

ISC Class 12 Biology Paper 1 Question Paper with Solutions

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| Time Allowed :3 Hour 15 Min | Maximum Marks :70 | Total Questions :18 |
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General Instructions

Read the following instructions very carefully and strictly follow them:

- You are allowed an additional fifteen minutes for only reading the question paper.
- You must NOT start writing during reading time.
- This question paper has 11 printed pages and one blank page.
- It has eighteen questions in all. Answer all questions.
- There are four sections in the paper: A, B, C and D. Internal choices have been provided in one question each in Sections B, C and D.
- Section A consists of one question. Each subpart carries one mark.
- While answering Multiple Choice Questions in Section A, you are required to write only one option as the answer.
- Section B consists of seven questions each carrying two marks.
- Section C consists of seven questions each carrying three marks.
- Section D consists of three questions each carrying five marks.
- Diagrams should be drawn wherever necessary using a pencil only.
- The intended marks for questions are given in brackets [].

1 (i). Zara is suffering from cough and has bluish lips. Her mucus is mixed with blood. What is the biological name of the causative organism responsible for Zara's condition?

Correct Answer: *Mycobacterium tuberculosis*

Solution:

Concept: Certain infectious diseases affect the lungs and respiratory system. One such disease is **tuberculosis (TB)**, which is caused by a bacterium. The disease spreads through air when an infected person coughs or sneezes. The bacterium primarily attacks the lungs and leads to characteristic symptoms.

Common symptoms of tuberculosis include:

- Persistent cough lasting more than two weeks
- Coughing up blood (hemoptysis)
- Chest pain and breathing difficulty

- Bluish lips due to reduced oxygen supply

The biological (scientific) name of the bacterium responsible for tuberculosis is *Mycobacterium tuberculosis*.

Step 1: Identify the symptoms given in the question.

The symptoms mentioned are:

- Persistent cough
- Bluish lips
- Mucus mixed with blood

Step 2: These symptoms are characteristic of **tuberculosis**, a serious bacterial infection that mainly affects the lungs.

Step 3: The causative organism responsible for tuberculosis is the bacterium:

Mycobacterium tuberculosis

Hence, the biological name of the causative organism is ***Mycobacterium tuberculosis***.

Quick Tip

Tuberculosis (TB) is caused by the bacterium *Mycobacterium tuberculosis*. A key identifying symptom is **coughing up blood along with persistent cough**.

1 (ii). Observe the relation between the first two words and complete the analogy.

Dengue : Aedes :: Plague : ?

Correct Answer: Rat flea (*Xenopsylla cheopis*)

Solution:

Concept: Many infectious diseases are transmitted through **vectors**. A vector is an organism that carries and transmits pathogens from one host to another.

Examples:

- Dengue is transmitted by the mosquito *Aedes*.
- Plague is transmitted by the **rat flea** *Xenopsylla cheopis*.

Thus, the analogy relates **a disease to its transmitting vector**.

Step 1: Understand the first pair in the analogy.

Dengue : Aedes

Here, **Aedes mosquito** is the vector that spreads dengue virus.

Step 2: Similarly, we must identify the vector responsible for spreading **plague**.

Step 3: Plague is caused by the bacterium *Yersinia pestis* and is transmitted by the **rat flea**, scientifically known as:

Xenopsylla cheopis

Step 4: Thus, completing the analogy:

Dengue : Aedes :: Plague : Rat flea

Hence, the correct answer is ****Rat flea (*Xenopsylla cheopis*)****.

Quick Tip

Remember important disease–vector pairs:

- Dengue – *Aedes* mosquito
- Malaria – *Anopheles* mosquito
- Plague – Rat flea (*Xenopsylla cheopis*)

1 (iii). If the number of chromosomes in the cells of the calyx is 16, how many chromosomes will be formed in the endosperm after double fertilisation?

Correct Answer: 24

Solution:

Concept: In flowering plants, fertilisation occurs through a special process called **double fertilisation**. It involves two fusion events:

- One male gamete fuses with the egg cell to form the **zygote (2n)**.
- The second male gamete fuses with two polar nuclei to form the **primary endosperm nucleus (3n)**.

Thus, the **endosperm is triploid (3n)**.

Step 1: Determine the diploid chromosome number.

The cells of the calyx are somatic cells, so they contain the **diploid number (2n)**.

$$2n = 16$$

Step 2: Find the haploid number.

$$n = \frac{16}{2} = 8$$

Step 3: During double fertilisation, the endosperm is formed by the fusion of:

- One male gamete ($n = 8$)
- Two polar nuclei ($n + n = 16$)

$$8 + 8 + 8 = 24$$

Step 4: Therefore, the chromosome number in the endosperm is:

$$3n = 24$$

Hence, **24 chromosomes** will be present in the endosperm.

Quick Tip

In angiosperms:

- Zygote = **2n**
- Endosperm = **3n** (formed after double fertilisation)

If the diploid number is known, first find **n** and then calculate **3n** for the endosperm.

1 (iv). A scientist isolates a second restriction endonuclease from the strain DC3 of *Helicobacter pyogenes*. What would the scientist name it using the standard naming technique of restriction enzyme?

Correct Answer: *HpyDC3II*

Solution:

Concept: Restriction endonucleases are named according to a **standard nomenclature system** based on the organism from which they are isolated. The naming follows these rules:

- The **first letter** comes from the **genus** name (capitalized).
- The **next two letters** come from the **species** name.
- The **strain designation** of the organism is added next.
- A **Roman numeral** indicates the order in which the enzyme was discovered from that strain.

Step 1: Identify the parts of the organism name.

The organism is *Helicobacter pyogenes*.

- Genus: *Helicobacter* → H
- Species: *pyogenes* → py

Thus, the first part becomes:

Hpy

Step 2: The strain of the bacterium is given as **DC3**. So the name becomes:

HpyDC3

Step 3: Since the enzyme isolated is the **second restriction endonuclease** from this strain, the Roman numeral **II** is added.

HpyDC3II

Step 4: Therefore, according to the standard naming convention, the enzyme will be named:

HpyDC3II

Quick Tip

Restriction enzyme naming rule:

- 1st letter of genus + next two letters of species
- Followed by strain name
- Roman numeral for the order of discovery

Example: *EcoRI* → **E** (*Escherichia*), **co** (*coli*), **R** (strain), **I** (first enzyme).

1 (v). Meenu is suffering from a genetic disorder in which phenylpyruvic acid and its metabolites accumulate in blood. It causes impairment of nervous tissues. Which enzyme deficiency has caused this disorder in Meenu?

Correct Answer: Phenylalanine hydroxylase

Solution:

Concept: The symptoms described in the question correspond to the genetic disorder **Phenylketonuria (PKU)**. It is an **autosomal recessive metabolic disorder** in which the body cannot properly metabolize the amino acid **phenylalanine**.

Normally, phenylalanine is converted into **tyrosine** by the enzyme **phenylalanine hydroxylase**. When this enzyme is deficient, phenylalanine accumulates in the body and is converted into abnormal metabolites such as **phenylpyruvic acid**. These metabolites accumulate in blood and damage the **nervous system**.

Step 1: Identify the key clue in the question.

The question states that:

- Phenylpyruvic acid accumulates in blood
- Nervous tissue impairment occurs

These are characteristic features of **Phenylketonuria (PKU)**.

Step 2: In PKU, the metabolic pathway:

Phenylalanine → Tyrosine

is blocked due to the absence of the enzyme **phenylalanine hydroxylase**.

