CBSE Class 12 2025 Biology Question Paper (57/6/1) With Solutions

Time Allowed :3 Hour	**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. 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. The process of splicing in eukaryotes represents the dominance of the:

(A) DNA world

(B) RNA world

(C) Protein world

(D) Lipid world

Correct Answer: (B) RNA world

Solution:

Splicing in eukaryotes is a process in which introns are removed from pre-mRNA. This process is carried out by small nuclear RNAs (snRNAs) that are components of the spliceosome. Since RNA itself plays a catalytic role, this highlights the concept of an "RNA world," where RNA molecules acted as both genetic material and catalysts in early forms of life.

Quick Tip

Splicing is catalyzed by RNA (snRNA), not proteins or DNA, emphasizing the idea of RNA's ancient dominance.

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2. Regulation of *lac* operon by repressor is referred to as:

(A) Inducible regulation

(B) Repressible regulation

(C) Negative regulation

(D) Positive regulation

Correct Answer: (C) Negative regulation

Solution:

In the *lac* operon, the repressor protein binds to the operator and inhibits transcription. This inhibition is lifted when an inducer (like lactose) is present. Since the default state is "off"

due to repressor action and transcription only happens when the repressor is inactivated, this is termed negative regulation.

Quick Tip

Negative regulation means a repressor must be removed or inactivated for transcription to occur.

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3. SNPs in Human Genome Project refers to:

(A) Polymorphism in repetitive sequences.

(B) Single-base DNA differences.

(C) Single changes in nucleotide of mRNA.

(D) Loss or gain of a gene function.

Correct Answer: (B) Single-base DNA differences

Solution:

SNPs (Single Nucleotide Polymorphisms) are the most common type of genetic variation among people. They involve a difference at a single base pair in the DNA sequence. The Human Genome Project identified these as critical markers for genetic traits and diseases.

Quick Tip

SNPs = Single Nucleotide Polymorphisms — changes at one base in the DNA.

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4. If a natural population with 50 individuals is in Hardy-Weinberg equilibrium for a gene with two alleles A and a, with the gene frequency of allele A of 0.6, the genotype frequency of Aa will be:

(A) 0.16

(B) 0.36

(C) 0.24

(D) 0.48

Correct Answer: (B) 0.36

Solution:

According to Hardy-Weinberg equilibrium, the genotype frequency of Aa is given by $2pq$, where $p = 0.6$ (frequency of A) and $q = 1 - p = 0.4$.

$$2pq = 2 \times 0.6 \times 0.4 = 0.48$$

Correction: The correct genotype frequency of Aa is actually 0.48, so the correct answer is:

Correct Answer (Revised): (D) 0.48

Quick Tip

Use $2pq$ for heterozygous (Aa) frequency; $p^2 + 2pq + q^2 = 1$.

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5. Given below are a few statements with respect to spermatogenesis in a human male.

(i) Sperms are released from the seminiferous tubules by the process of spermiation.

(ii) Spermiogenesis involves the maturation of spermatids into sperms.

(iii) Spermatogonia produce spermatids by the process of spermiogenesis.

(iv) Meiosis II in secondary spermatocytes results in the formation of four equal haploid spermatids.

(v) Primary spermatocyte completes the first meiotic division forming two equal, diploid cells called secondary spermatocytes.

Choose the option with all true statements from the given options:

(A) (i), (ii) and (iv)

(B) (ii), (iii) and (v)

(C) (ii), (iv) and (v)

(D) (i), (ii) and (iv)

Correct Answer: (A) (i), (ii) and (iv)

Solution:

(i) is correct — spermiation is the release of sperm from Sertoli cells.

(ii) is correct — spermiogenesis is the transformation of spermatids into mature sperm.

(iv) is correct — secondary spermatocytes undergo meiosis II to form haploid spermatids.

(iii) is incorrect — spermatogonia divide mitotically to produce primary spermatocytes, not directly spermatids.

(v) is incorrect — primary spermatocytes undergo meiosis I to form secondary spermatocytes, which are haploid, not diploid.

Quick Tip

Remember: Spermatogonia → Primary spermatocytes → Secondary spermatocytes → Spermatids → Sperm.

