# CBSE Class 12 2025 Biology Question Paper (57/4/1) With Solutions

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|---|---|---|
| **Time Allowed :**3 Hour | **Maximum Marks :**70 | **Total questions :**33 |

## General Instructions

**Read the following instructions very carefully and strictly follow them:**

1. This question paper contains 33 questions. All questions are compulsory.
2. This question paper is divided into five sections Sections A, B, C, D and E.
3. In Section A Questions no. 1 to 16 are Multiple Choice type questions. Each question carries 1 mark.
4. In Section B Questions no. 17 to 21 are Very Short Answer type questions.Each question carries 2 marks.
5. In Section C Questions no. 22 to 28 are Short Answer type questions. Each question carries 3 marks.
6. In Section D Questions no. 29 and 30 are case study based questions. Each question carries 4 marks.
7. In Section E Questions no. 31 to 33 are Long Answer type questions. Each question carries 5 marks.
8. There is no overall choice given in the question paper. However, an internal choice has been provided in few questions in all the Sections except Section A.
9. Kindly note that there is a separate question paper for Visually Impaired candidates.
10. Use of calculators is not allowed.

## SECTION A

**Questions no. 1 to 16 are Multiple Choice Type Questions, carrying 1 mark each. Choose the best option.**

**1. In its extended 'beads-on-string' form of chromatin, the 'beads' in the string represent:**

(A) Linker DNA

(B) Histone proteins

(C) Nucleosomes

(D) NHC proteins

**Correct Answer:** (C) Nucleosomes

**Solution:**

In the beads-on-string model of chromatin structure, the "beads" represent nucleosomes. Each nucleosome consists of DNA wrapped around a core of histone proteins. The "string" part is the linker DNA, which connects one nucleosome to the next. This structure helps in the packaging of DNA into a compact form within the nucleus.

**Quick Tip**

Nucleosomes are DNA-histone complexes that form the fundamental repeating unit of chromatin. Each bead is a nucleosome, and the string is linker DNA.

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**2. Given below are a few statements with reference to the accessory ducts of the human male reproductive system:**

(i) The seminiferous tubules of the testes open into rete testis then into the vas deferens.

(ii) The vasa efferentia leave the testes and open into the epididymis.

(iii) The epididymis leads to vas deferens that ascends into the abdomen.

(iv) The vas deferens receives a duct from the prostrate gland and opens into the urethra as ejaculatory duct.

(v) The urethra originates from the urinary bladder and extends through the penis to its external opening, urethral meatus.

**Choose the option with all true statements from the given options:**

(A) (i), (ii), (iv)

(B) (ii), (iii), (v)

(C) (ii), (iv), (v)

(D) (i), (iii), (iv)

**Correct Answer:** (B) (ii), (iii), (v)

**Solution:**

Statement (i) is incorrect because the seminiferous tubules open into the rete testis, but then into the **vasa efferentia**, not directly into the vas deferens.

Statement (ii) is correct – the vasa efferentia carry sperms from the testes to the epididymis.

Statement (iii) is correct – the epididymis leads into the vas deferens, which ascends into the abdominal cavity.

Statement (iv) is incorrect – the vas deferens joins with the duct of the **seminal vesicle** (not the prostate) to form the ejaculatory duct.

Statement (v) is correct – the urethra starts from the urinary bladder and ends at the external urethral opening (meatus).

Quick Tip

Remember: Vasa efferentia connect rete testis to epididymis; ejaculatory ducts form by the union of vas deferens and seminal vesicle ducts, not prostate.

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**3. The substrate used during DNA replication by the enzyme DNA-dependent DNA polymerase is:**

(A) Deoxyribonucleotide triphosphate

(B) Deoxyribonucleoside triphosphate

(C) Ribonucleotide triphosphate

(D) Ribonucleoside triphosphate

**Correct Answer:** (A) Deoxyribonucleotide triphosphate

**Solution:**

DNA-dependent DNA polymerase catalyzes the synthesis of DNA from a DNA template. The enzyme requires deoxyribonucleotide triphosphates (dATP, dGTP, dCTP, dTTP) as substrates. These molecules provide both the building blocks for the new DNA strand and the energy for the polymerization reaction through the hydrolysis of their high-energy phosphate bonds.

Quick Tip

DNA polymerases always use **deoxyribonucleotide triphosphates** (not ribose-containing ones) for DNA replication.

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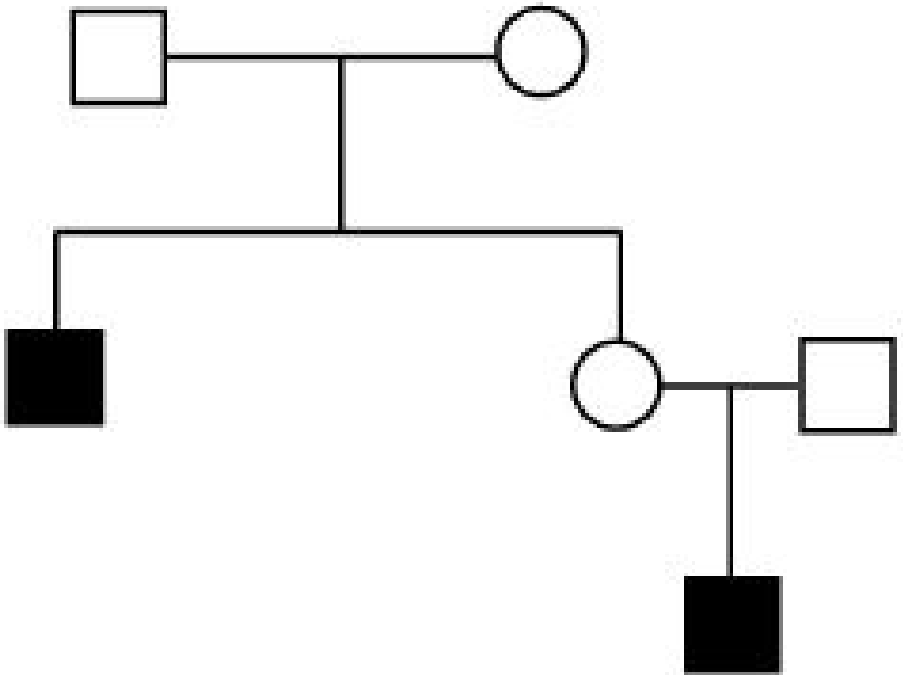
**4. In the given pedigree chart, a cross between a normal couple resulted in a son who was haemophilic and a normal daughter. In course of time, when the daughter was married to a normal man, to their surprise the grandson was also haemophilic.**



