

CBSE Class 12 Biology Question Paper 2014 with Solution PDF-Set 57/1/2

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 Section 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 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. State the cause of Accelerated Eutrophication.

[1 mark]

Solution:

Concept:

- Eutrophication is nutrient enrichment of a water body, increasing the growth of algae and other aquatic plants.
- Accelerated or cultural eutrophication is the speeding up of this process by human activities.

Step 1: Identify the nutrient input Domestic sewage, industrial effluents and agricultural runoff introduce large quantities of nutrients, especially nitrates and phosphates, into lakes and other water bodies.

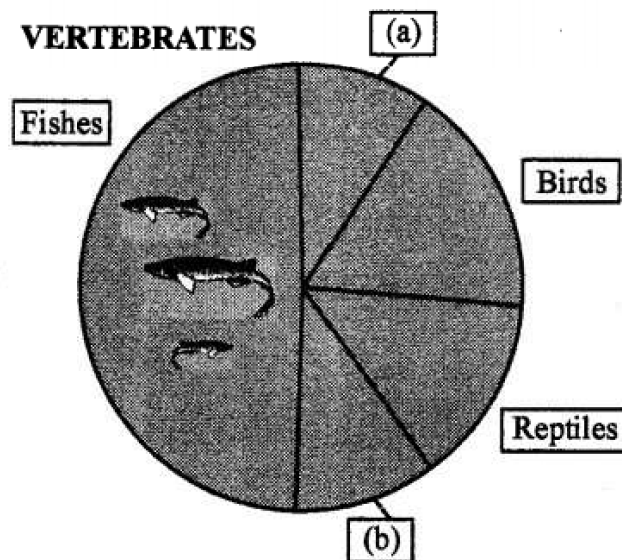
Step 2: Relate pollution to faster enrichment These nutrient inputs promote rapid algal growth and increase organic matter in the water. Thus human-caused nutrient loading speeds up the natural ageing of the water body.

Step 3: Conclusion Accelerated eutrophication is caused by nutrient-rich pollutants, especially nitrates and phosphates, entering water bodies through sewage, industrial effluents and agricultural runoff.

Quick Tip to Solve: For accelerated eutrophication, name human nutrient inputs; oxygen depletion is a consequence, not the initiating cause.

2. Identify 'a' and 'b' in the figure given below representing proportionate number of major vertebrate taxa.

[1 mark]



Solution:**Concept:**

- A pie chart represents the relative numbers of species in different taxonomic groups; each sector corresponds to one group.
- The five major vertebrate groups shown are fishes, mammals, birds, reptiles and amphibians.

Step 1: Read the labelled sectors The large left-hand sector is labelled fishes. The two larger right-hand sectors are already labelled birds and reptiles, so the two unlabelled sectors represent mammals and amphibians.

Step 2: Match the remaining positions In this standard vertebrate diversity chart, the small upper sector between fishes and birds represents mammals. The small lower sector between reptiles and fishes represents amphibians.

Step 3: Conclusion The labels are (a) mammals and (b) amphibians.

Quick Tip to Solve: Read the neighbours of each missing label: mammals lie between fishes and birds, and amphibians between reptiles and fishes.

3. Give an example of an organism that enters 'diapause' and why.

[1 mark]

Solution:**Concept:**

- Diapause is a stage of suspended development that helps an organism survive adverse environmental conditions.
- Some zooplankton species in lakes and ponds enter diapause when conditions become unfavourable.

Step 1: Choose the NCERT example Zooplankton in lakes and ponds provide an example of organisms that enter diapause. The relevant response is a temporary suspension of development.

Step 2: Explain its survival value During unfavourable conditions, normal growth and development may be difficult to sustain. Diapause enables the organism to tide over that adverse period and resume development when favourable conditions return.

Step 3: Conclusion Zooplankton enter diapause to survive unfavourable conditions by suspending their development.

Quick Tip to Solve: Link zooplankton with diapause and suspended development; distinguish it from winter sleep or summer sleep.

4. Name the two intermediate hosts which the human liver fluke depends on to complete its life cycle so as to facilitate parasitization of its primary host. [1 mark]

Solution:

Concept:

- An intermediate host supports an immature or developmental stage of a parasite during its life cycle.
- The human liver fluke uses two intermediate hosts before it reaches its primary host.

Step 1: Identify the first host The first intermediate host is a snail. The parasite passes through developmental stages in this host as part of its complex life cycle.

Step 2: Identify the second host The second intermediate host is a fish. This additional host facilitates the transmission of the parasite to the human primary host and helps complete its life cycle.

Step 3: Conclusion The two intermediate hosts are a snail and a fish.

Quick Tip to Solve: Remember the NCERT pair for the human liver fluke: snail and fish; humans are the primary host asked about separately.

5. Mention the type of host cells suitable for the gene guns to introduce an alien DNA. [1 mark]

Solution:

Concept:

- The gene gun, or biolistic method, is a direct method of introducing foreign DNA into host cells.
- DNA is coated onto microscopic particles of gold or tungsten, which are accelerated into the cells.

Step 1: Recognise the delivery method In biolistics, high-velocity metal particles carrying the alien DNA are directed at the target cells. This delivers DNA physically and does not require a biological vector.

Step 2: Connect the method to the host Plant cells have a rigid cell wall outside the plasma membrane. Bombardment with DNA-coated particles is particularly suitable for delivering DNA into these cells through their outer barriers.

Step 3: Conclusion Plant cells are suitable host cells for introducing alien DNA by a gene gun.

Quick Tip to Solve: Associate the gene gun with plant cells and DNA-coated gold or tungsten particles; microinjection instead uses a fine needle.

6. Name any two types of cells which act as 'Cellular barriers' to provide Innate Immunity in humans. [1 mark]

Solution:

Concept:

- Innate immunity provides a non-specific defence against invading pathogens from birth.

- Cellular barriers include defensive white blood cells that destroy microbes, such as neutrophils and macrophages.

Step 1: Name a circulating defensive cell Neutrophils are polymorphonuclear leukocytes present in blood. They engulf and destroy invading microbes by phagocytosis, thereby contributing to the cellular barrier.

Step 2: Name a tissue defensive cell Macrophages are phagocytic cells found in tissues. They also engulf and destroy pathogens and foreign material as part of the immediate, non-specific immune defence.

Step 3: Conclusion Two cellular barriers are neutrophils and macrophages.

Quick Tip to Solve: For a cellular barrier give cell names such as neutrophils and macrophages; skin and stomach acid are different barrier types.

7. Mention how does DNA polymorphism arise in a population.

[1 mark]

Solution:

Concept:

- DNA polymorphism means the occurrence of heritable variations in DNA sequence within a population.
- Mutations produce new sequence variants; inherited variants may persist and spread through generations.

Step 1: Identify the origin of variation DNA polymorphism originates through mutations that change the nucleotide sequence. A mutation in the germ line can be transmitted to offspring, whereas a purely somatic change is normally not inherited.

Step 2: Explain persistence in the population If an inherited variant persists and spreads among individuals over generations, alternative DNA sequences occur in the population. Such variations can accumulate particularly in non-coding regions where changes may not adversely affect reproductive ability.

Step 3: Conclusion DNA polymorphism arises from heritable mutations that accumulate and spread in a population over generations.

Quick Tip to Solve: Connect DNA polymorphism to inherited sequence mutations and their spread; acquired somatic changes alone do not explain population inheritance.

8. Write the name of the organism that is referred to as the 'Terror of Bengal'.

[1 mark]

Solution:

Concept:

- Alien species can become invasive when introduced into a habitat and can displace native organisms.

- Water hyacinth is a rapidly multiplying floating aquatic weed that spreads over freshwater surfaces.

Step 1: Identify the common name The expression “Terror of Bengal” refers to water hyacinth. It was introduced for its attractive flowers but became a troublesome invasive aquatic plant.

Step 2: Link the name to its impact Its rapid vegetative multiplication produces dense growth over water bodies. This growth interferes with aquatic life and depletes oxygen, which explains its notoriety.

Step 3: Conclusion The organism is water hyacinth, *Eichhornia crassipes*.

Quick Tip to Solve: Associate “Terror of Bengal” with the floating invasive weed water hyacinth, not a terrestrial weed.

Section B (20 marks)

9. Name the organic materials the exine and intine of an angiosperm pollen grains are made up of. Explain the role of exine. [2 marks]

Solution:

Concept:

- A pollen grain has an outer wall, the exine, and an inner wall, the intine; the two layers have different compositions.
- Sporopollenin is an exceptionally resistant organic material that protects the male gametophyte during dispersal.

Step 1: State the composition of both wall layers The hard outer exine is composed of sporopollenin. The thin, continuous inner intine is composed of cellulose and pectin. Thus, the resistant protective substance belongs to the outer wall, while the inner wall contains the usual cell-wall polysaccharides.

Step 2: Explain the protective role of the exine The exine protects the pollen grain from adverse environmental conditions during its transfer from the anther. Sporopollenin withstands high temperatures and strong acids and alkalis; no enzyme that degrades it is known. This resistant covering helps the male gametophyte survive exposure. At germ pores, sporopollenin is absent, allowing the pollen tube to emerge during germination.

