

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

## 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. What is pollen-pistil interaction and how is it mediated?

[1 mark]

#### Solution:

##### Concept:

- Pollen-pistil interaction includes the events from pollen deposition on the stigma until the pollen tube enters the ovule.
- The pistil recognises compatible pollen through chemical communication between pollen and pistil.

**Step 1: Identify the interaction** After pollination, the pistil recognises the pollen grain. Compatible pollen is accepted, germinates on the stigma and produces a pollen tube that grows through the style towards the ovule; incompatible pollen is rejected.

**Step 2: State the mediator** Recognition and subsequent acceptance or rejection are mediated by chemical components of the pollen interacting with those of the pistil. This chemical dialogue controls pollen germination and pollen-tube growth.

**Step 3: Conclusion** Pollen-pistil interaction is the series of events from pollen deposition to pollen-tube entry into the ovule, mediated by chemical components of pollen and pistil.

**Quick Tip to Solve:** Link pollen recognition to a chemical dialogue and then to acceptance or rejection.

### 2. Why do normal red blood cells become elongated sickle shaped structures in a person suffering from sickle cell anaemia?

[1 mark]

#### Solution:

##### Concept:

- Sickle cell anaemia results from a point mutation in the gene encoding the beta chain of haemoglobin.
- In abnormal haemoglobin, valine replaces glutamic acid at the sixth position of the beta chain.

**Step 1: Identify the molecular change** The mutation produces abnormal haemoglobin, called HbS. The replacement of glutamic acid by valine changes the properties of the haemoglobin molecule; the defect is in the protein inside the red blood cell.

**Step 2: Explain the change in shape** At low oxygen tension, HbS molecules polymerise into long fibres. These fibres distort the normally biconcave red blood cells, making them elongated and sickle shaped.

**Step 3: Conclusion** Under low oxygen tension, polymerisation of abnormal HbS distorts the red blood cells into elongated sickle shapes.

**Quick Tip to Solve:** Connect the beta-chain substitution to HbS polymerisation under low oxygen tension.

3. What is an autoimmune disease? Give an example.

[1 mark]

**Solution:**

**Concept:**

- The immune system normally distinguishes the body's own components from foreign substances.
- Autoimmunity occurs when immune responses are directed against the body's own cells or tissues.

**Step 1: Define the disease** An autoimmune disease is a disorder in which the immune system fails to recognise self components correctly and attacks the body's own cells or tissues. This inappropriate immune response damages the affected tissue.

**Step 2: Give a suitable example** Rheumatoid arthritis is an example. In this disorder, an immune attack on tissues of the joints produces inflammation and damage, illustrating an immune response against self rather than a foreign pathogen.

**Step 3: Conclusion** An autoimmune disease involves an immune attack on the body's own tissues; rheumatoid arthritis is an example.

**Quick Tip to Solve:** Use rheumatoid arthritis as the example and explicitly state that self tissues are attacked.

4. Write the two components of the first artificial recombinant DNA molecule constructed by Cohen and Boyer.

[1 mark]

**Solution:**

**Concept:**

- Recombinant DNA is formed by joining DNA fragments from different sources.
- A plasmid acts as a vector, carrying an inserted foreign DNA fragment.

**Step 1: Identify the inserted DNA** Cohen and Boyer isolated a DNA segment carrying a gene for antibiotic resistance by cutting it out of plasmid DNA. This resistance-gene fragment was one component of the recombinant molecule.

**Step 2: Identify the vector component** The antibiotic-resistance gene was linked to a native plasmid of *Salmonella typhimurium*. The plasmid served as the vector and DNA ligase joined the two DNA components to form the artificial recombinant molecule.

**Step 3: Conclusion** The two components were an antibiotic-resistance gene and a native plasmid of *Salmonella typhimurium*.

**Quick Tip to Solve:** Name the inserted antibiotic-resistance gene and the native *Salmonella* plasmid vector.

5. Name the host cells in which micro-injection technique is used to introduce an alien DNA.

[1 mark]

**Solution:**

**Concept:**

- Micro-injection introduces foreign DNA directly into a cell using a fine needle or micropipette.

- For animal cells, foreign DNA may be injected directly into the nucleus.

**Step 1: Name the host cells** Animal cells are the host cells in which micro-injection is used to introduce alien DNA. The technique delivers the genetic material physically into the recipient cell.

**Step 2: State how the DNA enters** A fine micropipette is used to inject the alien DNA directly into the nucleus of the animal cell. Direct delivery places the DNA inside the target compartment rather than relying on uptake from the surrounding medium.

**Step 3: Conclusion** Micro-injection is used in animal cells, with alien DNA injected directly into the nucleus.

**Quick Tip to Solve:** Associate micro-injection with direct nuclear injection in animal cells.

**6. Write the names of the enzymes that are used for isolation of DNA from bacterial and fungal cells respectively for Recombinant DNA Technology.** [1 mark]

**Solution:**

**Concept:**

- DNA isolation requires disruption of the cell envelope to release the cell contents.
- Cell-wall-degrading enzymes are selected according to the composition of the host cell wall.

**Step 1: Identify the bacterial enzyme** Bacterial cells are treated with lysozyme. It breaks down the peptidoglycan-containing bacterial cell wall, helping release cellular material for subsequent isolation of DNA.

**Step 2: Identify the fungal enzyme** Fungal cells are treated with chitinase because their cell walls contain chitin. Breaking down this wall permits release of the cell contents. Further purification then separates DNA from proteins and other cellular substances.

**Step 3: Conclusion** The enzymes are lysozyme for bacterial cells and chitinase for fungal cells, respectively.

**Quick Tip to Solve:** Preserve the printed order: bacteria–lysozyme; fungi–chitinase.

**7. State the purpose of signing the Montreal Protocol.** [1 mark]

**Solution:**

**Concept:**

- The stratospheric ozone layer absorbs much of the harmful ultraviolet radiation reaching Earth.
- Chlorofluorocarbons and related ozone-depleting substances damage the ozone layer.

**Step 1: Identify the environmental problem** Release of ozone-depleting substances, especially chlorofluorocarbons, causes depletion of stratospheric ozone. Loss of this protective layer allows more harmful ultraviolet radiation to reach Earth's surface.

**Step 2: State the purpose of the agreement** The Montreal Protocol was signed to protect the ozone layer by controlling and phasing out the production and consumption of ozone-depleting substances,

particularly chlorofluorocarbons. Reducing these substances addresses the cause of ozone depletion.

**Step 3: Conclusion** The Montreal Protocol aims to protect the ozone layer by controlling and phasing out ozone-depleting substances such as chlorofluorocarbons.

**Quick Tip to Solve:** Link the Montreal Protocol specifically to ozone protection and control of CFCs.

**8. In spite of being non-polluting, why are there great apprehensions in using nuclear energy for generating electricity?** [1 mark]

**Solution:**

**Concept:**

- Nuclear electricity generation does not release smoke like combustion of fossil fuels, but radioactive substances pose a separate environmental hazard.
- Ionising radiation can damage living cells and genetic material.

**Step 1: Identify the accident risk** Accidental leakage from a nuclear reactor can release dangerous ionising radiation into the surroundings. This can cause severe injury and can induce mutations and cancer in exposed organisms.

**Step 2: Identify the waste-disposal problem** Spent nuclear fuel and other radioactive wastes remain hazardous for long periods. Their safe storage and disposal are difficult, because radiation must be prevented from reaching people and the environment.