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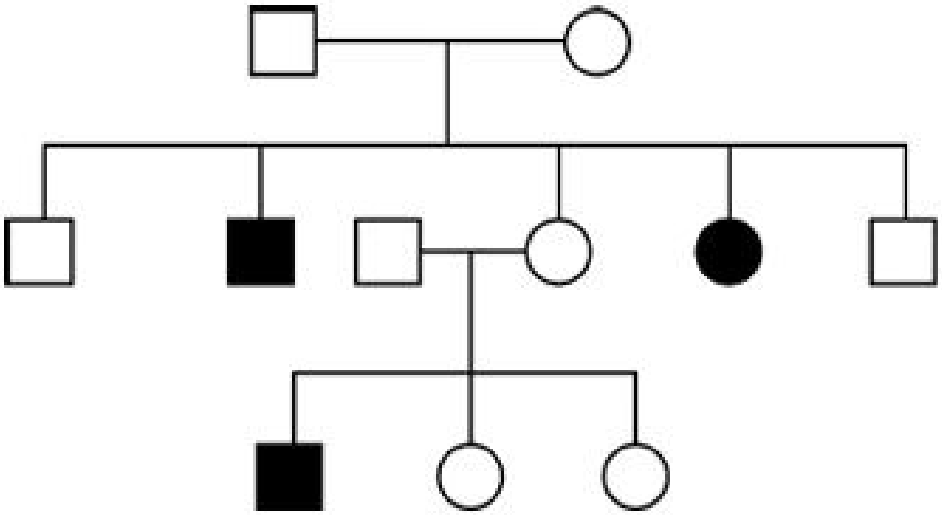
6. Study the pedigree chart of a family sharing the inheritance of sickle cell anemia.



The trait traced in the above pedigree chart is:

(A) Dominant X-linked

(B) Autosomal dominant

(C) Recessive X-linked

(D) Autosomal recessive

Correct Answer: (D) Autosomal recessive

Solution:

In the given pedigree, the trait appears in the offspring of unaffected parents, which is typical

of a recessive trait. Moreover, both males and females are affected in roughly equal proportions, indicating autosomal inheritance rather than sex-linked. Therefore, this pattern corresponds to an autosomal recessive mode of inheritance.

Quick Tip

Autosomal recessive traits often skip generations and affect both sexes equally.

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7. Select the statements that are true for the seed of angiosperm from the given options:

(i) Non-albuminous seeds have no residual endosperm.

(ii) Residual, persistent nucellus in wheat is known as perisperm.

(iii) Integuments of ovules harden as tough protective seed coat.

(iv) Metabolic activity of the embryo slows down in dormancy.

Choose the correct option:

(A) (i) and (ii)

(B) (ii) and (iii)

(C) (ii), (iv) and (v)

(D) (i), (iii) and (iv)

Correct Answer: (D) (i), (iii) and (iv)

Solution:

(i) is correct — Non-albuminous seeds like pea lack residual endosperm.

(ii) is incorrect — Persistent nucellus is termed perisperm, but wheat is typically albuminous and doesn't have perisperm.

(iii) is correct — Integuments become seed coat post-fertilization.

(iv) is correct — Dormancy involves reduced metabolic activity in the embryo.

Quick Tip

Non-albuminous seeds lack endosperm; integuments become seed coat; embryo dormancy slows metabolism.

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8. Which of the following do *not* follow the law of independent assortment?

(A) Genes on non-homologous chromosomes and absence of linkage

(B) Two or more genes on homologous chromosomes

(C) Linked genes located on the same chromosomes

(D) Two or more distant genes present on the same chromosome

Correct Answer: (C) Linked genes located on the same chromosomes

Solution:

Genes that are linked and located close together on the same chromosome tend to be inherited together and do not follow the law of independent assortment, which assumes independent segregation of genes on different chromosomes.

Quick Tip

Linked genes on the same chromosome do not assort independently during meiosis.

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9. A characteristic property that distinguishes a malignant tumor from a benign tumor is:

(A) Metamorphosis

(B) Metastasis

(C) Metabolism

(D) Metagenesis

Correct Answer: (B) Metastasis

Solution:

Malignant tumors spread to distant parts of the body through blood or lymph — this process is known as metastasis. Benign tumors do not exhibit this invasive behavior.

Quick Tip

Metastasis is the key feature that marks a tumor as malignant.

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10. The cloning site present in the tetracycline resistance gene of *E. coli* cloning vector pBR322 is:

(A) EcoR I

(B) Pvu II

(C) Sal I

(D) Pst I

Correct Answer: (C) Sal I

Solution:

In pBR322, the Sal I restriction site is present in the tetracycline resistance gene. Insertion at this site disrupts the tetracycline resistance, allowing for identification of recombinants.

Quick Tip

Sal I is used to insert DNA into the tetracycline resistance gene of pBR322.

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11. Bottled fruit juices are clearer as compared to those made at home, as they are clarified by the use of:

(A) Lipases and pectinases

(B) Pectinases and proteases

(C) Proteases and cellulases

(D) Nucleases and lipases

Correct Answer: (B) Pectinases and proteases

Solution:

Pectinases break down pectin, a component of plant cell walls that causes turbidity.

