CBSE 12 2024 Biology Set 2 (57/3/2) Question Paper with Solutions

Time Allowed :3 hours	**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. The question paper is divided into **FIVE sections**: Section A, B, C, D, and E.
3. **Section A:** Questions 1 to 16 are multiple-choice type questions. Each question carries 1 mark.
4. **Section B:** Questions 17 to 21 are very short answer-type questions. Each question carries 2 marks.
5. **Section C:** Questions 22 to 28 are short answer-type questions. Each question carries 3 marks.
6. **Section D:** Questions 29 and 30 are case-based questions. Each question carries 4 marks and has subparts with internal choice in one of the subparts.
7. **Section E:** Questions 31 to 33 are long answer-type questions. Each question carries 5 marks.
8. There is no overall choice. However, **internal choice** has been provided in some questions in Section B, Section C, and Section D. A candidate has to attempt only one of the alternatives in such questions.
9. A separate question paper is available for **Visually Impaired candidates**.
10. Wherever necessary, neat and properly labeled diagrams should be drawn.

SECTION A

Questions no. 1 to 16 are Multiple Choice Type Questions, carrying 1 mark each.

1. The ploidy of the apomictic embryos developing from the integument cells and synergids respectively would be:

(A) $n, 2n$

(B) $2n, n$

(C) $3n, 2n$

(D) $2n, 3n$

Correct Answer: (B) $2n, n$

Solution:

Apomictic embryos are unique in that they develop without fertilization, a process known as apomixis. In this form of reproduction, the embryo is produced from an unfertilized egg or other cells of the ovule, such as the integument cells.

Formation of Apomictic Embryos:

In apomixis, embryos can develop directly from somatic cells such as the integuments (which are part of the outer layers of the ovule). These somatic cells are diploid (2n), meaning they have two sets of chromosomes. As a result, the embryos produced from these cells also have the same diploid ploidy level (2n). This is in contrast to the typical fertilization process, where the egg cell is haploid (n) and fuses with a haploid sperm cell to form a diploid zygote.

Synergids:

Synergids, which are specialized cells found in the embryo sac, are haploid (n). These cells assist in guiding the pollen tube for fertilization, but in the case of apomixis, they do not participate in fertilization. They remain haploid (n) because they are formed from the egg cell, and since they are not involved in the fertilization process, their chromosome number does not change.

In summary, when an apomictic embryo is formed from integument cells, it retains the somatic ploidy level of $2n$, whereas the synergids remain n, which aligns with the option (B) $2n, n$.

Thus, the correct ploidy pattern in apomixis is that the embryos formed are diploid (2n) while the synergids are haploid (n), as fertilization does not occur in this process.

Quick Tip

Apomixis leads to clonal reproduction, maintaining genetic uniformity, as the offspring are genetically identical to the parent.

---

2. A DNA fragment has 2500 nucleotides, out of which 240 are Guanine. How many bases having double hydrogen bonds between them does this DNA fragment possess?

(A) 480

(B) 720

(C) 1010

(D) 2020

Correct Answer: (D) 2020

Solution: In the structure of DNA, Guanine (G) pairs with Cytosine (C) through triple hydrogen bonds, while Adenine (A) pairs with Thymine (T) through double hydrogen bonds. Given that there are 240 Guanine bases in the DNA sequence, it follows that there must also be 240 Cytosine bases to maintain the complementary pairing. This results in a total of 480 bases formed by G-C pairs.

Since the total number of bases in the sequence is 2500, the remaining bases, which must be Adenine and Thymine, can be calculated by subtracting the number of G-C pairs from the total number of bases:

$$2500 - 480 = 2020$$

These remaining 2020 bases represent the A-T pairs, as Adenine pairs with Thymine. Since A-T pairs form double hydrogen bonds, the number of bases that form these bonds is also 2020.

Thus, the number of bases forming double hydrogen bonds (A-T pairs) is 2020.

Quick Tip

Adenine pairs with Thymine (A-T) through double hydrogen bonds, while Guanine pairs with Cytosine (G-C) through triple hydrogen bonds.

---

3. The mechanism to produce seeds without fertilization has evolved in the given family of the flowering plants:

(A) Asteraceae

(B) Solanaceae

(C) Malvaceae

(D) Liliaceae

Correct Answer: (A) Asteraceae

Solution: Apomixis is a unique form of asexual reproduction in plants, where seeds are produced without the need for fertilization. This process leads to the creation of clonal offspring, which ensures genetic consistency from one generation to the next.

Apomixis is particularly common in the Asteraceae family, which includes plants like *Taraxacum* (dandelions) and Hieracium.

This form of reproduction offers several advantages, including the avoidance of meiotic recombination, the production of genetically identical offspring, and the preservation of stability in hybrid varieties.

Quick Tip
Apomixis is an evolutionary advantage that allows plants to reproduce without genetic variation, helping to maintain desirable traits in agricultural crops.

---

4. Louis Pasteur dismissed the theory of spontaneous generation by his experiments using pre-sterilized flasks and:

(A) Live yeast

(B) Killed yeast

(C) Live bacteria

(D) Killed bacteria

Correct Answer: (B) Killed yeast

Solution: The theory of spontaneous generation suggested that living organisms could emerge from non-living matter. Louis Pasteur disproved this theory through a carefully designed experiment using sterilized swan-neck flasks containing nutrient broth.

When the flasks were sealed, no microbial growth occurred, demonstrating that microorganisms do not arise spontaneously.
However, when the flasks were exposed to air, microbial contamination was observed, confirming that microorganisms come from pre-existing life forms in the environment.

Quick Tip
Louis Pasteur's experiment provided strong evidence for the biogenesis theory, which states that all life originates from existing life.

---

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:

(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: Prior to industrialization, white-winged moths were more prevalent because their color provided effective camouflage against lichen-covered tree trunks.
Industrial pollution caused the tree bark to darken due to soot accumulation, which made dark-winged moths harder to spot by predators, thereby improving their chances of survival.
As white-winged moths became more visible against the darker tree bark, they were more frequently preyed upon, leading to a decline in their population. This phenomenon is a classic example of natural selection, often referred to as industrial melanism.

Quick Tip
Natural selection favors traits that enhance survival in response to environmental changes.

---

6. A Snapdragon plant bearing red color flowers was crossed with a Snapdragon plant bearing white color flowers. The F_1 progeny on selfing produced the progeny in the ratio of:

(A) 50% Red : 50% White

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

(C) 50% Red : 50% Pink

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

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

Solution: The color of Snapdragon flowers exhibits incomplete dominance, where the heterozygous condition produces a pink flower rather than the dominant red.

Crossing a red flower (RR) with a white flower (rr) results in all pink (Rr) flowers in the F_1 generation.