**Step 3: Conclusion** Apprehensions arise from the risk of accidental radiation leakage and the difficulty of safely disposing of long-lived radioactive waste.

**Quick Tip to Solve:** Remember both nuclear hazards: accidental leakage and persistent radioactive waste.

## Section B (20 marks)

**9. Name any two organisms and the phenomenon involved where the female gamete undergoes development to form new organisms without fertilization.** [2 marks]

**Solution:**

**Concept:**

- Parthenogenesis is the development of an unfertilised female gamete into a new individual.
- It differs from ordinary sexual reproduction because there is no fusion of male and female gametes.

**Step 1: Name the phenomenon** The phenomenon is parthenogenesis. Here the egg begins development without fertilisation; hence the presence of an egg does not imply that a male gamete has fused with it. The new individual therefore originates from the female gamete itself, rather than from a fertilised zygote. This distinguishes the phenomenon from development following normal gamete fusion.

**Step 2: Give two examples** Honeybee and rotifer are two organisms that show parthenogenesis. In honeybees, an unfertilised egg develops into a male bee, called a drone. Rotifers also produce

offspring from unfertilised eggs during parthenogenetic reproduction.

**Step 3: Conclusion** The phenomenon is parthenogenesis; examples are honeybee and rotifer.

**Quick Tip to Solve:** Associate the honeybee drone with development from an unfertilised egg.

**10. Explain pleiotropy with the help of an example.**

[2 marks]

**Solution:**

**Concept:**

- Pleiotropy occurs when a single gene influences more than one phenotypic character.
- A change in one enzyme can affect several physiological processes and therefore produce multiple observable effects.

**Step 1: Explain the principle** In pleiotropy, the effects on several characters originate from the action of one gene. They are not evidence that a different independent gene controls each of the associated effects.

**Step 2: Explain phenylketonuria as an example** Phenylketonuria results from a mutation affecting the enzyme phenylalanine hydroxylase. The affected individual cannot metabolise phenylalanine normally into tyrosine. The consequent metabolic disturbance causes intellectual disability and can also reduce pigmentation of the skin and hair. Thus one altered gene affects both mental development and pigmentation.

**Step 3: Conclusion** Phenylketonuria illustrates pleiotropy: one defective gene produces multiple phenotypic effects, including intellectual disability and reduced pigmentation.

**Quick Tip to Solve:** For pleiotropy, connect one gene to several effects through its enzyme or protein product.

**11. A template strand is given below. Write down the corresponding coding strand and the mRNA strand that can be formed, along with their polarity.**

3'-ATGCATGCATGCATGCATGC-5'

[2 marks]

**Solution:**

**Concept:**

- DNA strands are complementary and antiparallel: A pairs with T, and G pairs with C.
- RNA polymerase reads the template in the 3' → 5' direction and synthesises RNA in the 5' → 3' direction. RNA uses U in place of T.

**Step 1: Construct the coding strand** The given template is 3'-ATGCATGCATGCATGCATGC-5'. Complement each base without reversing the displayed order, since the template is already written

from its 3-prime end to its 5-prime end. The antiparallel coding strand is therefore

5'-TACGTACGTACGTACGTACG-3'.

**Step 2: Transcribe the messenger RNA** The RNA is complementary to the template, so each template A specifies U, T specifies A, G specifies C and C specifies G. Equivalently, replace every T in the coding strand by U, retaining its polarity:

5'-UACGUACGUACGUACGUACG-3'.

**Step 3: Conclusion** The two required strands, both written from 5-prime to 3-prime, are:

Coding DNA: 5'-TACGTACGTACGTACGTACG-3'

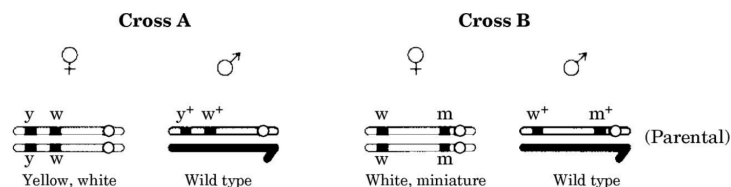
mRNA: 5'-UACGUACGUACGUACGUACG-3'.

**Quick Tip to Solve:** Copy the coding strand into mRNA by replacing T with U while keeping the same polarity.

OR

11. Study the figures given below and answer the question.

**Cross A:** female  $yw/yw$  x male  $y^+w^+/Y$  (parental phenotypes Yellow, white x Wild type). **Cross B:** female  $wm/wm$  x male  $w^+m^+/Y$  (parental phenotypes White, miniature x Wild type). Identify in which of the crosses is the strength of linkage between the genes higher. Give reasons in support of your answer. [2 marks]



**Solution:**

**Concept:**

- Linkage is the tendency of genes on the same chromosome to be inherited together.
- The closer two loci are, the smaller the probability of crossing over between them and the stronger their linkage.

**Step 1: Compare the positions shown** In cross A, the loci for yellow body ( $y$ ) and white eyes ( $w$ ) are situated close together on the X chromosome. In cross B, the white-eye ( $w$ ) and miniature-wing ( $m$ ) loci are shown farther apart. The relevant comparison is the separation of the two loci on the same chromosome.

**Step 2: Relate distance to recombination** Because  $y$  and  $w$  are closer, crossing over between these loci is less frequent. They therefore produce fewer recombinant combinations and are inherited together

more often. The greater separation of w and m permits more crossing over and a higher frequency of recombinants, indicating weaker linkage.

**Step 3: Conclusion** Linkage is stronger in cross A because the yellow-body and white-eye genes are closer together and show less recombination than the white-eye and miniature-wing genes in cross B.

**Quick Tip to Solve:** Compare the distance between loci: closer loci mean fewer recombinants and stronger linkage.

## 12. Where does peptide bond formation occur in a bacterial ribosome and how?

[2 marks]

### Solution:

#### Concept:

- A bacterial ribosome is a 70S ribosome made of a small 30S and a large 50S subunit. The large subunit contains the catalytic centre for peptide-bond formation.
- A peptide bond joins the carboxyl group of one amino acid to the amino group of another during translation.

**Step 1: Identify the site and catalyst** Peptide-bond formation occurs at the peptidyl-transferase centre of the large 50S subunit. Its 23S ribosomal RNA acts as the catalytic RNA, or ribozyme, responsible for this reaction.

**Step 2: Explain how the bond is formed** The ribosome positions the peptidyl-tRNA carrying the growing chain in its P site and the incoming aminoacyl-tRNA in its A site. Peptidyl transferase catalyses attachment of the chain to the amino group of the amino acid on the A-site tRNA. A new peptide bond forms, and the extended chain is transferred from the P-site tRNA to the A-site tRNA.

**Step 3: Conclusion** Thus, peptide bonds form in the 50S subunit, catalysed by its 23S rRNA through peptidyl transfer between adjacent tRNA-bound amino acids.

**Quick Tip to Solve:** For a bacterial ribosome, connect 50S with peptide-bond formation and 23S rRNA with the ribozyme catalyst.

## 13. What is 'withdrawal syndrome'? List any two symptoms it is characterised by.

[2 marks]

### Solution:

#### Concept:

- Repeated consumption of an addictive drug or alcohol can produce physical and psychological dependence. The body becomes accustomed to its regular presence.
- Withdrawal refers to the response when an established dependence is interrupted; it is distinct from the immediate effects of taking the substance.

**Step 1: Define withdrawal syndrome** Withdrawal syndrome is the characteristic group of unpleasant physical and psychological symptoms experienced by a dependent person when regular use of an addictive drug or alcohol is abruptly stopped or its supply is substantially reduced. The symptoms

arise because the body has adapted to functioning in the presence of the substance.