Step 3: Because of this enzyme deficiency, phenylalanine is converted into phenylpyruvic acid and other toxic metabolites that accumulate in the blood and affect brain development.

Step 4: Therefore, the disorder is caused by deficiency of the enzyme:

Phenylalanine hydroxylase

Hence, the correct answer is **Phenylalanine hydroxylase**.

Quick Tip

Phenylketonuria (PKU) is caused by deficiency of **phenylalanine hydroxylase**. It leads to accumulation of **phenylpyruvic acid** and can cause **mental retardation and nervous system damage** if untreated.

1 (vi). There were 770 frogs in a pond. 70 of them died within a month. Calculate the death rate of the population of frogs in the pond.

Correct Answer: $\frac{70}{770} = 0.091$ (approximately) or 9.09%

Solution:

Concept: Death rate (mortality rate) is defined as the number of individuals that die in a population during a given time period divided by the total population.

$$\text{Death Rate} = \frac{\text{Number of deaths}}{\text{Total population}}$$

It is often expressed either as a **fraction** or as a **percentage**.

Step 1: Identify the given values.

- Total frog population = 770
- Number of frogs that died = 70

Step 2: Apply the formula for death rate.

$$\text{Death Rate} = \frac{70}{770}$$

Step 3: Simplify the value.

$$\frac{70}{770} = 0.0909 \approx 0.091$$

Step 4: Expressing it as a percentage:

$$0.0909 \times 100 = 9.09\%$$

Thus, the **death rate of the frog population** is approximately **0.091** or **9.09%** per month.

Quick Tip

Death rate formula:

$$\text{Death rate} = \frac{\text{Number of individuals that died}}{\text{Total population}}$$

Multiply by **100** if the answer is required in percentage.

1 (vii). A farmer notices that the leaves of his cabbage plants are curling up because of heavy infestation of aphids. Suggest one ecofriendly method to control their spread in the cabbage plants.

Correct Answer: Use biological control such as releasing ladybird beetles (predators of aphids).

Solution:

Concept: Ecofriendly pest control involves using **biological methods** instead of harmful chemical pesticides. One common method is **biological control**, where natural predators are used to reduce pest populations.

Step 1: Identify the pest mentioned in the question.

The pest causing damage to cabbage plants is **aphids**. These insects suck plant sap and cause leaves to curl and weaken.

Step 2: An ecofriendly solution is to introduce natural predators that feed on aphids.

Step 3: **Ladybird beetles (ladybugs)** are natural predators of aphids and help reduce their population without harming the environment.

Therefore, releasing **ladybird beetles** in the field is an ecofriendly method to control aphids.

Quick Tip

Biological control uses natural enemies such as predators, parasites, or pathogens to manage pest populations. Example: Ladybird beetles feed on aphids and protect crop plants.

1 (viii). In a particular plant with bilobed dithecous anther, there were 50 Pollen Mother Cells. Only 25% could develop their pollen tubes. Calculate the number of pollen grains that would proceed for fertilisation.

Correct Answer: 50 pollen grains

Solution:

Concept: Each **Pollen Mother Cell (PMC)** undergoes meiosis to produce **four haploid pollen grains**. However, not all pollen grains are able to germinate and form pollen tubes for fertilisation.

Step 1: Determine the number of pollen grains produced.

Number of PMCs = 50

Each PMC produces 4 pollen grains.

$$50 \times 4 = 200 \text{ pollen grains}$$

Step 2: Only **25%** of these pollen grains develop pollen tubes.

$$\begin{aligned} 25\% \text{ of } 200 &= \frac{25}{100} \times 200 \\ &= 50 \end{aligned}$$

Step 3: Therefore, the number of pollen grains that proceed for fertilisation is:

$$50$$

Hence, **50 pollen grains** will proceed for fertilisation.

Quick Tip

Each **Pollen Mother Cell** produces **4 pollen grains** after meiosis. To find the number participating in fertilisation, first calculate total pollen grains and then apply the given percentage.

1 (ix). Choose the components that are required for the proper functioning of DNA polymerase enzyme.

- (P) DNA template
- (Q) A DNA primer
- (R) An RNA primer
- (S) Four different dNTPs

- (a) Only (P), (Q) and (R)
- (b) Only (P), (R) and (S)
- (c) Only (Q), (R) and (S)
- (d) Only (P), (Q) and (S)

Correct Answer: (b) Only (P), (R) and (S)

Solution:

Concept: DNA polymerase is the enzyme responsible for synthesizing new DNA strands during DNA replication. For proper functioning, the enzyme requires certain essential components.

- A **DNA template** to guide the sequence of nucleotides.
- A **primer** with a free 3'-OH group to initiate DNA synthesis.
- **Deoxyribonucleotide triphosphates (dNTPs)** as building blocks for the new DNA strand.

In living cells, the primer used during DNA replication is an **RNA primer**, which is synthesized by the enzyme **primase**.

Step 1: Identify the required components.

- (P) DNA template → Required
- (Q) DNA primer → Not required in normal replication
- (R) RNA primer → Required
- (S) Four different dNTPs → Required

Step 2: Thus, the correct set of components needed for DNA polymerase activity is:

(P), (R), (S)

Therefore, the correct option is **(b) Only (P), (R) and (S)**.

Quick Tip

DNA polymerase cannot start DNA synthesis on its own. It always requires an **RNA primer** providing a free **3'-OH group** to begin elongation of the DNA strand.

1 (x). The left hind limb of a person was swollen like an elephant's limb. Which one of the following was MOST likely the cause of swelling?

- (a) Accumulation of uric acid
- (b) Blockage of blood vessels
- (c) Blockage of lymph vessels
- (d) Hypertrophy of skeletal muscles

Correct Answer: (c) Blockage of lymph vessels

Solution:

Concept: Swelling of limbs resembling that of an elephant is characteristic of the disease **elephantiasis** (lymphatic filariasis). This condition occurs when the **lymphatic vessels are blocked**, leading to the accumulation of lymph fluid in tissues.

Elephantiasis is commonly caused by parasitic worms such as *Wuchereria bancrofti* that are transmitted through mosquito bites. These parasites live in the lymphatic system and obstruct the lymph vessels.

Step 1: Identify the key symptom mentioned.

The question states that the limb was swollen like an **elephant's limb**. This is a classic symptom of **elephantiasis**.

Step 2: In elephantiasis, parasites damage and block the **lymphatic vessels**.

Step 3: Due to this blockage, lymph fluid accumulates in tissues, causing severe swelling of limbs.

Therefore, the most likely cause of the swelling is:

Blockage of lymph vessels

Hence, the correct option is (c).

Quick Tip

Elephantiasis (Lymphatic Filariasis) occurs due to blockage of **lymph vessels** by parasitic worms such as *Wuchereria bancrofti*, leading to massive swelling of limbs.

1 (xi). Given below are two statements marked **Assertion** and **Reason**. Read the two statements carefully and choose the correct option.

Assertion: RNAi technique is applied to plants and animals to protect them from pest infestation.

Reason: This technique inhibits the expression of certain genes in pests.

- (a) Both Assertion and Reason are true and Reason is the correct explanation for Assertion.
- (b) Both Assertion and Reason are true but Reason is not the correct explanation for Assertion.
- (c) Assertion is true and Reason is false.
- (d) Both Assertion and Reason are false.

