CBSE 12 Biology (57/5/3) 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

Question Nos. 1 to 16 are Multiple Choice type Questions, carrying 1 mark each.

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1. A person with trisomy of 21st chromosome shows:

(i) Furrowed tongue

(ii) Characteristic palm crease

(iii) Rudimentary ovaries

(iv) Gynaecomastia

Select the correct option, from the choices given below:

(A) (ii) and (iv)

(B) (i), (ii) and (iv)

(C) (ii) and (iii)

(D) (i) and (ii)

Correct Answer: (D) (i) and (ii)

Solution:

A person with trisomy of 21st chromosome will be afflicted with Down's syndrome. This condition is characterized by a small round head, furrowed tongue, partially open mouth, and characteristic palm crease.

Quick Tip

For conditions like Down's syndrome, remember that trisomy 21 leads to physical and developmental traits such as furrowed tongue and palm crease.

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2. Which one of the following chromosomal events will not result in genetic variation amongst the offspring?

(A) Independent assortment

(B) Crossing over

(C) Linkage

(D) Mutation

Correct Answer: (C) Linkage

Solution:

Step 1: Understanding the impact of chromosomal events on genetic variation. - **Independent assortment** occurs during meiosis, leading to the random distribution of maternal and paternal chromosomes, which increases genetic variation. - **Crossing over** involves the exchange of genetic material between homologous chromosomes, creating new genetic combinations. - **Mutation** introduces new genetic variations in the DNA sequence. - **Linkage**, however, refers to genes located close together on the same chromosome being inherited together, reducing recombination and, therefore, genetic variation.

Step 2: Conclusion. The correct answer is **(C)**, as linkage does not contribute to genetic variation but rather conserves specific gene combinations.

Quick Tip

Linkage reduces the chance of recombination between genes, whereas independent assortment and crossing over actively promote genetic diversity.

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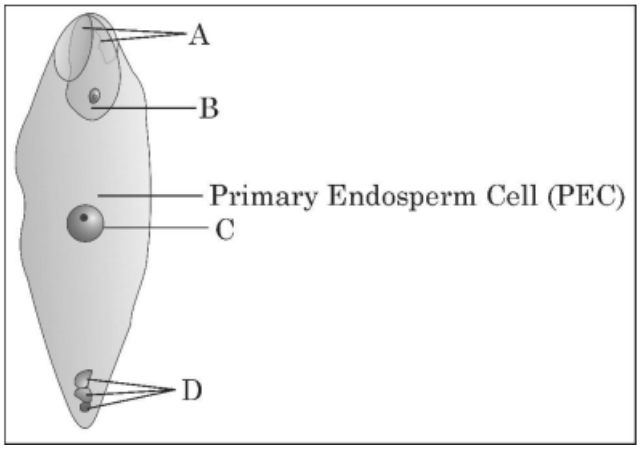
3. Identify the correct labellings in the figure of a fertilised embryo sac of an angiosperm given below:



(A) A – zygote, B – degenerating synergids, C – degenerating antipodals, D – PEN

(B) A – degenerating synergids, B – zygote, C – PEN, D – degenerating antipodals

(C) A – degenerating antipodals, B – PEN, C – degenerating synergids, D – zygote

(D) A – degenerating synergids, B – zygote, C – degenerating antipodals, D – PEN

Correct Answer: (B) A – degenerating synergids, B – zygote, C – PEN, D – degenerating antipodals

Solution:

The correct labellings in the figure are:

- A represents degenerating synergids as they are no longer needed after fertilization.
- B is the zygote formed after the fusion of the male and female gametes.
- C is the primary endosperm nucleus (PEN) formed by the fusion of a sperm with two polar nuclei.
- D represents degenerating antipodals as their function is complete.

Quick Tip

In a fertilised embryo sac: - Zygote forms at the center of the sac. - Degenerating synergids and antipodals are found at opposite poles. - PEN results from the fusion of a sperm with two polar nuclei.

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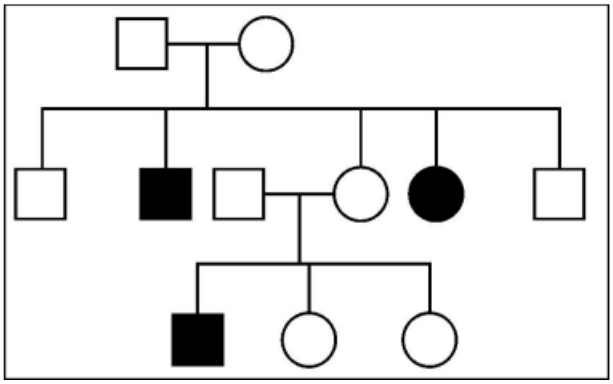
4. Study the pedigree chart of a family showing the inheritance pattern of a certain disorder. Select the option that correctly identifies the nature of the trait depicted in the pedigree chart:



(A) Dominant X-linked

(B) Recessive X-linked

(C) Autosomal dominant

(D) Autosomal recessive

Correct Answer: (D) Autosomal recessive

Solution:

The disorder depicted in the pedigree chart follows an autosomal recessive inheritance pattern. This can be inferred from the following observations:

1. The trait skips generations, which is typical for recessive traits.
2. Both males and females are equally affected, indicating an autosomal pattern.
3. The trait is expressed only when an individual inherits two copies of the recessive allele, one from each parent.

Quick Tip

In pedigree analysis: - Recessive traits often skip generations. - Autosomal traits affect males and females equally. - X-linked traits show gender bias (males more affected in recessive traits, females more affected in dominant traits).

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5. Which one of the following statements is correct in the context of observing DNA separation by agarose gel electrophoresis?

(A) DNA can be seen in visible light.

(B) DNA can be seen without staining in visible light.

(C) Ethidium bromide stained DNA can be seen in visible light.

(D) Ethidium bromide stained DNA can be seen under UV light.

Correct Answer: (D) Ethidium bromide stained DNA can be seen under UV light

Solution:

In agarose gel electrophoresis, DNA is separated based on size. Staining with ethidium bromide allows the DNA bands to be visualized under UV light. Ethidium bromide binds to DNA and fluoresces under UV light, making the bands visible.

Quick Tip

Always use UV light to observe ethidium bromide-stained DNA during gel electrophoresis.