**Step 2: State two characteristic symptoms** Two symptoms are anxiety and shakiness, or tremors. Anxiety produces marked uneasiness and apprehension, while shakiness involves involuntary trembling. These symptoms after interruption of habitual intake indicate dependence rather than simply a desire to use the substance again.

**Step 3: Conclusion** Withdrawal syndrome is the unpleasant response to abrupt discontinuation of a substance on which a person is dependent; anxiety and shakiness are two characteristic symptoms.

**Quick Tip to Solve:** Link withdrawal with stopping habitual intake, then name two clear symptoms such as anxiety and tremors.

**14. How is insertional inactivation of an enzyme used as a selectable marker to differentiate recombinants from non-recombinants?**

[2 marks]

**Solution:**

**Concept:**

- Insertional inactivation occurs when foreign DNA is inserted within a functional gene and disrupts its expression or the activity of its protein product.
- The enzyme  $\beta$ -galactosidase provides a convenient screen because its activity produces a blue colour in the presence of a suitable chromogenic substrate.

**Step 1: Insert the foreign DNA into the marker gene** A cloning vector carries the marker region for  $\beta$ -galactosidase activity. Inserting the desired foreign DNA into this region inactivates the marker. A recombinant vector therefore cannot produce the functional enzyme activity needed for the colour reaction. A non-recombinant vector retains the intact marker and its enzyme activity.

**Step 2: Distinguish colonies using colour** After transformation, the bacteria are grown on medium containing a chromogenic substrate such as X-gal. Colonies containing non-recombinant vectors produce active  $\beta$ -galactosidase and turn blue. Colonies containing recombinant vectors have the insertional inactivated marker and remain white. White colonies are selected as putative recombinants from the transformed colonies.

**Step 3: Conclusion** Insertional inactivation distinguishes white recombinant colonies from blue non-recombinant colonies by loss of  $\beta$ -galactosidase activity.

**Quick Tip to Solve:** Remember the colour test as intact enzyme gives blue; an insert interrupts the enzyme marker and gives white.

15. Explain how Eli Lilly, an American company, produced insulin by recombinant DNA technology.

[2 marks]

**Solution:**

**Concept:**

- Mature human insulin consists of an A polypeptide chain and a B polypeptide chain linked by disulphide bonds. These two chains together form the active hormone.
- Human proinsulin also contains a connecting C peptide, which is removed during maturation. Producing the mature A and B chains separately avoids retaining this C peptide in the final insulin.

**Step 1: Express the two insulin chains separately** In 1983, Eli Lilly prepared two DNA sequences corresponding to the A and B chains of human insulin. Each sequence was introduced separately into a plasmid of *Escherichia coli*. The transformed bacterial cells were cultured so that one set produced the A chain and another set produced the B chain.

**Step 2: Recover and assemble active insulin** The A and B polypeptide chains were extracted and purified separately from the bacterial cultures. The purified chains were then combined under conditions allowing the correct disulphide bonds to form between them. Joining these chains produced mature, functional human insulin without the connecting C peptide of proinsulin.

**Step 3: Conclusion** Eli Lilly produced the A and B chains separately using recombinant bacterial plasmids, then purified and joined the chains through disulphide bonds to obtain human insulin.

**Quick Tip to Solve:** Organise this answer into two stages: separate bacterial production of A and B chains, followed by disulphide-bond assembly.

16. Explain Verhulst-Pearl Logistic Growth of a population.

[2 marks]

**Solution:**

**Concept:**

- Population growth depends on available resources; a habitat can support only a finite population, called its carrying capacity,  $K$ .
- The Verhulst-Pearl logistic equation is  $\frac{dN}{dt} = rN \left( \frac{K - N}{K} \right)$ , where  $N$  is population size,  $t$  is time and  $r$  is the intrinsic rate of natural increase.

**Step 1: Describe growth under limited resources** When resources are initially abundant, the population increases rapidly after an initial lag phase. As population density rises, food, space and other resources become limiting. Competition increases and the rate of population growth slows, so exponential growth cannot continue indefinitely.

**Step 2: Explain the carrying-capacity limit** In the logistic equation, the factor  $(K - N)/K$  represents the effect of environmental resistance. It decreases as  $N$  approaches  $K$ . At  $N = K$ , the net growth rate becomes zero and population size becomes approximately stationary. A plot of population size against time therefore gives an S-shaped or sigmoid curve.

**Step 3: Conclusion** Verhulst-Pearl logistic growth is density-dependent growth under limited resources:

the population passes through lag, rapid growth and deceleration before stabilising near the carrying capacity  $K$ , producing a sigmoid curve.

**Quick Tip to Solve:** Remember logistic growth by linking limited resources to carrying capacity: the factor  $(K - N)/K$  becomes zero when  $N = K$ .

**17. Differentiate between commensalism and mutualism by taking one example each from plants only.** [2 marks]

**Solution:**

**Concept:**

- Commensalism is an interspecific interaction in which one partner benefits and the other is neither benefited nor harmed:  $(+, 0)$ .
- Mutualism is an interspecific interaction in which both partners benefit:  $(+, +)$ .

**Step 1: Explain commensalism with a plant example** An epiphytic orchid growing on a mango tree obtains physical support and a favourable position for receiving light. The orchid does not draw its food from the mango tree. Thus the orchid benefits, while the mango tree is neither helped nor harmed; this is commensalism.

**Step 2: Explain mutualism with a plant-associated example** Lichens represent a mutualistic association between an alga and a fungus. The photosynthetic algal partner prepares organic food, which is available to the fungal partner. The fungus supplies the alga with water and mineral nutrients and provides shelter. Since each partner receives a benefit from the association, the interaction is mutualism.

**Step 3: Conclusion** Commensalism benefits only one partner, as in an epiphytic orchid on a mango tree; mutualism benefits both partners, as in the algal-fungal association of a lichen.

**Quick Tip to Solve:** For each example, identify who receives what: orchid gets support only; in lichens, algae supply food and fungi supply water, minerals and shelter.

**18. List the two steps that are essential for carrying out artificial hybridization in crop plants and why.** [2 marks]

**Solution:**

**Concept:**

- Artificial hybridization brings together selected parental plants by transferring pollen from the chosen male parent to the stigma of the chosen female parent.
- Emasculation and bagging prevent unwanted pollination, ensuring that the intended pollen produces the hybrid.

**Step 1: Carry out emasculation** In a bisexual flower selected as the female parent, remove the anthers from the flower bud before they dehisce and release pollen. This prevents the flower from

pollinating itself with its own pollen. The stigma and other female reproductive parts must remain intact. Emasculation is unnecessary when the selected female flower is unisexual and lacks anthers.

**Step 2: Carry out bagging** Cover the emasculated flower with a suitable bag, usually made of butter paper, to prevent contamination of its stigma by unwanted pollen. When the stigma becomes receptive, dust pollen collected from the selected male parent onto it. Rebag the pollinated flower and allow fruit development. Bagging therefore protects the intended cross from foreign pollen.

**Step 3: Conclusion** The two essential protective steps are emasculation, to prevent self-pollination, and bagging, to prevent pollination by unwanted pollen and preserve the selected parental cross.

**Quick Tip to Solve:** Distinguish their purposes: emasculation removes the flower's own pollen source, while bagging blocks pollen arriving from outside.