Self-pollination of the F_1 generation (Rr × Rr) leads to a 1:2:1 phenotypic ratio in the F_2 generation:

25% Red (RR)

50% Pink (Rr)

25% White (rr)

Quick Tip
Incomplete dominance results in intermediate traits, where the heterozygous condition shows a blend of both alleles rather than the expression of one dominant trait.

---

7. In which of the following chromosomal disorders do individuals have short stature, underdeveloped feminine character, and sterile ovaries?

(A) Down's syndrome

(B) Turner's syndrome

(C) Klinefelter's syndrome

(D) Patau's syndrome

Correct Answer: (B) Turner's syndrome

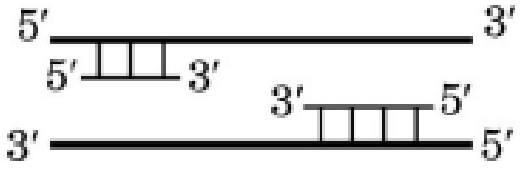
Solution: Turner's syndrome results from the monosomy of the X chromosome (45, X).

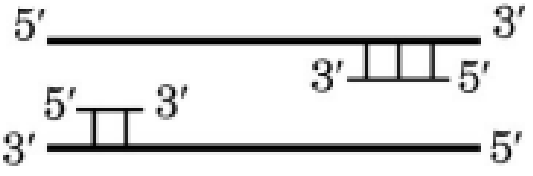
Individuals with this condition typically show characteristics such as short stature, a webbed neck, absence of secondary sexual characteristics, and infertility due to ovarian dysgenesis. Unlike Klinefelter's syndrome, which affects males, Turner's syndrome is exclusive to females.

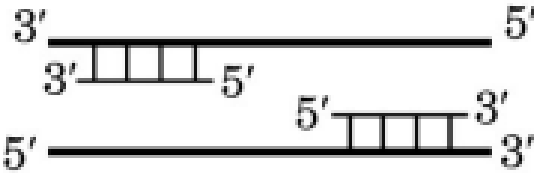
Quick Tip
Turner's syndrome is a chromosomal disorder caused by the absence of one X chromosome in females.

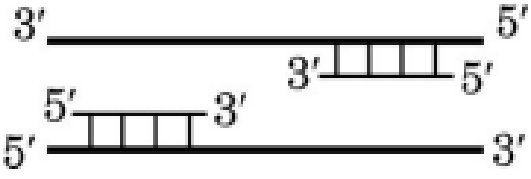
---

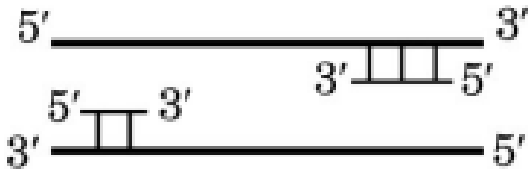
8. Which one of the following represents the correct annealing of primers to the DNA to be amplified in the PCR?

(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution: Polymerase Chain Reaction (PCR) is a method used to amplify specific DNA sequences by using primers that bind to the template strand.

The primers must anneal in a complementary fashion, with one primer binding to the 3' end of one strand and the other binding to the 3' end of the opposite strand.

Option (B) correctly illustrates the primers binding in an antiparallel orientation, which is essential for successful amplification.

Quick Tip
In PCR, primers must be complementary to the template DNA and bind in an antiparallel direction to allow DNA polymerase to extend in the 5' to 3' direction.

---

9. A patient is suffering from fever, chills, cough, headache, and bluish fingernails and lips. These symptoms are of the disease:

(A) Malaria

(B) Typhoid

(C) Common cold

(D) Pneumonia

Correct Answer: (D) Pneumonia

Solution: Pneumonia is a lung infection that leads to symptoms such as cough, chills, fever, and difficulty breathing.

The bluish tint seen in the fingernails and lips is a sign of oxygen deficiency, a prominent symptom in severe cases of pneumonia.

Other conditions, such as malaria and typhoid, do not primarily cause respiratory issues or oxygen shortage.

Quick Tip
Pneumonia is often caused by bacterial infections like *Streptococcus pneumoniae* or viral infections, and it requires prompt medical treatment.

---

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 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.

(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: Meselson and Stahl's experiment provided evidence for semi-conservative replication, where the parental DNA strands act as templates for the synthesis of new strands. Initially, *E. coli* grown in ^{14}N medium contains only light DNA. When transferred to ^{15}N medium, the newly synthesized DNA incorporates ^{15}N, resulting in a hybrid DNA fraction after the first round of replication.

After six generations in ^{15}N medium, most of the DNA will be heavy (completely incorporated with ^{15}N), but a small fraction (1 in 31) will still be in a hybrid form.

Quick Tip
In semi-conservative DNA replication, each daughter DNA strand consists of one original parental strand and one newly synthesized strand.

---

11. For the replication of the first recombinant DNA, Stanley Cohen and Herbert Boyer used the DNA polymerase of:

(A) Thermus aquaticus

(B) Salmonella typhimurium

(C) Escherichia coli

(D) Haemophilus influenzae

Correct Answer: (C) Escherichia coli

Solution: Stanley Cohen and Herbert Boyer were the pioneers in creating the first recombinant DNA by combining DNA from two different organisms.

They utilized DNA polymerase from Escherichia coli (E. coli), which played an essential role in amplifying the DNA during recombinant DNA technology.

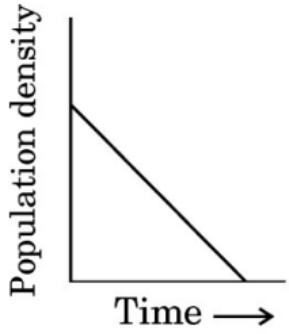
The use of E. coli was crucial due to its status as a model organism for genetic manipulation, along with its ability to grow rapidly, making it easier to clone recombinant DNA.

Quick Tip
Escherichia coli is a commonly used organism in molecular biology for cloning and recombinant DNA work due to its quick replication and genetic flexibility.

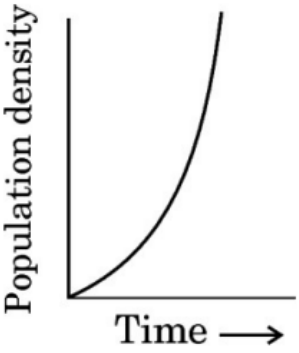
---

12. The population growth curve applicable for a population growing in nature with limited resources available to them will be:

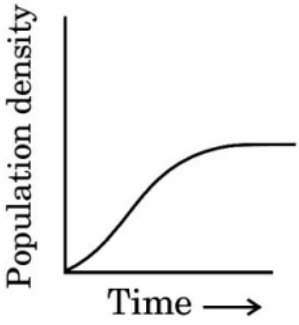
(A)

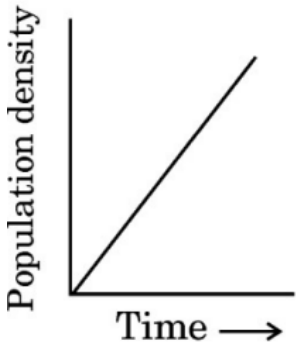


(B)



(C)



(D) 

Correct Answer: (C)

Solution: A population growing in the wild with limited resources follows a logistic growth model, where the population initially grows rapidly but slows down as it approaches the environment's carrying capacity.

