CBSE 12 Biology (57/3/1) 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 part of the ovule that develops into protective coats of a seed after fertilization in a typical flowering plant is:

(A) embryo sac

(B) nucellus

(C) integuments

(D) megaspore

Correct Answer: (C) integuments.

Solution: - After fertilization, the **integuments** of the ovule transform into the seed coat, which acts as a protective barrier for the developing seed. - The seed coat prevents the seed from physical damage, microbial infections, and desiccation, ensuring the embryo's safety until conditions are suitable for germination. - The other parts of the ovule play specific roles in seed formation: - **Embryo sac**: Develops into the embryo, the young plant in the seed. - **Nucellus**: Provides nourishment to the growing embryo. - **Megaspore**: Forms the embryo sac, which houses the egg cell that gets fertilized by pollen.
The **integuments** of the ovule form the seed coat, safeguarding the seed during its dormancy.

Quick Tip

The seed coat plays a crucial role in protecting the embryo, ensuring its survival through adverse conditions, and promoting seed dormancy until environmental conditions are favorable for germination.

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2. A DNA fragment has 2000 nucleotides, out of which 140 are Adenine. How many bases does this DNA segment possess that have triple hydrogen bonds between them?

(A) 280

(B) 860

(C) 1720

(D) 1860

Correct Answer: (C) 1720.

Solution: 1. **Key Information**: - Adenine (A) pairs with Thymine (T) with two hydrogen bonds. - Cytosine (C) pairs with Guanine (G) with three hydrogen bonds. 2. **Number of A-T pairs**: - Given Adenine (A) = 140, hence Thymine (T) = 140. - Total A-T pairs = 140, contributing to 280 bases with two hydrogen bonds. 3. **Remaining Bases**: - Total bases = 2000. - Bases with triple bonds = Total bases - A-T bases.

$$\text{Bases with triple hydrogen bonds} = 2000 - 280 = \mathbf{1720}.$$

The DNA fragment has 1720 bases with triple hydrogen bonds.

Quick Tip

Remember: Cytosine-Guanine (C-G) pairs have three hydrogen bonds, while Adenine-Thymine (A-T) pairs have two.

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3. During the 1850s in the pre-industrialisation era in England, the expected effect of natural selection on the number of dark-winged moths as compared to white-winged moths was:

(A) more in number

(B) less in number

(C) both were equal in number

(D) both were less in number

Correct Answer: (B) less in number.

Solution: - In the pre-industrial era, the environment was unpolluted, and tree trunks were light-colored. - White-winged moths were camouflaged and thus less likely to be preyed upon by predators. - Dark-winged moths were easily spotted and eaten, making them less in number due to natural selection.

Dark-winged moths were less in number in the pre-industrial era.

Quick Tip

Natural selection favors traits that provide better survival in a given environment.

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4. In which one of the following floral plants are many embryos formed in the seeds without fertilisation of the egg cell?

(A) Black pepper

(B) Mustard

(C) Groundnut

(D) Citrus

Correct Answer: (D) Citrus.

Solution: - In Citrus, many embryos are formed through a process called polyembryony, where embryos develop from cells other than the zygote (e.g., nucellus or integuments). - This occurs without fertilization, making it an example of apomixis.
Citrus exhibits polyembryony, forming many embryos without fertilization.

Quick Tip

Polyembryony is a form of asexual reproduction that enhances seed viability.

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5. A Snapdragon plant bearing pink color flowers is crossed with a Snapdragon plant bearing white color flowers. The expected phenotypic percentage of the offspring is:

(A) 50% Red : 50% White

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

(C) 50% Pink : 50% White

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

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

Solution: Snapdragon flowers exhibit incomplete dominance. When a pink-flowered plant

(Rr) is crossed with a white-flowered plant (rr), the following genetic distribution is expected:

$$\text{Genotypes: } Rr : Rr : rr : rr.$$

- The phenotypic distribution is as follows: - 50- 50

The phenotypic ratio is 50

Quick Tip

Incomplete dominance results in intermediate phenotypes where the heterozygous individual shows a blending of both traits, like in Snapdragon flowers.

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6. In which of the given chromosomal disorders does the individual have tall stature with feminized character?

(A) Klinefelter's syndrome

(B) Down's syndrome

(C) Turner's syndrome

(D) Edwards' syndrome

Correct Answer: (A) Klinefelter's syndrome.

Solution: Klinefelter's syndrome is caused by the presence of an extra X chromosome (47, XXY). This genetic condition leads to the following features: - Taller than average height. - Feminized traits such as gynecomastia (development of breast tissue). - Decreased fertility and reduced testosterone levels.

Klinefelter's syndrome is characterized by tall stature and feminized features.

Quick Tip

Klinefelter's syndrome arises due to a genetic abnormality involving extra sex chromosomes, which affects physical and reproductive characteristics.

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7. S.L. Miller in 1953, to support the theory of chemical evolution, created conditions in the closed flask that included:

(A) CH_4, O_2, NH_3, H_2O vapor at 1800°C

(B) CH_4, H_2, NH_3, H_2O vapor at 800°C

(C) CH_4, CO_2, H_2, H_2O vapor at 1800°C

(D) CH_4, NH_4, SO_2, H_2O vapor at 800°C

Correct Answer: (B) CH_4, H_2, NH_3, H_2O vapor at 800°C.