### Section C (27 marks)

**19. Write the differences between wind-pollinated and insect-pollinated flowers. Give an example of each type.** [3 marks]

#### Solution:

##### Concept:

- Wind pollination (anemophily) transfers pollen by air currents; insect pollination (entomophily) transfers pollen on visiting insects.
- Flower structure, pollen characteristics and stigma structure are adapted to the respective agent of pollen transfer.

**Step 1: Compare floral attraction and rewards** Wind-pollinated flowers are usually small and inconspicuous, without showy petals, fragrance or nectar because wind needs no attraction. Insect-pollinated flowers are generally conspicuous or brightly coloured and commonly offer fragrance, nectar or edible pollen to attract visiting insects.

**Step 2: Compare pollen and anthers** Wind-pollinated flowers produce very large quantities of light, dry, non-sticky pollen that air currents can carry. Their stamens are commonly well exposed so that pollen is readily dispersed. In insect-pollinated flowers, pollen grains are generally sticky and often spiny, helping them adhere to insect bodies. Their anthers are positioned so that visiting insects brush against them.

**Step 3: Compare stigmas and give examples** Wind-pollinated flowers usually have large, feathery and exposed stigmas that trap airborne pollen. Insect-pollinated flowers generally have sticky stigmas placed where the visiting insect deposits pollen; they do not require a large feathery surface. Maize is an example of wind pollination, while sunflower is an example of insect pollination.

**Step 4: Conclusion** Wind-pollinated flowers, such as maize, favour airborne dispersal with abundant light pollen and feathery stigmas. Insect-pollinated flowers, such as sunflower, attract insect visitors and use adhesive pollen and receptive stigmas to accomplish transfer.

**Quick Tip to Solve:** Compare the same features in both columns: attraction, pollen, anthers and stigma. Link each feature to wind carriage or insect contact.

**20. (a) How is placenta formed in the human female? (b) Name any two hormones which are secreted by it and are also present in a non-pregnant woman.** [3 marks]

**Solution:**

**Concept:**

- After implantation, the trophoblast of the human embryo develops finger-like projections called chorionic villi.
- The placenta is a temporary connection formed jointly by foetal chorionic villi and maternal uterine tissue; it also acts as an endocrine organ.

**Step 1: Explain placental formation (a)** Following implantation of the blastocyst in the endometrium, the trophoblast develops chorionic villi. These villi grow into and become closely interdigitated with the surrounding maternal uterine tissue. The chorionic villi, containing foetal blood capillaries, and the maternal endometrial tissue together form the placenta. This close association provides a large surface for exchange: oxygen and nutrients pass towards the foetus, while carbon dioxide and metabolic wastes pass towards the mother. Maternal and foetal blood normally remain in separate circulations, with exchange across the placental barrier.

**Step 2: Identify the two hormones (b)** The placenta secretes oestrogens and progesterone, both of which also occur in a non-pregnant woman. In a non-pregnant woman these hormones are produced by the ovaries: developing follicles are important sources of oestrogens, while the corpus luteum secretes progesterone after ovulation. During pregnancy, placental secretion of these hormones helps maintain the uterine endometrium and supports continuation of pregnancy.

**Step 3: Conclusion** The placenta forms through interdigitation of chorionic villi with maternal uterine tissue. The two required hormones are oestrogens and progesterone.

**Quick Tip to Solve:** For hormones shared by pregnant and non-pregnant women, recall the normal ovarian hormones: oestrogens and progesterone.

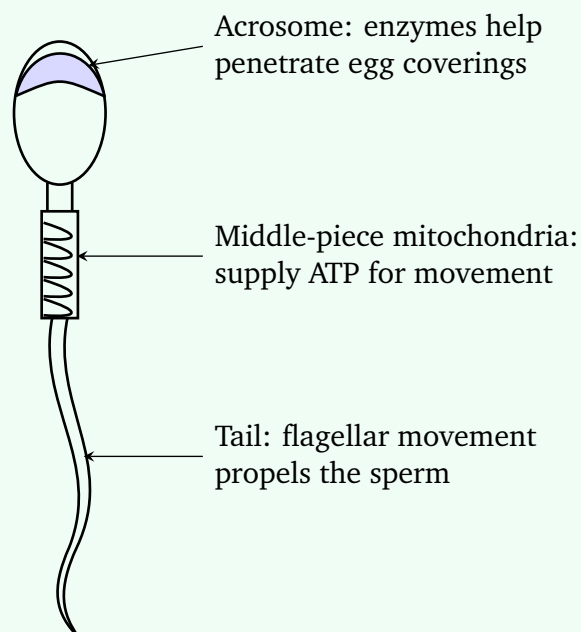
**21. Draw a diagram of a human sperm. Label only those parts along with their functions, that assist the sperm to reach and gain entry into the female gamete.** [3 marks]

**Solution:**

**Concept:**

- The sperm is a motile male gamete; its flagellar tail provides movement towards the female gamete.
- Mitochondria in the middle piece supply energy for motility, while enzymes in the acrosome assist penetration of the egg coverings.

**Step 1: Draw and identify the functional regions** The figure shows the outline of a human sperm. Only the regions directly involved in reaching the egg or gaining entry into it are labelled: the acrosome, the mitochondria of the middle piece, and the tail. The cap at the anterior end is the acrosome; the mitochondrial region is immediately behind the head; the long slender extension is the flagellar tail.



*Human sperm: parts involved in movement and entry into the egg*

**Step 2: Explain movement towards the female gamete** The tail produces flagellar movements that propel the sperm through the female reproductive tract towards the ovum. The middle piece contains numerous mitochondria, which generate ATP to supply the energy required for these movements. Thus the tail provides propulsion, while mitochondrial activity powers it; these functions work together to enable effective sperm motility.

**Step 3: Explain entry into the female gamete** The acrosome is the cap-like structure over the anterior part of the sperm head. It contains hydrolytic enzymes that are released during the acrosomal reaction and help the sperm penetrate the protective coverings surrounding the female gamete. After penetration, the sperm and egg plasma membranes can fuse, permitting entry of sperm contents into the egg.

**Step 4: Conclusion** The labelled functional parts are: tail for propulsion, middle-piece mitochondria for energy, and acrosome for enzymatic penetration of the egg coverings.

**Quick Tip to Solve:** Associate the three functional labels with three actions: tail moves, mitochondria supply ATP, and acrosome helps penetration.

**22. (a) Write the conclusions Mendel arrived at on dominance of traits on the basis of monohybrid crosses that he carried out in pea plants. (b) Explain why a recessive allele is unable to express itself in a heterozygous state.** [3 marks]

**Solution:**

**Concept:**

- A pair of alleles controls a character in a diploid individual; in complete dominance, the dominant allele determines the heterozygous phenotype.

- An allele may encode a functional enzyme. A recessive allele often produces a non-functional product, and one functional allele can produce enough enzyme for the normal phenotype.

**Step 1: State conclusions from the monohybrid crosses (a)** Mendel crossed true-breeding pea plants showing contrasting forms of a character, for example tall plants  $TT$  with dwarf plants  $tt$ . All  $F_1$  offspring were tall  $Tt$ , showing that only one of the two contrasting traits was expressed in the hybrid. He called the expressed trait dominant and the masked trait recessive. When the  $F_1$  plants were self-pollinated, the recessive dwarf trait reappeared in  $F_2$ , with tall and dwarf plants in an approximately 3 : 1 phenotypic ratio. Thus the recessive factor was retained intact in the hybrid; it had been masked rather than lost or blended with the dominant factor.

