CBSE Class 12 Biology 2026 — Set 2 — 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

To separate repetitive DNA from bulk genomic DNA, which of the following method is used ?

(a) Elution
(b) Southern Blotting
(c) Polymerase Chain Reaction
(d) Density Gradient Centrifugation <<

Explanation:

Repetitive DNA sequences have a different buoyant density compared to the bulk genomic DNA.

Density Gradient Centrifugation (e.g., CsCl gradient) separates DNA fragments based on their density, allowing repetitive DNA (satellite DNA) to band separately from the bulk genomic DNA.

Q.2

Select the correct option :

(a) Tropics between 23.5° N – 23.5° S — Higher biodiversity than temperate areas <<
(b) Columbia — 105 bird species
(c) New York — 1400 bird species
(d) India — 2000 bird species

Explanation:

The tropics (between 23.5° N and 23.5° S) indeed have higher biodiversity than temperate areas due to more stable climate, more solar energy, and longer evolutionary time.

Colombia (not Columbia) has about 1400 bird species;

New York (a temperate region) has far fewer.

India has approximately 1200+ bird species, not 2000.

Q.3

In a dihybrid cross, 2400 individuals are produced in F2 generation.

Approximately how many will be phenotypically similar to parents ?

(a) 2000

(b) 1500 <<

(c) 580

(d) 450

Explanation:

Parents (P): AABB × aabb → F1 AaBb → F2 ratio 9 : 3 : 3 : 1.

Parental phenotypes = dominant–dominant (9/16) + recessive–recessive (1/16) = 10/16.

10/16 × 2400 = 1500 individuals → (B) 1500.

Q.4

What could be the reason of extinction of Abingdon Tortoise from Galapagos Islands ?

(a) Intraspecific Competition

(b) Predation

(c) Parasitism

(d) Interspecific Competition <<

Explanation:

The Abingdon Tortoise (Chelonoidis abingdonii) became extinct primarily due to Interspecific Competition — goats introduced to the island outcompeted the tortoises for food resources (vegetation), leading to starvation and eventual extinction of the tortoise population.

Q.5

What conclusion can be drawn if the forelimbs of an aquatic animal and a terrestrial animal have similar anatomical structure ?

(a) Live in same habitat

(b) Share common ancestors <<

(c) Forelimbs perform same functions

(d) Forelimbs are analogous

Explanation:

Similar anatomical structures (homologous organs) in organisms that live in different habitats indicate divergent evolution from a common ancestor.

The forelimbs of an aquatic animal (e.g., whale) and a terrestrial animal (e.g., horse) have the same basic bone structure (humerus, radius, ulna, carpals etc.) but perform different functions — this is a hallmark of homologous structures, indicating shared common ancestry.

Q.6

How many of the following features are related to Nirodh – a popular brand of condoms ?

(i) Prevention of sexually transmitted infections.

(ii) Phagocytosis of sperms.

(iii) Male contraceptive device.

(iv) Acts as chemical barrier.

(v) Physiological changes in cervical mucus.

(a) (i), (ii), (iv)

(b) (i) and (iii) <<

(c) (i), (ii), (v)

(d) (ii) and (iv)

Explanation:

Nirodh is a condom — a male contraceptive device (iii) that physically prevents STI transmission (i).

It acts as a physical/mechanical barrier, NOT a chemical barrier (iv is false).

It does not cause phagocytosis of sperms (ii is false) nor physiological changes in cervical mucus (v is false — that is the mechanism of oral pills/IUDs).

Therefore only features (i) and (iii) are correct.

Q.7

A bacterium having radioactive thymidine in its DNA is allowed to multiply in a medium having non-radioactive thymidine for two generations. What percentage of bacteria will have radioactive thymidine in its DNA ?

(a) 100
(b) 50 <<
(c) 75
(d) 25

Explanation:
DNA replication is semi-conservative.
After generation 1 in non-radioactive medium: 2 bacteria each have one radioactive and one non-radioactive strand →
2/2 = 100% have radioactive DNA.
After generation 2: these 2 bacteria divide to give 4 bacteria total.
The 2 radioactive strands each serve as templates producing 2 new non-radioactive strands.
So 2 out of 4 bacteria have one radioactive strand →
2/4 = 50% of bacteria have radioactive thymidine in DNA.

Q.8

What is the role of histamine released by mast cells ?

(a) Lowers blood pressure
(b) Causes allergic symptoms <<
(c) Stimulates antibody formation
(d) Destroys pathogens

Explanation:
Histamine is released by mast cells during an allergic response.
It binds to histamine receptors on various cells, causing symptoms such as vasodilation, increased vascular permeability, smooth muscle contraction, mucus secretion — collectively the symptoms of allergy (sneezing, itching, watery eyes, etc.).

Q.9

Which of the following is used to visualize DNA bands under UV light after gel electrophoresis ?

(a) Acetocarmine
(b) Safranine

(c) Ethidium Bromide <<

(d) Potassium Iodide

Explanation:

Ethidium Bromide (EtBr) is a fluorescent dye that intercalates between the bases of DNA.

When exposed to UV light, it fluoresces bright orange, making DNA bands visible in agarose gel electrophoresis.

Acetocarmine and Safranine are histological stains for chromosomes/plant tissues; Potassium Iodide is used to test for starch.

Q.10

Given below are stages of embryo sac formation from megaspore mother cell. Identify the correct option for the cell division marked a, b, c and d.

(a) a – Meiosis-I, b – No division, c – Mitosis, d – Meiosis-II

(b) a – Meiosis-I, b – Meiosis-II, c – No division, d – Mitosis <<

(c) a – Mitosis, b – Meiosis-I, c – Meiosis-II, d – No division

(d) a – No division, b – Mitosis, c – Meiosis-I, d – Meiosis-II

Explanation:

Embryo sac formation from megaspore mother cell: the megaspore mother cell first undergoes Meiosis-I (a) to give 2 cells, then Meiosis-II (b) to give 4 megaspores (megaspore tetrad).

Three megaspores degenerate;

the functional megaspore undergoes 3 mitotic divisions (no meiosis here) to produce the 8-nucleate embryo sac.