Solution: S.L. Miller simulated early Earth's conditions by using a closed flask containing: - CH_4, H_2, NH_3, and H_2O vapor in a reducing atmosphere. - Electric sparks were used to mimic lightning, and a temperature of 800°C was maintained to simulate the extreme conditions of early Earth. - This experiment led to the formation of amino acids, providing support for the chemical evolution theory.
S.L. Miller used CH_4, H_2, NH_3, H_2O vapor at 800°C to simulate early Earth conditions.

Quick Tip

Miller's experiment demonstrated the possibility of abiotic synthesis of organic molecules, supporting the theory of chemical evolution.

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8. 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: - Initially, all DNA was labeled with ^{14}N (light nitrogen). - After six generations in ^{15}N (heavy nitrogen), the DNA exhibited two bands in the CsCl density gradient: - A hybrid

band ($^{14}N/^{15}N$) and - A heavy band ($^{15}N/^{15}N$). - The ratio of hybrid to heavy bands was 1 : 31, indicating the number of generations and the resulting DNA mix.
The ratio of hybrid to heavy bands is 1 : 31.

Quick Tip

Density gradient centrifugation helps distinguish DNA based on density differences, critical in DNA replication studies.

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9. Which disease is the patient suffering from who is showing symptoms such as sustained high fever (39°C to 40°C), stomach pain, constipation, headache, loss of appetite, and weakness?

(A) Pneumonia

(B) Malaria

(C) Typhoid

(D) Amoebiasis

Correct Answer: (C) Typhoid.

Solution: - Typhoid is caused by the bacterium Salmonella typhi. - Common symptoms include: - Sustained high fever (39°C to 40°C). - Stomach pain and constipation. - Headache, weakness, and loss of appetite. - Other diseases like pneumonia, malaria, and amoebiasis have distinct symptoms such as respiratory issues, chills, or diarrhea.
The disease is Typhoid, caused by Salmonella typhi.

Quick Tip

Maintaining good sanitation and hygiene can help prevent the spread of typhoid.

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10. Which native plasmid did Stanley Cohen and Herbert Boyer use for the construction of the first recombinant DNA?

(A) *Salmonella typhimurium*

(B) *Streptococcus pneumoniae*

(C) *Escherichia coli*

(D) *Haemophilus influenzae*

Correct Answer: (A) *Salmonella typhimurium*.

Solution: - Stanley Cohen and Herbert Boyer used the plasmid pSC101 from Salmonella typhimurium for the construction of the first recombinant DNA. - Plasmids are ideal for genetic engineering because: - They are small and easy to manipulate. - They can replicate independently within bacterial cells.
The plasmid from Salmonella typhimurium was used for the first recombinant DNA.

Quick Tip

Plasmids serve as important vectors in gene cloning and recombinant DNA technology.

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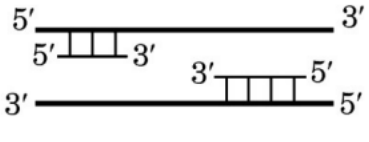
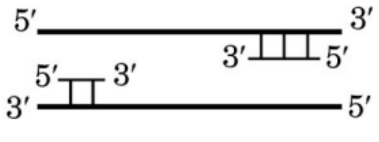
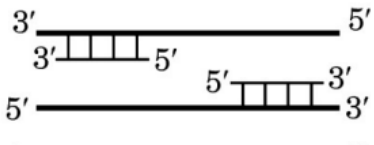
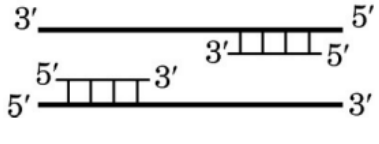
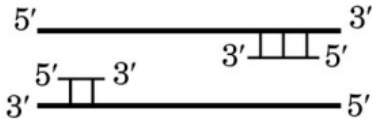
11. Which one of the following represents the correct annealing of primers to the DNA to be amplified in the PCR?

(A) 

(B) 

(C) 

(D) 

Correct Answer: (B) 

Solution: - In PCR (Polymerase Chain Reaction), primers are designed to anneal to the complementary strands of DNA in a 5’ to 3’ direction. - The primers must bind to the

template strand with their 3’ end aligning with the complementary strand’s 5’ end. - In this process, both primers are oriented in the 5’ to 3’ direction on the respective strands of the DNA.

Quick Tip

For PCR, ensure the primers are designed with complementary sequences and correctly oriented for proper DNA amplification.

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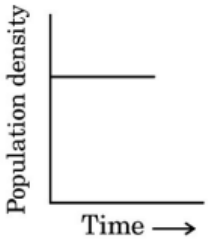
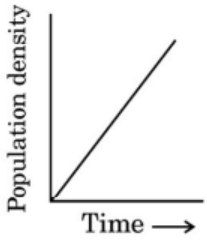
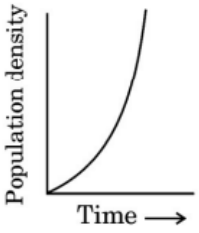
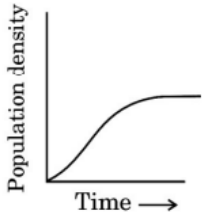
12. The population growth curve applicable for a population growing in a geometric fashion, when the resources are not limiting in the habitat will be:

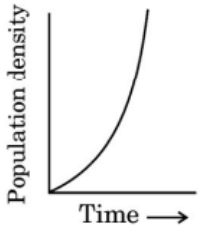
(A)


(B)


(C)


(D)


Correct Answer: (C)



Solution: - In geometric population growth, the population size increases rapidly without any resource limitations. - This type of growth is represented by an exponential growth curve initially, but over time, the growth rate slows as resources begin to limit population growth. - This transition is represented by a logarithmic growth curve (option C), where the growth rate gradually decreases as the population nears carrying capacity.
The geometric population growth curve is represented by a logarithmic growth curve (Option C).