Step 3: Conclusion Exine is made of sporopollenin, whereas intine is made of cellulose and pectin. The resistant exine protects the pollen grain against environmental and chemical damage.

Quick Tip to Solve: Pair exine with resistant sporopollenin and intine with cellulose plus pectin; remember the exine's germ pores.

10. (i) Name the scientist who suggested that the genetic code should be made of a combination of three nucleotides. (ii) Explain the basis on which he arrived at this conclusion. [2 marks]

Solution:

Concept:

- A codon is a sequence of nucleotides specifying an amino acid or a translation signal. There are four different nucleotide bases available for constructing codons.
- If a code word has n positions, and each position can contain any one of four bases, the number of possible code words is 4^n .

Step 1: (i) Identify the scientist George Gamow suggested that the genetic code should consist of combinations of three nucleotides. His suggestion used the number of available bases and the number of amino acids that must be specified.

Step 2: (ii) Apply the combinatorial argument A single-base code would provide only $4^1 = 4$ different combinations. A two-base code would provide $4^2 = 16$ combinations. Neither number is sufficient to specify the 20 amino acids. A three-base code provides $4^3 = 64$ combinations, which is sufficient. Thus, three is the smallest fixed number of nucleotide positions that can provide enough distinct code words; repeated bases are permitted in these combinations.

Step 3: Conclusion George Gamow proposed the triplet code because $4^2 = 16 < 20$, whereas $4^3 = 64$ combinations are enough to code for the 20 amino acids.

Quick Tip to Solve: Compare successive powers of four with 20: the first sufficient value, 64, corresponds to three bases.

11. How does the gene 'I' control ABO blood groups in humans? Write the effect the gene has on the structure of red blood cells. [2 marks]

Solution:

Concept:

- The ABO blood groups are controlled by the gene I , which has three alleles in the population: I^A , I^B and i . Each individual inherits only two of these alleles.
- I^A and I^B are codominant with each other, and both are dominant over i . Blood-group antigens are sugars associated with the red blood cell surface.

Step 1: Explain the effect of each allele The alleles I^A and I^B direct the formation of different sugar antigens, A and B respectively, on the plasma membrane of red blood cells. The allele i does not produce either A or B antigen. The gene therefore affects the surface chemical structure of the cells, rather than determining their overall shape.

Step 2: Relate genotype to the red blood cell surface Individuals with $I^A I^A$ or $I^A i$ have A antigen and blood group A; those with $I^B I^B$ or $I^B i$ have B antigen and group B. In $I^A I^B$, both alleles are expressed, so both antigens occur and the group is AB. In ii , neither A nor B antigen is present and the group is O.

Step 3: Conclusion Gene I controls ABO groups through its three alleles, which determine whether

red blood cells carry A antigen, B antigen, both antigens or neither antigen on their surface.

Quick Tip to Solve: For ABO inheritance, track red blood cell surface antigens: A, B, both for AB, and neither for O.

OR

11. Write the types of sex-determination mechanisms the following crosses show. Give an example of each type. (i) Female XX with Male XO (ii) Female ZW with Male ZZ. [2 marks]

Solution:

Concept:

- The heterogametic sex produces two kinds of gametes with respect to sex chromosomes; the homogametic sex produces one kind.
- In the XO system, O denotes the absence of a second sex chromosome, not a chromosome named O. In the ZW system, Z and W are different sex chromosomes.

Step 1: (i) Identify the XX-XO mechanism Female XX with male XO represents the XX-XO type of sex determination, involving male heterogamety. The female forms eggs carrying X. The male produces two kinds of sperm: those carrying X and those without a sex chromosome. Fertilisation yields XX females or XO males. Grasshoppers provide an example of this mechanism.

Step 2: (ii) Identify the ZW-ZZ mechanism Female ZW with male ZZ represents the ZW-ZZ type of sex determination, involving female heterogamety. The female produces eggs carrying either Z or W, while all sperm carry Z. A Z-bearing egg gives ZZ male offspring, whereas a W-bearing egg gives ZW female offspring. This mechanism occurs in birds, for example the domestic fowl.

Step 3: Conclusion (i) XX-XO: male heterogamety, as in grasshoppers. (ii) ZW-ZZ: female heterogamety, as in birds such as domestic fowl.

Quick Tip to Solve: Identify the parent producing two sex-chromosome types of gametes: XO males and ZW females are heterogametic.

12. A cross was carried out between two pea plants showing the contrasting traits of height of the plant. The result of the cross showed 50% of parental characters. (i) Work out the cross with the help of a Punnett square. (ii) Name the type of the cross carried out. [2 marks]

Solution:

Concept:

- In pea plants, the allele T for tallness is dominant over the allele t for dwarfness. A dwarf plant therefore has genotype tt .
- A test cross mates an individual showing a dominant trait with a homozygous recessive individual, revealing the genotype of the former through its offspring.

Step 1: Infer the parental genotypes The two contrasting parental traits are tall and dwarf. Since half of the offspring express dwarfness, the tall parent must contribute a recessive t allele to half its

gametes. It is therefore heterozygous Tt , whereas the dwarf parent is tt . A homozygous tall parent TT would produce only tall offspring in this cross.

Step 2: Work out the Punnett square The cross is $Tt \times tt$. The tall parent forms T and t gametes in equal proportions; the dwarf parent forms only t gametes. Showing two equivalent gametes from the dwarf parent gives:

	T	t
t	Tt	tt
t	Tt	tt

Thus two of the four equally probable combinations are Tt and two are tt , giving a genotypic ratio $Tt : tt = 1 : 1$. Their phenotypes are tall and dwarf, respectively, matching the two parental characters equally.

Step 3: Conclusion (i) $Tt \times tt$ produces 50% tall (Tt) and 50% dwarf (tt) offspring. (ii) This is a monohybrid test cross.

Quick Tip to Solve: A 1 : 1 tall-to-dwarf ratio in a cross with a dwarf plant identifies the tall parent as Tt .

13. How can healthy potato plants be obtained from a desired potato variety which is viral infected? Explain. [2 marks]

Solution:

Concept:

- Meristem culture is a tissue-culture method used to obtain healthy plants from a virus-infected plant of a desired variety.
- Apical and axillary meristems can remain free of viruses even when other tissues of the plant are infected. Their cells can regenerate complete plants under suitable culture conditions.

Step 1: Select and excise the meristem Take a small apical or axillary meristem from the desired infected potato plant. Excise it carefully under aseptic conditions. The meristem is chosen because this actively dividing region can be virus-free, unlike infected mature tissues; simply planting an infected tuber could transmit the infection to the new plant.

Step 2: Culture and regenerate healthy plants Grow the excised meristem on a sterile nutrient medium containing suitable plant growth regulators. It develops into shoots and roots, giving complete plantlets. After suitable acclimatisation, transfer the regenerated plantlets to soil. Vegetative regeneration retains the characteristics of the desired potato variety, while use of a virus-free meristem produces healthy plants.

Step 3: Conclusion Healthy potato plants of the desired variety can be obtained by aseptic culture of its virus-free apical or axillary meristem and regeneration of complete plantlets.

Quick Tip to Solve: For a virus-infected valuable plant, select meristem culture: name the apical or axillary meristem and describe regeneration on sterile medium.

14. How are 'sticky ends' formed on a DNA strand? Why are they so called?

[2 marks]

Solution:

Concept:

- Restriction endonucleases recognise specific DNA sequences and cleave phosphodiester bonds in the DNA backbone.
- A staggered cut across the two DNA strands leaves short, unpaired single-stranded overhangs called sticky ends. Complementary bases in these overhangs can form hydrogen bonds.

Step 1: Explain how the ends are formed Certain restriction endonucleases cut the two strands at different positions within their recognition sequence, rather than directly opposite each other. These staggered cuts leave a short segment of one strand projecting beyond the other at each cut end. For example, EcoRI cleaves between G and A in its recognition sequence, producing complementary 5'-AATT overhangs on the DNA fragments.

Step 2: Explain why the ends are sticky Exposed bases on an overhang can pair through hydrogen bonds with the complementary bases on another overhang. The ends therefore readily associate, or anneal, with compatible DNA ends and are called sticky ends. This pairing brings the fragments together; DNA ligase subsequently seals the sugar-phosphate backbones by forming covalent phosphodiester bonds. Base pairing alone does not complete covalent joining.

Step 3: Conclusion Sticky ends are single-stranded overhangs formed by staggered restriction-enzyme cuts. They are called sticky because complementary overhangs readily hydrogen-bond to one another.

Quick Tip to Solve: Distinguish the two events: restriction enzymes create overhangs, complementary bases anneal, and ligase seals the backbone.

15. What is Biopiracy? State the initiative taken by the Indian Parliament towards it.

[2 marks]

Solution:

Concept:

- Biological resources and the traditional knowledge associated with them may have commercial value in agriculture, medicine and biotechnology.
- Biopiracy involves using such resources without proper authorisation from the countries and people concerned and without providing compensatory payment or sharing benefits.

