CBSE Class 12 Biology(Set 57/5/2) Question Paper with Solutions

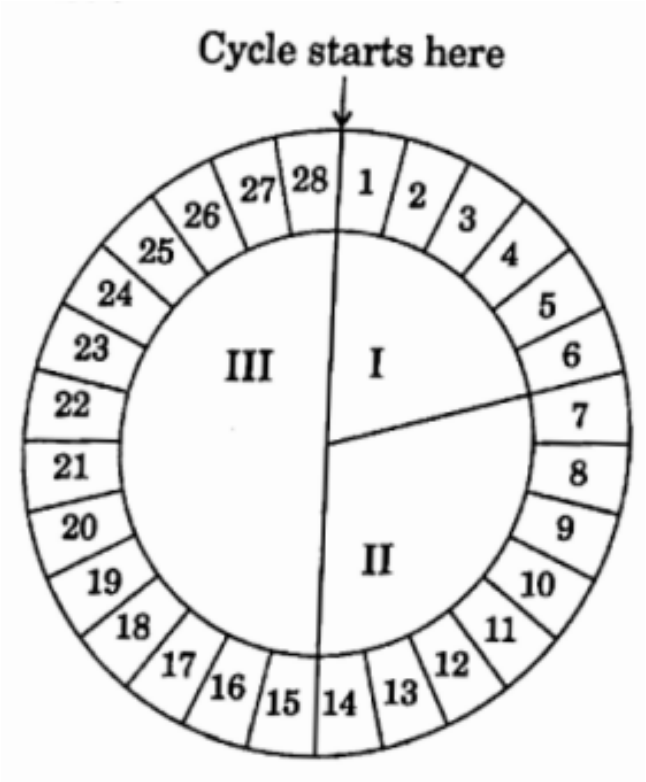
Time Allowed :3 Hour	Maximum Marks :70	Total Questions :33

General Instructions

Read the following instructions very carefully and strictly follow them:

- This question paper contains **33 questions**. **All questions are compulsory.**
- Question paper is divided into **five sections** – Sections A, B, C, D and E.
- **Section A** – questions number 1 to 16 are Multiple Choice Type questions. Each question carries 1 mark.
- **Section B** – questions number 17 to 21 are Very Short Answer Type questions. Each question carries 2 marks.
- **Section C** – questions number 22 to 28 are Short Answer Type questions. Each question carries 3 marks.
- **Section D** – questions number 29 and 30 are Case-Based questions. Each question carries 4 marks. Each question has sub parts with internal choice in one of the sub parts.
- **Section E** – questions number 31 to 33 are Long Answer Type questions. Each question carries 5 marks.
- There is no overall choice. However, an internal choice has been provided in Sections B, D and E of the question paper. A candidate has to write answer for only **one** of the alternatives in such questions.
- Kindly note that there is a separate question paper for Visually Impaired Candidates.
- Wherever necessary, neat and properly labelled diagrams should be drawn.

1. In a human female, the menstrual cycle of 28 days is represented by the diagram given below. Select the correct statement related to this diagram.



(A) Primary follicle of ovary matures into Graafian follicle in phase II.
(B) The hormone secreted in large amounts in phase III is also responsible for maintaining pregnancy in human females.
(C) Corpus luteum secretes progesterone in phase I, however it degenerates completely in phase III.
(D) Both (A) and (B).

Correct Answer: (4) Both (A) and (B)

Solution:

Concept: The menstrual cycle in human females typically lasts about **28 days** and is divided into different phases:

- **Phase I – Menstrual phase** (Day 1–5)
- **Phase II – Follicular / Proliferative phase** (Day 6–14)
- **Phase III – Luteal / Secretory phase** (Day 15–28)

Each phase is associated with specific hormonal changes and ovarian events.
Step 1: Analyze statement (A).
During the **follicular phase (Phase II)**, the ovarian follicles develop progressively and the **primary follicle matures into a Graafian follicle** before ovulation occurs.
Thus, statement (A) is **correct**.
Step 2: Analyze statement (B).
In **Phase III (luteal phase)**, the **corpus luteum** secretes large amounts of **progesterone**.
Progesterone plays a crucial role in:

- Preparing the uterus for implantation
- Maintaining pregnancy in early stages

Thus, statement (B) is also **correct**.
Step 3: Analyze statement (C).
The corpus luteum secretes progesterone during the **luteal phase (Phase III)**, not in Phase I. Therefore, this statement is **incorrect**.
Step 4: Determine the correct option.
Since both (A) and (B) are correct:

$$\boxed{\text{Both (A) and (B)}}$$

Quick Tip

In the menstrual cycle: Follicular phase leads to Graafian follicle formation, ovulation occurs around day 14, and the luteal phase is dominated by progesterone secretion from the corpus luteum.

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2. The cells of endosperm have 24 chromosomes. What will be the number of chromosomes in the gametes?
(A) 8
(B) 16
(C) 23
(D) 32

Correct Answer: (1) 8

Solution:

Concept: In flowering plants, the **endosperm** is formed as a result of **triple fusion**. It is therefore **triploid (3n)** in nature.
Step 1: Relationship between endosperm and gametes.
Endosperm develops by fusion of:

- One male gamete (n)
- Two polar nuclei (n + n)

Thus,

$$\text{Endosperm} = 3n$$

Step 2: Given chromosome number.
Number of chromosomes in endosperm cells:

$$3n = 24$$

Step 3: Find haploid number.

$$n = \frac{24}{3} = 8$$

Step 4: Chromosomes in gametes.
Gametes are haploid (n), therefore they contain:

$$\boxed{8 \text{ chromosomes}}$$

Quick Tip

Endosperm in flowering plants is triploid (3n) because it forms after fusion of one male gamete with two polar nuclei.

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7. Select the odd option in the context of convergent evolution.
(A) Eyes of Octopus and Mammals
(B) Flippers of Penguins and Dolphins
(C) Flying Squirrel and Flying Phalanger
(D) Thorns of Bougainvillea and Tendrils of Cucurbita

Correct Answer: (4) Thorns of Bougainvillea and Tendrils of Cucurbita

Solution:

Concept: Convergent evolution occurs when unrelated organisms independently evolve similar features due to adaptation to similar environments. Such structures are called **analogous organs**.
Step 1: Evaluate the first three options.

- **Eyes of Octopus and Mammals** – similar function but evolved independently.
- **Flippers of Penguins and Dolphins** – similar adaptation for swimming.
- **Flying Squirrel and Flying Phalanger** – independently evolved gliding membranes.

These are examples of **analogous structures** formed through convergent evolution.
Step 2: Analyze option (D).