Quick Tip

Logarithmic growth occurs when exponential growth slows down due to resource limitations, leading to a stabilized population.

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 (sD) 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): 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.

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

Solution: - Primary transcripts in eukaryotes (pre-mRNA) undergo splicing to remove non-coding introns, retaining the exons that code for the protein. - The reason why splicing happens is because introns do not contribute to the functional proteins and thus are discarded during the maturation of mRNA.
Both the Assertion and Reason are true, and Reason explains the Assertion correctly.

Quick Tip

Splicing ensures only the functional parts of the gene (exons) remain in the mature mRNA for translation.

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14. 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.
Correct Answer: (B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

Solution: - Chronic alcohol consumption can damage the liver leading to cirrhosis, a serious liver condition marked by scarring. - While alcohol addiction may contribute to mental and financial distress for the family, it does not directly cause cirrhosis.
Both Assertion and Reason are true, but Reason does not explain the Assertion correctly.

Quick Tip

Long-term alcohol use affects multiple body systems and contributes to several diseases, including cirrhosis.

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15. 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.

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

Solution: - The zygote, located at the micropylar end of the embryo sac, develops into an embryo in most angiosperms. - However, the statement regarding the heart-shaped embryo is not universally accurate as embryos can develop in several shapes and stages depending on the plant species.

Assertion is false, but Reason is true.

Quick Tip

Embryo development varies across species, with some angiosperms showing a different sequence of stages.

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

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

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

Solution: - Stirred-tank bioreactors contain stirrers to ensure uniform mixing and proper distribution of oxygen for optimal microbial growth. - However, stirred-tank bioreactors typically feature a curved base to facilitate mixing and avoid dead zones, contrary to the statement about flat bases.

The Assertion is true, but the Reason is false.

Quick Tip

Stirred-tank bioreactors are widely used in industrial applications for effective mixing and oxygen distribution.

Section B

17. Oral contraceptives are widely accepted for controlling the increasing rate of population. Name the two important components of oral contraceptives. Why is 'Saheli' considered a preferred contraceptive by women?

Solution:

1. Two key components of oral contraceptives:

- Progesterone

- Estrogen

2. Why 'Saheli' is preferred:

- Saheli is a non-steroidal oral contraceptive.

- It has fewer side effects compared to steroid-based contraceptives.

- Saheli is taken weekly, making it more convenient than daily pills.

Saheli is preferred due to its non-steroidal nature, convenience, and fewer side effects.

Quick Tip

Non-steroidal contraceptives like Saheli are a safer alternative to traditional hormonal contraceptives.

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

Solution:

1. Definition of Vaccine:

- A vaccine is a biological preparation containing inactivated or attenuated pathogens or their components that stimulate the immune system.

2. Basis of Action:

- When administered, a vaccine triggers an immune response by stimulating the production of antibodies.

- It induces immunological memory, protecting the body from future infections by the same pathogen.

Vaccines work by inducing an immune response and creating immunological memory.

Quick Tip

Vaccines are crucial in preventing infectious diseases and controlling pandemics.

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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:

$$\text{mRNA: } 5'\text{–}UCAUUAACCACGAUUCUUUAAAAAGA\text{–}3'$$

(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 codons are read in triplets, starting from the first codon:

$$UCA|UUA|ACC|ACG|AUU|CUU|UAA|AAA|GA$$

- A substitution at the 5th codon changes AUU to ACU, which still codes for the same amino acid (Threonine).

- The stop codon is at UAA, meaning 7 amino acids will be formed.

7 amino acids will be formed from the codons.

(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:

- Changing the 4th codon ACC to AUU introduces a premature stop codon AUU.

- Translation will stop at this codon, and no functional protein will be formed.

No amino acids will be formed due to the premature stop codon.

Quick Tip

Mutations in codons can lead to non-functional proteins or truncated polypeptides.

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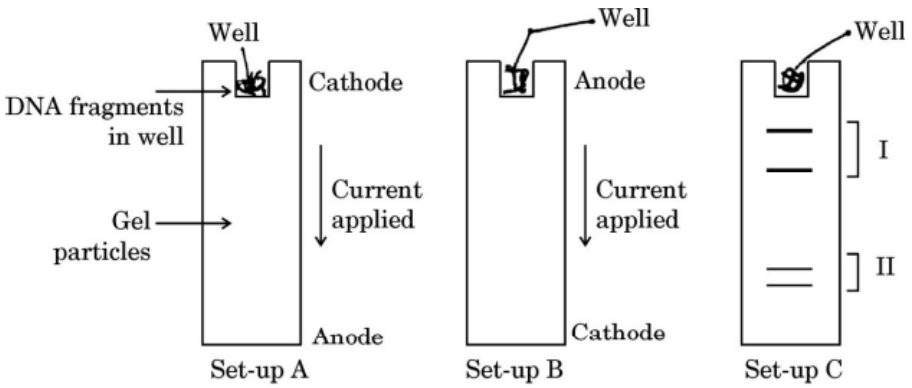
20. With reference to the set-ups (A, B, and C) given below, of the electrophoretic separation of a mixture of DNA fragments of varied lengths, answer the questions that follow:



(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:

- DNA fragments will separate in Set-up B because the electrodes are correctly aligned, allowing DNA to move towards the anode (positive electrode).
- In Set-up A, the electrodes are reversed, causing the DNA fragments to move in the wrong direction.