Correct Answer: (a) Both Assertion and Reason are true and Reason is the correct explanation for Assertion.

Solution:

Concept: RNA interference (RNAi) is a biological process used in biotechnology to **silence specific genes**. It works by preventing the expression of target genes through the degradation of their messenger RNA (mRNA).

This technique is used in genetically engineered organisms to protect crops from pests. When pests feed on such plants, the RNA molecules interfere with the pest's gene expression, leading to their death or reduced survival.

Step 1: Analyse the Assertion.

The statement says that RNAi is used in plants and animals to protect them from pest infestation. This is **true** because RNAi technology can silence essential genes in pests.

Step 2: Analyse the Reason.

The reason states that the technique inhibits the expression of certain genes in pests. This is also **true** and describes the mechanism of RNAi.

Step 3: Since the Reason correctly explains how RNAi protects organisms from pests, it is the **correct explanation** for the Assertion.

Therefore, the correct option is:

- (a) Both Assertion and Reason are true and Reason is the correct explanation for Assertion.

Quick Tip

RNA interference (RNAi) works by **silencing specific genes** through degradation of mRNA, preventing the production of harmful proteins in pests or pathogens.

1 (xii). Given below are two statements marked Assertion and Reason. Read the two statements carefully and choose the correct option.

Assertion: Individuals with Klinefelter syndrome lose their secondary sexual characters and develop gynaecomastia.

Reason: The presence of the XYY chromosomal pattern leads to underdeveloped testes and reduced testosterone levels in affected males.

- (a) Both Assertion and Reason are true and Reason is the correct explanation for Assertion.
- (b) Both Assertion and Reason are true but Reason is not the correct explanation for Assertion.
- (c) Assertion is true and Reason is false.
- (d) Both Assertion and Reason are false.

Correct Answer: (c) Assertion is true and Reason is false.

Solution:

Concept: Klinefelter syndrome is a chromosomal disorder in males caused by the presence of an extra X chromosome, resulting in the karyotype **XXY (47, XXY)**.

This condition leads to:

- Underdeveloped testes
- Reduced testosterone levels
- Poor development of secondary sexual characters
- **Gynaecomastia** (development of breast tissue in males)

Step 1: Analyse the Assertion.

The assertion states that individuals with Klinefelter syndrome lose their secondary sexual characters and develop gynaecomastia. This statement is **true**.

Step 2: Analyse the Reason.

The reason states that the condition occurs due to the **XYY chromosomal pattern**. This is **incorrect** because Klinefelter syndrome is caused by the **XXY pattern**, not XYY.

Step 3: Thus:

- Assertion → True
- Reason → False

Therefore, the correct option is:

(c) Assertion is true and Reason is false.

Quick Tip

Klinefelter syndrome occurs due to **XXY chromosomes**. Common features include **small testes, low testosterone levels, infertility, and gynaecomastia**.

1 (xiii). In a garden pea plant, the flowers are in axial (A) position. Find out the proportion of flowers in terminal position (a), if a cross is made between two heterozygous plants.

Correct Answer: $\frac{1}{4}$ or 25%

Solution:

Concept: In pea plants, the position of flowers is controlled by a pair of alleles:

- **A** → Axial flower position (dominant)
- **a** → Terminal flower position (recessive)

When two heterozygous plants are crossed, the genotype of each parent is:

$$Aa \times Aa$$

Step 1: Determine the gametes produced by each parent.

Each parent produces two types of gametes:

$$A \quad \text{and} \quad a$$

Step 2: Construct the Punnett square.

| | | |
|---|----|----|
| | A | a |
| A | AA | Aa |
| a | Aa | aa |

Step 3: The genotypic ratio obtained is:

$$1 AA : 2 Aa : 1 aa$$

Step 4: Terminal flowers appear only in the **recessive genotype**:

$$aa$$

Thus, the proportion of terminal flowers is:

$$\frac{1}{4}$$

or **25%**.

Quick Tip

In a **monohybrid cross** between two heterozygous individuals ($Aa \times Aa$), the genotypic ratio is **1 : 2 : 1**. The recessive phenotype appears in **1/4 of the offspring**.

1 (xiv). Name the autoimmune disorder that affects the skeletal muscles in humans.

Correct Answer: Myasthenia gravis

Solution:

Concept: Autoimmune diseases occur when the body's immune system mistakenly attacks its own cells or tissues. One such disorder affecting skeletal muscles is **Myasthenia gravis**. In this condition, antibodies are produced against the **acetylcholine receptors** present at the neuromuscular junction. As a result, nerve impulses are not properly transmitted to the muscles.

Step 1: Understand the effect on muscles.

Because the acetylcholine receptors are blocked or destroyed by antibodies, the skeletal muscles cannot respond effectively to nerve signals.

Step 2: This leads to:

- Muscle weakness
- Fatigue of skeletal muscles
- Difficulty in movements such as speaking, chewing, or lifting objects

Step 3: The autoimmune disorder responsible for these symptoms is known as:

Myasthenia gravis

Hence, the autoimmune disorder affecting skeletal muscles is **Myasthenia gravis**.

Quick Tip

Myasthenia gravis is an autoimmune disease where antibodies attack **acetylcholine receptors** at the neuromuscular junction, causing weakness of skeletal muscles.

1 (xv). Answer the following:

(a) Expand the abbreviation IUI.

(b) The enzyme polynucleotide phosphorylase helps the *in-vitro* synthesis of RNA. Name the scientist who discovered this enzyme.

Correct Answer: (a) Intrauterine Insemination (b) Severo Ochoa

Solution:

Concept: Modern reproductive and molecular biology techniques involve artificial methods of fertilisation and enzymatic synthesis of nucleic acids.

(a) IUI

Step 1: Understand the abbreviation.

IUI is a medical procedure used in assisted reproductive technology (ART).

Step 2: In this technique, semen collected from the husband or a donor is artificially introduced directly into the uterus of the female to increase the chances of fertilisation.

Thus,

IUI = Intrauterine Insemination

(b) Discovery of polynucleotide phosphorylase

Step 1: The enzyme **polynucleotide phosphorylase** is capable of synthesising RNA molecules in laboratory conditions (*in-vitro*).

Step 2: This enzyme was discovered by the scientist **Severo Ochoa**.

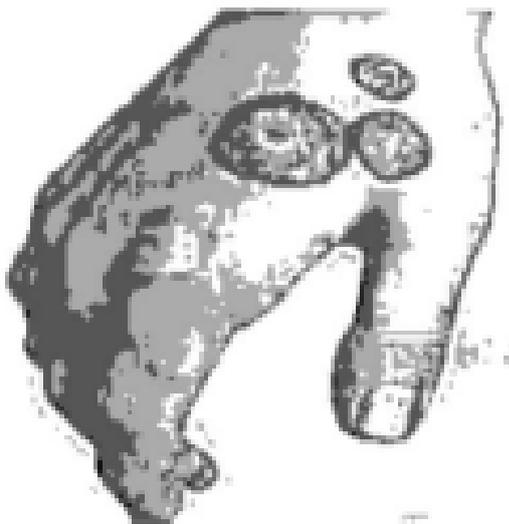
Therefore, the answers are:

- IUI – Intrauterine Insemination
- Scientist – Severo Ochoa

Quick Tip

IUI is an assisted reproductive technique where semen is directly placed into the uterus. **Severo Ochoa** discovered the enzyme **polynucleotide phosphorylase**, which helps synthesise RNA in laboratory conditions.

