CBSE 12 Biology (57/3/3) Question Paper with Solutions

Time Allowed :3 hours	**Maximum Marks :**100	**Total questions :**65

General Instructions

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

1. This question paper contains 33 questions. **All questions are compulsory.**
2. The question paper is divided into **five sections**: Sections **A, B, C, D, and E**.
3. **Section A** – questions number 1 to 16 are **multiple-choice type questions**. Each question carries 1 mark.
4. **Section B** – questions number 17 to 21 are **very short answer type questions**. Each question carries 2 marks.
5. **Section C** – questions number 22 to 28 are **short answer type questions**. Each question carries 3 marks.
6. **Section D** – questions number 29 and 30 are **case-based questions**. Each question carries 4 marks. Each question has subparts with **internal choice** in one of the subparts.
7. **Section E** – questions number 31 to 33 are **long answer type questions**. Each question carries 5 marks.
8. There is **no overall choice.** However, an internal choice has been provided in Sections **B, C, and D** of the question paper. A candidate has to write the answer for **only one of the alternatives** in such questions.
9. Kindly note that there is a separate question paper for **Visually Impaired candidates**.
10. Wherever necessary, **neat and properly labelled diagrams** should be drawn.

1. Embryo formation without fertilization is observed in some species of:

(A) Maize

(B) Rose

(C) Mango

(D) Rice

Correct Answer: (C) Mango

Solution:

- Apomixis is a unique process where embryos form without fertilization.

- In species like Mango, apomictic reproduction occurs, allowing seeds to develop from somatic or gametophytic cells.

- This ensures genetic consistency as the offspring are genetically identical to the parent plant.

Quick Tip

Apomixis is an asexual mode of reproduction that maintains genetic uniformity and bypasses the need for fertilization.

---

2. The origin of life according to the early Greek philosophers was transfer of unit of life from outer space to the different planets in the form of:

(A) seeds

(B) spores

(C) gemmules

(D) gametes

Correct Answer: (B) spores

Solution:

- The theory of Panspermia suggests that life is distributed across the universe via celestial objects like comets or meteoroids.

- According to this hypothesis, life on Earth may have originated from spores or microscopic life forms that traveled through space and reached Earth.

- These life-bearing entities could survive harsh cosmic conditions and initiated life on Earth

upon finding suitable conditions.

Quick Tip

Panspermia supports the possibility of life's extraterrestrial origins and highlights the resilience of spores to extreme environments.

---

3. The ploidy of apomictic embryos developing from the nucellus and antipodal cells respectively would be:

Options:

(A) 2n, 3n

(B) 2n, n

(C) 3n, 2n

(D) n, 2n

Correct Answer: (B) 2n, n

Solution:

- In apomictic reproduction, embryos may arise from nucellus (somatic cells) or gametophytic tissue.
- Nucellus cells are somatic and hence diploid (2n). Thus, apomictic embryos from nucellus cells have a ploidy of 2n.
- Antipodal cells are part of the female gametophyte, which is haploid (n) due to their origin from meiotic division.
- Therefore, the ploidy of embryos is 2n for nucellus-derived and n for antipodal-derived embryos.

Quick Tip

Apomixis enables reproduction without fertilization and preserves the parental genetic composition.

---

4. A DNA fragment has 3000 nucleotides, out of which 160 are Guanine. How many bases having double hydrogen bonds between them does this DNA fragment possess?

Options:

(A) 160

(B) 320

(C) 1340

(D) 2680

Correct Answer: (D) 2680

Solution:

- Adenine (A) pairs with Thymine (T) via 2 hydrogen bonds, while Guanine (G) pairs with Cytosine (C) via 3 hydrogen bonds.

- Given: Total nucleotides = 3000, Guanine (G) = 160.

- Cytosine (C) = 160 (as G pairs with C).

- Remaining nucleotides form A-T pairs:

A + T = Total nucleotides - (G + C) = 3000 - (160 + 160) = 2680.

- Thus, the number of bases forming double hydrogen bonds is 2680.

Quick Tip

In DNA, A-T pairs form 2 hydrogen bonds, while G-C pairs form 3 hydrogen bonds.

---

5. After the 1850s in the post-industrialization era in England, the expected effect of natural selection on the number of white-winged moths as compared to the dark-winged moths was:

Options:

(A) Less in number

(B) More in number

(C) Both were less in number

(D) Both were more in number

Correct Answer: (A) Less in number

Solution:

- During industrialization, tree trunks darkened due to soot, favoring the camouflage of dark-winged moths.

- As a result, dark-winged moths were less visible to predators and their numbers increased.
- In contrast, white-winged moths became more visible to predators, leading to a decline in their population.
- This phenomenon demonstrates natural selection driven by environmental changes.

Quick Tip

Industrial melanism is a classic example of natural selection influenced by environmental changes.

---

6. In which of the following chromosomal disorders do the individuals have short stature, small head, furrowed tongue, and partially open mouth?

Options:

(A) Turner's syndrome

(B) Down's syndrome

(C) Klinefelter's syndrome

(D) Edwards' syndrome

Correct Answer: (B) Down's syndrome

Solution:

- Down's syndrome is caused by trisomy of chromosome 21, meaning there are three copies of this chromosome instead of two.
- The disorder is characterized by:
- Short stature and small head size.
- A furrowed tongue and partially open mouth.
- Cognitive impairments and developmental delays.
- This condition arises due to nondisjunction during meiosis.