DNA fragments separate in Set-up B due to correct alignment of the electrodes.

Quick Tip

DNA fragments separate in gel electrophoresis based on size, with smaller fragments moving faster through the gel matrix. The correct set-up must have an electric field applied properly, ensuring migration from the negative to the positive electrode.

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

Solution:

- In Set-up C, the bands of longer DNA fragments are at position I.
- Larger DNA fragments move more slowly through the gel and therefore remain closer to the well (position I).

The bands of longer DNA fragments are at position I because they migrate slower through the gel.

Quick Tip

Smaller DNA fragments travel farther during gel electrophoresis due to lower resistance in the gel.

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

1. Humus is a dark organic material formed by the decomposition of plant and animal matter.
2. It is resistant to microbial action and decomposes slowly.
3. Humus serves as a reservoir of nutrients, releasing them gradually to support plant growth.
4. It enhances soil fertility and improves the soil's water retention capacity.

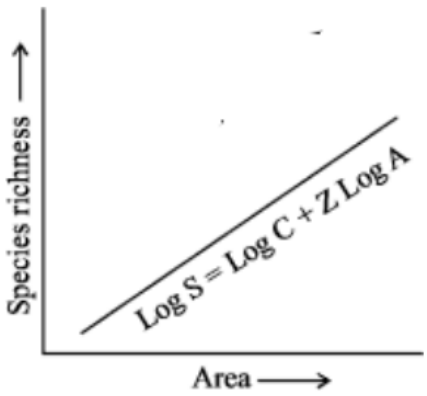
Humus plays a crucial role in maintaining soil health and supporting ecosystem productivity.

Quick Tip

Humus formation is essential for nutrient cycling in ecosystems, improving soil quality and sustaining plant life.

OR

(b)(i) Graphically represent the relationship between species richness and area on a log-log scale for bats and fishes. Solution: - The relationship is represented as a straight line on a log-log scale, showing a positive correlation between species richness and area.
- The graph will have separate lines for bats and fishes, each showing the relationship between area and species richness.



(ii) Write the equation for the relationship as on a logarithmic scale. Solution: The relationship between species richness (S) and area (A) is given by the equation:

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

Where: - S represents species richness - A represents the area - C is a constant - Z is the slope of the line (species-area relationship constant).
The equation is $\log S = \log C + Z \log A$.

Quick Tip

The species-area relationship is key to understanding biodiversity patterns across different habitats.

Section C

22. Draw a longitudinal section of pistil of a flower showing growth of the pollen tube. Label the part:

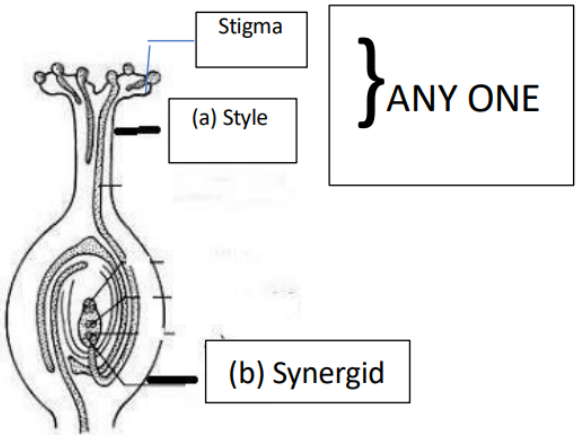
(a) Through which the pollen tube moves down.

(b) The cell wherein the pollen tube releases its contents.

Solution: - The pollen tube first grows through the style, which is the tissue connecting the stigma to the ovary. This allows the pollen to travel down towards the ovule for fertilization. - The pollen tube moves towards the micropylar end of the ovule, where it reaches the embryo sac. Upon arrival, the tube releases its contents (sperm cells) into one of the synergid cells, which plays a vital role in fertilization by facilitating the entry of sperm cells into the egg cell. - After releasing the sperm cells, the pollen tube disintegrates. The sperm cells then fuse with the egg cell and the central cell of the ovule to form a zygote and endosperm, respectively.

(a) The pollen tube moves through the style.

(b) The sperm cells are released into the synergid of the embryo sac.



L.S. of Pistil

Quick Tip

The growth of the pollen tube and its interaction with the synergid cells is critical for successful fertilization in flowering plants.

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23. Explain the IUI and IUT methods of assisted reproductive technologies.