Step 1: Define biopiracy Biopiracy is the unauthorised use of bioresources, including associated traditional knowledge, by multinational companies or other organisations without proper permission from the countries or communities concerned and without compensatory payment. The issue is not merely collecting a biological sample: it includes obtaining commercial advantages from another community's resources or knowledge without recognising and compensating that community.

Step 2: State the parliamentary initiative The Indian Parliament cleared the second amendment of the Indian Patents Bill to take such issues into consideration. The amendment addressed matters including patent terms, emergency provisions, and research and development initiatives. This is the parliamentary initiative cited in the context of protecting India's bioresources and addressing

unauthorised exploitation and patent-related concerns.

Step 3: Conclusion Biopiracy is the unauthorised, uncompensated exploitation of bioresources and associated traditional knowledge. The Indian Parliament's initiative was clearing the second amendment of the Indian Patents Bill, taking these issues into account.

Quick Tip to Solve: Include both missing authorisation and missing compensation in the definition; name the second amendment of the Indian Patents Bill for the initiative.

16. Construct an age pyramid which reflects a stable growth status of human population. [2 marks]

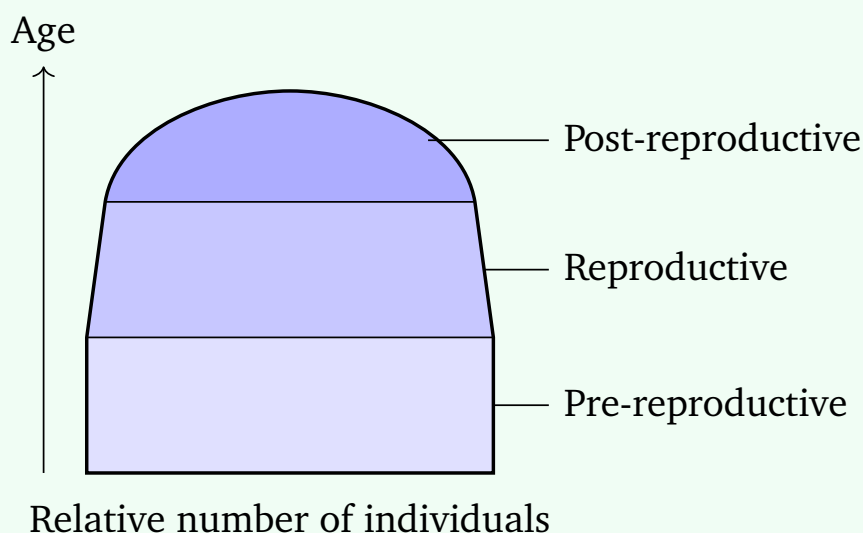
Solution:

Concept:

- An age pyramid represents the relative proportions of individuals in pre-reproductive, reproductive and post-reproductive age groups.
- A stable population has approximately equal proportions of pre-reproductive and reproductive individuals, with a smaller post-reproductive group; its characteristic outline is bell-shaped.

Step 1: Arrange the age groups Place the pre-reproductive group at the base, the reproductive group above it and the post-reproductive group at the top. The horizontal width represents the relative number of individuals, while age increases upwards. These labels distinguish an age pyramid from a pyramid of numbers in a food chain.

Step 2: Construct the stable population profile Make the base and the reproductive region approximately equal in width. Narrow the outline towards the older, post-reproductive group to obtain a bell-shaped age pyramid. In a stable population, births approximately balance deaths and the younger group replaces the reproductive group without a sustained increase or decrease in population size.



Age pyramid for a stable human population

Step 3: Conclusion The required pyramid is bell-shaped, with nearly equal pre-reproductive and reproductive groups and a smaller post-reproductive group, as shown.

Quick Tip to Solve: For stable growth, draw the base approximately as broad as the middle; a very broad base would instead indicate an expanding population.

17. Apart from being part of the food chain, predators play other important roles. Mention any two such roles supported by examples. [2 marks]

Solution:

Concept:

- Predation regulates prey populations because predators remove individuals that would otherwise survive and reproduce.
- By reducing the abundance of competitively dominant prey, predators can prevent competitive exclusion and help maintain species diversity in a community.

Step 1: Explain population control with an example Predators keep prey populations under control and can therefore serve as biological control agents. The prickly pear cactus introduced into Australia spread widely; its population was brought under control by introducing a cactus-feeding moth. The moth checked the cactus population by feeding on it. Similarly, ladybirds help control aphids on crop plants.

Step 2: Explain the maintenance of species diversity Predators reduce the intensity of competition among prey species by checking the abundance of dominant competitors. The starfish *Pisaster* is an important predator in intertidal communities of the American Pacific coast. When it was removed experimentally, more than ten invertebrate species disappeared within a year because of interspecific competition. Its presence thus helps several prey species coexist.

Step 3: Conclusion Two roles are population control, illustrated by the cactus-feeding moth in Australia, and maintenance of species diversity, illustrated by *Pisaster* in intertidal communities.

Quick Tip to Solve: Pair each role with its own example: cactus-feeding moth for population control and *Pisaster* for maintaining diversity.

18. Write the role of 'Ori' and 'restriction' site in a cloning vector pBR322. [2 marks]

Solution:

Concept:

- A cloning vector carries foreign DNA into a host and enables it to be replicated. pBR322 is a plasmid cloning vector used in bacteria.
- The origin of replication, or *ori*, enables replication; a restriction site provides a specific position at which the vector can be cut for insertion of foreign DNA.

Step 1: State the function of ori *Ori* is the DNA sequence from which replication starts. Any DNA fragment linked to this sequence can be replicated within the host cell along with the vector. It is also responsible for controlling the copy number of the linked DNA, so it influences how many copies of the recombinant plasmid are maintained in the host.

Step 2: State the function of a restriction site A restriction site is a specific DNA sequence recognized and cut by its corresponding restriction endonuclease. Cutting pBR322 at a suitable unique site opens the plasmid so that foreign DNA with compatible ends can be inserted and joined by DNA ligase.

A unique site is useful because cutting there linearizes the vector without fragmenting it at several positions. If insertion occurs within an antibiotic-resistance gene, disruption of that gene can also help identify recombinants by insertional inactivation.

Step 3: Conclusion In pBR322, *ori* starts replication and controls copy number, while a suitable restriction site allows the vector to be cut at a defined position for inserting foreign DNA.

Quick Tip to Solve: Keep the roles separate: *ori* answers where replication starts, while a restriction site answers where an enzyme cuts for DNA insertion.

Section C (27 marks)

19. A colourblind child is born to a normal couple. Work out a cross to show how it is possible. Mention the sex of this child. [3 marks]

Solution:

Concept:

- Colour blindness is an X-linked recessive trait. Let X^C carry the allele for normal colour vision and X^c carry the colour-blindness allele; the Y chromosome does not carry a corresponding allele.
- A female with genotype $X^C X^c$ has normal vision but is a carrier. A male with genotype $X^c Y$ expresses colour blindness because he has only one X chromosome.

Step 1: Identify the parental genotypes The normal father must be $X^C Y$. For a colour-blind child to receive the recessive allele despite both parents having normal vision, the normal mother must be a carrier, $X^C X^c$. The required cross is therefore

$$\begin{array}{ccc} X^C X^c & \times & X^C Y \\ \text{normal carrier mother} & & \text{normal father} \end{array}$$

The mother's eggs carry either X^C or X^c ; the father's sperm carry either X^C or Y .

Step 2: Work out the offspring Combining one maternal and one paternal sex chromosome gives the following equally likely genotypes:

Maternal / paternal gametes	X^C	Y
X^C	$X^C X^C$	$X^C Y$
X^c	$X^C X^c$	$X^c Y$

The daughters are $X^C X^C$, normal and non-carrier, or $X^C X^c$, normal carriers. The sons are $X^C Y$, normal, or $X^c Y$, colour-blind. Thus half of the sons, or one quarter of all children assuming equal probabilities of sons and daughters, are expected to be colour-blind.

Step 3: Determine the sex of the affected child A son receives his X chromosome from his mother and his Y chromosome from his father. He can therefore inherit X^c from his carrier mother and express the recessive trait. Every daughter receives the father's normal X^C , so none is colour-blind in this cross.

Step 4: Conclusion A normal carrier mother $X^C X^c$ and a normal father $X^C Y$ can have a colour-blind

son X^cY . The affected child is male.

Quick Tip to Solve: In an X-linked recessive cross, trace a son's X chromosome to his mother; a normal father's X makes all daughters in this cross phenotypically normal.

OR

19. Mendel published his work on inheritance of characters in 1865, but it remained unrecognized till 1900. Give three reasons for the delay in accepting his work. [3 marks]

Solution:

Concept:

- Mendel proposed that inheritance is controlled by discrete factors passed from parents to offspring; these factors retain their identity rather than blending.
- Acceptance of a scientific finding depends on its communication, the evidence available and the scientific ideas prevailing at that time.

Step 1: Identify the communication barrier Communication and dissemination of scientific work were limited in Mendel's time. His findings were not widely publicised or readily brought to the attention of other biologists. Consequently, many scientists remained unaware of his experiments and conclusions for a long time.

