CBSE Class 12 Biology 2026 — Set 3 — Answer Key

English Medium

Time Allowed: 3 Hours

General Instructions:

1. This is an answer key — each question is shown with its correct answer and a step-by-step explanation.
2. Questions appear in the original paper order.

Q.1

Foetal ejection reflex in human female triggers the release of which hormone ?

(a) Oxytocin from foetal pituitary gland
(b) hCG from placenta
(c) Progesterone from corpus luteum
(d) Oxytocin from maternal pituitary gland <<

Explanation:

Foetal ejection reflex (Ferguson reflex) is triggered by the fully developed foetus pressing on the cervix.

This stimulates the maternal pituitary gland to release oxytocin, which causes uterine contractions and initiates parturition.

Q.2

Which of the following is not a functional unit of an ecosystem ?

(a) Energy flow
(b) Decomposition
(c) Stratification <<
(d) Productivity

Explanation:

The four functional aspects of an ecosystem are: productivity, energy flow, decomposition, and nutrient cycling.

Stratification refers to the vertical distribution of different species at different levels (a structural feature), not a functional unit of an ecosystem.

Q.3

Match Column I with Column II and select the correct option :

Column I:

a. Primers

b. Insertional inactivation

c. Bioreactor

d. Downstream processing

Column II:

i. beta-galactosidase

ii. To separate and purify products

iii. Chemically synthesized oligonucleotides

iv. Large scale production of specific product of activity of microbes

(a) a-iii, b-i, c-iv, d-ii <<

(b) a-iii, b-i, c-ii, d-iv

(c) a-i, b-iii, c-iv, d-ii

(d) a-i, b-iv, c-ii, d-iii

Explanation:

Primers (a) are chemically synthesized oligonucleotides (iii) used to initiate DNA synthesis.

Insertional inactivation (b) uses the lacZ gene encoding beta-galactosidase (i) — insertion of foreign DNA inactivates this gene.

Bioreactor (c) is used for large-scale production of specific products via microbial activity (iv).

Downstream processing (d) involves separation and purification of products (ii).

Q.4

Golden rice is a promising transgenic crop. When released for cultivation, it will help in :

(a) Producing petrol-like fuel

(b) Reduction of Vitamin A deficiency in humans <<

(c) Pest resistance

(d) Herbicide tolerance

Explanation:

Golden rice is a transgenic variety of rice engineered to biosynthesize beta-carotene (a precursor of Vitamin A) in the edible parts of the grain.

It was developed to address Vitamin A deficiency, which is a major nutritional problem in developing countries.

Q.5

Four different transcription units are shown below. Choose the option with the correct image.

(a) Option A
(b) Option B
(c) Option C <<
(d) Option D

Explanation:

Option (C) is correct.

By convention the coding strand runs 5'→3' with the promoter at its 5' end (upstream) and the terminator at its 3' end.

In (C) the coding strand runs 5'→3' left to right, the promoter is on the left and the terminator on the right, and the template strand runs 3'→5' left to right.

RNA polymerase reads the template 3'→5' and makes RNA 5'→3'.

In (A) the promoter is at the 3' end of the coding strand.

In (B) the strand polarities are reversed, so the promoter again sits at the 3' end of the coding strand.

In (D) the strand labels are exchanged, which also puts the promoter at the 3' end of the coding strand.

Q.6

Appearance of antibiotic-resistant bacteria is an example of evolution due to :

(a) Adaptive radiation
(b) Divergent evolution
(c) Artificial selection
(d) Anthropogenic action <<

Explanation:

The appearance of antibiotic-resistant bacteria is an example of evolution driven by anthropogenic (human-caused) action.

The widespread and excessive use of antibiotics by humans creates selection pressure that favours bacteria with resistance mutations, leading to the rise of resistant strains.

This is a human-induced evolutionary change.

Q.7

Identify the statements that correctly describe Darwin's Theory of Evolution.

(i) Overproduction of organisms leads to competition.
(ii) Variation is inherited and causes evolution.
(iii) Acquired characters are inherited.
(iv) Survival depends on favourable traits.
(v) New species arise due to accumulation of favourable variations.

Choose the correct option.

(a) (i), (ii), (iv) and (v) are correct <<
(b) (ii), (iii) and (iv) are correct
(c) All are correct
(d) Only (i) and (iv) are correct

Explanation:

Statements (i), (ii), (iv) and (v) correctly describe Darwin's theory: overproduction leads to competition for resources (i);

heritable variation exists in populations and drives evolution (ii);

survival of the fittest — survival depends on favourable traits (iv);

accumulation of favourable variations leads to new species (v).

Statement (iii) — 'acquired characters are inherited' — is Lamarck's theory, NOT Darwin's.

Q.8

Which of the following is not a symptom of Ascariasis ?

(a) Intestinal blockage

(b) Muscular pain and fever

(c) Anaemia

(d) Skin ulcers <<

Explanation:

Ascariasis is caused by the roundworm Ascaris lumbricoides.

Its symptoms include intestinal blockage (due to worm mass), muscular pain, fever, and anaemia (due to blood feeding).

Skin ulcers are not a symptom of Ascariasis;

skin ulcers are associated with conditions like Leishmaniasis or other diseases.

Q.9

Every trophic level has a certain mass of living material at a particular time. What is it called ?

(a) Standing crop <<

(b) Primary productivity

(c) Standing state

(d) Ecological efficiency

Explanation:

The mass of living material (biomass) present at each trophic level at a particular time is called the standing crop.

It is measured as the mass of living organisms (biomass) or the number in a unit area.

Standing state refers to the amount of nutrients (like carbon, nitrogen, phosphorus) present in the soil at a given time.

Q.10

The smallest part of DNA molecule that can be changed by point mutation is :

(a) Oligonucleotide

(b) Codon
(c) Gene
(d) Nucleotide <<

Explanation:
A point mutation involves a change in a single nucleotide base pair in the DNA sequence.
Therefore, the smallest part of a DNA molecule that can be changed by point mutation is a nucleotide (a single base pair).