**Choose the option that indicates the correct inheritance of trait in the above pedigree chart:**

(A) Autosome linked dominant trait

(B) Sex-linked dominant trait

(C) Autosomal recessive trait

(D) Sex-linked recessive trait

**Correct Answer:** (D) Sex-linked recessive trait

**Solution:**

**Step 1:** The trait (haemophilia) is seen only in males and skips a generation, as the daughter of the affected male is a carrier (normal phenotype) but passes the trait to her son.

**Step 2:** This suggests the trait is inherited through the X chromosome, and since females are generally carriers while males are affected, it fits the pattern of a sex-linked recessive trait.

**Step 3:** If it were dominant or autosomal, affected females would appear more frequently or the inheritance pattern would not be restricted by gender as seen here.

Quick Tip

Sex-linked recessive traits like haemophilia often affect males more because they have only one X chromosome. Carrier females can pass the gene to their sons.

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**5. In which of the following human diseases does the body's self-defence mechanism attack self-cells?**

(A) Thalassemia

(B) Phenylketonuria

(C) Filariasis

(D) Rheumatoid arthritis

**Correct Answer:** (D) Rheumatoid arthritis

**Solution:**

Rheumatoid arthritis is an autoimmune disorder in which the body's immune system mistakenly attacks its own tissues, especially the synovial joints. This results in inflammation, pain, and damage to joint linings. Unlike infections caused by external pathogens, autoimmune diseases arise from a failure of self-tolerance in the immune system.

Quick Tip

Autoimmune diseases like rheumatoid arthritis occur when the immune system fails to distinguish self from non-self and begins to attack the body's own cells.

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**6. Select the statements that are true for a typical dicotyledonous embryo from the given options.**

**(i) It consists of an embryonal axis and scutellum.**

**(ii) The portion of embryonal axis above the level of cotyledon is epicotyl.**

**(iii) The portion of embryonal axis below the level of cotyledon is coleorhiza.**

**(iv) The lower end of the embryo has radicle covered with a root cap.**

**Choose the correct answer:**

(A) (i) and (ii)

(B) (i) and (iii)

(C) (iii) and (iv)

(D) (ii) and (iv)

**Correct Answer:** (D) (ii) and (iv)

**Solution:**

In a typical dicot embryo:

- Statement (ii) is correct: The epicotyl is the part of the embryonal axis above the level of cotyledons and gives rise to the shoot system.
- Statement (iv) is correct: The radicle is the embryonic root, and it is covered by a root cap.
- Statement (i) is incorrect because scutellum is a feature of monocot embryos, not dicots.
- Statement (iii) is incorrect as coleorhiza is also a monocot feature.

Quick Tip

Dicot embryos have two cotyledons, an epicotyl, a radicle with root cap, and lack structures like coleorhiza and scutellum that are found in monocots.

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**7. About 15 mya during human evolution, the primates which used to walk like gorillas and chimpanzees were:**

(A) Australopithecine and Neanderthal

(B) Dryopithecus and Ramapithecus

(C) Homo erectus and Homo sapiens

(D) Homo habilis and Homo erectus

**Correct Answer:** (B) Dryopithecus and Ramapithecus

**Solution:**

Around 15 million years ago (mya), Dryopithecus and Ramapithecus were among the primates living on earth. Dryopithecus was more ape-like, while Ramapithecus was considered to be more man-like. Both walked in a quadrupedal manner, similar to modern-day gorillas and chimpanzees, indicating their evolutionary proximity to those primates.

Quick Tip

Dryopithecus and Ramapithecus are among the earliest ancestors of humans, showing transitional forms in posture and locomotion.

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**8. Use the given information to select the amino acid attached to the 3 end of tRNA during the process of translation, if the coding strand of the structural gene being transcribed has the nucleotide sequence TAC.**

Codons for the amino acids:

| Codon | Amino Acid |
|---|---|
| AUC | Isoleucine |
| AUG | Methionine |
| UAC | Tyrosine |
| GUA | Valine |

**Options:**

(A) Isoleucine

(B) Methionine

(C) Tyrosine

(D) Valine

**Correct Answer:** (C) Tyrosine

**Solution:**

**Step 1:** The given sequence is from the **coding strand**, which is TAC.

**Step 2:** The template strand (used for mRNA synthesis) is complementary to the coding strand, so it will be ATG.

**Step 3:** During transcription, mRNA is synthesized using the template strand, so the mRNA sequence becomes **UAC**.

**Step 4:** According to the codon table, the mRNA codon UAC codes for the amino acid **Tyrosine**.

Quick Tip

Always remember: the codon table is based on mRNA, not DNA. So convert the DNA coding strand to mRNA before matching it to codons.

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**9. The technique for the early detection of a disease based on the principle of antigen-antibody interaction is:**

(A) RNAi

(B) EST

(C) PCR

(D) ELISA

**Correct Answer:** (D) ELISA

**Solution:**

ELISA (Enzyme-Linked Immunosorbent Assay) is a biochemical technique used to detect the presence of an antigen (such as proteins or pathogens) or antibody in a sample. It is based on the specific binding between an antigen and its antibody and is widely used for early diagnosis of diseases like HIV, hepatitis, and certain cancers.

Quick Tip

ELISA works on the principle of antigen-antibody interaction and is a sensitive, early-detection tool in clinical diagnostics.