- **Thorns of Bougainvillea** and **Tendrils of Cucurbita** originate from the same plant part (axillary buds).
- They have different functions but share the same origin.

Thus, they are **homologous structures** representing **divergent evolution**.

$$\boxed{\text{Therefore option (D) is the odd one}}$$

Quick Tip

Analogous organs arise due to convergent evolution, while homologous organs arise due to divergent evolution.

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8. *Monascus purpureus* is a yeast used commercially in the production of which one of the following?
(A) Ethanol
(B) Streptokinase
(C) Citric acid
(D) Statins

Correct Answer: (4) Statins

Solution:

Concept: Certain microorganisms are used in biotechnology for producing medically important compounds.
Step 1: Identify the organism.
Monascus purpureus is a yeast used in industrial fermentation.
Step 2: Product obtained from this yeast.
It produces compounds called **statins**, which help in lowering blood cholesterol levels by inhibiting enzymes involved in cholesterol synthesis.
Step 3: Eliminate other options.

- **Ethanol** – produced by *Saccharomyces cerevisiae*
- **Streptokinase** – produced by *Streptococcus*
- **Citric acid** – produced by *Aspergillus niger*

Hence the correct answer is Statins

Quick Tip

Statins produced by *Monascus purpureus* are widely used as cholesterol-lowering drugs.

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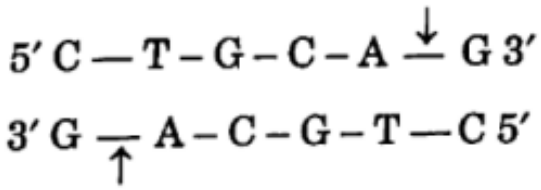
9. Given below is the restriction site of a restriction endonuclease Pst I and the cleavage sites on a DNA molecule. Choose the option that gives the correct resultant fragments.



(A)

$$5'\ C-T-G \qquad C-A-G\ 3'$$
$$3'\ G-A-C-G-T \qquad C\ 5'$$

(B)

$$5'\ C-T \qquad G-C-A-G\ 3'$$
$$3'\ G-A-C-G \qquad T-C\ 5'$$

(C)

$$5'\ C-T-G-C \qquad A-G\ 3'$$
$$3'\ G-A-C-G \qquad T-C\ 5'$$

(D)

$$5'\ C-T-G-C-A \qquad G\ 3'$$
$$3'\ G \qquad A-C-G-T-C\ 5'$$

Correct Answer: (3)

Solution:

Concept: Restriction endonucleases are enzymes that recognize specific DNA sequences called **restriction sites** and cut DNA at those positions. Many restriction enzymes produce **sticky ends** by making staggered cuts in the DNA strands.
The enzyme **Pst I** recognizes the palindromic sequence:

$$5'\ CTGCAG\ 3'$$
$$3'\ GACGTC\ 5'$$

and cleaves between:

$$CTGCA \downarrow G$$

$$G \uparrow ACGTC$$

Step 1: Identify the cleavage positions.
The enzyme cuts after the nucleotide **A** in the upper strand and before **A** in the complementary strand, producing staggered ends.
Step 2: Separate the fragments after cleavage.
After cutting, the fragments produced are:

$$5'\ C-T-G-C \qquad A-G\ 3'$$

$$3'\ G-A-C-G \qquad T-C\ 5'$$

These fragments contain **sticky ends** that can easily pair with complementary DNA fragments.
Step 3: Match with the options.
The fragment arrangement exactly matches **Option (C)**.
Thus, the correct resultant fragments correspond to:

Option (C)

Quick Tip

Restriction enzymes recognize palindromic DNA sequences and usually create sticky ends by cutting DNA in a staggered manner, which helps in recombinant DNA technology.

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10. Which of the following ecosystem is most productive in terms of net primary productivity?
(A) Desert
(B) Tropical rainforests
(C) Oceans
(D) Estuaries

Correct Answer: (4) Estuaries

Solution:

Concept: Net Primary Productivity (NPP) is the rate at which producers synthesize organic matter (biomass) after accounting for respiration losses. Ecosystems with abundant nutrients and favorable environmental conditions generally have higher productivity.
Step 1: Evaluate each ecosystem.

- **Deserts** – Very low productivity due to lack of water and vegetation.
- **Oceans** – Moderate productivity but nutrient levels are often limited.
- **Tropical rainforests** – High productivity due to dense vegetation and favorable climate.
- **Estuaries** – Extremely high productivity because nutrient-rich river water mixes with seawater.

Step 2: Identify the most productive ecosystem.
Estuaries receive nutrients from both terrestrial and marine sources and support abundant plant and phytoplankton growth.

Estuaries show the highest net primary productivity

Quick Tip

Among natural ecosystems, estuaries are considered one of the most productive due to high nutrient availability.

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11. Bt-toxin genes have been expressed in plants in order to provide resistance against:

(*i*) Lepidopterans and fungi(*ii*) Animals and bacteria(*iii*) Coleopterans and dipterans(*iv*) Lepidopterans

(A) (ii) and (iii)
(B) (i), (ii) and (iv)
(C) (iii) and (iv)
(D) (ii) and (iv)

Correct Answer: (3) (iii) and (iv)

Solution:

Concept: Bt-toxin is produced by the bacterium *Bacillus thuringiensis*. Genes encoding this toxin are inserted into crop plants to protect them from insect pests.
Step 1: Target organisms of Bt toxin.
Bt toxin specifically affects certain groups of insects such as:

- **Lepidopterans** (moths and butterflies)
- **Coleopterans** (beetles)
- **Dipterans** (flies and mosquitoes)

Step 2: Evaluate the statements.

- (i) Lepidopterans and fungi – incorrect (Bt toxin does not target fungi).
- (ii) Animals and bacteria – incorrect.
- (iii) Coleopterans and dipterans – correct.
- (iv) Lepidopterans – correct.

Correct option: (iii) and (iv)

Quick Tip

Bt crops contain genes from *Bacillus thuringiensis* that produce toxins effective against specific insect pests.

12. According to IUCN, some of the extinctions include:

(i) Dodo(ii) Indian gazelle(iii) Thylacine(iv) Steller's Sea Cow

(A) (i), (ii), (iii) and (iv)
(B) (ii) and (iv)
(C) (i), (iii) and (iv)
(D) (iii) and (iv)

Correct Answer: (3) (i), (iii) and (iv)

Solution:

Concept: The **IUCN Red List** documents species that are threatened, endangered, or extinct.
Step 1: Identify extinct species.

- **Dodo** – extinct bird from Mauritius.
- **Thylacine** – also known as Tasmanian tiger; declared extinct.
- **Steller's Sea Cow** – marine mammal hunted to extinction.