In the diagram, a = Meiosis-I, b = Meiosis-II, c = No division (degeneration step) and d = Mitosis (functional megaspore develops into embryo sac).

Option (B) is correct.

Q.11

Genetically modified tobacco plants were produced using Agrobacterium vectors. Which property of Agrobacterium helps in carrying nematode specific genes into the host plant ?

(a) Infectious for monocot plant ; has Ti plasmid

(b) Infectious for dicot plant ; has Ti plasmid <<

(c) Infectious for plants and animals ; has Ti plasmids

(d) Infectious for monocot and dicot plants ; has cry gene

Explanation:

Agrobacterium tumefaciens is a soil bacterium that naturally infects dicotyledonous plants.

It carries the Ti (Tumour-inducing) plasmid, which has the ability to transfer a segment of DNA (T-DNA) into the host plant's genome.

In recombinant DNA technology, the Ti plasmid (with its tumour-forming genes removed and replaced with desired genes) is used as a vector to deliver foreign genes (such as nematode-specific RNAi genes) into dicot plants like tobacco.

Q.12

Observe the contents 1, 2, 3 and 4 of soil samples I, II and III shown in the graph. If the temperature and moisture of all soil samples are identical, which soil sample(s) will show faster decomposition ?

(a) Soil Sample I

(b) Soil Sample II

(c) Soil Sample III <<

(d) Both Soil Samples II and III

Explanation:

From the graph (1 lignin, 2 chitin, 3 nitrogen, 4 sugar): Soil I has lignin about 8%, chitin about 15%, nitrogen only about 5%, sugar about 20%.

Soil II has the highest lignin (about 15%) and chitin (about 20%), nitrogen about 7%, sugar about 12%.

Soil III has lignin about 8%, chitin about 10%, but the highest nitrogen (about 18%) and sugar (about 20%).

Decomposition is faster when lignin and chitin are low and nitrogen is high (low C : N ratio), so Soil Sample III decomposes fastest.

Correct option is (C).

Q.13

Assertion (A) : Apomixis leads to production of genetically identical offsprings.

Reason (R) : Apomixis involves fertilization between two genetically similar plants.

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

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

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

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

Explanation:

Assertion (A) is TRUE — apomixis produces genetically identical offspring (clones) since it is a form of asexual reproduction via seeds without fertilization.

Reason (R) is FALSE — apomixis does NOT involve fertilization at all;

it is the development of seeds without fertilization (from the nucellus or unreduced embryo sac cells).

Hence option (C) is correct.

Q.14

Assertion (A) : Microbes are used for commercial production of alcohol and beverages.

Reason (R) : Yeast converts glucose into ethanol and carbon dioxide during fermentation.

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

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

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

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

Explanation:

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

Yeast (Saccharomyces cerevisiae) is the microbe used commercially for alcohol production.

During anaerobic fermentation, yeast converts glucose into ethanol and CO_2: $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$.

This is the basis of beer, wine, and other alcoholic beverage production.

Q.15

Assertion (A) : IUCN Red List helps in identifying and protecting endangered species worldwide.

Reason (R) : The list includes the species facing risk of extinction.

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

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

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

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

Explanation:

Both A and R are true.

The IUCN Red List does help in identifying and protecting endangered species, and it does include species facing risk of extinction.

However, R is not the complete/correct explanation for A — the Red List serves multiple conservation functions beyond just listing extinction-risk species;

it also guides policy, prioritizes conservation funding, and monitors biodiversity trends.

The reason doesn't fully explain why it 'helps in protecting' species.

Hence option (B) is correct.

Note: this key is unconfirmed.

Q.16

Assertion (A) : DNA Ligase is used to join DNA fragments.

Reason (R) : It catalyses the formation of glycosidic bonds between nucleotides.

(a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation for Assertion (A).
(b) Both Assertion (A) and Reason (R) are true, but Reason (R) is not correct explanation for Assertion (A).
(c) Assertion (A) is true, Reason (R) is false. <<
(d) Assertion (A) is false, Reason (R) is true.

Explanation:

Assertion (A) is TRUE — DNA Ligase is indeed used to join (seal nicks in) DNA fragments by forming phosphodiester bonds between them.

Reason (R) is FALSE — DNA Ligase catalyses the formation of phosphodiester bonds (not glycosidic bonds) between the 3'-OH end and 5'-phosphate end of adjacent nucleotides.

Glycosidic bonds join the nitrogenous base to the deoxyribose sugar.

Hence option (C) is correct.

Q.17

(a) The diagram below shows the sequence of amino acids in part of haemoglobin molecule. (See the figure.)

(i) If the base T* is substituted with A, in 'CTT'* of DNA strand how would it affect the haemoglobin chain ?

(ii) Name the condition and the effects associated with the above substitution.

Answer: (i) The codon CTT (DNA template strand) codes for Glutamic acid. If T* at the 6th position is substituted with A, the codon becomes CAT (DNA template), which codes for Valine instead of Glutamic acid. This is a point mutation (substitution). The haemoglobin chain will have Valine at the 6th position of beta-globin chain instead of Glutamic acid.

(ii) Condition: Sickle Cell Anaemia (SCA). Effects: The abnormal haemoglobin (HbS) polymerises under low oxygen tension, causing RBCs to become

sickle-shaped. Sickle-shaped RBCs have reduced oxygen-carrying capacity, cause blockage of blood vessels, and are destroyed faster, leading to anaemia, pain crises, and organ damage.

Explanation:

The figure shows DNA codons CAT, GTA, AAT, TGA, GGA, CTT, CTC for Val, His, Leu, Thr, Pro, Glu, Glu.

The mRNA for CTT is GAA (Glu).

Changing the middle T of CTT to A gives CAT, whose mRNA codon GUA codes for valine.

Glutamic acid is replaced by valine, which causes sickle cell anaemia (HbS).

OR

Q.17

(b) DNA is considered a more stable genetic material than RNA. Justify this statement with suitable reasons.