Quick Tip

Karyotyping is a diagnostic tool used to detect chromosomal disorders like Down's syndrome.

---

7. A Snapdragon plant bearing pink-colored flowers is crossed with a Snapdragon plant bearing white-colored flowers. Their F1 progeny will show:

Options:

(A) 25% Red : 50% Pink : 25% White

(B) 50% Red : 50% White

(C) 50% Pink : 50% White

(D) 25% Pink : 50% Red : 25% White

Correct Answer: (C) 50% Pink : 50% White

Solution:

- Snapdragon plants exhibit incomplete dominance, where the heterozygous genotype results in an intermediate phenotype.

- A pink flowered plant has the genotype Rr, while a white flowered plant has the genotype rr.

- The cross is represented as:

$$Rr \times rr \quad \rightarrow \quad \text{Gametes: } R, r \text{ and } r, r$$

$$\text{F1 Progeny: } 50\%Rr(\text{Pink}) \text{ and } 50\%rr(\text{White}).$$

Quick Tip

Incomplete dominance results in an intermediate phenotype, blending traits from both parent genotypes.

---

8. A patient is suffering from the infection of the alveoli of lungs and is showing the symptoms of fever, chills, cough, headache, and bluish-colored lips and fingernails. The patient was diagnosed to be suffering from the infection of:

Options:

(A) Epidermophyton

(B) Entamoeba histolytica

(C) Haemophilus influenzae

(D) Salmonella typhi

Correct Answer: (C) Haemophilus influenzae

Solution:

- Haemophilus influenzae is a bacterial pathogen responsible for pneumonia, an infection of the alveoli in the lungs.
- Symptoms include: - Fever, chills, and cough.
- Cyanosis, which causes bluish lips and fingernails due to reduced oxygen levels.
- Additional symptoms like headache and difficulty breathing.

Quick Tip

Pneumonia caused by Haemophilus influenzae can be treated with antibiotics. Early detection ensures better recovery.

---

9. The linking of the antibiotic resistance gene with the plasmid vector of *Salmonella typhimurium* by Stanley Cohen and Herbert Boyer was made possible by the enzyme:

Options:

(A) Taq polymerase

(B) DNA ligase

(C) Restriction endonuclease

(D) -galactosidase

Correct Answer: (B) DNA ligase

Solution:

- Stanley Cohen and Herbert Boyer pioneered recombinant DNA technology by linking the antibiotic resistance gene to the plasmid vector.
- DNA ligase was the enzyme that joined the DNA fragments by forming phosphodiester bonds between the sugar and phosphate groups.
- This experiment laid the foundation for genetic engineering and the creation of recombinant DNA molecules.

Quick Tip

DNA ligase acts as a ”molecular glue” in genetic engineering, ensuring stable insertion of DNA fragments.

10. In an experiment, *E. coli* is grown in a medium containing $^{14}NH_4Cl$ (^{14}N is the light isotope of Nitrogen) followed by growing it for six generations in a medium having the heavy isotope of nitrogen (^{15}N). After six generations, their DNA was extracted and subjected to CsCl density gradient centrifugation. Identify the correct density (Light/Hybrid/Heavy) and ratio of the bands of DNA in CsCl density gradient centrifugation:

Options:

(A) Hybrid : Heavy, 1 : 16

(B) Light : Heavy, 1 : 31

(C) Hybrid : Heavy, 1 : 31

(D) Light : Heavy, 1 : 05

Correct Answer: (C) Hybrid : Heavy, 1 : 31

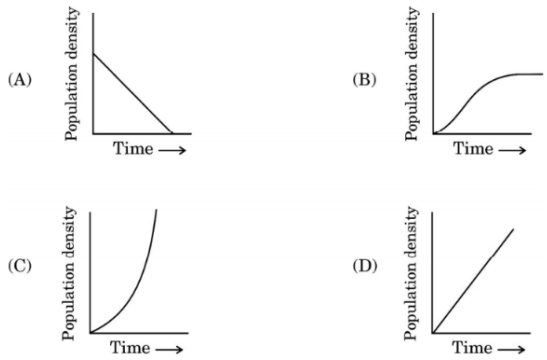
Solution:

- In the first generation, all DNA will be hybrid (one strand ^{14}N, one strand ^{15}N).
- With successive generations in the ^{15}N medium, the proportion of hybrid DNA decreases, while heavy DNA (^{15}N) increases.
- After six generations, the DNA bands will show a ratio of 1:31 for hybrid to heavy DNA.
- This result is due to the exponential replication of ^{15}N-labeled DNA in the absence of ^{14}N.

Quick Tip

Density gradient centrifugation effectively separates DNA based on its density, allowing the observation of isotopic incorporation.

11. The population growth curve applicable for a population of beetles growing in nature under unlimited resource conditions available to them will be:



Options:

(A) Population density decreases linearly with time.

(B) Sigmoid growth curve.

(C) Exponential growth curve.

(D) Population density increases linearly with time.

Correct Answer: (C) Exponential growth curve

Solution:

- In an ideal environment with unlimited resources, population growth follows an exponential pattern.

- The population size increases at a constant rate, represented mathematically as:

$$N_t = N_0 e^{rt}$$

where N_t is the population at time t, N_0 is the initial population, and r is the intrinsic growth rate.

- This results in a J-shaped curve, where the population doubles at regular intervals.

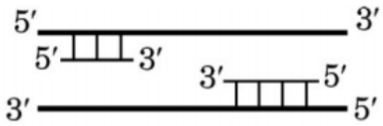
- Such conditions rarely occur in nature due to limiting factors like food, space, and predation.

