

CBSE Class 12 2025 Biology Question Paper (57/1/2) With Solutions

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| Time Allowed :3 Hour | Maximum Marks :70 | Total questions :33 |
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General Instructions

Read the following instructions very carefully and strictly follow them:

1. This question paper contains 33 questions. All questions are compulsory.
2. This question paper is divided into five sections Sections A, B, C, D and E.
3. In Section A Questions no. 1 to 16 are Multiple Choice type questions. Each question carries 1 mark.
4. In Section B Questions no. 17 to 21 are Very Short Answer type questions. Each question carries 2 marks.
5. In Section C Questions no. 22 to 28 are Short Answer type questions. Each question carries 3 marks.
6. In Section D Questions no. 29 and 30 are case study based questions. Each question carries 4 marks.
7. In Section E Questions no. 31 to 33 are Long Answer type questions. Each question carries 5 marks.
8. There is no overall choice given in the question paper. However, an internal choice has been provided in few questions in all the Sections except Section A.
9. Kindly note that there is a separate question paper for Visually Impaired candidates.
10. Use of calculators is not allowed.

SECTION A

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

Choose the best option.

1. Mohit performed an analysis of two different soil samples from two areas A and B.

He recorded these results:

Soil Sample A: Lignin 40%, Sugar 0%, Chitin 45%, Nitrogen 5%

Soil Sample B: Lignin 5%, Sugar 35%, Chitin 15%, Nitrogen 45%

Which of these is true about their rate of decomposition in both the soil?

- (A) Soil A has a slower rate of decomposition than Soil B.
- (B) Soil A has a faster rate of decomposition than Soil B.
- (C) Both have the same rate of decomposition.
- (D) No decomposition occurs in A and B.

Correct Answer: (A) Soil A has a slower rate of decomposition than Soil B.

Solution:

Step 1: Decomposition rates depend on the composition of organic matter in the soil. Sugar decomposes the fastest, followed by chitin, and lignin decomposes the slowest. Nitrogen content also enhances microbial activity, speeding up decomposition.

Step 2: Soil A has 40% lignin (slow to decompose), 0% sugar (fast to decompose), 45% chitin, and 5% nitrogen. The high lignin and low nitrogen suggest a slower decomposition rate.

Step 3: Soil B has 5% lignin, 35% sugar (fast to decompose), 15% chitin, and 45% nitrogen. The high sugar and nitrogen content indicate a faster decomposition rate.

Step 4: Comparing the two, Soil A, with more lignin and less sugar/nitrogen, will decompose more slowly than Soil B, which has more sugar and nitrogen to support faster microbial activity.

Thus, Soil A has a slower rate of decomposition than Soil B.

Quick Tip

In soil decomposition, high sugar and nitrogen content accelerate microbial activity, while high lignin content slows down the process.

2. Diameter of the pollen grain is

- (A) 5 to 10 micrometer
- (B) 10 to 15 micrometer
- (C) 25 to 50 micrometer
- (D) 50 to 100 micrometer

Correct Answer: (C) 25 to 50 micrometer

Solution:

Step 1: Pollen grains vary in size depending on the plant species, but their diameter typically ranges from 10 to 100 micrometers.

Step 2: For most plants, the average diameter of pollen grains is between 25 and 50 micrometers, which is a common range for many species.

Step 3: Comparing the given options, 25 to 50 micrometers aligns best with the typical size of pollen grains.

Thus, the diameter of the pollen grain is most accurately 25 to 50 micrometers.

Quick Tip

Pollen grain size can vary by species, but a typical range for many plants is 25 to 50 micrometers, making them visible under a light microscope.

3. Menstrual cycle in human females consists of various events. Select the option that indicates the correct sequence of these events of menstrual cycle.

- (A) Menstrual phase, Follicular phase, Luteal phase, Ovulatory phase
- (B) Menstrual phase, Follicular phase, Ovulatory phase, Luteal phase
- (C) Menstrual phase, Follicular phase, Ovulatory phase, Luteal phase
- (D) Follicular phase, Luteal phase, Menstrual phase, Ovulatory phase

Correct Answer: (B) Menstrual phase, Follicular phase, Ovulatory phase, Luteal phase

Solution:

Step 1: The menstrual cycle in human females consists of four main phases that occur in a specific order.

Step 2: The cycle begins with the Menstrual phase (shedding of the uterine lining), followed by the Follicular phase (follicle development), then the Ovulatory phase (release of the egg), and finally the Luteal phase (preparation for potential pregnancy).

Step 3: Comparing the options, option (B) correctly lists the sequence as Menstrual phase, Follicular phase, Ovulatory phase, and Luteal phase.

Thus, the correct sequence is Menstrual phase, Follicular phase, Ovulatory phase, Luteal phase.

Quick Tip

The menstrual cycle typically lasts 28 days and follows the order: Menstrual phase (days 1-5), Follicular phase (days 1-13), Ovulatory phase (day 14), and Luteal phase (days 15-28).

4. A Dihybrid cross is done between two parent pea plants (pure line) who differ in two pairs of contrasting traits: Seed colour and seed shape. In the F₂ generation the number of phenotypes and genotypes will be:

- (A) phenotypes = 4; genotypes = 16
- (B) phenotypes = 9; genotypes = 14
- (C) phenotypes = 4; genotypes = 8
- (D) phenotypes = 4; genotypes = 9

Correct Answer: (D) phenotypes = 4; genotypes = 9

Solution:

Step 1: A dihybrid cross involves two traits. Assuming seed color (Yellow YY vs. Green yy) and seed shape (Round RR vs. Wrinkled rr), pure line parents are YYRR and yyrr.

Step 2: The F₁ generation from YYRR × yyrr is YyRr (yellow round, heterozygous). In the F₂ generation (YyRr × YyRr), the phenotypic ratio is 9:3:3:1, giving 4 distinct phenotypes: yellow round, yellow wrinkled, green round, and green wrinkled.

Step 3: The genotypic ratio is 1:2:1:2:4:2:1:2:1, resulting in 9 distinct genotypes: YYRR, YYRr, YyRR, YyRr, YYrr, Yyrr, yyRR, yyRr, and yyrr.

Step 4: Comparing the options, option (D) correctly states 4 phenotypes and 9 genotypes. Thus, in the F₂ generation, there are 4 phenotypes and 9 genotypes.

Quick Tip

In a dihybrid cross, the F₂ phenotypic ratio is 9:3:3:1 (4 phenotypes), and the genotypic ratio is 1:2:1:2:4:2:1:2:1 (9 genotypes), assuming independent assortment.

5. RNA interference (RNAi) helps in making tobacco resistant to a nematode (*Meloidogyne incognita*). Choose the correct option that shows how RNAi is achieved:

- (A) Preventing the process of translation of mRNA of the nematode.
- (B) Preventing the process of replication of mRNA of the nematode.
- (C) Preventing the process of transcription of DNA of the nematode.
- (D) Preventing the process of replication of DNA of the plant.

Correct Answer: (A) Preventing the process of translation of mRNA of the nematode.

Solution:

Step 1: RNA interference (RNAi) is a biological process where RNA molecules inhibit gene expression, typically by targeting mRNA.

Step 2: In the case of *Meloidogyne incognita*, RNAi is used to silence specific genes in the nematode by introducing double-stranded RNA that matches the target mRNA.

Step 3: This double-stranded RNA is processed into small interfering RNAs (siRNAs), which prevent the translation of the nematode's mRNA into proteins, effectively silencing the gene.

Thus, RNAi is achieved by preventing the translation of mRNA of the nematode.

Quick Tip

RNAi is a powerful tool in biotechnology, often used to silence harmful genes in pests like nematodes, by targeting their mRNA to prevent protein synthesis.

6. The sequence of nitrogenous bases in a segment of a coding strand of DNA is 5'-AATGCTAGGCAC-3'. Choose the option that shows the correct sequence of nitrogenous bases in the mRNA transcribed by the DNA.

- (A) 5'-UUACGATCCGUG-3'
- (B) 5'-AAUGCUAGGCAC-3'
- (C) 5'-UUACGUACCGUG-3'
- (D) 5'-AAUGCUAGGCAC-3'

Correct Answer: (D) 5'-AAUGCUAGGCAC-3'

Solution:

Step 1: The given DNA sequence, 5'-AATGCTAGGCAC-3', is the coding strand. The mRNA is transcribed from the template strand, which is complementary to the coding strand.

Step 2: The template strand (3' to 5') is 3'-TTACGATCCGTG-5'. The mRNA is synthesized 5' to 3', complementary to the template strand, replacing T with U: 5'-AAUGCUAGGCAC-3'.

Step 3: Comparing the options, option (D) matches the correct mRNA sequence: 5'-AAUGCUAGGCAC-3'.

Thus, the mRNA sequence is 5'-AAUGCUAGGCAC-3'.

Quick Tip

In transcription, mRNA is synthesized from the template strand of DNA, where A pairs with U (instead of T), and G pairs with C, following base-pairing rules.

7. A man whose father was colour-blind marries a woman who had a colour-blind mother and normal father. What percentage of male children of this couple will be colour-blind?

- (A) 25%
- (B) 0%
- (C) 50%

(D) 75%

Correct Answer: (C) 50%

Solution:

Step 1: Colour blindness is an X-linked recessive disorder. A man inherits his X chromosome from his mother and Y chromosome from his father.