Answer: DNA is more stable than RNA due to the following reasons: (1) Deoxyribose sugar — DNA has deoxyribose (lacks 2'-OH group), making it chemically less reactive and more resistant to hydrolysis than RNA which has ribose with a 2'-OH group that makes it susceptible to alkaline hydrolysis. (2) Double-stranded structure — DNA is double-stranded, so even if one strand is damaged, the complementary strand serves as a template for repair. RNA is usually single-stranded and more vulnerable. (3) Thymine instead of Uracil — DNA has thymine (methylated base) instead of uracil. Thymine is more stable; uracil is formed by deamination of cytosine, and cells use the presence of uracil as a signal for DNA repair. Using thymine prevents ambiguity in repair. (4) Lower reactivity — The absence of the 2'-OH group in deoxyribose makes DNA less prone to enzymatic and non-enzymatic degradation.

Explanation:

These four reasons — deoxyribose vs ribose, double-stranded nature, thymine vs uracil, and structural stability — are the standard NCERT-based justifications for DNA being a more stable genetic material than RNA.

Q.18

How do scientists use microinjection and gene gun in biotechnology ?

Answer: Microinjection: A recombinant DNA construct is directly injected into the nucleus of an animal cell using a fine glass needle (micropipette) under a microscope. This method is used for introducing genes into animal cells, especially in transgenesis (producing transgenic animals). It allows precise delivery of DNA directly into the nucleus. Gene Gun (Biolistics): Microscopic gold or tungsten particles coated with the desired recombinant DNA are accelerated at high velocity into plant cells using a device called the gene gun (particle gun / biolistics device). The metal particles penetrate the cell wall and membrane, delivering DNA into the cell. This method is particularly useful for transforming plant cells (especially monocots) that are resistant to Agrobacterium-mediated transformation. It has been used to develop Bt crops and other transgenic plants.

Explanation:

Both microinjection and gene gun (biolistics) are direct gene delivery methods (non-biological/physical methods) used when biological vectors like Agrobacterium are not suitable.

Microinjection is predominantly used for animal cells;

gene gun is predominantly used for plant cells.

Q.19

After significant reduction of BOD during secondary treatment of sewage, what further processes are carried out ? Mention any one important outcome of these processes.

Answer: After secondary treatment the effluent is passed into a settling tank where the bacterial flocs (activated sludge) settle. A small part of the sludge is pumped back to the aeration tank as inoculum, and the remaining sludge is passed into large anaerobic sludge digesters, where anaerobic bacteria digest the bacteria and fungi in the sludge. The treated effluent is then released into rivers or streams.

One important outcome: during digestion the anaerobic bacteria produce biogas (a mixture of methane, hydrogen sulphide and carbon dioxide), a source of energy.

Explanation:

After BOD falls in the aeration tank, the effluent goes to a settling tank, the sludge is partly recycled and partly digested anaerobically, and the digester releases biogas. The effluent is then discharged into natural water bodies.

Q.20

(a) In some cases, measuring population density by counting individuals may not be feasible. Mention two other parameters that can be used and justify their use with suitable examples.

Answer: Two alternative parameters for measuring population density: (1) Biomass — When individual counting is difficult (e.g., for trees in a forest), biomass (total dry weight of all individuals per unit area) can be used as a measure of population density. Example: For a dense grass meadow, measuring the total weight of grass per unit area is more practical than counting individual grass plants. (2) Percentage cover — For plants that form dense mats or cover the ground (e.g., lichens, turf grasses), the percentage of ground area covered by the species is used as a measure. Example: For Parthenium (invasive weed) in a field, percentage cover gives a better estimate than individual count. Other acceptable parameters: number of fish caught per unit effort (catch per unit effort for fish populations); pug marks or dung counts for tigers or elephants.

Explanation:

NCERT mentions that for large trees, sea weeds, or colonial organisms, biomass and percentage cover are appropriate proxies for population density because counting individuals is impractical.

OR

Q.20

(b) What factors contribute to the Amazonian rain forests in South America

being the most biodiverse regions on Earth ?

Answer: The Amazon rainforest is the most biodiverse region due to the following factors: (1) Tropical location — Located near the equator, it receives abundant, consistent solar radiation throughout the year, driving high productivity and supporting more niches. (2) Warm and wet climate — High temperature and high rainfall (~2000–3000 mm/year) create ideal conditions for plant growth and diverse habitats. (3) High species interactions — Greater plant productivity supports diverse herbivores, which in turn support diverse predators — creating complex food webs. (4) Evolutionary time — Tropical regions have been stable for a longer geological time, allowing more speciation events and accumulation of species. (5) More species can coexist — The stable, resource-rich environment allows more species to partition resources (niche differentiation) and coexist without competitive exclusion. (6) Spatial heterogeneity — Diverse microhabitats (canopy, understory, forest floor) allow more species to occupy different niches.

Explanation:

This covers the key reasons from NCERT's biodiversity chapter: more solar energy input, stable environment, longer evolutionary time, greater productivity, and higher niche diversity in tropical regions.

Q.21

(a) (i) Name the organ that forms a connection between foetus and the uterus of a pregnant human female.

(ii) How does it support both nutrition and hormonal regulation ?

Answer: (i) Placenta.

(ii) Nutritional support: The placenta is a disc-like structure embedded in the uterine wall. It has villi that increase surface area for exchange. Nutrients (glucose, amino acids, fatty acids, vitamins, minerals) and oxygen from maternal blood diffuse across the placental membrane into foetal blood. Metabolic wastes (CO_2, urea) and deoxygenated blood pass from foetus to mother through the placenta. Hormonal regulation: The placenta acts as a temporary endocrine organ

and secretes several important hormones: (a) Human Chorionic Gonadotropin (hCG) — maintains the corpus luteum during early pregnancy, sustaining progesterone secretion. (b) Human Placental Lactogen (hPL) / Somatomammotropin — promotes mammary gland development for lactation. (c) Oestrogen — promotes uterine growth and breast development. (d) Progesterone — maintains the uterine lining (endometrium) and prevents uterine contractions. (e) Relaxin — relaxes pelvic ligaments near parturition.

