CBSE Class 12 2025 Biology Question Paper (57/4/2) With Solutions

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' are composed of:

(A) Histones and linker DNA

(B) Histones and about 200 bp of DNA

(C) NHC proteins and linker DNA

(D) NHC proteins and about 200 bp of DNA

Correct Answer: (B) Histones and about 200 bp of DNA

Solution:

In the beads-on-string model of chromatin, the "beads" are nucleosomes, each composed of a histone core with approximately 146 base pairs of DNA wrapped around it. Including the linker DNA (20–60 bp), the total DNA per nucleosome unit is often approximated as 200 bp. The "string" refers to the linker DNA connecting the nucleosomes, while the beads are the nucleosomes themselves, made of histones and DNA.

Quick Tip

The "beads" in the beads-on-string model are nucleosomes, composed of histones and roughly 200 bp of DNA, including both the DNA wrapped around the histones and the linker DNA.

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2. Given below are few statements with respect to the process of oogenesis in a human ovary:

(i) Each granulosa cell gets surrounded by a primary oocyte to form the primary follicle.

(ii) A couple of million of oogonia are formed within each fetal ovary during the embryonic development.

(iii) Tertiary follicle is characterised by antrum and theca layers.

(iv) Secondary follicles form a zona pellucida layer around it.

(v) Mature graafian follicle ruptures to release the secondary oocyte from the ovary.

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

(A) (i), (iii), (iv)

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

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

(D) (i), (iii), (v)

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

Solution:

In oogenesis, (i) is incorrect because granulosa cells surround the primary oocyte, not the other way around, to form the primary follicle. (ii) is correct, as around 1–2 million oogonia are formed in each fetal ovary during development. (iii) is correct, as the tertiary follicle has an antrum and theca layers. (iv) is correct, as the zona pellucida forms in the secondary follicle stage. (v) is correct, as the Graafian follicle ruptures to release the secondary oocyte during ovulation.

Quick Tip

Oogenesis involves the formation of follicles, with the tertiary follicle having an antrum and the Graafian follicle releasing the secondary oocyte during ovulation.

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3. The simplest definition of a gene in eukaryotes is — A unit of DNA that has information to mainly specify the synthesis of:

(A) Single polypeptide chain and mRNA only

(B) Many polypeptide chains and mRNA only

(C) Single polypeptide chain and functional RNA only

(D) Many polypeptide chains and functional RNA only

Correct Answer: (C) Single polypeptide chain and functional RNA only

Solution:

In eukaryotes, a gene is a unit of DNA that codes for a functional product, either a single polypeptide chain (via mRNA) or a functional RNA (e.g., tRNA, rRNA). The simplest

definition includes both possibilities, as genes can produce either a polypeptide or functional RNA, but not necessarily many polypeptide chains or mRNA alone.

Quick Tip

A eukaryotic gene typically codes for either a single polypeptide or a functional RNA, such as tRNA or rRNA, as its primary product.

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4. A colourblind man marries a woman with normal sight who has no history of colourblindness in her family. What is the probability of their son being colourblind?

(A) 0.5

(B) 1

(C) Nil

(D) 0.25

Correct Answer: (C) Nil

Solution:

Colorblindness is an X-linked recessive trait. The man is colorblind (X^c Y), and the woman has normal sight with no family history of colorblindness (X X), so she is not a carrier. Their son inherits the Y chromosome from the father and one X from the mother. Since the mother can only pass a normal X, the son will be X Y (normal), and the probability of him being colorblind is 0, or nil.

Quick Tip

In X-linked recessive traits like colorblindness, a son inherits his X chromosome from his mother. If the mother is not a carrier, the son cannot inherit the trait.

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5. The type of antibodies produced during an immune response to allergens as dust and pollen grains in a person is:

(A) IgE

(B) IgA

(C) IgG

(D) IgD

Correct Answer: (A) IgE

Solution:

Allergens like dust and pollen trigger an allergic response, which primarily involves IgE antibodies. IgE binds to mast cells and basophils, leading to the release of histamine, causing allergic symptoms. IgA, IgG, and IgD are not primarily involved in allergic responses.

Quick Tip

IgE is the key antibody in allergic reactions, binding to mast cells and basophils to trigger histamine release in response to allergens.