Solution: 1. IUI (Intrauterine Insemination): - Intrauterine Insemination is a fertility treatment where sperm is directly inserted into a woman's uterus during ovulation. This method bypasses the cervix and increases the chances of sperm reaching the egg. It is most commonly used for individuals with low sperm count, low sperm motility, or unexplained infertility. IUI can also be used for women with cervical mucus problems or those who have ovulatory issues. - This procedure is often combined with ovulation induction to maximize the chances of successful fertilization.

2. IUT (Intrauterine Transfer): - In this method, embryos or zygotes are transferred into the uterus after fertilization has occurred outside the body. IUT is typically used in cases where the embryo faces difficulty implanting naturally due to conditions like endometrial issues or previous implantation failure. The embryo is transferred directly into the uterus through the cervix, allowing it to implant and develop. - This procedure is a crucial part of in vitro fertilization (IVF) and has helped many couples with infertility issues successfully conceive. - IUI involves the direct placement of sperm into the uterus during ovulation to aid fertilization. - IUT involves transferring embryos into the uterus after fertilization to enhance

implantation.

Quick Tip

Assisted reproductive technologies like IUI and IUT increase the success rates of pregnancy by bypassing natural barriers to fertilization and implantation.

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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 the table of 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:

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

- The progeny shows a phenotypic ratio of 6:2:6:2, indicating that both parents are heterozygous for both traits, i.e., both have one dominant and one recessive allele for each gene.
- This results in a cross between $VvAa \times vvAa$, where:
- Vv is the heterozygous violet allele,
- vv is the homozygous recessive white allele,
- Aa is the heterozygous axial allele.
2. Cross (b): Violet, Axial $\times$ White, Terminal
- The progeny shows a 1:1:1:1 phenotypic ratio, indicating that one parent is heterozygous for both traits while the other is homozygous recessive for one trait.
- This cross is between $VvAa \times vvAa$, where:
- Vv is the heterozygous violet allele,
- vv is the homozygous recessive white allele,
- Aa is the heterozygous axial allele.
3. Cross (c): Violet, Axial $\times$ Violet, Axial
- The progeny shows a phenotypic ratio of 3:1, which indicates that both parents are heterozygous for both traits.
- This results in a monohybrid cross for both the flower color and position, specifically $VvAA \times VvAA$.
- The cross gives a ratio of:
- $VvAA$ for 3/4 of the progeny with violet, axial phenotype, and
- $vvAA$ for 1/4 of the progeny with white, axial phenotype.
- (a) $VvAa \times vvAa$
- (b) $VvAa \times vvAa$
- (c) $VvAA \times VvAA$

Quick Tip

Punnett squares and phenotypic ratios are useful tools for predicting offspring traits and understanding inheritance patterns.

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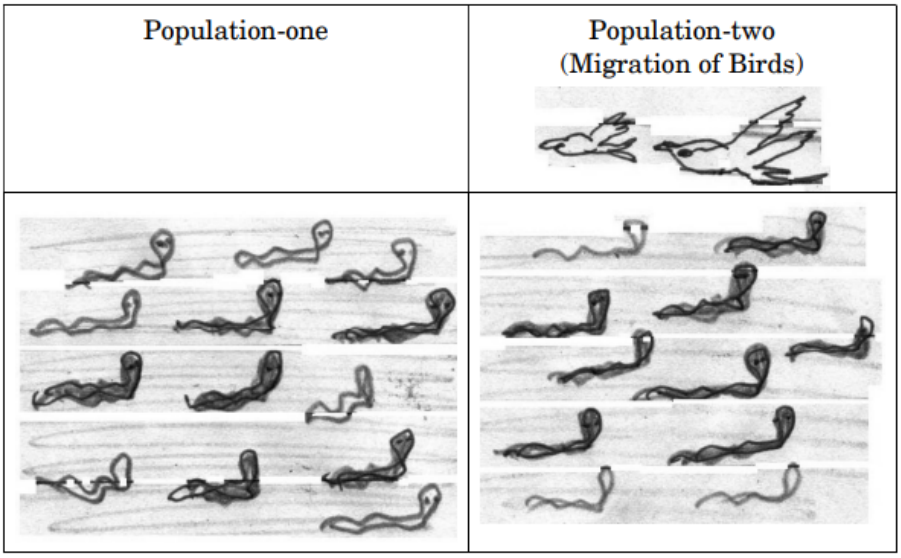
25. A population of snakes lived in a desert with brown sand. Study the drawings given below showing the change in the population from 'one' to 'two' over time and answer the question that follows. Brown snakes and Grey snakes are represented by alleles *A/a* (Dominant/recessive).



(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:

- The frequency of the recessive genotype (aa) = $q^2 = 9\%$ = 0.09.
- The frequency of the recessive allele (q) = $\sqrt{0.09} = 0.3$.
- The frequency of the dominant allele (p) = $1 - q = 1 - 0.3 = 0.7$.
- 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%).
- Homozygous dominant snakes (AA) = 49%.
- Heterozygous dominant snakes (Aa) = 42%.

Quick Tip

Natural selection favors traits that provide a survival advantage in a given environment. In this case, brown snakes had better camouflage in the desert sand, reducing predation and increasing their survival and reproduction rates.

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

Solution:

- The mechanism of evolution is natural selection.

- In the desert habitat, the grey snakes, which are better camouflaged against the brown sand, have a survival advantage over the brown snakes.

Over time, this selective pressure increases the frequency of grey snakes in the population, leading to evolutionary change.