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6. A phenomenon where a male insect mistakenly identifies the patterns of an orchid flower as the female insect partner, and tries to copulate and thereby pollinates the flower is said to be:

(A) Pseudocopulation

(B) Pseudopollination

(C) Pseudoparthenocarpy

(D) Pseudofertilisation

Correct Answer: (A) Pseudocopulation

Solution:

Step 1: Understanding the phenomenon. Pseudocopulation occurs when a male insect is deceived by the appearance of a flower, mistaking it for a female insect partner, and attempts to copulate with it. This behavior leads to pollination of the flower. - The other options: - Pseudopollination: Not a valid term in this context. - Pseudoparthenocarpy: Refers to fruit development without fertilization, unrelated here. - Pseudofertilisation: Does not describe this phenomenon.

Step 2: Conclusion. The correct answer is **(A)**, as pseudocopulation is the phenomenon described.

Quick Tip

Pseudocopulation is a strategy used by certain flowers, such as orchids, to mimic female insects and achieve pollination without offering nectar or other rewards.

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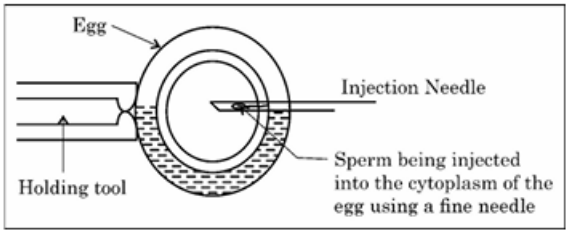
7. Observe the schematic representation of assisted reproductive technology given below:



Identify the most appropriate technique depicted in the above diagram.

(A) IUT

(B) IUI

(C) ICSI

(D) ZIFT

Correct Answer: (C) ICSI

Solution:

The diagram represents Intracytoplasmic Sperm Injection (ICSI), where a single sperm is directly injected into the cytoplasm of the egg using a fine needle. This technique is used in cases of severe male infertility or failed fertilization in conventional IVF.

Quick Tip

Remember: In ICSI, a single sperm is injected directly into the egg's cytoplasm using a fine needle.

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8. The source of 'Smack' is:

(A) Leaves of *Cannabis sativa*

(B) Flowers of *Datura*

(C) Fruits of *Erythroxylum coca*

(D) Latex of *Papaver somniferum*

Correct Answer: (D) Latex of *Papaver somniferum*

Solution:

Step 1: Identifying the source of 'Smack'. - Smack is a street name for heroin, which is derived from the latex of *Papaver somniferum* (the opium poppy). - The other options: - *Cannabis sativa*: Source of marijuana and hashish. - *Datura*: Contains toxic alkaloids but not heroin. - *Erythroxylum coca*: Source of cocaine, unrelated to heroin.

Step 2: Conclusion. The correct answer is **(D)**, as the opium poppy produces the raw material for heroin.

Quick Tip

Heroin is synthesized from morphine, which is extracted from the opium latex of *Papaver somniferum*.

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9. The first antibiotic was discovered accidentally by A while working on B. 'A' and 'B' are:

(A) A – Waksman; B – *Streptococcus*

(B) A – Fleming; B – *Penicillium notatum*

(C) A – Waksman; B – *Bacillus brevis*

(D) A – Fleming; B – *Staphylococci*

Correct Answer: (D) A – Fleming; B – *Staphylococci*

Solution:

Step 1: Understanding the discovery of the first antibiotic. - Alexander Fleming discovered penicillin accidentally in 1928 while studying the bacterium *Staphylococci*. - The mold *Penicillium notatum* inhibited bacterial growth in his cultures.

Step 2: Analyzing the options. - Options (A) and (C) refer to discoveries by Selman Waksman, not Fleming. - Option (B) incorrectly pairs Fleming with *Penicillium notatum* as the working organism. Fleming observed *Staphylococci*.

Step 3: Conclusion. The correct answer is **(D)**, as Fleming's work involved *Staphylococci*.

Quick Tip

Penicillin's discovery marked the start of the antibiotic era, with Fleming's observation of inhibited *Staphylococci* growth.

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10. If the sequence of nitrogen bases of the coding strand in a transcription unit is 5' – ATGAATG – 3', the sequence of bases in its RNA transcript would be:

(A) 5' – AUGAAUG – 3'

(B) 5' – UACUUAC – 3'

(C) 5’ – CAUUCAU – 3’

(D) 5’ – GUAAGUA – 3’

Correct Answer: (A) 5’ – AUGAAUG – 3’

Solution:

The RNA transcript is complementary to the template strand and identical to the coding strand (except that uracil (U) replaces thymine (T) in RNA). Therefore, the RNA transcript of the sequence 5’ – ATGAATG – 3’ is 5’ – AUGAAUG – 3’.

Quick Tip

Remember: RNA is complementary to the template strand and identical to the coding strand, except that U replaces T.

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11. Match the following genes of the lac operon listed in column ‘A’ with their respective products listed in column ‘B’:

A (Gene)	B (Products)
a. ‘i’ gene	(i) β-galactosidase
b. ‘z’ gene	(ii) lac permease
c. ‘a’ gene	(iii) repressor
d. ‘y’ gene	(iv) transacetylase

Select the correct option:

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

(B) (iii), (i), (iv), (ii)

(C) (iii), (i), (iv), (ii)

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

Correct Answer: (C) (iii), (i), (iv), (ii)

Solution:

In the lac operon: - The ‘i’ gene codes for the repressor protein, which inhibits the operon when lactose is absent.

- The ‘z’ gene produces β-galactosidase, which breaks down lactose into glucose and galactose.

- The ‘a’ gene encodes transacetylase, which helps in lactose metabolism.

- The ‘y’ gene produces lac permease, which facilitates the entry of lactose into the cell.

Quick Tip

Remember the lac operon genes: - ‘i’ gene $\rightarrow$ Repressor - ‘z’ gene $\rightarrow$ β-galactosidase - ‘y’ gene $\rightarrow$ Lac permease - ‘a’ gene $\rightarrow$ Transacetylase

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12. The human chromosome with the highest and least number of genes in them are respectively:

(A) Chromosome 21 and Y

(B) Chromosome 1 and X

(C) Chromosome 1 and Y

(D) Chromosome X and Y

Correct Answer: (C) Chromosome 1 and Y

Solution:

Step 1: Understanding the gene distribution among chromosomes. - Chromosome 1 has the highest number of genes, as it is the largest human chromosome. - Chromosome Y has the least number of genes, as it primarily carries genes related to male sex determination and reproduction.