Q.11
Some statements regarding drugs and alcohol are given below :

(i) Adolescents are more vulnerable to peer pressure.
(ii) Drug addiction leads to increased tolerance level of the receptors present in our body.
(iii) Alcohol affects the central nervous system.
(iv) Excessive use of drugs helps to increase energy.
(v) Anabolic steroids decrease aggressiveness.

Choose the option with correct statement(s).

(a) Statements (i), (iv) and (v) are correct
(b) Statements (i), (ii) and (iii) are correct <<
(c) Only statements (i) and (v) are correct
(d) Only statement (iii) is correct

Explanation:
Statement (i) is correct — adolescents are indeed more vulnerable to peer pressure regarding drug/alcohol use.
Statement (ii) is correct — drug addiction leads to increased tolerance (the body needs more of the drug to achieve the same effect).
Statement (iii) is correct — alcohol is a CNS depressant.
Statement (iv) is incorrect — excessive drug use does not increase energy;

it causes deterioration of health.

Statement (v) is incorrect — anabolic steroids increase aggressiveness, not decrease it.

Q.12

Select the correct option for the pair of plants pollinated by water.

(a) Vallisneria and Hydrilla <<

(b) Zostera and Water lily

(c) Water lily and Parthenium

(d) Water hyacinth and Water lily

Explanation:

Vallisneria and Hydrilla are both aquatic plants pollinated by water (hydrophily).

Zostera is also hydrophilous but water lily is pollinated by insects.

Parthenium is pollinated by wind (anemophily).

Water hyacinth and water lily are both insect-pollinated (entomophilous), not water-pollinated.

Q.13

Assertion (A) : Activated sludge contains large population of bacteria.

Reason (R) : These bacteria help in anaerobic digestion of human waste in biogas plant.

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

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

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

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

Explanation:

Assertion (A) is true: activated sludge is rich in aerobic bacteria and fungi (flocs).

Reason (R) is false: the activated sludge is pumped into anaerobic sludge digesters where OTHER, anaerobic bacteria digest it;

the aerobic bacteria of the sludge do not carry out anaerobic digestion in a biogas plant.

Option (C).

Note: this key is unconfirmed.

Q.14

Assertion (A) : Ecosystems require a constant supply of energy to synthesize the molecules they require.

Reason (R) : This is to counteract the universal tendency towards increasing disorderliness as per Second Law of Thermodynamics.

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

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

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

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

Explanation:

Both A and R are true and R correctly explains A.

The Second Law of Thermodynamics states that entropy (disorder) of the universe always increases.

Living organisms maintain order (low entropy) only by continuously utilizing energy.

Ecosystems require a constant supply of energy to build and maintain complex molecules (maintaining order), thus counteracting the universal tendency toward increasing entropy/disorder.

Q.15

Assertion (A) : DNA cannot pass through cell membrane of a bacterial cell.

Reason (R) : DNA is a hydrophilic molecule.

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

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

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

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

Explanation:

Both A and R are true and R correctly explains A.

The cell membrane is a phospholipid bilayer that is hydrophobic in nature.

DNA is a hydrophilic (water-loving) molecule due to its charged phosphate backbone.

Since like dissolves like, the hydrophilic DNA cannot freely pass through the hydrophobic lipid bilayer of the cell membrane — this is why bacterial cells need to be made competent (e.g., using calcium chloride) to allow DNA uptake in recombinant DNA technology.

Q.16

Assertion (A) : Repetitive sequences are stretches of DNA sequences that are thought to have no direct coding functions.

Reason (R) : They shed light on chromosome structure, dynamics and evolution.

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

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

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

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

Explanation:

Both A and R are true but R is not the correct explanation of A.

Repetitive sequences (satellite DNA) do lack direct coding function (A is true).

They do shed light on chromosome structure, dynamics and evolution (R is true), but R does not explain WHY they have no coding function.

The reason they have no coding function is that they are non-transcribed, highly repetitive sequences — their role in chromosomal research is a separate property, not the explanation for their non-coding nature.

Q.17

(a) A person complains of persistent itching in the groin region and scalp. The person also shows dry and scaly lesions on skin, nails, etc.

(i) Identify the disease.

(ii) Name its two causative agents.

(iii) Mention its mode of transmission.

Answer: (i) Ringworm (Dermatophytosis / Tinea). (ii) Two causative agents: Microsporum and Trichophyton (both are fungi; Epidermophyton is a third genus also acceptable). (iii) Mode of transmission: direct contact with infected person or through sharing of personal items like towels, combs, clothes; also from infected animals or soil (indirect contact).

Explanation:

Ringworm is a fungal infection (not caused by a worm) affecting skin, nails, and scalp.

It is caused by dermatophyte fungi belonging to genera Microsporum, Trichophyton, and Epidermophyton.

The disease spreads by direct contact with infected individuals or through contaminated objects.

OR

Q.17

(b) A girl develops sneezing, watery eyes and difficulty in breathing every time she visits a flower garden.

(i) Identify the condition.

(ii) Name the immune component responsible for this condition.

(iii) Name the chemical released.

(iv) State one medicine used to treat such a condition.

Answer: (i) Allergy (Hypersensitivity / Allergic rhinitis). (ii) IgE (Immunoglobulin E) — the immune component responsible. (iii) Histamine (also leukotrienes and prostaglandins are released from mast cells). (iv) Antihistamine (e.g., Adrenaline / epinephrine or anti-histamine drugs like cetirizine/loratadine).

Explanation:

The girl is showing an allergic reaction (Type I hypersensitivity) to pollen from flowers.

Allergens trigger production of IgE antibodies, which bind to mast cells.

On re-exposure, IgE-coated mast cells degranulate, releasing histamine and other chemicals that cause sneezing, watery eyes, and breathing difficulty.

Treatment involves antihistamines or decongestants.

Q.18

(a) (i) Mention any two characteristics of Neanderthal man that lived near East and Central Asia.

(ii) Identify the following hominids with respect to human evolution :

(I) Brain capacity 900 cc, probably ate meat.