Proteases remove proteins that also contribute to cloudiness, resulting in clearer juices.

Quick Tip

Pectinases and **proteases** are used in fruit juice clarification.

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12. In his observations of small black birds in the Galapagos Islands, Darwin found that all the finches arose from the original ancestor:

(A) Insect-eating finches

(B) Seed-eating finches

(C) Cactus-eating finches

(D) Fruit-eating finches

Correct Answer: (B) Seed-eating finches

Solution:

Darwin concluded that the various species of finches on the Galapagos Islands evolved from a common ancestor — a seed-eating ground finch. Adaptive radiation led to diversification in feeding habits.

Quick Tip

Adaptive radiation of **seed-eating finches** led to the variety of finches Darwin observed.

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

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

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

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

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

13. Assertion (A): In dihybrid crosses involving sex-linked genes in *Drosophila* generation of non-parental gene combinations are observed.

Reason (R): Two genes present on different chromosomes show linkage and recombination in *Drosophila*.

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

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

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

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

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

Solution:

In *Drosophila*, non-parental gene combinations can arise due to recombination involving sex-linked genes. However, the Reason is incorrect because genes on different chromosomes do not show linkage; linkage occurs between genes on the same chromosome.

Quick Tip

Linkage is only between genes on the same chromosome — not different ones.

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14. Assertion (A): Male contraceptive 'Nirodh' works on the principle of avoiding chances of ovum and sperm meeting.

Reason (R): It is made of thin rubber/latex sheath and is used to cover the penis before coitus.

(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:

'Nirodh' prevents the sperm from entering the female reproductive tract by covering the penis with a latex sheath, thereby avoiding fertilization. Thus, the Reason correctly explains the Assertion.

Quick Tip

Barrier contraceptives like ‘Nirodh’ prevent fertilization physically.

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15. Assertion (A): Isolated single cells can be fused to produce somatic hybrids.

Reason (R): Cells selected for somatic hybridisation have desirable characters.

(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:

Somatic hybridisation involves the fusion of isolated protoplasts from different plant species or varieties with desirable traits to produce hybrids. Therefore, the Reason correctly explains the Assertion.

Quick Tip

Somatic hybrids are made by fusing selected desirable plant cells.

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16. Assertion (A): In humans, filariasis is characterized by inflammation in the lower limbs.

Reason (R): Filarial worm usually lives in the lymphatic vessels of the lower limbs.

(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:

Filariasis, caused by filarial worms such as *Wuchereria bancrofti*, results in the blockage and inflammation of lymphatic vessels, particularly in the lower limbs. The Reason accurately explains the Assertion.

Quick Tip

Filarial worms block lymph vessels in legs, causing inflammation.

SECTION B

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

(A) How is the interaction between *Ophrys* and its specific bee pollinator one of the best examples of co-evolution? Explain.

OR

(B) Arrange the given important steps of decomposition in their correct order of occurrence in the breakdown of complex organic matter and explain the fourth step in the process.

Solution:

(A) Step 1: Co-evolution is a process where two or more species reciprocally affect each other's evolution.

Step 2: In the case of *Ophrys*, the orchid flower mimics the female bee in appearance and scent.

Step 3: This mimicry attracts the male bee for mating, during which pollination occurs.

Step 4: The specific bee species and *Ophrys* have co-evolved to maintain this highly specialized pollination strategy.

Conclusion: This precise and exclusive interaction is one of the best examples of co-evolution.

OR

(B) Step 1: Correct order of decomposition steps:

1. Fragmentation
2. Leaching
3. Catabolism
4. **Humification**
5. Mineralisation

Step 2: Explanation of the fourth step — Humification:

- Humification leads to the formation of a dark-colored, amorphous substance called humus.
- Humus is highly resistant to microbial action and hence persists in the soil for a long time.
- It plays a key role in soil fertility by improving its texture and water-holding capacity.

Quick Tip

Ophrys-bee pollination is a classic example of species-specific co-evolution. In decomposition, humification forms stable humus essential for fertile soil.

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18. Study the given flow diagram and answer the questions that follow:

Step 1: Vector DNA (Plasmid) + Alien DNA

(cut using Restriction Enzyme) (cut using Restriction Enzyme)

⇓

Step 2: Recombinant DNA molecule

⇓

Step 3: Transfer of recombinant DNA molecule in *E. coli* (Host)

⇓

Step 4: Replication of the recombinant DNA molecule in *E. coli* to form multiple copies of the alien gene.

(a) What is the technical term used for Step 4 in the above process?

(b) Which of the given two combinations of restriction enzyme should be used in Step 1? Justify your answer.

(i) EcoR I to cut the plasmid and Hind III to cut the alien DNA.