Step 2: Since the man's father was colour-blind, and the disorder is X-linked, the man himself is **not** colour-blind (he received the normal X from his mother). His genotype is XY with a normal X.

Step 3: The woman had a colour-blind mother and normal father, so she must be a carrier ($X^C X$).

Step 4: Cross between man (XY) and woman ($X^C X$) gives:

- Male offspring: 50% XY (normal), 50% $X^C Y$ (colour-blind)

Thus, 50% of male children will be colour-blind.

Quick Tip

In X-linked disorders, sons get their X chromosome from their mother. Carrier mothers can pass the defective gene to 50% of sons.

8. Evolution of modern man involves the following man-like primates. Choose the correct series of human evolution.

(A) *Dryopithecus* → *Homoerectus* → *Australopithecines* → *Homosapiens*

(B) *Australopithecines* → *Homoerectus* → *Neanderthal* → *Homosapiens*

(C) *Australopithecines* → *Ramapithecus* → *Dryopithecus* → *Homosapiens*

(D) *Homoerectus* → *Australopithecines* → *Homosapiens* → *Neanderthal*

Correct Answer: (B) *Australopithecines* → *Homoerectus* → *Neanderthal* → *Homosapiens*

Solution:

Step 1: Human evolution follows a specific sequence of primate ancestors leading to modern humans (*Homo sapiens*).

Step 2: The correct sequence begins with early primates like *Dryopithecus* (not listed in the correct option but part of the broader timeline), followed by *Ramapithecus*, then *Australopithecines* (early hominids), *Homo erectus*, Neanderthals (*Homo neanderthalensis*), and finally *Homo sapiens*.

Step 3: Option (B) lists Australopithecines → *Homoerectus* → *Neanderthal* → *Homosapiens*, which aligns with the accepted evolutionary timeline.

Thus, the correct series is *Australopithecines* → *Homoerectus* → *Neanderthal* → *Homosapiens*.

Quick Tip

Human evolution progressed from early primates like Australopithecines to Homo erectus, then to Neanderthals, before the emergence of modern Homo sapiens.

9. GEAC stands for

- (A) Genome Engineering Action Committee
- (B) Ground Environment Action Committee
- (C) Genetic and Environmental Approval Committee
- (D) Genetic Engineering Approval Committee

Correct Answer: (D) Genetic Engineering Approval Committee

Solution:

Step 1: GEAC is an acronym related to biotechnology and genetic engineering in India.

Step 2: It is a regulatory body that oversees the approval of genetically modified organisms and products.

Step 3: The correct full form of GEAC is Genetic Engineering Approval Committee, which matches option (D).

Thus, the answer is (D) Genetic Engineering Approval Committee.

Quick Tip

GEAC is a key regulatory body in India for approving GMOs and ensuring biosafety.

10. Transplantation of tissues/organs to some patients often fails due to rejection of such tissues/organs by the body of the patient. Which type of immune response is responsible for such rejections?

- (A) Autoimmune response
- (B) Humoral immune response
- (C) Physiological immune response
- (D) Cell mediated immune response

Correct Answer: (D) Cell mediated immune response

Solution:

Step 1: Transplantation rejection occurs when the recipient's immune system identifies the transplanted tissue/organ as foreign.

Step 2: The immune system has two main types of responses: humoral (antibody-mediated) and cell-mediated (T-cell mediated).

Step 3: Rejection of transplants is primarily due to the action of T-cells, which recognize foreign antigens on the transplanted tissue and attack it. This is a cell-mediated immune response.

Step 4: Autoimmune response (A) targets the body's own tissues, humoral response (B) involves antibodies, and physiological immune response (C) is not a standard term in this context.

Thus, the correct answer is (D) Cell mediated immune response.

Quick Tip

Cell-mediated immunity, driven by T-cells, is critical in transplant rejection, which is why immunosuppressive drugs are often used post-transplant.

11. Amplification of gene of interest by using DNA polymerase may go upto

- (A) 0.1 million times
- (B) 1 million times
- (C) 1 billion times
- (D) 1 trillion times

Correct Answer: (C) 1 billion times

Solution:

Step 1: Amplification of a gene of interest is typically done using the Polymerase Chain Reaction (PCR) technique, which relies on DNA polymerase.

Step 2: In PCR, the DNA is doubled in each cycle. A standard PCR run often includes 30–40 cycles.

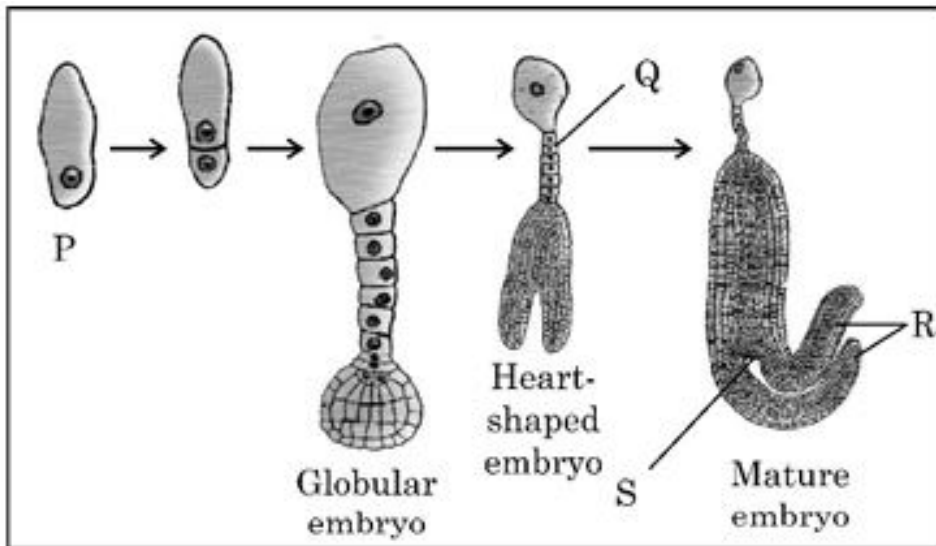
Step 3: Mathematically, after n cycles, the amplification factor is 2^n . For 30 cycles, $2^{30} \approx 1.07 \times 10^9$, which is roughly 1 billion.

Step 4: Options (A), (B), and (D) are either too low or too high for typical PCR amplification. Thus, the correct answer is (C) 1 billion times.

Quick Tip

PCR amplification is exponential: after 30 cycles, a single DNA molecule can theoretically be amplified to over 1 billion copies.

12. The diagram given below shows labelling of four parts of a dicot embryo during its development as P, Q, R and S.



Choose the option that indicates correct labelling of P, Q, R and S of embryo in different stages of its development:

- (A) P: Egg Q: Suspensor R: Radicle S: Cotyledon
- (B) P: Zygote Q: Suspensor R: Cotyledon S: Plumule
- (C) P: Egg Q: Radicle S: Suspensor R: Cotyledon
- (D) P: Zygote Q: Suspensor R: Cotyledon S: Radicle

Correct Answer: (B) P: Zygote Q: Suspensor R: Cotyledon S: Plumule

Solution:

Step 1: The development of a dicot embryo begins with the zygote, which is formed after fertilization (P).

Step 2: The zygote divides to form a proembryo, where the suspensor develops as a structure that supports the embryo by anchoring it and providing nutrients (Q).

Step 3: As the embryo develops into a globular and then heart-shaped stage, the cotyledons (seed leaves) form, which are visible in the heart-shaped embryo (R).

Step 4: In the mature embryo, the plumule (the shoot tip that will develop into the shoot system) is visible between the cotyledons (S).

Step 5: The radicle (future root) is also part of the mature embryo but is not labeled as S in the correct option. Comparing options, (B) correctly labels P as Zygote, Q as Suspensor, R as Cotyledon, and S as Plumule.

Thus, the correct answer is (B).

Quick Tip

In dicot embryo development, the suspensor supports the early embryo, while the cotyledons and plumule are key structures in the mature embryo.

For Question numbers **13 to 16**, two statements are given – one labelled as Assertion (A) and the other labelled as Reason (R). Answer these questions by selecting the appropriate option given below :

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

13. Assertion (A): Perisperm is a diploid tissue.

Reason (R): Perisperm is the remains of nucellus which surrounds the embryo in certain seeds.

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

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

Solution:

Step 1: Perisperm is the remnant of the nucellus, a maternal tissue in the seed, which surrounds the embryo in some seeds (e.g., in black pepper). Thus, Reason (R) is true.

Step 2: The nucellus is a diploid tissue ($2n$) since it is part of the maternal sporophyte. Hence, perisperm, being the remains of the nucellus, is also diploid. Assertion (A) is true.

Step 3: While both statements are true, the reason does not explain why perisperm is diploid; it only describes what perisperm is. The ploidy explanation requires understanding the maternal origin of the nucellus, which is not directly stated in (R).

Thus, the correct answer is (B).

Quick Tip

Perisperm (diploid) is different from endosperm (triploid). Perisperm is maternal tissue (nucellus), while endosperm results from double fertilization.

14. Assertion (A): While working on Staphylococci, Alexander Fleming observed that *Penicillium notatum* inhibits the growth of bacteria.

Reason (R): The inhibiting chemical was commercially extracted and its full potential was established by Alexander Fleming.

- (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: Alexander Fleming, while working on Staphylococci, observed that a mold, *Penicillium notatum*, inhibited bacterial growth, leading to the discovery of penicillin. Assertion (A) is true.