Step 2: Evaluate Indian gazelle.
Indian gazelle (Chinkara) is not extinct; it is still found in parts of India.

Thus extinct species are (i), (iii) and (iv)

Quick Tip

Examples of recently extinct species include Dodo, Thylacine, and Steller's Sea Cow.

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13. Assertion (A): Genetically modified microbes help in crop protection.
Reason (R): *Bacillus thuringiensis* (Bt) bacteria control insects by producing protoxins.
Choose the correct option:
(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).
(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).
(C) Assertion (A) is true, but Reason (R) is false.
(D) Assertion (A) is false, but Reason (R) is true.

Correct Answer: (1) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

Solution:

Concept: Genetically modified microbes and genes derived from microorganisms are widely used in agriculture to protect crops from insect pests.
Step 1: Analyze Assertion (A).
Genetically modified microbes or microbial genes can be used to develop pest-resistant crops. For example, Bt genes inserted into crops enable them to resist insect attacks.
Thus, Assertion (A) is **true**.
Step 2: Analyze Reason (R).
The bacterium *Bacillus thuringiensis* produces crystalline **protoxins**. When insects ingest these protoxins, they are converted into active toxins in the alkaline gut of the insect, leading to the death of the pest.
Thus, Reason (R) is **true**.
Step 3: Check explanation relationship.
Bt genes from *Bacillus thuringiensis* are introduced into crops to produce insecticidal proteins that protect plants from pests. Hence, the reason correctly explains the assertion.

Both Assertion and Reason are true and Reason correctly explains the Assertion

Quick Tip

Bt crops contain genes from *Bacillus thuringiensis* that produce toxins lethal to specific insect pests but safe for humans.

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14. Assertion (A): *Trichoderma* species are free living fungi that are very common in the root ecosystems.
Reason (R): They are effective bio-control agents of several plant pathogens.
Choose the correct option:
(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).
(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).
(C) Assertion (A) is true, but Reason (R) is false.
(D) Assertion (A) is false, but Reason (R) is true.

Correct Answer: (2) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

Solution:

Concept: *Trichoderma* is a genus of fungi commonly found in soil and plant root ecosystems. It plays an important role in agriculture as a biological control agent.
Step 1: Analyze Assertion (A).

Trichoderma species are free-living fungi widely present in soil, particularly in the **rhizosphere (root ecosystem)** of plants.
Thus, Assertion (A) is **true**.
Step 2: Analyze Reason (R).
These fungi are widely used as **biocontrol agents** because they inhibit the growth of harmful plant pathogens through competition, antibiosis, and parasitism.
Thus, Reason (R) is also **true**.
Step 3: Check explanation relationship.
Although both statements are correct, the fact that *Trichoderma* acts as a biocontrol agent does not explain why it is commonly found in root ecosystems.

Both Assertion and Reason are true, but Reason is not the correct explanation

Quick Tip

Trichoderma species are widely used in agriculture as biological control agents to protect crops from fungal pathogens.

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15. Assertion (A): The endometrium undergoes cyclic changes during the menstrual cycle.
Reason (R): Perimetrium contracts strongly during delivery of the baby.
Choose the correct option:
(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).
(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).
(C) Assertion (A) is true, but Reason (R) is false.
(D) Assertion (A) is false, but Reason (R) is true.

Correct Answer: (3) Assertion (A) is true, but Reason (R) is false.

Solution:

Concept: The uterus consists of three layers: **perimetrium**, **myometrium**, and **endometrium**. Each layer has different functions during the reproductive cycle.
Step 1: Analyze Assertion (A).
The **endometrium** (inner lining of the uterus) undergoes cyclic changes during the menstrual cycle. It thickens to prepare for implantation and is shed during menstruation if fertilisation does not occur.
Thus, Assertion (A) is **true**.
Step 2: Analyze Reason (R).
Strong contractions during childbirth are produced by the **myometrium**, the muscular middle layer of the uterus, not by the perimetrium.
Thus, Reason (R) is **false**.

Assertion is true but Reason is false

Quick Tip

Endometrium undergoes cyclic changes during menstruation, while myometrium is responsible for strong uterine contractions during childbirth.

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16. Assertion (A): Repetitive sequences make up a very large portion of the human genome.
Reason (R): Repetitive sequences do not have direct coding functions in the genome.
Choose the correct option:
(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).
(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).
(C) Assertion (A) is true, but Reason (R) is false.
(D) Assertion (A) is false, but Reason (R) is true.

Correct Answer: (1) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

Solution:

Concept: The human genome contains a large amount of **non-coding DNA**, including repetitive DNA sequences.
Step 1: Analyze Assertion (A).
The Human Genome Project revealed that a large portion of the human genome consists of **repetitive sequences** such as satellite DNA, minisatellites, and microsatellites.
Thus, Assertion (A) is **true**.
Step 2: Analyze Reason (R).
Most repetitive DNA sequences do not code for proteins and therefore lack direct coding functions in the genome.
Thus, Reason (R) is **true**.
Step 3: Check explanation relationship.
Because these sequences are non-coding, they accumulate extensively in the genome, which explains why they form a large portion of it.

Both Assertion and Reason are true and Reason correctly explains the Assertion

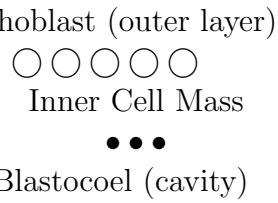
Quick Tip

Less than 2% of the human genome codes for proteins, while a large portion consists of repetitive non-coding DNA.

17. Draw a labelled diagram of the embryonic stage that gets implanted in the human uterus. State the functions of two labelled parts.

Solution:

Concept: The embryonic stage that implants in the uterus is called the **blastocyst**. It is formed after several cleavage divisions of the zygote and contains specialized structures that aid in implantation and development.
Step 1: Labelled diagram of blastocyst.



Main labelled parts:

- **Trophoblast**
- **Inner Cell Mass**
- **Blastocoel**

Step 2: Functions of labelled parts.
Trophoblast:

- Forms the outer layer of the blastocyst.
- Helps in **implantation** by attaching the embryo to the uterine wall.
- Later contributes to the formation of the **placenta**.

Inner Cell Mass:

- Gives rise to the **embryo**.
- Develops into different tissues and organs of the developing fetus.

Blastocyst is the stage that implants into the uterine endometrium

Quick Tip

Blastocyst consists of trophoblast, inner cell mass, and blastocoel; implantation occurs when the trophoblast attaches to the uterine wall.