Explanation:

The placenta serves dual roles: (1) as the nutritional/excretory interface between mother and foetus, and (2) as a temporary endocrine gland secreting hCG, hPL, oestrogen, progesterone and relaxin to maintain pregnancy.

OR

Q.21

(b) Give reasons for :

(i) All copulations do not lead to pregnancy.

(ii) Meiosis I in spermatogenesis and oogenesis are markedly different.

Answer: (i) All copulations do not lead to pregnancy because: Fertilization is possible only during the fertile period (around ovulation, approximately day 10–17 of a 28-day cycle) when a secondary oocyte is available in the fallopian tube. If copulation occurs outside this window, no egg is available for fertilization. Additionally, not all sperms reach the egg; many are destroyed by the acidic vaginal environment, cervical mucus, or immune responses. Hormonal conditions must be right for implantation. Structural abnormalities in sperm or egg can prevent fertilization. Implantation may fail even if fertilization occurs.

(ii) Meiosis I in spermatogenesis vs oogenesis is markedly different because: In spermatogenesis — Meiosis I is an equal division producing two secondary spermatocytes of equal size. In oogenesis — Meiosis I is highly unequal (asymmetric cytokinesis). The primary oocyte divides to produce a large secondary oocyte (which retains most of the cytoplasm, organelles and nutrients) and a small, non-functional first polar body. This asymmetry conserves nutrients

for the potential zygote/embryo.

Explanation:

These are standard NCERT-based answers.

The asymmetric nature of oogenesis meiosis conserves cytoplasmic resources, which is critical since the egg must nourish the early embryo before implantation.

Q.22

There are limitations of traditional breeding techniques that led to promotion of micro-propagation ?

(a) Mention two advantages of micropropagation.

(b) Give two examples where it is commercially adopted.

Answer: (a) Two advantages of micropropagation: (1) Rapid multiplication — A very large number of plants (thousands to millions) can be produced in a short time from a very small amount of plant material (explant). This is much faster than conventional vegetative propagation. (2) Production of disease-free plants — Meristematic tissue used as explant is often free of viruses and pathogens; plants produced are disease-free (pathogen-free clones). Other valid advantages: year-round production independent of season; conservation of endangered plant species; plants produced are genetically identical (true-to-type clones).

(b) Two commercial examples of micropropagation: (1) Orchids — commercially produced in large numbers by micropropagation for the ornamental plant industry. (2) Tomatoes / Asparagus / Banana — commercially propagated for agriculture. Also accepted: Chrysanthemum, Carnation (ornamental plants); Potato (virus-free seed tubers).

Explanation:

Micropropagation (tissue culture-based plant propagation) overcomes limitations of traditional breeding like slow multiplication rates, seasonal dependency, and disease transmission through vegetative parts.

Q.23

(a) Give the scientific name of the organism used by Morgan to study sex-linked traits.

(b) Write any four reasons why this organism made it an ideal experimental model.

Answer: (a) Drosophila melanogaster (fruit fly).

(b) Four reasons why Drosophila melanogaster is an ideal experimental model: (1) Short life cycle — Drosophila completes its life cycle in about 2 weeks (14 days), allowing observation of many generations in a short time. (2) Large number of offspring — A single mating produces a large number of progeny, making statistical analysis reliable. (3) Easy and inexpensive to maintain — They can be reared on simple culture medium (fermenting fruit/cornmeal) in small bottles at low cost. (4) Sexual dimorphism — Males and females are easily distinguishable (males are smaller, have a dark abdomen tip and sex combs on forelegs), making sex-based crosses easy to set up. Additional reasons (also valid): Only 4 pairs of chromosomes (3 autosomes + 1 sex chromosome pair) making genetic analysis simpler; many morphological mutants available for study; has been extensively studied so genetic map is well established.

Explanation:

T.H.

Morgan used Drosophila melanogaster to establish the chromosomal theory of heredity and discovered sex-linkage, linkage groups, and crossing over.

These features make it an ideal model organism for genetics.

Q.24

Draw a neat diagram of enlarged view of one microsporangium of a Young anther of an angiosperm. Label the different layers of the wall and write the functions of the outermost and innermost layer.

Answer: Diagram: A cross-section of one microsporangium should show a roughly circular structure with the following wall layers from outside to inside: (1) Epidermis (outermost), (2) Endothecium, (3) Middle layers (1-3 layers), (4)

Tapetum (innermost), surrounding the central Sporogenous tissue (microspore mother cells/pollen grains).

Functions: Outermost layer — Epidermis: provides protective covering to the microsporangium; mechanical protection against physical damage and desiccation. Innermost layer — Tapetum: nourishes the developing pollen grains (microspores); provides nutrients, enzymes, precursors for sporopollenin, pollen-kitt and other substances needed for pollen development; also produces Ubisch bodies that help in sporopollenin deposition on pollen wall.

Explanation:

The microsporangium wall has 4 layers: Epidermis (protection), Endothecium (helps in dehiscence by hygroscopic thickening), Middle layers (nutritive, crushed at maturity), and Tapetum (most important — nourishes developing pollen).

The question specifically asks about outermost (epidermis) and innermost (tapetum).

Q.25

Study the diagram given below :

(a) Name and explain the procedure shown in the diagram. Mention one of its advantage and one disadvantage.

(b) How is 'Saheli' different from other oral pills in terms of its composition and advantage ?

Answer: (a) The diagram shows Amniocentesis. Procedure: Amniocentesis is a prenatal diagnostic technique in which a needle is inserted through the mother's abdominal wall into the amniotic cavity (guided by ultrasound) to withdraw a small amount of amniotic fluid (~10-20 mL). The amniotic fluid contains foetal cells (shed from the foetus). The fluid is centrifuged: (i) The fluid component is analysed for biochemical/chemical composition (e.g., AFP levels for neural tube defects). (ii) The foetal cells obtained are cultured and the chromosomes are analysed (karyotyping) to detect chromosomal abnormalities (e.g., Down syndrome — trisomy 21, Turner syndrome, Klinefelter syndrome) and genetic

disorders. Typically performed between 14–16 weeks of pregnancy. Advantage: Enables early prenatal detection of chromosomal and genetic abnormalities, allowing informed decisions and early medical intervention. Disadvantage: Invasive procedure with a small risk (~0.5–1%) of miscarriage or infection; requires skilled medical personnel; results may cause anxiety and raise ethical dilemmas regarding termination of pregnancy.