Step 2: However, Fleming did not commercially extract penicillin or establish its full potential. This was done later by Howard Florey and Ernst Chain, who developed penicillin into a usable drug. Reason (R) is false.

Step 3: Since (A) is true and (R) is false, the correct option is (C).

Thus, the correct answer is (C).

Quick Tip

Fleming discovered penicillin, but Florey and Chain were key in its commercial production and application, earning them a shared Nobel Prize with Fleming in 1945.

15. Assertion (A): One of the property of genetic code is degeneracy.

Reason (R): Some amino acids can be coded by more than one codon.

- (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: Degeneracy is a property of the genetic code, meaning that multiple codons can code for the same amino acid. Assertion (A) is true.

Step 2: For example, amino acids like leucine are coded by multiple codons (e.g., CUU, CUC, CUA, CUG). This is exactly what degeneracy means. Reason (R) is true.

Step 3: Since (R) directly explains why the genetic code is degenerate, the correct option is (A).

Thus, the correct answer is (A).

Quick Tip

Degeneracy in the genetic code reduces the impact of mutations, as a change in a codon might still code for the same amino acid.

16. Assertion (A): A bioreactor provides the optimal conditions for achieving the desired product by providing optimum growth conditions.

Reason (R): The most commonly used bioreactors are of stirring type.

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

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

Solution:

Step 1: A bioreactor does provide optimal conditions (e.g., temperature, pH, oxygen levels)

for microorganisms to grow and produce the desired product, such as enzymes or antibiotics. Assertion (A) is true.

Step 2: Stirring-type bioreactors (stirred-tank bioreactors) are indeed the most commonly used due to their efficiency in mixing and aeration. Reason (R) is true.

Step 3: However, the type of bioreactor (stirring type) does not explain why a bioreactor provides optimal conditions; it's just a common design. The explanation for (A) lies in the control of growth parameters, not the bioreactor type.

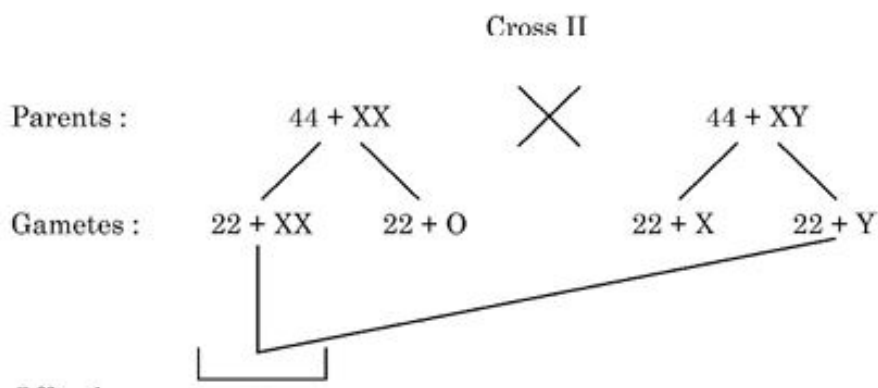
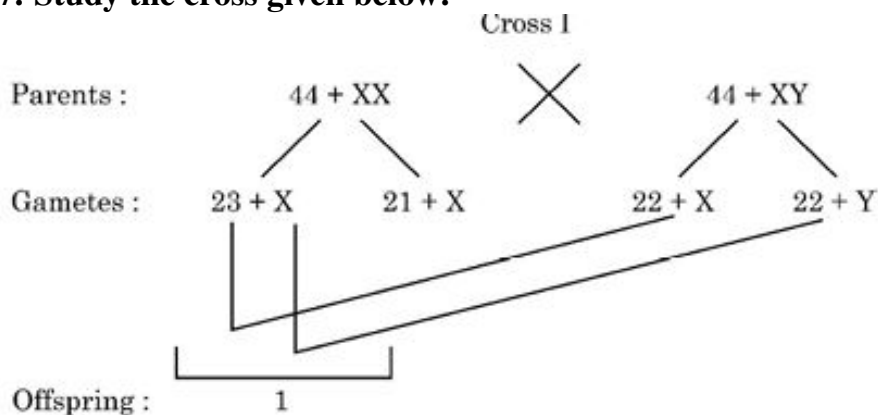
Thus, the correct answer is (B).

Quick Tip

Bioreactors optimize growth by controlling factors like pH, temperature, and oxygen, regardless of their design (e.g., stirred-tank or air-lift).

SECTION B

17. Study the cross given below:



Identify the abnormalities '1' and '2' in the offsprings of a cross done between a couple and distinguish between them.

Solution:

Offspring 1: Turner's Syndrome (45, XO)

- Caused due to absence of one X chromosome (Monosomy).
- Genotype: 44 + XO (total 45 chromosomes).
- Phenotype: Female with underdeveloped secondary sexual characters, short stature, and sterility.

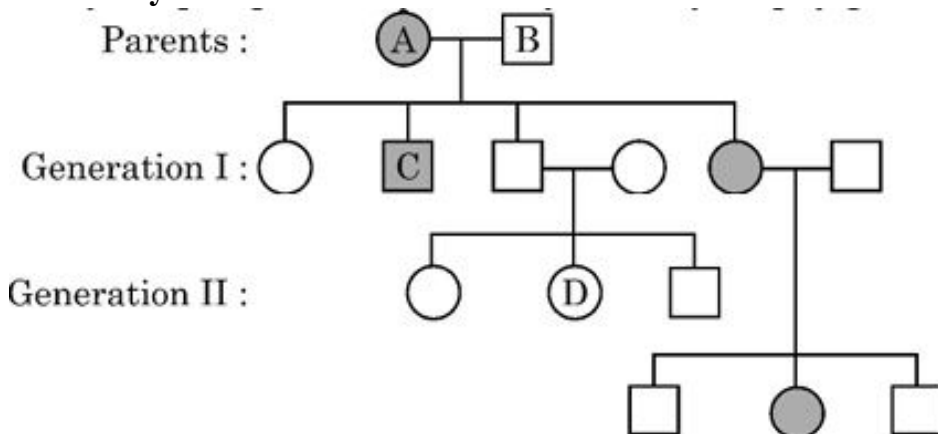
Offspring 2: Klinefelter's Syndrome (47, XXY)

- Caused due to the presence of an extra X chromosome (Trisomy).
- Genotype: 44 + XXY (total 47 chromosomes).
- Phenotype: Male with feminine body features, gynecomastia, and sterility.

Quick Tip

Turner's syndrome (XO) results in 45 chromosomes (female), while Klinefelter's syndrome (XXY) results in 47 chromosomes (male). These are chromosomal disorders caused by non-disjunction during gamete formation.

18. Study the pedigree chart given below, showing the inheritance pattern of blood group in a family:



Answer the following questions:

- (a) Give the possible genotypes of individual 1 and 2.
- (b) Which antigen or antigens will be present on the plasma membranes of the R.B.Cs of individuals '5' and '8'?

Solution:

- (a) – Individual 1 (B): Possible genotype = $I^B I^O$
 - Individual 2 (A): Possible genotype = $I^A I^O$

(Since their child (individual 8) has blood group O, both parents must carry the I^O allele.)
- (b) – Individual 5 (AB): Antigens present = A and B antigens
 - Individual 8 (O): Antigens present = None (no A or B antigen present on RBC membrane)

Quick Tip

Blood group inheritance follows codominance (A and B alleles) and simple recessiveness (O allele). Genotype must be inferred from both phenotype and offspring data.

19.(A) A patient with ADA deficiency requires periodic infusion of genetically engineered lymphocytes. Explain why such periodic infusion is required and also suggest a permanent cure for such ADA deficiency.

Solution: Step 1: ADA (Adenosine Deaminase) deficiency leads to severe combined immunodeficiency (SCID), where lymphocytes are non-functional.

Step 2: Periodic infusion of genetically engineered lymphocytes is needed because these modified cells have a limited lifespan and cannot multiply to maintain the therapeutic effect.

Step 3: Since these engineered cells are not incorporated into the patient's genome permanently, repeated infusions are necessary.

Step 4: A permanent cure can be achieved by gene therapy where a functional ADA gene is introduced into embryonic stem cells or early bone marrow cells of the patient, allowing lifelong expression.

Quick Tip

Gene therapy offers a long-term solution for ADA deficiency by incorporating the correct gene into the patient's genome—eliminating the need for repeated infusions.

OR

19.(B) Describe in brief any two techniques that can be utilised to transfer recombinant DNA into the host cell directly without using any vector.

Solution: Step 1: Microinjection: The recombinant DNA is directly injected into the nucleus of an animal cell using a fine micro-needle under a microscope.

Step 2: Gene Gun or Biolistics: High-velocity micro-particles coated with DNA are bombarded into plant cells to deliver the recombinant DNA directly.

Step 3: These physical methods bypass the need for a vector, allowing direct DNA transfer into host cells.

Quick Tip

Microinjection and gene gun are physical, vector-free methods for direct DNA delivery—commonly used in animal and plant biotechnology.

20.(A) How are morphine and heroin related? Mention their effect on the human body.

Solution:

Step 1: Morphine and heroin are both opioids derived from the opium poppy plant, *Papaver somniferum*.

Step 2: Morphine is a natural alkaloid extracted directly from the opium poppy, while heroin is a semi-synthetic drug produced by chemically modifying morphine (diacetylmorphine).