(II) First human-like with brain capacity 650 – 800 cc.

Answer: (i) Two characteristics of Neanderthal man: (1) Brain size around 1400 cc (larger than modern humans); (2) They used hides/skins to protect their bodies and buried their dead. (Other acceptable: they were stocky/robust, lived in caves, used stone tools/fire, communicated in a simple language.) (ii) (I) Brain capacity 900 cc, probably ate meat — Homo erectus. (II) First human-like with brain capacity 650–800 cc — Homo habilis.

Explanation:

Neanderthals (Homo neanderthalensis) lived ~1,00,000–40,000 years ago and had large brain capacity (~1400 cc), used hides for clothing, and buried their dead.

Homo erectus had a brain capacity of about 900 cc and is thought to have eaten meat (hunted).

Homo habilis was the first hominid with human-like features, brain size 650–800 cc, possibly did not eat meat.

OR

Q.18

(b) The allele for brown eyes (B) is dominant over blue eyes (b). In a population, 36% of individuals have blue eyes. Assuming Hardy-Weinberg equilibrium, calculate :

(i) Frequency of allele B

(ii) Percentage of heterozygous individuals

(iii) Percentage of individuals that are homozygous dominant

(Working to be shown)

Answer: Given: frequency of blue eyes (bb) = q^2 = 36% = 0.36. Therefore q = $\sqrt{0.36}$ = 0.6. Since p + q = 1, p = 1 – 0.6 = 0.4. (i) Frequency of allele B = p = 0.4. (ii) Percentage of heterozygous individuals (Bb) = 2pq = 2 × 0.4 × 0.6 = 0.48 = 48%. (iii) Percentage of homozygous dominant (BB) = p^2 = $(0.4)^2$ = 0.16 = 16%.

Explanation:

Using Hardy-Weinberg principle: $p^2 + 2pq + q^2 = 1$, where p = frequency of B (dominant) and q = frequency of b (recessive).

Blue eyes = homozygous recessive = q^2 = 0.36, so q = 0.6, p = 0.4.

Heterozygous = 2pq = 0.48 = 48%.

Homozygous dominant = p^2 = 0.16 = 16%.

Q.19

What did Henking observe in his experiments on insects that led to the discovery of sex chromosome ? How did his observation contribute to our understanding of sex determination ?

Answer: Henking observed that in 50% of the sperm of insects (grasshoppers), a specific nuclear element (which he called 'X-body') was present, while it was absent in the other 50% of sperm. This element underwent normal behaviour during cell division but he could not confirm if it was a chromosome. Later, it was identified as a sex chromosome (X chromosome). His observation contributed by showing that sex determination is linked to the presence or absence of this specific chromosome: females have two copies (XX) and males have one copy (XY or XO), explaining why sex of offspring is determined at fertilization depending on which type of sperm fertilizes the egg.

Explanation:

Henking (1891) found during spermatogenesis in insects that a specific deeply-staining 'X-body' (later identified as the X chromosome) passed to only half the sperm.

This led to the understanding of chromosomal sex determination — the XX-XY and XX-XO mechanisms — explaining 1:1 sex ratios in offspring.

Q.20

(a) (i) Given below is the schematic representation of the process of electrophoresis. Identify the alphabets representing the :

(I) Anode end, and

(II) Lightest/Smallest DNA in matrix.

(ii) What is Agarose gel and why is it used in this process ?

Answer: (i)(I) Anode end = S (the right-hand end, End S). DNA is negatively charged and migrates toward the positive terminal (anode). Wells are loaded at End U (left); DNA bands migrate rightward toward End S — so End S is the anode. (II) Lightest/Smallest DNA = R. The label R marks the band position farthest from the wells (toward End S / anode). Smaller fragments face less resistance in the agarose gel and migrate the greatest distance, so the band at position R (farthest migrated) corresponds to the smallest/lightest DNA fragment. (ii) Agarose gel is a polysaccharide derived from sea algae (Gelidium). It is used in gel electrophoresis because it forms a porous molecular sieve — DNA fragments are separated by size as smaller fragments move faster and farther through the pores, while larger fragments are retarded. After electrophoresis the gel is stained with ethidium bromide and visualised under UV light.

Explanation:

In gel electrophoresis, negatively charged DNA fragments migrate toward the anode (positive terminal) when current is applied.

Smaller/lighter fragments face less resistance and migrate farther.

Agarose is a natural polysaccharide that forms a porous gel serving as a molecular sieve for size-based separation of DNA.

OR

Q.20

(b) After performing gel electrophoresis, a student observes that DNA fragments are not visible.

(i) Suggest a reason for this and explain how fragments can be made visible.

(ii) Also explain how a specific DNA fragment can be collected from the gel for further use.

Answer: (i) Reason: DNA fragments are not stained/not treated with a visualizing dye. To make them visible: stain the gel with ethidium bromide (EtBr) — it intercalates between DNA bases and fluoresces bright orange-red under UV light (UV transilluminator). Alternatively, SYBR Green or other fluorescent dyes can be used. (ii) Elution: The specific DNA band of interest is cut out from the gel using a scalpel/blade under UV light. The gel slice is then processed by elution (using electroelution, freeze-squeeze, or gel extraction kit with chaotropic salts) to extract/recover the DNA fragment from the gel matrix. This purified DNA can then be used for further molecular techniques.

Explanation:

DNA is colourless and invisible under normal light.

Ethidium bromide staining followed by UV illumination makes DNA bands visible as orange fluorescent bands.

Elution involves excising the specific band from the gel and recovering the DNA, which can be used for cloning, sequencing, etc.

Q.21

GEAC is a regulatory body under the Ministry of Environment, Forest and Climate Change in India.

(a) Write the full form of GEAC.

(b) Mention two of its important functions related to biotechnology.

Answer: (a) GEAC: Genetic Engineering Appraisal Committee. (b) Two important functions: (1) It makes decisions regarding the validity of GM research and the safety of introducing GM organisms for public use. (2) It approves large-scale use

of Genetically Modified Organisms (GMOs) / transgenic organisms after evaluating their safety for human health and the environment.