The mechanism of evolution is natural selection.

Quick Tip

Natural selection helps organisms adapt to their environment, increasing their chances of survival and reproduction.

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

Solution:

1. Cow-dung contains methanogenic bacteria, which are essential for the anaerobic breakdown of organic matter into methane gas during the biogas production process. These bacteria help in efficiently producing biogas.

2. Cow-dung is readily available in large quantities and is biodegradable, making it an easily accessible and suitable feedstock for biogas plants. Domestic sewage may not have the necessary microorganisms in sufficient amounts for efficient biogas production.

Quick Tip

Cow dung is preferred over domestic sewage in biogas plants due to its higher organic content and better methane yield. Additionally, it is safer to handle and reduces the risk of pathogenic contamination.

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

Solution:

- The unspent slurry, which is the residual solid material left after the biogas has been extracted, can be used as a high-quality organic fertilizer for crops. It enriches the soil with nutrients like nitrogen, phosphorus, and potassium, promoting plant growth.
- Cow-dung is preferred due to its methanogenic bacteria and availability. - The slurry is used as fertilizer to improve soil quality.

Quick Tip

The unspent slurry from a biogas plant is an excellent organic fertilizer that improves soil fertility, enhances crop yield, and reduces dependency on chemical fertilizers.

OR

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

(i) Myocardial infarction:

Solution: Streptokinase from *Streptococcus* species.

(ii) High blood cholesterol level:

Solution: Statins from *Monascus purpureus*.

(iii) Organ transplantation:

Solution: Cyclosporin A from *Trichoderma polysporum*.

- (i) Streptokinase - (ii) Statins - (iii) Cyclosporin A

Quick Tip

Microbial products, such as streptokinase and cyclosporin, are invaluable tools in modern medicine for treating cardiovascular diseases, controlling cholesterol levels, and preventing organ rejection in transplants.

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

Solution: The scientific name of the bacterium widely used in biotechnology to create genetically modified (GM) cotton crops resistant to bollworm attacks is Bacillus thuringiensis. This bacterium naturally produces a protein toxin, which, when ingested by certain insect pests, disrupts their digestive system and leads to their death. This property makes it highly effective in pest control.

Quick Tip

Bacillus thuringiensis (Bt) is a naturally occurring bacterium in the soil, known for its ability to produce insecticidal proteins that specifically target certain pests. Its use in genetically modified crops helps in reducing chemical pesticide usage.

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

Solution: GM cotton crops are genetically engineered by inserting a gene from Bacillus thuringiensis (Bt), which produces a protein toxic to specific insect pests such as bollworms. The protein is embedded in every cell of the cotton plant, including its leaves, stems, and flowers. When the bollworm larvae consume parts of the plant, they ingest the toxin, which interferes with their digestive system, ultimately killing them. This allows the cotton crop to resist insect attacks without the need for external chemical insecticides.
Additionally, the gene insertion makes the cotton plant inherently resistant to these pests, reducing the environmental impact of pesticide use and promoting a more sustainable agricultural practice. This process also reduces the cost for farmers by decreasing the need for repeated pesticide applications.

Quick Tip

Genetically modified crops like Bt cotton not only help in controlling pest populations but also contribute to environmental sustainability by reducing the reliance on harmful chemical insecticides, which can have negative effects on non-target species and ecosystems.

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28. Describe how fig tree and wasp relationship is a spectacular example of mutualism.

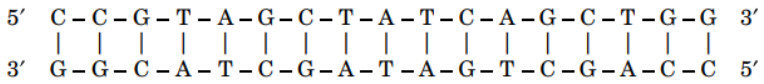
Solution: The relationship between the fig tree and fig wasp is a fascinating example of mutualism, where both species derive benefits from the interaction. Fig trees rely on fig wasps for pollination, and fig wasps depend on fig trees for their reproduction. The fig tree produces a specialized fruit, called a syconium, which contains both the flowers and seeds of the tree. Female fig wasps enter the fig through a small opening to lay their eggs inside the fig's flowers. As they do this, they inadvertently pollinate the fig flowers. The wasp larvae feed on the fig's flowers, and once they mature, the male wasps mate with the females inside the fig and then die. The fertilized female wasps exit the fig, carrying pollen with them, and find another fig to lay their eggs in, thus continuing the cycle.
This mutualistic relationship ensures that the fig tree can reproduce through pollination, while the wasp species can reproduce by using the fig tree's flowers as a breeding ground. Both species rely on each other for survival, and neither would thrive without the other.

Quick Tip

The fig tree and fig wasp demonstrate how highly specialized mutualistic relationships can evolve between species. Such relationships benefit both parties involved, ensuring the survival and reproductive success of each.

Section D

29. Read the passage given below and answer the questions that follow.
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-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 3and 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 formed with its polarity.



Solution: - Alu I recognizes the sequence AG↓CT and cuts the DNA at this site. - The provided DNA sequence would be cleaved as follows:

Two fragments are produced:

1. 5’ - CGT GAT AG - 3’
2. 5’ - CTA TAG CTA C - 3’

Quick Tip

Restriction enzymes like Alu I recognize specific palindromic sequences and cut DNA at precise locations. The number of DNA fragments formed is equal to (n+1), where n is the number of recognition sites.