Step 2: Conclusion. The correct answer is **(C)**, as Chromosome 1 has the highest and Chromosome Y has the least number of genes.

Quick Tip

Remember: Chromosome 1 is the largest and most gene-rich, while Chromosome Y is the smallest and least gene-dense.

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13. Assertion (A): In birds, the sex of the offspring is determined by males.

Reason (R): Males are homogametic while females are heterogametic.

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

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

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

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

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

Solution:

Step 1: Understanding sex determination in birds. - In birds, the sex of the offspring is determined by females, not males, as females are heterogametic (ZW), while males are homogametic (ZZ). - Thus, the assertion (A) is incorrect.

Step 2: Analyzing the reason. - The reason (R) correctly states that males are homogametic while females are heterogametic in birds.

Step 3: Conclusion. Since the assertion is false and the reason is true, the correct answer is **(D)**.

Quick Tip

In birds: - Males (ZZ) are homogametic. - Females (ZW) are heterogametic and determine the offspring's sex.

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14. Assertion (A): "Biodiversity hotspots" are the regions which possess high levels of species richness, high degree of endemism.

Reason (R):Total number of biodiversity hotspots in the world is 22 with two of these hotspots found in India.

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

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

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

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

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

Solution:

Step 1: Analyzing the assertion (A). - Biodiversity hotspots are indeed regions of high

species richness and endemism, so the assertion is true.

Step 2: Analyzing the reason (R). - The total number of biodiversity hotspots worldwide is 36, not 22. India is home to 4 biodiversity hotspots (the Himalayas, Indo-Burma, Western Ghats-Sri Lanka, and Sundaland). Hence, the reason is false.

Step 3: Conclusion. Since the assertion is true but the reason is false, the correct answer is **(C)**.

Quick Tip

Currently, there are 36 biodiversity hotspots in the world, with four located in India: Himalayas, Indo-Burma, Western Ghats-Sri Lanka, and Sundaland.

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15. Assertion (A): AIDS is a syndrome caused by HIV.

Reason (R): HIV is a virus that damages the immune system with DNA as its genetic material.

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

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

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

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

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

Solution:

Step 1: Analyzing the assertion (A). - AIDS (Acquired Immunodeficiency Syndrome) is indeed caused by the HIV (Human Immunodeficiency Virus). Hence, the assertion is true.

Step 2: Analyzing the reason (R). - HIV is a retrovirus with RNA, not DNA, as its genetic material. Therefore, the reason is false.

Step 3: Conclusion. Since the assertion is true but the reason is false, the correct answer is **(C)**.

Quick Tip

HIV is a retrovirus with RNA as its genetic material, not DNA.

16. Assertion (A): In molecular diagnosis, single stranded DNA or RNA tagged with radioactive molecule is called a probe.

Reason (R): A probe always searches and hybridises with its complementary DNA in a clone of cells.

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

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

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

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

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

Solution:

Step 1: Analyzing the assertion (A). - Single-stranded DNA or RNA tagged with a radioactive molecule is indeed called a probe. Probes are used in molecular diagnosis to detect specific DNA sequences. Hence, the assertion is true.

Step 2: Analyzing the reason (R). - A probe searches for and hybridizes with its complementary DNA sequence within a sample, confirming the assertion's purpose. The reason is true and correctly explains the assertion.

Step 3: Conclusion. Both the assertion and the reason are true, and the reason explains the assertion. The correct answer is **(A)**.

Quick Tip

Probes in molecular biology: - Single-stranded DNA or RNA tagged with a radioactive or fluorescent molecule. - Used to detect specific DNA/RNA sequences by hybridization.

SECTION – B

17. If the base adenine constitutes 31% of an isolated DNA fragment, then write what

will be the expected percentage of the base cytosine in it. Explain how did you arrive at the answer given.

Solution:

DNA follows Chargaff's rule, which states:

- The percentage of adenine (A) equals the percentage of thymine (T), and the percentage of cytosine (C) equals the percentage of guanine (G).
- Since adenine constitutes 31%, thymine also constitutes 31%. Together, A + T = 62%.
- The remaining 38% is divided equally between cytosine and guanine. Thus, cytosine constitutes 19%.

Quick Tip

Chargaff's Rule: A = T and C = G. Use this to calculate the percentage of any base in DNA when the percentage of one base is known.

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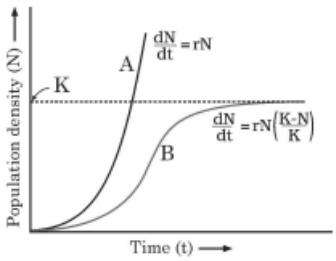
18. Observe the population growth curve and answer the questions given below:



(a) State the conditions under which growth curve 'A' and growth curve 'B' plotted in the graph are possible.

(b) Mention what does 'K' in the graph represent.

Solution:

(a)

- Growth curve 'A' represents exponential growth, which occurs when resources are unlimited and environmental constraints are absent.
- Growth curve 'B' represents logistic growth, which occurs when resources are limited, leading to population stabilization at carrying capacity.

(b) 'K' in the graph represents the carrying capacity of the environment, which is the maximum population size that can be sustained indefinitely with available resources.

Quick Tip

- Exponential growth: Unlimited resources, no constraints.
- Logistic growth: Limited resources, stabilizes at carrying capacity (K).
- Carrying capacity (K): Maximum sustainable population size.

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19. 5' – G↓AATTC – 3'

3' – CTTAA↑G – 5'

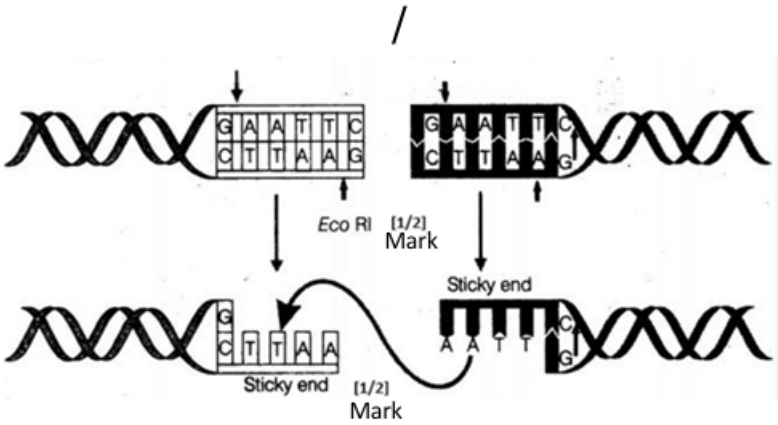
(a) Name the restriction enzyme that recognizes the given specific sequence of bases. What are such sequences of bases referred to as?