Explanation:

GEAC (Genetic Engineering Appraisal Committee) is India's apex body for evaluating proposals relating to the release of genetically engineered organisms and products into the environment.

It assesses safety and grants approval for GMO research and commercialization, protecting both human health and biodiversity.

Q.22

Answer the following questions :

(a) Explain the different ways by which apomictic seeds can be developed.

(b) Mention one advantage of apomictic seeds for farmers.

Answer: (a) Apomictic seeds can develop through: (1) Diploid egg cells (without meiosis and fertilization) — the embryo develops directly from the diploid megaspore mother cell without reduction division; (2) From nucellar cells (nucellar polyembryony) — somatic cells of the nucellus start dividing and develop into embryo(s) without fertilization; (3) Through parthenogenesis — the egg cell develops into embryo without fertilization (from an unreduced egg or after mitosis).
(b) One advantage for farmers: Farmers can use seeds from hybrid plants year after year without losing hybrid vigour (heterosis), as apomictic seeds maintain the same genetic constitution as the parent plant. This saves the cost of purchasing new hybrid seeds every season.

Explanation:

Apomixis is the development of seeds without fertilization.

The main methods include diplospory (unreduced egg from MMC), apospory (nucellar/somatic cells forming embryo sac), and adventive embryony (nucellar polyembryony).

The key agricultural benefit is that hybrid seed performance is preserved across generations.

Q.23

(a) What is meant by translation in protein synthesis ?

(b) Explain charging of tRNA (aminoacylation of tRNA) and mention its importance in the process of translation.

Answer: (a) Translation is the process by which the sequence of codons in mRNA is decoded into a sequence of amino acids to synthesize a specific polypeptide/protein. It involves the reading of the genetic information (mRNA sequence) and its conversion into a protein, with ribosomes as the site of synthesis. (b) Charging of tRNA (aminoacylation): This is the process of attaching a specific amino acid to its cognate tRNA molecule. It is catalyzed by the enzyme aminoacyl-tRNA synthetase, which is specific for each amino acid–tRNA pair. The reaction uses ATP energy: Amino acid + tRNA + ATP → Aminoacyl-tRNA + AMP + PPi. Importance: The charged tRNA (aminoacyl-tRNA) acts as an adapter molecule — the anticodon of tRNA recognizes the complementary codon on mRNA, while the amino acid is transferred to the growing polypeptide chain at the ribosome. Without charging, the correct amino acid cannot be incorporated at the right position.

Explanation:

Translation converts mRNA codons to amino acid sequences.

Aminoacylation (charging) by aminoacyl-tRNA synthetases links the correct amino acid to its cognate tRNA using ATP, enabling codon-anticodon recognition and accurate polypeptide synthesis.

Q.24

(a) What is the carrying capacity of a species in a habitat ?

(b) Explain the growth curve that takes this capacity into account.

Answer: (a) Carrying capacity (K) is the maximum population size of a species that a particular habitat can support indefinitely, given the food, water, habitat space, and other resources available in the environment. It is the upper limit to population growth in a given environment. (b) The logistic growth curve (S-shaped

/ sigmoid curve): When a population grows in a habitat with limited resources, the growth follows a logistic pattern. Initially, the growth rate accelerates (lag phase followed by exponential phase). As the population size approaches the carrying capacity (K), the growth rate slows down (deceleration phase). Finally, the population stabilizes at K — the number of individuals added equals the number lost. The equation is: dN/dt = rN(K–N)/K, where r = intrinsic rate of natural increase, N = population size, K = carrying capacity.

Explanation:

Carrying capacity (K) is the maximum sustainable population in a habitat.

Logistic growth (S-curve) models realistic population growth with limited resources — population grows rapidly when small, slows as it approaches K, and stabilizes at K.

Contrast with J-shaped exponential growth (unlimited resources).

Q.25

In vitro fertilization (IVF) is a popular method these days that is helping childless couples to bear a child.

(a) Write the different steps that are carried out in this technique.

(b) Would you consider gamete intra fallopian transfer as a type of IVF ? Justify your answer.

Answer: (a) Steps in IVF: (1) Hormonal stimulation of the woman to produce multiple eggs (superovulation). (2) Retrieval of eggs (ova) from the ovary via minor surgical procedure. (3) Collection of sperms from the partner/donor. (4) Fertilization of the eggs with sperm under laboratory conditions (in vitro, in a culture dish). (5) Culture of the fertilized egg (zygote) until it develops into an embryo (usually 8-cell stage). (6) Transfer of the embryo into the uterus of the woman (Embryo Transfer / ET) for implantation and further development. (b) No, GIFT (Gamete Intra Fallopian Transfer) is NOT a type of IVF. In GIFT, the gametes (eggs and sperm) are directly transferred into the fallopian tube of the woman, where fertilization occurs in vivo (inside the body). In IVF, fertilization takes place outside the body (in vitro, in the laboratory). Since GIFT does not

involve in vitro fertilization, it cannot be considered a type of IVF.

Explanation:

IVF (in vitro fertilization) involves fertilization outside the body, while GIFT transfers gametes to the fallopian tube for in vivo fertilization.

ZIFT (Zygote Intra Fallopian Transfer) would be closer to IVF as it transfers the fertilized egg (zygote formed in vitro) to the fallopian tube.

Q.26

Draw a neat diagram of a maize grain showing the internal structure and label any five parts.

Answer: A neat labelled diagram of a maize grain (monocot seed) showing internal structure with the following five parts labelled (any five): (1) Pericarp (fruit wall / seed coat); (2) Aleurone layer; (3) Endosperm; (4) Scutellum (cotyledon); (5) Plumule (embryonic shoot); (6) Radicle (embryonic root); (7) Coleoptile; (8) Coleorhiza; (9) Embryo axis; (10) Starchy endosperm. The diagram must clearly show the endosperm occupying most of the grain, the embryo on one side (embryonic axis), the scutellum (large single cotyledon) adjacent to endosperm, and protective sheaths (coleoptile over plumule, coleorhiza over radicle).