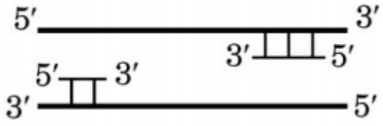
Quick Tip

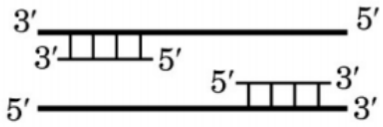
Exponential growth occurs in ideal conditions but is limited in natural ecosystems due to environmental resistance.

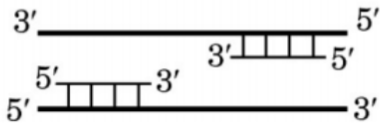
---

12. Which one of the following represents the correct annealing of primers to the DNA to be amplified in the PCR?

(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) Primers anneal perfectly in opposite directions to the DNA template.

Solution:

- PCR (Polymerase Chain Reaction) is used to amplify a specific segment of DNA.
- Primers are short nucleotide sequences designed to bind to opposite strands of the DNA template in a complementary manner.
- The binding occurs at the 3’ ends of the primers, allowing DNA polymerase to extend the sequence in the 5’ to 3’ direction.
- This ensures amplification of the target DNA region between the primer binding sites.

Quick Tip

Primer design is critical in PCR; ensure primers are complementary to the template DNA and face opposite directions.

---

13. Assertion (A): The zygote gives rise to heart-shaped embryo and subsequently proembryo in most angiosperms.

Reason (R): The zygote is present at the micropylar end of the embryo sac and develops into an embryo.

Options:

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

Solution:

- The zygote in angiosperms develops into a heart-shaped embryo before transitioning into the proembryo stage. This is a key stage of embryogenesis.
- The zygote is indeed located at the micropylar end of the embryo sac, but this does not explain the heart-shaped stage.
- The heart-shaped embryo results from cell differentiation and tissue patterning during embryogenesis.
- Thus, both statement (A) is false but (R) is true

Quick Tip

Embryogenesis involves key stages like globular, heart-shaped, and torpedo stages, leading to a mature embryo.

---

14. Assertion (A): The stirrer facilitates the even mixing of oxygen availability in a bioreactor.

Reason (R): Stirred-tank bioreactors generally have a flat base.

Options:

(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:

- In a stirred-tank bioreactor, the stirrer facilitates the even distribution of oxygen and nutrients throughout the culture medium.

- The flat base of a bioreactor provides structural stability, but it has no role in oxygen mixing.
- Thus, while the assertion (A) is correct, the reason (R) is incorrect.

Quick Tip

Stirred-tank bioreactors are designed for efficient mixing and aeration, essential for large-scale microbial growth.

---

15. Assertion (A): Primary transcripts in eukaryotes are subjected to splicing to remove the introns.

Reason (R): Primary transcripts contain both exons and introns, and the introns are non-functional in eukaryotes.

Options:

(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)

Solution:

- Eukaryotic primary transcripts are processed to remove non-functional regions called introns. This process is called splicing.
- The primary transcript consists of both exons (functional coding regions) and introns (non-functional sequences).
- Splicing ensures that only exons remain in the mature mRNA, which is then translated into proteins.
- The assertion (A) is correct as splicing removes introns, and the reason (R) correctly explains the presence of both exons and introns in the primary transcript.

Quick Tip

Splicing enhances genetic diversity through alternative splicing, where one gene can produce multiple protein variants.

---

16. Assertion (A): The chronic use of alcohol by a person leads to cirrhosis.

Reason (R): Alcohol addiction at times becomes the cause of mental and financial distress to the entire family of the addicted person.

Options:

(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)

Solution:

- Chronic alcohol consumption damages liver cells, leading to cirrhosis, a condition where the liver is scarred and its function is impaired.
- While alcohol addiction may cause mental and financial distress to families, this is unrelated to the physiological process of cirrhosis development.
- Thus, both the assertion and reason are correct, but the reason is not the correct explanation of the assertion.

Quick Tip

Cirrhosis can be prevented by moderating alcohol consumption and adopting a healthy lifestyle.

---

17. Amniocentesis is a very useful and important technique, but due to some reason there is a statutory ban on amniocentesis. Justify this statement.

Solution:

- Amniocentesis is a prenatal diagnostic technique used to detect genetic disorders and

chromosomal abnormalities in the fetus.

- However, it is banned in many countries due to its misuse for determining the sex of the fetus, which may lead to:

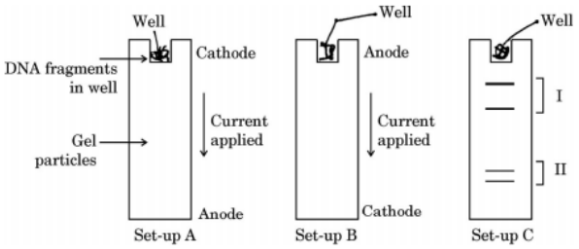
1. Female feticide, causing a decline in the female-to-male ratio.
2. Ethical concerns regarding the deliberate termination of pregnancies based on the fetus's sex.
3. Social and cultural issues promoting gender discrimination.

Quick Tip

Amniocentesis is useful for detecting genetic abnormalities but must be regulated to prevent unethical applications like sex determination.