(b) What are the arrows in the given figure indicating? Write the result obtained thereafter.

Solution (a):

The restriction enzyme that recognizes the given sequence is EcoRI. Such sequences are referred to as palindromic sequences, which read the same forward and backward on complementary strands.

Solution (b):



The arrows indicate the sites where the restriction enzyme EcoRI cuts the DNA. The result obtained thereafter is the formation of sticky ends, which are single-stranded overhangs that facilitate the joining of DNA fragments during genetic engineering.

Quick Tip

Remember: - EcoRI recognizes the sequence 5' – GAATTC – 3'. - Palindromic sequences are the same on complementary strands when read in opposite directions. - Sticky ends are crucial for recombination in genetic engineering.

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20. List the events that reduce the Biochemical Oxygen Demand (BOD) of a primary effluent during sewage treatment.

Solution:

The following events occur during sewage treatment to reduce the Biochemical Oxygen Demand (BOD) of primary effluent:

- The primary effluent is passed into a large aeration tank.
- The effluent is constantly agitated mechanically, and air is pumped into it.
- Vigorous growth of useful aerobic microbes (such as fungi and bacteria) occurs, forming flocs.
- These microbes consume the major part of the organic matter present in the effluent, reducing the BOD.

Quick Tip

Remember: BOD reduction is achieved in the aeration tank through the action of aerobic microbes that degrade organic matter in the primary effluent.

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21. (a) "Farmers prefer apomictic seeds to hybrid seeds." Justify giving two reasons.

Solution:

Farmers prefer apomictic seeds because:

- They do not require repeated hybridization, saving time and cost.
- They maintain the hybrid vigor (heterosis) over generations, as apomixis produces genetically identical offspring.

Quick Tip

Remember: Apomictic seeds are cost-effective and maintain hybrid vigor across generations, making them favorable for farmers.

OR

21. (b) Mention one advantage and one disadvantage of amniocentesis.

Solution:

Advantage:

Amniocentesis can detect genetic abnormalities and chromosomal disorders in the fetus, aiding in early diagnosis and management.

Disadvantage:

It carries a small risk of complications such as miscarriage or infection.

Quick Tip

Amniocentesis: Think of ”genetic diagnosis” (advantage) vs. ”risk of miscarriage” (disadvantage).

SECTION – C

Question Nos. 22 to 28 are short answer type questions. Each question carries 3 marks.

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22. Explain the processing of heterogeneous nuclear RNA (hnRNA) into a fully functional mRNA in eukaryotes. Where does this processing occur in the cell?

Solution:

The processing of hnRNA into mRNA in eukaryotes involves the following steps:

- **Capping:** A 7-methylguanosine cap is added to the 5’ end of hnRNA to protect it from degradation and assist in ribosome binding during translation.
- **Tailing:** A poly-A tail (a string of adenine nucleotides) is added to the 3’ end of the

hnRNA to enhance stability and facilitate export from the nucleus.

- **Splicing:** Introns (non-coding regions) are removed, and exons (coding regions) are joined together to form a continuous sequence that codes for a protein.

This processing occurs in the **nucleus** of the eukaryotic cell.

Quick Tip

Remember the three main steps in hnRNA processing: Capping, Tailing, and Splicing. These modifications occur in the nucleus and are essential for mRNA stability and functionality.

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23. (a) "Mother's milk is considered very essential for the newborn infant." Justify.

(b) What is a 'vaccine'? Explain the principle on which it works.

Solution:

(a) Importance of Mother's Milk:

- Mother's milk provides all essential nutrients required for the growth and development of the newborn.
- It contains antibodies (such as IgA) that boost the immune system and protect the baby from infections.
- Breast milk promotes healthy gut flora and reduces the risk of allergies and illnesses.

(b) Vaccine and Its Principle:

- A vaccine is a biological preparation containing dead or weakened pathogens or their components.
- The principle of vaccination is to stimulate the immune system to produce memory cells against a specific pathogen, enabling a faster and stronger response upon subsequent exposure.

Quick Tip

Breastfeeding provides both nutritional and immunological benefits. Vaccines work on the principle of immunological memory.

24. (a) Tropical regions harbor more species than temperate regions. How have biologists tried to explain this in their own ways? Explain.

OR

(i) What does an ecological pyramid represent?

(ii) The Ecological pyramids may have an 'upright' or an 'inverted' shape. Justify with the help of suitable examples.

Solution:

(a) Reasons for Higher Biodiversity in Tropical Regions:

- **Favorable Climate:** Tropical regions have a warm and stable climate throughout the year, which promotes the growth and reproduction of diverse organisms.
- **Higher Productivity:** Abundant sunlight and rainfall increase primary productivity, supporting a variety of life forms.
- **Long Evolutionary Time:** Tropical regions have been relatively undisturbed over geological timescales, allowing species to evolve and diversify.

(b) (i): An ecological pyramid represents the flow of energy and the number of organisms at each trophic level in an ecosystem. It is a graphical representation that shows the relative amount of energy or biomass at each level, starting with producers at the base, followed by herbivores, carnivores, and top predators. The pyramid illustrates the decrease in energy and number of organisms as we move up through the trophic levels.

(b) (ii): Ecological pyramids may take two forms:

- **Upright Ecological Pyramid:** In this type, the number of organisms, biomass, or energy decreases as we move up from the producers to the apex consumers. It is the most common shape of ecological pyramids, where producers form the base and each subsequent level contains fewer organisms or less energy. **Example:** A forest ecosystem is an example of an upright pyramid, where plants (producers) form the base, followed by herbivores (primary consumers), then carnivores (secondary consumers), and finally apex predators.

- **Inverted Ecological Pyramid:** This occurs when the number of organisms or the biomass increases at higher trophic levels. This happens typically in aquatic ecosystems, where the biomass of primary producers (e.g., phytoplankton) is less than that of primary consumers (e.g., zooplankton). In these ecosystems, producers are consumed rapidly, and a large number of consumers are supported. **Example:** In a pond or lake, the pyramid of biomass may be inverted, with more zooplankton than phytoplankton.