1 (xvi). Shama complained of severe itching in certain parts of her body where patches as shown below appeared on her skin. Write the biological name of the causative agent responsible for her condition.



Correct Answer: *Trichophyton*

Solution:

Concept: The symptoms described indicate a common fungal infection of the skin known as **ringworm**. It causes circular patches on the skin accompanied by itching.

Ringworm is caused by fungi belonging to genera such as:

- *Trichophyton*
- *Microsporum*
- *Epidermophyton*

Step 1: Identify the symptoms.

The question describes:

- Severe itching
- Circular patches on the skin

These are characteristic symptoms of **ringworm infection**.

Step 2: One of the most common causative fungi responsible for this infection is:

Trichophyton

Hence, the biological name of the causative agent is ***Trichophyton***.

Quick Tip

Ringworm is a fungal infection of the skin caused by fungi such as *Trichophyton*, *Microsporum*, and *Epidermophyton*. It typically produces **itchy circular patches** on the skin.

1 (xvii). Name the chemical messenger that activates Natural Killer T-cells and macrophages.

Correct Answer: Interferon- γ (IFN- γ)

Solution:

Concept: The immune system uses chemical messengers called **cytokines** to regulate immune responses. These molecules help immune cells communicate with each other and coordinate defense against pathogens.

Step 1: Identify the immune cells mentioned.

The question refers to:

- Natural Killer (NK) cells
- Macrophages

Step 2: A specific cytokine known as **Interferon- γ (IFN- γ)** activates macrophages and enhances the cytotoxic activity of NK cells and T-cells.

Step 3: Thus, the chemical messenger responsible for activating these immune cells is:

Interferon- γ

Hence, the answer is **Interferon- γ (IFN- γ)**.

Quick Tip

Interferon- γ is an important cytokine that activates macrophages and enhances the activity of Natural Killer cells and T-cells in immune defense.

1 (xviii). Give a reason for each of the following:

- (a) Kanika was suffering from SCID and needed periodic infusion of transformed lymphocytes.
(b) In HIV infected persons, the immune system is compromised.

Solution:

Concept: Certain diseases affect the immune system and reduce the body's ability to fight infections.

(a) SCID (Severe Combined Immunodeficiency)

Step 1: Understand the disorder.

SCID is a genetic disorder in which the body fails to produce functional **T-lymphocytes** and **B-lymphocytes**.

Step 2: Due to this deficiency, the immune system becomes extremely weak and cannot defend the body against infections.

Step 3: Therefore, patients require **periodic infusion of genetically transformed lymphocytes** to restore immune function.

Reason: Because SCID patients lack functional lymphocytes, transformed lymphocytes are infused to help build immune defense.

(b) HIV infection

Step 1: The **Human Immunodeficiency Virus (HIV)** specifically infects and destroys **CD4⁺ helper T-lymphocytes**.

Step 2: These cells play a crucial role in coordinating immune responses.

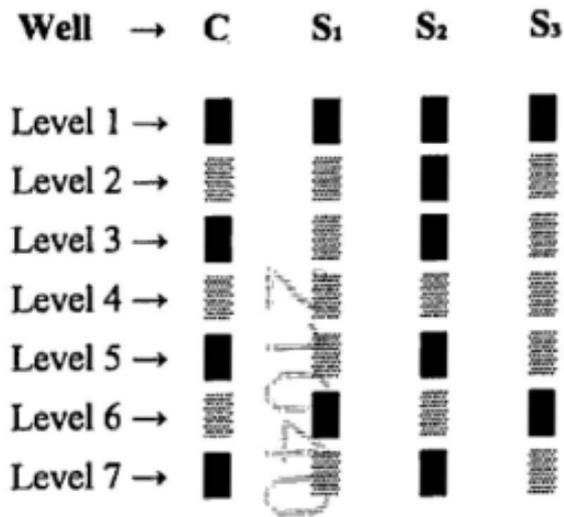
Step 3: As the number of helper T-cells decreases, the immune system becomes weak and unable to fight infections.

Reason: In HIV infection, destruction of **CD4⁺ T-cells** leads to weakening of the immune system.

Quick Tip

SCID results from absence of functional lymphocytes, while **HIV** weakens immunity by destroying **CD4⁺ helper T-cells**.

Question 2. The diagram below shows DNA banding patterns obtained after DNA samples collected from a crime scene were subjected to gel electrophoresis. Samples from the crime scene are denoted by C and three suspects are represented by S₁, S₂, S₃.



- (i) Which suspect's DNA sample matches the sample collected from the crime scene?
(ii) Mention the principle on which DNA profiling is based.

Correct Answer: (i) S₂ (ii) DNA profiling is based on DNA polymorphism in VNTR (Variable Number Tandem Repeats).

Solution:

Concept: DNA fingerprinting (DNA profiling) is a technique used to identify individuals based on unique patterns in their DNA. The DNA samples are cut using restriction enzymes and separated by gel electrophoresis, producing a pattern of bands.

Each individual has a unique pattern of DNA fragments due to variations in repetitive DNA sequences called VNTRs (Variable Number Tandem Repeats).

Step 1: Compare the banding patterns.

The DNA bands from the crime scene sample (C) must be compared with the bands of the suspects (S₁, S₂, S₃).

Step 2: The suspect whose DNA banding pattern exactly matches all the bands of the crime scene sample is the likely source of the DNA.

Step 3: On comparing the bands level by level, the pattern of the crime scene sample matches with S₂.

Therefore, suspect S₂ is the match.

(ii) Principle of DNA profiling

Step 1: DNA profiling relies on the fact that certain regions of DNA contain repetitive sequences that vary greatly among individuals.

Step 2: These regions are called Variable Number Tandem Repeats (VNTRs).

Step 3: The variation in the number of these repeats produces unique banding patterns when DNA fragments are separated by gel electrophoresis.

Thus, DNA profiling is based on DNA polymorphism in VNTR regions.

Quick Tip

DNA fingerprinting identifies individuals using variations in repetitive DNA sequences such as **VNTRs**. These variations produce unique banding patterns after gel electrophoresis.

Question 3. In a group discussion on pollination, Shubham argued that Cleistogamy was a type of Xenogamy whereas Ameena was of the opinion that it was a kind of Autogamy. Whose argument is correct? Justify.

Correct Answer: Ameena is correct.

Solution:

Concept: Pollination is the transfer of pollen grains from the anther to the stigma of a flower. It can occur in different ways:

- **Autogamy:** Transfer of pollen from the anther to the stigma of the **same flower**.
- **Geitonogamy:** Transfer of pollen between different flowers of the same plant.
- **Xenogamy:** Transfer of pollen between flowers of **different plants**.

Cleistogamy refers to flowers that **do not open at all**. In such flowers, the anthers and stigma remain close to each other, ensuring self-pollination within the same flower.

Step 1: Understand the nature of cleistogamous flowers.

Cleistogamous flowers remain closed and therefore cannot receive pollen from other plants.

Step 2: Since pollination occurs within the same flower, it represents a form of **autogamy**.

Step 3: Xenogamy involves pollen transfer between different plants, which is impossible in closed cleistogamous flowers.

Therefore, Ameena's argument that cleistogamy is a type of **autogamy** is correct.

Quick Tip

Cleistogamous flowers remain closed and always undergo **self-pollination (autogamy)**, ensuring assured seed formation without the need for pollinating agents.