18 (a). Mention the functions of each of the following:

- (i) Tassels of Corn Cob
- (ii) Scutellum

Solution:

Concept: Different plant structures perform specific roles in reproduction and seed development. Understanding their functions helps in explaining plant physiology and reproduction.
Step 1: Function of Tassels of Corn Cob.
Tassels in maize represent the **male inflorescence**. Their main functions are:

- Production of **pollen grains**.
- Facilitation of **pollination** by releasing pollen into the air (wind pollination).

Step 2: Function of Scutellum.
The scutellum is a part of the **embryo in monocot seeds** (like maize). Its functions include:

- Acting as a **cotyledon**.
- Absorbing nutrients from the **endosperm**.
- Transferring nutrients to the growing embryo during germination.

Quick Tip

In maize, tassel = male reproductive part, while scutellum = nutrient-absorbing cotyledon of the embryo.

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18 (b). Farmers prefer apomictic seeds over hybrid seeds. Give any two reasons.

Solution:

Concept: **Apomixis** is a type of asexual reproduction in plants where seeds are formed without fertilization. It results in offspring genetically identical to the parent plant.
Step 1: Understand advantage of apomixis.
Apomictic seeds preserve desirable traits across generations without genetic variation.
Step 2: State reasons for preference.

- Farmers can **reuse seeds every year** without loss of hybrid vigor, unlike hybrid seeds.
- Apomictic seeds maintain **genetic uniformity and desirable traits** (such as high yield) across generations.

Apomixis ensures stable, high-yielding crops without repeated seed purchase

Quick Tip

Hybrid seeds need to be purchased every season, whereas apomictic seeds can be reused without losing their superior traits.

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19 (a). Suggest how a virus-free healthy plant can be obtained from a diseased sugarcane plant.

Solution:

Concept: Virus-free plants can be produced from infected plants using **plant tissue culture techniques**. The most commonly used method is **meristem culture** because viruses generally do not infect the actively dividing meristematic cells.
Step 1: Selection of meristem tissue.
A small portion of the **apical meristem** is removed from the diseased sugarcane plant. Meristem cells divide rapidly and are usually free from viral infection.
Step 2: In vitro culture.
The meristem tissue is placed in a sterile **nutrient culture medium** containing appropriate growth regulators.
Step 3: Development of plantlets.
Under controlled laboratory conditions, the meristem develops into a **complete plantlet**.
Step 4: Transfer to soil.
The plantlets are hardened and then transferred to soil, where they grow into **virus-free healthy sugarcane plants**.

This technique is known as meristem culture

Quick Tip

Meristem culture is widely used in agriculture to produce virus-free plants such as potato, banana, and sugarcane.

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19 (b). In order to force bacteria to take up the recombinant DNA, they must be made competent. Explain how it can be achieved.

Solution:

Concept: For bacteria to take up recombinant DNA, their cell membranes must be made **permeable**. This process is called making the cells **competent**.
Step 1: Treatment with divalent cations.
Bacterial cells are treated with **calcium chloride ($CaCl_2$)**. Calcium ions increase the permeability of the bacterial cell membrane and facilitate the entry of DNA.
Step 2: Incubation with recombinant DNA.

The competent bacterial cells are mixed with recombinant DNA so that the DNA can attach to the bacterial cell surface.
Step 3: Heat shock treatment.
The mixture is briefly exposed to **high temperature (around 42°C)** followed by rapid cooling on ice. This heat shock creates pores in the membrane through which the DNA enters the bacterial cell.
Step 4: Recovery and growth.
The bacteria are then allowed to grow in suitable culture media where the recombinant DNA replicates inside the host cells.

Thus bacteria become competent and can take up recombinant DNA

Quick Tip

Competent bacterial cells are commonly produced using calcium chloride treatment followed by heat shock to allow uptake of recombinant DNA.

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

Solution:

Concept: Food chains represent the flow of energy from one organism to another in an ecosystem. Two major types are the **grazing food chain** and the **detritus food chain**.
Step 1: Grazing Food Chain.

- Begins with **living green plants (producers)**.
- Energy flows from producers to **herbivores** and then to **carnivores**.
- Example: Grass → Deer → Tiger.

Step 2: Detritus Food Chain.

- Begins with **dead organic matter (detritus)**.
- Energy flows through **decomposers** and **detritivores**.
- Example: Dead leaves → Earthworms → Birds.

Step 3: Key Differences.

Feature	**Grazing Food Chain**	**Detritus Food Chain**
$StartingPoint$	$Livingproducers$	$Deadorganicmatter$
$PrimaryConsumers$	$Herbivores$	$Decomposers/Detritivores$
$EnergySource$	$Photosynthesis$	$Decomposition$

Quick Tip

Grazing food chains begin with green plants, whereas detritus food chains begin with dead organic matter.

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20 (b). Ecological pyramids are widely accepted but they still have some limitations. Write any two limitations.

Solution:

Concept: Ecological pyramids represent the relationship between organisms at different trophic levels in terms of number, biomass, or energy. However, they have certain limitations.
Step 1: Limitation 1.
Ecological pyramids **do not account for organisms that occupy more than one trophic level**. For example, humans may act as both herbivores and carnivores.
Step 2: Limitation 2.
They **do not represent food webs**. In nature, organisms are connected through complex feeding relationships rather than simple linear food chains.
Step 3: Additional limitation (conceptual).
Ecological pyramids also do not adequately represent **decomposers and detritivores**, which play an essential role in ecosystems.

Thus ecological pyramids provide a simplified but incomplete representation of ecosystems

Quick Tip

Ecological pyramids simplify energy flow but cannot accurately represent complex food webs or organisms occupying multiple trophic levels.

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21. One of the salient features of the genetic code is that it is nearly universal from bacteria to humans. Mention two exceptions to this rule. Why are some codes said to be degenerates?

Solution:

Concept: The **genetic code** refers to the sequence of nucleotide triplets (codons) in mRNA that specify particular amino acids during protein synthesis. It is considered **nearly universal**, meaning the same codon generally codes for the same amino acid in most organisms.
Step 1: Exceptions to universality of genetic code.
Although the genetic code is almost universal, some exceptions exist:

- In **mitochondria of some organisms**, certain codons code for different amino acids.

- In some **protozoans such as *Paramecium***, certain stop codons code for amino acids instead of acting as termination signals.

Exceptions occur mainly in mitochondria and some protozoans

Step 2: Degeneracy of genetic code.
The genetic code is described as **degenerate** because:

- More than one codon can specify the same amino acid.
- For example, the amino acid **Leucine** is coded by six different codons.

Degeneracy means multiple codons can code for the same amino acid

Quick Tip

There are 64 codons in total, but only 20 amino acids, which leads to degeneracy of the genetic code.