Step 3: Both act on the central nervous system by binding to opioid receptors, leading to pain relief, euphoria, and sedation. However, they also cause side effects like drowsiness, respiratory depression, and constipation.

Step 4: Heroin is more potent and addictive than morphine, crossing the blood-brain barrier faster, leading to a higher risk of dependency and overdose. Long-term use of both can result in tolerance, addiction, and severe withdrawal symptoms.

Quick Tip

Morphine and heroin are structurally related as opioids, but heroin's faster action makes it more addictive and dangerous.

OR

20.(B) (i) Name an alcoholic drink which is produced by the help of microbes:

- (1) With distillation
- (2) Without distillation

(ii) Explain how cyanobacteria can be used as bio-fertilizer.

Solution:

Step 1: (i) Alcoholic drinks produced by microbes:

(1) *With distillation:* Whisky is produced by fermenting grains (e.g., barley) using yeast (*Saccharomyces cerevisiae*), followed by distillation to increase alcohol content.

(2) *Without distillation:* Beer is produced by fermenting barley malt with yeast, without distillation, resulting in a lower alcohol content.

Step 2: (ii) Cyanobacteria as bio-fertilizer: Cyanobacteria, such as *Anabaena* and *Nostoc*, can fix atmospheric nitrogen into ammonia due to the presence of heterocysts (specialized cells).

Step 3: This ammonia is converted into nitrates, enriching the soil with nitrogen, which is essential for plant growth. Cyanobacteria are often used in paddy fields to naturally enhance soil fertility.

Step 4: Additionally, cyanobacteria produce growth-promoting substances and improve soil structure, making them effective bio-fertilizers.

Quick Tip

Cyanobacteria are eco-friendly bio-fertilizers, especially in rice fields, as they fix nitrogen naturally and reduce the need for chemical fertilizers.

21.(A) Analyse the following ecosystems and discuss, which will be more productive in terms of primary productivity: A young forest, a natural old forest, a shallow polluted lake.

Solution:

Step 1: Primary productivity refers to the rate at which biomass is produced by photosynthetic organisms (producers) in an ecosystem, measured as energy or biomass per unit area per unit time.

Step 2: A young forest: A young forest has rapidly growing plants with high photosynthetic rates, leading to high primary productivity due to less competition and more resources (light, nutrients). However, the total biomass is lower than in an old forest.

Step 3: A natural old forest: An old forest has mature trees with high biomass but lower growth rates. Primary productivity is moderate because, while photosynthesis occurs, much energy is used for maintenance rather than new growth.

Step 4: A shallow polluted lake: A shallow polluted lake often suffers from eutrophication (nutrient overload), leading to algal blooms that increase primary productivity initially. However, pollution can cause oxygen depletion, harming aquatic life and reducing overall productivity over time.

Step 5: Comparison: The young forest is likely the most productive in terms of primary productivity because of its rapid growth and high photosynthetic rate. A shallow polluted lake may have high productivity during algal blooms but is unsustainable. An old forest, while stable, has lower productivity due to slower growth rates.

Thus, the young forest will be the most productive in terms of primary productivity.

Quick Tip

Young ecosystems often have higher primary productivity due to rapid growth, while old ecosystems have more biomass but slower growth rates.

OR

21.(B) Differentiate between Net primary productivity and Gross primary productivity in an ecosystem.

Solution:

Step 1: Gross Primary Productivity (GPP): GPP is the total amount of energy or biomass produced by photosynthetic organisms (producers) through photosynthesis per unit area per unit time in an ecosystem.

Step 2: Net Primary Productivity (NPP): NPP is the energy or biomass that remains after accounting for the energy used by producers for respiration. It is the energy available for consumption by herbivores and decomposers.

Step 3: Mathematical Relationship: $NPP = GPP - \text{Respiration (R)}$, where respiration is the energy used by plants for metabolic activities like growth and maintenance.

Step 4: Key Difference: GPP represents the total energy fixed by photosynthesis, while NPP is the energy left after plants' respiratory losses, which supports the rest of the ecosystem (e.g., herbivores).

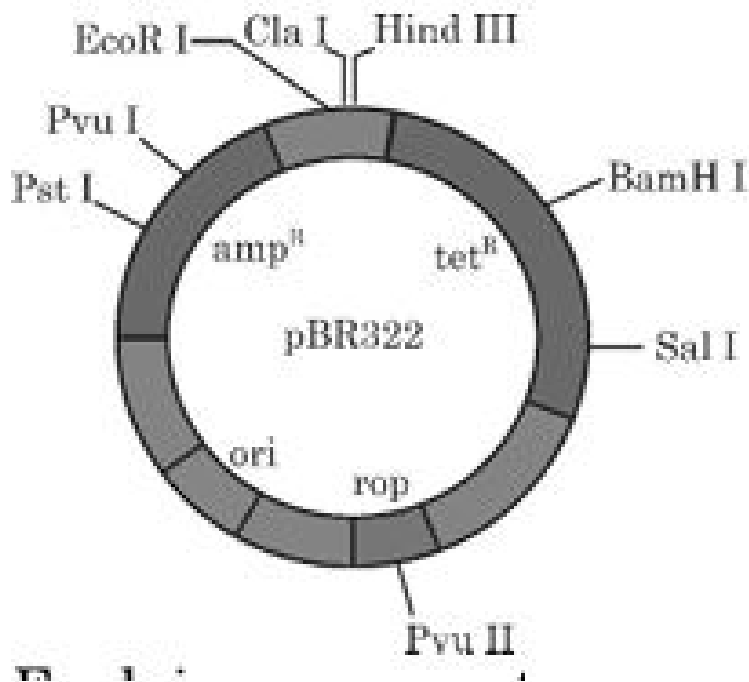
For example, in a forest, GPP might be high due to photosynthesis, but NPP is lower because mature trees use a significant portion of energy for respiration.

Quick Tip

NPP is what sustains ecosystems as it represents the energy available for higher trophic levels, while GPP includes energy plants use themselves.

SECTION C

22.(a) Explain the importance of 'ori' and 'rop' in the *E. coli* cloning vector shown in the above diagram.



Solution:

Step 1: 'ori' (origin of replication) is a DNA sequence that initiates the replication of the plasmid within the host *E. coli* cell.

Step 2: The presence of 'ori' ensures that the plasmid can replicate independently of the host chromosome, allowing multiple copies of the recombinant DNA to be produced per cell.

Step 3: 'rop' (repressor of primer) is a gene that encodes a protein regulating the copy number of the plasmid by controlling replication at the 'ori'.

Step 4: The 'rop' protein helps maintain a stable, moderate copy number of the plasmid, preventing over-replication, which could be toxic to the host cell.

Thus, 'ori' enables replication, while 'rop' ensures controlled replication for efficient cloning.

Quick Tip

'ori' is essential for plasmid replication, and 'rop' fine-tunes the process to avoid over-burdening the host cell.

22.(b) Differentiate between exonuclease and endonuclease.

Solution:

Step 1: Exonuclease: An exonuclease is an enzyme that removes nucleotides from the ends (either 5' or 3') of a DNA or RNA strand.

Step 2: Endonuclease: An endonuclease is an enzyme that cleaves the phosphodiester bonds within the DNA or RNA strand, cutting at specific internal sites.

Step 3: Key Difference: Exonucleases act on the terminal ends of the nucleic acid, while endonucleases cut within the strand. For example, restriction enzymes like EcoRI (seen in the diagram) are endonucleases, cutting at specific recognition sites.

Step 4: Application: Exonucleases are used to remove unwanted nucleotides (e.g., in DNA polishing), while endonucleases are crucial in cloning for cutting DNA at specific sites to insert foreign DNA.

Thus, the primary difference lies in their site of action—ends versus internal regions.

Quick Tip

Endonucleases like restriction enzymes are widely used in genetic engineering to create sticky or blunt ends for DNA ligation.

23.(a) The great German naturalist and geographer Alexander Von Humboldt observed that within a region species richness increased with increasing explored area, but only up to a limit.

For the above situation, construct a graph and write an equation.

Solution:

Step 1: Alexander Von Humboldt's observation describes the species-area relationship, where species richness (S) increases with area (A) but eventually levels off due to habitat saturation or other limiting factors.

Step 2: Graph Construction: Plot species richness (S) on the y-axis and area (A) on the x-axis. The graph starts with a steep increase in S as A increases, then gradually levels off, forming a curve that approaches a maximum value (asymptote). This is typically a logarithmic

or power-law relationship that plateaus.

Step 3: Equation: The species-area relationship is often expressed as a power law: $S = cA^Z$, where S is the number of species, A is the area, c is a constant, and Z is the regression coefficient. However, since the increase levels off, a more appropriate model might be a logarithmic form: $S = k \log(A) + b$, where k and b are constants, reflecting the slowing growth rate of species richness.

Step 4: In practice, the graph would show a curve that rises quickly at first (when A is small) and then flattens as A becomes very large, indicating that new species are harder to find in larger areas due to ecological limits.

Quick Tip

The species-area relationship often follows a power law ($S = cA^Z$) or logarithmic curve, but always levels off due to ecological constraints like habitat diversity.

23.(b) Also write the various values of Z (regression coefficient).

Solution:

Step 1: The regression coefficient Z in the species-area relationship equation $S = cA^Z$ represents the slope of the relationship on a log-log scale, indicating how quickly species richness increases with area.