Quick Tip

- Tropical regions have high biodiversity due to favorable conditions and longer evolutionary times. - In species-area relationships, larger areas generally support more species, but the rate of increase diminishes.

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25. State why plant breeders are interested in artificial hybridisation programmes. How do they carry out this process?

Solution:

Reasons for Interest in Artificial Hybridisation:

- It allows breeders to combine desirable traits from two different plants, such as disease resistance and high yield.
- It enhances genetic variation in crops, increasing the potential for better adaptability and productivity.
- It helps in developing new crop varieties with improved quality and performance.

Process of Artificial Hybridisation:

- The process involves emasculation, where the anthers of a flower are removed to prevent self-pollination.
- The emasculated flower is then covered with a bag (bagging) to protect it from unwanted pollen.
- Pollen from the desired parent plant is collected and dusted onto the stigma of the emasculated flower, ensuring cross-pollination.

Quick Tip

Artificial hybridisation is widely used to develop high-yielding, disease-resistant, and stress-tolerant crop varieties.

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26. (a) What are transgenic animals?

(b) Name the transgenic animal having the largest number amongst all the existing transgenic animals.

(c) State any three reasons for which these types of animals are being produced.

Solution:

(a) Definition of Transgenic Animals:

Transgenic animals are those that have had their DNA modified by the introduction of a foreign gene or genes, making them capable of expressing traits that are not naturally found in their species.

(b) Transgenic Animal with the Largest Population:

Mice are the transgenic animals with the largest number among all existing transgenic animals. They are extensively used in genetic and biomedical research.

(c) Reasons for Producing Transgenic Animals:

- To study the function of specific genes and their role in development and diseases.
- For producing pharmaceutical proteins and drugs (e.g., recombinant insulin).
- To create animal models for human diseases, enabling research on treatments and therapies.

Quick Tip

Transgenic animals like mice and sheep are instrumental in biomedical research, drug production, and understanding genetic functions.

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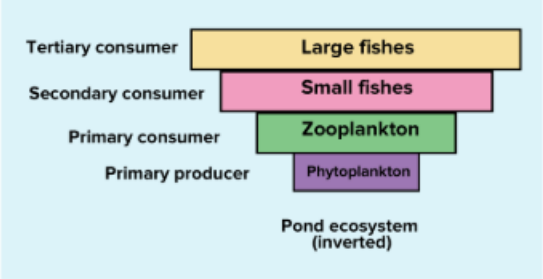
27. (a) Construct a pyramid of biomass in the sea with phytoplankton and fishes. Explain, giving reasons, the characteristics of the constructed pyramid.

(b) In which condition will the pyramid remain always upright?

Solution:



(a) Pyramid of Biomass in the Sea:

The pyramid of biomass in the sea is typically inverted. This is because:

- The biomass of phytoplankton (producers) is much smaller than the biomass of the fishes (primary and secondary consumers).
- Phytoplankton have a high turnover rate due to rapid reproduction and consumption by herbivorous fishes, maintaining their population despite low biomass.

Inverted Pyramid of Biomass (Marine Ecosystem)

Fishes (Consumers) - Large Biomass at the Top

Phytoplankton (Producers) - Small Biomass at the Bottom

(b) Conditions for an Upright Pyramid:

The pyramid of biomass will always remain upright in terrestrial ecosystems where:

- The biomass of producers is always higher than the biomass of consumers.
- Energy transfer follows the 10% rule, with significant energy loss at each trophic level.

Quick Tip

- In marine ecosystems, the pyramid of biomass is often inverted due to the high productivity and turnover of phytoplankton. - Terrestrial ecosystems generally have upright pyramids due to greater producer biomass.

28. (a) Why does DNA replication occur within a replication fork and not in its entire length simultaneously?

(b) "DNA replication is continuous and discontinuous on the two strands within the replication fork." Explain with the help of a schematic representation.

Solution:

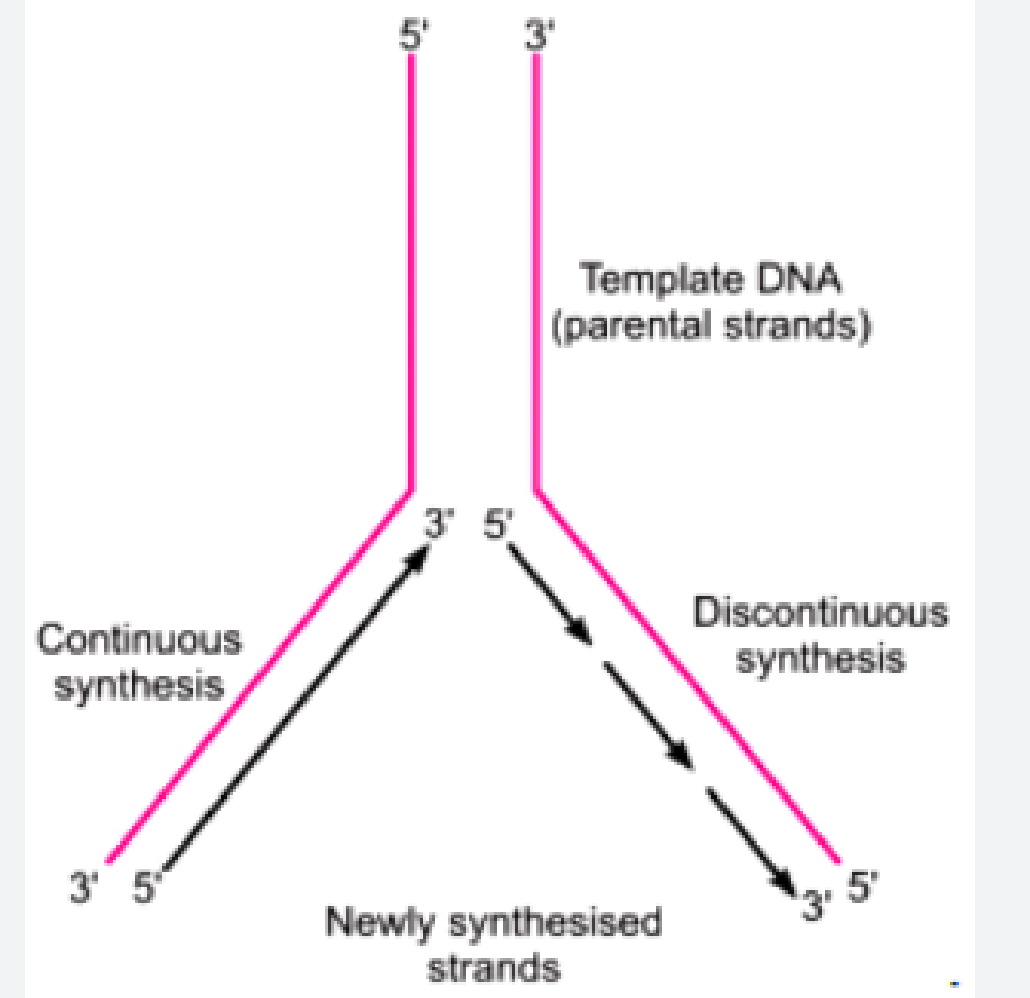
(a) Reason for Replication within the Replication Fork:

- DNA replication occurs within the replication fork because DNA unwinds progressively at the fork to expose the two strands for replication.
- The entire length of DNA cannot replicate simultaneously as it would require the entire molecule to be unwound at once, which is not feasible due to its length and complexity.
- The replication fork allows for localized unwinding and replication, ensuring accuracy and efficiency.

(b) Continuous and Discontinuous Replication:

- DNA polymerase synthesizes DNA only in the 5' to 3' direction.
- On the leading strand, replication is continuous because it proceeds in the same direction as the unwinding of the helix.
- On the lagging strand, replication is discontinuous, as it proceeds in short segments (Okazaki fragments) opposite to the direction of unwinding.
- These fragments are later joined by DNA ligase to form a continuous strand.

Schematic Representation:

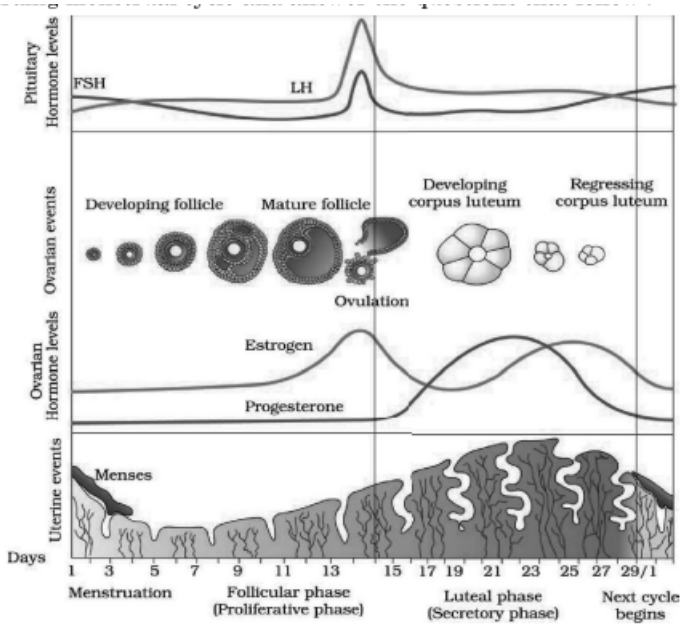


Quick Tip

- Leading strand: Continuous synthesis (5' to 3'). - Lagging strand: Discontinuous synthesis via Okazaki fragments. - DNA replication is semi-discontinuous due to the opposite orientation of strands.

SECTION – D

29. In a human female, the reproductive phase starts on the onset of puberty and ceases around the middle age of the female. Study the graph given below regarding the menstrual cycle and answer the questions that follow:



(a) Name the hormones and their source organ, which are responsible for the menstrual cycle at puberty.

(b) For successful pregnancy, at what phase of the menstrual cycle can an early embryo (up to 3 blastomeres) be implanted in the uterus (IUT) of a human female who has opted for Assisted Reproductive Technology (ART)? Support your answer with a reason.

(c) Name the hormone and its source organ responsible for the events occurring during the proliferative phase of the menstrual cycle. Explain the event.

OR

(c) In a normal human female, why does menstruation occur only if the released ovum is not fertilised? Explain.

Solution:

(a) The hormones responsible for the menstrual cycle at puberty are:

- **FSH (Follicle Stimulating Hormone)**: Secreted by the anterior pituitary gland, stimulates follicle development.
- **LH (Luteinizing Hormone)**: Secreted by the anterior pituitary gland, triggers ovulation and corpus luteum formation.
- **Estrogen and Progesterone**: Secreted by the ovaries, regulate the uterine lining during the cycle.

(b) Implantation should occur during the secretory phase (days 15-28) of the menstrual cycle. During this phase, the uterine lining (endometrium) is thick and vascularized due to the action of progesterone, creating a suitable environment for embryo implantation.

(c) The hormone responsible for the proliferative phase is Estrogen, secreted by the developing ovarian follicles. It stimulates the regeneration and thickening of the uterine lining (endometrium) after menstruation.

OR

If the released ovum is not fertilized, the corpus luteum degenerates, leading to a drop in progesterone levels. This causes the uterine lining (endometrium) to break down and shed, resulting in menstruation.

Quick Tip

- Menstrual cycle phases: Menses, Proliferative, Secretory. - Implantation occurs in the secretory phase due to high progesterone levels. - Progesterone = Maintains endometrium; Estrogen = Builds endometrium.

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30. Read the following passage and answer the questions that follow:

"Mosquitoes are drastically affecting human health in almost all the developing tropical countries. Different species of mosquitoes cause very fatal diseases so much so that many humans lose their life and if they survive, are unable to put in productive hours to sustain their life. With the result, the health index of the country goes down."

(a) Name the form in which *Plasmodium* gains entry into (i) human body (ii) the female *Anopheles* body.

(b) Why do the symptoms of malaria not appear in a person immediately after being bitten by an infected female *Anopheles*? Give one reason. Explain when and how do the symptoms of the disease appear.

OR

(b) Explain the events which occur within a female *Anopheles* mosquito after it has sucked blood from a malaria patient.

(c) Name a species of mosquito other than female *Anopheles* and the disease for which it

carries the pathogen.

Solution:

(a)

- (i) In humans, *Plasmodium* enters in the form of sporozoites, which are injected by the female *Anopheles* mosquito during a bite.
- (ii) In the female *Anopheles* body, *Plasmodium* enters in the form of gametocytes, which are taken up with the blood meal from an infected person.