This growth pattern is illustrated by a sigmoid curve (S-shaped curve), where the population density begins low, grows exponentially, and then levels off once resources become scarce.

Graph 3 represents this logistic growth, showing the population density stabilizing at the carrying capacity.

Quick Tip
Logistic growth is a common model for natural population growth, where resource limitations prevent continuous increases in population size.

For Questions number 13 to 16, two statements are given one labelled as Assertion (A) and the other labelled as Reason (R). Select the correct answer to these questions from the codes (A), (B), (C) and (D) as given below.

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

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

(C) Assertion (A) is true, but Reason (R) is false

(D) Assertion (A) is false, but Reason (R) is true

13. Assertion (A): The zygote gives rise to a 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.

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

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

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

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

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

Solution: The assertion about the zygote developing into a heart-shaped embryo is true, as it forms the proembryo in angiosperms.

However, the reason incorrectly states that the zygote develops from the micropylar end. The zygote actually forms from fertilization, and the assertion explains the general process rather than being directly related to the specific micropylar location.

Quick Tip
In angiosperms, the zygote develops into a heart-shaped proembryo, but the micropylar end refers to the fertilization site, not the development origin.

---

14. 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.

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

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

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

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

Correct Answer: (A)

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

Solution: In eukaryotes, primary RNA transcripts indeed contain both exons (coding regions) and introns (non-coding regions).

The assertion that primary transcripts undergo splicing to remove the introns is true, and the reason correctly explains that the introns are removed because they are non-functional for protein coding.

Both the assertion and reason are true and the reason directly explains the assertion.

Quick Tip
In eukaryotic cells, splicing removes non-functional introns to ensure the correct formation of mature mRNA for translation.

---

15. Assertion (A): The stirrer facilitates the even mixing of oxygen availability in a bioreactor. **Reason (R):** Stirred-tank bioreactors generally have a flat base.

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

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

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

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

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

Solution: The assertion is correct as the stirrer in a bioreactor is used to mix the medium, ensuring an even distribution of oxygen for microbial growth.

However, the reason is incorrect as stirred-tank bioreactors typically have a cylindrical base rather than a flat one. The base shape doesn't directly explain the stirrer's function.

The assertion is true, but the reason does not properly explain the assertion.

Quick Tip
In bioreactors, efficient mixing is essential for uniform oxygen distribution, which supports optimal microbial growth.

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.

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

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

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

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

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

Solution: The assertion is correct because chronic alcohol consumption can result in cirrhosis, which is liver scarring due to prolonged damage.

The reason is also valid, as alcohol addiction can significantly affect the family, causing both mental and financial strain.

However, the reason does not directly explain cirrhosis; it pertains to the impact on the family, not the liver itself. Therefore, the reason does not provide an explanation for the assertion.

Quick Tip
Chronic alcohol consumption can lead to irreversible liver damage, causing cirrhosis, while also affecting the emotional and financial stability of the family.

SECTION B

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

Solution:

Humus is the dark, organic material formed during the decomposition process in soil. The key features of humus are:

1. Humus is a rich source of essential nutrients such as nitrogen, phosphorus, and sulfur, which are crucial for plant growth.
2. It enhances the soil's water retention and aeration, which supports healthy root development.
3. Humus improves soil structure by making it more porous, aiding in better drainage.
4. It plays a vital role in maintaining soil fertility and pH stability, acting as a buffer against extreme fluctuations.
5. The process of humus decomposition is slow but important for recycling organic matter and facilitating nutrient cycling.
6. Humus increases biological activity in the soil, fostering a thriving community of microorganisms and beneficial soil fauna.

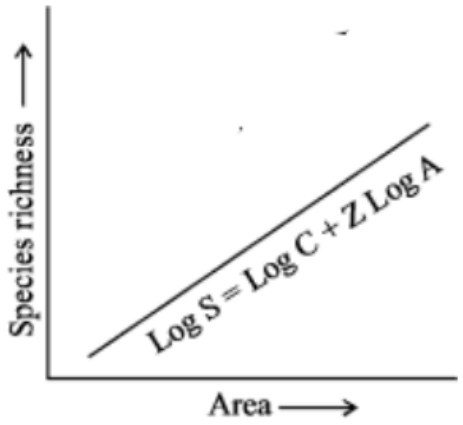
Quick Tip
Humus is vital for maintaining soil health and fertility, and it supports the long-term sustainability of ecosystems by promoting nutrient cycling.

OR

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

Solution: On a log-log scale, the relationship between species richness and area can be represented by the following graph:

1. The x-axis represents the area (on a log scale), while the y-axis represents species richness (also on a log scale).
2. The general trend shows that as the area increases, species richness tends to increase as well, following a power law.
3. The curve typically demonstrates a positive correlation, with a steep slope at the beginning of the area increase, which then levels off as the area continues to grow.



Quick Tip
On a log-log scale, the relationship between area and species richness typically follows a power law, indicating that larger areas tend to support more species.

---

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

Solution:

The species-area relationship on a logarithmic scale is expressed by the following equation:

$$\log(S) = z \cdot \log(A) + c$$

where:

1. S represents species richness,
2. A represents the area,
3. z is the slope of the curve (the species-area exponent), and
4. c is a constant.

Quick Tip
The species-area relationship is key to understanding biodiversity patterns in ecosystems, and this equation helps quantify how species richness varies with area.

---

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

Solution: A vaccine is a biological substance that provides active acquired immunity against a specific infectious disease. It generally contains weakened or inactivated forms of the microorganism, its toxins, or one of its surface proteins.

Basis of Action:

1. When administered, a vaccine prompts the immune system to recognize and prepare to combat the pathogen if encountered in the future.
2. In response to the vaccine, the immune system produces antibodies that ”remember” the pathogen, allowing for a faster immune response if the body is exposed to the same pathogen later.
3. This process, called immunization, helps prevent future infections by providing ”memory” immunity.

Quick Tip
Vaccines are a powerful public health tool for preventing the spread of infectious diseases by ”training” the immune system to recognize harmful pathogens.

---

19. State the procedure followed in the technique of amniocentesis. List any two advantages of this technique.

Solution: Amniocentesis is a procedure used to collect a sample of amniotic fluid for testing during pregnancy. The steps involved are:

1. A needle is inserted through the abdomen and into the uterus to collect a small amount of amniotic fluid, which contains fetal cells.
2. The fluid is then sent to a laboratory for analysis to identify genetic conditions or other potential abnormalities in the fetus.