---

18. With reference to the set-ups (A, B, and C) given below, of the electrophoretic separation of a mixture of DNA fragments of varied lengths, answer the questions that follow:



(a) In which one of the two Set-ups, A or B, would you see the DNA fragments separated and why?

Solution:

- Set-up B. DNA fragments are negatively charged and migrate toward the positive electrode (anode) under an electric field. Set-up B correctly places the positive electrode opposite the sample, ensuring proper separation.

(b) In Set-up C, which one of the two, I/II, are the bands of longer fragments of DNA? Justify your answer.

Solution:

- Band II contains longer DNA fragments. Larger molecules move more slowly through the gel matrix compared to smaller fragments, causing them to remain closer to the loading well.

Quick Tip

Electrophoresis separates DNA fragments based on size; smaller fragments move faster and travel farther in the gel.

---

19. Consider the given data of a hypothetical small portion of mRNA that codes for a functional polypeptide chain and answer the questions that follow:

mRNA Sequence: 5'– UCAUUAACCCAGAUCUUCUUAAAAGGA –3'

(a) How many amino acids will be formed from the given codons, if substitution of 'U' by 'C' takes place at the 5th codon? Explain your answer.

Solution:

- After substitution, the sequence changes to:

$5'$–$UCAUUAACCCAGACCUUCUUAAAAGGA$–$3'$.

- The 5th codon changes from UCU (Serine) to CCU (Proline). The total number of codons encoding amino acids remains the same.

- Amino acids = Total codons – Stop codon = 8.

(b) Write the number of amino acids that would be in the polypeptide synthesized by a similar mRNA as above, where in the fourth codon instead of 'C' there is 'U'. Justify your answer.

Solution:

- The sequence changes to: $5'$–$UCAUUAAUCCAGAUCUUCUUAAAAGGA$–$3'$.

- This causes the fourth codon to become UAA, a premature stop codon, halting translation.

- The polypeptide chain will be shorter as translation stops earlier.

Quick Tip

Mutations introducing premature stop codons can truncate proteins, potentially impairing their function.

---

20. Write important features of 'humus' formed during the decomposition cycle in a terrestrial ecosystem.

Solution:

- Humus is a dark, organic material formed by the decomposition of plant and animal matter.

- Key features include:

1. Rich in nutrients: Humus provides essential nutrients for plant growth.

2. Improves soil fertility: Enhances water retention and microbial activity.

3. Resistant to decomposition: Remains in the soil for a long time, supporting ecosystem stability.

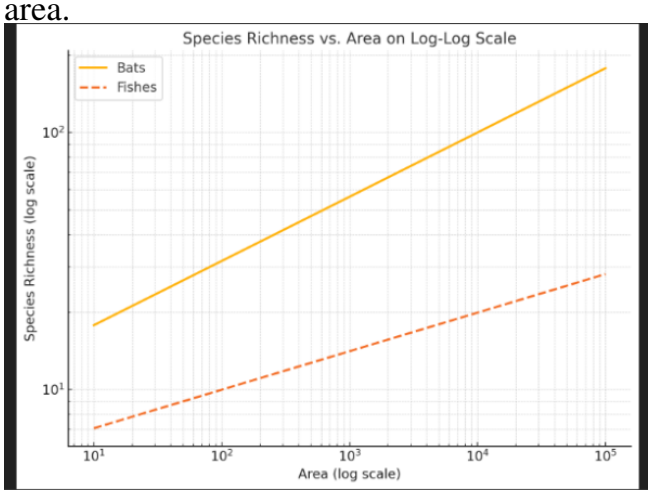
Quick Tip

Humus plays a crucial role in soil health by improving fertility, water retention, and microbial diversity.

OR

(b) (i) Graphically represent the relationship between species richness and area on a log-log scale for bats and fishes.

Solution: The graph shows a logarithmic relationship, with species richness increasing with area.



Quick Tip

Species richness often shows a logarithmic growth trend with habitat area.

(ii) Write the equation for the relationship as on a logarithmic scale.

Solution: $\mathbf{S = cA^z}$, where:

- S = Species richness.

- A = Area.
- c = Constant.
- z = Slope of the line (logarithmic).

Quick Tip

The species-area relationship demonstrates how biodiversity scales with habitat size.

---

21. What is a vaccine? Write the basis on which it acts when administered in the body.

Solution:

- A vaccine is a biological preparation that provides active immunity against specific diseases.

- It contains inactivated or weakened pathogens/antigens that stimulate the immune system to:

1. Recognize and neutralize pathogens upon future exposure.
2. Produce memory cells for long-term immunity.

Quick Tip

Vaccines are essential for preventing infectious diseases and achieving herd immunity to protect communities.

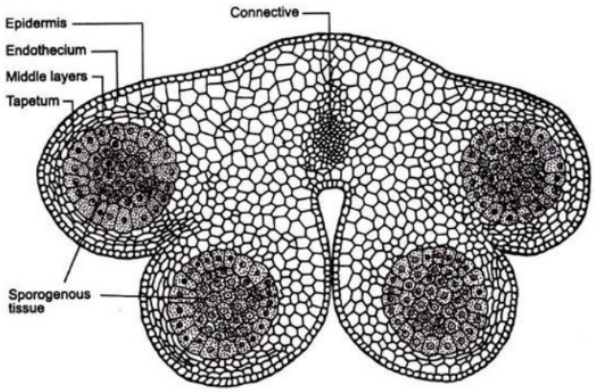
---

22. Draw a T.S. of a mature anther of an angiosperm. Label its any three wall layers and mention their functions.

Solution:

The transverse section (T.S.) of a mature anther includes the following wall layers:

- **Epidermis:** The outermost layer that provides mechanical protection.
- **Endothecium:** Helps in the dehiscence of the anther to release pollen grains.
- **Tapetum:** Nourishes developing pollen grains by supplying nutrients and enzymes.