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22. (a) Draw a sectional view of seminiferous tubule of a human. Label the following cells in the seminiferous tubule:

- (i) Cells that divide by mitosis to increase their number
- (ii) Cells that undergo meiosis I
- (iii) Cells that undergo meiosis II
- (iv) Cells that help in the process of spermiogenesis

(b) Mention the role of Leydig cells.

Solution:

Concept: The seminiferous tubules in the testes are the sites of sperm production. Different stages of germ cells are arranged from the outer wall toward the lumen.
Step 1: Sectional view of seminiferous tubule.

Lumen
Spermatozoa
Secondary Spermatocytes
Primary Spermatocytes
Spermatogonia
Basement membrane

Step 2: Labelled cells.

- (i) **Spermatogonia** – divide by mitosis to increase their number.

- (ii) **Primary spermatocytes** – undergo meiosis I.
- (iii) **Secondary spermatocytes** – undergo meiosis II.
- (iv) **Sertoli cells** – help in the process of spermiogenesis and provide nourishment to developing sperms.

Step 3: Role of Leydig cells.

- Leydig cells are located in the interstitial spaces between seminiferous tubules.
- They secrete the male sex hormone **testosterone**.
- Testosterone regulates **spermatogenesis** and development of **male secondary sexual characters**.

Leydig cells produce testosterone essential for male reproductive functions

Quick Tip

Sertoli cells support sperm development, while Leydig cells produce testosterone in the testes.

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23. Explain the polygenic inheritance pattern with the help of a suitable example.

Solution:

Concept: Polygenic inheritance refers to the inheritance of a character that is controlled by two or more genes. Each gene contributes a small additive effect to the phenotype, resulting in continuous variation.

Step 1: Characteristics of polygenic inheritance.

- A single trait is controlled by multiple genes.
- Each gene contributes equally and additively to the phenotype.
- The trait shows **continuous variation** rather than distinct categories.
- Environmental factors may also influence the expression of the trait.

Step 2: Example – Human skin colour.

Human skin colour is controlled by three pairs of genes.

- Alleles represented as A, B, C contribute to darker skin.
- Recessive alleles a, b, c contribute to lighter skin.

When individuals with very dark skin ($AABBCC$) are crossed with individuals having very light skin ($aabbcc$):

$$AABBCC \times aabbcc$$

F_1 Generation:
All offspring have intermediate skin colour.

$$AaBbCc$$

F_2 Generation:
A wide range of skin colour phenotypes appears due to different combinations of contributing alleles.
Step 3: Result.
The phenotypic variation forms a continuous distribution from very light to very dark skin colour.

Polygenic inheritance produces continuous variation in traits

Quick Tip

Examples of polygenic traits include human skin colour, height, body weight, and wheat kernel colour.

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24. Mention a product of human welfare obtained with the help of each one of the following:

- (a) *Saccharomyces cerevisiae*
- (b) *Propionibacterium shermanii*
- (c) *Aspergillus niger*
- (d) *Trichoderma polysporum*
- (e) *Acetobacter aceti*
- (f) *Streptococcus*

Solution:

Concept: Many microorganisms are beneficial to humans and are widely used in industrial fermentation, medicine, and food production.
Step 1: (a) *Saccharomyces cerevisiae.*
This yeast is used in fermentation processes to produce:

Ethanol / Alcohol

It is also commonly used in the **baking industry** for bread making.

Step 2: (b) *Propionibacterium shermanii.*
This bacterium is used in the production of:

Swiss cheese

It produces carbon dioxide which forms the characteristic holes in the cheese.
Step 3: (c) *Aspergillus niger.*
This fungus is used for the commercial production of:

Citric acid

Citric acid is widely used in the food and pharmaceutical industries.
Step 4: (d) *Trichoderma polysporum.*
This fungus produces:

Cyclosporin A

Cyclosporin A is an immunosuppressive drug used during organ transplantation.
Step 5: (e) *Acetobacter aceti.*
This bacterium converts alcohol into:

Acetic acid (Vinegar)

It is widely used in the food industry.
Step 6: (f) *Streptococcus.*
Certain species of *Streptococcus* are used to produce:

Streptokinase

Streptokinase is used as a **clot-busting drug** to remove blood clots.

These microorganisms provide several products important for human welfare

Quick Tip

Microbes are widely used in industries to produce antibiotics, acids, enzymes, and fermented foods.

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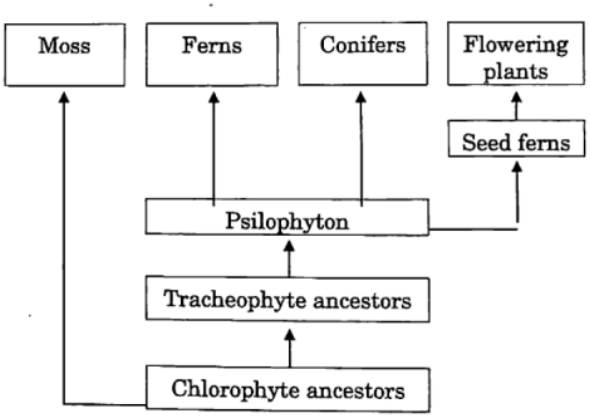
25. Study the given chart showing evolution of plants and answer the following questions.



Solution:

Concept: Plant evolution shows a gradual progression from primitive aquatic plants to advanced flowering plants. Major groups evolved from common ancestors, leading to diversification of plant forms.

Step 1: (a) Identify the plant which acts as an immediate ancestor of both ferns and conifers.
From the evolutionary chart, both **ferns** and **conifers** originate from **Psilophyton**.

Psilophyton

Step 2: (b) Name the nearest ancestors of flowering plants.
The chart shows that flowering plants evolved from **seed ferns**.

Seed ferns

Step 3: (c) Name the most primitive group of plants.
At the base of the evolutionary chart are **chlorophyte ancestors**, which represent the earliest plant forms.

Chlorophyte ancestors

Step 4: (d) Psilophyton provides common ancestry to which classes?
According to the chart, **Psilophyton** gives rise to:

- Ferns
- Conifers
- Seed ferns

Ferns, Conifers, and Seed ferns

Step 5: (e) Name the common ancestor of Psilophyton and seed ferns.
Both **Psilophyton** and **seed ferns** arise from **tracheophyte ancestors**.

Tracheophyte ancestors

Step 6: (f) Name the common ancestor of mosses and tracheophytes.
The chart shows that both **mosses** and **tracheophytes** evolved from **chlorophyte ancestors**.