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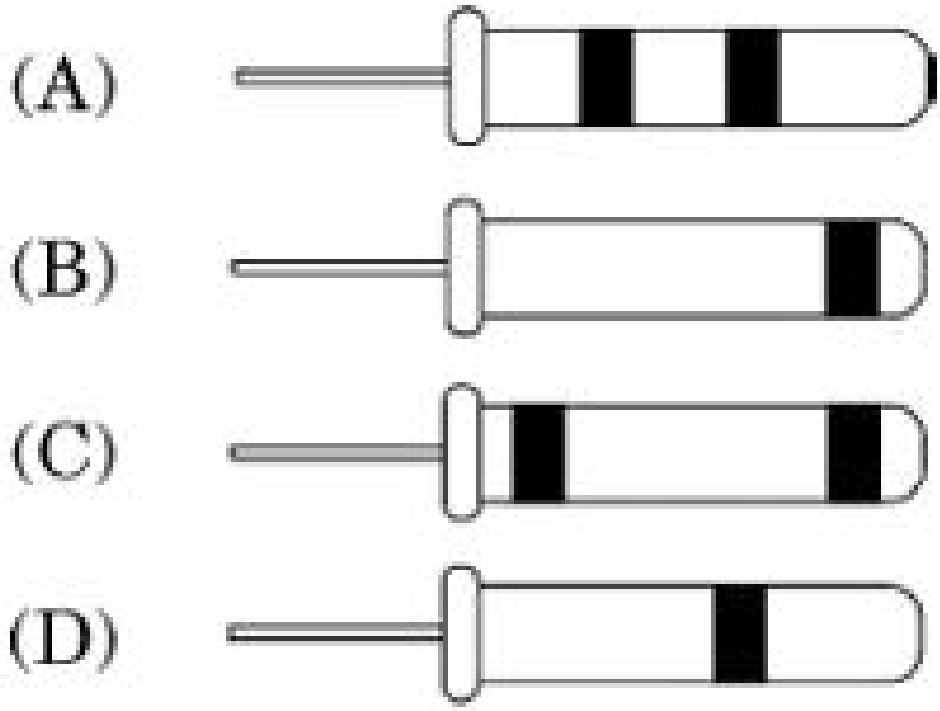
**10. The correct depiction of the experiment performed by Matthew Meselson and Franklin Stahl to prove that DNA replicates semi-conservatively on separation of DNA by centrifugation after 40 minutes is:**




**Correct Answer:** (C) One band: at intermediate density

**Solution:**

**Step 1:** Meselson and Stahl used $^{15}N$ (heavy nitrogen) to label the DNA in *E. coli*, which was then transferred to a $^{14}N$ (light nitrogen) medium.

**Step 2:** After 40 minutes (approximately one generation), DNA was extracted and centrifuged.

**Step 3:** Semi-conservative replication means that each daughter DNA consists of one old (heavy) and one new (light) strand.

**Step 4:** This results in a single band of intermediate density in the centrifuge.

Quick Tip

In semi-conservative DNA replication, the first generation after switching to $^{14}N$ medium always shows a single intermediate band—half heavy, half light strands.

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**11. Bioactive molecule Cyclosporin A used for human welfare is derived from:**

(A) Propionibacterium sharmanii

(B) Monascus purpureus

(C) Trichoderma polysporum

(D) Aspergillus niger

**Correct Answer:** (C) Trichoderma polysporum

**Solution:**

Cyclosporin A is an immunosuppressive drug widely used during organ transplantation to prevent graft rejection. It is obtained from the fungus *Trichoderma polysporum*. This molecule acts by inhibiting the activity of T-cells, thereby suppressing the immune response.

**Quick Tip**

Cyclosporin A, used to suppress immune responses in transplant patients, is derived from *Trichoderma polysporum*.

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**12. In a pea plant (*Pisum sativum*) inflated pod shape is dominant over constricted pod shape. The expected ratio of phenotypes of the offspring in a cross between both the parents with heterozygous inflated pod shape will be:**

(A) 1:0

(B) 1:1

(C) 2:1

(D) 3:1

**Correct Answer:** (D) 3:1

**Solution:**

Let the allele for inflated pod shape be $I$ and for constricted pod shape be $i$. The genotype of heterozygous inflated pod shape is $Ii$. A cross between two heterozygous parents results in:

$$Ii \times Ii \Rightarrow II,\ Ii,\ iI,\ ii$$

Phenotypic ratio = 3 Inflated : 1 Constricted.

Quick Tip

In a monohybrid cross between two heterozygotes, the phenotypic ratio is always 3:1 (dominant:recessive).

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**Question numbers 13 to 16 consist of two statements — Assertion (A) and Reason (R). Answer these questions selecting the appropriate option given below:**

**(A) Both (A) and (R) are true and (R) is the correct explanation of (A).**

**(B) Both (A) and (R) are true, but (R) is not the correct explanation of (A).**

**(C) (A) is true, but (R) is false.**

**(D) (A) is false, but (R) is true.**

**13. Assertion (A):** The meristems are grown *'in vitro'* to obtain virus-free plants from an infected plant.

**Reason (R):** If the plant is infected with a virus, the roots and the stems are free of virus.

(A) Both (A) and (R) are true and (R) is the correct explanation of (A).

(B) Both (A) and (R) are true, but (R) is not the correct explanation of (A).

(C) (A) is true, but (R) is false.

(D) (A) is false, but (R) is true.

**Correct Answer:** (C) (A) is true, but (R) is false.

**Solution:**

**Step 1:** In plant tissue culture, meristems are used to regenerate virus-free plants because viruses do not usually invade the actively dividing meristematic tissue.

**Step 2:** However, it is not true that roots and stems are free of virus in an infected plant. Thus, the reason is incorrect.

**Step 3:** Assertion is true but the reason is false.

Quick Tip

Meristem culture is an effective method to produce virus-free plants, as meristematic tissues are typically virus-free.

**14. Assertion (A):** A person infected with malaria suffers from chill and high fever, recurring every three or four days.

**Reason (R):** The parasite attacks the RBC resulting in their rupture and release of haemozoin.

(A) Both (A) and (R) are true and (R) is the correct explanation of (A).

(B) Both (A) and (R) are true, but (R) is not the correct explanation of (A).