(b) Saheli is different from conventional oral contraceptive pills: Composition: Saheli contains a non-steroidal compound called Centchroman (Ormeloxifene). Conventional oral pills contain synthetic estrogen and progesterone (steroidal hormones). Advantage: Saheli is non-steroidal with very few side effects (unlike steroidal pills which may cause nausea, weight gain, hormonal imbalance). It is taken once a week (not daily), improving compliance. It is an indigenous Indian drug.

Explanation:

The diagram shows amniocentesis: a needle withdraws amniotic fluid from the amniotic cavity;

the fluid is centrifuged, and the foetal cells are cultured for chromosome (karyotype) analysis while the fluid is analysed biochemically.

Q.26

S.L. Miller conducted an experiment in 1953 to simulate the conditions of early earth in a laboratory setup. Answer the following questions based on the experiment :

(a) What was the aim of his experiment ?

(b) Name the gases used and the source of energy.

Answer: (a) Aim of Miller's experiment: To demonstrate that organic molecules (amino acids) could be formed abiotically under conditions simulating the primitive (early) Earth atmosphere. Miller aimed to test the Oparin-Haldane hypothesis of chemical origin of life — that the reducing atmosphere of early Earth could support the synthesis of organic compounds from inorganic molecules.

(b) Gases used: Methane (CH_4), Ammonia (NH_3), Hydrogen (H_2), and Water vapour (H_2O). These simulated the presumed reducing atmosphere of primitive Earth. Source of energy: Electric spark (simulating lightning/electrical discharges from thunderstorms on early Earth). In the experiment, electric sparks were passed through the gas mixture in a closed flask. After one week, Miller found that amino acids (glycine, alanine, aspartic acid, glutamic acid) and other organic molecules had formed in the condensed water (simulating the primitive ocean).

Explanation:

Miller's 1953 experiment is a landmark in the study of origin of life.

The reducing atmosphere of CH_4, NH_3, H_2, and H_2O, with lightning as energy source, produced amino acids — supporting abiotic synthesis of biomolecules.

Q.27

(a) What is a genetic code ?

(b) Why did scientists feel the need to propose a genetic code ?

(c) Genetic code is said to be 'Universal'. Why ?

Answer: (a) Genetic code: The genetic code is the relationship between the sequence of nucleotide bases (codons) in mRNA and the sequence of amino acids in a polypeptide. It is the set of rules by which information encoded in the mRNA (as triplet codons) is translated into the sequence of amino acids during protein synthesis. There are 64 codons in total (4^3), of which 61 code for amino acids and 3 are stop codons.

(b) Scientists felt the need to propose a genetic code because: After it was established that DNA (genes) carry information that determines the sequence of amino acids in proteins, the question arose — how does a 4-letter nucleotide language (A, T, G, C) code for a 20-letter amino acid language (20 amino acids)? Since a singlet code ($4^1 = 4$) or doublet code ($4^2 = 16$) would not be enough to code for all 20 amino acids, a triplet code ($4^3 = 64$) was proposed as the minimum sufficient code. Theoretical work by George Gamow and experiments by Nirenberg, Khorana and others established the triplet codon concept.

(c) Genetic code is Universal because: The same codon codes for the same amino acid in all organisms — from bacteria to humans. For example, the codon AUG (start codon) codes for Methionine in all living organisms. This universality is evidence that all life on Earth shares a common ancestor. Exception: Some codons in mitochondria and some protists (e.g., Mycoplasma) show slight deviations, so the code is nearly universal.

Explanation:

The genetic code is triplet, degenerate, non-overlapping, non-ambiguous, commaless, and universal.

The universality (same codon = same amino acid across all organisms) is the basis for genetic engineering — human genes can be expressed in bacteria.

Q.28

(a) A person inhales dust and pathogens but does not always fall sick. Explain how the body protects against such infections.

(b) Name and describe any two barriers involved in this protection.

Answer: (a) The body does not always fall sick because it has multiple non-specific (innate) defence barriers that prevent pathogens from entering and establishing infection. These physical, physiological, and cellular barriers act as the first and second lines of defence before the specific (adaptive) immune response is mounted.

(b) Two barriers: (1) Physical/Mechanical barriers — The skin: forms an impenetrable physical barrier against most pathogens when intact; its dry, slightly acidic surface (due to lactic acid and fatty acids in sebum) inhibits microbial growth. The mucus lining of the respiratory tract (nose, trachea, bronchi): traps inhaled dust particles, microbes and foreign materials. Cilia in the respiratory epithelium beat upward (mucociliary escalator) to sweep trapped particles and microbes out of the airways, preventing them from reaching the lungs. (2) Physiological barriers — Stomach acid (HCl, pH ~2): kills most pathogens that are swallowed. Lysozyme in tears, saliva and nasal secretions: an enzyme that

cleaves the peptidoglycan cell walls of bacteria, destroying them. Interferons: proteins secreted by virus-infected cells that protect non-infected neighboring cells from viral infection by inducing an antiviral state.

Explanation:

The innate immune system has three types of barriers: (1) Physical/Mechanical — skin and mucus-cilia, (2) Physiological — stomach acid, lysozyme, interferons, and (3) Cellular — phagocytes (neutrophils, macrophages) and NK cells.

The question asks for any two barriers.

Q.29

Gene manipulation is a fast emerging science. It started with the development of recombinant DNA molecules. This technology which mostly involves cutting and pasting of desired DNA fragments is based on two most important discoveries in bacteria – presence of plasmid and restriction endonucleases. The science of r-DNA technology took birth when Cohen and Boyer (1973) were able to produce a piece of gene containing foreign DNA introduced into plasmid of E.coli.

(a) Name one core technique of biotechnology that alters the genetic material.

(b) What is a plasmid ? Mention its importance in biotechnology.

(c) Which gene was isolated by Cohen and Boyer and from which bacteria ?