Question 4. (i) The amount of energy at the fourth trophic level in the food chain given below is 4 J.

Grass → Zebra → Crocodile → Vulture

What will be the amount of energy available at the sunlight and transducer level?

Correct Answer: Energy at producer (transducer) level = 4000 J Energy at sunlight level = 4,00,000 J

Solution:

Concept: Energy transfer in a food chain follows the **10% law** proposed by **Lindeman**. According to this law, only **10% of the energy** from one trophic level is transferred to the next trophic level, while the remaining 90% is lost as heat.

Trophic levels in the given chain:

- Grass → Producer (1st trophic level)
- Zebra → Primary consumer (2nd trophic level)
- Crocodile → Secondary consumer (3rd trophic level)
- Vulture → Tertiary consumer (4th trophic level)

Step 1: Energy at the fourth trophic level is given as 4 J.

Using the 10% law, energy at the previous level must be **10 times higher**.

$$\text{Energy at 3rd level} = 4 \times 10 = 40 \text{ J}$$

$$\text{Energy at 2nd level} = 40 \times 10 = 400 \text{ J}$$

$$\text{Energy at 1st level (producer)} = 400 \times 10 = 4000 \text{ J}$$

Step 2: Producers capture only about **1% of solar energy**. Therefore:

$$\text{Sunlight energy} = 4000 \times 100 = 4,00,000 \text{ J}$$

Step 3: Thus,

- Energy at transducer (producer) level = **4000 J**
- Energy at sunlight level = **4,00,000 J**

Quick Tip

According to the **10% law**, only 10% of energy is transferred to the next trophic level. Plants capture roughly **1% of the total solar energy** falling on them.

(ii) Roselin had an aquarium at her home with 10 fish in it. In a year, a fish gave birth to 7 fish. During this period, 3 adult fish had died. Roselin's father purchased 2 more pairs of fish from the market for the aquarium. Later, Roselin gifted 4 fish from the aquarium to her friend. Find out the growth rate of fish in Roselin's aquarium.

Correct Answer: Growth rate = 4 fish per year

Solution:

Concept: Population growth rate depends on the following factors:

$$\text{Growth} = (\text{Births} + \text{Immigration}) - (\text{Deaths} + \text{Emigration})$$

Step 1: Identify the initial population.

Initial number of fish = 10

Step 2: Births = 7 fish

Step 3: Deaths = 3 fish

Step 4: Immigration (fish purchased) = 2 pairs = 4 fish

Step 5: Emigration (fish gifted away) = 4 fish

Step 6: Apply the formula:

$$\begin{aligned}\text{Growth} &= (7 + 4) - (3 + 4) \\ &= 11 - 7 \\ &= 4\end{aligned}$$

Thus, the **growth rate of fish population** in the aquarium is:

4 fish per year

Quick Tip

Population growth is calculated using:

$$(B + I) - (D + E)$$

where B = Births, I = Immigration, D = Deaths, E = Emigration.

Question 5. Anthony is a scientist who has been provided with raw materials to obtain a specific biological product in large quantities. His laboratory has two large vessels for this purpose – one with a sparger and the other vessel with a stirrer. Which vessel will be more advantageous to Anthony? Why?

Correct Answer: The vessel with a sparger (bioreactor) will be more advantageous.

Solution:

Concept: In biotechnology, large-scale production of biological products such as enzymes, vaccines, or antibiotics is carried out in specialized vessels called **bioreactors**. These bioreactors maintain optimal conditions for microbial growth and product formation.

Step 1: Understand the function of a sparger.

A **sparger** is a device used in bioreactors to introduce sterile air or oxygen into the culture medium in the form of bubbles.

Step 2: This ensures:

- Proper **aeration** of the culture
- Adequate **oxygen supply** for aerobic microorganisms
- Improved **mixing and nutrient distribution**

Step 3: Although a stirrer helps in mixing the medium, a vessel with a **sparger** is more advantageous because it provides continuous oxygen supply which is essential for microbial growth and efficient production of biological products.

Step 4: Therefore, the vessel with a **sparger** is preferred for large-scale production.

Quick Tip

A **sparger** in a bioreactor introduces sterile air into the culture medium, ensuring proper oxygen supply and efficient microbial growth during large-scale biological production.

Question 6. The data given below shows a significant decline in the population of migratory birds in a wetland in Southern India over the last three years.

| Year | Population of Birds | Aquatic Plants (%) | Aquatic Area (ha) |
|------|---------------------|--------------------|-------------------|
| 2023 | 10,000 | 85 | 350 |
| 2024 | 8,000 | 60 | 280 |
| 2025 | 5,000 | 45 | 220 |

Based on the above data, interpret two reasons for change in the population of migratory birds.

Solution:

Concept: Migratory birds depend heavily on wetlands for food, shelter, and breeding. Any decline in habitat quality or availability of food resources can lead to a decrease in their population.

Step 1: Observe the trend in aquatic plants.

The percentage of aquatic plants has decreased from:

$$85\% \rightarrow 60\% \rightarrow 45\%$$

Aquatic plants provide food and shelter for many aquatic organisms that serve as food for migratory birds. Reduction in aquatic vegetation leads to a decline in food availability.

Reason 1: Decrease in aquatic plant cover has reduced food resources and habitat for migratory birds.

Step 2: The aquatic area of the wetland has also decreased:

$$350 \text{ ha} \rightarrow 280 \text{ ha} \rightarrow 220 \text{ ha}$$

This indicates shrinkage of the wetland habitat.

Reason 2: Reduction in wetland area has decreased the available habitat for migratory birds.

Thus, the decline in bird population is mainly due to:

- Decrease in aquatic plant cover
- Reduction in wetland (aquatic) area

Quick Tip

Wetlands are important habitats for migratory birds. Decline in **aquatic vegetation** and **wetland area** directly affects food availability and habitat, leading to reduced bird populations.

Question 7. *Paramecium caudatum* and *Paramecium aurelia* were growing in separate culture media in a laboratory. When both the species were transferred to the same culture medium for growth, it was observed that *Paramecium caudatum* got eliminated from the habitat after some time. Identify and explain the type of ecological interaction between the aforementioned species of *Paramecia* on the basis of Gause's principle.

Correct Answer: Interspecific competition (Competitive exclusion principle).

Solution:

Concept: Gause's Competitive Exclusion Principle states that two species competing for the same limited resources cannot coexist indefinitely in the same habitat. One species that is better adapted will outcompete and eliminate the other species.

Step 1: Identify the interaction between the two species.

Both *Paramecium caudatum* and *Paramecium aurelia* were placed in the same culture medium where they competed for the same resources such as food and space.

Step 2: Since both species occupy the same ecological niche, competition occurs between them. This type of interaction between different species is called **interspecific competition**.

Step 3: According to Gause's experiments, *Paramecium aurelia* was more efficient in utilizing the available resources and therefore outcompeted *Paramecium caudatum*.

Step 4: As a result, *Paramecium caudatum* was eliminated from the habitat.

Thus, the interaction observed is **interspecific competition**, explained by the **Competitive Exclusion Principle**.

Quick Tip

According to **Gause's Competitive Exclusion Principle**, two species competing for the same ecological niche cannot coexist indefinitely; the better adapted species eliminates the other.

Question 8. In an experiment to produce recombinant cells, a plasmid without selectable marker was chosen as the vector for cloning a gene.

(i) Predict the outcome of this experiment.