Step 2: Explain the conflict with prevailing ideas Mendel's idea of stable, discrete hereditary factors did not fit the widely held view that parental characters blend in offspring. His factors did not blend even when their expression was masked in a hybrid. This was difficult to accept because nature appeared to show continuous variation rather than the sharply contrasting traits he studied in pea plants.

Step 3: Explain the unfamiliar quantitative approach Mendel used mathematics and statistical analysis to interpret large numbers of offspring and identify predictable inheritance ratios. This quantitative approach was new to many biologists of his time, who did not readily appreciate its significance. Thus, the numerical evidence supporting his laws was not immediately accepted.

Step 4: Conclusion Three reasons were limited dissemination of his work, conflict between discrete factors and the prevailing blending view of inheritance, and the unfamiliar use of mathematics and statistics in biology.

Quick Tip to Solve: Organise the three reasons as communication, prevailing beliefs and mathematical method; explain why each delayed acceptance.

20. A cross between a normal couple resulted in a son who was haemophilic and a normal daughter. In course of time, when the daughter was married to a normal man, to their surprise, the grandson was also haemophilic. (a) Represent this cross in the form of a pedigree chart. Give the genotypes of the daughter and her husband. (b) Write the conclusion you draw of the inheritance pattern of this disease. [3 marks]

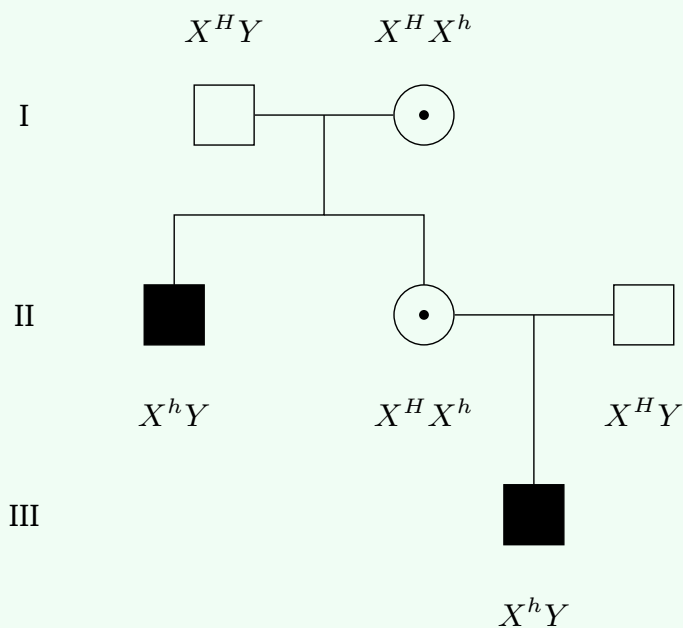
Solution:

Concept:

- Haemophilia is an X-linked recessive disorder. Let X^H carry the normal allele and X^h carry the haemophilia allele; the Y chromosome lacks the corresponding allele.
- A male with X^hY is affected, whereas a heterozygous female $X^H X^h$ is a phenotypically normal carrier. A son receives his X chromosome from his mother and Y from his father.

Step 1: Infer the first-generation parental genotypes The normal father must be $X^H Y$. Their haemophilic son is $X^h Y$, so his X^h must have come from his mother. Since she is phenotypically normal, she must be a carrier, $X^H X^h$. Thus the original parental cross is $X^H Y \times X^H X^h$.

Step 2: Construct the pedigree and identify the daughter's genotype The normal daughter receives X^H from her father. Her haemophilic son later establishes that she also carries X^h , inherited from her carrier mother. Therefore, the daughter's genotype is $X^H X^h$, and her normal husband's genotype is $X^H Y$. The pedigree shows only the family members described in the question; a central dot denotes a carrier female.



Three-generation pedigree: square = male; circle = female; filled square = affected male; dotted circle = carrier female.

Step 3: Explain the inheritance pattern The daughter's cross, $X^H X^h \times X^H Y$, can produce $X^H X^H$ (normal daughter), $X^H X^h$ (carrier daughter), $X^H Y$ (normal son) and $X^h Y$ (haemophilic son), each with probability $1/4$. Thus half the sons are expected to be affected. The disease passes through phenotypically normal carrier females to affected males, characteristic of X-linked recessive

inheritance. There is no father-to-son transmission of the X-linked allele.

Step 4: Conclusion The daughter is a carrier, $X^H X^h$, and her husband is $X^H Y$. The pedigree demonstrates **X-linked recessive inheritance** of haemophilia.

Quick Tip to Solve: Trace an affected son's X chromosome to his mother; a normal mother of an affected son must carry the recessive allele in this pedigree.

21. Women are often blamed for producing female children. Consequently, they are ill treated and ostracized. How will you address this issue scientifically if you were to conduct an awareness programme to highlight the values involved? [3 marks]

Solution:

Concept:

- In humans, females normally have $44 + XX$ chromosomes and males $44 + XY$. Females are homogametic and males are heterogametic with respect to sex chromosomes.
- Every ovum carries $22 + X$, whereas sperms are of two types, $22 + X$ and $22 + Y$, produced in approximately equal proportions.

Step 1: Explain fertilisation scientifically I would explain that the mother supplies an X chromosome to every child. If an X-bearing sperm fertilises the ovum, the zygote is $44 + XX$ and develops as a female. If a Y-bearing sperm fertilises it, the zygote is $44 + XY$ and develops as a male. The possible combinations are

$$(22 + X) + (22 + X) = 44 + XX \quad (\text{female}),$$

$$(22 + X) + (22 + Y) = 44 + XY \quad (\text{male}).$$

Therefore, it is the type of sperm fertilising the ovum that determines the chromosomal sex of the child.

Step 2: Remove blame and explain probability Fertilisation by either type of sperm is a chance event, giving approximately equal probabilities of a male or female child at each conception. The mother does not determine whether an X-bearing or Y-bearing sperm fertilises her ovum. Neither parent consciously controls this event, so there is no scientific basis for blaming, ill-treating or ostracising a woman for giving birth to a daughter. The explanation must remove blame, not transfer it to the father.

Step 3: Promote the values involved The awareness programme should promote scientific temper, gender equality, compassion and respect for women's dignity. Boys and girls deserve equal affection, education, opportunities and care. I would use the chromosome combinations above to correct the misconception, oppose discrimination and encourage families to support both the mother and the child.

Step 4: Conclusion The mother always contributes X; the fertilising sperm contributes X or Y. A daughter's birth is a natural chance outcome, and blaming or mistreating the mother is scientifically unjustified and violates equality and human dignity.

Quick Tip to Solve: Pair the XX/XY explanation with the social message: random fertilisation gives no basis for blame, and both sexes deserve equal respect.

22. Draw a labelled diagram of the sectional view of a human seminiferous tubule. (six parts to be labelled) [3 marks]

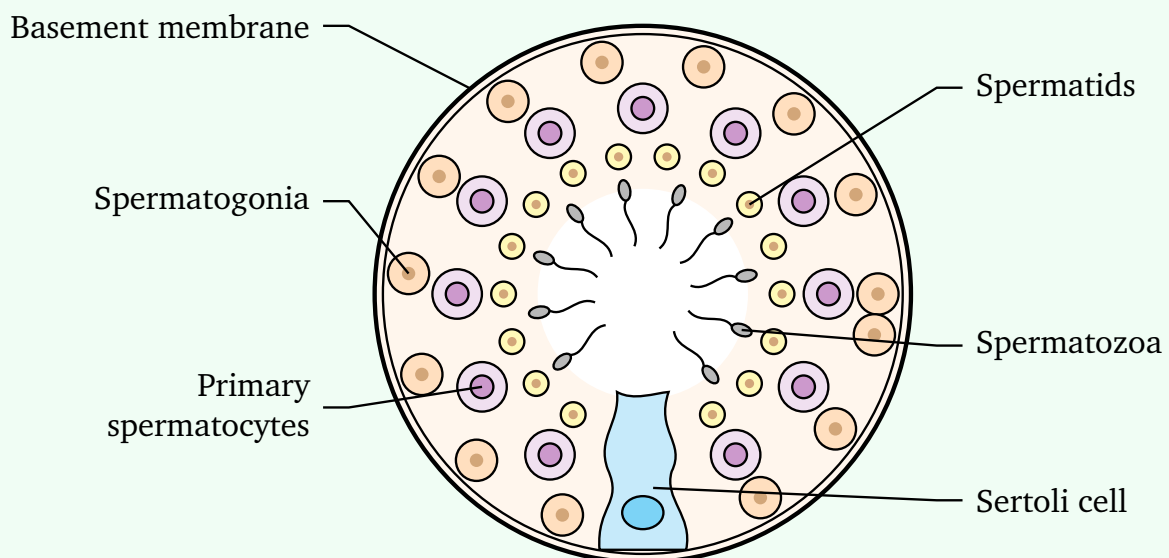
Solution:

Concept:

- Seminiferous tubules are the sites of sperm formation in the testes. Their germinal epithelium contains developing male germ cells and supporting Sertoli cells.
- Germ cells mature from the basement membrane towards the lumen: spermatogonia give rise to spermatocytes, then spermatids, and finally spermatozoa.