Chlorophyte ancestors

Quick Tip

Plant evolution generally follows the sequence: Chlorophyte ancestors → Tracheophytes → Psilophyton → Ferns / Seed ferns → Conifers → Flowering plants.

---

26. (a) Write the scientific name of the nematode that infects tobacco plants. Also name the part of the plant that it infects.
(b) How is *Agrobacterium* used to protect tobacco plants from attack by this pest?

Solution:

Concept: Some plant-parasitic nematodes attack crop plants and reduce productivity. Genetic engineering techniques have been used to develop resistance against such pests.
Step 1: (a) Scientific name of the nematode and infected plant part.

- The nematode that infects tobacco plants is ***Meloidogyne incognita***.
- It infects the **roots** of the tobacco plant and causes root-knot disease.

Meloidogyne incognita infects the roots of tobacco plants

Step 2: (b) Role of *Agrobacterium*.

- The bacterium ***Agrobacterium tumefaciens*** is used as a vector in genetic engineering.
- Scientists introduce a gene that produces **RNA interference (RNAi)** against the nematode.
- The introduced gene produces RNA molecules that interfere with the nematode's essential gene expression.
- As a result, the nematode cannot survive in the host plant.

RNA interference using Agrobacterium provides resistance to nematode infection

Quick Tip

RNA interference (RNAi) technology is used to develop nematode-resistant tobacco plants by silencing essential genes of the parasite.

---

27. Explain the level of biodiversity at genetic, species and ecological levels with the help of one example each.

Solution:

Concept: Biodiversity refers to the variety of life forms present on Earth. It can be studied at three major levels: genetic diversity, species diversity, and ecosystem diversity.
Step 1: Genetic diversity.
Genetic diversity refers to the variation of genes within a species. These genetic differences allow populations to adapt to environmental changes.
Example:
Different varieties of rice or wheat cultivated in different regions.

Example: Different varieties of rice

Step 2: Species diversity.
Species diversity refers to the variety of species present in a particular area or ecosystem.
Example:
A tropical rainforest contains numerous species of plants, animals, fungi, and microorganisms.

Example: High species diversity in tropical rainforests

Step 3: Ecological (ecosystem) diversity.
Ecological diversity refers to the variety of ecosystems present in a geographical region.
Example:
Different ecosystems such as forests, grasslands, deserts, and wetlands.

Example: Forests, deserts, and wetlands in a region

Quick Tip

Biodiversity is studied at three levels: genetic diversity (within species), species diversity (among species), and ecosystem diversity (among ecosystems).

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28. Explain Gause's 'Competitive Exclusion Principle' with the help of a suitable example.

Solution:

Concept: The **Competitive Exclusion Principle**, proposed by **G. F. Gause**, states that two species competing for the same limited resources cannot coexist indefinitely in the same habitat.
Step 1: Statement of the principle.
If two species occupy the same ecological niche and compete for identical resources, one species will eventually outcompete and eliminate the other from that habitat.
Step 2: Explanation.
When two species use the same food, space, or other environmental resources, competition occurs. Over time, the species that is better adapted to the environment will survive, while the weaker competitor will be excluded.

Step 3: Example.
Gause conducted experiments using two species of *Paramecium*:

- *Paramecium aurelia*
- *Paramecium caudatum*

When both species were grown together in the same culture medium, *Paramecium aurelia* outcompeted and eliminated *Paramecium caudatum*.

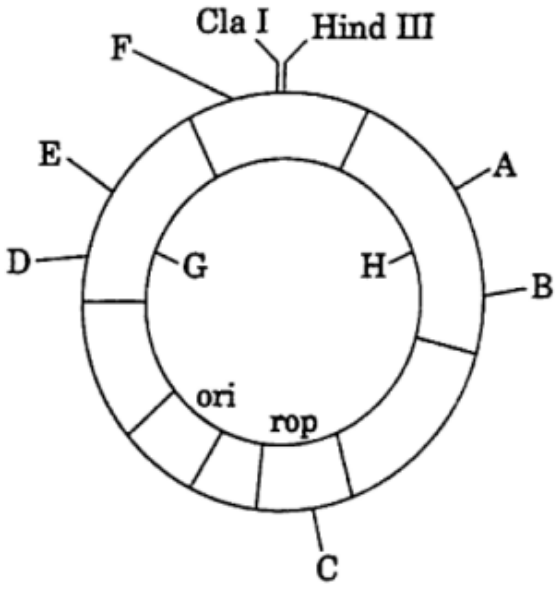
This experiment demonstrated the Competitive Exclusion Principle

Quick Tip

Two species with identical ecological niches cannot coexist permanently; one species will dominate and the other will be eliminated.

---

29. Read the following passage and answer the questions that follow:
We know that plasmids and bacteriophages are the most commonly used vectors in biotechnology experiments. If we can link an alien piece of DNA to the plasmid DNA, the alien DNA can be multiplied equal to the copy number of the plasmid. Engineered vectors are used these days. Study the diagram of the E. coli cloning vector pBR322 and answer the questions that follow.



(a) Why are plasmids and bacteriophages used as cloning vectors?

Solution:

Concept: A cloning vector is a DNA molecule used to carry foreign DNA into a host cell and replicate it.
Step 1: Independent replication.

Plasmids and bacteriophages contain an **origin of replication (ori)** which allows them to replicate independently inside host cells.
Step 2: Multiplication of inserted DNA.
When a foreign DNA fragment is inserted into these vectors, it replicates along with the vector, producing many copies.
Step 3: Ease of genetic manipulation.
They are small, easy to isolate, and can be engineered with restriction sites and selectable markers.

Hence they efficiently carry and replicate foreign DNA

Quick Tip

Cloning vectors must contain an origin of replication, selectable markers, and restriction enzyme sites.

(b) (i) Identify:
(I) The gene in the cloning vector that controls the copy number of the vector.
(II) The restriction site – C in the 'rop' gene.

Solution:

Step 1: Gene controlling copy number.
The gene that regulates the copy number of plasmid pBR322 is the:

rop gene

Step 2: Restriction site C in rop gene.
The restriction enzyme site located at position C within the rop gene is:

Pvu II

Quick Tip

The rop gene in pBR322 regulates plasmid copy number and contains restriction enzyme sites used for cloning.

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

Solution:

Concept: Selectable markers are genes that help identify cells that have taken up the recombinant plasmid.

Step 1: Selectable markers in pBR322.
Two selectable marker genes present in the vector are:

- **amp^{R}** – Ampicillin resistance gene
- **tet^{R}** – Tetracycline resistance gene

Ampicillin resistance and Tetracycline resistance

Quick Tip

Selectable markers help identify transformed bacteria by providing resistance to specific antibiotics.