Step 2: Z values typically range between 0.1 and 0.3 for most ecosystems, depending on the type of habitat and the taxonomic group studied.

Step 3: For small areas or islands (e.g., island biogeography), Z is often between 0.2 and 0.3, as seen in studies of birds or insects on islands. For larger continental areas, Z can be lower, around 0.1 to 0.2, because species diversity increases more slowly due to greater habitat homogeneity.

Step 4: In extreme cases, such as highly isolated or species-poor regions, Z might approach 0.4 or higher, but this is less common. For example, in Humboldt's observations of tropical regions, Z might be around 0.15 to 0.25, reflecting high biodiversity but with a plateau effect. Thus, typical Z values range from 0.1 to 0.3, with higher values in more isolated or diverse ecosystems.

Quick Tip

Z values are higher in isolated ecosystems like islands (0.2–0.3) and lower in continental areas (0.1–0.2) due to differences in habitat diversity and species dispersal.

24.(a) Shyam and Radha are expecting their first child with Radha being in her second month of pregnancy with no complications. Shyam’s family has a history of cystic fibrosis while Radha’s family has a history of Down’s syndrome, leading to a concern that the baby may have one of these conditions. Suggest and explain a way of testing if their baby is at risk for any genetic disorders.

Solution:

Step 1: To test for genetic disorders like cystic fibrosis and Down’s syndrome, prenatal genetic testing is recommended.

Step 2: One common method is **amniocentesis**, which can be performed between 15–20 weeks of pregnancy, but since Radha is in her second month (around 8 weeks), a more suitable option is **Chorionic Villus Sampling (CVS)**. CVS can be done between 10–13 weeks.

Step 3: In CVS, a small sample of placental tissue (chorionic villi) is taken and analyzed for genetic abnormalities. For Down’s syndrome, a karyotype analysis can detect an extra chromosome 21 (trisomy 21). For cystic fibrosis, DNA testing can identify mutations in the CFTR gene.

Step 4: Additionally, non-invasive prenatal testing (NIPT) can be done as early as 10 weeks by analyzing fetal DNA in the mother’s blood to screen for Down’s syndrome, though it’s less definitive for cystic fibrosis.

Thus, CVS is a suitable method at this stage to test for both conditions, followed by specific genetic analysis.

Quick Tip

CVS and NIPT are early prenatal tests for genetic disorders; CVS is invasive but diagnostic, while NIPT is non-invasive but a screening tool.

24.(b) In case of the presence of one or both of the abnormalities and posing a risk to the mother's health, mention one possible option for them to consider. Is that option safe for Radha at the current gestational age? Justify.

Solution:

Step 1: If the fetus is diagnosed with cystic fibrosis or Down's syndrome and poses a risk to Radha's health (e.g., due to complications like severe stress or related medical issues), one option is **medical termination of pregnancy (MTP)**.

Step 2: Radha is in her second month (around 8 weeks) of pregnancy. MTP is generally considered safe in the first trimester (up to 12 weeks) using methods like medication (e.g., mifepristone and misoprostol) or a minor surgical procedure (e.g., aspiration).

Step 3: At 8 weeks, MTP is safe for Radha as the fetus is small, and the procedure carries lower risks compared to later stages. Complications like infection or heavy bleeding are rare when performed by a medical professional.

Step 4: However, Radha's overall health, emotional well-being, and local legal regulations must be considered before proceeding with MTP.

Thus, MTP is a viable and safe option at 8 weeks, provided it's medically supervised.

Quick Tip

MTP is safest in the first trimester; early intervention reduces risks to the mother compared to later stages of pregnancy.

24.(c) Under what conditions is the process mentioned in (b) illegal?

Solution:

Step 1: The process mentioned in (b) is medical termination of pregnancy (MTP). Its legality depends on the country's laws and specific conditions.

Step 2: In many countries, MTP may be illegal if performed beyond a certain gestational age (e.g., after 20–24 weeks) unless the mother's life is at risk or the fetus has severe abnormalities, as per local laws (e.g., in India under the MTP Act).

Step 3: It may also be illegal if done without medical supervision, by unqualified practition-

ers, or for reasons not permitted by law, such as sex-selective abortion (e.g., banned in India under the PCPNDT Act).

Step 4: Additionally, if the procedure is performed without the mother's informed consent or in a region where abortion is entirely prohibited (e.g., in some countries with strict anti-abortion laws), it would be illegal.

Thus, MTP can be illegal if it violates gestational limits, lacks medical oversight, or is performed for unapproved reasons like sex selection.

Quick Tip

MTP laws vary globally; always check local regulations, especially regarding gestational age and approved medical reasons.

25.(a) Write the palindromic nucleotide sequence for the following sequence of DNA segment: 5'–GAATTC–3'.

Solution:

Step 1: A palindromic sequence in DNA reads the same on both strands in the 5' to 3' direction when considering complementary base pairing.

Step 2: The given sequence is 5'–GAATTC–3'. Its complementary strand (3' to 5') is determined by base pairing: G pairs with C, A with T, T with A, etc.

Step 3: Complementary strand (3' to 5'): 3'–CTTAAG–5'. When read in the 5' to 3' direction, the complementary strand is 5'–GAATTC–3', which matches the original sequence.

Step 4: Thus, the palindromic sequence is:

5'–GAATTC–3'

3'–CTTAAG–5'

This is a palindromic sequence because both strands read 5'–GAATTC–3' in their respective directions.

Quick Tip

Palindromic sequences are targets for restriction enzymes; they read the same on both strands in the 5' to 3' direction.

25.(b) Name the restriction endonuclease that recognizes this sequence.

Solution:

Step 1: The sequence 5'–GAATTC–3' is a well-known palindromic sequence recognized by a specific restriction endonuclease.

Step 2: The restriction endonuclease that recognizes this sequence is **EcoRI**, derived from the bacterium *Escherichia coli* RY13.

Step 3: EcoRI cuts between the G and A on both strands, producing sticky ends. This makes it widely used in genetic engineering for cloning.

Thus, the restriction endonuclease is EcoRI.

Quick Tip

EcoRI is a commonly used restriction enzyme in biotechnology, producing sticky ends that facilitate DNA ligation.

25.(c) How are sticky ends produced? Mention their role.

Solution:

Step 1: Sticky ends are produced when a restriction endonuclease like EcoRI cuts a palindromic DNA sequence asymmetrically, leaving overhanging single-stranded regions.

Step 2: For the sequence 5'–GAATTC–3', EcoRI cuts between G and A on both strands:

5'–G↓AATTC–3'

3'–CTTAA↑G–5'

This results in:

5'–G AATTC–3'

3'–CTTAA G–5'

The overhanging sequences (5'–AATT–3' and 3'–TTAA–5') are the sticky ends.

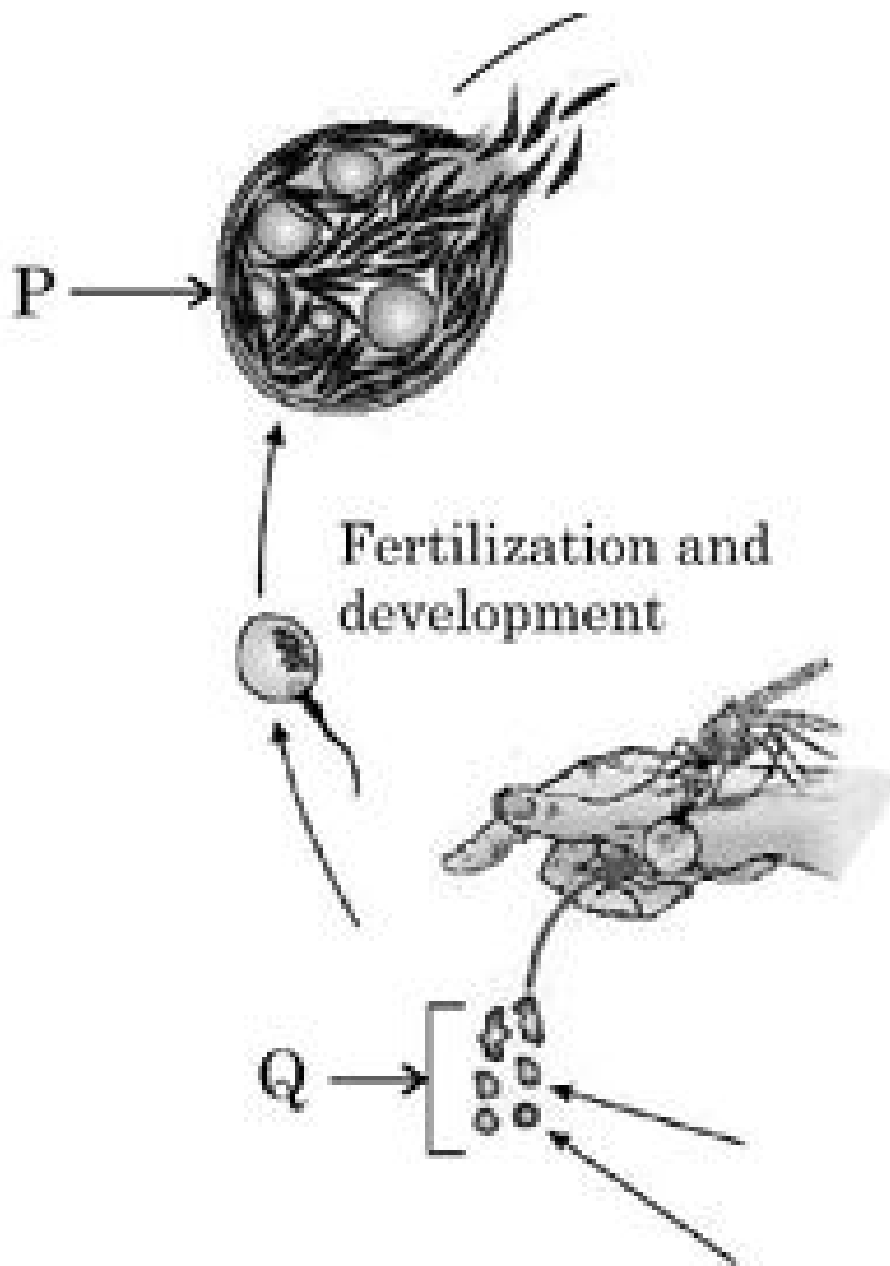
Step 3: Role of Sticky Ends: Sticky ends can base-pair with complementary overhangs on other DNA fragments cut by the same enzyme, facilitating ligation during cloning.