**Step 2: Explain recessiveness in the heterozygote (b)** In a typical enzyme-controlled character, the normal dominant allele produces a functional enzyme, whereas a modified recessive allele may produce a non-functional enzyme or no enzyme. In the heterozygous condition, the dominant allele still supplies enough functional enzyme to carry out the biochemical reaction and produce the dominant phenotype. The recessive allele therefore does not determine a visibly different phenotype in that heterozygote. In the homozygous recessive condition, no functional copy is available, so the altered phenotype becomes evident. This explanation applies to the complete-dominance situation asked about here.

**Step 3: Conclusion** Mendel concluded that one trait is dominant and masks its recessive counterpart in the hybrid. A recessive allele is masked in a heterozygote because the functional product of the dominant allele is sufficient to produce the dominant phenotype.

**Quick Tip to Solve:** Use the reappearance of dwarf plants in the second generation to show that the recessive allele was masked, not destroyed.

**23. Name the form of Plasmodium that gains entry into the human body. Explain the different stages of its life-cycle in the human body.** [3 marks]

**Solution:**

**Concept:**

- Malaria is caused by the protozoan parasite *Plasmodium*. Its infective stage for humans is the sporozoite, introduced by an infected female Anopheles mosquito.
- Asexual multiplication occurs first in liver cells and subsequently in red blood cells. Gametocytes are the stages taken up by another mosquito.

**Step 1: Entry and liver stage** An infected female Anopheles mosquito injects sporozoites along with its saliva while taking a blood meal. The sporozoites reach the liver through the bloodstream and enter liver cells. They multiply asexually within these cells, producing numerous merozoites. Rupture of the infected liver cells releases these merozoites into the blood.

**Step 2: Multiplication in red blood cells** Merozoites invade red blood cells (RBCs), where they grow and undergo repeated asexual multiplication. The infected RBCs rupture, releasing a fresh generation of merozoites that invade more RBCs. Rupture also releases the toxic substance haemozoin, which is responsible for the characteristic chills and high fever recurring in malaria. Thus the RBC cycle

repeatedly amplifies the infection.

**Step 3: Formation of gametocytes** Some parasites in RBCs differentiate into male and female gametocytes instead of continuing asexual multiplication. These remain in human blood and are ingested by a female Anopheles mosquito when it bites the infected person. Fertilisation and further development occur in the mosquito, completing the connection between the two hosts; they do not occur in human blood.

**Step 4: Conclusion** The sporozoite enters the human body. In humans, the sequence is liver-cell multiplication, repeated RBC infection and rupture, and differentiation of some parasites into gametocytes.

**Quick Tip to Solve:** Remember the human sequence: sporozoite to liver to RBCs to gametocytes; associate RBC rupture with haemozoin and fever.

OR

**23. (a) Name and explain giving reasons, the type of immunity provided to the newborn by the colostrum and vaccinations. (b) Name the type of antibody (i) present in colostrum (ii) produced in response to allergens in human body.** [3 marks]

**Solution:**

**Concept:**

- Passive immunity is acquired by receiving preformed antibodies; active immunity develops when the recipient responds to an antigen and forms an immune response.
- Antibody classes differ in function: IgA protects mucosal surfaces, whereas IgE mediates immediate allergic responses.

**Step 1: (a) Immunity from colostrum** Colostrum, the first milk secreted by the mother after childbirth, is rich in antibodies. It gives the newborn naturally acquired passive immunity because ready-made maternal antibodies are transferred to the infant. The infant does not have to make these antibodies in response to that exposure. They provide immediate protection, especially at mucosal surfaces, but protection is temporary because the transferred antibodies are gradually degraded and do not themselves establish the infant's immune memory.

**Step 2: (a) Immunity from vaccination** Vaccination provides artificially acquired active immunity. A vaccine introduces antigens, such as weakened or killed pathogens or their antigenic components, into the body. These stimulate the infant's own immune system to produce specific antibodies and memory cells. Consequently, a later encounter with the same pathogen evokes a faster and stronger secondary immune response. Unlike colostrum, vaccination relies on the recipient generating the protective response rather than merely receiving preformed antibodies.

**Step 3: (b) Identify the antibodies** (i) The principal protective antibody in colostrum is immunoglobulin A (IgA), particularly secretory IgA. It helps protect the infant's mucosal surfaces. (ii) The antibody produced in response to allergens and associated with allergic reactions is immunoglobulin E (IgE). IgE binds to mast cells; exposure to the corresponding allergen can trigger release of mediators such

as histamine.

**Step 4: Conclusion** Colostrum provides natural passive immunity, while vaccination provides artificial active immunity. The antibodies requested are (i) IgA in colostrum and (ii) IgE in allergic responses.

**Quick Tip to Solve:** Ask whether antibodies are received or made: received means passive; made after vaccination means active. Link milk with IgA and allergy with IgE.

24. Identify a, b, c, d, e and f in the table given below :

| Scientific Name of the organism | Product produced                      | Use in human welfare |
|---------------------------------|---------------------------------------|----------------------|
| Streptococcus                   | Streptokinase that was later modified | a                    |
| b                               | Cyclosporin A                         | c                    |
| Monascus purpureus              | d                                     | e                    |
| Lactobacillus                   | f                                     | sets milk into curd  |

[3 marks]

**Solution:**

**Concept:**

- Microbes produce medically useful enzymes, immunosuppressants and cholesterol-lowering compounds through industrial cultivation.
- Lactic acid bacteria ferment milk sugar to lactic acid, which causes coagulation of milk proteins and curd formation.

**Step 1: Identify a: role of modified streptokinase** The enzyme streptokinase is obtained from Streptococcus and is modified for therapeutic use as a clot buster. Thus a is removal or dissolution of blood clots, especially in blood vessels of patients who have suffered myocardial infarction. Its relevant role is helping to clear a blocked blood vessel, rather than preventing organ rejection or lowering blood cholesterol.

**Step 2: Identify b and c: cyclosporin A** The organism b is the fungus Trichoderma polysporum. Its product, cyclosporin A, is used as an immunosuppressive agent in organ-transplant patients, so c is suppression of the immune response to reduce graft rejection. This treatment limits the recipient's immune attack on transplanted tissue.

**Step 3: Identify d and e: product of Monascus** The yeast Monascus purpureus produces statins, so d is statins. They are used as blood-cholesterol-lowering agents, so e is lowering blood cholesterol. Statins act by competitively inhibiting the enzyme responsible for cholesterol synthesis; this distinguishes their action from clot dissolution by streptokinase.

**Step 4: Identify f: product of Lactobacillus** Lactobacillus produces lactic acid by fermentation of lactose in milk. Therefore f is lactic acid. Accumulation of this acid lowers the pH and causes milk proteins to coagulate, setting milk into curd. The blank asks for the microbial product responsible for this change, not the name of the curd itself.

**Step 5: Conclusion** a: clot buster; b: Trichoderma polysporum; c: immunosuppression in organ transplantation; d: statins; e: lowering blood cholesterol; f: lactic acid.

**Quick Tip to Solve:** Pair each microbe with its distinctive function: Streptococcus-clots, Trichoderma-transplants, Monascus-cholesterol, Lactobacillus-curd.

**25. (a) List the three steps involved in Polymerase Chain Reaction (PCR). (b) Name the source organism of Taq polymerase. Explain the specific role of this enzyme in PCR.** [3 marks]

**Solution:**

**Concept:**

- PCR amplifies a selected DNA segment by repeated cycles of strand separation, primer binding and DNA synthesis.
- A thermostable DNA polymerase extends primers using the template strands and deoxyribonucleotides.

