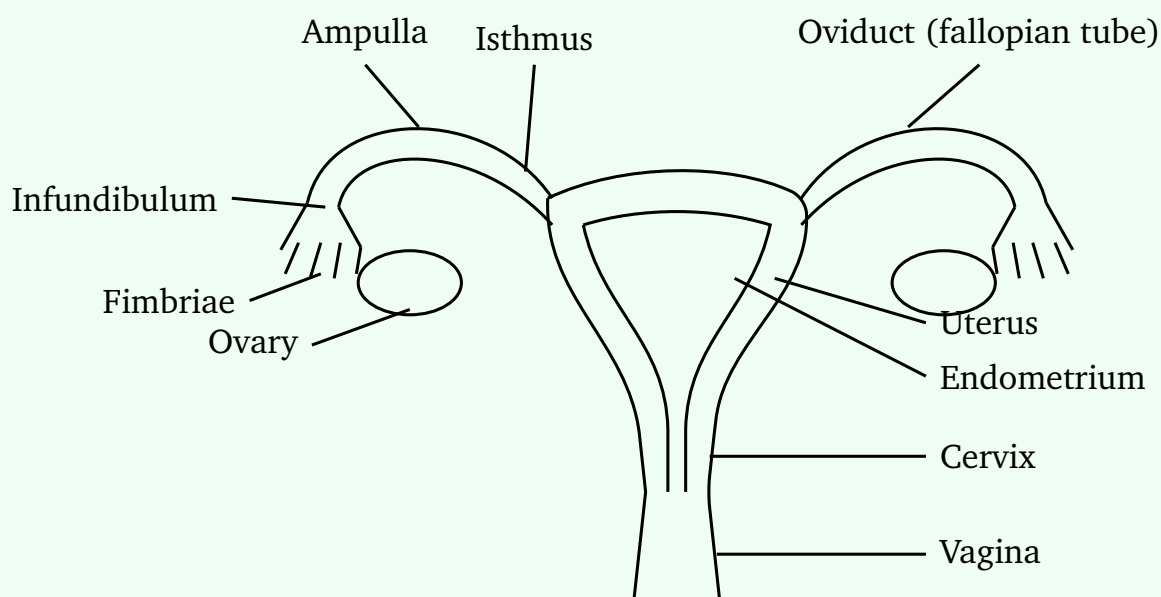
[5 marks]

Solution:

Concept:

- The female reproductive tract comprises paired ovaries and oviducts, the uterus, cervix and vagina. Ovaries produce oocytes and ovarian hormones.
- FSH stimulates follicular growth; the LH surge causes ovulation. After ovulation, LH supports the corpus luteum, which secretes mainly progesterone.

Step 1: (a) Female reproductive system The labelled schematic shows the two ovaries beside the funnel-shaped infundibula of the oviducts. Fimbriae help collect the released oocyte. Each oviduct comprises the infundibulum, ampulla and isthmus and opens into the uterus. The uterus narrows into the cervix, whose canal opens into the vagina. The uterine wall has an inner endometrium and a muscular myometrium.



Human female reproductive system (schematic anterior view)

Step 2: (b)(i) Follicular phase: follicle maturation and ovulation Under the influence of pituitary FSH, ovarian follicles grow and mature. A developing primary follicle acquires more granulosa-cell layers and a theca, becoming a secondary follicle; a fluid-filled antrum then appears in the tertiary follicle. The selected follicle develops into a mature Graafian follicle.

The growing follicles secrete increasing amounts of oestrogen. In the mature follicle, the primary oocyte completes meiosis I to form a large secondary oocyte and a small first polar body. The secondary oocyte begins meiosis II and arrests at metaphase II.

A high oestrogen level produces positive feedback that triggers the mid-cycle LH surge. Around day 14 of a typical 28-day cycle, the Graafian follicle ruptures and releases the secondary oocyte: this is ovulation and marks the transition to the luteal phase.

Step 3: (b)(ii) Luteal phase: formation and fate of the corpus luteum Following ovulation, the remaining cells of the ruptured Graafian follicle transform into the yellow corpus luteum under LH stimulation. The corpus luteum secretes large amounts of progesterone and some oestrogen. Progesterone maintains the thick, glandular uterine endometrium for possible implantation.

If fertilisation and implantation do not occur, the corpus luteum degenerates into the corpus albicans. Progesterone and oestrogen levels fall, leading to breakdown of the endometrium and the start of menstruation. If pregnancy occurs, hCG from the developing trophoblast maintains the corpus luteum in early pregnancy and sustains its hormonal secretion.

Step 4: Conclusion Follicular growth and oestrogen secretion precede ovulation; corpus-luteum formation and progesterone secretion characterise the luteal phase. The labelled reproductive-system diagram accompanies part (a).