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

Solution: - BamHI is preferred in recombinant DNA technology because it produces sticky ends, which enhance the ability to ligate foreign DNA into the target sequence. - In contrast, Alu I generates blunt ends, which are less efficient in terms of ligation, as they do not form overhangs that facilitate DNA joining.

BamHI is favored due to its ability to create sticky ends, which simplifies the process of recombinant DNA formation.

Quick Tip

Restriction enzymes like BamHI create sticky ends, which enhance the efficiency of DNA ligation in recombinant DNA technology. In contrast, Alu I produces blunt ends, making ligation more challenging.

(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.

Action of Restriction Enzymes: - Restriction enzymes act at specific palindromic sequences in the DNA. - A palindromic sequence is a nucleotide sequence that reads the same forward and backward on complementary strands.

Example of a Palindromic Sequence:

5' GAATTC 3'

3' CTTAAG 5'

Quick Tip

Restriction enzymes are essential tools in genetic engineering. - Sticky ends (produced by enzymes like BamH I) are better for DNA recombination. - Blunt ends (produced by Alu I) require additional steps for ligation.

OR

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

Solution: - EcoRI recognizes the sequence:

$$5' - G\_AATTC - 3'3' - CTTAA\hat{}G - 5'$$

This is the specific site where EcoRI cuts the DNA.

The EcoRI recognition sequence is 5' - G↓AATTC - 3'.

Quick Tip

Restriction enzymes like EcoRI are essential tools in genetic manipulation as they create sticky ends for DNA ligation.

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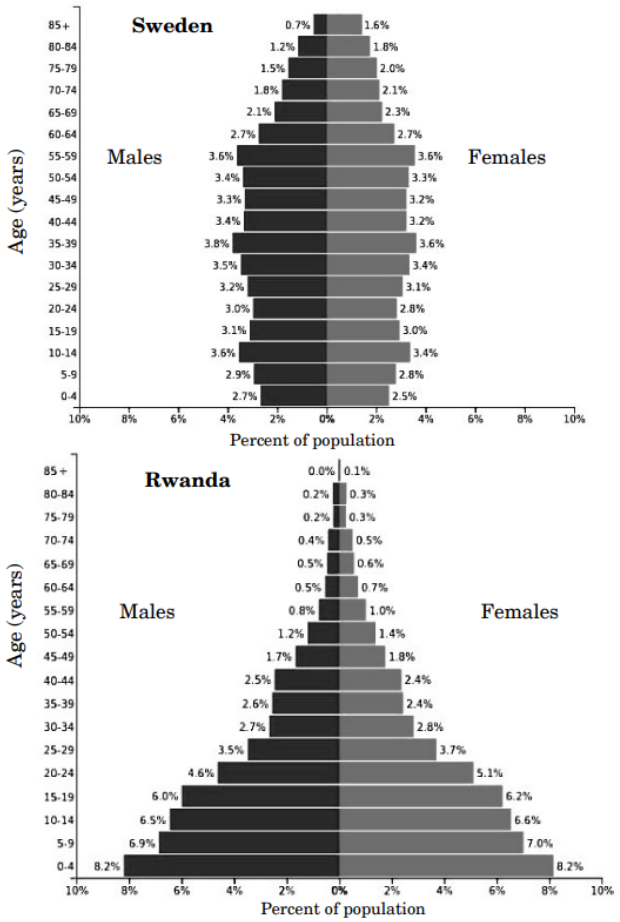
30. Study the figures given below that depict the comparative age distribution of human populations in Sweden and Rwanda (International Data Base 2003) and answer the questions that follow:



(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:

- A broad base on the age pyramid reflects a high birth rate in Rwanda, which leads to a large proportion of the population being in the younger age brackets.
- For example, 8.2

Rwanda's broad age pyramid indicates a high birth rate and rapid population growth.

Quick Tip

A broad-based age pyramid indicates a high birth rate and young population, leading to rapid population growth and high dependency ratios.

(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:

- The uniform width of Sweden's age pyramid suggests low birth and death rates, which is characteristic of a stable population.
- The even distribution across age groups indicates that the population growth is balanced, with a high life expectancy.

Sweden's population is stable, showing low birth and death rates.

Quick Tip

A uniform age distribution in a population pyramid, as seen in Sweden, indicates low birth and death rates, leading to a stable or slowly growing population.

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

Solution: - Sweden's age pyramid is classified as stationary, with a balanced number of individuals across all age groups, indicating low growth and high stability.

Sweden's age pyramid is stationary.

Quick Tip

A stationary age pyramid, as seen in Sweden, indicates low birth and death rates, leading to a stable population.

OR

Name the type of age pyramid shown above for Rwanda.

Solution: - Rwanda's pyramid is classified as expanding, as it has a wide base, which is characteristic of a high birth rate and rapidly growing population.

Rwanda's age pyramid is expanding.

Quick Tip

Age pyramids are valuable tools for understanding the demographic structure and growth patterns of a population.

Section E

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

Solution:

1. Dichogamy: The male and female reproductive parts mature at different times, preventing self-pollination.

2. Herkogamy: Physical separation of anthers and stigma prevents self-pollination by keeping male and female parts from interacting directly.

3. Unisexuality: Male and female flowers are on separate plants (dioecy), ensuring cross-pollination.

4. Self-incompatibility: The plant's genetic makeup prevents fertilization with its own pollen, promoting cross-pollination.