Answer: (a) Recombinant DNA (r-DNA) technology (also called Genetic Engineering).

(b) Plasmid: A plasmid is a small, circular, double-stranded, extra-chromosomal DNA molecule found in bacteria (and some other organisms) that replicates independently of the chromosomal DNA. Importance in biotechnology: Plasmids are used as vectors (cloning vehicles) in recombinant DNA technology. The desired foreign gene is inserted into the plasmid using restriction enzymes and DNA ligase. The recombinant plasmid is then introduced into a host cell (e.g., E. coli) where it replicates, producing multiple copies of the foreign gene (gene

cloning). Plasmids may carry antibiotic resistance genes used as selectable markers to identify transformed cells.

(c) Cohen and Boyer isolated the antibiotic resistance gene (specifically ampicillin resistance gene and tetracycline resistance gene) from Salmonella typhimurium (or from Staphylococcus) and incorporated it into the plasmid of E. coli. In their landmark 1973 experiment, they isolated an antibiotic resistance gene from Salmonella typhimurium and transferred it into E. coli using plasmid pSC101.

Explanation:

The 1973 Cohen-Boyer experiment is the foundation of recombinant DNA technology. They used the plasmid pSC101 as a vector and demonstrated that a gene from Salmonella could be cloned and expressed in E.
coli — establishing the feasibility of r-DNA technology.

OR

Q.29

(c) How is the action of exonuclease different from that of endonuclease ?

Answer: Exonuclease: An exonuclease cleaves nucleotides one by one from the ends (either 5' or 3' end) of a DNA or RNA strand. It acts progressively from the terminus of a polynucleotide chain. Examples: DNA polymerase I (has 3'→5' and 5'→3' exonuclease activity), exonuclease III.

Endonuclease: An endonuclease cleaves the phosphodiester bond within (internally) the polynucleotide chain, i.e., it cuts at specific or non-specific internal sites. It does not require a free end to act. Restriction endonucleases (e.g., EcoRI, HindIII) are a special class of endonucleases that recognize specific palindromic sequences and cut DNA at or near those sequences.

Key difference: Exonucleases cut from the ends of DNA strands; endonucleases cut within (internally) the DNA strand.

Explanation:

This is a straightforward distinction: endo = within (cuts internally), exo = outside/from ends (cuts from the ends of the chain).

Restriction enzymes are endonucleases because they cut within the DNA molecule at specific recognition sequences.

Q.30

Below is shown a pond that represents a self-sustaining natural ecosystem with both biotic and abiotic components interacting in a balanced food web. (See the figure.)

Based on the diagram, answer the questions :

(a) Mention two abiotic components of a pond ecosystem.

(b) Differentiate between the roles of producers and decomposers in such an ecosystem.

(c) Draw a simple food chain operating in such an ecosystem and label each trophic level.

Answer: (a) Two abiotic components of a pond ecosystem: (1) Water (aquatic medium providing the physical habitat and dissolving nutrients). (2) Sunlight (solar energy, driving photosynthesis by producers). Other valid answers: Temperature, dissolved oxygen (O_2), dissolved CO_2, pH, inorganic nutrients (nitrates, phosphates), sediment/soil at the bottom.

(b) Producers vs Decomposers: Producers (e.g., phytoplankton, aquatic plants like Hydrilla): Autotrophs that capture sunlight and convert inorganic compounds (CO_2, H_2O, minerals) into organic matter (biomass) through photosynthesis. They form the base of the food chain and transfer energy to consumers. They produce O_2 as a byproduct. Decomposers (e.g., bacteria, fungi in pond sediment): Heterotrophs (saprotrophs) that break down dead organic matter (detritus — dead organisms, faeces, fallen leaves) into inorganic molecules (CO_2, H_2O, minerals) through decomposition. They return nutrients to the abiotic pool (nutrient cycling/mineralization), making them available for producers again. Unlike producers, they do not produce energy — they release it as heat during decomposition.

(c) Simple food chain in a pond: Phytoplankton (T1: Producers) → Zooplankton (T2: Primary Consumers/Herbivores) → Small fish (T3: Secondary

Consumers/Carnivores) → Large fish (T4: Tertiary Consumers/Top Carnivores). Each trophic level: T1 = Producers, T2 = Primary consumers, T3 = Secondary consumers, T4 = Tertiary consumers.

Explanation:

A pond ecosystem is a classic aquatic ecosystem example in NCERT.

The question covers abiotic components, producer-decomposer roles, and food chain construction — all standard biodiversity/ecosystem chapter topics.

OR

Q.30

(c) Why is transfer of energy not 100% efficient between trophic levels ?

Answer: Energy transfer between trophic levels is not 100% efficient (only about 10% is transferred — the 10% law / Lindemann's law) because: (1) Respiratory losses — A significant portion of energy assimilated at each trophic level is used for the organism's own metabolic activities (cellular respiration — maintenance, growth, reproduction, movement), releasing heat that is lost from the ecosystem and cannot be used by the next trophic level. (2) Heat loss — Energy is degraded to heat at every metabolic step (second law of thermodynamics); heat cannot be recycled. (3) Not all biomass is consumed — Some organic matter at each trophic level dies without being eaten and passes to detritus food chain instead of being available to the next trophic level. (4) Incomplete digestion — Some ingested food is not digested and is lost in faeces, going to decomposers rather than being assimilated. (5) Structural components — Some energy is locked in structural materials (bones, cellulose, lignin) that are not easily digestible. Therefore, at each successive trophic level, available energy decreases by approximately 90%, limiting food chains to 4–5 trophic levels.

Explanation:

The 10% law of energy transfer (Lindemann, 1942) explains why energy decreases at each trophic level.

Respiration, heat loss, incomplete digestion, and unutilized biomass are the main

reasons for this inefficiency.

Q.31

(a) (i) Explain the role of stigma in pollen pistil interaction.

(ii) Describe the post pollination events leading to double fertilization in angiosperms starting with 2-celled pollen grain.