Quick Tip to Solve: Link the ovarian sequence as follicle, ovulation, corpus luteum; associate oestrogen with growing follicles and progesterone with the corpus luteum.

OR

28. (a) Write the specific location and the functions of the following cells in human males:

(i) Leydig cells

(ii) Sertoli cells

(iii) Primary spermatocyte

(b) Explain the role of any two accessory glands in human male reproductive system.

[5 marks]

Solution:

Concept:

- The testes contain seminiferous tubules, where spermatogenesis occurs, and interstitial tissue between the tubules. The position of a cell determines whether it produces hormones, supports developing germ cells or takes part in sperm formation.
- Male accessory glands add secretions to spermatozoa to form semen. These secretions provide a suitable fluid medium and support sperm nutrition, transport and survival.

Step 1: (a)(i) Leydig cells: location and function Leydig cells, also called interstitial cells, lie in the interstitial spaces between the seminiferous tubules of the testes, outside the tubules. They synthesize and secrete testicular androgens, chiefly testosterone, under the influence of luteinising hormone (LH). These hormones support spermatogenesis and the development and maintenance of male secondary sexual characteristics and accessory reproductive organs.

Step 2: (a)(ii) Sertoli cells: location and function Sertoli cells occur in the germinal epithelium of the seminiferous tubules, among the developing male germ cells. They support and nourish the developing sperm cells throughout spermatogenesis. Under the influence of follicle-stimulating

hormone (FSH), they secrete factors that assist sperm development and spermiogenesis; they also secrete inhibin, which helps regulate FSH secretion.

Step 3: (a)(iii) Primary spermatocyte: location and function Primary spermatocytes are present in the germinal epithelium of the seminiferous tubules of the testes. They arise from spermatogonia and are diploid, with 46 chromosomes in humans. Each primary spermatocyte undergoes the first meiotic division, a reduction division, to form two haploid secondary spermatocytes, each with 23 chromosomes. These subsequently undergo meiosis II to form spermatids. Thus, the primary spermatocyte initiates the meiotic stages that reduce chromosome number for sexual reproduction.

Step 4: (b) Seminal vesicles The paired seminal vesicles add a fructose-rich secretion to semen. Fructose provides an energy source for sperm movement and metabolism. Their secretion also supplies much of the fluid volume of semen, providing the medium in which spermatozoa are transported through the reproductive tract.

Step 5: (b) Bulbourethral glands The paired bulbourethral glands release a mucus-like secretion into the urethra before ejaculation. This secretion lubricates the urethra and the penis, facilitating the passage of semen during ejaculation. Their secretion is an accessory contribution to semen; these glands do not produce spermatozoa.

Step 6: Conclusion Leydig cells between the testicular tubules produce androgens; Sertoli cells within the tubules nourish developing germ cells; primary spermatocytes within the tubules undergo meiosis I. Two accessory glands are the seminal vesicles, whose fructose-rich fluid nourishes sperm, and the bulbourethral glands, whose mucus lubricates the passage.

Quick Tip to Solve: Link each cell to its location first: between tubules means Leydig, while support cells and meiotic germ cells occur within tubules. For glands, name the secretion and then state what it does.

29. Explain the salient features of Hugo de Vries theory of mutation. How is Darwin's theory of natural selection different from it? Explain. [5 marks]

Solution:

Concept:

- A mutation is a sudden, heritable change. Hugo de Vries proposed that mutations could produce new forms and account for the origin of species.
- Darwin's natural selection acts on inherited variation: individuals with favourable variations leave more offspring, so those variations become more common over generations.

Step 1: State the basis of de Vries' mutation theory Hugo de Vries studied the evening primrose, *Oenothera lamarckiana*, and observed the sudden appearance of distinct variants. He regarded such heritable changes, called mutations, as the principal cause of evolution. In his explanation, a new form need not arise through a long series of intermediate forms.

Step 2: Explain its salient features Mutations arise suddenly and discontinuously, rather than as minute, continuous changes. They are inherited, allowing the new character to appear in descendants. They are random and directionless: they do not arise because an organism needs a particular adaptation. De Vries emphasised relatively large changes and suggested that a single major mutational

step could give rise to a new species. This origin of a new form by a large evolutionary jump is called saltation. Thus, his theory allowed speciation to occur abruptly instead of requiring the slow accumulation of small differences.

Step 3: Contrast the variations emphasised by Darwin and de Vries Darwin emphasised small inherited variations among individuals. In the struggle for existence, some of these variations improve survival and reproductive success. De Vries instead emphasised sudden, conspicuous, discontinuous mutations as the source of new species. In the textbook contrast, mutations are random and directionless, whereas Darwinian variations accumulate in a direction favoured by selection. This does not mean that organisms deliberately produce the variations they require; natural selection determines which existing variations become common.