Step 1: Draw the tubule wall and arrange the germ cells Draw a circular section with a basement membrane enclosing the germinal epithelium and an open central lumen. Place spermatogonia against the basement membrane and the larger primary spermatocytes farther inward. Show smaller spermatids near the lumen and spermatozoa with their tails projecting into the lumen. These positions indicate the direction of maturation within the tubule; the outermost cells are not mature sperm.

Step 2: Show the supporting cell and label six parts Show a Sertoli cell extending from the basement membrane towards the lumen among the developing germ cells. It supports and nourishes these cells during spermatogenesis. Label the six indicated structures clearly: basement membrane, spermatogonia, primary spermatocytes, spermatids, spermatozoa and Sertoli cell. The small secondary spermatocyte stage occurs between the primary spermatocytes and spermatids; it is not one of the six labels selected here.



Sectional view of a human seminiferous tubule (schematic; six labelled parts)

Step 3: Conclusion The labelled section shows the basement membrane, spermatogonia, primary spermatocytes, spermatids, spermatozoa and a Sertoli cell in their appropriate positions.

Quick Tip to Solve: Arrange the germ-cell stages from the outer wall towards the centre, and draw sperm tails projecting into the lumen.

23. (i) What is primary productivity? Why does it vary in different types of ecosystems? (ii) State the relation between gross and net primary productivity. [3 marks]

Solution:

Concept:

- Primary productivity is the rate at which producers form biomass or organic matter by photosynthesis per unit area per unit time.
- Gross primary productivity includes all the organic matter produced, whereas net primary productivity excludes the portion used in the producers' respiration.

Step 1: Define primary productivity and explain its variation (i) Primary productivity measures the rate of biomass production by plants through photosynthesis. It can be expressed as biomass per unit area per unit time, such as $\text{g m}^{-2} \text{yr}^{-1}$, or as energy per unit area per unit time, such as $\text{kcal m}^{-2} \text{yr}^{-1}$. Thus, productivity is a rate; it is different from the amount of biomass present at a particular instant. It varies among ecosystems because the plant species present, their photosynthetic capacity, environmental conditions and nutrient availability differ. Light, temperature and water availability influence photosynthesis. For example, favourable light and water conditions with adequate nutrients allow a greater rate of organic matter production, while water shortage or low nutrient supply can limit it.

Step 2: Relate gross productivity to net productivity (ii) Let GPP denote gross primary productivity, NPP denote net primary productivity, and R denote the rate of respiratory loss by the producers. Plants consume part of their gross production in respiration to meet their own energy requirements. Subtracting this loss gives the organic matter retained as new plant biomass:

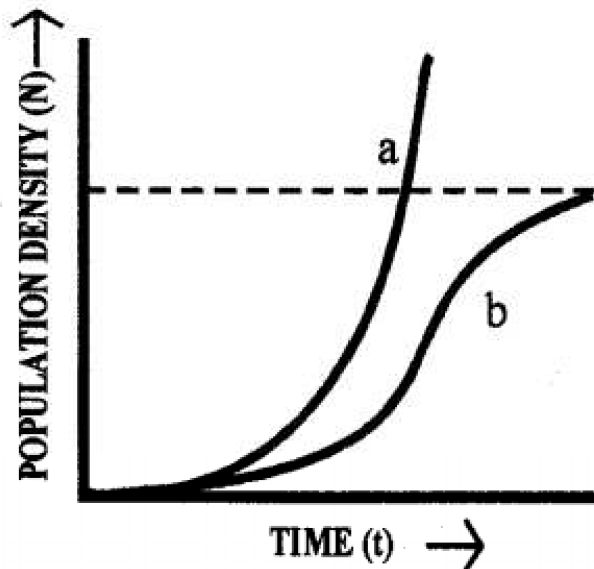
$$\text{NPP} = \text{GPP} - R.$$

All three quantities must refer to the same area and time interval and use the same units. NPP is the biomass available for consumption by heterotrophs, including herbivores and decomposers. Here R is the producers' respiration, not the respiration of every organism in the ecosystem.

Step 3: Conclusion Primary productivity is the rate of organic matter production by producers. It varies with plant species, photosynthetic capacity, environmental factors and nutrient availability; $\text{NPP} = \text{GPP} - R$.

Quick Tip to Solve: Remember that net production is what remains after the plants use part of their gross production in respiration; always include area and time in productivity units.

24. Study the graph given below and answer the questions that follow: (i) Write the status of food and space in the curves (a) and (b). (ii) In the absence of predators, which one of the two curves would appropriately depict the prey population? (iii) Time has been shown on X-axis and there is a parallel dotted line above it. Give the significance of this dotted line. [3 marks]



Solution:

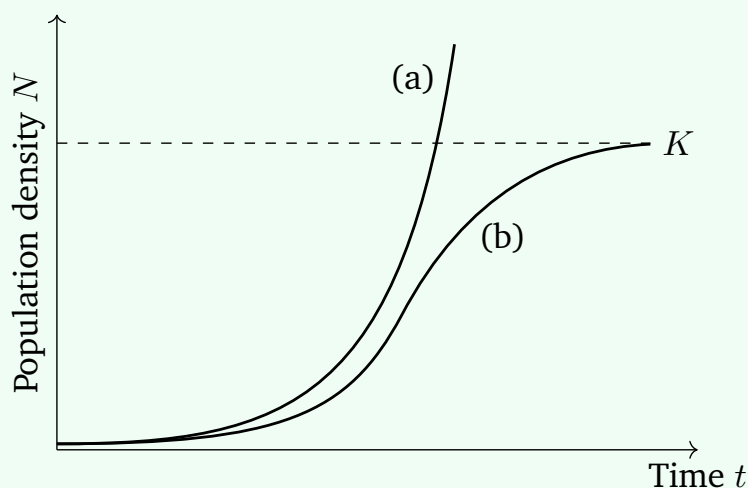
Concept:

- Exponential growth occurs when resources are unlimited; the population follows a J-shaped curve. Logistic growth occurs when resources become limiting and gives an S-shaped curve.
- Carrying capacity, K , is the maximum population density that the available resources of a habitat can sustain under the prevailing conditions.

Step 1: Compare food and space in curves (a) and (b) In curve (a), food and space are unlimited, so increasing population density does not impose a resource constraint. The population therefore grows exponentially. In curve (b), food and space are limited. As the population increases, competition for these resources increases, slowing growth and causing the curve to level off near carrying capacity.

Step 2: Identify the prey curve without predators Curve (a) is the expected curve for prey when predators are absent and resources are favourable. Removal of predation reduces mortality and permits rapid, unchecked population increase. This is the exponential-growth situation represented by the J-shaped curve; in nature, resource limitation would eventually restrict such growth even without predators.

Step 3: Interpret the horizontal dotted line The dotted line denotes the carrying capacity K of the habitat, not a particular time. The logistic population approaches this level because its growth rate decreases as resources become limiting. In the logistic equation $dN/dt = rN(1 - N/K)$, N is population density, t is time and r is the intrinsic rate of natural increase. At $N = K$, the growth rate is zero and population density is maintained around this level.



Exponential and logistic growth, with carrying capacity indicated.

Step 4: Conclusion (i) Curve (a): unlimited food and space; curve (b): limited food and space. (ii) Curve (a) represents prey growth without predators under favourable resource conditions. (iii) The dotted line represents carrying capacity K .

Quick Tip to Solve: Match J-shaped growth with unlimited resources and S-shaped growth with a plateau at carrying capacity.

25. How did the process of RNA interference help to control the nematode from infecting roots of tobacco plants? Explain. [3 marks]

Solution:

Concept:

- RNA interference (RNAi) is the sequence-specific silencing of a messenger RNA by a complementary double-stranded RNA (dsRNA). It prevents expression of the corresponding gene.
- The nematode *Meloidogyne incognita* infects the roots of tobacco plants and reduces their yield. RNAi can protect the host by suppressing an essential nematode gene.

Step 1: Introduce nematode gene sequences into tobacco Using *Agrobacterium* as a vector, specific DNA sequences from the nematode were introduced into tobacco cells. The introduced construct was designed so that the plant produced both sense RNA and antisense RNA corresponding to the target nematode gene.

Step 2: Form double-stranded RNA and silence the target The sense and antisense RNAs were complementary, so they paired to form dsRNA. This initiated RNA interference. During feeding on the transgenic host, the parasite encountered the RNAi trigger; sequence-specific silencing of its matching mRNA prevented translation and hence production of the corresponding protein. The effect depended on complementarity to the target RNA, rather than on a general poison acting on all organisms.

Step 3: Explain protection of the tobacco roots Because the silenced gene was necessary for the parasite, the nematode could not survive successfully in the transgenic tobacco host. Consequently, it

could not establish the damaging root infection, and the plant was protected. The protective product was RNA that blocked parasite gene expression; it was not a protein toxin like the Bt toxin.

Step 4: Conclusion Tobacco expressing complementary sense and antisense nematode RNA generated dsRNA, triggering RNAi against an essential *Meloidogyne incognita* mRNA. Translation was blocked, the parasite could not survive in the host, and root infection was controlled.