Explanation:

Maize (Zea mays) is a monocot with a caryopsis-type fruit.

The internal structure shows a large starchy endosperm, an aleurone layer (outer endosperm), and the embryo consisting of the embryo axis (plumule + radicle), scutellum, coleoptile, and coleorhiza.

The pericarp is fused with the seed coat.

Q.27

Cow dung and water are mixed and fed into a biogas plant to allow digestion of biowastes. The person performing this process says that there is no need to provide an inoculum.

(a) Do you agree with him ? Justify your answer.

(b) What happens to the biowaste inside the digester ?

(c) Name the useful by-products obtained from this process and mention how they are used.

Answer: (a) Yes, I agree with him. Cow dung (gobar) naturally contains a rich consortium of methanogenic (anaerobic) bacteria/microbes that are already present in the digestive system of cattle and in the dung. Therefore, no additional inoculum (external source of bacteria) needs to be added — the bacteria naturally present in the cow dung are sufficient to initiate and sustain anaerobic digestion. (b) Inside the digester, the biowastes undergo anaerobic digestion: the complex organic material (cellulose, hemicellulose, proteins, fats) in the waste is broken down by anaerobic microorganisms in stages — hydrolysis, acidogenesis, acetogenesis, and finally methanogenesis — converting the organic matter into simpler compounds and ultimately into biogas (methane + CO2) and a liquid effluent. (c) Useful by-products: (1) Biogas (primarily methane ~75%, CO2 ~25%) — used as a fuel for cooking, lighting, and generating electricity. (2) Slurry (effluent/spent slurry) — the remaining liquid/semi-solid material is rich in nitrogen (as ammonia) and other minerals; it is used as manure/biofertilizer for agricultural fields.

Explanation:

Cow dung contains methanogenic bacteria naturally, so no external inoculum is needed.

Anaerobic digestion in the biogas plant breaks down organic waste through microbial action, producing biogas (fuel) and nutrient-rich slurry (fertilizer).

Q.28

(a) Describe the experiment conducted by T.H. Morgan on Drosophila melanogaster involving eye colour and body colour.

(b) How did the results deviate from Mendelian inheritance pattern ?

(c) Explain the two genetic terms used by Morgan for his observations.

Answer: (a) Morgan crossed yellow-bodied, white-eyed female Drosophila with brown-bodied, red-eyed male and intercrossed the F1 progeny. He studied the F2

for body colour and eye colour (two genes on the X chromosome). (b) If the two genes assorted independently (Mendel's law of independent assortment), the F2 should show the 9:3:3:1 dihybrid ratio. Instead the two parental combinations (yellow-white and brown-red) appeared far more often than the new combinations, so the F2 ratio deviated from 9:3:3:1; the closer the two genes lie on the chromosome, the lower the frequency of recombinants. (c) Two terms: (1) Linkage: physical association of genes on the same chromosome, so they tend to be inherited together. (2) Recombination: generation of non-parental gene combinations, caused by crossing over between homologous chromosomes in meiosis.

Explanation:

Morgan's cross for two X-linked genes (body colour and eye colour) gave parental combinations in excess of recombinants, deviating from the 9:3:3:1 ratio.

This showed linkage; crossing over produced the few recombinants (recombination).

Q.0

The data below shows the concentration of nicotine smoked by a smoker taking 10 puffs/minute. (See the figure.)

(a)(i) With reference to the above graph, explain the concentration of nicotine in the blood at 10 minutes.

Answer: At 10 minutes, the nicotine concentration in the blood is at its PEAK — approximately 45 mg/cm³. The graph shows a steady, rapid rise in blood nicotine from minute 1 through minute 10 (10 puffs/minute means continuous inhalation and lung absorption). At exactly 10 minutes the curve reaches its maximum (~45 mg/cm³) before falling sharply. This peak occurs because nicotine absorption rate from continuous smoking matches or exceeds metabolic clearance up to this point; after the smoker stops (or reduces puffing), elimination dominates and concentration falls.

Explanation:

Nicotine is rapidly absorbed through the lungs into the blood.

With continuous smoking (10 puffs/min), blood nicotine rises sharply and peaks around 10 minutes of smoking, corresponding to the maximum absorption rate matching or exceeding the metabolic clearance rate.

Q.0

(a)(ii) How will this affect the concentration of carbon monoxide and haem-bound oxygen at 10 minutes ?

Answer: At 10 minutes of smoking (10 puffs/min): (1) Carbon monoxide (CO) concentration in blood will INCREASE — CO is present in cigarette smoke and is rapidly absorbed into the blood. CO has about 200–250 times greater affinity for haemoglobin than oxygen, displacing oxygen from haemoglobin. (2) Haem-bound oxygen (oxyhaemoglobin) concentration will DECREASE — because CO binds to haemoglobin at the same sites as oxygen (forming carboxyhaemoglobin, COHb), preventing oxygen from binding. This reduces the oxygen-carrying capacity of the blood, leading to oxygen deprivation in tissues.

Explanation:

CO from cigarette smoke binds haemoglobin with ~240× greater affinity than O2, forming carboxyhaemoglobin.

This reduces O2 transport capacity.

At 10 min of active smoking, CO in blood rises substantially and haem-bound O2 decreases proportionally.

Q.29(b)

(b) How does cigarette smoking result in high blood pressure and increase in heart rate ?

Answer: Cigarette smoking causes high blood pressure and increased heart rate primarily through the action of nicotine: (1) Nicotine stimulates the adrenal medulla to release adrenaline (epinephrine) and noradrenaline (catecholamines). (2) These hormones stimulate the heart to beat faster (increased heart rate /

tachycardia) and cause vasoconstriction (narrowing of blood vessels). (3) Vasoconstriction increases peripheral resistance to blood flow, resulting in elevated blood pressure (hypertension). (4) Additionally, CO from cigarette smoke reduces oxygen delivery, prompting the heart to compensate by beating faster. The combined effects of catecholamines and CO thus cause hypertension and tachycardia.