(C) (A) is true, but (R) is false.

(D) (A) is false, but (R) is true.

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

**Solution:**

**Step 1:** Malarial parasite *Plasmodium* invades red blood cells (RBCs), multiplies, and causes their rupture.

**Step 2:** This leads to the release of toxic substance haemozoin which causes periodic chill and fever.

**Step 3:** Both assertion and reason are correct and the reason explains the assertion.

Quick Tip

Haemozoin is responsible for the typical fever pattern in malaria patients.

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**15. Assertion (A):** 'Saheli', an oral contraceptive inhibits ovulation and increases phagocytosis of sperms.

**Reason (R):** It is a non-steroidal preparation.

(A) Both (A) and (R) are true and (R) is the correct explanation of (A).

(B) Both (A) and (R) are true, but (R) is not the correct explanation of (A).

(C) (A) is true, but (R) is false.

(D) (A) is false, but (R) is true.

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

**Solution:**

**Step 1:** 'Saheli' is a non-steroidal oral contraceptive that contains Centchroman.

**Step 2:** It works by preventing ovulation and also by making the uterus less receptive to implantation.

**Step 3:** While both statements are true, being non-steroidal is not the reason for inhibiting ovulation and increasing phagocytosis of sperms.

Quick Tip

'Saheli' is India's first non-steroidal contraceptive — works differently than typical hormonal pills.

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**16. Assertion (A):** ABO blood grouping in humans is an example of multiple allelism.

**Reason (R):** More than two genes in a population govern the same character in ABO blood grouping in humans.

(A) Both (A) and (R) are true and (R) is the correct explanation of (A).

(B) Both (A) and (R) are true, but (R) is not the correct explanation of (A).

(C) (A) is true, but (R) is false.

(D) (A) is false, but (R) is true.

**Correct Answer:** (C) (A) is true, but (R) is false.

**Solution:**

**Step 1:** ABO blood grouping is governed by a single gene (I) with three alleles — $I^A, I^B,$ and $i$, which is an example of multiple allelism.

**Step 2:** The reason incorrectly states that more than two genes are involved. In reality, it is one gene with more than two alleles.

**Step 3:** Assertion is true, reason is false.

Quick Tip

Multiple alleles = one gene with more than two allele forms, not multiple genes.

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## SECTION B

**17. Student to attempt either option (A) or (B):**

**(A) Explain how the immunity of a person is affected if there is atrophy (degeneration) of the thymus gland at an early stage of life.**

**OR**

**(B) (i) What are interferons? Explain their role in providing immunity to a person.**
**(ii) Which category of innate immunity defence barrier can interferons be classified into?**

**Solution:**

**(A) Step 1:** The thymus gland is a primary lymphoid organ responsible for the maturation of T-lymphocytes (T-cells), which play a central role in cell-mediated immunity.
**Step 2:** If thymus undergoes atrophy at an early stage of life, it results in reduced T-cell production.
**Step 3:** This weakens the body's immune response, making the person more susceptible to infections and immune-related disorders.

**OR**

**(B) (i) Step 1:** Interferons are proteins released by virus-infected cells.
**Step 2:** They inhibit viral replication in surrounding uninfected cells by activating antiviral enzymes, thus preventing the spread of infection.
**Step 3:** They also stimulate the immune cells such as natural killer cells and macrophages.

**(ii) Step 1:** Interferons are classified under the *physiological barriers* of innate immunity.
**Step 2:** These barriers include antimicrobial substances produced in the body that inhibit the growth of pathogens.

**Quick Tip**

The thymus is vital for T-cell maturation; early atrophy leads to compromised cell-mediated immunity. Interferons are antiviral proteins and form part of innate physiological barriers.

**18.** Assume that the given mRNA (start site is not depicted) is theoretically translated in two reading frames.

(a) Translation starting from the first nucleotide (Reading frame 1)

(b) Translation starting from the second nucleotide (Reading frame 2)

| |
|---|
| **Frame 1:** 5′--CUCGCUUUGCCGAUCAAGGGUUA--3′ |
| **Frame 2:** 5′--GUGGCACUCAGUCCUUAAUGGCG--3′ |

Answer the following question:

**How many amino acids will be specified in case (a) and case (b) on translation? Justify your answer.**

**Solution:**

**Case (a) — Frame 1:**

The sequence is: CUC GCU UUG CCG AUC AAG GGU UA

Grouping codons from the first nucleotide:

CUC → Leu, GCU → Ala, UUG → Leu, CCG → Pro, AUC → Ile, AAG → Lys, GGU →

The last codon fragment "UA" is incomplete (only 2 bases), so it will not be translated.

**Total amino acids in case (a): 7**

**Case (b) — Frame 2:**

The sequence is: GUG GCA CUC AGU CCU UAA UGG CG

Grouping codons from the second nucleotide:

GUG → Val, GCA → Ala, CUC → Leu, AGU → Ser, CCU → Pro, UAA → Stop

Translation terminates at the stop codon UAA. So, codons after UAA will not be translated.

**Total amino acids in case (b): 5**

Quick Tip

Translation occurs in triplets (codons), and stops when a stop codon (e.g., UAA, UAG, UGA) is encountered.

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**19. Student to attempt either option (A) or (B):**

**(A) Explain what is meant by the term MTP. What was the main reason to legalize MTP by the Government of India?**

**OR**

**(B) Name any two STIs which might occur in a human female. State its two early symptoms.**

**Solution:**

**(A) Step 1:** MTP stands for Medical Termination of Pregnancy, which refers to the intentional termination of a pregnancy before the full term using medicines or surgical methods.

**Step 2:** The Government of India legalised MTP in 1971 under the Medical Termination of Pregnancy Act.

**Step 3:** The main reason was to control the population and to reduce the incidence of illegal and unsafe abortions that posed serious health risks to women.

**OR**

**(B) Step 1:** Two sexually transmitted infections (STIs) that may occur in human females are:

- Gonorrhoea
- Chlamydia

**Step 2:** Two early symptoms of STIs in females include:

- Abnormal vaginal discharge
- Burning sensation during urination

Quick Tip

MTP is legal and safe when performed by certified professionals. STIs often show mild symptoms early on; early detection is key to effective treatment.