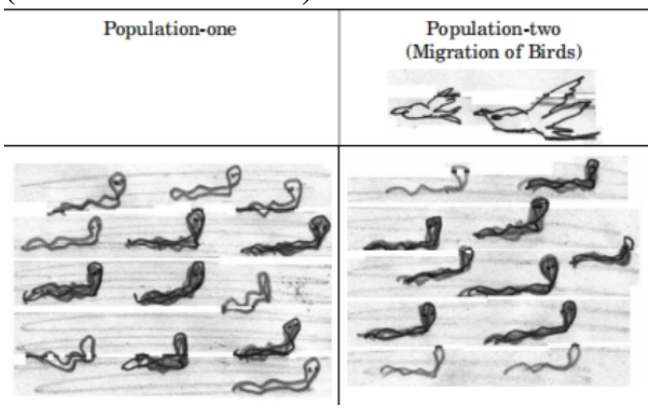


Quick Tip

The anther wall layers work together to protect, nurture, and release mature pollen grains for reproduction.

---

23. A population of snakes lived in a desert with brown sand. Study the drawings given below showing the change in the population from 'one' to 'two' over time and answer the question that follows. Brown snakes and grey snakes are represented by alleles A/a (Dominant/recessive).



(a) If the frequency of the recessive trait is 9% in population-one, work out the frequency of homozygous dominant and heterozygous dominant snakes.

Solution:

Given: Recessive trait frequency (q^2) = 9% = 0.09.

$$q^2 = 0.09 \implies q = \sqrt{0.09} = 0.3.$$

$$p + q = 1 \implies p = 1 - 0.3 = 0.7.$$

Homozygous dominant (AA) frequency: $p^2 = (0.7)^2 = 0.49 = 49\%$.

Heterozygous dominant (Aa) frequency: $2pq = 2(0.7)(0.3) = 0.42 = 42\%$.

Quick Tip

The Hardy-Weinberg principle allows us to calculate allele and genotype frequencies in a population under genetic equilibrium.

(b) Name the mechanism of evolution that must have operated so that population-two evolved from population-one.

Solution:

The mechanism is Natural Selection. Brown snakes had better camouflage in the desert environment, leading to higher survival and reproductive success, whereas grey snakes were more visible to predators. Over generations, this selection led to an increased frequency of the brown allele.

Quick Tip

Natural selection favors traits that increase an organism's fitness in a specific environment, driving evolutionary changes.

---

24. (a) (i) List two major reasons for using cow-dung in a biogas plant instead of using domestic sewage.

Solution:

- Cow-dung contains methanogenic bacteria that are highly efficient in producing biogas.
- It is readily available in rural areas and environmentally sustainable as a resource.

Quick Tip

Cow-dung is ideal for biogas plants due to its microbial richness and availability, making it an eco-friendly energy source.

(ii) Mention one use of the unspent slurry of the biogas plant.

Solution:

Unspent slurry is used as a nutrient-rich organic fertilizer, improving soil fertility and supporting sustainable agriculture.

Quick Tip

The unspent slurry from biogas plants is a cost-effective and eco-friendly alternative to chemical fertilizers.

(b) Name the bioactive molecule and its microbial source generally used by physicians to treat the patients for:

- **(i) Myocardial infarction:** Streptokinase (source: *Streptococcus*).
- **(ii) High blood cholesterol level:** Statins (source: *Monascus purpureus*).
- **(iii) Organ transplantation:** Cyclosporine A (source: *Trichoderma polysporum*).

Quick Tip

Bioactive molecules like streptokinase, statins, and cyclosporine A have revolutionized modern medicine for treating critical conditions.

---

25. Differentiate between spermatogenesis and oogenesis in humans on the basis of the following:

(a) When the process is initiated.

Solution:

- **Spermatogenesis:** Begins at puberty.
- **Oogenesis:** Begins during fetal development.

(b) Number of functional gametes produced per primary spermatocyte/oocyte.

Solution:

- **Spermatogenesis:** Produces four functional sperm from one primary spermatocyte.
- **Oogenesis:** Produces one ovum and two polar bodies from one primary oocyte.

(c) Specific site at which meiosis II is completed.

Solution:

- **Spermatogenesis:** Completed in the seminiferous tubules of the testes.
- **Oogenesis:** Completed in the fallopian tubes after fertilization.

Quick Tip

Spermatogenesis and oogenesis are essential for sexual reproduction, ensuring the formation of male and female gametes with half the chromosome number.

---

26. Three crosses were carried out in pea plants with respect to flower colour violet/white (V/v) and flower position axial/terminal (A/a). Study in the table the crosses 'a', 'b' and 'c' where parental phenotypes and their F_1 progeny phenotypes are given. Find the genotypes of each of the parental pairs of crosses 'a', 'b' and 'c'.