Explanation:

Nicotine triggers release of catecholamines (adrenaline/noradrenaline) from adrenal glands, causing vasoconstriction (elevated BP) and increased heart rate.

CO further stresses the cardiovascular system by reducing O2 delivery.

Q.29(c)

(c) To which class of compounds does nicotine belong ? Name one other drug from the same class.

Answer: Nicotine belongs to the class of alkaloids. One other drug from the same class (alkaloids): Morphine (from opium poppy) / Heroin / Cocaine / Caffeine / Quinine. (Any one alkaloid is acceptable — e.g., morphine, cocaine, caffeine.)

Explanation:

Alkaloids are a class of naturally occurring nitrogenous compounds with physiological effects.

Nicotine (from tobacco), morphine (from poppy), cocaine (from coca), caffeine (from coffee/tea), and quinine (from cinchona) are all alkaloids.

Q.30(a)

India is one of the megadiverse countries housing around 8.1 per cent of global species diversity, although its land area is only 2.4 per cent of the world's land area. Many of the species are highly threatened due to human activities like deforestation, mining and habitat fragmentation. Laws like Wildlife (Protection) Act, 1972 were enacted by the Government of India to preserve our biological wealth. Various conservation measures are being implemented to save the threatened species.

The following bar graph shows the number of species conserved under different biodiversity conservation methods. (See the figure.)

Study the graph and answer the questions.

(a) Which method conserves the highest number of species ? Is it ex situ or in situ conservation ?

Answer: The method that conserves the highest number of species is Wildlife Sanctuaries (2500 species, as shown in the bar graph). This is in situ conservation — conservation of species within their natural habitat. Wildlife sanctuaries protect species in the wild, allowing them to live and breed naturally, which conserves the maximum number of species including their natural ecological interactions.

Explanation:

In situ conservation (conservation within the natural habitat) through protected areas, sacred groves, biosphere reserves, etc., generally conserves the maximum number of species as entire ecosystems and their interdependencies are preserved.

Ex situ conservation (zoos, botanical gardens, seed banks) conserves fewer species due to resource limitations.

Q.30(b)

(b) Which other methods shown in the diagram are opposite to the one identified by you in question (a) ? How are these two conservation approaches different ?

Answer: The methods opposite to Wildlife Sanctuaries (in situ) shown in the bar graph are the ex situ conservation methods: Zoological Parks (990 species) and Botanical Gardens (1100 species). These are the only ex situ methods shown in the diagram. Differences: (1) In situ conservation (Wildlife Sanctuaries, National Parks, Biosphere Reserves) — species are conserved in their natural habitat with natural ecological processes intact; whole ecosystems are protected. (2) Ex situ

conservation (Zoological Parks, Botanical Gardens) — species are removed from their natural habitat and maintained under human care in artificial environments. In situ conserves more species and maintains natural behaviour and ecological interactions; ex situ provides immediate protection for critically endangered species but cannot replicate natural processes.

Explanation:

In situ = conservation in natural habitat; ex situ = conservation outside natural habitat.
In situ protects whole ecosystems and natural behaviors;
ex situ is a backup strategy for endangered species, providing protection from immediate threats but cannot replicate natural ecological processes.

Q.0

(c)(i) Write two features of Biodiversity hotspots.

Answer: Two features of Biodiversity hotspots: (1) They contain a large number of endemic species (species found nowhere else in the world) — specifically, regions with more than 1500 endemic vascular plant species qualify as hotspots. (2) They have lost at least 70% (or more) of their original habitat — they are areas with high species richness but also under severe threat from human activities (habitat loss, degradation). [Alternatively: (2) They contain a high concentration of biodiversity / high species richness; (3) They have a disproportionately large number of species relative to their area.]

Explanation:

Biodiversity hotspots are regions with exceptionally high species diversity and endemism, but which have lost a significant portion of their original habitat.
Criteria (Norman Myers): >1500 endemic vascular plant species AND >70% of original habitat lost.
India has three hotspots: Western Ghats & Sri Lanka, Indo-Burma, Himalayas.

Q.0

(c)(ii) To which category do sacred groves belong and how do they help in bio-conservation ?

Answer: Sacred groves belong to the category of in situ conservation. Sacred groves are forest patches around places of worship that are declared sacred by tribal/local communities, who protect them from any human interference or exploitation. They help in bio-conservation by: (1) Providing a refuge for many rare, threatened, and endemic species — the strict protection from felling trees, hunting, and human disturbance allows diverse flora and fauna to survive undisturbed. (2) Acting as reservoirs of biodiversity in an otherwise disturbed landscape — they maintain species that might have disappeared from surrounding areas. (3) Preserving entire forest ecosystems with natural ecological processes intact. India has several sacred groves — e.g., 'Devarakadu' in Karnataka, 'Jahera' in Odisha, 'Orans' in Rajasthan.

Explanation:

Sacred groves are traditionally protected forest patches — a form of community-based in situ conservation.

They are protected by religious sentiments and local customs, providing sanctuaries for wildlife and plant diversity, including endemic and rare species.

Q.31(a)

(a)(i) Describe the series of experiments conducted by Frederick Griffith. Comment on the significance of the result obtained.

(ii) State the contribution of Avery, MacLeod and McCarty.