Step 4: This base-pairing ensures precise joining of DNA fragments, making sticky ends crucial for constructing recombinant DNA in genetic engineering.

Thus, sticky ends are produced by staggered cuts and are essential for efficient DNA ligation in cloning.

Quick Tip

Sticky ends allow specific and efficient joining of DNA fragments, unlike blunt ends, which are harder to ligate accurately.



26.(a) Name the infective stage of Plasmodium that is stored in the female Anopheles mosquito.

Solution:

Step 1: The life cycle of Plasmodium, the parasite causing malaria, involves multiple stages, and the female Anopheles mosquito acts as the vector.

Step 2: The infective stage of Plasmodium that is stored in the salivary glands of the female Anopheles mosquito is the *sporozoite*.

Step 3: When the mosquito bites a human, sporozoites are injected into the bloodstream, initiating infection.

Thus, the infective stage is the **sporozoite**.

Quick Tip

Sporozoites are the motile, infective forms of Plasmodium that target the liver cells of the human host to begin the infection cycle.

26.(b) Where does fertilization and development of the parasite take place?

Solution:

Step 1: In the life cycle of Plasmodium, fertilization and development occur within the mosquito vector, as shown in the diagram at stage Q.

Step 2: Fertilization occurs when male and female gametocytes, taken up by the mosquito during a blood meal, fuse in the mosquito's gut to form a zygote.

Step 3: The zygote develops into an ookinete, which then forms an oocyst in the mosquito's gut wall. The oocyst eventually ruptures, releasing sporozoites that migrate to the salivary glands.

Thus, fertilization and development of the parasite take place in the **gut of the female Anopheles mosquito**.

Quick Tip

The mosquito's gut provides the environment for Plasmodium's sexual reproduction, while the human host supports asexual reproduction.

26.(c) Identify labels P and Q in the given diagram.

Solution:

Step 1: The diagram shows a part of the Plasmodium life cycle, with labels P and Q indicating specific stages.

Step 2: Label P represents the stage where sporozoites are present in the mosquito's salivary glands, ready to infect a human host. This stage is the *sporozoite stage*.

Step 3: Label Q represents the process of fertilization and development, where gametocytes fuse and develop into sporozoites within the mosquito's gut. This is the *fertilization and development stage*.

Thus, P is the **sporozoite stage**, and Q is the **fertilization and development stage**.

Quick Tip

Understanding the stages of Plasmodium's life cycle helps in developing strategies to interrupt malaria transmission.

26.(d) Asexual and sexual phases of the Plasmodium take place in two different hosts.

Write their names.

Solution:

Step 1: Plasmodium's life cycle involves two hosts: a primary host (where asexual reproduction occurs) and a secondary host (where sexual reproduction occurs).

Step 2: The asexual phase occurs in the human host, where sporozoites develop into merozoites in the liver and blood, causing malaria symptoms.

Step 3: The sexual phase occurs in the female Anopheles mosquito, where gametocytes undergo fertilization and development to produce sporozoites.

Thus, the asexual phase occurs in the **human**, and the sexual phase occurs in the **female Anopheles mosquito**.

Quick Tip

The dual-host life cycle of Plasmodium makes malaria control challenging, requiring interventions targeting both humans and mosquitoes.

27. Compare and contrast convergent and divergent evolution. Solution:

Step 1: Convergent and divergent evolution are two patterns of evolution that describe how

species adapt and evolve over time.

Step 2: Convergent Evolution: This occurs when unrelated species develop similar traits due to similar environmental pressures, despite not sharing a common ancestor. For example, the wings of birds and insects both serve the purpose of flight, but they evolved independently.

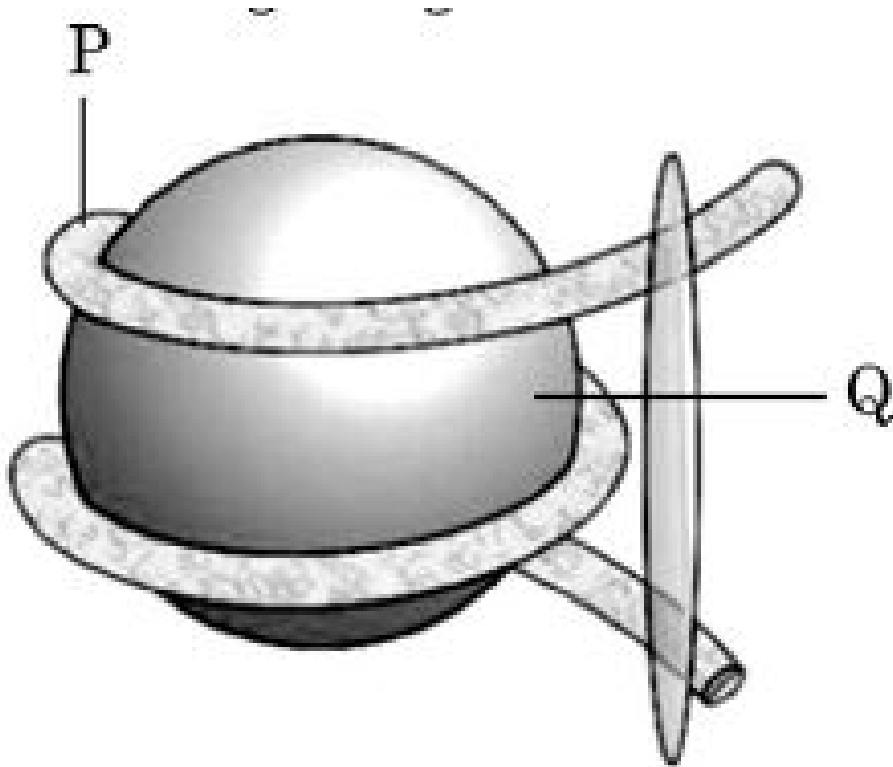
Step 3: Divergent Evolution: This occurs when related species or populations diverge and develop distinct traits due to different environmental pressures or adaptations. For example, Darwin's finches evolved different beak shapes from a common ancestor to adapt to different food sources.

Step 4: Comparison: In convergent evolution, species become more similar in function or structure (analogous structures), while in divergent evolution, species become more distinct (homologous structures). Convergent evolution reflects adaptation to similar environments, while divergent evolution reflects adaptation to different environments.

Thus, convergent evolution leads to **similar traits in unrelated species**, while divergent evolution leads to **distinct traits in related species**.

Quick Tip

Convergent evolution results in analogous structures (e.g., wings of birds and insects), while divergent evolution results in homologous structures (e.g., forelimbs of mammals).



28.(a) Identify the structure shown in the above figure.

Solution:

Step 1: The diagram shows a structure with a DNA double helix wrapped around a core, which is a characteristic feature of eukaryotic chromosome organization.

Step 2: This structure is known as a *nucleosome*, where DNA is wound around a histone protein core to compact the genetic material.

Step 3: The nucleosome is the fundamental unit of chromatin, aiding in DNA packaging within the nucleus.

Thus, the structure shown is a **nucleosome**.

Quick Tip

Nucleosomes help in compacting DNA into the nucleus and play a role in regulating gene expression by controlling access to DNA.

28.(b) Identify the labels P and Q.

Solution:

Step 1: In the diagram of the nucleosome, label P points to the core around which the DNA is wrapped, and label Q points to the DNA strand itself.

Step 2: The core (P) consists of histone proteins, specifically a histone octamer made of two copies each of histones H2A, H2B, H3, and H4.

Step 3: The strand (Q) is the DNA double helix that wraps around the histone core, approximately 147 base pairs in length.

Thus, P is the **histone core**, and Q is the **DNA double helix**.

Quick Tip

The histone core and DNA together form the nucleosome, with linker DNA connecting adjacent nucleosomes in chromatin.

28.(c) Write the nature of histone proteins.

Solution:

Step 1: Histone proteins are a key component of the nucleosome, facilitating DNA packaging in eukaryotic cells.

Step 2: Histones are small, positively charged proteins due to their high content of basic amino acids like lysine and arginine.

Step 3: This positive charge allows histones to interact strongly with the negatively charged phosphate backbone of DNA, stabilizing the nucleosome structure.