(b) The symptoms of malaria do not appear immediately after the bite because the parasite undergoes an incubation period inside the human liver and blood cells. Symptoms appear 10–14 days later when the parasite multiplies and ruptures red blood cells, releasing toxins. This results in fever, chills, and sweating.

OR

In the female *Anopheles* mosquito, after sucking blood from an infected person:

- The gametocytes of *Plasmodium* develop into sporozoites in the mosquito's gut.
- The sporozoites migrate to the salivary glands of the mosquito, making it ready to infect another human during its next bite.

(c) A mosquito species other than *Anopheles* is *Aedes aegypti*, which carries the pathogen for dengue fever.

Quick Tip

- *Plasmodium* stages: Sporozoites enter humans; gametocytes enter mosquitoes.
- *Aedes aegypti*: Carries pathogens for dengue and chikungunya. - Malaria symptoms appear after the incubation period (10–14 days).

SECTION – E

31. (a)

1. **Draw a diagram of a human sperm. Label any four parts and write their functions.**

2. **In a human female, the probability of an ovum getting fertilized by more than one sperm is impossible. Give a reason.**

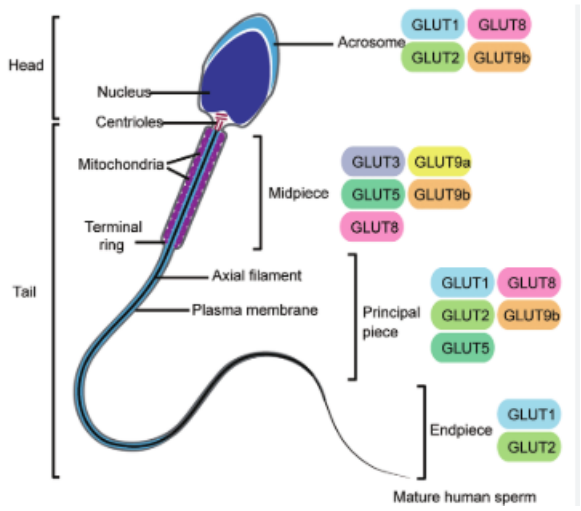
OR

(b) (i) With the help of a labelled diagram only, show the different stages of embryo development in a dicot plant.

Endosperm development precedes embryo development. Justify.

Solution (a):

(i) Diagram of a human sperm:



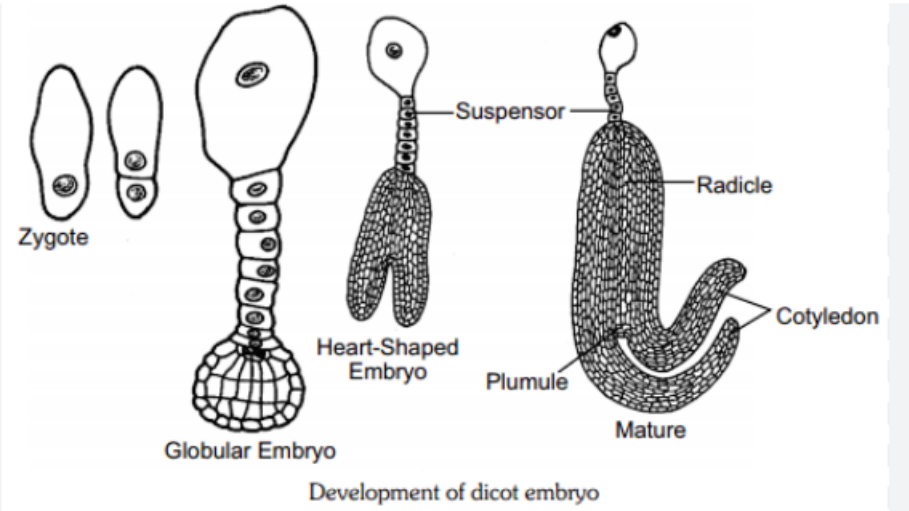
Functions of labelled parts:

- **Head**: Contains the nucleus with genetic material and acrosome for penetrating the egg.
- **Middle Piece**: Contains mitochondria that provide energy for motility.
- **Tail**: Facilitates movement of the sperm towards the egg.
- **Plasma Membrane**: Encloses the sperm and maintains its structural integrity.

(ii) The probability of an ovum being fertilized by more than one sperm is impossible due to a phenomenon called cortical reaction, where the egg membrane changes after the first sperm enters, preventing entry of additional sperms.

Solution (b):

(i) Diagram showing stages of embryo development in a dicot plant:



Development of dicot embryo

(ii) Endosperm development precedes embryo development because the endosperm provides nutrients to the developing embryo. It supports early stages of growth until the plant can photosynthesize independently.

Quick Tip

- Human sperm: Acrosome helps penetrate the egg; mitochondria in the middle piece generate energy.
- Cortical reaction prevents polyspermy in humans.
- Dicot embryos develop after endosperm formation, ensuring nutrient availability.

SECTION – E

31. (a)

1. **Draw a schematic diagram of the cloning vector pBR 322 and label (1) Bam HI site (2) gene for ampicillin resistance (3) 'ori' (4) 'rop' gene.**

2. **State the role of 'rop' gene.**

3. **A cloning vector does not have a selectable marker. How will it affect the process of cloning?**

4. **Why is insertional inactivation preferred over the use of selectable markers in cloning vectors?**

OR

(b)

1. **Name the nematode (scientific name) that infects the roots of tobacco plant and reduces its yield.**

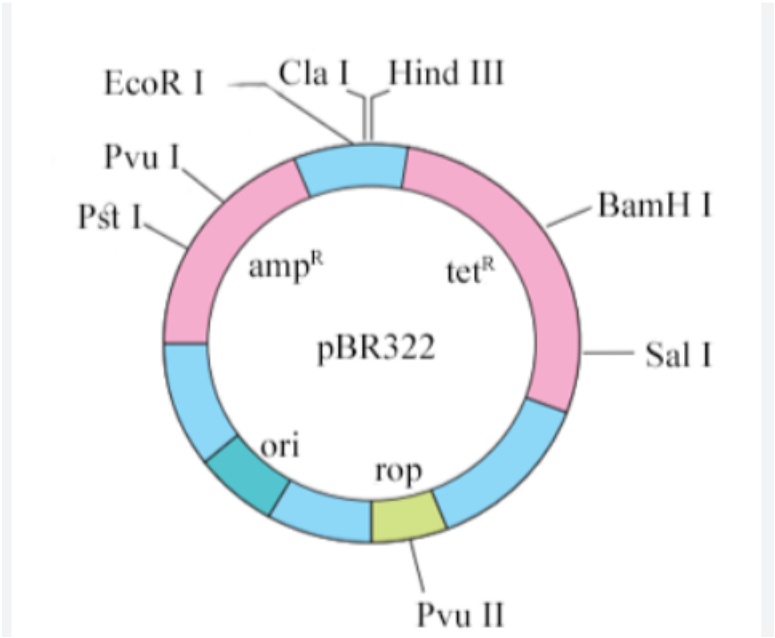
2. **Name the vector that is used to introduce nematode-specific genes into the host plant (tobacco).**