(ii) EcoR I to cut both the plasmid and alien DNA.

Solution:

(a) Step 1: Step 4 involves producing multiple copies of the recombinant DNA.

Step 2: The correct technical term for this process is **cloning**.

Step 3: Cloning allows amplification of the gene of interest inside the host cell.

(b) Step 1: To ligate both vector and foreign DNA, compatible ends are required.

Step 2: If different enzymes (like EcoR I and Hind III) are used, the ends will not match and ligation will be unsuccessful.

Step 3: Therefore, the correct option is (ii): **EcoR I to cut both the plasmid and alien DNA.**

Step 4: Using the same restriction enzyme ensures that both DNA fragments have complementary sticky ends that can easily join.

Quick Tip

Cloning is the term for replicating recombinant DNA. Always use the same restriction enzyme on both vector and insert to produce compatible sticky ends.

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

(A) (i) Explain why the milk produced by the mother during the initial days of lactation is considered to be very essential for the newborn infant.

(ii) What is the term used for the milk produced during the initial days of lactation?

OR

(B) Many children in the metro cities are suffering from a very common exaggerated response of the immune system to certain weak antigens in air.

(i) What is the term used for the above mentioned disease?

(ii) Name the main type of antibody produced by the immune system in response to this disease.

(iii) Which two main inflammation-causing chemicals are produced by the mast cells in such an immune response?

Solution:

(A) Step 1: The milk produced in the initial days is rich in antibodies, especially IgA, which provides passive immunity to the infant.

Step 2: It helps protect the newborn against infections during early life when the baby's immune system is still developing.

Step 3: The term used for this milk is **colostrum**. It is yellowish and secreted in small quantities but highly nutritious.

OR

(B) Step 1: The exaggerated immune response to weak antigens is called **allergy**.

Step 2: The main type of antibody produced during this response is **IgE**.

Step 3: The mast cells release two major chemicals—**histamine** and **serotonin**—which cause inflammation.

Quick Tip

Colostrum is crucial for neonatal immunity. Allergies involve IgE antibodies and release of histamine and serotonin from mast cells.

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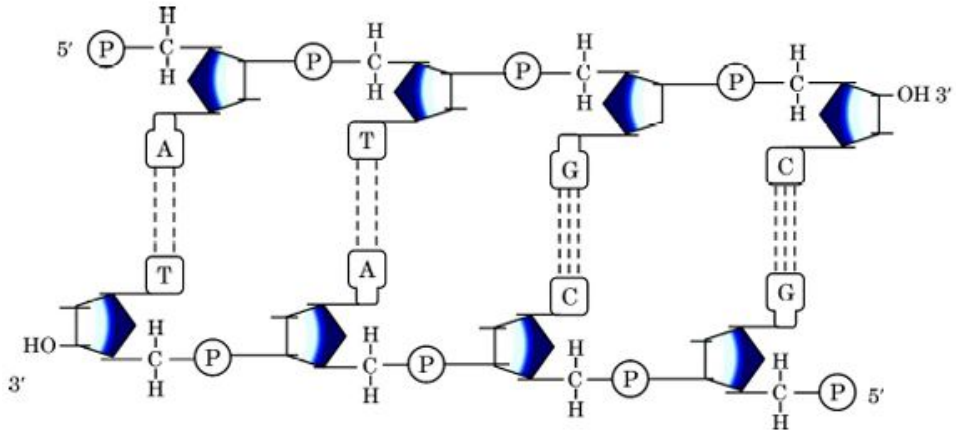
20. Study the given molecular structure of double-stranded polynucleotide chain of DNA and answer the questions that follow.



(a) How many phosphodiester bonds are present in the given double-stranded polynucleotide chain?

(b) How many base pairs are there in each helical turn of double helix structure of DNA? Also write the distance between a base pair in a helix.

(c) In addition to H-bonds, what confers additional stability to the helical structure of DNA?

Solution:

Step 1: Phosphodiester bonds link nucleotides within a single DNA strand. Each strand here has 6 nucleotides, so 5 bonds per strand. Therefore, in a double strand:

$$5 + 5 = 10 \text{ phosphodiester bonds}$$

Step 2: Each turn of the DNA double helix has approximately **10 base pairs**. The distance between two adjacent base pairs is approximately **0.34 nm (nanometers)**. Thus, each helical turn spans:

$$10 \times 0.34 = 3.4 \text{ nm}$$

Step 3: Besides hydrogen bonds, **base stacking interactions** (hydrophobic interactions between bases) contribute additional stability to the helical structure.

Quick Tip

Phosphodiester bonds are between adjacent nucleotides. DNA has 10 base pairs per turn and 0.34 nm spacing. Stacking interactions stabilize DNA helices.