Thus, histone proteins are **basic and positively charged**.

Quick Tip

The basic nature of histones enables tight DNA binding, while their modifications (like acetylation) regulate gene expression.

28.(d) Distinguish between Euchromatin and Heterochromatin.

Solution:

Step 1: Chromatin in eukaryotic cells exists in two forms: euchromatin and heterochromatin, differing in structure and function.

Step 2: Euchromatin is loosely packed, transcriptionally active, and rich in gene expression, as it allows access to DNA for transcription machinery.

Step 3: Heterochromatin is tightly packed, transcriptionally inactive, and often found in regions like centromeres and telomeres, where it helps maintain structural integrity.

Step 4: Structurally, euchromatin has a more open conformation, while heterochromatin is condensed, often with more histone modifications that silence genes.

Thus, euchromatin is **loosely packed and transcriptionally active**, while heterochromatin is **tightly packed and transcriptionally inactive**.

Quick Tip

Euchromatin and heterochromatin states can switch during the cell cycle or development, influencing gene regulation and genome stability.

SECTION D

Question Nos. 29 and 30 are case-based questions. Each question has 3 sub-questions with internal choice in one sub-question.

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

In nature, we rarely find isolated, single individuals of any species; majority of them live in groups in a well-defined geographical area, share or compete for similar resources, potentially interbreed and thus constitute a population. The population has certain attributes whereas, an individual organism does not. A population at a given time is composed of individuals of different ages. The size of the population tells us a lot about its status in the habitat. Whatever ecological processes we wish to investigate in a population, be it the outcome of competition with another species, the impact of the predator or the effect of pesticide application, we always evaluate in terms of any change in the population size. The size, in nature, could be low or go into millions. Population size, technically called population density (N) need not necessarily be measured in numbers

only. The size of a population for any species is not a static parameter. It keeps on changing with time depending on various factors including food availability, predation pressure and adverse weather.

(a) The Monarch butterfly is highly distasteful to its predator because of a special chemical present in its body. How does the butterfly acquire this chemical?

(b) If population density at a time $t + 1$ is 800, Emigration = 100, Immigration = 200, Natality = 200 and Mortality = 150, calculate the population density at time t and comment upon the type of age pyramid that will be formed in this case.

Student to attempt either sub-part (c) or (d):

(c) What is the difference in a method of measuring population density in an area if there are 200 carrot grass plants to only single huge banyan tree?

OR

(d) Name two methods to measure the population density of tigers.

Solution:

Step 1 (a): Monarch butterflies acquire the chemical by feeding on poisonous milkweed plants during their larval stage. These chemicals accumulate in their body making them unpalatable to predators.

Step 2 (b):

Population at $t + 1 = 800$

Using formula:

$$N_{t+1} = N_t + \text{Natality} + \text{Immigration} - \text{Mortality} - \text{Emigration}$$

$$800 = N_t + 200 + 200 - 150 - 100$$

$$800 = N_t + 150 \Rightarrow N_t = 650$$

Since natality and immigration are higher than mortality and emigration, it indicates a growing population. Therefore, the type of age pyramid formed would be ****expanding****.

Step 3 (c):

For carrot grass (uniform, small individuals), population density is best measured in terms of

****number of individuals per unit area**.**

For a huge banyan tree (single large organism with many offshoots), population is better measured in terms of ****biomass**** or ****canopy cover****.

OR

Step 3 (d):

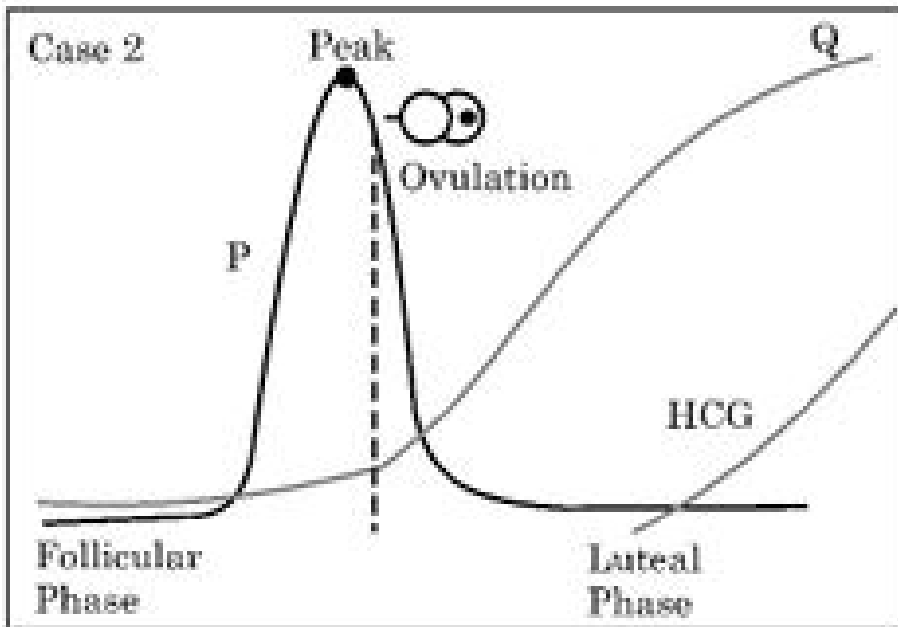
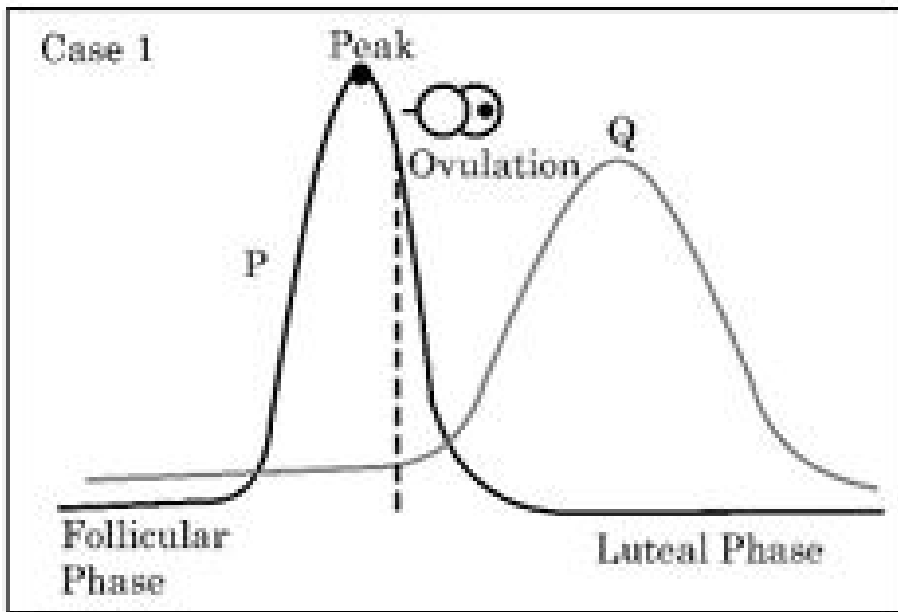
Two methods to measure tiger population density:

1. ****Pugmark method**** – tracking and counting footprints.
2. ****Camera trapping**** – using motion-sensor cameras to photograph and identify individual tigers.

Quick Tip

Population density is dynamic and varies with birth, death, immigration, and emigration. Different species require different techniques to estimate their population effectively.

30. Study the graphs given below for Case 1 and Case 2 showing different levels of certain hormones and answer the question that follows:



- (a) Which hormone is responsible for the peak observed in Case 1 and Case 2? Write one function of that hormone.
- (b) Write changes that take place in the ovary and uterus during follicular phase.
- Student to attempt either sub-part (c) or (d):
- (c) Name the hormone Q of Case 2. Write one function of hormone Q.

OR

- (d) Which structure in the ovary will remain functional in Case 2? How is it formed?

Solution:

Step 1 (a): The hormone responsible for the peak in both Case 1 and Case 2 is **Luteinizing Hormone (LH)**.

Function: LH stimulates ovulation and formation of corpus luteum.

Step 2 (b): During the follicular phase, in the ovary, a primary follicle develops into a Graafian follicle.

In the uterus, the endometrium regenerates under the influence of estrogen.

Step 3 (c): Hormone Q in Case 2 is **Progesterone**.

Function: Maintains the endometrial lining for implantation and supports early pregnancy.

OR

Step 3 (d): The functional structure in Case 2 is the **Corpus luteum**.

It is formed from the Graafian follicle after ovulation under the influence of LH.

Quick Tip

LH surge is essential for ovulation. Progesterone from the corpus luteum helps maintain pregnancy until the placenta takes over.