Parental plants (Phenotypes)	*F_1 Progeny (Phenotypes)*
(a) Violet, axial × white, axial	6/16 white, axial 2/16 white, terminal 6/16 violet, axial 2/16 violet, axial
(b) Violet, axial × white, terminal	1/4 violet, axial 1/4 violet, terminal 1/4 white, axial 1/4 white, terminal
(c) Violet, axial × violet, axial	3/4 violet, axial 1/4 white, axial

Solution:

(a) Cross: Violet, axial × White, axial

Genotype of parents: $VvAa \times vvAa$

Explanation:

- $6/16$ Violet, axial: $VvAa$.
- $2/16$ White, terminal: $vvAa$.

- $6/16$ Violet, axial: $VvAa$.
- $2/16$ White, axial: $vvAa$.

(b) Cross: Violet, axial × White, terminal

Genotype of parents: $VvAa \times vvaa$

Explanation:

- $1/4$ Violet, axial: $VvAa$.
- $1/4$ Violet, terminal: $Vvaa$.
- $1/4$ White, axial: $vvAa$.
- $1/4$ White, terminal: $vvaa$.

(c) Cross: Violet, axial × Violet, axial

Genotype of parents: $VvAa \times VvAa$

Explanation:

- $3/4$ Violet, axial: $VvAa$.
- $1/4$ White, axial: $vvAa$.

Quick Tip

In dihybrid crosses, phenotypic ratios help deduce the parental genotypes using Mendel's laws of inheritance.

---

27. Explain any three roles of 'predation' in an ecosystem with the help of suitable examples.

Solution:

Roles of predation:

- **Maintains species diversity:** Predators control prey populations, preventing any one species from dominating. Example: Tigers preying on herbivores in forests.
- **Regulates ecosystem balance:** Predators prevent overgrazing by herbivores, maintaining a balance between plant and animal populations. Example: Wolves controlling deer populations in Yellowstone National Park.

- **Promotes natural selection:** Predation drives evolutionary adaptations in prey species to develop defense mechanisms. Example: Camouflage in stick insects and moths.

Quick Tip

Predation is essential for maintaining biodiversity, balancing ecosystems, and driving evolutionary changes.

---

28. (a) Give the scientific name of the bacteria widely used in biotechnology to create a GM cotton crop resistant to bollworm attacks.

Solution:

Bacillus thuringiensis (Bt)

Quick Tip

Bacillus thuringiensis is a soil bacterium producing Bt toxin, widely used for pest-resistant crops.

(b) Explain how GM cotton crop is able to resist insect attacks.

Solution:

GM cotton incorporates a gene from *Bacillus thuringiensis* to resist insect attacks:

- The Bt gene produces a toxin that becomes active in the alkaline gut of bollworms.
- The toxin binds to gut receptors, causing cell lysis, leading to the death of the insect.

Quick Tip

Bt cotton significantly reduces the use of chemical pesticides, promoting sustainable and eco-friendly farming.

---

29. Read the passage given below and answer the questions that follow:

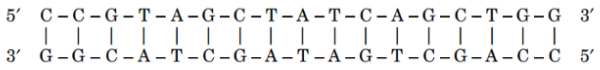
In recombinant DNA technology, restriction enzymes are used as they recognize and cut DNA within a specific recognition sequence. BamHI is one such restriction enzyme which binds at the recognition sequence 5'-G↓GATCC-3' and cleaves this sequence between G and

G on each strand, whereas AluI binds at the recognition sequence 5'-AG↓CT-3' and cleaves these sequences between G and C on each strand.

(a) If AluI is used to cut the given DNA strand, how many DNA fragments would be formed? Write the sequence of each fragment formed with its polarity.

Solution:

The sequence contains three AluI recognition sites. DNA fragments formed:



- 5'-CCGG-3'
- 5'-ATCCTG-3'
- 5'-CGAT-3'

Quick Tip

AluI recognizes specific palindromic sequences and cuts DNA to produce blunt ends, suitable for certain molecular biology applications.

(b) Which one of the two restriction enzymes, BamHI or AluI, will preferably be used on the same given DNA strand to make a recombinant DNA molecule and why?

Solution:

BamHI is preferred because it generates sticky ends, which facilitate the joining of DNA fragments to form recombinant DNA.

Quick Tip

Sticky ends created by enzymes like BamHI improve the efficiency and stability of recombinant DNA formation.

(c) After binding to the two strands of the double helix DNA, where specifically does the restriction enzyme act to cut the two strands of DNA? Write the specific term used for the specific nucleotide sequences of DNA recognised by a restriction endonuclease.

Solution:

Restriction enzymes cut DNA at specific recognition sites, which are typically palindromic sequences. These sequences enable the enzyme to cleave at precise locations, generating

sticky or blunt ends.

- The specific term used for these sequences is recognition sequence.

Quick Tip

Recognition sequences are short, palindromic nucleotide stretches that guide restriction enzymes to their cutting sites.

OR

(29 c) Write the specific sequence of DNA segment recognised by the restriction endonuclease EcoRI.