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6. Select the statements that are true for a typical megasporangium of flowering plants:

(i) It is attached to the placenta by hilum.

(ii) It has a chalaza end that represents the basal part of the ovule.

(iii) It has nucellus enclosed by integuments.

(iv) Its micropylar end is known as chalaza.

Choose the correct answer:

(A) (i) and (ii)

(B) (ii) and (iii)

(C) (iii) and (iv)

(D) (i) and (iv)

Correct Answer: (B) (ii) and (iii)

Solution:

A typical megasporangium (ovule) in flowering plants has the following features: (i) is correct, as the ovule is attached to the placenta via the hilum. (ii) is correct, as the chalaza is the basal part of the ovule. (iii) is correct, as the nucellus is enclosed by integuments. (iv) is

incorrect, as the micropylar end, where the pollen tube enters, is opposite the chalaza. The true statements are (i), (ii), and (iii), but since option (B) includes only (ii) and (iii), it is the closest match.

Quick Tip

The ovule's chalaza is its basal part, opposite the micropylar end, and the nucellus, containing the embryo sac, is protected by integuments.

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7. The primates that probably lived in East Africa grasslands about two mya were:

(A) Dryopithecus

(B) Ramapithecus

(C) Australopithecines

(D) Neanderthal

Correct Answer: (C) Australopithecines

Solution:

Australopithecines, such as Australopithecus afarensis, lived in East African grasslands from about 4 to 1 million years ago and were adapted to savanna environments, making them the primates present around 2 million years ago. Dryopithecus (20–9 mya) and Ramapithecus (12–14 mya, now classified under Sivapithecus) lived much earlier, while Neanderthals (400,000–40,000 years ago) lived later and primarily in Europe and Asia.

Quick Tip

Australopithecines were bipedal primates that thrived in East African grasslands around 2 million years ago, a key step in human evolution.

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

Codons for the amino acids:

UAU – Tyrosine

AUG – Methionine

AUA – Isoleucine

AGU – Serine

(A) Isoleucine

(B) Methionine

(C) Tyrosine

(D) Serine

Correct Answer: (A) Isoleucine

Solution:

The coding strand is 5'-ATA-3', so the template strand is 3'-TAT-5'. During transcription, the template strand is transcribed into mRNA: 5'-AUA-3'. The mRNA codon AUA codes for Isoleucine. The tRNA with anticodon 3'-UAU-5' pairs with AUA and carries Isoleucine at its 3' end during translation.

Quick Tip

The tRNA anticodon pairs with the mRNA codon, and the amino acid attached to the tRNA's 3' end corresponds to the mRNA codon's translation, here AUA for Isoleucine.

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9. Early detection of HIV in suspected AIDS patients can be done using the diagnostic technique of:

(A) ELISA

(B) PCR

(C) EST

(D) RNAI

Correct Answer: (A) ELISA

Solution:

ELISA (Enzyme-Linked Immunosorbent Assay) is the standard first-line test for early detection of HIV in suspected AIDS patients, as it detects antibodies against HIV in the blood. PCR can confirm HIV by detecting its DNA/RNA but is typically used as a follow-up. EST and RNAI (likely RNAi) are not diagnostic tools for HIV.

Quick Tip

ELISA is widely used for initial HIV screening due to its high sensitivity in detecting HIV antibodies, often followed by PCR for confirmation.