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

(A) Why are restrictions imposed on MTP in India? Up to how many weeks or trimesters is MTP considered relatively safe for a female, if necessary to perform, by a medical practitioner?

OR

(B) Expand PID. Name any two common viral infections transmitted through sexual contact in human females.

Solution:

(A) Step 1: MTP (Medical Termination of Pregnancy) is regulated to avoid misuse and ensure female health and safety.

Step 2: It is legally allowed up to **20 weeks** of pregnancy under certain conditions and up to **24 weeks** under special circumstances (like risk to mother or fetal abnormalities).

Step 3: It must be conducted by a **qualified medical practitioner** in a registered medical facility.

OR

(B) Step 1: PID stands for **Pelvic Inflammatory Disease**.

Step 2: Two viral STDs transmitted through sexual contact in females include:

- **HIV (Human Immunodeficiency Virus)**
- **Herpes Simplex Virus (HSV)**

Quick Tip

MTP is allowed up to 20–24 weeks with conditions in India. PID is a serious reproductive tract infection. HIV and HSV are common viral STDs.

SECTION C

22. Flowering plants with hermaphrodite flowers have developed many reproductive strategies to ensure cross-pollination. Study the given outbreeding devices adopted by certain flowering plants and answer the questions that follow.

Pollen grains / Stigma	Pollen grains of Plant A	Pollen grains of Plant B	Pollen grains of Plant C
Stigma of Plant A	×	✓	✓
Stigma of Plant B	✓	×	✓
Stigma of Plant C	✓	✓	×

Note :

All plants belong to the same species.

× – No pollen tube growth/inhibition of pollen germination on stigma.

✓ – Pollen germination on stigma.

(a) Name and define the outbreeding device described in the above table.

(b) Explain what would have been the disadvantage to the plant in the absence of the given strategy.

Solution:

Step 1: The outbreeding device shown in the table is **self-incompatibility**.

Definition: Self-incompatibility is a genetic mechanism that prevents self-pollen (or pollen from genetically similar individuals) from fertilizing the ovule by inhibiting pollen germination or pollen tube growth on the stigma of the same plant.

Step 2:

Disadvantage of absence: In the absence of self-incompatibility, the plant would undergo self-pollination, which would lead to:

- Reduced genetic variability.
- Increased chances of inbreeding depression (accumulation of harmful alleles).
- Reduced adaptability of the species in changing environments.

Quick Tip

Self-incompatibility ensures genetic diversity by preventing self-fertilization, even within the same species. It helps in maintaining vigour and adaptability in plant populations.

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23. (a) Alien species are highly invasive and are a threat to indigenous species. Substantiate this statement with the help of any two examples.
(b) State any two criteria for determining biodiversity hotspots.

Solution:
Step 1 (a): Alien species, also called exotic species, are non-native species introduced—intentionally or unintentionally—into an ecosystem. They often become invasive and outcompete native species.
Examples:

- **Parthenium hysterophorus (Congress grass)**: Invasive weed that causes ecological imbalance and allergic reactions in humans.
- **Eichhornia crassipes (Water hyacinth)**: Blocks waterways, reduces oxygen levels, and hampers aquatic biodiversity.

Step 2 (b): Two criteria for identifying biodiversity hotspots:

- The region must have at least **1,500 species of vascular plants** as endemics.
- It must have lost at least **70% of its original natural vegetation**.

Quick Tip

Alien species can cause ecological disruption by displacing native species. Biodiversity hotspots are rich in endemic species and under severe threat due to habitat loss.

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24. Answer the following questions with respect to the sex determining mechanism observed in honey bee.

(a) Name the type of sex determination system observed in honey bee.

(b) Fill in the blanks (i), (ii) and (iii) in the given question.

Parent	**Male**
• Type of cell division involved during gamete formation in males	(i) _____
• Number of chromosomes in the gametes	(ii) _____
• Number of chromosomes in the diploid cell of the progeny	(iii) _____

(c) What will be the sex and chromosome number of the progeny formed from the unfertilised eggs of honey bee?

Solution:

Step 1 (a): The type of sex determination system observed in honey bees is called the **Haplodiploid sex determination system**.

Step 2 (b):

(i) **Mitosis** — Males are haploid and produce sperm by mitosis.

(ii) **n** — Since males are haploid, their gametes have *n* chromosomes.

(iii) **2n** — Fertilized eggs (diploid) form female progeny with 2n chromosomes.

Step 3 (c): Unfertilized eggs develop into haploid males (drones) with **n chromosomes**. The sex will be **male**.

Quick Tip

In honey bees, males develop from unfertilized eggs (haploid), while females (workers and queen) develop from fertilized eggs (diploid). Males produce gametes by mitosis.