Quick Tip to Solve: Recall the sequence: nematode DNA in tobacco, sense plus antisense RNA, dsRNA, target mRNA silencing, and parasite protection.

26. Why are beehives kept in crop field during flowering period? Name any two crop fields where this is practiced. [3 marks]

Solution:

Concept:

- Bees are important pollinators of many crop plants. Pollination transfers pollen from an anther to a receptive stigma and makes subsequent fertilisation possible.
- Apiculture is the maintenance of beehives for obtaining honey and other bee products. Placing hives near flowering crops benefits both crop production and honey production.

Step 1: Explain how bees improve crop yield During the flowering period, bees visit flowers to collect nectar and pollen. Pollen grains adhere to their bodies and are carried to stigmas as the bees move between flowers. Keeping hives in a crop field increases the availability of pollinators when flowers are receptive. More effective pollination improves fertilisation and the setting of seeds and fruits, thereby increasing crop yield.

Step 2: Explain the benefit to honey production Flowering crops provide abundant nectar and pollen close to the hive. Nectar is used in honey production, while pollen provides food for the bee colony. Thus, placing hives in the field during flowering also increases honey yield. The timing matters because flowers are then providing food for the bees while needing pollen transfer for successful reproduction.

Step 3: Name two suitable crop fields This practice is used in **sunflower fields** and **mustard fields**. Bees visiting the flowers of these crops assist pollen transfer, and the flowering crop supplies nectar and pollen to the managed bee colonies.

Step 4: Conclusion Beehives are kept in crop fields during flowering to increase pollination and crop yield, while also increasing honey yield. Two examples are sunflower and mustard fields.

Quick Tip to Solve: Link both benefits: bees transfer pollen to raise crop yield, and flowering crops supply nectar to raise honey yield.

27. (a) Name the tropical Sugar cane variety grown in South India. How has it helped in improving the sugar cane quality grown in North India? (b) Identify 'a', 'b' and 'c' in the following table:

No.	Crop	Variety	Insect Pests
1.	Brassica	Pusa Gaurav	(a)
2.	Flat bean	Pusa Sem 2, Pusa Sem 3	(b)
3.	(c)	Pusa Sawani, Pusa A-4	Shoot and fruit borer

[3 marks]

Solution:

Concept:

- Interspecific hybridisation combines desirable characters of two related species in a crop adapted to the intended growing region.
- Insect-resistant varieties reduce crop damage by particular pests; the variety name must be matched to both its crop and the pest resisted.

Step 1: Identify the tropical sugarcane and its contribution (a) The tropical sugarcane grown in South India is *Saccharum officinarum*. It has thick stems and a high sugar content, but does not grow well in North India. In contrast, *Saccharum barberi*, traditionally grown in North India, has poorer sugar content and yield but is adapted to northern conditions. The two species were crossed. Selection from the hybrids produced sugarcane combining the desirable high sugar content, thick stems and high yield of *S. officinarum* with the ability to grow in North India. Thus, hybridisation improved the quality and productivity of northern sugarcane.

Step 2: Complete the crop-resistance table (b) Match each variety with its known insect resistance:

Blank	Identification
(a)	Aphids
(b)	Jassids, aphids and fruit borer
(c)	Bhindi (okra)

Pusa Gaurav is a Brassica variety resistant to aphids. Pusa Sem 2 and Pusa Sem 3 are flat-bean varieties resistant to jassids, aphids and fruit borer. Pusa Sawani and Pusa A-4 are bhindi varieties resistant to shoot and fruit borer. The last blank asks for the crop, whereas the first two ask for insect pests.

Step 3: Conclusion (a) *Saccharum officinarum* improved northern sugarcane through hybridisation with *S. barberi*. (b) The blanks are (a) aphids, (b) jassids, aphids and fruit borer, and (c) bhindi (okra).

Quick Tip to Solve: Associate Pusa Gaurav with aphids, Pusa Sem with flat bean, and Pusa Sawani/Pusa A-4 with bhindi; check whether each blank asks for a pest or a crop.

Section D (15 marks)

28. (a) Explain the process of DNA replication with the help of a schematic diagram. (b) In which phase of the cell cycle does replication occur in Eukaryotes? What would happen if cell-division is not followed after DNA replication? [5 marks]

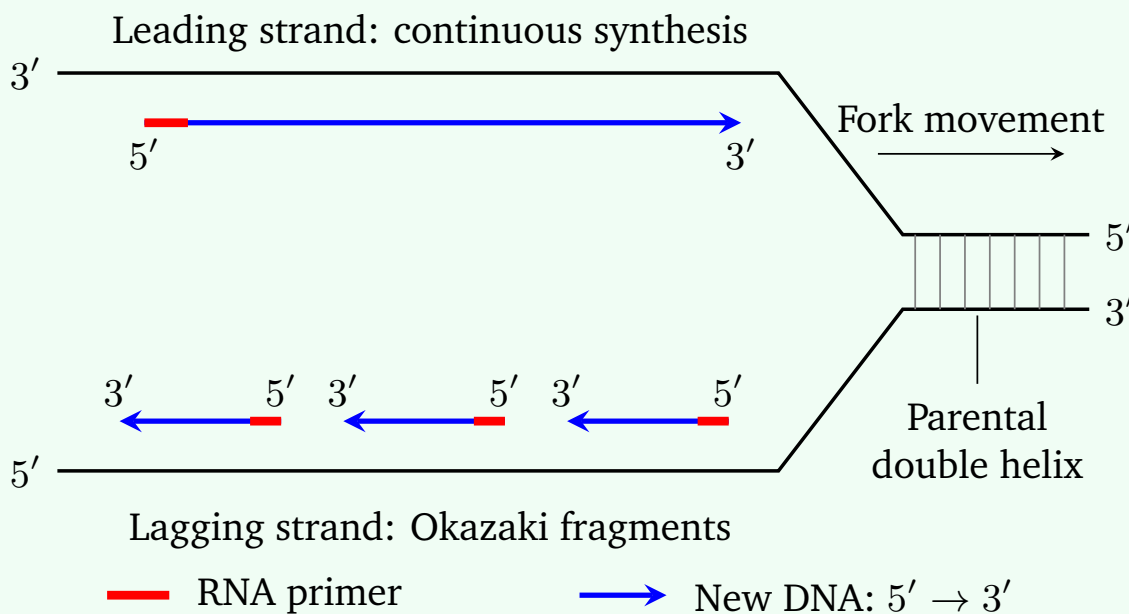
Solution:

Concept:

- DNA replication is semiconservative: each daughter DNA double helix contains one parental strand and one newly synthesised strand.
- Complementary base pairing (A with T, and G with C) allows each parental strand to act as a template. DNA polymerase adds nucleotides only to a free 3'-OH end, so new DNA grows in the 5' → 3' direction.
- Replication normally occurs once before cell division, coordinating duplication of the genome with its distribution to daughter cells.

Step 1: Open the parental DNA at the origin (a) Replication begins at specific sites called origins of replication. Helicase unwinds the double helix by breaking the hydrogen bonds between complementary bases, producing a replication fork. The separated strands serve as templates. Single-strand binding proteins keep them apart, while topoisomerase relieves the twisting strain ahead of the fork. Eukaryotic chromosomes have multiple origins, permitting their long DNA molecules to be copied efficiently.

Step 2: Synthesise complementary strands Primase synthesises short RNA primers that provide free 3'-OH ends. DNA-dependent DNA polymerase extends these primers using deoxyribonucleoside triphosphates. These act both as substrates and as sources of energy for polymerisation. The enzyme reads the template in the 3' → 5' direction and synthesises new DNA in the 5' → 3' direction. Since the parental strands are antiparallel, synthesis is continuous towards the advancing fork on the leading strand. On the other template, synthesis proceeds discontinuously away from the fork in short Okazaki fragments, each initiated by a primer. The diagram shows the directions of synthesis; both daughter strands grow 5' → 3'.



Replication fork: solid black lines are parental templates; blue arrows show new DNA synthesis. RNA primers initiate each new segment.

Step 3: Join the fragments and complete replication RNA primers are removed and replaced with DNA. DNA ligase seals the remaining breaks between adjacent fragments by forming phosphodiester bonds. Replication therefore produces two DNA molecules with the same base sequence as the original, apart from rare copying errors. Each has one conserved parental strand and one newly synthesised complementary strand, establishing the semiconservative nature of replication.

Step 4: Relate replication to the cell cycle (b) In eukaryotes, DNA replication occurs during the **S phase (synthesis phase) of interphase**. The DNA content doubles before division; for example, a diploid cell changes from $2C$ to $4C$ DNA content, where C is the DNA content of a haploid genome. If cell division does not follow, the duplicated DNA remains in one cell instead of being distributed to daughter cells. Repeated rounds of replication without cell division can consequently produce **polyploidy**, an increase in the number of chromosome sets. One S phase alone doubles DNA content but does not immediately double the chromosome number counted by centromeres, because the replicated chromatids remain joined.