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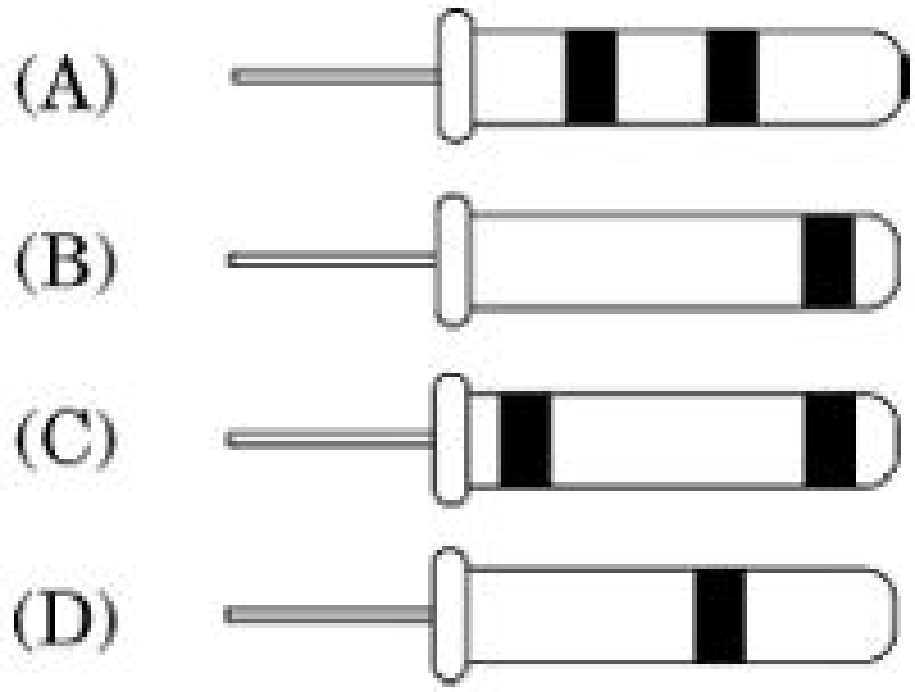
10. The correct depiction of the experiment performed by Matthew Meselson and Franklin Stahl to prove that DNA replicates semi-conservatively on separation of DNA by centrifugation after 40 minutes is:



Correct Answer: (C) One band: intermediate

Solution:

Meselson and Stahl's experiment showed that DNA replication is semi-conservative. E. coli grown in ^{1}N medium were transferred to ^{1}N medium for one generation (40 minutes). After

centrifugation, semi-conservative replication results in hybrid DNA (^{1}N-^{1}N), forming a single band at intermediate density between heavy (^{1}N-^{1}N) and light (^{1}N-^{1}N) DNA.

Quick Tip

In semi-conservative replication, after one generation in a lighter isotope medium, all DNA molecules are hybrids, showing a single band of intermediate density in centrifugation.

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11. Large holes in 'Swiss cheese' are formed by the activity of microbes:

(A) Streptococcus pneumoniae

(B) Monascus purpureus

(C) Trichoderma polysporum

(D) Propionibacterium shermanii

Correct Answer: (D) Propionibacterium shermanii

Solution:

Large holes in Swiss cheese are formed by Propionibacterium shermanii, which ferments lactic acid to produce carbon dioxide gas, creating the characteristic 'eyes' or holes. Streptococcus pneumoniae causes pneumonia, Monascus purpureus is used in red yeast rice, and Trichoderma polysporum produces cyclosporin A, none of which are involved in Swiss cheese production.

Quick Tip

Propionibacterium shermanii is key in Swiss cheese production, producing CO that forms the large holes during fermentation.

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12. In pea plant (Pisum sativum) axial flower position is dominant over terminal flower position. The expected ratio of phenotypes of the offspring in a cross between both the parents with heterozygous axial flower will be:

(A) 3:1

(B) 2:1

(C) 1:1

(D) 1:0

Correct Answer: (A) 3:1

Solution:

In pea plants, axial flower position (A) is dominant over terminal (a). Both parents are heterozygous (Aa). A cross (Aa × Aa) yields offspring in a phenotypic ratio of 3 axial (AA, Aa, Aa) to 1 terminal (aa), as seen in a standard monohybrid cross.

Quick Tip

A monohybrid cross between two heterozygotes (Aa × Aa) results in a 3:1 phenotypic ratio for a dominant-recessive trait.

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): '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' (Centchroman) is a non-steroidal oral contraceptive that inhibits ovulation and alters the uterine environment, potentially increasing phagocytosis of sperms by making cervical mucus hostile, so Assertion (A) is true.

Step 2: Reason (R) is true, as 'Saheli' is indeed non-steroidal, unlike hormonal contraceptives.

Step 3: However, being non-steroidal does not directly explain its mechanism of inhibiting ovulation and increasing phagocytosis, so (R) is not the correct explanation of (A).