(ii) Name an artificial chromosome that can be used as a vector to transfer the recombinant DNA in *Penicillium notatum*.

Correct Answer: (i) Recombinant cells cannot be easily identified or selected. (ii) Yeast Artificial Chromosome (YAC).

Solution:

Concept: In recombinant DNA technology, **vectors** such as plasmids are used to transfer foreign DNA into host cells. These vectors usually contain **selectable marker genes** (e.g., antibiotic resistance genes) which help in identifying transformed cells.

(i) Outcome of the experiment

Step 1: Understand the role of selectable markers.

Selectable markers help scientists distinguish between:

- Cells that have successfully taken up the recombinant plasmid
- Cells that have not taken up the plasmid

Step 2: If the plasmid used in the experiment does not contain a selectable marker, it becomes impossible to differentiate recombinant cells from non-recombinant cells.

Step 3: Therefore, the desired recombinant cells cannot be easily identified or isolated.

(ii) Artificial chromosome used as vector

Step 1: Artificial chromosomes are large DNA molecules used as cloning vectors for transferring large DNA fragments.

Step 2: One such artificial chromosome commonly used in eukaryotic organisms and fungi is the **Yeast Artificial Chromosome (YAC)**.

Step 3: Thus, YAC can be used as a vector to transfer recombinant DNA in organisms such as *Penicillium notatum*.

Quick Tip

Selectable markers help identify transformed cells in recombinant DNA experiments. Examples of artificial chromosome vectors include **YAC (Yeast Artificial Chromosome)** and **BAC (Bacterial Artificial Chromosome)**.

Question 9. (i) How is mature insulin different from pro-insulin secreted by pancreas in humans?

(ii) Name the company that produced genetically engineered insulin for the first time.

(iii) Why is functional insulin produced by r-DNA technology better than the ones produced earlier?

Correct Answer:

- (i) Mature insulin contains only A and B chains, while pro-insulin contains an additional C-peptide.
- (ii) Eli Lilly
- (iii) Recombinant insulin is highly pure, safe, and does not cause allergic reactions like earlier animal-derived insulin.

Solution:

Concept: Insulin is a hormone produced by the pancreas that regulates blood glucose levels. Initially, insulin is synthesized in an inactive form called **pro-insulin**. Later it is converted into **mature insulin**. Modern biotechnology uses **recombinant DNA (r-DNA) technology** to produce insulin for medical use.

(i) Difference between pro-insulin and mature insulin

Step 1: Structure of pro-insulin.

Pro-insulin is the precursor form of insulin and contains three peptide segments:

- A-chain
- B-chain
- Connecting peptide (C-peptide)

Step 2: During maturation, the **C-peptide is removed**, leaving only the A and B chains linked by disulfide bonds.

Step 3: Thus:

- **Pro-insulin** = A-chain + B-chain + C-peptide
- **Mature insulin** = A-chain + B-chain only

(ii) First company to produce genetically engineered insulin

The first genetically engineered human insulin, known as **Humulin**, was produced by the biotechnology company:

Eli Lilly

(iii) Advantage of recombinant insulin

Earlier, insulin used for treatment was extracted from the pancreas of animals such as pigs and cattle.

Step 1: Animal insulin was slightly different from human insulin.

Step 2: This sometimes caused **allergic reactions or immune responses** in patients.

Step 3: Recombinant insulin produced using r-DNA technology is identical to human insulin, highly pure, and safer for medical use.

Thus, recombinant insulin is **more effective and causes fewer side effects**.

Quick Tip

Pro-insulin contains an extra **C-peptide**. Removal of this peptide produces **mature insulin**. The first recombinant human insulin was produced by **Eli Lilly**.

Question 10. A biologist surveyed islands of different sizes and consolidated the results in the form of the data given below. Study the data carefully and answer the questions that follow.

| Name of Islands | Island Area (sq. km) | No. of mammalian species |
|-----------------|----------------------|--------------------------|
| P | 1 | 5 |
| Q | 10 | 18 |
| R | 100 | 60 |
| S | 1000 | 150 |

- (i) What pattern do you observe in the above data?
(ii) Name the scientist who proposed the concept of relationship between area and species.
(iii) Write the mathematical expression for this relationship.

Correct Answer:

- (i) As the island area increases, the number of species also increases.
- (ii) Alexander von Humboldt
- (iii) $S = CA^Z$

Solution:

Concept: The relationship between the **area of a habitat** and the **number of species present** is known as the **species–area relationship**. Larger areas generally support a greater diversity of species because they provide more habitats and resources.

Step 1: Observe the trend in the data.

From the table:

- Island P (1 sq. km) → 5 species
- Island Q (10 sq. km) → 18 species
- Island R (100 sq. km) → 60 species
- Island S (1000 sq. km) → 150 species

Step 2: As the **area of the island increases**, the **number of mammalian species also increases**. This shows a positive relationship between habitat area and species richness.

(ii) Scientist who proposed the concept

The species–area relationship was first described by the naturalist:

Alexander von Humboldt

(iii) Mathematical expression

The relationship between species richness and area is expressed as:

$$S = CA^Z$$

where:

- S = Number of species
- A = Area of the habitat

- C = Constant
- Z = Regression coefficient

Quick Tip

The **species–area relationship** shows that larger habitats support more species. It is expressed mathematically as $S = CA^Z$.

Question 11. (i) Draw a flowchart to show the process of sex determination in honeybees.

(ii) If there are 16 chromosomes in the somatic cells of a male honeybee, how many chromosomes would be present in spermatozoa?

Correct Answer:

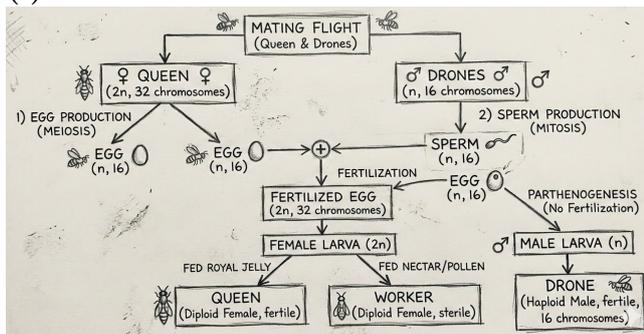
- (i) Sex determination in honeybees follows the haplodiploid mechanism.
- (ii) 16 chromosomes

Solution:

Concept: Honeybees show a special type of sex determination known as the **haplodiploid mechanism**. In this system:

- Fertilised eggs develop into **diploid females** (queen or worker).
- Unfertilised eggs develop into **haploid males** (drones).

(i) **Flowchart of sex determination in honeybees**



(ii) **Chromosome number in spermatozoa**

Step 1: Understand the chromosome condition of male honeybees.

Male honeybees (drones) are **haploid** and develop from unfertilised eggs.

Step 2: Their somatic cells already contain the haploid number of chromosomes.

Given:

$$\text{Chromosomes in somatic cells of male} = 16$$

Step 3: Since the male is haploid, its sperm cells are produced by **mitosis** and contain the same number of chromosomes.

Chromosomes in spermatozoa = 16

Thus, the spermatozoa will contain **16 chromosomes**.