Advantages:

1. It aids in identifying genetic disorders such as Down’s syndrome, cystic fibrosis, and other chromosomal abnormalities.
2. It can also detect infections, neural tube defects, and other conditions that could impact the health of the fetus.

Quick Tip

Amniocentesis is an important diagnostic tool in prenatal care, though it does carry some risks, such as miscarriage, and is usually performed when there are medical indications.

---

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

$$\text{mRNA } 5'\text{–}UCAUUACACCGAUUCUUUUAAAAGA\text{–}3'$$

(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: The given mRNA sequence has the following codons:

UCA UUA CAC GAA UCU UUU AAA GAA

If 'U' is substituted by 'C' at the 5th codon, the new sequence will be:

UCA UUA CAC GAA C(U)U UUU AAA GAA

From the above sequence, the number of amino acids will be 8 since there are 8 codons that code for amino acids.

(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: If in the fourth codon, 'C' is replaced with 'U', the new sequence becomes:

UCA UUA UUA GAA UCU UUU AAA GAA

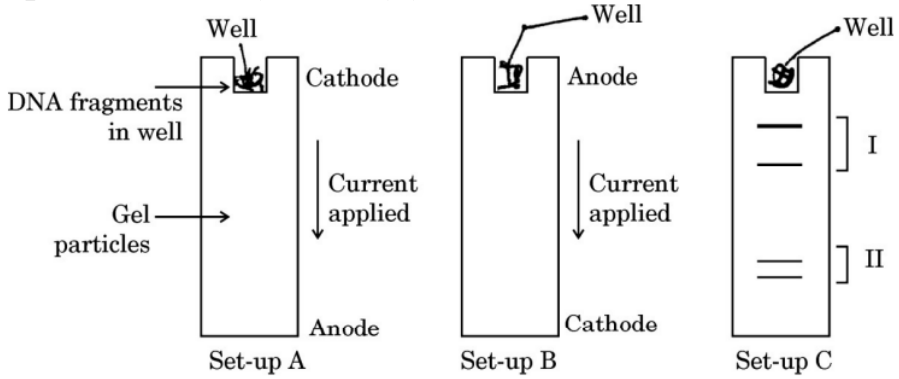
The new codon is 'UUA', which still codes for an amino acid. The sequence will still produce 8 amino acids.

Quick Tip

The number of amino acids is determined by the number of codons, and a change in one codon (like substituting a 'C' for a 'U') can still code for an amino acid if the new codon is valid.

21. 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? Justify your answer.



Solution:

In Set-up A, the DNA fragments will be separated.

The gel matrix, along with the applied current, generates an electric field that separates DNA fragments according to their size. Smaller fragments move more quickly towards the anode, while larger fragments move at a slower pace.

Quick Tip
Electrophoresis separates charged particles based on their size and charge using an electric field. Smaller DNA fragments travel faster through the gel.

---

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

Solution: In Set-up C, the bands at position I correspond to longer DNA fragments, while the bands at position II correspond to shorter DNA fragments.

Longer DNA fragments move more slowly through the gel matrix because of their larger size, so they form bands closer to the well at position I.

Quick Tip
In gel electrophoresis, longer DNA fragments travel more slowly and therefore appear closer to the well, while shorter fragments migrate farther.

SECTION C

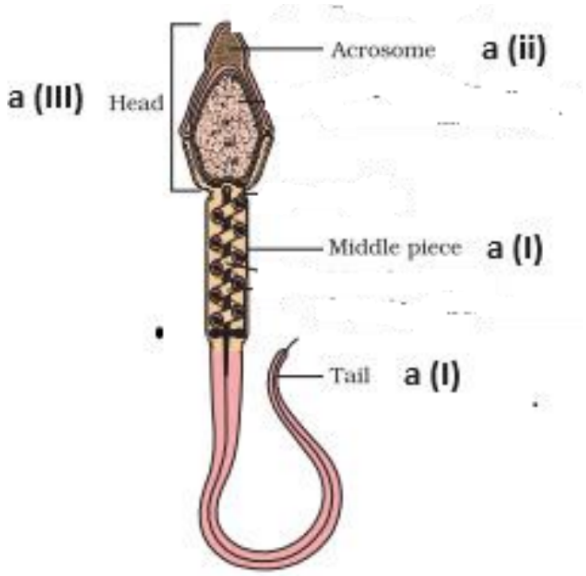
22. (a) Draw a diagram of a human sperm. Label the following parts:

(i) Which helps in the motility of the sperm.

(ii) Which helps in penetrating through the corona radiata and zona pellucida.

(iii) Which enters into the cytoplasm of the human egg.

Solution:



Explanation of labeled parts:

(i) Tail (Flagellum) - Responsible for movement

The tail, also known as the flagellum, enables the sperm to propel forward.

It moves in a whip-like motion, allowing the sperm to navigate through the female reproductive tract to reach the egg.

(ii) Acrosome - Aids in penetration

The acrosome is situated at the tip of the sperm's head.

It contains digestive enzymes like hyaluronidase and acrosin, which help break down the

egg's protective layers, such as the corona radiata and zona pellucida, facilitating fertilization.

(iii) Head - Enters the egg's cytoplasm

The sperm head contains the nucleus, which holds the genetic material (haploid chromosomes).

During fertilization, the head fuses with the egg's plasma membrane and releases its genetic material, resulting in the formation of a zygote.

Quick Tip
The acrosome contains enzymes like hyaluronidase, which help the sperm penetrate the egg's protective layers during fertilization.

---

22. (b) Mention how polyspermy is prevented during the course of fertilization in humans.

Solution: Polyspermy, the fertilization of an egg by multiple sperm, is prevented by the following mechanisms:

1. After the first sperm fuses with the egg, the egg's membrane undergoes a change that prevents other sperm from fusing with it.

2. A cortical reaction occurs, which causes the release of enzymes that alter the zona pellucida, making it impenetrable to additional sperm.

Quick Tip
Polyspermy is prevented through mechanisms that modify the egg's membrane and zona pellucida to ensure only one sperm fertilizes the egg.

---

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

Solution: 1. Cow dung is rich in organic matter and microorganisms, making it a more efficient source for biogas production.

2. It is easier to handle and process cow dung compared to domestic sewage, which may

contain chemicals and non-organic substances that could interfere with the biogas production process.

Quick Tip
Cow dung is a preferred substrate for biogas production due to its high organic content and the presence of microorganisms that aid in the fermentation process.

---

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

Solution: The unspent slurry produced by a biogas plant, often referred to as digestate, contains valuable organic matter and nutrients that make it an excellent fertilizer for crops. This slurry is the residual solid material left after biogas production, and it is rich in essential nutrients such as nitrogen, phosphorus, and potassium, which are crucial for plant growth.