Quick Tip

'Saheli' is a non-steroidal contraceptive that works by inhibiting ovulation and affecting sperm viability, but its non-steroidal nature isn't the direct cause of these effects.

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14. 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: Meristems are used in *in vitro* culture to regenerate virus-free plants because viruses typically do not invade the actively dividing meristematic tissue, making Assertion (A) true.

Step 2: However, in a virus-infected plant, the virus is often systemic and can spread to roots and stems via the vascular system, so Reason (R) is false.

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

Quick Tip

Meristems are used to produce virus-free plants because they are often virus-free, not because roots and stems are uninfected.

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15. 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 controlled by a single gene (I) with three alleles (I^A, I^B, i), making it an example of multiple allelism, so Assertion (A) is true.

Step 2: The reason incorrectly states that more than two genes are involved; ABO blood grouping is governed by one gene with multiple alleles, so Reason (R) is false.

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

Quick Tip

Multiple allelism involves one gene with more than two alleles, as in the ABO system with I^A, I^B, and i, not multiple genes.

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16. 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: Malaria, caused by the *Plasmodium* parasite, leads to chills and high fever recurring every 48–72 hours (every three or four days), depending on the species, so Assertion (A) is true.

Step 2: The parasite infects RBCs, multiplies, and causes their rupture, releasing haemozoin, a toxic byproduct that triggers fever and chills, so Reason (R) is true.

Step 3: The release of haemozoin due to RBC rupture directly causes the fever pattern, so (R) correctly explains (A).

Quick Tip

The periodic fever in malaria is due to haemozoin release following RBC rupture by the *Plasmodium* parasite, with cycles of 48–72 hours.

SECTION B

17. 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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18. 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.

19. 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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20. 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.

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

(A) Write two features of an ideal contraceptive. Explain any one natural contraceptive method that makes the chances of conception almost nil.

OR

(B) Explain GIFT and ICSI.

Solution:

(A) Step 1: Two features of an ideal contraceptive:

- It should be user-friendly, easily available, and reversible.
- It should be effective with minimal side effects.

Step 2: Natural contraceptive method — **Periodic Abstinence**:

- In this method, the couple avoids coitus during the fertile period of the menstrual cycle (days 10-17).
- Since ovulation occurs around the middle of the cycle, avoiding intercourse during this period reduces chances of fertilization.
- This method is safe and has no side effects, and if properly followed, chances of conception are almost nil.

OR

(B) Step 1: GIFT (Gamete Intra-Fallopian Transfer)

- It is an assisted reproductive technique where ovum and sperms are collected from donors and placed together into the fallopian tube of a woman.

- It is used in cases where the fallopian tube is functional and natural fertilization is preferred inside the body.

Step 2: ICSI (Intra-Cytoplasmic Sperm Injection)

- In this method, a sperm is directly injected into the cytoplasm of an ovum in laboratory conditions.
- It is used in cases of male infertility where the sperm count is very low or motility is poor.

Quick Tip

Periodic abstinence is a reliable natural method if practiced accurately. Assisted techniques like GIFT and ICSI are helpful for infertility management.

SECTION C

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

Solution:

Step 1: Primary effluent from a sewage treatment plant contains organic matter and microbes.

Step 2: It is passed into large aeration tanks where it is constantly agitated and supplied with air.

Step 3: This promotes the growth of aerobic bacteria and filamentous fungi which form flocs.

Step 4: These microbes consume organic matter and reduce the biochemical oxygen demand (BOD) of the effluent.

Step 5: The effluent is then passed into a settling tank where flocs are allowed to sediment, forming activated sludge.

Step 6: A small portion of this activated sludge is recycled as inoculum while the remaining is sent for anaerobic digestion.

Quick Tip

Aeration tanks help aerobic microbes reduce BOD by decomposing organic matter in sewage effluent.