These mechanisms—dichogamy, herkogamy, unisexuality, and self-incompatibility—facilitate cross-pollination.

Quick Tip

Flowering plants encourage cross-pollination through mechanisms like dichogamy (different maturation times), herkogamy (spatial separation), self-incompatibility (genetic rejection), and unisexuality (separate male and female flowers). These adaptations promote genetic diversity and evolution.

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

Solution: - Self-pollination leads to inbreeding depression, reducing genetic diversity and

the plant's ability to adapt to environmental changes.

Plants discourage self-pollination to avoid inbreeding depression.

Quick Tip

Self-pollination reduces genetic variation, making plants more susceptible to diseases and environmental changes.

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

Solution: (i) Follicular phase/proliferative phase:

- Under the influence of FSH, follicles in the ovaries develop and secrete estrogen, which helps to proliferate the uterine lining (endometrium).

(ii) Luteal phase/secretory phase:

- After ovulation, the ruptured follicle transforms into the corpus luteum, which secretes progesterone to prepare the endometrium for possible implantation.

(iii) Menstrual phase:

- If fertilization does not occur, the corpus luteum degenerates, leading to a drop in progesterone, causing the shedding of the endometrial lining (menstruation).

The menstrual cycle involves follicular, luteal, and menstrual phases, regulated by hormones like FSH, LH, estrogen, and progesterone.

Quick Tip

The menstrual cycle ensures the female reproductive system is prepared for pregnancy while maintaining a regular cycle of hormonal regulation.

32(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 codominance, both alleles contribute equally to the phenotype in heterozygous individuals.
- In the ABO blood group system:
- IA and IB are codominant, meaning both A and B antigens are present on red blood cells in individuals with genotype IAIB.
Codominance is illustrated by the ABO blood group system, where both alleles are expressed equally in the heterozygous individual.

Quick Tip

Codominance occurs when both alleles in a heterozygous state are fully expressed. The ABO blood group system is an example, where individuals with $I^A I^B$ genotype express both A and B antigens on red blood cells, resulting in blood group AB.

OR

(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:

- When lactose is present, it binds to the repressor protein, inactivating it.
- This allows RNA polymerase to bind to the promoter region and transcribe the lac operon genes, which are involved in lactose metabolism.

Quick Tip

The lac operon is an inducible operon in bacteria that controls lactose metabolism. It is switched on when lactose is present, as it binds to the repressor protein, preventing it from blocking the operon's promoter.

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

Solution: - The lac operon is negatively regulated because the repressor protein binds to the operator, blocking transcription of the operon when lactose is not available.

The lac operon is negatively regulated, as the repressor inhibits transcription in the absence of lactose.

Quick Tip

The lac operon model is an important example of gene regulation, demonstrating how bacteria control enzyme production in response to environmental changes.

33(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:

1. Entry into the human body:

- Infected female Anopheles mosquitoes inject sporozoites into the human bloodstream during a bite. 2. Liver stage:

- Sporozoites travel to the liver, infect hepatocytes, and mature into merozoites.

3. RBC stage:

- Merozoites enter red blood cells, replicate, and cause them to burst, releasing more merozoites.

4. Gamete formation:

- Some merozoites differentiate into male and female gametocytes, which circulate in the blood.

5. Uptake by mosquito:

- When a mosquito bites an infected human, it ingests the gametocytes, continuing the cycle.

The Plasmodium life cycle includes sporozoite entry, liver stage, RBC stage, gametocyte formation, and mosquito uptake.

Quick Tip

The life cycle of *Plasmodium* involves two hosts: humans and female Anopheles mosquitoes.

(ii) Mention the two events of Plasmodium life cycle that occur within the female

Anopheles body.

Solution:

1. Fertilization: Male and female gametocytes fuse in the mosquito's gut, forming a zygote.

2. Sporozoite formation: The zygote develops into sporozoites, which migrate to the mosquito's salivary glands.

Fertilization and sporozoite formation occur within the mosquito's body.

Quick Tip

Plasmodium's lifecycle is digenetic, involving both humans and mosquitoes as hosts, making it a complex parasitic process.

OR

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

Solution:

1. Malignant tumor:

- Invasive, spreading to other parts of the body (metastasis).
- Grows rapidly and is life-threatening.

2. Benign tumor:

- Non-invasive, localized.
- Grows slowly and is usually not life-threatening.

Malignant tumors are invasive and life-threatening, while benign tumors are localized and grow slowly.

Quick Tip

Malignant tumors are cancerous, grow rapidly, invade nearby tissues, and can spread (metastasize). Benign tumors are non-cancerous, grow slowly, remain localized, and do not spread.

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

Solution:

1. Biopsy:

- A sample of tissue is taken and analyzed for abnormal cells under a microscope.

2. Imaging techniques (e.g., CT scan, MRI):

- These methods create images of tumors and their spread within the body.

3. Blood tests:

- Detect specific biomarkers (e.g., PSA for prostate cancer) indicating the presence of cancer.

Diagnostic techniques for cancer include biopsy, imaging, and blood tests to detect abnormal cell growth and spread.

Quick Tip

Early cancer detection through advanced diagnostic methods significantly improves treatment outcomes and survival rates.