Step 5: Conclusion DNA replicates semiconservatively through complementary, continuous leading-strand and discontinuous lagging-strand synthesis. In eukaryotes this occurs in S phase. Failure of subsequent cell division retains the duplicated genome in one cell and can lead to polyploidy.

Quick Tip to Solve: Label both new strands $5' \rightarrow 3'$: the leading strand grows towards the fork and Okazaki fragments away from it. Distinguish DNA-content doubling from an immediate doubling of chromosome number.

28. (a) Explain Darwinian theory of evolution with the help of one suitable example. State the two key concepts of the theory. (b) Mention any three characteristics of Neanderthal man that lived in near east and central Asia. [5 marks]

Solution:

Concept:

- Darwinian evolution explains how heritable variations become more or less common through differential survival and reproduction in a particular environment.
- Natural selection acts on existing variations; it does not create a favourable character because an organism needs it. Fitness means reproductive success.
- Branching descent describes the diversification of descendants from common ancestors. Fossil and cultural evidence also reveals characteristics of early humans.

Step 1: (a) Explain the mechanism of Darwinian evolution Organisms produce more offspring than the available resources can support. Individuals in a population differ, and many of these variations are heritable. Limited food, space and other resources lead to a struggle for existence. Individuals with variations favourable in the prevailing environment are more likely to survive and reproduce, passing these variations to their offspring. This differential reproductive success is natural selection. Over many generations, favourable heritable variations increase in frequency, producing adaptation; accumulated divergence between populations can eventually produce new species.

Step 2: Illustrate natural selection with industrial melanism In the peppered moth, *Biston betularia*, both light-coloured and dark-coloured variants existed. Before industrialisation, pale, lichen-covered tree trunks concealed light moths, whereas dark moths were more visible to insect-eating birds. Light moths therefore survived and reproduced more successfully.

Industrial pollution darkened tree trunks with soot and reduced lichens. Dark moths then became better camouflaged, while light moths became conspicuous to birds. Consequently, dark moths survived and reproduced more successfully, and their proportion increased over generations. Thus the change in environment changed which pre-existing variant was favoured. The individual light moths did not turn dark in response to soot.

Step 3: State the two key concepts The two key concepts of Darwin's theory are **branching descent** and **natural selection**. Branching descent means that different lineages arise from common ancestors; natural selection explains the preferential survival and reproduction of individuals with favourable heritable variations under the prevailing conditions.

Step 4: (b) List three characteristics of Neanderthal man Neanderthal man, who lived in the Near East and Central Asia, had the following characteristics: (i) a brain capacity of about 1400 cm^3 ; (ii) use of animal hides to protect the body; and (iii) burial of the dead. These are distinct anatomical and cultural features described for Neanderthals.

Step 5: Conclusion Darwinian evolution rests on branching descent and natural selection, illustrated by the increase in dark peppered moths in polluted surroundings. Neanderthal man had a brain capacity of about 1400 cm^3 , used hides for body protection, and buried the dead.

Quick Tip to Solve: For industrial melanism, link background colour to camouflage, bird predation and reproductive success. Name both branching descent and natural selection explicitly.

29. (a) Name the technology that has helped the scientists to propagate on large scale the desired crops in short duration. List the steps carried out to propagate the crops by the said technique. (b) How are somatic hybrids obtained? [5 marks]

Solution:

Concept:

- Totipotency is the capacity of a plant cell to regenerate a complete plant under suitable culture conditions. It is the basis of plant tissue culture.
- Micropropagation is the rapid production of a large number of plants through tissue culture. The plants produced from a selected parent are called somaclones and retain its desirable characters.
- A protoplast is a plant cell from which the cell wall has been removed. Fusion of protoplasts of two different varieties or species permits somatic hybridisation without the fusion of gametes.

Step 1: (a) Identify the technology and select an explant The technology is **plant tissue culture**, used for large-scale multiplication by **micropropagation**. Select a healthy parent plant possessing the desired crop characters. Excise a small piece of living tissue, called an explant, such as a shoot tip or a piece of another suitable plant part. Surface-sterilise the explant and use sterile instruments and vessels so that bacteria and fungi do not contaminate the culture.

Step 2: (a) Establish and multiply the culture Place the explant aseptically on a sterile nutrient medium. The medium supplies a carbon source such as sucrose, inorganic salts, vitamins, amino acids and plant growth regulators such as auxins and cytokinins. Under controlled conditions, the cells divide. Depending on the explant and hormone balance, an unorganised mass of cells called a callus or directly developing shoots may be produced. Transfer growing tissue to fresh suitable medium repeatedly to multiply the culture rapidly.

Step 3: (a) Regenerate and establish complete plants Adjust the growth regulators in the medium to induce shoot formation and then root formation, producing complete plantlets. Acclimatise or harden the plantlets gradually to conditions outside the culture vessels. Transfer them to soil and establish them in the field. Thus, a small amount of selected tissue gives many plants in a short period. These tissue-culture plants are called somaclones because they are genetically identical to the source plant in the intended clonal propagation process.

Step 4: (b) Isolate and fuse the protoplasts Obtain somatic cells from the two selected plant varieties or species. Digest their cell walls using suitable wall-degrading enzymes, such as cellulase and pectinase, to obtain naked protoplasts surrounded by plasma membranes. Bring the protoplasts together and induce their fusion, for example with polyethylene glycol or an electrical treatment. Fusion combines the cytoplasm and, following nuclear fusion, the genetic material of the two parents in a hybrid cell.

Step 5: (b) Regenerate the somatic hybrid Select the hybrid cells and culture them on a suitable nutrient medium. They regenerate cell walls, divide to form a callus and can be induced to develop shoots and roots. The regenerated plants are **somatic hybrids**, combining genetic material from the two parental plants. Fusion of potato and tomato protoplasts to produce pomato is an example. This process joins somatic cells; it does not require pollination or sexual fertilisation.

Step 6: Conclusion (a) Micropropagation through tissue culture rapidly multiplies selected crops by explant culture, multiplication, plantlet regeneration and transfer to soil. (b) Somatic hybrids are

obtained by fusing isolated protoplasts from two parents and regenerating the resulting hybrid cells into plants.

Quick Tip to Solve: Keep the sequences distinct: micropropagation starts with one selected explant, whereas somatic hybridisation starts with protoplasts from two parents and requires fusion before regeneration.

OR

29. (a) Cancer is one of the most dreaded diseases of humans. Explain 'Contact inhibition' and 'Metastasis' with respect to the disease. (b) Name the group of genes which have been identified in normal cells that could lead to cancer and how they do so? (c) Name any two techniques which are useful to detect cancers of internal organs. (d) Why are cancer patients often given α -interferon as part of the treatment?

[5 marks]

Solution:

Concept:

- Normal cells regulate their growth and division; cancer cells lose these controls and divide continuously, forming a mass of cells called a tumour.
- Malignant tumours invade surrounding tissues and can spread to distant sites. Detecting internal tumours and stimulating immune responses are important aspects of cancer management.

Step 1: (a) Explain contact inhibition Contact inhibition is the property by which normal cells stop dividing when they come into contact with neighbouring cells. It helps maintain orderly growth and prevents cells from piling up. Cancer cells lose this property: even when in contact with other cells, they continue dividing in an uncontrolled manner and form a tumour.

Step 2: (a) Explain metastasis Metastasis is the spread of cancer cells from a primary malignant tumour to other parts of the body. Cells detach from the original tumour, enter the blood or lymph, and travel to distant tissues. There they establish new, secondary tumours. Thus, a malignant tumour can damage organs far from its original site; a benign tumour remains confined to its original location and does not show metastasis.

Step 3: (b) Identify the genes and explain their activation The genes are cellular oncogenes, also called proto-oncogenes. In normal cells, proto-oncogenes participate in the regulation of growth and division. When activated under certain conditions, for example by cancer-causing mutations, they can become oncogenes whose altered activity promotes uncontrolled cell proliferation. This activation can therefore lead to the oncogenic transformation of a normal cell into a cancerous cell.

Step 4: (c) Name techniques for detecting internal cancers Two useful techniques are computed tomography (CT) and magnetic resonance imaging (MRI). CT uses X-rays and computer processing to produce detailed cross-sectional images of internal structures. MRI uses strong magnetic fields and non-ionising radiation to obtain detailed images, especially of soft tissues. These imaging methods help locate abnormal masses in internal organs.

Step 5: (d) Explain the role of alpha-interferon Cancer patients may be given α -interferon as a biological response modifier in immunotherapy. Tumour cells can evade recognition and destruction

by the immune system. Alpha-interferon activates the patient's immune system, helping it recognise and destroy tumour cells. Its role in this answer is therefore to strengthen the body's immune response against the cancer.

Step 6: Conclusion Cancer cells lose contact inhibition, and malignant cells spread by metastasis. Activated proto-oncogenes can cause cancer; CT and MRI help detect internal tumours, while α -interferon stimulates immune defence against tumour cells.

Quick Tip to Solve: Link each term to its distinct role: contact inhibition controls division, metastasis spreads tumours, proto-oncogene activation initiates transformation, imaging detects, and interferon stimulates immunity.