Answer: (i) Role of stigma in pollen-pistil interaction: The stigma is the receptive surface of the pistil. It plays a crucial role in pollen recognition: (a) Recognition — The stigma secretes a specific surface coat (stigmatic exudate with proteins, lipids, polysaccharides). When a pollen grain lands on it, the pollen coat proteins interact with the stigma surface proteins. This is a lock-and-key type recognition mechanism. (b) Compatible pollen is recognized and allowed to hydrate and germinate; incompatible pollen (self-pollen in self-incompatible species, or pollen from a different species) is recognized and rejected — the pollen tube growth is inhibited. (c) The stigma provides a moist, nutrient-rich surface that promotes pollen hydration and germination in compatible interactions.

(ii) Post-pollination events leading to double fertilization (starting from 2-celled pollen grain): A 2-celled pollen grain consists of a larger vegetative cell (tube cell) and a smaller generative cell enclosed within it. Step 1 — Pollen hydration and germination: The pollen grain absorbs water from the stigmatic surface, hydrates, and the intine bulges out through the germ pore to form a pollen tube. The pollen tube grows down through the style guided by chemotropic substances. Step 2 — Generative cell division: As the pollen tube grows through the style, the generative cell divides mitotically to produce two non-motile male gametes (sperms). Now the pollen tube is 3-celled (vegetative cell nucleus + 2 male gametes). Step 3 — Pollen tube entry into ovule: The pollen tube enters the ovule, usually through the micropyle (porogamy), and reaches the embryo sac. The tip of the pollen tube bursts, releasing the two male gametes into the embryo sac. Step 4 — Double fertilization: First fertilization (syngamy): One male gamete fuses with the egg cell (n + n) to form the zygote (2n), which will develop into the embryo. Second fertilization: The other male gamete fuses with the diploid secondary nucleus

(central cell, 2n, formed by fusion of two polar nuclei) to form the Primary Endosperm Nucleus (PEN) = 3n (triploid). This is called triple fusion. The PEN develops into the endosperm, which nourishes the developing embryo. Both fusions together constitute double fertilization — a unique feature of angiosperms.

Explanation:

Double fertilization (discovered by Nawaschin) is the defining feature of angiosperms: syngamy (egg + sperm = zygote, 2n) and triple fusion (secondary nucleus + sperm = PEN, 3n).

Starting from a 2-celled pollen grain, the generative cell divides to form 2 sperms during pollen tube growth.

OR

Q.31

(b) (i) Explain menstrual phase in the menstrual cycle of human female.

(ii) Why is follicular phase also called proliferative phase ?

(iii) Explain the events that occur in Graafian follicle at the time of ovulation and thereafter.

(iv) Draw a Graafian follicle and label – Antrum and secondary oocyte.

Answer: (i) Menstrual phase (Days 1–5): The menstrual phase begins if the released egg is not fertilized (no pregnancy). As a result: (a) The corpus luteum degenerates, causing a sharp decline in progesterone and oestrogen levels. (b) The withdrawal of progesterone/oestrogen causes the thickened endometrial lining (stratum functionalis) of the uterus to break down and shed. (c) Blood vessels supplying the endometrium rupture. (d) The endometrial tissue, blood, mucus, and the unfertilized ovum are expelled through the vagina as menstrual flow (menses) over 3–5 days. The first day of menstruation is considered Day 1 of the menstrual cycle. Note: Menstruation does not occur if fertilization and implantation have taken place.

(ii) Follicular phase is also called proliferative phase because: During the follicular phase (Days 1–13), rising FSH levels stimulate follicular growth and maturation in the ovary. The developing follicles secrete increasing amounts of oestrogen.

Oestrogen acts on the uterus and stimulates the proliferation (rapid mitotic cell division) of the endometrial cells, causing the endometrium to regenerate and thicken (from ~1mm to ~3–5mm). Thus, during this phase there is active proliferation of the endometrium, hence it is called the proliferative phase.

(iii) Events in Graafian follicle at ovulation and thereafter: At ovulation (around Day 14): The LH surge (peak of LH) triggers ovulation. The wall of the Graafian follicle ruptures, releasing the secondary oocyte (arrested in meiosis II) surrounded by the zona pellucida and a layer of follicular cells (cumulus oophorus / corona radiata) into the fallopian tube. After ovulation: The ruptured Graafian follicle collapses. Under the influence of LH, the remaining follicular cells (granulosa cells and theca cells) undergo luteinization — they hypertrophy, accumulate lipid droplets and a yellow pigment (lutein). The structure transforms into the corpus luteum (yellow body). The corpus luteum secretes large amounts of progesterone and some oestrogen, which: maintain and further thicken the endometrium (secretory phase), prepare the uterus for implantation, and inhibit new follicle development (negative feedback on FSH/LH). If fertilization does not occur, the corpus luteum degenerates into corpus albicans (white fibrous scar tissue) after ~10–12 days, causing hormone levels to drop and menstruation to begin.

(iv) Diagram of Graafian follicle should show: Antrum — the fluid-filled cavity in the centre of the follicle (filled with follicular fluid/liquor folliculi). Secondary oocyte — the large cell in the antrum sitting on a stalk of granulosa cells (cumulus oophorus), arrested in meiosis II. Other structures (for complete labelling): Granulosa cells (wall), Theca interna, Theca externa, Zona pellucida (around the oocyte), Corona radiata (immediately surrounding oocyte).

Explanation:

The menstrual cycle involves four phases: menstrual (1–5), follicular/proliferative (1–13), ovulatory (14), and luteal/secretory (15–28).

The Graafian follicle →

corpus luteum →

corpus albicans transformation is a central event of the cycle regulated by LH.

Q.32

(a) Observe the segment of mRNA given below and answer the questions given below : (See the figure.)

(i) Explain and illustrate the steps involved to make fully processed hn RNA.

(ii) Gene encoding RNA polymerase I and RNA polymerase III have been affected by mutation. Explain its impact on the synthesis of polypeptide giving reasons.