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

Solution:

Concept: Restriction enzyme sites within selectable marker genes allow insertion of foreign DNA and help in screening recombinant clones.
Step 1: Restriction sites in tetracycline resistance gene.

- **Bam HI**
- **Hind III**

Step 2: Restriction sites in ampicillin resistance gene.

- **Pst I**
- **Sal I**

Bam HI, Hind III, Pst I, and Sal I

Quick Tip

Insertion of foreign DNA into selectable marker genes disrupts antibiotic resistance and helps identify recombinant colonies.

---

29. Read the following passage and answer the questions that follow:
The process of copying genetic information from template strand of DNA into RNA is called transcription. It is mediated by RNA polymerase. Transcription takes place in the nucleus of eukaryotic cells. In transcription, only a segment of DNA and only one of the strands is copied into RNA.

(a) Why is the strand of DNA with 3' → 5' polarity transcribed and not the other strand of 5' → 3' polarity?

Solution:

Concept: RNA polymerase synthesizes RNA only in the **5' → 3'** direction. Therefore, it must read the template strand in the opposite direction.
Step 1: Direction of RNA synthesis.
RNA polymerase adds nucleotides in the **5' → 3'** direction.
Step 2: Template strand requirement.
To synthesize RNA in this direction, the enzyme must read the DNA strand in the **3' → 5'** direction.
Step 3: Conclusion.
Hence, the DNA strand with **3' → 5'** polarity is transcribed, while the other strand is not used.

Because RNA polymerase synthesizes RNA in 5' → 3' direction

Quick Tip

Template strand is always read in 3' → 5' direction so that RNA can be synthesized in 5' → 3' direction.

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

Solution:

Concept: In eukaryotes, the primary RNA transcript (hnRNA) contains both coding and non-coding sequences.
Step 1: Structure of hnRNA.
hnRNA contains:

- **Exons** – coding sequences
- **Introns** – non-coding sequences

Step 2: Need for splicing.
Introns do not code for proteins and must be removed to produce functional mRNA.
Step 3: Conclusion.
Splicing removes introns and joins exons to form **mature mRNA**.

To remove non-coding introns and form functional mRNA

Quick Tip

Splicing converts hnRNA into mature mRNA by removing introns and joining exons.

(b) (ii) Mention the two additional processes which hnRNA needs to undergo after splicing to become functional.

Solution:

Concept: After splicing, hnRNA undergoes further processing to become mature mRNA.
Step 1: 5' capping.
Addition of a **methyl guanosine cap** at the 5' end which protects mRNA and helps in translation.
Step 2: 3' tailing.
Addition of a **poly-A tail** at the 3' end which increases stability and facilitates transport.

5' capping and 3' polyadenylation

Quick Tip

mRNA processing includes splicing, 5' capping, and 3' poly-A tailing.

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

Solution:

Concept: Although DNA is double-stranded, only one strand is transcribed for each gene to ensure correct protein synthesis.
Step 1: Avoidance of conflicting RNA.
If both strands were transcribed, two RNA molecules would be formed with **complementary sequences**, leading to non-functional or double-stranded RNA.
Step 2: Gene specificity.
Each gene is coded on only one strand, called the **template strand**, ensuring accurate transcription.

Only one strand is transcribed to ensure correct and functional RNA synthesis

Quick Tip

Only one DNA strand acts as template for a gene to prevent formation of non-functional RNA.

---

31 (a). Work out separate monohybrid crosses up to F_2 generation between two pea plants and two *Antirrhinum* plants, both having contrasting traits with respect to the colour of the flower. Comment on the patterns of inheritance in the crosses carried out in such two cases.

Solution:

Concept: Monohybrid crosses help to understand patterns of inheritance. In pea plants the inheritance shows **complete dominance**, while in *Antirrhinum* (snapdragon) it shows **incomplete dominance**.

Step 1: Monohybrid cross in pea plants (complete dominance).

Let:

$$P = \text{Purple flower (dominant)}, \quad p = \text{White flower (recessive)}$$

Parental Generation (P):

$$PP \text{ (Purple)} \times pp \text{ (White)}$$

F_1 Generation:

All offspring:

$$Pp \text{ (Purple)}$$

F_2 Generation:

$$Pp \times Pp$$

Genotypic ratio:

$$1PP : 2Pp : 1pp$$

Phenotypic ratio:

$$3 \text{ Purple} : 1 \text{ White}$$

Step 2: Monohybrid cross in *Antirrhinum* (incomplete dominance).

Let:

$$R = \text{Red flower}, \quad r = \text{White flower}$$

Parental Generation:

$$RR \text{ (Red)} \times rr \text{ (White)}$$

F_1 Generation:

$$Rr \text{ (Pink)}$$

F_2 Generation:

$$Rr \times Rr$$

Genotypic ratio:

$$1RR : 2Rr : 1rr$$

Phenotypic ratio:

$$1 \text{ Red} : 2 \text{ Pink} : 1 \text{ White}$$

Step 3: Conclusion.

- Pea plants show **complete dominance**.
- *Antirrhinum* shows **incomplete dominance**.

Thus different organisms may exhibit different inheritance patterns

Quick Tip

Complete dominance gives a 3:1 phenotypic ratio, whereas incomplete dominance results in a 1:2:1 phenotypic ratio.

OR

31 (b) (i). How does a chromosomal disorder differ from a Mendelian disorder? Write one example for each.

Solution:

Concept: Genetic disorders can arise due to changes in individual genes or due to abnormalities in chromosome number or structure.
Step 1: Chromosomal disorders.

- Caused by **abnormal number or structure of chromosomes**.
- Usually occur due to errors in chromosome segregation.
- **Example: Down syndrome**.

Step 2: Mendelian disorders.

- Caused by **mutation in a single gene**.
- Follow Mendelian patterns of inheritance.
- **Example: Sickle-cell anaemia**.

Chromosomal disorders involve chromosomes; Mendelian disorders involve single genes

Quick Tip

Chromosomal disorders arise from chromosome abnormalities, while Mendelian disorders result from mutations in specific genes.

---

31 (b) (ii). Name the phenomenon that leads to situations like 'XO' abnormality in humans. Also name this genetic disorder. How are individuals with an XO chromosomal abnormality affected? Write its symptoms as well as karyotype.

Solution:

Step 1: Phenomenon causing XO abnormality.
The condition arises due to **non-disjunction** during meiosis, where chromosomes fail to separate properly.