**Step 1: Identify the three steps in part (a)** Denaturation: heat the double-stranded DNA, generally to about 94–95 °C, to separate its two strands. Annealing: lower the temperature so that two specific primers bind to complementary sequences flanking the target region on opposite strands. Extension: raise the temperature to about 72 °C, allowing DNA polymerase to extend the primers and form complementary DNA strands. Repetition of these three steps produces many copies of the selected segment.

**Step 2: Name the source and explain the enzyme in part (b)** Taq polymerase is obtained from the thermophilic bacterium *Thermus aquaticus*. It catalyses the addition of deoxyribonucleotides to the free 3' ends of the annealed primers, synthesising new DNA in the 5' → 3' direction. Its thermostability allows it to remain active despite the high temperature used to denature DNA in successive cycles, so fresh enzyme need not be supplied after every denaturation step.

**Step 3: Conclusion** The three PCR steps are denaturation, annealing and extension. Taq polymerase, from *Thermus aquaticus*, performs thermostable primer extension to synthesise new DNA.

**Quick Tip to Solve:** Remember PCR in the order separate, bind, build: heat separates DNA, cooling binds primers, and Taq builds DNA.

**26. What is 'biofortification'? Write its importance. Mention the contribution of Indian Agricultural Research Institute towards it with the help of two examples.** [3 marks]

**Solution:**

**Concept:**

- Biofortification improves the nutritional quality of food crops through plant breeding.
- Nutritional improvement may target protein content and quality, oil quality, vitamins or mineral nutrients.

**Step 1: Define biofortification and its importance** Biofortification is the breeding of crops to increase their nutritional value, for example by raising their vitamin, mineral or protein content or improving protein and fat quality. It helps combat malnutrition and nutrient-deficiency disorders by making commonly eaten foods more nutritious. This is especially useful where people depend heavily on a limited range of staple foods and cannot regularly obtain a varied, balanced diet. The aim is improved nutritional quality, not merely a larger crop yield.

**Step 2: Give two contributions of IARI** The Indian Agricultural Research Institute (IARI), New Delhi,

has released vegetable crops enriched with vitamins and minerals. Two examples are: (i) vitamin A-enriched carrot, which improves dietary intake of provitamin A carotenoids; and (ii) vitamin C-enriched bitter melon, which supplies more vitamin C through a commonly consumed vegetable. These illustrate how breeding for particular nutrients can improve the quality of everyday diets. Both the crop and the enriched nutrient should be identified in each example.

**Step 3: Conclusion** Biofortification breeds nutritionally improved crops to help reduce malnutrition. IARI examples include vitamin A-enriched carrot and vitamin C-enriched bitter melon.

**Quick Tip to Solve:** Pair each IARI crop with its nutrient: carrot with vitamin A, and bitter melon with vitamin C.

**27. Presently, air quality of Delhi has significantly improved in comparison to what existed before 1997. This is the result of a lot of conscious human efforts. You are being asked to conduct an awareness programme in your locality wherein you will comment on the steps taken by Delhi Government to improve the air quality. (a) Write any two of your comments. (b) List any two ways that you would include in your programme so as to ensure the maintenance of good quality of air. (c) State any two values your programme will inculcate in the people of your locality.** [3 marks]

**Solution:**

**Concept:**

- Air pollution can be reduced by cleaner fuels, lower vehicle emissions and community participation.
- Maintaining clean air requires both governmental measures and responsible everyday choices.

**Step 1: Part (a): two comments on government measures** (i) Delhi switched its public bus transport from diesel to compressed natural gas (CNG). CNG burns more cleanly than diesel and reduces smoke and particulate emissions from this important transport source. (ii) Old, highly polluting vehicles were phased out and vehicle-emission norms were made stricter. Removing poorly performing vehicles and enforcing emission limits help reduce the amount of harmful exhaust released into city air. These comments describe the measures referred to in the historical setting of the question.

**Step 2: Part (b): two practices for the locality** (i) Encourage residents to use public transport or carpools and to walk or cycle for short trips. Fewer private vehicle journeys reduce fuel consumption and exhaust emissions. (ii) Ensure regular vehicle servicing and pollution-under-control checks, with prompt repair of vehicles that emit excessive smoke. Proper maintenance improves combustion and helps keep emissions within prescribed limits. The awareness programme should explain these actions in practical terms so that residents can adopt them regularly.

**Step 3: Part (c): two values promoted** (i) Environmental responsibility: people recognise their duty to protect clean air and the health of other living beings. (ii) Cooperation and social responsibility: residents work together, follow pollution-control measures and consider the health of the entire community when choosing transport and maintaining vehicles.

**Step 4: Conclusion** Cleaner public transport and control of polluting vehicles improved air quality. Shared transport and vehicle maintenance help sustain it, while the programme encourages environmental responsibility and cooperation.

**Quick Tip to Solve:** Keep the three parts distinct: two government measures, two personal practices, and two values.

### Section D (15 marks)

**28. (a)** What was proposed by Oparin and Haldane on origin of life? How did S.L. Miller's experiment support their proposal? **(b)** Which human chromosome has (i) maximum number of genes, and which one has (ii) fewest genes? **(c)** Write the scientific importance of single nucleotide polymorphism identified in human genome. [5 marks]

#### Solution:

##### Concept:

- Chemical evolution is the formation of organic molecules from inorganic substances under the conditions of the primitive Earth; these molecules preceded the first cellular life.
- Miller's experiment tested whether organic compounds could form abiotically in a simulated reducing atmosphere supplied with an energy source.
- A single nucleotide polymorphism (SNP) is a variation at a single nucleotide position in the genome among individuals; such variations can serve as genetic markers.

**Step 1: (a) State the Oparin-Haldane proposal** Oparin and Haldane proposed that the first life arose from pre-existing, non-living organic molecules, such as those leading to RNA and proteins. Before biological evolution, chemical evolution produced complex organic molecules from inorganic precursors. The primitive Earth had high temperature and a reducing atmosphere containing gases such as methane, ammonia, hydrogen and water vapour, with little or no free oxygen. Energy from lightning could drive organic synthesis; further changes eventually led to life.

**Step 2: (a) Explain Miller's experimental support** In 1953, S. L. Miller established a closed apparatus containing methane, ammonia, hydrogen and water vapour to simulate the primitive atmosphere. Water was heated to provide vapour, and electric discharges were passed through the gas mixture to simulate lightning. The circulating products were cooled and collected. Analysis revealed the formation of amino acids, the building blocks of proteins, from these simple starting substances. Thus, the experiment supplied experimental evidence for the abiotic synthesis of organic molecules under proposed early-Earth conditions. It supported the chemical-evolution stage of the proposal; it did not create a living cell.

**Step 3: (b) Identify the chromosomes** (i) Human chromosome 1 has the maximum number of genes; the Human Genome Project account gives about 2968 genes. (ii) The Y chromosome has the fewest genes, about 231 in the same account.

**Step 4: (c) Explain the significance of SNPs** Single nucleotide polymorphisms provide identifiable points of DNA variation distributed across the human genome. They are useful markers for locating chromosomal regions associated with diseases: researchers can compare SNP patterns and disease occurrence to help identify disease-associated genes or sequences. Comparing these variations among individuals and populations also helps trace human evolutionary history and relationships.

**Step 5: Conclusion** Oparin and Haldane proposed chemical evolution before the origin of life, and Miller supported it by synthesising amino acids abiotically. Chromosome 1 has the most genes and the Y chromosome the fewest. SNPs help locate disease-associated sequences and trace human evolutionary history.