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**20.** The basic scheme of the essential steps involved in the process of recombinant DNA technology is summarized below in the form of a flow diagram. Study the given flow diagram and answer the questions that follow.

**Step-1:** Vector DNA (cut using Restriction Enzyme EcoR I) + Alien DNA (cut using Restriction Enzyme EcoR I)

↓ **Enzyme A**

**Step-2:** Recombinant DNA molecule

↓

**Step-3:** Transfer of recombinant DNA molecule in *E. coli* (Host)

↓

**Step-4:** Replication of recombinant DNA molecule in *E. coli*

(a) Name the enzyme used in Step-1 to join the cut plasmid and alien DNA.

(b) State the technical term used for Step-3.

(c) Justify the use of same Restriction Enzyme EcoR I to cut both the vector DNA and the alien DNA.

**Solution:**

**(a)** The enzyme used in Step-1 is **DNA ligase**. It joins the sticky ends of the vector DNA and the alien DNA to form a recombinant DNA molecule.

**(b)** The technical term for Step-3 is **transformation**, which is the process of introducing recombinant DNA into the host cell (*E. coli*).

**(c)** Using the same restriction enzyme (EcoR I) to cut both vector and alien DNA ensures that both fragments have **complementary sticky ends**. This compatibility facilitates the easy and specific joining of the DNA fragments using DNA ligase, ensuring successful recombination.

Quick Tip

Restriction enzymes produce specific and compatible ends for ligation, and transformation allows host cells to take up recombinant plasmids.

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**21. Student to attempt either option (A) or (B):**

**(A) Explain how the interaction between sea anemone and clownfish is one of the best examples of commensalism in nature.**

**OR**

**(B) Correctly depict (also indicate the trophic level) and describe the ecological pyramid of biomass in sea with 40 standing crop of phytoplankton supporting 90 standing crop of zooplankton which further supports 120 small fishes.**

**Solution:**

**(A) Step 1:** Commensalism is an interaction where one species benefits while the other is neither harmed nor benefited.

**Step 2:** In the case of sea anemone and clownfish:

- The clownfish lives among the tentacles of sea anemones.
- The tentacles protect the clownfish from predators, as they are stinging in nature.
- The clownfish is immune to these stings due to a protective mucus layer on its body.
- The sea anemone does not receive any benefit or harm from this association.

**Step 3:** This interaction is a classic example of commensalism — clownfish benefits from protection while sea anemone remains unaffected.

**OR**

**(B) Step 1:** The ecological pyramid of biomass in a sea ecosystem is inverted because the biomass of producers (phytoplankton) is lower than that of primary and secondary consumers.

**Step 2:** Representation of the inverted pyramid:

| Trophic Level | Organisms with Biomass (Standing Crop) |
|---|---|
| Trophic Level 3 (Secondary Consumers) | Small fishes – 120 units |
| Trophic Level 2 (Primary Consumers) | Zooplankton – 90 units |
| Trophic Level 1 (Producers) | Phytoplankton – 40 units |

**Step 3:**

- Phytoplankton reproduce rapidly but have low biomass at a given time.
- Zooplankton feed on them and accumulate more biomass.
- Small fishes feeding on zooplankton accumulate even higher biomass.

Thus, the pyramid of biomass in an aquatic ecosystem is inverted.

Quick Tip

In aquatic ecosystems, fast turnover of phytoplankton causes an inverted biomass pyramid. Commensalism involves one-sided benefit without harming the other species.

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## SECTION C

**22. Explain the process of formation of placenta in a human female after the implantation of the blastocyst in the endometrium of the uterus.**

**Solution: Step 1:** After implantation, the finger-like projections called chorionic villi develop from the trophoblast (outer layer of the blastocyst) into the surrounding uterine tissue.
**Step 2:** These villi grow into the maternal tissue and are surrounded by blood spaces called lacunae formed in the endometrium.
**Step 3:** The chorionic villi and uterine tissue together form a structural and functional unit called the placenta.
**Step 4:** Placenta acts as a nutritive, respiratory, excretory, and endocrine organ. It facilitates the exchange of oxygen, nutrients, and waste between mother and foetus.

Quick Tip

Placenta forms from chorionic villi and maternal tissue post-implantation; it supports foetal development and hormone secretion.

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**23. Gregor Mendel conducted hybridisation experiments in garden pea for seven years and proposed the law of inheritance.**

**(a) Why was he successful in his hybridisation experiments? Give two reasons.**

**(b) State the law of independent assortment as proposed by Mendel after his dihybrid crosses.**

**Solution:**

**(a) Step 1:** Mendel's success can be attributed to:

- Selection of true-breeding pea plants with distinct, contrasting traits.
- Quantitative analysis and statistical interpretation of data over a large number of crosses.

**(b) Step 2:** The law of independent assortment states that: *"When two pairs of traits are combined in a hybrid, segregation of one pair of characters is independent of the other pair of characters."*

**Step 3:** It means that alleles of different genes are assorted independently during gamete formation, leading to new combinations in the offspring.

Quick Tip

Mendel used clear traits, large samples, and statistical tools. Independent assortment creates variety by shuffling genes independently.