30. Explain the ovarian and uterine events that occur during a menstrual cycle in a human female, under the influence of Pituitary and Ovarian hormones respectively. [5 marks]

Solution:

Concept:

- The menstrual cycle is a coordinated sequence of ovarian and uterine changes, averaging about 28 days. Day 1 is the first day of menstrual bleeding.
- The anterior pituitary secretes follicle-stimulating hormone (FSH) and luteinising hormone (LH), which regulate follicular growth, ovulation and the corpus luteum in the ovary.
- Ovarian oestrogens and progesterone regulate regeneration, thickening and maintenance of the uterine endometrium, preparing it for implantation.

Step 1: Explain the menstrual phase During approximately days 1–5, menstrual flow occurs. If fertilisation did not occur in the preceding cycle, the corpus luteum degenerates and ovarian progesterone and oestrogen levels fall. The endometrial lining and its blood vessels break down and are shed through the vagina as menstrual flow. Thus, withdrawal of ovarian hormones initiates menstruation. Meanwhile, the increase in pituitary FSH initiates the development of ovarian follicles for the next cycle.

Step 2: Relate follicular growth to endometrial proliferation In the follicular phase, following the onset of menstruation and extending to about day 13, pituitary FSH, with LH, stimulates growth of ovarian follicles; a selected follicle matures into a Graafian follicle. Growing follicles secrete increasing amounts of oestrogens. These ovarian hormones cause the uterine endometrium to regenerate, proliferate and thicken, with development of glands and blood vessels. This uterine stage is therefore called the proliferative phase.

Step 3: Explain the hormonal trigger for ovulation Near the middle of a typical 28-day cycle, high oestrogen secretion by the mature follicle produces positive feedback on the hypothalamic-pituitary system. Gonadotropin secretion rises, especially LH, producing the LH surge. Around day 14 this surge causes rupture of the Graafian follicle and release of the secondary oocyte: ovulation.

Step 4: Describe the luteal and secretory phases After ovulation, LH promotes conversion of the ruptured follicle into the corpus luteum. During the luteal phase, approximately days 15–28, the corpus luteum secretes large amounts of progesterone and also oestrogens. Progesterone maintains

the thickened endometrium and promotes its secretory activity; its glands and blood supply prepare the uterus for implantation and nourishment of the early embryo. The corresponding uterine phase is the secretory phase. Ovarian hormones exert negative feedback that limits further FSH and LH secretion during this phase.

Step 5: State how the cycle ends or is interrupted In the absence of fertilisation, the corpus luteum degenerates, progesterone and oestrogen secretion falls, and the endometrium breaks down to begin the next menstrual cycle. If fertilisation and successful implantation occur, the corpus luteum is maintained initially by human chorionic gonadotropin from the developing trophoblast. Progesterone secretion continues, the endometrium is maintained and menstruation does not occur during pregnancy.

Step 6: Conclusion Pituitary FSH and LH coordinate follicular maturation, ovulation and corpus-luteum formation in the ovary. Ovarian oestrogens rebuild the endometrium, while progesterone maintains its secretory state; withdrawal of these hormones causes menstruation when pregnancy does not occur.

Quick Tip to Solve: Link each ovarian event to its uterine effect: growing follicle–oestrogen–proliferation; corpus luteum–progesterone–secretion; corpus-luteum degeneration–hormone fall–menstruation.

OR

30. (a) Why does endosperm development precede embryo development in angiosperm seeds? State the role of endosperm in mature albuminous seeds. (b) Describe with the help of three labelled diagrams the different embryonic stages that include mature embryo of dicot plants. [5 marks]

Solution:

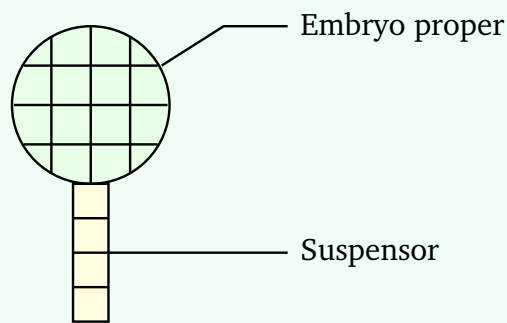
Concept:

- After double fertilisation, the primary endosperm nucleus produces the nutritive endosperm, while the zygote develops into the embryo.
- Dicot embryogenesis passes through a proembryo, globular and heart-shaped stages before forming a mature embryo with two cotyledons and an embryonal axis.

Step 1: (a) Explain the earlier development and role of endosperm Endosperm development precedes embryo development because the dividing and differentiating embryo needs a ready supply of food. The endosperm cells accumulate reserve food materials and nourish the developing embryo. Thus, endosperm formation establishes the nutritional support needed before extensive embryonic growth begins. In a mature albuminous seed, such as castor, a portion of the endosperm persists because it is not completely consumed during embryo development. This remaining endosperm stores food, which is mobilised during germination to nourish the embryo and young seedling until the seedling can sustain itself by photosynthesis.

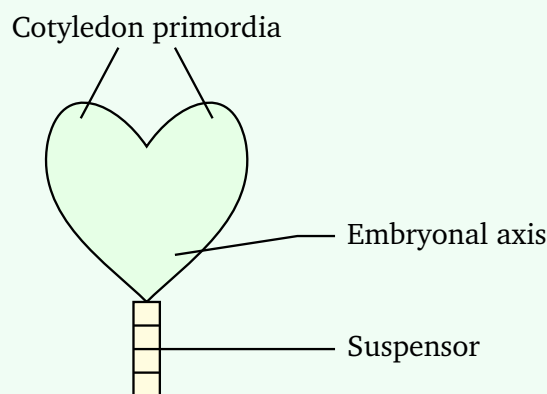
Step 2: (b) Trace the proembryo and globular stages The zygote divides mitotically to form a proembryo. Its terminal cell gives rise to most of the embryo proper, while the basal cell forms the suspensor. The suspensor supports the young embryo and pushes it into the nutritive endosperm. Further divisions of the embryo proper produce a rounded, multicellular globular embryo. At this

stage the two cotyledons are not yet distinct. The first labelled diagram shows this globular stage with its suspensor.



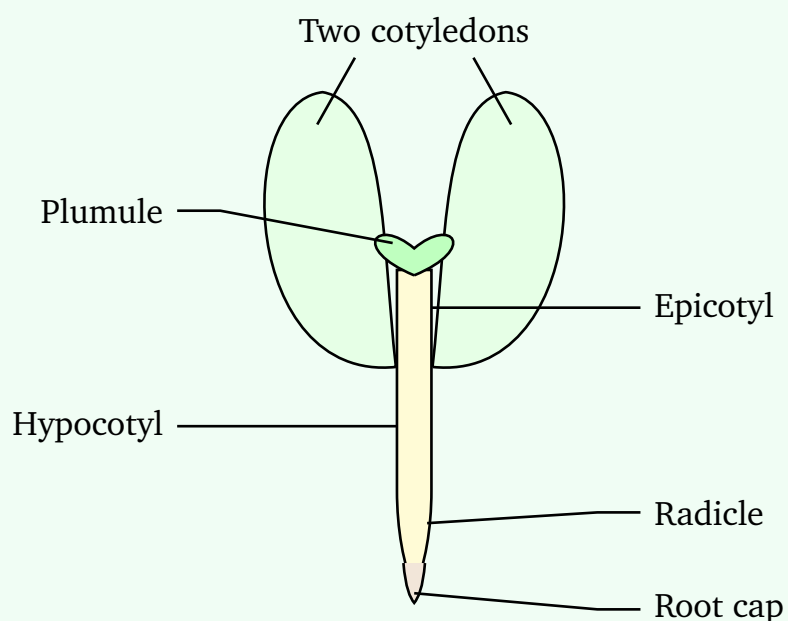
Globular embryo with suspensor

Step 3: Identify the heart-shaped stage Two lateral outgrowths develop from the globular embryo as cotyledon primordia. Their growth gives the embryo a characteristic heart-shaped outline, as shown in the second diagram. The two lobes will develop into the two cotyledons; the region between them is associated with the future shoot apex. The embryonal axis begins to become distinct below the cotyledons. Further elongation produces the torpedo stage and then the mature embryo.



Heart-shaped embryo with cotyledon primordia

Step 4: Describe the mature dicot embryo The mature embryo has two cotyledons attached to an embryonal axis. The part of the axis above the level of cotyledon attachment is the epicotyl, which terminates in the plumule, the future shoot. The part below this level is the hypocotyl, which ends in the radicle, the future root. A root cap covers the root tip. The third diagram labels these structures. The suspensor is a temporary embryonic structure and degenerates as the embryo matures.



Mature dicot embryo (schematic)

Step 5: Conclusion Endosperm forms first to supply nutrition for embryogenesis; persistent endosperm in albuminous seeds provides stored food during germination. The three diagrams show the globular, heart-shaped and mature dicot embryo stages, ending in an embryo with two cotyledons, a plumule and a radicle.

Quick Tip to Solve: Draw the sequence round embryo, two-lobed heart, mature two-cotyledon embryo; label plumule above and radicle below the cotyledon attachment level.