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25. Explain how the addition of lactose in the medium regulates the switching on of the *lac* operon in bacteria.

Solution:

Step 1: The *lac* operon in *E. coli* is an inducible operon that controls the metabolism of lactose. It is normally turned off due to the binding of a repressor protein to the operator region.

Step 2: When lactose is added to the medium, a small amount of it is converted into **allolactose**, which acts as an inducer.

Step 3: Allolactose binds to the repressor protein, causing a conformational change that prevents the repressor from binding to the operator region. This removal of the repressor allows RNA polymerase to bind to the promoter and initiate transcription of structural genes.

Step 4: As a result, the genes *lacZ*, *lacY*, and *lacA* are expressed, leading to the synthesis of enzymes that help in lactose uptake and metabolism.

Quick Tip

The *lac* operon is regulated by a repressor protein. Lactose acts as an inducer by inactivating the repressor, thus enabling transcription of genes for lactose metabolism.

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26. (a) Name and explain the role of inner and middle walls of the human female uterus.
(b) Write the location and function of fimbriae in human female.

Solution:

Step 1 (a): The inner and middle walls of the uterus are:

- **Endometrium (Inner lining)**: It undergoes cyclic changes during the menstrual cycle and is essential for implantation of the embryo. It provides nourishment to the developing embryo.
- **Myometrium (Middle muscular layer)**: It consists of smooth muscle fibers that help in the contraction of the uterus during childbirth and menstrual flow.

Step 2 (b):

- **Location of fimbriae:** Fimbriae are finger-like projections present at the distal end of the fallopian tubes near the ovary.

- **Function:** They help in capturing the ovum released from the ovary and direct it into the fallopian tube.

Quick Tip

Endometrium supports implantation, while myometrium helps in uterine contractions. Fimbriae assist in ovum pickup and transport toward the fallopian tube.

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27. (a) What do you mean by activated sludge in an STP?
(b) Explain the biological treatment of the major part of the sludge transferred from the large aeration tank into the anaerobic sludge digesters before its final release into the natural water bodies.

Solution:
Step 1 (a): Activated sludge refers to the thick, flocculent mass of bacteria and fungi formed in the aeration tank of a Sewage Treatment Plant (STP). These microbial flocs actively digest the organic matter present in sewage.
Step 2 (b): After aerobic treatment in the aeration tank, the major part of the sludge is transferred to anaerobic sludge digesters, where:

- Anaerobic bacteria break down the organic matter in the absence of oxygen.
- This process releases **biogases** such as methane, carbon dioxide, and hydrogen sulfide.
- The digested sludge settles at the bottom and is used as **manure**, while the treated water is released into water bodies after disinfection.

Quick Tip

Activated sludge contains microbes that digest sewage. In anaerobic digesters, microbes degrade organic matter and release biogas, reducing pollution.

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28. Explain the beneficial role of the following, produced as a result of the processes of biotechnology, to mankind:

(a) Cow named Rosie

(b) α-1-antitrypsin

Solution:

Step 1 (a): Rosie is the first transgenic cow. She was genetically engineered to produce human protein-enriched milk.

- Rosie's milk contains the human protein **alpha-lactalbumin**, which is nutritionally more balanced for infants.
- This is beneficial in developing infant formula for babies who cannot be breastfed.

Step 2 (b): α-1-antitrypsin is a protein used in the treatment of **emphysema**, a genetic disorder.

- It is produced using recombinant DNA technology in genetically engineered organisms.
- It helps protect the lungs from enzymatic damage caused by *neutrophil elastase*.

Quick Tip

Rosie's milk is enriched with human protein for infant nutrition. α-1-antitrypsin is a biotech-derived therapeutic protein used in genetic lung disorders.

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.

According to evolutionary theory, every evolutionary change involves the substitution of a new gene for the old one and the new allele arises from the old one. Continuous accumulation of changes in the DNA coding for proteins leads to evolutionary differences.

The chemical composition of DNA is basically the same in all living beings, except for differences in the sequence of nitrogenous bases. Given below are percentage relative similarities between human DNA and DNA of other vertebrates:

S.No.	Vertebrates	Percentage similarities
1.	Chimpanzee	100
2.	Gibbon	94
3.	Rhesus Monkey	88
4.	Lemur	47
5.	Treeshrew	28
6.	Mouse	21
7.	Hedgehog	19
8.	Chicken	10

(a) What is the term used for the substitution of a new gene for the old one and the new allele arising from the old one during evolutionary process?

(b) Which one of the following holds true for the data provided in the above table?

(A) Greater the evolutionary distance, greater are the differences in the nitrogenous bases.

(B) Lesser the evolutionary distance, greater are the differences in the nitrogenous bases.