Phenomenon: Non-disjunction

Step 2: Name of the genetic disorder.
The XO chromosomal abnormality results in:

Turner Syndrome

Step 3: Symptoms.
Individuals with Turner syndrome show:

- Short stature
- Webbed neck
- Underdeveloped ovaries
- Sterility
- Lack of secondary sexual characters

Step 4: Karyotype.

$45, XO$

This indicates the presence of **45 chromosomes** with only one X chromosome.

Thus Turner syndrome results from monosomy of the X chromosome

Quick Tip

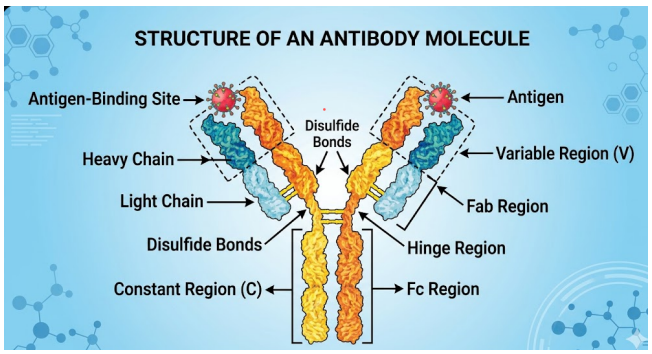
Turner syndrome occurs due to loss of one X chromosome (45,XO) and affects only females.

---

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

Solution:

Concept: Antibodies (immunoglobulins) are Y-shaped glycoproteins produced by B-lymphocytes in response to antigens. They consist of two heavy chains and two light chains linked by disulfide bonds.
Step 1: Structure of antibody.



Step 2: Parts of an antibody molecule.

- **Heavy chains**
- **Light chains**
- **Antigen binding site**
- **Hinge region**
- **Disulfide bonds**

Antibody consists of two heavy chains and two light chains forming a Y-shaped structure

Quick Tip

The tips of the Y-shaped antibody contain antigen-binding sites that specifically recognize antigens.

---

32 (a) (ii). Differentiate between active and passive immunity. Write any three differences.

Solution:

Concept: Immunity refers to the ability of the body to resist infections. It can be either active or passive depending on how antibodies are acquired.

Feature	Active Immunity	Passive Immunity
$Source of antibodies$	$Produced by the body$	$Received from outside$
$Time of response$	$Develops slowly$	$Provides immediate protection$
$Memory$	$Immunological memory present$	$No immunological memory$

Active immunity is long lasting whereas passive immunity is temporary

Quick Tip

Vaccination produces active immunity, while antibodies transferred from mother to child provide passive immunity.

OR

32 (b) (i) (I). Write the scientific names of the two species of filarial worms causing filariasis.

Solution:

Wuchereria bancrofti and *Wuchereria malayi*

---

32 (b) (i) (II). How do they affect the body of infected persons?

Solution:

The filarial worms live in the **lymphatic vessels** of humans. They cause:

- Blockage of lymphatic vessels
- Accumulation of lymph fluid
- Severe swelling of body parts such as legs and scrotum

This condition is commonly known as:

Elephantiasis

---

32 (b) (i) (III). How does the disease spread?

Solution:

Filariasis spreads through the bite of infected **female Culex mosquitoes**. The mosquito acts as a vector transmitting the infective larvae to humans.

Transmission occurs through mosquito bites

---

32 (b) (ii). Mention the source and the role of the following in providing defence against infection in the human body:

- (I) Histamine
- (II) Interferons

Solution:

(I) Histamine

- **Source:** Mast cells and basophils
- **Role:** Causes inflammation and increases blood flow to infected tissues.

(II) Interferons

- **Source:** Virus-infected cells
- **Role:** Protect neighbouring cells by inhibiting viral replication.

Both histamine and interferons help the body defend against infections

Quick Tip

Histamine is involved in inflammatory responses, whereas interferons provide defence against viral infections.

---

33 (a). Briefly explain the events of fertilisation and implantation in an adult human female.

Solution:

Concept: Fertilisation and implantation are two important stages in human reproduction that lead to the establishment of pregnancy.
Step 1: Fertilisation.

- Fertilisation is the fusion of the **male gamete (sperm)** and the **female gamete (ovum)**.
- It usually occurs in the **ampullary–isthmic junction** of the fallopian tube.
- During fertilisation, the sperm penetrates the ovum and their nuclei fuse to form a **diploid zygote**.

Step 2: Cleavage and blastocyst formation.

- The zygote undergoes repeated mitotic divisions called **cleavage**.
- It forms a solid mass of cells called **morula**.
- The morula develops into a **blastocyst** consisting of an inner cell mass and trophoblast.

Step 3: Implantation.

- The blastocyst moves into the uterus and attaches to the **endometrium**.
- The trophoblast helps the blastocyst embed within the uterine wall.

- This process is called **implantation** and marks the beginning of pregnancy.

Implantation ensures nourishment and development of the embryo

Quick Tip

Fertilisation occurs in the fallopian tube, whereas implantation occurs in the uterine endometrium.

OR

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

hCG, LH, FSH, Relaxin

Solution:

Concept: Hormones regulate ovulation and the maintenance of pregnancy.
Step 1: Hormones before fertilisation.

- **FSH** stimulates development of ovarian follicles.
- **LH** triggers ovulation and formation of corpus luteum.

Step 2: Hormones during pregnancy.

- **hCG** is secreted by the developing placenta to maintain the corpus luteum.
- **Relaxin** is secreted later during pregnancy.

Sequence: FSH $\rightarrow$ LH $\rightarrow$ hCG $\rightarrow$ Relaxin

Quick Tip

To remember the sequence, use the mnemonic: "**F**lowers **L**ook **H**appy **R**ecently"

- **F**SH: **F**irst (starts the follicle).
- **L**H: **L**iberates (ovulation).
- **hCG**: **C**onfirms (maintains pregnancy).
- **R**elaxin: **R**elaxes (prepares for birth).

---

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

Solution:

FSH (Follicle Stimulating Hormone)

- **Source:** Anterior pituitary gland
- **Function:** Stimulates growth and maturation of ovarian follicles.

LH (Luteinising Hormone)

- **Source:** Anterior pituitary gland
- **Function:** Triggers ovulation and formation of corpus luteum.

hCG (Human Chorionic Gonadotropin)

- **Source:** Placenta
- **Function:** Maintains corpus luteum and stimulates secretion of progesterone during early pregnancy.

Relaxin

- **Source:** Corpus luteum of ovary and placenta
- **Function:** Relaxes pelvic ligaments and softens cervix to facilitate childbirth.

These hormones regulate ovulation, pregnancy maintenance and parturition

Quick Tip

hCG maintains pregnancy in early stages, while relaxin prepares the reproductive tract for delivery.