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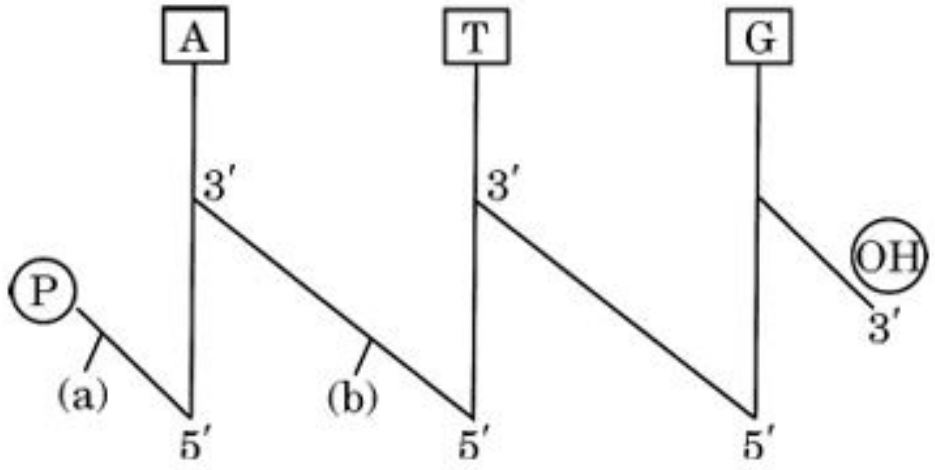
**24. Study the given below single strand of deoxyribonucleic acid depicted in the form of a "stick" diagram with 5 – 3 end directionality, sugars as vertical lines and bases as single letter abbreviations and answer the questions that follow.**




(a) Name the covalent bonds depicted as (a) and (b) in the form of slanting lines in the diagram.

(b) How many purines are present in the given "stick" diagram?

(c) Draw the chemical structure of the given polynucleotide chain of DNA.

**Solution:**

**(a)** The covalent bond labeled as (a) is a **phosphoester bond**, and (b) is a **phosphodiester bond**. These bonds link the phosphate group to the 5 carbon of one sugar and the 3 carbon of the next sugar, forming the sugar-phosphate backbone.

**(b)** In the stick diagram, the nitrogenous bases shown are A, T, and G. Out of these, **adenine (A)** and **guanine (G)** are purines. Therefore, the total number of purines present is **2**.

**(c)** The chemical structure of the given polynucleotide chain includes:

- A phosphate group at the 5 end (indicated by P),
- A sugar-phosphate backbone,
- Three deoxyribose sugars each attached to a nitrogenous base: Adenine (A), Thymine (T), and Guanine (G),
- A free hydroxyl group (-OH) at the 3 end.

A hand-drawn or digital structure should depict the sequence A-T-G from 5 to 3, with proper covalent linkages between phosphate and deoxyribose, and the bases attached to the 1 carbon of each sugar.

Quick Tip

Remember: Purines are double-ringed nitrogenous bases (A and G), while pyrimidines are single-ringed (T and C in DNA). The phosphodiester bond links the 3 carbon of one sugar to the 5 phosphate of the next.

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**25. Explain the biological treatment of primary effluent when passed into the large aeration tanks in a sewage treatment plant (STP).**

**Solution: Step 1:** The primary effluent obtained after sedimentation is transferred to large aeration tanks where it is subjected to secondary (biological) treatment.
**Step 2:** In these tanks, air is pumped to facilitate the vigorous growth of aerobic microbes, especially bacteria and protozoa, which form flocs (masses of bacteria and fungal filaments).
**Step 3:** These microbes digest the organic matter in the effluent, significantly reducing the biochemical oxygen demand (BOD), which is an indicator of organic pollution.
**Step 4:** Once the BOD is sufficiently reduced, the effluent is passed into a settling tank where the flocs settle as activated sludge.
**Step 5:** Part of this activated sludge is recycled back to the aeration tank as inoculum, and the rest is sent for anaerobic digestion or dried and used as manure.

Quick Tip

In secondary treatment, aerobic microbes in aeration tanks form flocs and reduce BOD by breaking down organic waste.

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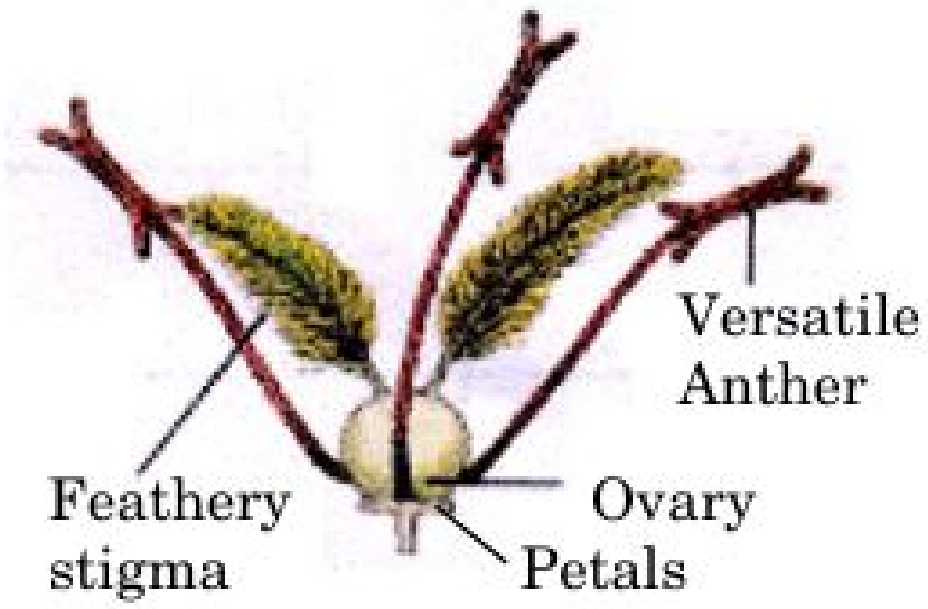
**26. Given below is a flower with its characteristic features specialised for the most common type of abiotic pollination.**




Answer the following questions based on the above diagram:

(a) Name the mode of abiotic pollination that will be adopted by the given plant species in the above picture.

(b) State the need of exposed large feathery stigmas for the flower.

(c) What will be the two important adaptations in the pollen grains of the flowers pollinated by the above mode of pollination?

(d) What could be the probable reason for the petals being small and non-green?

**Solution:**

**(a)** The mode of abiotic pollination depicted is **anemophily** (pollination by wind).

**(b)** Exposed large feathery stigmas are needed to effectively trap airborne pollen grains from the environment, increasing the chances of successful pollination.

**(c)** The two important adaptations of pollen grains for wind pollination are:

- Pollen grains are **lightweight** and **non-sticky**, so they can be easily carried by wind.
- Pollen is produced in **large quantities** to compensate for the randomness and inefficiency of wind dispersal.