(C) Greater the evolutionary distance, lesser are the differences in the nitrogenous bases.

(D) Lesser the evolutionary distance, lesser are the differences in the nitrogenous bases.

(c) (i) To which category of evolution (divergent or convergent) does the following relationship belong? Justify your answer.

Human and Rhesus Monkey

OR

(ii) Differentiate between Convergent and Divergent evolution.

Solution:

(a) The process is called **mutation**. It refers to a sudden, heritable change in the genetic material. In this context, it results in the substitution of a new allele from the old one.

(b) The correct answer is **(A)** — Greater the evolutionary distance, greater are the differences in the nitrogenous bases.
As organisms diverge over millions of years, more mutations accumulate, decreasing the percentage similarity in their DNA sequences.

(c) (i) The relationship between Human and Rhesus Monkey belongs to **Divergent evolution**.
Justification: Both species have evolved from a common ancestor but have accumulated genetic differences over time due to different environmental adaptations and selective pressures.

OR

(ii)

Convergent Evolution	**Divergent Evolution**
Different organisms evolve similar traits independently.	Related organisms evolve different traits from a common ancestor.
Example: Wings of insects and birds.	Example: Forelimbs of human and bat.

Quick Tip

Greater DNA similarity indicates closer evolutionary relationships. Divergent evolution occurs when organisms evolve from a common ancestor and accumulate differences.

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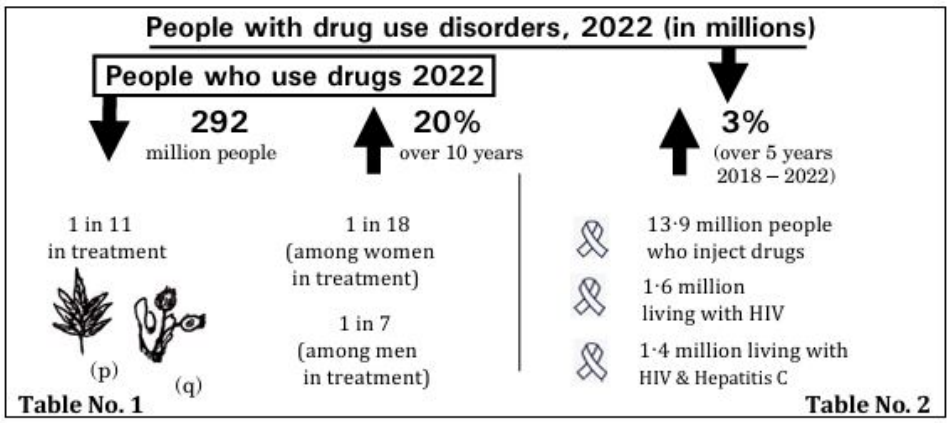
30. Read the following passage and answer the questions that follow.

Prevention is the frontline response to drug use. Effective interventions address the underlying conditions contributing to drug use, such as a lack of connection to family or community, instability, insecurity, trauma, mental health issues, etc. When addressed, these factors can effectively prevent the initiation of drug use and the progression to drug use

disorders. Study the few key figures of drug use given below and answer the questions that follow.

People with drug use disorders, 2022 (in millions)



(a) What do you infer from the figures in Table No. 1 about the people with drug use disorders, 2022 (in million)? State any two of your observations.

(b) How are Hepatitis C and HIV related to drug use disorders by people, as shown in Table No. 2? State the correlation between the two.

(c) (i) Give the scientific name of (p) shown in Table No. 1.

OR

(ii) Give the scientific name of (q) shown in Table No. 1.

Solution:

(a)
- Around **292 million** people used drugs in 2022, showing a **20% increase** over the past decade.
- Only **1 in 11** drug users receive treatment, with lower treatment rates for women (1 in 18) compared to men (1 in 7), indicating a significant treatment gap.

(b) Drug injection increases the risk of transmission of blood-borne diseases such as HIV and Hepatitis C. Among 13.9 million people who inject drugs:

- 1.6 million are living with HIV.
- 1.4 million live with both HIV and Hepatitis C.

This shows a strong correlation between drug injection practices and the spread of infectious diseases.

(c) (i) The scientific name of (p) is **Cannabis sativa**.

OR

(ii) The scientific name of (q) is **Papaver somniferum**.

Quick Tip

Substance abuse not only leads to addiction but also increases the risk of infectious diseases like HIV and Hepatitis C due to practices such as injecting drugs.

SECTION E

31. Answer the following questions:

(a) (i) Explain how some strains of *Bacillus thuringiensis* produce proteins that kill certain insects such as *lepidopterans* but do not kill the *Bacillus*.