Solution:

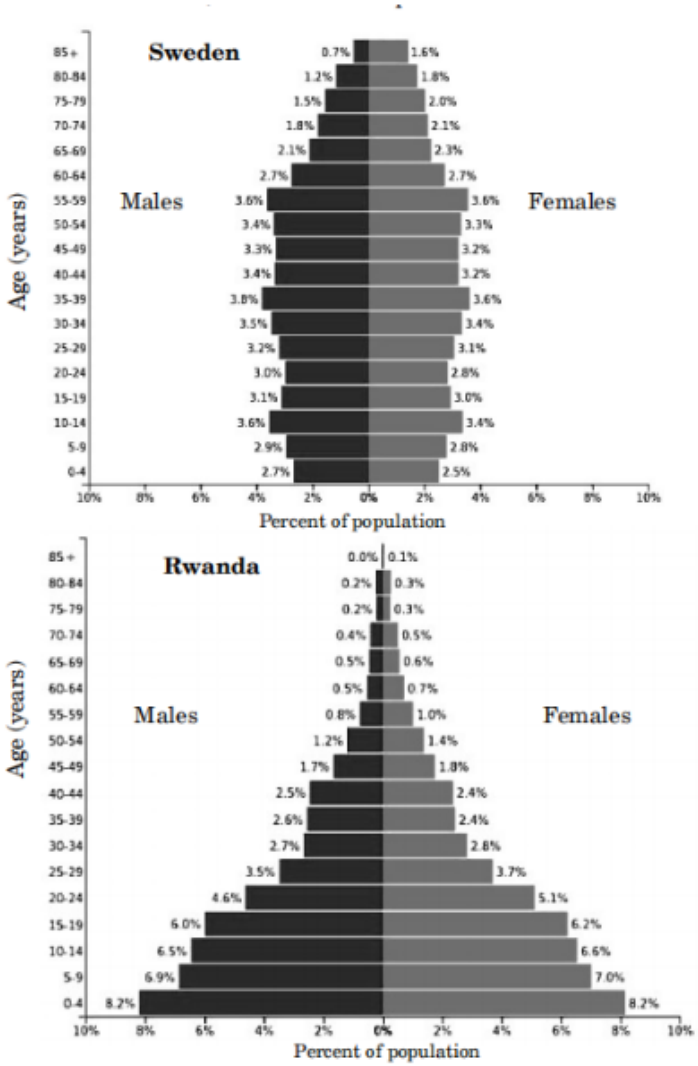
EcoRI recognises the palindromic DNA sequence 5'-GAATTC-3' and cleaves it between G and A, producing sticky ends.

Quick Tip

EcoRI is one of the most commonly used restriction enzymes in molecular biology, particularly for generating cohesive (sticky) ends in DNA fragments to facilitate ligation.

---

30. Study the figures given below that depict the comparative age distribution of human populations in Sweden and Rwanda (International Data Base 2003) and answer the questions that follow:



(a) What can be inferred from the very broad base of Rwanda's age pyramid? Support your answer with the data provided in the figure.

Solution:

The broad base of Rwanda's age pyramid indicates:

- High birth rate: A significant proportion of the population is in the younger age groups (0-14 years).
- Rapid population growth: As a developing nation, Rwanda has a higher fertility rate with more children being born than individuals dying.

Quick Tip

Age pyramids visually represent demographic trends, allowing us to analyze birth rates, death rates, and population growth over time.

(b) Sweden has an age distribution that is approximately of the same width near its base as at the apex. What does this indicate?

Solution:

Sweden's age pyramid indicates:

- Stable population: The population growth rate is low due to effective family planning and healthcare.
- Low birth and death rates: Nearly equal proportions of individuals in all age groups indicate balanced demographic growth.

Quick Tip

Stable pyramids reflect nations with consistent growth rates, often associated with developed countries.

(c) Name the type of age pyramid shown above for Sweden.

Solution:

Stationary age pyramid.

Quick Tip

A stationary pyramid depicts equal proportions across all age groups, typical of countries with low fertility and mortality rates.

(d) Name the type of age pyramid shown above for Rwanda.

Solution:

Expanding age pyramid.

Quick Tip

Expanding pyramids are typical of developing nations with high birth rates and a larger proportion of younger individuals.

---

31. (a) "The influence of both alleles in a heterozygous state is clearly expressed in codominance." Explain with the help of inheritance of ABO blood group in humans.

Solution:

Codominance occurs when both alleles in a heterozygous state are fully expressed without blending.

- Example: ABO blood group inheritance.
- The ABO blood group system involves three alleles: **IA**, **IB**, and **i**.
- The **IA** and **IB** alleles are codominant, while **i** is recessive.
- A person with the genotype **IAIB** will express both alleles equally, resulting in the AB blood group.

Quick Tip

Codominance allows both alleles to contribute equally to the phenotype, exemplified by the AB blood group where both A and B antigens are expressed.

OR

(b)(i) Explain the mechanism of switching 'on' of the structural genes of the *lac operon*.

Solution:

The *lac operon* is switched 'on' in the presence of lactose:

- Lactose acts as an inducer by binding to the repressor protein, changing its conformation.
- The altered repressor cannot bind to the operator region of the operon.

- This allows RNA polymerase to bind to the promoter region and transcribe the structural genes (*lacZ, lacY, lacA*).
- The enzymes produced metabolize lactose, enabling its utilization as an energy source.

Quick Tip

The *lac operon* demonstrates an inducible system where transcription occurs only in the presence of an inducer like lactose.

(b)(ii) "Regulation of *lac operon* is referred to as negatively regulated." Justify giving a reason.

Solution:

The *lac operon* is negatively regulated because:

- In the absence of lactose, the repressor protein binds to the operator region, preventing RNA polymerase from transcribing the structural genes.
- This ensures that the operon is inactive when lactose is unavailable, conserving energy.

Quick Tip

Negative regulation of the *lac operon* ensures efficient use of resources, activating gene expression only when necessary.

32(a). (i) Describe the life cycle of *Plasmodium* from the time it enters the human body till a female *Anopheles* mosquito bites an infected person.