**(d)** The petals are small and non-green because they do not need to attract pollinators (like insects or animals), as the plant relies on wind rather than biotic agents for pollination.

Quick Tip

Wind-pollinated flowers are usually small, inconspicuous, produce enormous quantities of pollen, and have large feathery stigmas. They do not rely on color, scent, or nectar to attract pollinators.

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**27. According to a recent wildlife report, the biggest threat to the tiger's survival in Mudumalai Tiger Reserve (MTR) was found to be a small, beautiful flower, *Lantana camara*, a tropical American shrub, that invaded 40% of India's tiger range. Tamil Nadu department's Lantana weed eradication drive helped to restore the dying MTR thereby also reducing human-wildlife conflicts. MTR is home to 25 species of grasses and legumes.**

**(a) Explain how did the removal of Lantana help in restoring the dying Mudumalai Tiger Reserve.**

**(b) Why is the invasion of *Lantana camara* a cause of concern in MTR?**

**Solution:**

**(a) Restoration through Lantana removal:**

- Removal of *Lantana camara* allowed native grasses and legumes to regenerate.
- These native plants are crucial for maintaining the herbivore population, which is the primary prey base for tigers.
- Increased herbivore availability in turn supports a stable and growing tiger population.
- It also helped in reducing human-wildlife conflict, as animals were no longer forced to migrate outside the reserve in search of food.

**(b) Concerns due to *Lantana camara* invasion:**

- *Lantana camara* is an invasive alien species that displaces native flora.
- It forms dense thickets, reducing biodiversity and food sources for herbivores.
- Its spread degrades the natural habitat, leading to ecosystem imbalance.

- The loss of native vegetation and prey drives tigers to venture into human settlements, increasing conflict and threat to their survival.

Quick Tip

Invasive species like *Lantana camara* disrupt native ecosystems. Their removal helps restore biodiversity and balance in protected reserves.

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**28. Enlist one advantage and two disadvantages of Green Revolution.**

**Solution:**

**Advantage of Green Revolution:**

- It significantly increased food grain production, especially wheat and rice, ensuring food security in India.

**Disadvantages of Green Revolution:**

- Overuse of chemical fertilizers and pesticides led to soil and water pollution.
- It caused a decline in genetic diversity due to the cultivation of a few high-yielding varieties.

Quick Tip

The Green Revolution boosted food production but also introduced environmental and ecological challenges that need sustainable solutions.

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## SECTION D

**Question Nos.29 and 30 are case based questions.Each question has 3 sub-questions with internal choice in one sub-question.**

**29. Read the following passage and answer the questions that follow. The most convincing evidence to trace evolutionary relationships between humans and different**

**groups of animals comes from the basic similarities seen at the molecular level. Study the table given below that depicts the number of amino acid differences between the haemoglobin polypeptide of few animals with that of humans and answer the questions that follow.**

| S.No. | Animal | No. of amino acid differences in haemoglobin with that of humans |
|---|---|---|
| 1. | Macaque | 08 |
| 2. | Dog | 32 |
| 3. | Bird | 45 |
| 4. | Frog | 67 |
| 5. | Lamprey | 125 |

(a) To which category of evolution (Divergent or Convergent) do the following evolutionary relationships belong to:

(i) Humans and Macaque

(ii) Humans and Frog

(b) What do the biochemical similarities in haemoglobin suggest about the evolutionary relationship between humans, frog, and lamprey?

(c) (i) Which one of the two – **lampreys' or macaques'** evolution is more closely related to humans and why?

**OR**

(ii) Which one of the two – **frogs' or dogs'** evolution is more closely related to humans and why?

**Solution:**

**(a)**

(i) Humans and Macaque: **Divergent evolution** – both share a common ancestor and have evolved differently.

(ii) Humans and Frog: **Divergent evolution** – indicates a common ancestry but more distantly related due to higher differences.

**(b)** Biochemical similarities (fewer amino acid differences) indicate a **closer evolutionary relationship**. Hence, humans are more closely related to frogs than to lampreys, and even more closely related to macaques.

**(c)**

(i) Macaques' evolution is more closely related to humans because they have only **8 amino acid differences**, whereas lampreys have **125 differences**.

(ii) Dogs' evolution is more closely related to humans than frogs because dogs have **32 amino acid differences**, while frogs have **67 differences**.

**Quick Tip**

Fewer amino acid differences in homologous proteins such as haemoglobin suggest closer evolutionary relationships. Molecular evidence often provides the most reliable data for constructing phylogenetic trees.

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**30. Read the following passage and answer the questions that follow. Deaths related to the use of drugs were estimated at about 5,00,000 in 2019, 17.5 percent more than in 2009. Liver diseases attributed to Hepatitis B are a major cause of drug-related deaths, according to UNODC, accounting for more than half of the total number of deaths attributed to the use of drugs. Drug overdoses account for a quarter of drug-related deaths. Opioids contribute to account for the most severe drug-related harm, including fatal overdoses, when used non-medically. At the global level, two-third of direct drug-related deaths are due to opioids, and in some sub-regions the proportion can be as high as three-quarters of such deaths.**

(a) Why are people taking opioids more prone to liver diseases attributed to Hepatitis B?

(b) What is meant by direct drug-related disease?

(c) (i) What is the scientific name of the plant from which the opioids are derived and from which part of the plant is it extracted?

**OR**

(ii) State two common warning signs of drug abuse among the youth.

**Solution:**

**(a)** People taking opioids are more prone to liver diseases caused by Hepatitis B because opioid abuse can weaken the immune system and often involves risky behaviors like sharing contaminated needles, increasing the risk of Hepatitis B virus transmission.

**(b)** Direct drug-related disease refers to diseases that are directly caused by drug consumption, such as overdoses, liver damage, or infections due to contaminated needles.

**(c)**

(i) The scientific name of the plant is **Papaver somniferum**. Opioids are extracted from the **latex (milky sap)** obtained from the seed capsule of the plant.

(ii) Two common warning signs of drug abuse among the youth are:

- Sudden behavioral changes, such as withdrawal from family or friends.
- Drop in academic performance or disinterest in activities once enjoyed.