1. Organic Matter Content:

The slurry is primarily composed of decomposed organic material from the input waste, which helps improve soil structure, enhancing its ability to retain moisture and improve aeration. These properties support healthier root development and increase soil productivity.

2. Nutrient Enrichment:

The presence of nitrogen, phosphorus, and potassium, as well as trace elements, in the unspent slurry makes it an ideal fertilizer. These nutrients are vital for the growth of crops and are often required in large quantities, making the slurry a sustainable alternative to synthetic fertilizers.

3. Environmental Benefits:

Using the unspent slurry as fertilizer reduces the need for chemical fertilizers, which can have adverse environmental impacts such as nutrient runoff, soil degradation, and pollution. Additionally, it helps in recycling organic waste, promoting a circular economy approach. Thus, the unspent slurry from a biogas plant not only serves as an effective fertilizer but also contributes to sustainable agricultural practices by enhancing soil health and reducing reliance on chemical fertilizers.

Quick Tip

Biogas plants not only generate renewable energy but also provide valuable by-products like fertilizer, which plays a key role in promoting sustainable agriculture.

OR

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

(i) Myocardial infarction

(ii) High blood cholesterol level

(iii) Organ transplantation

Solution:

- (i) **Streptokinase** is used to treat myocardial infarction (heart attack) and is derived from **Streptococcus bacteria**.
- (ii) **Statins** are used to lower high blood cholesterol levels and are produced by fungi like **Aspergillus terreus**.
- (iii) **Cyclosporine** is used in organ transplantation to prevent rejection and is derived from the fungus **Tolypocladium inflatum**.

Quick Tip

Bioactive molecules like Streptokinase, Statins, and Cyclosporine are important in treating critical conditions and have revolutionized medical treatments.

---

24. 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:

For cross (a): The offspring show both violet and white flowers, which indicates that the violet parent is heterozygous (Vv) and the white parent is homozygous recessive (vv).

The axial flower phenotype suggests that both parents must have at least one dominant allele for flower position, meaning both are either homozygous (AA) or heterozygous (Aa).

Therefore, the genotypes of the parents are:

Violet, axial: VvAa

White, axial: vvAA

For cross (b):

The presence of both axial and terminal flowers in the offspring implies that the violet, axial parent is heterozygous for both traits (VvAa).

The white, terminal parent must be homozygous recessive for both traits (vvaa). Therefore,

the parental genotypes are:

Violet, axial: VvAa

White, terminal: vvaa

For cross (c):

The offspring consist of both violet axial and white axial plants, suggesting that the violet, axial parents are heterozygous for both traits (VvAa).

The genotypes of the parents in this cross are:

Violet, axial: VvAa

Violet, axial: VvAa

Quick Tip
In Mendelian genetics, analyzing phenotypic ratios and their genetic origins helps determine the genotypes of the parents.

---

25. (a) Mention the advantages of 'ART'.

Solution: Assisted Reproductive Technology (ART) offers several benefits:

It assists couples facing infertility issues by utilizing techniques like in-vitro fertilization (IVF) and intrauterine insemination (IUI) to help them conceive.

ART enables genetic testing of embryos, increasing the likelihood of healthy pregnancies.

It supports fertility preservation for individuals with medical conditions, such as cancer or age-related fertility decline, that may impact their reproductive health.

ART provides opportunities for single women and same-sex couples to have biological children.

It helps overcome reproductive challenges caused by male or female infertility.

Quick Tip
ART has transformed reproductive medicine by offering practical solutions to infertility, enabling many individuals and couples to achieve parenthood.

---

25. (b) Explain the 'ICSI' and 'AI' methods of assisted reproductive technologies.

Solution:

ICSI (Intracytoplasmic Sperm Injection):

ICSI is a type of in-vitro fertilization (IVF) in which a single sperm is injected directly into an egg to achieve fertilization.

This method is commonly used for male infertility, especially in cases of low sperm count or poor sperm motility.

AI (Artificial Insemination):

Artificial insemination involves introducing sperm into a woman's reproductive system by means other than sexual intercourse.

It is used when a male has low sperm count, motility issues, or other fertility problems.

Intrauterine insemination (IUI) is a common type of AI, where sperm is directly placed into the uterus.

Quick Tip
ICSI is particularly beneficial for men with severe male factor infertility, while AI helps couples with unexplained infertility or male fertility issues.

---

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

Solution: The bacterium commonly used in biotechnology to develop genetically modified (GM) cotton resistant to bollworm infestations is Bacillus thuringiensis (Bt).

Bacillus thuringiensis produces a protein known as Cry protein, which is toxic to certain pests, such as the cotton bollworm, but is harmless to humans, animals, and beneficial insects.

The incorporation of Bt in GM crops like cotton reduces the need for chemical pesticides, benefiting both the environment and farmers by lowering pesticide-related expenses.

Quick Tip

Bacillus thuringiensis (Bt) acts as a natural insecticide in genetically modified crops, offering sustainable pest control without the harmful effects of chemical pesticides.

---

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

Solution: GM cotton is engineered to produce **Bacillus thuringiensis** (Bt) proteins, specifically the Cry proteins, which are toxic to specific pests like the cotton bollworm. Here's how the mechanism works:

1. The cotton plants express the Bt protein in their tissues. When a bollworm feeds on the cotton, it ingests the Cry protein.

2. The Cry protein is activated in the alkaline environment of the insect's gut and binds to receptors in the gut wall, causing a disruption in the digestive system.

3. This leads to the insect's inability to digest food, causing it to stop feeding and ultimately die.

4. This built-in protection reduces the need for chemical insecticides, providing an environmentally friendly and cost-effective solution to pest control.

Quick Tip

Bt cotton is an example of an environmentally sustainable solution to pest control, as it uses the plant's own defenses to protect against harmful insects, reducing pesticide use.

---

27. Describe the mutualistic relationship that exists between the Mediterranean orchid Ophrys and a bee species.

Solution: The Mediterranean orchid Ophrys forms a mutualistic relationship with male bees of certain species. Here's how the interaction works:

The Ophrys flower closely resembles the appearance and scent of a female bee, attracting male bees that mistake it for a potential mate.

As the male bee attempts to mate with the flower, it inadvertently collects pollen from the

flower's anthers.

When the bee tries to mate with another flower, it transfers the pollen, thereby pollinating the orchid.

While the bee does not receive any direct benefit, its behavior aids in its reproductive strategy, and the orchid benefits from successful pollination.