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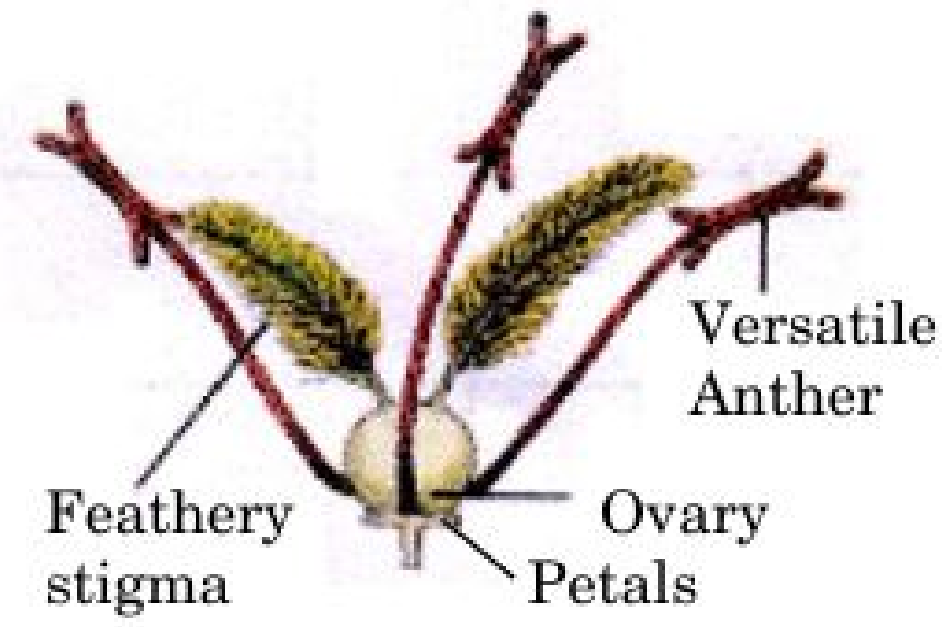
23. Given below is a flower with its characteristic features specialised for the most common type of abiotic pollination.



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) Step 1: The mode of abiotic pollination is **anemophily (wind pollination).**

(b) Step 2: Large, feathery stigmas are exposed to effectively trap airborne pollen grains.

(c) Step 3: Two important adaptations in pollen grains:

- Pollen grains are light and non-sticky to be easily carried by wind.
- Pollen grains are produced in large numbers to increase the chance of pollination.

(d) Step 4: The petals are small and non-green as they do not need to attract insects for pollination.

Quick Tip

Wind-pollinated flowers typically have large feathery stigmas, light pollen, and inconspicuous petals.

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24. Enlist one advantage and two disadvantages of Green Revolution.

Solution:

Step 1: Advantage:

- Increased food grain production ensured food security in many developing countries.

Step 2: Disadvantages:

- Overuse of chemical fertilizers and pesticides led to soil and water pollution.
- Intensive agriculture practices depleted soil fertility and groundwater levels.

Quick Tip

While the Green Revolution boosted crop production, it also caused serious environmental issues due to excessive chemical use.

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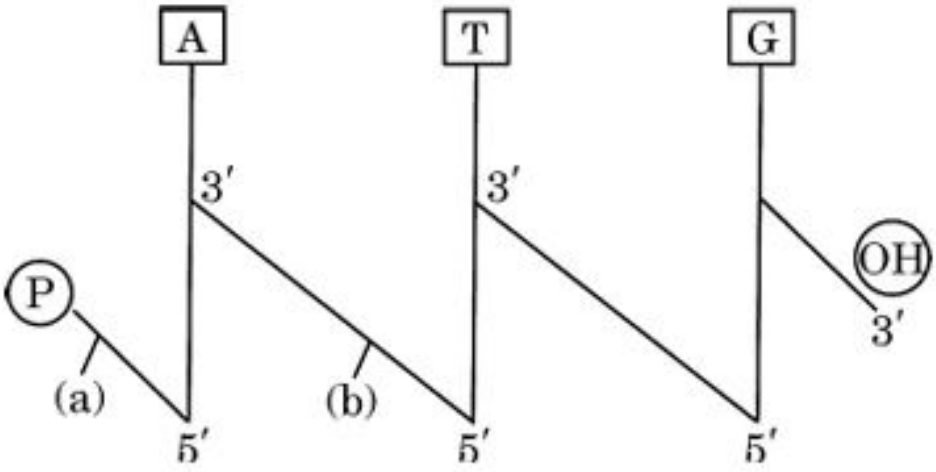
25. Study the given below single strand of deoxyribonucleic acid depicted in the form of a "stick" diagram with 5–3 end directionality, sugars as vertical lines and bases as single letter abbreviations and answer the questions that follow.