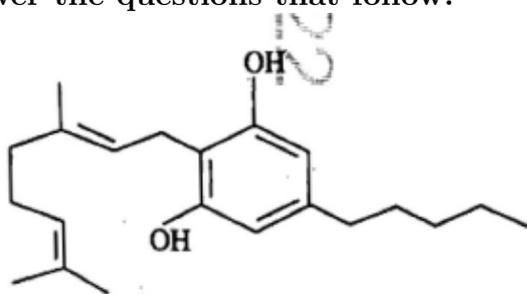
Quick Tip

Honeybees show **haplodiploid sex determination**.

- Fertilised eggs (2n) → Female
- Unfertilised eggs (n) → Male

Male honeybees produce sperm by **mitosis**.

Question 12. Study the chemical structure of an addictive drug shown below and answer the questions that follow.



- Mention the scientific name of the source plant of the above drug.
- State any one effect of this drug on human body.
- What is meant by withdrawal symptom?

Correct Answer:

- (i) *Cannabis sativa*
- (ii) It affects the central nervous system and may cause hallucinations or impaired coordination.
- (iii) Withdrawal symptoms are unpleasant physical or psychological effects experienced when a person stops taking an addictive drug.

Solution:

Concept: The chemical structure shown represents an addictive compound belonging to the **cannabinoids**. Cannabinoids are obtained from the plant *Cannabis sativa* and include substances such as tetrahydrocannabinol (THC), which affect the brain.

(i) Source plant of the drug

Step 1: Identify the class of drug.

The structure belongs to cannabinoids which are derived from the plant:

Cannabis sativa

Thus, the scientific name of the source plant is *Cannabis sativa*.

(ii) Effect on the human body

Cannabinoids act on the **central nervous system** and can produce several effects such as:

- Altered perception
- Hallucinations
- Impaired memory and coordination
- Reduced reaction time

Any one effect: **hallucinations or impaired coordination.**

(iii) Withdrawal symptom

Step 1: When a person who is addicted to a drug suddenly stops using it, the body reacts negatively.

Step 2: This leads to unpleasant symptoms such as anxiety, irritability, nausea, and restlessness.

Step 3: These effects are collectively known as **withdrawal symptoms**.

Withdrawal symptoms = Physical or psychological discomfort after stopping an addictive drug

Quick Tip

Cannabinoids are addictive drugs obtained from the plant *Cannabis sativa*. **Withdrawal symptoms** occur when an addicted individual suddenly stops using the drug.

Question 13. A researcher compares two embryos, X and Y.

- Embryo X shows equal division of the zygote, forming two cells that are almost identical in size.
- Embryo Y shows an unequal first division and produces a small apical cell and a large basal cell.

(i) Which embryo is likely to develop into a normal dicot embryo?

(ii) What is the fate of:

- (a) Apical cell?**
(b) Basal cell?

Correct Answer:

- (i) Embryo Y
- (ii)
 - (a) Apical cell forms the embryo proper.

- (b) Basal cell forms the suspensor.

Solution:

Concept: During the development of a dicot embryo, the first division of the zygote is **unequal**. This produces two cells of different sizes: a **small apical cell** and a **large basal cell**. Each of these cells has a specific role in embryo development.

Step 1: Identify the correct embryo.

In the given question:

- Embryo X shows equal division.
- Embryo Y shows unequal division producing an apical and a basal cell.

Since dicot embryo development begins with an **unequal division**, **Embryo Y** will develop into a normal dicot embryo.

Step 2: Fate of the apical cell

The **apical cell** divides repeatedly and gives rise to the **embryo proper**, which later forms structures such as:

- Cotyledons
- Plumule
- Hypocotyl

Step 3: Fate of the basal cell

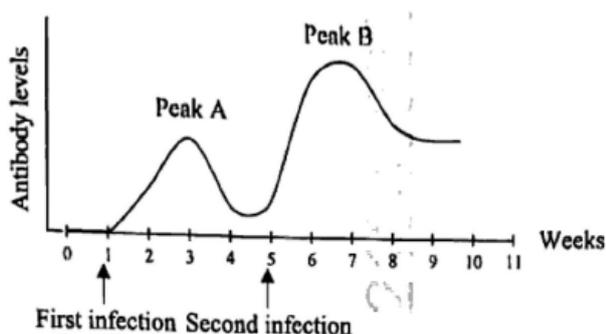
The **basal cell** divides to form the **suspensor**. The suspensor helps in pushing the developing embryo into the endosperm and facilitates nutrient transfer to the embryo.

Quick Tip

In dicot embryo development, the zygote divides unequally to form:

- **Apical cell** → Embryo proper
- **Basal cell** → Suspensor

Question 14. (i) The graph given below shows the level of antibodies in the blood after exposure to a pathogen.



- (a) What types of responses of the immune system do the peaks A and B represent?
(b) Name the type of antibody that is at the highest level in the 7th week.

Correct Answer:

- (a) Peak A – Primary immune response; Peak B – Secondary immune response.
- (b) IgG

Solution:

Concept: When the body is exposed to an antigen for the first time, it produces a **primary immune response**. This response is slow and produces fewer antibodies. Upon second exposure to the same antigen, the body produces a **secondary immune response**, which is faster and stronger due to the presence of memory cells.

Step 1: Identify Peak A.

Peak A occurs after the **first infection**. This represents the **primary immune response**, which develops slowly and produces a moderate level of antibodies.

Step 2: Peak B occurs after the **second infection**. This represents the **secondary immune response**, which is faster and produces a much higher level of antibodies.

Step 3: During the secondary immune response, the antibody that reaches the highest level is **IgG**.

Thus:

- Peak A → Primary immune response
- Peak B → Secondary immune response
- Highest antibody in 7th week → IgG

Quick Tip

The **primary immune response** occurs during the first exposure to an antigen and is slow. The **secondary immune response** is faster and stronger due to **memory cells**, with **IgG** antibodies predominating.

(ii) *Plasmodium* is a digenetic parasite, completing its life cycle in humans and mosquitoes. In humans, it completes different parts of its life cycle in the liver and RBCs. Draw a flow chart to outline its erythrocytic cycle in humans.

Solution:

Concept: The **erythrocytic cycle** of *Plasmodium* occurs in the red blood cells of humans. During this stage, the parasite multiplies inside RBCs and causes their rupture, leading to the characteristic symptoms of malaria.

Flow chart of erythrocytic cycle:

Merozoites released from liver → Enter RBCs

→ Trophozoite stage (feeding stage)

→ Schizont stage (multiple nuclear divisions)

→ Formation of many merozoites

→ Rupture of RBC

→ Release of merozoites and toxins

→ Invasion of new RBCs

This cycle repeats and leads to the periodic fever observed in malaria.

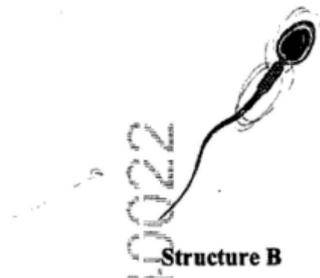
Quick Tip

In the **erythrocytic cycle**, *Plasmodium* multiplies inside **RBCs** as trophozoites and schizonts, eventually causing RBC rupture and release of **merozoites**.

Question 15. The two structures shown below are formed in the process of spermatogenesis. Study them carefully and answer the questions that follow.



Structure A



Structure B

- (i) Identify the process which converts Structure A to Structure B.
- (ii) State any two modifications observable in Structure B.

Correct Answer:

- (i) Spermiogenesis
- (ii)
 - Formation of a flagellum (tail) for motility.
 - Development of an acrosome on the head of the sperm.