Step 4: Contrast the mechanism and pace of evolutionary change In Darwin's theory, organisms produce more offspring than available resources can support. Individuals possessing favourable inherited variations tend to survive and reproduce more successfully. Repeated natural selection accumulates these differences over many generations, gradually producing divergence and new species. De Vries attributed the decisive step in species formation to a sudden mutation, so the new species could arise by saltation. The central difference is therefore gradual change through selection of small inherited variations in Darwin's account, compared with abrupt species formation through major mutations in de Vries' account.

Step 5: Conclusion De Vries proposed sudden, heritable, random and directionless mutations, with speciation possible by saltation. Darwin explained evolution primarily as the gradual accumulation of favourable inherited variations through natural selection over successive generations.

Quick Tip to Solve: Compare both theories under the same headings: nature of variation, mechanism of change and speed of speciation. Link saltation specifically to de Vries.

OR

29. (a) Name the primates that lived about 15 million years ago. List their characteristic features.

(b) (i) Where was the first man-like animal found?

(ii) Write the order in which Neanderthals, Homo habilis and Homo erectus appeared on earth. State the brain capacity of each one of them.

(iii) When did modern Homo sapiens appear on this planet?

[5 marks]

Solution:

Concept:

- Fossil evidence traces human evolution through changes in posture, dentition, tool use and cranial capacity. Cranial capacity is the internal volume of the skull, expressed in cm^3 or cc.
- Early ape-like primates preceded the human lineage. Dates in this evolutionary sequence are approximate; the standard textbook sequence distinguishes early primates, early human forms and modern humans.

Step 1: (a) Identify the primates of about 15 million years ago *Dryopithecus* and *Ramapithecus* lived

about 15 million years ago. Both had hairy bodies and walked in a manner similar to gorillas and chimpanzees. *Dryopithecus* was more ape-like, whereas *Ramapithecus* was more man-like. Thus, although they shared several primate features, they differed in their resemblance to later apes and humans.

Step 2: (b)(i) State the place where early man-like animals were found Fossils of early man-like animals were found in East Africa, particularly Ethiopia and Tanzania. The fossils suggest that man-like primates lived there about 3 to 4 million years ago. They probably walked upright and were no more than about four feet tall. Africa is therefore the geographical location required here.

Step 3: (b)(ii) Arrange the human forms and state their brain capacities The order of appearance, from earlier to later, is

Homo habilis → *Homo erectus* → Neanderthals.

Homo habilis, the early human-like hominid, had a brain capacity of about 650–800 cm³. *Homo erectus*, represented by fossils from about 1.5 million years ago, had a brain capacity of about 900 cm³. Neanderthals had a brain capacity of about 1400 cm³ and lived about 100,000 to 40,000 years ago. The sequence requested is chronological, not the order in which the names occur in the question.

Step 4: (b)(iii) Date the appearance of modern humans Modern *Homo sapiens* arose during the ice age, between about 75,000 and 10,000 years ago, according to the textbook human-evolution timeline. This date range describes the appearance of modern humans in the sequence asked here.

Step 5: Conclusion The early primates were *Dryopithecus* and *Ramapithecus*; early man-like fossils were found in Ethiopia and Tanzania. The sequence is *H. habilis* (650–800 cc), *H. erectus* (900 cc), then Neanderthals (1400 cc). Modern *H. sapiens* appeared about 75,000 to 10,000 years ago.

Quick Tip to Solve: Recall the sequence habilis–erectus–Neanderthal together with 650–800, 900 and 1400 cc; do not copy the question's name order.

30. (a) Explain primary productivity and the factors that influence it.

(b) Describe how do oxygen and chemical composition of detritus control decomposition. [5 marks]

Solution:

Concept:

- Primary productivity is the rate at which producers form biomass or organic matter by photosynthesis per unit area per unit time. It may be expressed as g m⁻² yr⁻¹ or kcal m⁻² yr⁻¹.
- Gross primary productivity (GPP) is the total rate of organic matter production. Net primary productivity (NPP) is what remains after producers use some of it in respiration: $NPP = GPP - R$, where R is the respiratory loss of producers.
- Decomposition is the breakdown of dead organic matter into simpler substances. Decomposer activity depends on oxygen availability and the chemical nature of the detritus.

Step 1: (a) Explain primary productivity Green plants capture solar energy and convert inorganic substances into organic matter through photosynthesis. The amount produced per unit area in a given

time gives primary productivity; therefore it is a rate, rather than merely the standing amount of vegetation. GPP includes all the organic matter synthesised. Since plants consume part of this material during respiration, NPP is smaller than GPP. NPP represents the biomass available to consumers, including herbivores and decomposers, in the ecosystem.