(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) Step 1: The covalent bond (a) is a **phosphodiester bond**. **Step 2:** The covalent bond (b) is a **glycosidic bond**.

(b) Step 3: Purines are **Adenine (A)** and **Guanine (G)**. In the given diagram: A = 1, G = 1

So, total purines = **2.**

(c) Step 4: The chemical structure consists of a sugar-phosphate backbone with attached nitrogenous bases:

- Phosphate connected to 5 carbon of sugar.
- 3 carbon of sugar connected to next phosphate group via phosphodiester bond.
- Nitrogenous base attached to 1 carbon of sugar by glycosidic bond.

Quick Tip

Phosphodiester bonds link sugar molecules via phosphate groups in the DNA backbone, while glycosidic bonds attach bases to sugars.

26. Thomas Hunt Morgan carried out several dihybrid crosses in *Drosophila melanogaster* to study genes that were sex linked.

(a) Give four major reasons for using the tiny fruit flies by Morgan for his experiments.

(b) How did Morgan and his group explain the physical association of the two genes on a chromosome to the frequency of recombination between gene pairs on the same chromosome?

Solution:

(a) Step 1: Reasons for using *Drosophila melanogaster*:

- Easy to rear in laboratory.
- Short life cycle of about 2 weeks.
- Produces large number of progeny.
- Clear and distinguishable sexual dimorphism and genetic traits.

(b) Step 2: Morgan and his group observed that genes located on the same chromosome tend to be inherited together. **Step 3:** The frequency of recombination between two genes is directly proportional to the physical distance between them on a chromosome. **Step 4:** This led to the concept of gene linkage and genetic mapping based on recombination frequency.

Quick Tip

Linkage reduces recombination frequency; closely linked genes are often inherited together.

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27. 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, finger-like projections called **chorionic villi** appear on the trophoblast part of the blastocyst.

Step 2: The uterine tissue and maternal blood vessels surround these villi.

Step 3: Chorionic villi and uterine tissue combine to form the **placenta**.

Step 4: The placenta facilitates the exchange of nutrients, gases, and wastes between the mother and the embryo and acts as an endocrine tissue by secreting hormones like hCG, progesterone, and estrogens.

Quick Tip

Placenta forms through interaction of chorionic villi and uterine tissues, serving as a nutritive, respiratory, excretory, and endocrine organ for the embryo.

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28. 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.

Answer the given questions based on the information given above.

(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) Step 1: *Lantana camara* is an invasive species that suppresses the growth of native plant species, reducing biodiversity. **Step 2:** Its removal helped native grasses and legumes to regenerate, restoring the natural habitat of herbivores. **Step 3:** This, in turn, supported the prey base for tigers, thereby contributing to the revival of the Mudumalai Tiger Reserve's ecosystem.

(b) Step 4: The invasion of *Lantana camara* is a cause of concern because:

- It displaces native flora, reducing food availability for herbivores.
- Leads to habitat degradation and decline in biodiversity.
- Ultimately affects the entire food chain, including apex predators like tigers.

Quick Tip

Invasive alien species like *Lantana camara* outcompete native flora, damaging ecosystems and threatening wildlife habitats.

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.

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-thirds 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 non-medically often use unsterile needles and share injection equipment, which increases the risk of transmission of Hepatitis B virus leading to liver diseases.

(b) Direct drug-related diseases refer to illnesses that occur directly due to the consumption of drugs, such as liver failure, overdoses, and infections like Hepatitis B contracted through unsafe drug practices.

(c)

(i) The scientific name of the plant is **Papaver somniferum** and opioids are extracted from its **latex of immature capsules**.

OR

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

- Sudden change in behavior or mood swings.
- Drop in academic performance or frequent absences.

Quick Tip

Always be cautious about signs of drug abuse, especially injectable drugs, as they significantly increase the risk of contracting infections like Hepatitis B and C.

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30. 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 a 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:

(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 evolved from a common ancestor but diverged over time.

(ii) Humans and Frog: **Divergent evolution** — indicating a more distant but still common ancestry.