3. **How do sense and anti-sense RNAs function?**

4. **Why could the parasite not survive in a transgenic tobacco plant?**

Solution (a):

(i) A schematic diagram of the cloning vector pBR 322 is shown below:



(ii) The 'rop' gene in pBR 322 encodes proteins involved in maintaining the copy number of the plasmid.

(iii) If a cloning vector does not have a selectable marker, it would be difficult to differentiate between transformed and non-transformed cells, complicating the identification of successful clones.

(iv) Insertional inactivation is preferred because it allows direct identification of recombinant colonies. It inactivates a selectable marker gene (e.g., antibiotic resistance), so only recombinant cells are easily identified.

Solution (b):

(i) The nematode that infects the roots of tobacco plants is Meloidogyne incognita.

(ii) The vector used to introduce nematode-specific genes into the host plant is Agrobacterium tumefaciens.

(iii) Sense and anti-sense RNAs are complementary RNA strands. When expressed together, they form a double-stranded RNA that silences the target nematode gene through RNA interference (RNAi).

(iv) The parasite could not survive in the transgenic tobacco plant because the RNAi mechanism silences the nematode-specific genes, preventing its growth and reproduction.

Quick Tip

- Cloning vectors: pBR 322 has ori (replication origin), selectable markers, and restriction sites.
- RNAi: Silences specific genes by degrading their mRNA using double-stranded RNA.
- *Agrobacterium tumefaciens* is commonly used for plant genetic transformation.

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32. (b)

(i) Name the nematode (scientific name) that infects the roots of tobacco plants and reduces its yield.

(ii) Name the vector that is used to introduce nematode-specific genes into the host plant (tobacco).

(iii) How do sense and anti-sense RNAs function?

(iv) Why could the parasite not survive in a transgenic tobacco plant?

Solution:

(a) Selectable Markers:

- Selectable markers are genes introduced into a host organism along with the gene of interest to identify and select transformed cells that have successfully incorporated the foreign DNA.
- They allow researchers to distinguish between transformed and non-transformed cells.
- Common examples include antibiotic resistance genes like amp^r (ampicillin resistance) and tet^r (tetracycline resistance).
- Significance:

– Only transformed cells survive and grow in a medium containing the corresponding antibiotic.

– Non-transformed cells are eliminated, simplifying the identification process.

(b) Responses:

(i) The nematode that infects the roots of tobacco plants is *Meloidogyne incognita*.

(ii) The vector used to introduce nematode-specific genes into the host plant is the *Agrobacterium tumefaciens*-based Ti plasmid.

(iii) **Function of Sense and Anti-sense RNAs:**

- Sense RNA corresponds to the sequence of the target gene, while anti-sense RNA is complementary to it.
- When anti-sense RNA binds to the sense RNA, it forms a double-stranded RNA, which is non-functional and prevents the production of the target protein.

(iv) **Why the Parasite Cannot Survive in a Transgenic Tobacco Plant:**

- In transgenic tobacco plants, nematode-specific genes are introduced that produce double-stranded RNA (dsRNA).
- This dsRNA triggers RNA interference (RNAi), which silences the expression of essential genes in the nematode, leading to its death.

Quick Tip

Selectable markers like antibiotic resistance genes simplify the identification of transformed cells. RNA interference (RNAi) is a powerful tool for silencing specific genes in parasites like nematodes.

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33. (a) Work out a dihybrid cross up to F_2 generation between pea plants bearing violet-coloured axial flowers and white-coloured terminal flowers using Punnett's square. Give their F_2 phenotypic ratio. State the Mendel's law of inheritance that was derived from such a cross.

OR

(b) Explain the process of transcription in prokaryotes. How is it different from transcription in eukaryotes?

Solution:

(a) Dihybrid Cross:

Let:

- Violet axial flowers = $VVAA$
- White terminal flowers = $vvaa$

Punnett's Square for F_2 Generation:

	VA	Va	vA	va
VA	$VVAA$	$VVAa$	$VvAA$	$VvAa$
Va	$VVAa$	$VVaa$	$VvAa$	$Vvaa$
vA	$VvAA$	$VvAa$	$vvAA$	$vvAa$
va	$VvAa$	$Vvaa$	$vvAa$	$vvaa$

F_2 Phenotypic Ratio:

9 (Violet Axial) : 3 (Violet Terminal) : 3 (White Axial) : 1 (White Terminal)

Mendel's Law Derived: Mendel's law of **Independent Assortment** states that the inheritance of one trait is independent of the inheritance of another.

(b) Transcription in Prokaryotes:

Transcription in prokaryotes involves the synthesis of mRNA from DNA using RNA polymerase. The process includes:

- **Initiation:** RNA polymerase binds to the promoter region of DNA, aided by sigma factors.
- **Elongation:** RNA polymerase synthesizes RNA in the 5' to 3' direction using the DNA template strand.

- **Termination:** Transcription ends when RNA polymerase reaches a terminator sequence, releasing the mRNA.

Differences from Eukaryotic Transcription:

- In eukaryotes, transcription occurs in the nucleus, whereas in prokaryotes, it occurs in the cytoplasm.
- Eukaryotic transcription requires multiple RNA polymerases and transcription factors, whereas prokaryotes use a single RNA polymerase.
- Eukaryotic mRNA undergoes capping, tailing, and splicing, which are absent in prokaryotic transcription.

Quick Tip

- In a dihybrid cross, the F_2 phenotypic ratio is always $9:3:3:1$. - Prokaryotic transcription is simpler, whereas eukaryotic transcription involves additional post-transcriptional modifications.