**Quick Tip to Solve:** Link Miller's gases, electric sparks and amino-acid products to chemical evolution; remember chromosome 1 for most genes and Y for fewest.

**28.** A cross was carried out between a pea plant heterozygous for round and yellow seeds with a pea plant having wrinkled and green seeds. (a) Show the cross in a Punnett square. (b) Write the phenotype of the progeny of this cross. (c) What is this cross known as? State the purpose of conducting such a cross.

[5 marks]

**Solution:****Concept:**

- In pea plants, round seed shape ( $R$ ) is dominant over wrinkled shape ( $r$ ), and yellow seed colour ( $Y$ ) is dominant over green colour ( $y$ ). A plant heterozygous for both characters therefore has genotype  $RrYy$ .
- During gamete formation the alleles of each pair segregate. With independent assortment of the two gene pairs,  $RrYy$  produces  $RY$ ,  $Ry$ ,  $rY$  and  $ry$  gametes in equal proportions.
- A test cross mates an individual showing dominant characters with a homozygous recessive individual. The offspring reveal which alleles were contributed by the dominant parent.

**Step 1: (a) Identify the parents and their gametes** The round, yellow parent is heterozygous for both traits, so its genotype is  $RrYy$ . The wrinkled, green parent must be homozygous recessive for both genes,  $rryy$ . Thus the parental cross is

$$RrYy \text{ (round, yellow)} \times rryy \text{ (wrinkled, green)}.$$

The first parent forms four kinds of gametes,  $RY$ ,  $Ry$ ,  $rY$  and  $ry$ , each with probability  $1/4$ . The recessive parent forms only  $ry$  gametes because it has no dominant allele at either locus.

**Step 2: (a) Construct the Punnett square** Place the four gametes of the heterozygous parent along the top and the sole gamete type of the recessive parent along the side. Each cell combines one allele for each gene from each parent:

|      | $RY$   | $Ry$   | $rY$   | $ry$   |
|------|--------|--------|--------|--------|
| $ry$ | $RrYy$ | $Rryy$ | $rrYy$ | $rryy$ |

Each of the four combinations has an expected frequency of  $1/4$ . The recessive parent's identical gametes need only one row; repeating that row would give the same proportions.

**Step 3: (b) Interpret the progeny phenotypes** The four genotypes express the following phenotypes:

| Genotype | Phenotype        | Expected fraction |
|----------|------------------|-------------------|
| $RrYy$   | Round, yellow    | $1/4$             |
| $Rryy$   | Round, green     | $1/4$             |
| $rrYy$   | Wrinkled, yellow | $1/4$             |
| $rryy$   | Wrinkled, green  | $1/4$             |

A dominant  $R$  produces round seeds and a dominant  $Y$  produces yellow seeds; only  $rr$  and  $yy$  express the corresponding recessive characters. Therefore all four phenotype classes occur equally in the expected progeny.

**Step 4: (c) Name the cross and explain its purpose** This is a dihybrid test cross, because an individual heterozygous for two characters is crossed with a double homozygous recessive individual. Its purpose is to determine the genotype of a plant showing dominant phenotypes: appearance alone cannot distinguish a homozygote from a heterozygote. Since the tester supplies only recessive alleles, each offspring's phenotype reveals the alleles carried by the gamete from the parent being tested. Here the four equally frequent classes reveal that this parent is heterozygous at both loci and are consistent with independent assortment. In contrast, a parent homozygous dominant for both genes would produce only round, yellow progeny with this tester.

**Step 5: Conclusion** The cross  $RrYy \times rryy$  yields round-yellow, round-green, wrinkled-yellow and wrinkled-green progeny in the expected ratio 1 : 1 : 1 : 1. It is a dihybrid test cross, used to establish the genotype underlying dominant phenotypes.

**Quick Tip to Solve:** In a test cross, write the recessive tester's single gamete first: every offspring then directly records one gamete type of the parent being tested.

**29. (a) Name the category of microbes occurring naturally in sewage and making it less polluted during the treatment. (b) Explain the different steps involved in the secondary treatment of sewage.**

[5 marks]

**Solution:**

**Concept:**

- Naturally occurring heterotrophic microorganisms, chiefly bacteria and fungi, use organic matter in sewage as food and thereby help purify it.
- Secondary treatment is biological treatment. Aerobic microbial activity lowers biochemical oxygen demand (BOD), the oxygen required by microbes to oxidise the organic matter in a water sample.
- Aerobic flocs and anaerobic sludge digesters act at different stages: flocs remove organic matter from the effluent, while digesters break down the settled sludge.

**Step 1: (a) Identify the microbes** The microbes are **heterotrophic microorganisms**, mainly bacteria and fungi, which occur naturally in sewage. They obtain their nutrients from its organic substances. During biological treatment, conditions are provided for their growth, so their consumption and decomposition of organic matter make the sewage less polluted.

**Step 2: (b) Aerate the primary effluent** After primary treatment has removed floating debris and settleable solids, the primary effluent enters large aeration tanks. It is continuously agitated mechanically and air is pumped into it. This promotes vigorous growth of useful aerobic microbes into **flocs**: masses of bacteria associated with fungal filaments, forming mesh-like structures.

**Step 3: Allow microbial oxidation to lower BOD** As the aerobic microbes grow, they consume a major part of the organic matter in the effluent. Their activity substantially reduces the BOD. The sewage is treated until its BOD is significantly reduced; a lower BOD indicates that less biodegradable organic pollution remains in the water.

**Step 4: Settle the flocs and recycle activated sludge** The treated effluent is passed into a settling tank, where the microbial flocs sediment. This sediment is called **activated sludge**. A small portion is

pumped back into the aeration tank as an inoculum, supplying active microbes to treat fresh primary effluent. The remaining major portion is sent to anaerobic sludge digesters.

**Step 5: Digest the sludge and release treated effluent** In the anaerobic sludge digesters, anaerobic bacteria digest the bacteria and fungi present in the sludge. During this digestion, gases such as methane, hydrogen sulphide and carbon dioxide are produced; together these form biogas, which can be used as fuel. The effluent from the secondary settling tank, having a substantially reduced BOD, is generally released into natural water bodies after treatment.

**Step 6: Conclusion** (a) Heterotrophic microorganisms, chiefly bacteria and fungi, purify sewage. (b) Secondary treatment involves aeration and floc formation, microbial reduction of BOD, settling as activated sludge, recycling a small inoculum, and anaerobic digestion of the remaining sludge with biogas production.

**Quick Tip to Solve:** Follow the flow: aeration tank to flocs to low BOD to activated sludge; recycle a small portion and digest the major portion anaerobically.

OR

**29. (a) Name and explain any four lymphoid organs present in humans. (b) Categorise the named lymphoid organs as primary or secondary lymphoid organs, giving reasons.** [5 marks]

**Solution:**

**Concept:**

- Lymphoid organs are sites concerned with the origin, maturation, proliferation and immune activity of lymphocytes, the cells responsible for specific immunity.
- Primary lymphoid organs provide the environment in which immature lymphocytes differentiate into antigen-sensitive lymphocytes. Secondary lymphoid organs provide sites where mature lymphocytes encounter antigens and initiate immune responses.

**Step 1: (a) Bone marrow and thymus** Bone marrow is the soft tissue inside bones. It is the main lymphoid organ where all blood cells, including lymphocytes, are produced. In humans, B lymphocytes also mature in the bone marrow and become capable of recognising specific antigens.