Step 2: (a) State the factors controlling primary productivity Primary productivity depends on the plant species inhabiting an area and their photosynthetic capacity. It also depends on environmental conditions: the availability and intensity of sunlight, suitable temperature, and adequate water influence photosynthesis and plant growth. The availability of essential mineral nutrients, such as nitrogen and phosphorus, is another major control. Carbon dioxide supplies the carbon used in photosynthesis. These factors act together: abundant light alone cannot maintain high productivity if water or a required nutrient is limiting. Thus productivity varies between ecosystems as their vegetation and growing conditions differ.

Step 3: (b) Explain the role of oxygen Decomposition is largely an oxygen-requiring process. In well-aerated conditions, aerobic decomposers can respire actively and break down organic matter rapidly. When oxygen is deficient, as in waterlogged soil, aerobic microbial activity is inhibited and decomposition is slower. Anaerobic breakdown may still occur, but organic residues tend to accumulate because their complete breakdown is restricted.

Step 4: (b) Explain the role of detritus composition Detritus rich in resistant compounds, especially lignin and chitin, decomposes slowly because these complex materials resist microbial enzymatic attack. In contrast, detritus rich in nitrogen and readily usable, water-soluble substances such as sugars decomposes faster. Such materials supply accessible substrates and nutrients for microbial growth. Therefore, under otherwise similar conditions, soft, nutrient-rich residues disappear sooner than lignin-rich woody material.

Step 5: Conclusion Primary productivity measures the rate of biomass formation by producers and is controlled by vegetation, photosynthetic capacity, environmental conditions and nutrients. Decomposition is promoted by adequate oxygen and nitrogen-rich, soluble detritus, whereas oxygen deficiency and lignin- or chitin-rich detritus slow it down.

Quick Tip to Solve: Separate productivity into production and respiratory loss; for decomposition, contrast oxygen-rich with oxygen-poor conditions and soluble nutrients with resistant lignin or chitin.

OR

30. (a) What is El Nino effect? Explain how it accounts for biodiversity loss.

(b) Explain any three measures that you as an individual would take, to reduce environmental pollution. [5 marks]

Solution:

Concept:

- El Nino is an abnormal warming of surface waters in the central and eastern equatorial Pacific Ocean, associated with altered ocean circulation and atmospheric weather patterns.

- Biodiversity depends on suitable temperature, rainfall, habitats and food supplies; climatic disturbances can reduce populations and eliminate sensitive species.
- Individual pollution control rests on reducing waste and emissions at their source, reusing materials and disposing of different wastes responsibly.

Step 1: (a) Explain the El Nino effect Under normal conditions, winds drive warm surface water towards the western tropical Pacific, and cold, nutrient-rich water rises near the South American coast. During El Nino, weakened trade winds allow unusually warm surface water to spread into the central and eastern equatorial Pacific. This warming alters atmospheric circulation, so rainfall and temperature patterns are disturbed over large regions. Some regions experience drought, whereas others receive excessive rainfall and floods.

Step 2: (a) Relate the disturbance to biodiversity loss Warm surface water suppresses the normal upwelling of nutrient-rich water. The reduced nutrient supply lowers phytoplankton production, leaving less food for fish and for the birds and other animals that depend on them. Marine populations may therefore decline or move away. Abnormally high water temperatures can also cause coral bleaching: stressed corals lose their symbiotic algae, and prolonged stress can kill corals and damage the reef habitat supporting many species. On land, droughts, fires and floods damage habitats and disrupt reproduction and food supplies. Sensitive species that cannot migrate or tolerate these rapid changes may die, causing biodiversity loss.

Step 3: (b) Use cleaner transport and conserve energy I would walk or cycle for short journeys and use public transport or share vehicles for longer journeys. I would also switch off unused lights and appliances. These actions reduce fuel consumption and the release of smoke, particulate matter and harmful gases from vehicles and power generation, thereby reducing air pollution.

Step 4: (b) Reduce, reuse and recycle materials I would avoid unnecessary packaging and single-use plastic bags, carry a reusable cloth bag and water bottle, and reuse suitable containers. I would separate paper, glass, metals and recyclable plastics for recycling. This reduces the quantity of persistent waste dumped into land and water and reduces the resources and energy used to manufacture replacement products.

Step 5: (b) Manage household waste responsibly I would segregate biodegradable kitchen waste and compost it instead of mixing it with other refuse. Batteries and electronic waste would go to authorised collection facilities, and I would never burn mixed garbage or pour oils and harmful chemicals into drains. Such disposal prevents toxic substances and smoke from contaminating air, soil and water; composting also provides useful manure.

Step 6: Conclusion El Nino is abnormal warming of equatorial Pacific surface waters that disturbs climate and marine productivity, threatening habitats and biodiversity. As an individual, I would reduce transport and energy emissions, practise reduction, reuse and recycling, and segregate and safely dispose of household waste to reduce environmental pollution.

Quick Tip to Solve: Link El Nino to both reduced marine nutrient upwelling and disturbed weather; for each personal measure, state the pollution it prevents.