**Quick Tip**

Awareness of the health risks associated with opioid abuse, especially liver damage and overdoses, is vital for prevention. Identifying early signs of drug abuse can help in timely intervention and rehabilitation.

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## SECTION E

**31.**

(a) (i) Explain how does double fertilisation take place in a flowering plant.

(ii) Write the fate of the products of double fertilization in these plants.

**OR**

(b) (i) Explain the structure of testicular lobules in human male reproductive system. Name the two types of cells present in the seminiferous tubules and state their role.

(ii) Describe the role of hypothalamic hormone GnRH in spermatogenesis.

**Solution:**

**(a)**

(i) **Double fertilisation in flowering plants:** It is a unique event in angiosperms where two male gametes are involved. One male gamete fuses with the egg cell to form a diploid zygote (syngamy), and the other fuses with the two polar nuclei to form a triploid primary endosperm nucleus (PEN). This process is called triple fusion. Together, syngamy and triple fusion constitute double fertilization.

(ii) **Fate of products:**

- The zygote develops into an embryo.
- The primary endosperm nucleus (PEN) develops into the endosperm, which nourishes the developing embryo.

**OR**

**(b)**

(i) **Structure of testicular lobules:** Each testis has about 250 compartments called testicular lobules. Each lobule contains 1–3 highly coiled seminiferous tubules. These tubules are the sites of spermatogenesis. Two main types of cells are present:

- **Sertoli cells:** Provide nourishment and structural support to developing sperms.
- **Leydig cells (interstitial cells):** Located outside the seminiferous tubules; they secrete the male hormone testosterone.

(ii) **Role of GnRH in spermatogenesis:** The hypothalamus releases GnRH (Gonadotropin Releasing Hormone), which stimulates the anterior pituitary to secrete:

- **FSH (Follicle Stimulating Hormone):** Acts on Sertoli cells and promotes spermatogenesis.
- **LH (Luteinizing Hormone):** Stimulates Leydig cells to secrete testosterone, which also supports spermatogenesis.

Quick Tip

In flowering plants, double fertilisation ensures both embryo and endosperm formation. In humans, GnRH is a master regulator of reproductive function, initiating the hormonal cascade leading to sperm production.

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**32. Student to attempt either option (A) or (B):**

**(A)**

**Name and explain the biotechnological strategy wherein the infection by the nematode *Meloidogyne incognita* can be prevented using *Agrobacterium* vectors in the roots of tobacco plant by RNA interference.**

**Solution (A):** The biotechnological strategy used is called **RNA interference (RNAi)**.

**Explanation:**

- RNA interference is a method of gene silencing where double-stranded RNA (dsRNA) prevents the expression of specific genes.
- In this technique, genes encoding dsRNA specific to the nematode's essential genes are introduced into the tobacco plant using *Agrobacterium tumefaciens* vectors.
- These genes transcribe RNA molecules which form dsRNA, initiating RNAi in the plant.
- When the nematode feeds on the transgenic roots, the silencing RNA affects its gene expression, thus preventing its infection and development.

Quick Tip

RNAi involves silencing of a specific gene using complementary double-stranded RNA to inhibit pests or pathogens at the genetic level.

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**(B) Explain the amplification of gene of interest using the technique of Polymerase Chain Reaction (PCR).**

**Solution (B):**

Polymerase Chain Reaction (PCR) is a technique used to amplify a gene or DNA segment of interest.

**Steps of PCR:**

1. **Denaturation:** The double-stranded DNA is heated to $94°C - 96°C$ to separate it into two single strands.
2. **Annealing:** The temperature is lowered to $50°C - 65°C$ to allow primers to bind (anneal) to the complementary sequences on the single-stranded DNA.
3. **Extension:** The temperature is raised to around $72°C$, and Taq DNA polymerase adds nucleotides to the primers, extending the DNA and synthesizing new strands.

**Cycle Repetition:** These steps are repeated for 25–35 cycles, exponentially increasing the quantity of the target DNA.

**Quick Tip**

PCR enables rapid and specific amplification of DNA using repeated cycles of denaturation, annealing, and extension.

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**33.**

(a) (i) Describe the population growth curve applicable in a population of any species in nature that has limited resources at its disposal.

(ii) Give the equation of this growth curve.

(iii) Name the growth curve and depict a graphical plot for this type of population growth.

**OR**

(b) (i) Explain the Species-Area relationship within a natural forest and also predict the nature of graph when species richness is plotted against the area for a wide variety of taxa.

(ii) Depict the graphical relationship between species richness and area.

(iii) Give the equation of the Species-Area relationship for a wide variety of taxa on a logarithmic scale.

**Solution:**

**(a)**

(i) When a population of any species grows in a habitat with limited resources, it follows a **logistic growth curve**. Initially, the population grows exponentially due to abundant resources, but as resources become limited, the growth rate slows and finally stabilizes at the carrying capacity ($K$) of the environment.

(ii) The equation for logistic growth is:

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

where,

$N$ = Population density at time $t$,

$r$ = Intrinsic rate of natural increase,

$K$ = Carrying capacity.

(iii) The name of this curve is the **Logistic Growth Curve (S-shaped curve)**.

*Graphical representation of Logistic Growth Curve*

**OR**

**(b)**

(i) The **Species-Area Relationship** states that the number of species (species richness) increases with increasing area, but at a decreasing rate. In a natural forest, as we explore larger and larger areas, we find more species. When plotted, this forms a rectangular hyperbola. However, for a wide variety of taxa, the graph becomes a straight line on a logarithmic scale.

(ii) The graph between species richness and area is:

(iii) The equation for the Species-Area Relationship on a logarithmic scale is:

$$\log S = \log C + Z \log A$$

where,

$S$ = Species richness,

$A$ = Area,

$C$ = Y-intercept constant,

$Z$ = Slope of the line (regression coefficient).

**Quick Tip**

Population growth curves are essential to understand how populations respond to environmental limitations. The species-area relationship helps ecologists predict biodiversity patterns across regions and scales.

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