(ii) How is the above mechanism exploited for the production of Bt cotton plant by biotechnologists?

OR

(b) (i) Explain how the amplification of gene of interest is done using PCR.

(ii) State two applications of the desired amplified fragment of DNA.

Solution:

(a) (i) Some strains of *Bacillus thuringiensis* (Bt) produce crystal proteins called Cry proteins. These are toxic to insects like *lepidopterans* (e.g., bollworms) when ingested. The Cry protein binds to specific receptors in the gut of the insect, causing cell lysis and death. These receptors are absent in *Bacillus* and in humans, hence they remain unaffected.

(ii) Biotechnologists isolate the gene coding for Cry protein from Bt and insert it into the genome of cotton plants. These genetically modified plants express the Cry protein, making them resistant to insect pests like bollworms. This results in reduced pesticide use and better crop yield.

(b) (i) Polymerase Chain Reaction (PCR) is a technique used to amplify a specific gene of interest. It involves repeated cycles of denaturation, annealing of primers, and extension by a thermostable DNA polymerase. Billions of copies of the desired gene can be synthesized in a few hours.

(ii) Two applications of the amplified DNA fragment are:

- Used in DNA fingerprinting and forensic analysis.
- Used in diagnostics for detecting genetic disorders or pathogens.

Quick Tip

Bt cotton is an example of genetic engineering used for pest resistance. PCR revolutionized molecular biology by allowing fast amplification of DNA for multiple applications.

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32. Answer the following questions:

(a) (i) Explain the structure of a mature embryo sac of a typical flowering plant.

(ii) How is triple fusion achieved in these plants?

OR

(b) (i) Describe the changes in the ovary and the uterus as induced by the changes in the level of pituitary and ovarian hormones during menstrual cycle in a human female.

Solution:

(a) (i) A mature embryo sac in angiosperms is an 8-nucleated, 7-celled structure. It consists of:

- Three cells at the micropylar end: one egg cell and two synergids.
- Three antipodal cells at the chalazal end.

– Two polar nuclei in the central cell which later fuse to form a diploid secondary nucleus.

(ii) Triple fusion occurs when one male gamete fuses with the diploid secondary nucleus (formed by two polar nuclei) in the central cell. This forms a triploid primary endosperm nucleus (PEN), leading to the formation of endosperm. Along with syngamy, this is called double fertilisation, a unique feature of angiosperms.

(b) (i) During the menstrual cycle:

– In the follicular phase, FSH stimulates growth of ovarian follicles, leading to increased estrogen production.
– Around the 14th day, a surge in LH induces ovulation.
– In the luteal phase, the corpus luteum secretes progesterone, which prepares the endometrium for implantation.
– If fertilisation does not occur, corpus luteum degenerates, progesterone levels drop, and menstruation begins.

Quick Tip

Double fertilisation involves both syngamy (fusion with egg) and triple fusion (fusion with central cell). Menstrual cycle is hormonally regulated through a feedback mechanism.

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33. Answer the following questions:

(a) (i) Describe the Species-Area relationship as observed by Alexander von Humboldt, for a wide variety of taxa in nature.

(ii) Draw the graph showing Species-Area relationship for $S = CA^Z$. What is the significance of 'Z' in Species-Area relationship?

OR

(b) (i) Describe the logistic population growth curve with the help of a suitable graphical representation.

(ii) Write the equation of Verhulst-Pearl logistic growth curve and explain what 'K' and 'r' suggest in the given equation.

Solution:

(a) (i) Alexander von Humboldt observed that species richness increases with increasing area, but not linearly. Initially, the increase is rapid, then slows down. This pattern holds for different types of organisms in various habitats.

(ii) The mathematical expression is:

$$S = CA^Z$$

where:

- S = species richness
- A = area
- C = constant
- Z = slope of the curve on a log scale

The value of Z typically ranges from 0.1 to 0.2 for smaller areas and 0.6 to 1.2 for large areas like continents. Z represents the rate at which species richness increases with area.

(b) (i) Logistic growth is more realistic as it considers environmental resistance. The curve has three phases:

- Lag phase: slow growth.
- Exponential phase: rapid growth.
- Stationary phase: population stabilises due to limited resources.

The curve is S-shaped.

(ii) The Verhulst-Pearl equation is:

$$\frac{dN}{dt} = rN\left(\frac{K-N}{K}\right)$$

where:

- N = population size
- r = intrinsic rate of natural increase

- K = carrying capacity
- $\frac{dN}{dt}$ = rate of change in population

Here, K represents the maximum population size that the environment can sustain. r indicates the population's potential for growth.

Quick Tip

Species richness grows with area in a predictable manner. Logistic growth is more applicable in nature than exponential due to resource limitations.