Answer: (i) Griffith's experiments (1928): Griffith worked with two strains of Streptococcus pneumoniae (pneumococcus): S-strain (Smooth — virulent, with polysaccharide capsule) and R-strain (Rough — non-virulent, no capsule). Experiment 1: Injection of live S-strain into mice → mice died. Experiment 2: Injection of live R-strain into mice → mice survived. Experiment 3: Injection of heat-killed S-strain into mice → mice survived (killed bacteria are harmless). Experiment 4: Injection of heat-killed S-strain + live R-strain into mice → mice DIED. Blood of these mice showed live S-strain bacteria. Conclusion: Some 'transforming principle' from the heat-killed S-strain had transformed the

non-virulent R-strain into the virulent S-strain. This transformation was heritable (passed to progeny bacteria). Significance: This was the first evidence that genetic information could be transferred from one organism to another (transformation), indicating the existence of a chemical molecule that carries hereditary information — the first hint of a 'transforming principle' (though Griffith did not identify it as DNA). (ii) Contribution of Avery, MacLeod and McCarty (1944): They performed biochemical characterization of the transforming principle from Griffith's experiment. They extracted the transforming principle from heat-killed S-strain and treated it separately with: Protease (destroys proteins) — transformation still occurred. RNase (destroys RNA) — transformation still occurred. DNase (destroys DNA) — transformation DID NOT occur. Conclusion: DNA is the transforming principle, i.e., DNA is the genetic material. This was the first biochemical proof that DNA carries genetic information.

Explanation:

Griffith showed heritable transformation exists.

Avery, MacLeod and McCarty biochemically proved that DNA (not protein or RNA) is the transforming principle — the first direct evidence that DNA is the genetic material.

OR

Q.31(b)

(b) The following questions are based on haemophilia.

(i) Work out the crosses between :

(I) Normal female and Haemophilic male

(II) Carrier female and Normal male

(III) Carrier female and Haemophilic male

(ii) Write the conclusions you draw from these crosses. Comment on the type of inheritance of the disease.

(Use : X – Normal, X^h – Haemophilic)

Answer: (i) Haemophilia is X-linked recessive. Notation: X = normal X chromosome; X^h = X chromosome with haemophilia allele.

Cross (I): Normal female (XX) × Haemophilic male (X^h Y)
Parents: XX × X^hY
Gametes: X, X from female; X^h, Y from male
Offspring: XX^h (carrier female) : XY (normal male) : XX^h (carrier female) : XY (normal male)
Ratio: 50% carrier females : 50% normal males (all daughters are carriers; all sons are normal)

Cross (II): Carrier female (X X^h) × Normal male (X Y)
Parents: XX^h × XY
Gametes: X, X^h from female; X, Y from male
Offspring: XX (normal female) : XX^h (carrier female) : XY (normal male) : X^hY (haemophilic male)
Ratio: 1 normal female : 1 carrier female : 1 normal male : 1 haemophilic male

Cross (III): Carrier female (X X^h) × Haemophilic male (X^h Y)
Parents: XX^h × X^hY
Gametes: X, X^h from female; X^h, Y from male
Offspring: X X^h (carrier female) : X^h X^h (haemophilic female) : X^h Y (haemophilic male) : XY (normal male)
Ratio: 1 carrier female : 1 haemophilic female : 1 haemophilic male : 1 normal male

(ii) Conclusions:
(1) Haemophilia is more common in males than females — males need only one copy of the defective allele (X^h Y) to be affected, while females need two copies (X^h X^h) which is rare.
(2) Females can be carriers (X X^h) — they carry the allele but do not show the disease (protected by the normal allele).
(3) A haemophilic female is possible (as shown in Cross III) but is very rare in real

populations.

(4) Sons of carrier mothers have a 50% chance of being haemophilic.

Type of inheritance: X-linked recessive inheritance. The disease is carried on the X chromosome and is recessive — it primarily affects males (who are hemizygous for X-linked genes). It cannot pass from father to son (son receives Y from father); an affected father always passes the allele to all daughters (who become carriers).

Explanation:

Haemophilia A (factor VIII deficiency) is X-linked recessive.

The criss-cross inheritance pattern (affected father →

carrier daughters) and higher prevalence in males are characteristic features.

Famous historical case: the 'Royal Disease' in Queen Victoria's descendants.

Q.32(a)

(a)(i) Explain any two basic principles/core techniques on which biotechnology is based.

(ii) Describe any three key tools used in Recombinant DNA technology.

Answer: (i) Two basic principles/core techniques of biotechnology:

(1) Genetic engineering (Recombinant DNA technology): The ability to alter the chemistry of genetic material (DNA/RNA) and to introduce these into host organisms to change their phenotype. This involves manipulation of DNA in vitro — cutting, ligating, and inserting genes into vectors which are then introduced into host cells.

(2) Maintenance of sterile/aseptic conditions: The ability to maintain microbe-free (aseptic) conditions in chemical engineering processes — using bioreactors, fermenters and culture vessels under sterile conditions — so that only the desired microorganism or cell line grows and produces the required product. This is essential for large-scale production of biotechnological products.

(ii) Three key tools used in Recombinant DNA technology:

(1) Restriction enzymes (Restriction Endonucleases): These are molecular scissors that cut DNA at specific recognition sequences (palindromic sequences), producing sticky ends or blunt ends. They allow cutting of donor DNA and vector DNA at specific sites for precise joining. Example: EcoRI cuts at 5'-GAATTC-3' producing sticky ends.

(2) Cloning vectors: These are DNA molecules (carriers) into which the foreign DNA fragment is inserted for replication and expression in the host cell. They must have: origin of replication (ori), selectable marker (antibiotic resistance gene), cloning sites (restriction enzyme recognition sites). Examples: plasmids, bacteriophages, cosmids, BACs.

(3) Host organism / Competent host: The organism (usually bacteria like E. coli) into which the recombinant DNA is introduced. The host must be made competent (capable of taking up foreign DNA), e.g., by $CaCl_2$ treatment (chemical competence) or electroporation. The host provides the cellular machinery for replication and expression of the foreign gene.

Explanation:

The two core principles of biotechnology are genetic engineering (DNA manipulation in vitro) and maintenance of aseptic conditions (essential for bioreactor-based production).

Key tools for rDNA technology: restriction enzymes (cut DNA), vectors (carry and replicate foreign DNA), and competent host cells (express the recombinant gene).

OR

Q.32(b)

(b) 'Early and accurate diagnosis of diseases is vital in medical technology.'

(i) Name the conventional methods of diagnosis and their disadvantages.

(ii) Which three diagnostic techniques have been developed through Biotechnology ? Explain how each one helps in detecting diseases.