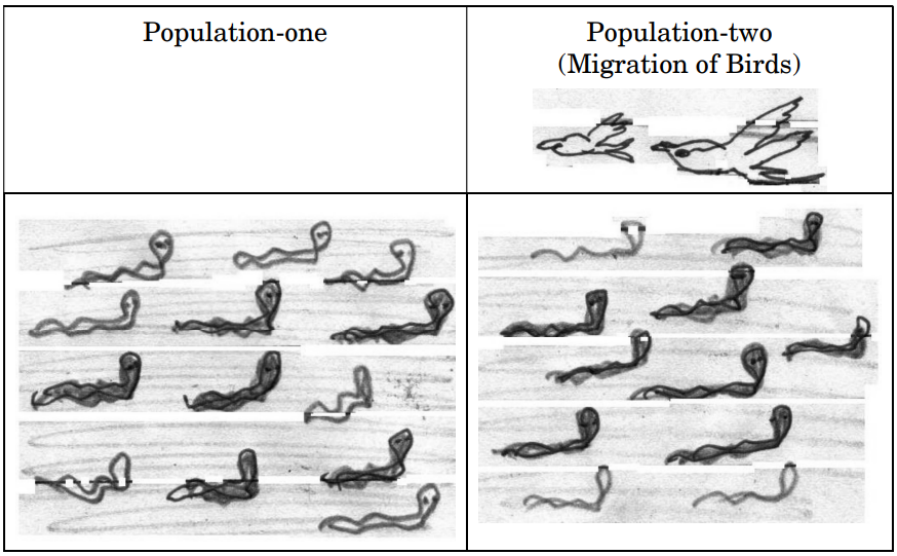
Thus, the relationship is mutualistic, as the orchid receives pollination, while the bee's mating behavior plays a role in its reproductive cycle.

Quick Tip
Mutualistic relationships, like that between orchids and bees, can lead to evolutionary adaptations, where plants evolve traits to attract specific pollinators for effective reproduction.

---

28. 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 that the frequency of the recessive trait (aa) in population-one is 9%, we can

use Hardy-Weinberg equilibrium to calculate the frequencies of the homozygous dominant (AA) and heterozygous dominant (Aa) genotypes.

First, we find the frequency of the recessive allele (a) using $q = \sqrt{0.09} = 0.3$.

The frequency of the dominant allele (A) is then calculated as $p = 1 - q = 1 - 0.3 = 0.7$.

The frequency of homozygous dominant (AA) is $p^2 = (0.7)^2 = 0.49$.

The frequency of heterozygous dominant (Aa) is $2pq = 2(0.7)(0.3) = 0.42$.

Therefore, the genotype frequencies are: Homozygous dominant (AA): 49% Heterozygous dominant (Aa): 42%

Quick Tip
The Hardy-Weinberg equilibrium principle allows the calculation of genotype frequencies based on allele frequencies, providing insights into genetic variation in populations.

---

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

Solution: The mechanism of evolution that must have operated is natural selection. The change in the snake population can be attributed to selective pressures in the environment. The brown sand likely provided camouflage for brown-colored snakes, offering them a survival advantage over grey snakes, leading to an increase in the frequency of brown-colored (dominant) snakes in the population. Additionally, migration and genetic drift might have contributed to the change in allele frequencies.

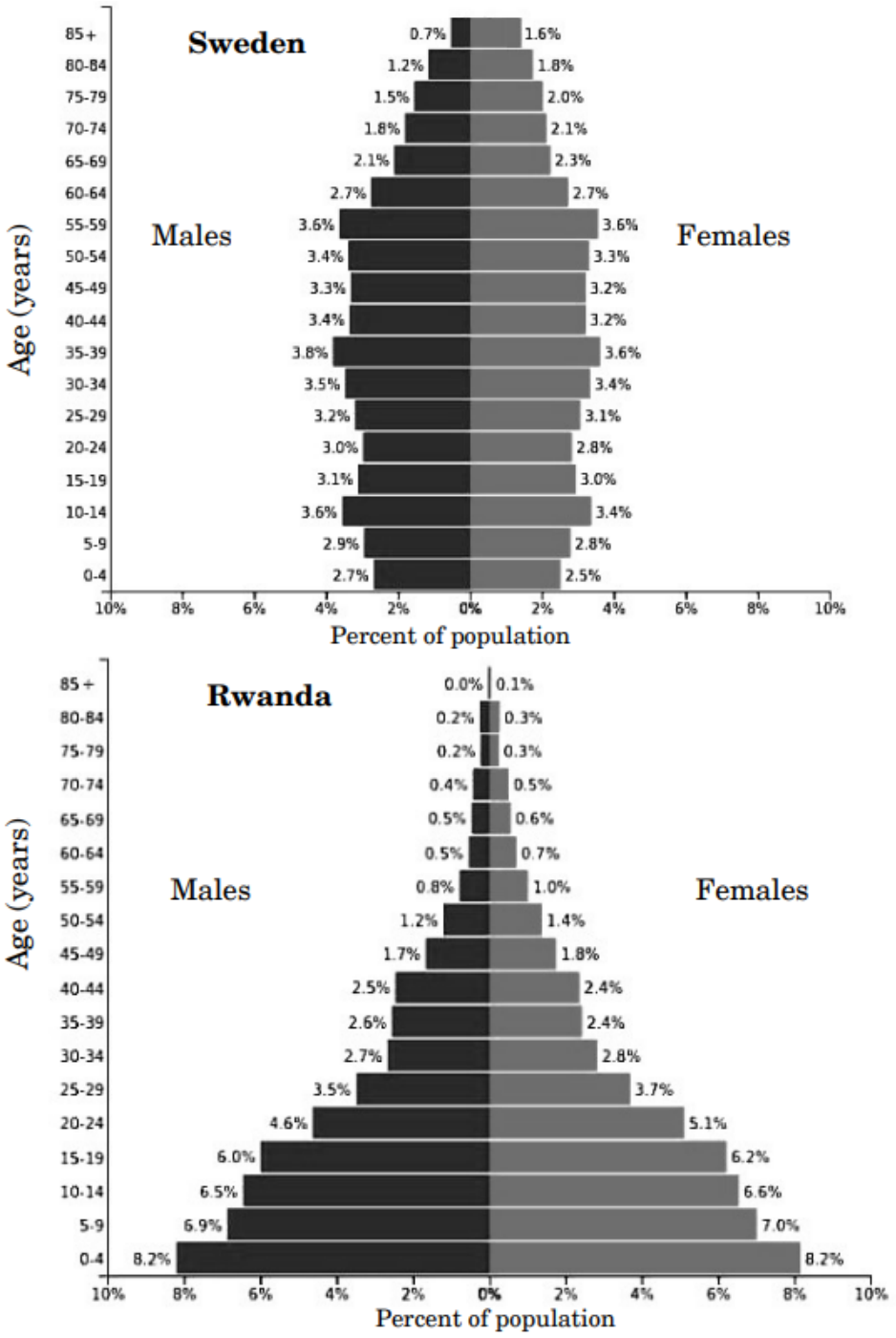
Quick Tip
Natural selection leads to the adaptation of populations over time as individuals with traits that are favorable for survival are more likely to reproduce and pass on those traits.