Solution:

The life cycle of *Plasmodium*:

- Sporozoites enter the human bloodstream through a mosquito bite and travel to the liver.
- In liver cells, sporozoites multiply to form merozoites, which are released into the bloodstream.
- Merozoites infect red blood cells, causing them to rupture. This leads to malaria symptoms like fever and chills.

- Some merozoites develop into gametocytes, which circulate in the blood.
- When a mosquito bites an infected person, it ingests gametocytes, continuing the cycle.

Quick Tip

Understanding the life cycle of *Plasmodium* is essential for designing effective malaria control measures.

(ii) Mention the two events of *Plasmodium* life cycle that occur within the female *Anopheles* body.

Solution:

- Gametogenesis: Gametocytes develop into male and female gametes inside the mosquito.
- Sporozoite Formation: The zygote develops into sporozoites, which migrate to the salivary glands, ready to infect the next host.

Quick Tip

Malaria control focuses on breaking the life cycle of *Plasmodium*, either by targeting mosquitoes or treating infected individuals.

32(b) (i) Write two differences between malignant tumor and benign tumor.

Solution:

- **Malignant Tumor:**
  - Malignant tumors are cancerous and invade nearby tissues, causing significant damage.
  - They have the ability to metastasize, spreading to other parts of the body via blood or lymphatic systems.
- **Benign Tumor:**

- Benign tumors are non-cancerous and grow at a slower rate, staying confined to their original location.
- They do not invade surrounding tissues or metastasize to distant parts of the body.

Quick Tip

Malignant tumors are life-threatening due to their invasive and metastatic nature, whereas benign tumors are less dangerous but may require monitoring if they grow large.

(b) (ii) Explain any three diagnostic techniques for the detection of cancer.

Solution:

Three widely used diagnostic techniques for cancer detection are:

- **Biopsy:** Involves taking a small sample of tissue from the affected area, which is then analyzed under a microscope to check for cancerous cells.
- **Imaging Techniques:**
  - *X-rays:* Effective for identifying abnormalities in bones or certain organs.
  - *MRI (Magnetic Resonance Imaging):* Produces detailed cross-sectional images of soft tissues, helping to locate and assess tumors.
- **Blood Tests:** Used to detect tumor markers, which are specific proteins or substances produced by cancer cells.

Quick Tip

Early diagnosis of cancer using tools like biopsy, imaging, and blood tests improves the chances of successful treatment and recovery.

33. (a) (i) Explain any four devices that flowering plants have developed to encourage cross-pollination.

Solution:

Flowering plants have evolved the following mechanisms to promote cross-pollination:

- **Dichogamy:** The male and female reproductive parts of a flower mature at different times to prevent self-pollination. For example, protandry (male matures first) in sunflower.
- **Self-incompatibility:** A genetic mechanism prevents the germination of self-pollen on the stigma, ensuring cross-pollination. Example: Brassica species.
- **Herkogamy:** Structural adaptation in which male and female organs are spatially separated, making self-pollination unlikely. Example: Hibiscus.
- **Monoecy and Dioecy:** In monoecious plants, male and female flowers are present on the same plant (e.g., maize), while in dioecious plants, they occur on separate plants (e.g., papaya).

Quick Tip

Cross-pollination enhances genetic diversity, making plants more adaptable to environmental changes and improving evolutionary success.

(ii) Why do plants discourage self-pollination? State any one reason.

Solution:

Plants discourage self-pollination because it leads to inbreeding depression, which reduces genetic variation and adaptability, making the population more susceptible to diseases and environmental changes.

Quick Tip

Self-pollination is limited by mechanisms like dichogamy, herkogamy, and genetic self-incompatibility to promote healthier and more diverse offspring.

(b) Explain the ovarian and uterine events taking place along with the role of pituitary and ovarian hormones, during menstrual cycle in a normal human female under the following phases:

(i) Follicular phase/proliferative phase

Solution:

- **Ovarian events:** A primary follicle develops into a mature Graafian follicle in the ovary.
- **Uterine events:** The endometrium of the uterus regenerates and thickens in preparation for possible implantation.
- **Hormones:**
  - FSH (Follicle Stimulating Hormone): Promotes follicular growth and maturation.
  - Estrogen: Secreted by the growing follicle, aiding in endometrial repair and stimulating LH secretion.

Quick Tip

The follicular phase prepares the ovary for ovulation and the uterus for potential embryo implantation.

(ii) Luteal phase/secretory phase

Solution:

- **Ovarian events:** The ruptured follicle transforms into the corpus luteum, which secretes progesterone.
- **Uterine events:** The endometrium thickens further, becoming more vascularized and glandular to prepare for embryo implantation.
- **Hormones:**
  - Progesterone: Maintains the thickened endometrium and inhibits FSH and LH secretion.
  - Estrogen: Supports the uterine lining.

Quick Tip

The luteal phase ensures the uterus is ready for implantation; in the absence of fertilization, the corpus luteum degenerates.

(iii) Menstrual phase

Solution:

- **Ovarian events:** If fertilization does not occur, the corpus luteum degenerates into the corpus albicans.
- **Uterine events:** The thickened endometrium breaks down, leading to menstrual bleeding.
- **Hormones:**
  - Progesterone and Estrogen: Their levels decline, causing the breakdown of the uterine lining.
  - FSH secretion increases: This initiates the next cycle by stimulating the growth of new follicles.

Quick Tip

The menstrual phase marks the beginning of a new cycle, shedding the old endometrial lining and preparing for the next potential pregnancy.