Answer: (i) Conventional methods of diagnosis:

- Based on serum/blood analysis: microscopy, cell culture, biochemical tests (e.g., blood glucose, urine test, ELISA for antibodies).

- Disadvantages: (1) They are often not very sensitive or specific — early-stage infections or low-level pathogens may not be detected. (2) They cannot detect the pathogen/disease at an early stage when the pathogen titre is very low (below detection threshold). (3) Cultural/microscopic methods require the pathogen to be culturable and are time-consuming. (4) They may give false positives/negatives due to cross-reactions or technical errors.

(ii) Three diagnostic techniques developed through biotechnology:
(1) Recombinant DNA technology: a probe (a labelled single-stranded DNA/RNA) hybridises to its complementary DNA in a clone of cells, so a mutated gene or a pathogen's DNA can be detected, e.g. genetic disorders and cancer-causing mutations.
(2) PCR (Polymerase Chain Reaction): amplifies a pathogen's nucleic acid from a very small sample so even a few copies (e.g. HIV in suspected AIDS patients, or mutated genes in cancer) can be detected early, before symptoms appear.
(3) ELISA (Enzyme Linked Immunosorbent Assay): based on antigen-antibody interaction; the presence of a pathogen is detected by its antigens or by antibodies synthesised against it (e.g. HIV, hepatitis B).

Explanation:
Conventional diagnosis (culture, microscopy, serology) lacks sensitivity for early/low-titre infections.
Biotechnology-based techniques — PCR (amplifies pathogen DNA), ELISA with recombinant antigens (detects antibodies/antigens sensitively), and DNA probes (hybridization to specific sequences) — enable early, accurate, and highly specific detection of diseases.

Q.33(a)

(a) Oogenesis is a discontinuous process that begins before birth and is completed after puberty.
(i) Trace the development of a gamete mother cell till its release from the ovary during ovulation.

(ii) Name the two pituitary hormones that play an important role in the process.

Answer: (i) Development of gamete mother cell through oogenesis (path to ovulation):

1. Oogonium (2n) — primordial germ cell / gamete mother cell in the foetal ovary undergoes mitosis to form many oogonia.
2. Primary oocyte (2n) — oogonia enter meiosis I but are arrested at prophase I (diplotene stage) before birth. Each primary oocyte is surrounded by a layer of granulosa cells, forming a primary follicle.
3. At puberty, under hormonal influence, primary follicles grow — layers of granulosa cells multiply and a fluid-filled antrum forms, creating secondary follicle → then Graafian follicle (tertiary follicle).
4. The primary oocyte (arrested in prophase I since foetal life) resumes meiosis I just before ovulation → completes meiosis I → produces secondary oocyte (n, larger) + first polar body (n, smaller, non-functional).
5. Secondary oocyte enters meiosis II but is arrested at metaphase II.
6. Ovulation: The Graafian follicle ruptures and the secondary oocyte (along with the first polar body and zona pellucida, surrounded by corona radiata) is released from the ovary.
7. Meiosis II is completed only if fertilization occurs → mature ovum + second polar body.

(ii) Two pituitary hormones important in oogenesis/ovulation:

(1) FSH (Follicle Stimulating Hormone) — stimulates growth of the primary follicle and maturation of the Graafian follicle; also stimulates granulosa cells to produce oestrogen.

(2) LH (Luteinizing Hormone) — the LH surge (mid-cycle surge) triggers completion of meiosis I, formation of secondary oocyte, and ovulation (rupture of Graafian follicle to release the secondary oocyte).

Explanation:

Oogenesis: Oogonium →
primary oocyte (arrested prophase I from foetal stage) →
under FSH →
Graafian follicle →
LH surge triggers meiosis I completion →
secondary oocyte released at ovulation (arrested metaphase II) →
meiosis II completes only if fertilized.
FSH drives follicle growth; LH surge triggers ovulation.

OR

Q.33(b)

(b)(i) Draw a labelled two-celled structure of male gametophyte of an angiosperm.

(ii) Name the three layers that surround the cytoplasm of a male gametophyte starting from innermost to outermost layer.

(iii) Which organic material makes the outermost layer ? Mention its advantage.

(iv) Why is the outermost layer of male gametophyte not continuous ?

Answer: (i) A neat labelled diagram of the two-celled male gametophyte (pollen grain at 2-cell stage) of an angiosperm, showing: generative cell (small, lens-shaped/spindle-shaped, with dense cytoplasm, enclosed within the larger vegetative cell), vegetative cell (large cell with prominent nucleus — vegetative nucleus/tube nucleus), intine (inner wall), exine (outer wall with sporopollenin), apertures (germination pores/colpi).

(ii) Three layers surrounding cytoplasm of male gametophyte (pollen grain), innermost to outermost:

(1) Plasma membrane (innermost — encloses the cytoplasm directly)

(2) Intine (cellulose and pectin — inner layer of pollen wall)

(3) Exine (sporopollenin — outer layer of pollen wall, outermost)

(iii) Outermost layer (exine) is made of sporopollenin.
Advantage of sporopollenin: It is one of the most chemically resistant biological materials known — it can withstand high temperatures, strong acids, and strong alkalis. This extreme resistance makes the exine highly durable, protecting the pollen (and its genetic material) from desiccation, UV radiation, and chemical degradation during transport through the environment.

(iv) The outermost layer (exine) is not continuous because it has apertures — regions called germ pores or colpi (apertures) where the exine is absent (thin/lacking). These apertures are sites through which the pollen tube emerges during germination after the pollen lands on the stigma. The apertures allow pollen tube growth — if the exine were completely continuous, the pollen tube could not emerge from the pollen grain during germination.

Explanation:
The male gametophyte (pollen grain) has two cells at the 2-celled stage: vegetative cell and generative cell.
Three wall layers (inner to outer): plasma membrane →
intine (cellulose/pectin) →
exine (sporopollenin).
Sporopollenin's chemical resistance protects pollen during wind/insect dispersal.
Apertures (germ pores) in the exine allow pollen tube emergence during germination.