SECTION D

Questions no. 29 and 30 are case-based questions. Each question has 3 sub-questions with internal choice in one sub-question

29. 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: Rwanda's age pyramid features a very wide base, indicating a high birth rate, which is characteristic of developing countries. This suggests that a significant portion of the population is in the younger age groups (0-14 years), with the numbers gradually decreasing as age increases.

The pyramid data shows that the proportion of people in younger age groups, such as 0-4 years and 5-9 years, is considerably higher compared to older age groups. For instance, in Rwanda, the age group 0-4 years comprises 8.2% of the male population and 8.2% of the

female population.

This wide base points to a youthful population with a high fertility rate.

Quick Tip
A broad base in an age pyramid signifies a high birth rate and a large proportion of the population in younger age groups, typically indicating rapid population growth.

---

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

Solution: The similar width of Sweden's age pyramid at both the base and the apex suggests that the country has a stable population with slow growth. This is typical of developed nations with low birth and death rates, where the population is more evenly spread across various age groups.

In Sweden, the proportion of individuals in younger age groups (e.g., 0-4 years, 5-9 years) is relatively smaller compared to countries like Rwanda, and the older age groups (60-64 years and 65+) make up a comparable percentage of the population.

This distribution indicates that Sweden's population is gradually aging, with a steady rate of younger individuals replacing the older generation, contributing to a stable, non-expanding population.

Quick Tip
An age pyramid with a similar width at both the base and the apex indicates a stable population, which is characteristic of developed countries with low birth and death rates.

---

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

Solution: The age pyramid for Sweden is classified as a stationary pyramid. In this type of pyramid, the population is evenly distributed across different age groups, which indicates a stable or zero-growth population. This pattern suggests that birth and death rates are in balance, and the population is neither expanding nor shrinking significantly.

The stationary pyramid shape is characterized by similar proportions of people in each age group, from the youngest to the oldest. This reflects a demographic equilibrium where the number of births is roughly equal to the number of deaths, leading to a population that remains stable over time.

Such a population typically has low fertility rates and high life expectancy, which are common characteristics of developed countries like Sweden. In these countries, healthcare improvements, family planning, and social support systems contribute to lower birth rates and higher survival rates across all age groups.

Quick Tip
A stationary age pyramid reflects a stable population with low fertility rates and high life expectancy, commonly found in developed nations.

OR

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

Solution: The type of age pyramid shown for Rwanda is a **expansive pyramid**. This pyramid has a very broad base, indicating a high birth rate and a youthful population, which is typical of developing countries with high fertility rates and lower life expectancy.

Quick Tip
An expansive age pyramid is characteristic of developing countries with high birth rates and a younger population, often associated with rapid population growth.

---

30. 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. BamH I is one such restriction enzyme which binds at the recognition sequence

5' G-G-A-T-T-C-C 3' and cleaves this sequence between G and G on each strand, whereas Alu I binds at the recognition sequence

5' A-G-C-T 3' and cleaves these sequences between G and C on each strand.

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

$$\begin{array}{ll} 5' & C-C-G-T-A-G-C-T-A-T-C-A-G-C-T-G-G \quad 3' \\ & \quad | \quad | \quad | \quad | \quad | \quad | \quad | \quad | \quad | \quad | \quad | \quad | \quad | \quad | \quad | \quad | \quad | \\ 3' & G-G-C-A-T-C-G-A-T-A-G-T-C-G-A-C-C \quad 5' \end{array}$$

Solution: The given DNA strand is:

$$\begin{array}{ll} 5' & C-C-G-T-A-G-C-T-A-T-C-A-G-C-T-G-G \quad 3' \\ & \quad | \quad | \quad | \quad | \quad | \quad | \quad | \quad | \quad | \quad | \quad | \quad | \quad | \quad | \quad | \quad | \quad | \\ 3' & G-G-C-A-T-C-G-A-T-A-G-T-C-G-A-C-C \quad 5' \end{array}$$

When Alu I cuts this sequence at the recognition sequence 5' A-G-C-T 3', the DNA strand is cleaved between G and C on each strand. The cuts will result in two fragments. The sequence of each fragment is as follows:

First fragment:

$$5'\,\text{C-C-G-T-A-G-C-T}\,3'$$

Second fragment:

$$5'\,\text{A-G-C-T-A-T-C-G-A-C-T-G-C-T-G-G}\,3'$$

Thus, 2 DNA fragments would be formed.

Quick Tip
Restriction enzymes like Alu I cut the DNA at specific sequences, creating fragments with sticky ends that can be used for cloning or recombinant DNA technologies.

---

30. (b) Which one of the two restriction enzymes BamH I or Alu I will preferably be used on the same given DNA strand to make a recombinant DNA molecule and why?

Solution: BamH I would preferably be used on the given DNA strand to make a recombinant DNA molecule. The reason is that BamH I creates sticky ends by cutting between G and G, which can facilitate the insertion of foreign DNA into a vector.
Sticky ends are useful in recombinant DNA technology as they allow for the ligation of complementary DNA fragments with high specificity.
In contrast, Alu I produces blunt ends, which are less efficient for ligating DNA into vectors compared to sticky ends.

Quick Tip
Sticky ends created by BamH I are ideal for the ligation of foreign DNA into vectors, while blunt ends created by Alu I are less efficient for recombination.

---

30. (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 recognized by a restriction endonuclease.
Solution: Restriction enzymes act at specific sequences of nucleotides called **restriction sites**. The restriction enzyme binds to these sequences and cuts both strands of the DNA, usually between specific nucleotides. For example, the restriction enzyme BamH I recognizes the sequence

$$5'\,\text{G-G-A-T-T-C-C}\,3'$$

and cuts between the G and G on each strand. Similarly, Alu I recognizes the sequence

$$5'\,\text{A-G-C-T}\,3'$$

and cuts between G and C on each strand.
The process is called **restriction digestion** or **restriction enzyme cleavage**.

Quick Tip
Restriction enzymes recognize specific DNA sequences, and by cutting the DNA at these sites, they allow for precise manipulation of DNA in molecular biology experiments.

OR

30. (c) Write the specific sequence of DNA segment recognized by the restriction endonuclease EcoRI.

Solution: EcoRI is a commonly used restriction endonuclease that recognizes the specific palindromic DNA sequence:

$$5'\,\text{G-A-A-T-T-C}\,3'$$

It cuts between the G and A on each strand, resulting in sticky ends with overhanging bases. These overhangs allow the DNA fragments to easily pair with complementary sequences, making EcoRI invaluable in cloning and recombinant DNA technology.

The EcoRI recognition site is highly specific, meaning only DNA fragments containing this sequence will be cleaved by the enzyme.