(b) Biochemical similarities in haemoglobin suggest that fewer amino acid differences indicate a closer evolutionary relationship. Thus, humans are closely related to macaques, followed by dogs, frogs, and lampreys.

(c)

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

OR

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

Quick Tip

Fewer amino acid differences in homologous proteins like haemoglobin point to a closer evolutionary relationship. Molecular evidence often gives the most reliable clues for phylogenetic trees.

SECTION E

31. Answer either option-(A) or (B):

(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 an environment with limited resources, initially the growth is slow, followed by a phase of exponential growth. Eventually, it slows down due to environmental resistance and reaches a stable state known as carrying capacity.

(ii) The equation of this logistic growth curve is:

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

where N is the population density at time t, r is the intrinsic growth rate, and K is the carrying capacity.

(iii) This growth curve is called a **Sigmoid or S-shaped curve**.

OR

(B)

(i) The Species-Area relationship explains that within a natural habitat, the species richness increases with the area, but this increase becomes less significant in larger areas. The graph is a rectangular hyperbola.

(ii)

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

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

where S is species richness, A is area, C is a constant, and Z is the slope of the line.

Quick Tip

Remember: Population growth in nature typically follows a sigmoid curve due to environmental constraints, while the species-area relationship follows a logarithmic increase with diminishing returns.

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32. Answer either option-(A) or (B):

(A)

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

(ii) Write the fate of the products of double fertilisation 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) In flowering plants, double fertilisation occurs when two male gametes are released into the embryo sac by the pollen tube. One male gamete fuses with the egg cell to form a diploid zygote (syngamy), while the other fuses with the two polar nuclei to form a triploid primary endosperm nucleus (PEN).

(ii) The zygote develops into the embryo, and the triploid PEN develops into the endosperm that provides nourishment to the developing embryo.

OR

(B)

(i) The testes are divided into 250–300 compartments called testicular lobules. Each lobule contains 1–3 highly coiled seminiferous tubules, where spermatogenesis occurs. The seminiferous tubules are lined by two types of cells:

- **Sertoli cells:** Provide nutrition to developing sperms.
- **Spermatogonia:** Undergo division to form sperms.

(ii) The hypothalamus secretes Gonadotropin-releasing hormone (GnRH), which stimulates the anterior pituitary to secrete LH and FSH. LH acts on Leydig cells to secrete testosterone, while FSH stimulates Sertoli cells for spermatogenesis.

Quick Tip

Double fertilisation is unique to angiosperms and results in both embryo and endosperm formation. In humans, GnRH plays a crucial regulatory role in initiating and maintaining sperm production.

33. Answer either option-(A) or (B):

(A)

(i) Name the two genes encoding for the Bt toxin protein used in biotechnology for the control of cotton bollworms.

(ii) How does the expression of Bt toxin gene in Bt cotton plant help in providing resistance to cotton bollworms? Explain.

OR

(B)

(i) Explain the given methods of introducing the alien DNA in the host cells:

- (I) Biolistics
- (II) Microinjection

(ii) How is *E. coli* made 'competent' to take up a recombinant plasmid or DNA?

Solution:

(A)

(i) The two genes encoding Bt toxin proteins are:

- **cry IAc**
- **cry IIAb**

(ii) In Bt cotton, the Bt toxin gene is expressed in plant tissues. When the cotton bollworm feeds on these tissues, the toxin is activated in the insect's alkaline gut, creating pores in the gut epithelium, leading to swelling, cell lysis, and death of the insect — thereby providing resistance to cotton bollworms.

OR

(B)

(i)
- **Biolistics (Gene gun method):** Tiny gold or tungsten particles coated with the desired DNA are shot into plant cells at high velocity to deliver foreign DNA.

- **Microinjection:** The foreign DNA is directly injected into the nucleus or cytoplasm of animal cells using a fine glass needle.

(ii) *E. coli* cells are made 'competent' by treating them with a solution of calcium chloride followed by a brief heat shock at 42°C. This creates temporary pores in the bacterial cell membrane, allowing recombinant plasmids or DNA to enter.

Quick Tip

Biolistics is especially useful for plant genetic transformation, while microinjection is ideal for animal cells. Bt cotton expresses bacterial genes to provide in-built pest resistance.