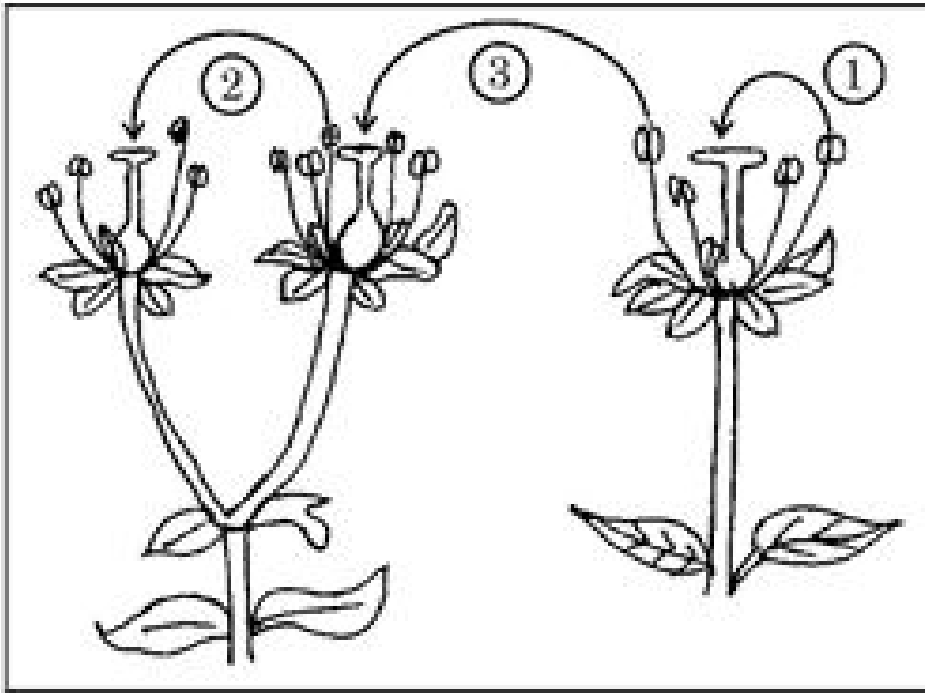
SECTION E

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

(A) (a) Distinguish between the two cells enclosed in a mature male gametophyte of an angiosperm.

(b) Study the diagram given below showing the modes of pollination.

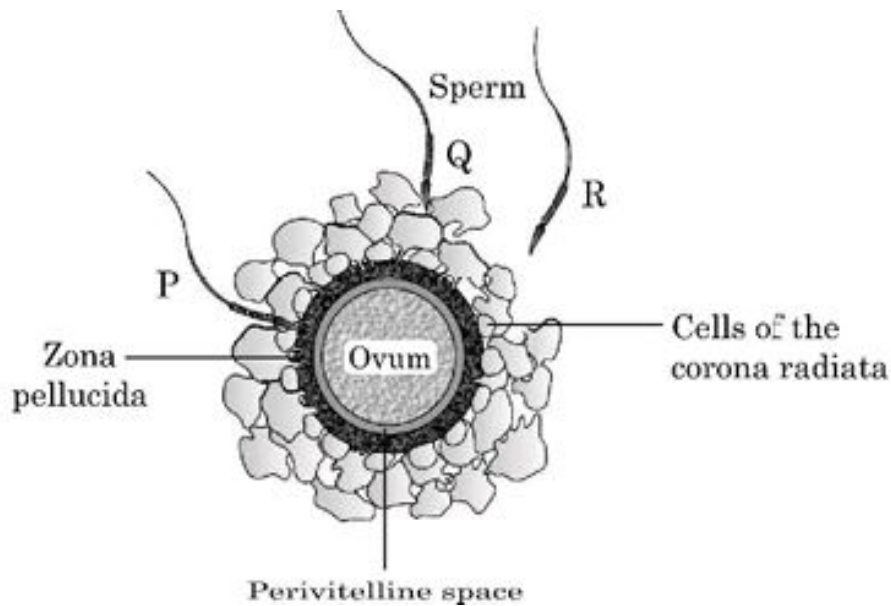
Answer the questions that follow.



- (i) The given diagram shows three methods of pollen transfer in plants. Examine them carefully and write the technical terms used for pollen transfer methods '1', '2' and '3'.
- (ii) How do the following plants achieve pollination successfully?
- Water lily
 - Vallisneria
- (iii) Write advantages of pollen transfer in method '3'.

OR

(B) Given below is the diagram of human ovum surrounded by a few sperms. Observe the diagram and answer the questions that follow:



1. Compare the fate of sperms 'P', 'Q' and 'R' shown in the diagram.
2. Write the role of Zona pellucida in this process.
3. Analyse the changes occurring in the ovum after the entry of sperm.
4. How acrosome and middle piece of a human sperm are able to play an important role in human fertilization?

Solution:

Step 1 (A):

1. In a mature male gametophyte of an angiosperm, two cells are enclosed:
 - **Generative cell:** Divides to form two male gametes (sperms).
 - **Vegetative cell:** Forms the pollen tube for gamete transfer.
2. (a) Technical terms:
 - 1 — Autogamy
 - 2 — Geitonogamy
 - 3 — Xenogamy
- (b) Pollination modes:

- **Water lily:** By insects (entomophily)
- **Vallisneria:** By water (hydrophily)

(c) Advantages of Xenogamy (method '3'):

- Introduces genetic variation.
- Helps in evolution and adaptability.

Step 2 (B):

1. Fate of sperms:

- **P:** Fails to penetrate the ovum.
- **Q:** Successfully fertilizes the ovum.
- **R:** Degenerates.

2. Role of Zona pellucida:

- It prevents polyspermy by blocking entry of additional sperms once one sperm has penetrated.

3. Changes after sperm entry:

- Completion of meiosis II.
- Formation of female pronucleus.
- Zona reaction to block polyspermy.

4. Role of acrosome and middle piece:

- **Acrosome:** Contains enzymes to digest egg membranes.
- **Middle piece:** Packed with mitochondria providing energy for sperm motility.

Quick Tip

Remember — pollen transfer can occur within the same flower, between flowers of the same plant, or different plants. Similarly, acrosomal enzymes like hyaluronidase and zona lysin aid sperm entry during fertilization.

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

(A) Answer the following questions:

1. State what do you understand by “MALT”? Where is it located inside our body?
2. Explain cytokine barriers.
3. Name the diagnostic test for AIDS. On what principle does it work?
4. Bone marrow and thymus play an important role in human immune system. Explain how are they able to achieve this.

OR

(B)

1. Study the following table & fill ‘H’, ‘T’, ‘J’, ‘K’, ‘L’ and ‘M’ in the following table with suitable words:

| | Chemical / Bioactive Molecule | Micro-organism | Category | Use |
|-----|-------------------------------|---------------------------|----------|--|
| (a) | Butyric acid | H | I | Important applications in food, chemical & pharma industry Inhibit cholesterol biosynthesis pathway |
| (b) | J | <u>Monascus purpureus</u> | K | |
| (c) | Cyclosporin A | L | Fungus | |

2. Why are baculoviruses used as biological control agents?

Solution:

Step 1 (A):

1. **MALT (Mucosa-Associated Lymphoid Tissue)** is a component of the immune system found in mucosal linings such as the respiratory tract, gut, and urogenital tract. It provides localized immunity at the mucosal surfaces.

2. **Cytokine barriers** refer to proteins like interferons secreted by virus-infected cells that protect non-infected cells from further viral infection.
3. The diagnostic test for AIDS is the **ELISA test**. It works on the principle of antigen-antibody interaction, detecting HIV antibodies in the blood.
4. Bone marrow produces lymphocytes while the thymus is where T-lymphocytes mature. Together, they generate a functional immune system capable of defending the body.

Step 2 (B):

1. See the filled table above in the question section.
2. **Baculoviruses** are used as biological control agents because they are species-specific, do not harm non-target organisms, and are safe for the environment. They infect only specific insect pests.

Quick Tip

Interferons and cytokines are key natural defense mechanisms against viral infections. Also, microbes provide a wide range of bioactive compounds used in medical and industrial applications.

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

(A) Answer the following questions:

1. Haemophilia and red-green colourblindness is usually observed in men. Why?
2. Perform a cross (or crosses) where haemophilic daughter(s) and haemophilic son(s) are produced in the same ratio.

OR

(B)

1. Where do transcription and translation occur in bacteria and eukaryotes respectively?
2. Draw a labelled schematic sketch of replication fork of DNA.

3. A DNA segment has a total of 1000 nucleotides, out of which 240 of them are Adenine-containing nucleotides. How many pyrimidine bases does this segment possess?

Solution:

Step 1 (A):

1. Haemophilia and red-green colourblindness are X-linked recessive disorders. Since men have only one X chromosome, the presence of a single defective gene leads to expression of the disorder. Women, having two X chromosomes, must inherit two defective copies to express the condition, which is less likely.
2. For equal production of haemophilic daughters and sons, the cross must be between a carrier female ($X^H X^h$) and a haemophilic male ($X^h Y$):

| | X^H | X^h |
|-------|------------------------------|----------------------------------|
| X^h | $X^H X^h$ (Carrier Daughter) | $X^h X^h$ (Haemophilic Daughter) |
| Y | $X^H Y$ (Normal Son) | $X^h Y$ (Haemophilic Son) |

This cross results in 1 haemophilic daughter and 1 haemophilic son out of 4 children.

Step 2 (B):

1. In bacteria, both transcription and translation occur in the cytoplasm. In eukaryotes, transcription occurs in the nucleus, and translation occurs in the cytoplasm.
2. *[Insert labelled diagram of DNA replication fork here]*
3. DNA has base pairing: Adenine pairs with Thymine, and Guanine pairs with Cytosine. So, 240 Adenine means 240 Thymine. That's 480 purines.
Total nucleotides = 1000, so remaining 520 are pyrimidines (240 Thymine + 280 Cytosine).

Quick Tip

X-linked disorders affect males more due to the presence of a single X chromosome. Always use complementary base pairing logic when calculating nucleotide distribution in DNA.