The sticky ends generated by EcoRI are particularly advantageous in molecular cloning, as they facilitate the ligation of DNA fragments with matching sticky ends.

Quick Tip
EcoRI is one of the most widely used restriction enzymes in molecular biology. Its ability to generate sticky ends makes it essential for the efficient recombination of DNA fragments in genetic engineering.

SECTION E

31. (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 involves both humans and Anopheles mosquitoes. The key stages in the life cycle are as follows:

1. Infection of the human host: When a female Anopheles mosquito bites an infected person, it injects Plasmodium sporozoites into the bloodstream. These sporozoites travel to the liver, where they mature and reproduce.

2. Liver stage: Inside the liver, the sporozoites undergo asexual reproduction, forming merozoites. These merozoites are released into the bloodstream.
3. Blood stage: The merozoites invade red blood cells, where they continue to reproduce asexually. This causes the red blood cells to burst, releasing more merozoites into the bloodstream, which can infect additional red blood cells.
4. Transmission to the mosquito: Some merozoites transform into gametocytes, which are then ingested by another Anopheles mosquito when it bites an infected person. Within the mosquito's gut, the gametocytes fuse to form zygotes, which mature into sporozoites that travel to the salivary glands, ready to be transmitted to a new human host.

Quick Tip
The Plasmodium life cycle alternates between human and mosquito hosts, involving both asexual and sexual reproduction stages, which makes its transmission complex.

---

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

Solution: The two key events of the **Plasmodium** life cycle that occur within the female **Anopheles** body are:
1. The fusion of male and female gametocytes to form a zygote, which develops into an ookinete.
2. The ookinete penetrates the mosquito's gut lining and forms an oocyst, where it undergoes division to produce sporozoites. These sporozoites travel to the salivary glands of the mosquito, ready to infect a new human host.

Quick Tip
The sexual cycle of **Plasmodium** occurs in the mosquito host, leading to the production of sporozoites that are essential for transmission to the human host.

OR

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

Solution: The two main differences between malignant and benign tumors are:

1. Malignant tumors are cancerous and can invade nearby tissues and spread to other parts of the body through the blood or lymphatic system, whereas benign tumors are non-cancerous and do not spread to other parts of the body.

2. Malignant tumors grow uncontrollably and can metastasize, while benign tumors grow slowly and are generally encapsulated, making them easier to remove surgically.

Quick Tip
Malignant tumors are more dangerous because they spread and invade other tissues, while benign tumors are typically localized and non-threatening.

---

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

Solution: Three common diagnostic techniques for detecting cancer are:

1. Biopsy: A sample of tissue is removed from the suspected tumor and examined under a microscope to check for cancer cells.

2. Imaging techniques: Methods such as X-rays, CT scans, and MRIs are used to visualize tumors inside the body.

3. Blood tests: Some cancers produce specific markers that can be detected in the blood, helping in diagnosis and monitoring the progress of treatment.

Quick Tip
Early detection through various diagnostic techniques improves the chances of successful cancer treatment.

---

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

Solution: Four devices that flowering plants have developed to encourage cross-pollination include:

1. Colorful flowers: Brightly colored flowers attract pollinators such as bees, butterflies, and birds.

2. Scent: Flowers often release scents that attract pollinators, ensuring they visit and transfer pollen between flowers.
3. Nectar: The presence of nectar in flowers encourages pollinators to visit flowers and aids in the transfer of pollen.
4. Specialized floral structures: Some plants have specialized mechanisms, like long tubes or sticky pollen, which ensure that pollen is transferred effectively from one flower to another.

Quick Tip
Cross-pollination helps maintain genetic diversity, which is important for the health and survival of plant species.

---

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

Solution: Plants discourage self-pollination to promote genetic diversity. Cross-pollination allows for the mixing of genetic material, which helps in producing offspring with a broader genetic pool, making them more resilient to diseases and environmental changes.

Quick Tip
Self-pollination can limit genetic diversity, while cross-pollination promotes healthier and more adaptable offspring.

OR

32. (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

(ii) Luteal phase/secretory phase

(iii) Menstrual phase

Solution: The menstrual cycle involves several phases that are regulated by hormones from the pituitary and ovaries. The phases are:

1. Follicular phase (Proliferative phase):

During this phase, the pituitary hormone FSH (follicle-stimulating hormone) stimulates the growth of ovarian follicles.
The growing follicles release estrogen, which thickens the endometrium in preparation for implantation.
2. Luteal phase (Secretory phase):
After ovulation, the ruptured follicle forms the corpus luteum, which secretes progesterone.
Progesterone further thickens the endometrium and prepares it for potential pregnancy.
3. Menstrual phase:
If fertilization does not occur, the corpus luteum degenerates, leading to a drop in progesterone levels.
This causes the endometrial lining to break down and shed, leading to menstruation.

Quick Tip
The menstrual cycle is regulated by the interplay between pituitary and ovarian hormones, ensuring proper reproductive function.

---

33. (a) "The influence of both the alleles in a heterozygous state is clearly expressed in codominance." Explain with the help of inheritance of ABO blood group in humans.
Solution: In the case of ABO blood groups, the alleles A and B exhibit codominance. This means that when both alleles are present in a heterozygous individual, both are fully expressed.
For example:
Genotype AB results in a person having both A and B antigens on the surface of their red blood cells.
This is in contrast to dominant-recessive inheritance, where one allele is completely dominant over the other.
The ABO blood group system is controlled by three alleles: A, B, and O.
A and B alleles are dominant, while O is recessive.
Individuals with genotype AO or AA have blood group A, BO or BB have blood group B, AB has blood group AB, and OO has blood group O.

Quick Tip

Codominance results in both alleles being expressed simultaneously in a heterozygous individual, as seen in the ABO blood group inheritance pattern.

---

33. (b) A group of genes are regulated and expressed together as a unit in lac operon. (i) Explain the mechanism of switching 'on' of the structural genes of lac operon.

Solution: The **lac operon** is regulated by the presence of lactose. When lactose is available, it binds to the repressor protein, causing a conformational change that prevents the repressor from binding to the operator. This allows RNA polymerase to bind to the promoter region and transcribe the structural genes, which are involved in the breakdown of lactose.

Quick Tip

The presence of lactose induces the transcription of the **lac operon** genes by inactivating the repressor protein, allowing the production of enzymes for lactose metabolism.

---

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

Solution: The regulation of the **lac operon** is considered negatively regulated because the repressor protein normally binds to the operator region of the operon and prevents transcription. The presence of lactose inactivates the repressor, thus allowing transcription to occur. Without lactose, the repressor remains bound to the operator, blocking the operon.

Quick Tip

In negative regulation, the default state of the operon is "off," and the presence of an inducer like lactose removes the repression to allow gene expression.