The thymus is a lobed organ situated near the heart, beneath the breastbone. It provides the environment for T lymphocytes to mature and become antigen-sensitive. It is relatively large at birth and progressively reduces in size with age; by puberty much of it has become reduced in size.

**Step 2: (a) Spleen and lymph nodes** The spleen is a large bean-shaped organ containing lymphocytes and phagocytes. It filters the blood and traps blood-borne microorganisms and other antigens, allowing immune cells to act against them. It also serves as a reservoir of erythrocytes.

Lymph nodes are small solid structures situated at intervals along lymphatic vessels. They trap microorganisms and other antigens entering the lymph. These antigens activate the lymphocytes present in the nodes, which proliferate and produce an immune response.

**Step 3: (b) Classify the four organs with reasons** Bone marrow and thymus are primary lymphoid organs because lymphocytes undergo maturation and differentiation into antigen-sensitive cells there:

B lymphocytes mature in bone marrow, whereas T lymphocytes mature in thymus. Their defining role is lymphocyte maturation before antigen-triggered immune responses.

Spleen and lymph nodes are secondary lymphoid organs because they provide sites for mature lymphocytes to interact with antigens. Following antigen recognition, lymphocytes proliferate and differentiate into effector cells. The spleen chiefly encounters antigens carried in blood, whereas lymph nodes encounter those carried in lymph.

**Step 4: Conclusion** The four lymphoid organs are bone marrow, thymus, spleen and lymph nodes. Bone marrow and thymus are primary organs for lymphocyte maturation; spleen and lymph nodes are secondary organs for antigen encounter and initiation of immune responses.

**Quick Tip to Solve:** Pair B-cell maturation with bone marrow and T-cell maturation with thymus; then distinguish spleen as a blood filter and lymph nodes as lymph filters.

**30. (a) Differentiate between primary and secondary ecological successions. (b) Explain the different steps of xerarch succession occurring in nature.** [5 marks]

**Solution:**

**Concept:**

- Ecological succession is the orderly, gradual change in species composition of a community over time. Successive communities modify the habitat, enabling other species to establish.
- Primary succession begins on a previously unoccupied substrate without soil, whereas secondary succession begins where a community existed earlier and soil remains.
- Xerarch succession starts in a dry habitat. Weathering, humus accumulation and increasing water retention gradually produce more mesic conditions.

**Step 1: (a) Distinguish primary and secondary succession** Primary succession starts in an area where no living community previously existed, such as newly exposed bare rock or a newly formed volcanic surface. Soil is initially absent; pioneer organisms must help create it. Consequently, establishment and replacement of communities are usually very slow.

Secondary succession starts in an area that previously supported a community but was disturbed, for example an abandoned cultivated field or a forest cleared by fire. Soil, organic matter and often seeds, spores or surviving underground plant parts are already present. Therefore, recolonisation and succession are generally faster. Its pioneers depend on the habitat and the surviving biological material, and need not be the lichens characteristic of bare-rock succession.

**Step 2: (b) Pioneer lichens establish on bare rock** In a typical xerarch succession on bare rock, lichens are the pioneers. They tolerate the exposed, dry surface and secrete acids that help weather the rock. Rock particles combine with organic matter from dead lichens to form a thin initial soil layer. This changes the substrate so that other plants can establish.

**Step 3: Mosses replace lichens and deepen the soil** Small plants such as mosses follow the lichens. Mosses trap particles and retain moisture. Their growth and decomposition add humus, while weathering continues. The soil layer becomes thicker and its capacity to hold water improves. Thus the surface becomes less dry and more favourable for rooted plants.

**Step 4: Herbs and grasses are followed by shrubs** As sufficient soil develops, herbaceous plants and grasses establish. Their roots penetrate and bind the developing soil; dead plant material adds further organic matter. Continued soil development and improved moisture availability allow shrubs to invade. Taller vegetation changes light, temperature and humidity near the ground, favouring the next community while gradually replacing earlier species.

**Step 5: Trees establish and a stable climax community develops** With deeper soil and more favourable moisture conditions, trees establish and gradually replace the shrub community. In a region whose climate supports forest, the succession ultimately produces a relatively stable climax forest community in equilibrium with the prevailing environment. The overall transition is from a xeric habitat towards mesic conditions; the precise climax vegetation depends on regional climate.

**Step 6: Conclusion** Primary succession begins without pre-existing soil and is generally slower; secondary succession begins with soil remaining from an earlier community and is generally faster. Typical bare-rock xerarch succession proceeds through lichens, mosses, herbs and grasses, shrubs, and finally a climate-appropriate climax community, commonly forest.

**Quick Tip to Solve:** Link each xerarch stage to soil formation and improved water retention: lichens weather rock, mosses build humus, and deeper soil permits herbs, shrubs and trees.

OR

**30. (a) Why is there a need to conserve biodiversity? (b) Name and explain any two ways that are responsible for the loss of biodiversity.** [5 marks]

**Solution:**

**Concept:**

- Biodiversity includes genetic, species and ecosystem diversity. Its conservation protects biological resources and the ecological processes on which human life depends.
- Reasons for conservation include narrowly utilitarian benefits, broadly utilitarian ecosystem services, and the ethical responsibility to protect other forms of life.
- Habitat loss and fragmentation and over-exploitation are two major human-driven causes of biodiversity loss.

**Step 1: (a) Conserve biodiversity for its direct uses** Biodiversity supplies food, fuel, fibre, timber and medicines. Many drugs originate from plants and other organisms, and wild relatives of crops provide useful genes for crop improvement. These are narrowly utilitarian reasons for conservation. Protecting species also preserves biological resources whose potential uses have yet to be discovered; extinction permanently removes those possibilities.

**Step 2: (a) Protect ecosystem services and fulfil our ethical duty** Biodiversity supports ecosystem services such as oxygen production through photosynthesis, pollination, nutrient cycling, soil formation, decomposition and regulation of climate and water. Diverse communities help maintain ecosystem functioning and stability, while nature also provides aesthetic and recreational benefits. These are broadly utilitarian reasons. In addition, every species has intrinsic value: humans have an ethical

responsibility to protect other organisms and pass on this biological heritage to future generations.

**Step 3: (b) Habitat loss and fragmentation** Destruction of natural habitats for agriculture, settlements, industries and other human uses removes the food, shelter and breeding sites of their species. Tropical rainforests are especially rich in species, so clearing them causes extensive biodiversity loss. When a large continuous habitat is broken into small isolated fragments, populations become separated and movement and breeding are restricted. Animals needing large territories and species with specialised habitat requirements are particularly affected; small isolated populations face a greater risk of extinction.

**Step 4: (b) Over-exploitation** Over-exploitation occurs when humans harvest organisms faster than their populations can replace the losses through reproduction. Excessive hunting, fishing or collection depletes populations and can ultimately cause extinction. The extinction of the passenger pigeon and Steller's sea cow illustrates the consequences of excessive human exploitation. Similarly, overharvesting marine fish reduces populations and threatens commercially important species. Conservation therefore requires protection of habitats and sustainable use of biological resources.

**Step 5: Conclusion** (a) Biodiversity must be conserved for its direct economic uses, essential ecosystem services and the intrinsic value of every species. (b) Habitat loss and fragmentation destroy and isolate natural populations, while over-exploitation removes organisms faster than they can reproduce; both can lead to extinction.

**Quick Tip to Solve:** Organise conservation reasons as direct benefits, ecosystem services and ethical duty; explain each selected cause of loss with its mechanism and an example.