Solution:

Concept: Spermatogenesis is the process by which male gametes (sperms) are produced in the testes. During this process, immature spermatids transform into mature spermatozoa through a series of structural changes.

Step 1: Identify the structures.

- Structure A represents a **spermatid**, which is a round immature male gamete.
- Structure B represents a **spermatozoon (sperm)**, the mature male gamete.

Step 2: The transformation of a spermatid into a mature spermatozoon is called:

Spermiogenesis

Step 3: Modifications observed in Structure B

During spermiogenesis, several structural changes occur:

- Formation of a **flagellum (tail)** which enables movement.
- Development of the **acrosome** from the Golgi apparatus at the head of the sperm, containing enzymes required for fertilisation.
- Condensation of the nucleus.
- Reduction of cytoplasm.

Any two modifications can be stated.

Quick Tip

Spermiogenesis is the transformation of spermatids into mature spermatozoa. Key changes include formation of the **acrosome**, development of a **flagellum**, and condensation of the nucleus.

Question 16. As a part of his research, Arun conducted a study on the number of locusts in a forest. He compiled his findings in the form of the following data.

| Day | Number of locusts |
|-----|-------------------|
| 1 | 5 |
| 2 | 10 |
| 5 | 25 |
| 10 | 50 |
| 15 | 105 |
| 20 | 170 |
| 25 | 280 |
| 30 | 360 |
| 35 | 200 |

- (i) Construct a growth curve based on the above data. What type of a growth curve is obtained?
 (ii) Write a mathematical expression for the growth curve obtained.

Correct Answer:

- (i) Sigmoid (S-shaped) growth curve / Logistic growth curve.

- (ii) $\frac{dN}{dt} = rN \left(\frac{K - N}{K} \right)$

Solution:

Concept: Population growth in nature usually follows a **logistic growth pattern**. Initially the population grows slowly, then rapidly, and finally stabilizes or declines due to limited resources such as food, space, and environmental resistance. This produces a **sigmoid (S-shaped) curve**.

Step 1: Observe the data trend.

- The population increases steadily from day 1 to day 30.
- The population reaches a peak at day 30 (360 locusts).
- Afterwards the population decreases to 200 by day 35 due to limiting factors.

Step 2: This pattern indicates that the population initially grows rapidly and then slows down due to environmental limitations. Such growth results in a **sigmoid or logistic growth curve**.

Step 3: Mathematical expression

The logistic growth equation is expressed as:

$$\frac{dN}{dt} = rN \left(\frac{K - N}{K} \right)$$

where:

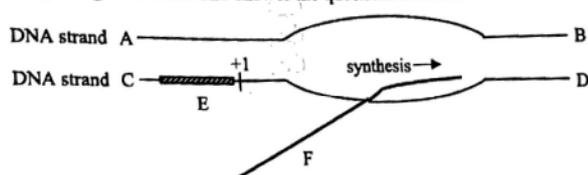
- N = Population size
- r = Intrinsic rate of natural increase
- K = Carrying capacity of the environment
- $\frac{dN}{dt}$ = Rate of population growth

Thus, the growth curve obtained from the given data is a **sigmoid (logistic) growth curve**.

Quick Tip

Population growth commonly follows a **logistic (S-shaped) curve** when environmental resources become limiting. The logistic growth equation is $\frac{dN}{dt} = rN \left(\frac{K - N}{K} \right)$.

Question 17. Study the diagram given below and answer the questions that follow.



- (i) Identify the parts marked 'E' and 'F'.
(ii) Explain the post-transcriptional modifications that occur in part 'F'.

Correct Answer:

- (i) E – Promoter region ; F – Primary RNA transcript (hnRNA / pre-mRNA)
- (ii) Post-transcriptional modifications include capping, tailing and splicing.

Solution:

Concept: Transcription is the process in which genetic information from DNA is copied into RNA. In eukaryotes, the RNA initially formed is called **primary transcript or hnRNA**. This transcript undergoes several **post-transcriptional modifications** before becoming functional mRNA.

Step 1: Identify part E.

Part **E** is located upstream of the transcription start site (+1). This region is known as the **promoter**. It is the site where RNA polymerase binds to initiate transcription.

Step 2: Part **F** represents the **primary RNA transcript (hnRNA)** produced during transcription.

Step 3: Post-transcriptional modifications

The primary RNA transcript undergoes the following modifications to become mature mRNA:

- **Capping:** Addition of a methyl guanosine cap at the 5' end of the RNA.
- **Tailing:** Addition of a poly-A tail (multiple adenine nucleotides) at the 3' end.
- **Splicing:** Removal of non-coding sequences called **introns** and joining of coding sequences called **exons**.

These modifications convert hnRNA into **mature mRNA** which can then be translated into protein.

Quick Tip

In eukaryotes, the primary RNA transcript (hnRNA) undergoes three key modifications: **5' capping, 3' poly-A tailing, and splicing** to produce mature mRNA.

**Question 18. (i) Outline three major steps in the process of artificial hybridisation.
(ii) Discuss the role of pollen–pistil interaction in ensuring successful hybrid formation.**

OR

- (iii) Draw a flowchart to represent the process of oogenesis.
(iv) Differentiate between oogenesis and spermatogenesis on the following basis:
(a) Number of products
(b) Gonadal hormones

Solution:

(i) Major steps in artificial hybridisation

Concept: Artificial hybridisation is a plant breeding technique in which pollen from a selected male parent is manually transferred to the stigma of a chosen female parent to obtain desired hybrids.

Steps:

- **Emasculation:** Removal of anthers from a bisexual flower before they release pollen to prevent self-pollination.
- **Bagging:** The emasculated flower is covered with a suitable bag to prevent contamination from unwanted pollen.
- **Artificial Pollination:** Pollen grains from the desired male parent are dusted onto the stigma of the female flower and the flower is again bagged.

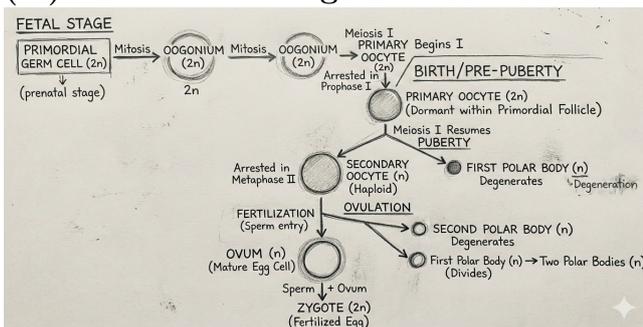
(ii) Role of pollen–pistil interaction

Concept: Pollen–pistil interaction refers to the series of events that occur from the time pollen lands on the stigma until fertilisation occurs.

- The stigma recognises whether the pollen is compatible or incompatible.
- Compatible pollen grains germinate on the stigma and produce pollen tubes.
- The pollen tube grows through the style and reaches the ovule.
- This interaction ensures that only the correct pollen fertilises the ovule, leading to successful hybrid formation.

OR

(iii) Flowchart of oogenesis



(iv) Difference between oogenesis and spermatogenesis

| Basis | Oogenesis | Spermatogenesis |
|--------------------|---------------------------------|------------------------|
| Number of products | One ovum and three polar bodies | Four functional sperms |
| Gonadal hormones | Estrogen and progesterone | Testosterone |

Quick Tip

Artificial hybridisation involves emasculation, bagging, and controlled pollination. **Oogenesis** produces one functional ovum, whereas **spermatogenesis** produces four functional sperms.