Answer: (i) Steps to make fully processed hnRNA (heterogeneous nuclear RNA → mature mRNA): The primary RNA transcript (pre-mRNA / hnRNA) is synthesized in the nucleus by RNA polymerase II from the DNA template. Post-transcriptional processing (RNA processing) converts hnRNA into mature mRNA: Step 1 — Capping (5' capping): A 7-methylguanosine (m7G) cap is added to the 5' end of the hnRNA. This cap protects the mRNA from degradation by 5' exonucleases, facilitates nuclear export, and is essential for ribosome binding (translation initiation). Step 2 — Tailing (3' polyadenylation): A poly-A tail (chain of ~150–250 adenine nucleotides) is added to the 3' end of the hnRNA by the enzyme poly-A polymerase after cleavage of the transcript ~10–30 nucleotides downstream of the AATAAA signal sequence. The poly-A tail protects mRNA from 3' exonucleolytic degradation and aids in nuclear export and translation efficiency. Step 3 — Splicing (removal of introns): The hnRNA contains coding sequences (exons) interrupted by non-coding sequences (introns). A large ribonucleoprotein complex called the spliceosome (composed of snRNPs — small nuclear ribonucleoproteins) recognizes splice sites (GU...AG rule) and precisely removes the introns and ligates the exons together. The result is a continuous coding sequence. The fully processed mRNA (with 5' cap + exons only + poly-A tail) is exported from the nucleus to the cytoplasm for translation.

(ii) Impact of mutations in genes encoding RNA polymerase I and RNA polymerase III on polypeptide synthesis: RNA polymerase I transcribes ribosomal RNA genes (28S rRNA, 18S rRNA, 5.8S rRNA). RNA polymerase III transcribes small RNA genes including 5S rRNA and tRNA genes. Impact: RNA Pol I mutation

→ no/reduced rRNA (28S, 18S, 5.8S) synthesis → ribosomes cannot be assembled properly (ribosomes require rRNA as structural and functional components). Without functional ribosomes, translation cannot occur → no polypeptide synthesis. RNA Pol III mutation → no/reduced tRNA synthesis → even if mRNA is present and ribosomes exist, amino acids cannot be brought to the ribosome (tRNA is the adaptor molecule that carries specific amino acids and recognizes codons). Also, no 5S rRNA → ribosome assembly is further impaired. Net effect: Polypeptide synthesis would be severely impaired or completely abolished because both ribosome assembly (rRNA) and amino acid delivery (tRNA) are compromised. Note: RNA Pol II (which synthesizes mRNA/hnRNA) is unaffected by these mutations, so mRNA would still be made — but it cannot be translated due to lack of ribosomes and tRNA.

Explanation:

The three eukaryotic RNA polymerases have distinct roles: Pol I → rRNA (ribosome structure), Pol II → mRNA/hnRNA (template), Pol III → tRNA and 5S rRNA.

Mutations in Pol I and III prevent ribosome formation and aminoacyl-tRNA delivery respectively, blocking translation despite intact mRNA.

OR

Q.32

(b) In a particular cattle, the coat colour red and white are controlled by single pair of alleles. A calf that receives allele for red coat from mother and allele for white coat from father shows equal number of red and white hairs on its coat.

(i) Is this an example of Co-dominance or incomplete dominance. Give a reason for your answer.

(ii) With the help of a genetic cross upto F2 generation, explain what will be the consequent phenotype of calf when (1) Red is dominant over white, (2) Red is incompletely dominant.

Answer: (i) This is an example of Co-dominance. Reason: Co-dominance is when both alleles are simultaneously and independently expressed in the heterozygote, producing a phenotype in which BOTH parental traits are visible side by side (e.g., both red and white hairs present in equal numbers — a roan coat). In incomplete dominance, the heterozygote would show an intermediate blending phenotype (e.g., pink/pale red — a mixture, not distinct patches). Since the calf shows EQUAL NUMBERS OF RED and WHITE HAIRS distinctly (not a blend), both alleles are expressed independently and simultaneously — this is co-dominance.

(ii) (1) Red is DOMINANT over white:
Let R = red (dominant), r = white (recessive).
P: RR (red) × rr (white)
F1: All Rr (red phenotype, since R is dominant)
F1 × F1: Rr × Rr
F2 gametes: R, r (from each parent)
F2 genotypes: 1 RR : 2 Rr : 1 rr
F2 phenotypes: 3 red (RR + Rr) : 1 white (rr)
Phenotypic ratio = 3 red : 1 white

(2) Red is INCOMPLETELY dominant over white:
Let R^R = red, R^W = white (using superscript notation for incomplete dominance).
P: R^R R^R (red) × R^W R^W (white)
F1: All R^R R^W (roan/pink — intermediate phenotype)
F1 × F1: R^R R^W × R^R R^W
F2 genotypes: 1 R^R R^R : 2 R^R R^W : 1 R^W R^W
F2 phenotypes: 1 red (R^R R^R) : 2 roan/intermediate (R^R R^W) : 1 white (R^W R^W)
Phenotypic ratio = 1 red : 2 roan : 1 white
(In incomplete dominance, genotypic ratio = phenotypic ratio = 1:2:1)

Explanation:

Co-dominance (both alleles expressed — ABO blood group, roan cattle) vs incomplete dominance (intermediate blending — snapdragon flower colour, Mirabilis).

In co-dominance, heterozygote shows both parental traits;

in incomplete dominance, heterozygote shows an intermediate trait.

For dominant F2: 3:1 ratio; for incomplete dominant F2: 1:2:1 ratio.

Q.33

(a) A 30 year old man was admitted to a hospital with recurrent infections, weight loss, prolonged fever. His blood report showed a decline in count of T-Lymphocytes thus affecting immune system.

(i) Identify the disease and its causative agent.

(ii) How did the pathogen affect the immune system once it entered the body ? Explain.

(iii) Mention two major modes of its transmission.

Answer: (i) Disease: AIDS (Acquired Immuno Deficiency Syndrome). Causative agent: HIV (Human Immunodeficiency Virus) — a retrovirus (RNA virus with reverse transcriptase enzyme).

(ii) How HIV affects the immune system: Step 1 — HIV enters the body and, in the blood, encounters and infects macrophages (which have CD4 receptors). Inside macrophages, HIV's RNA genome is reverse transcribed into DNA by reverse transcriptase. The viral DNA integrates into the host macrophage's chromosome. Macrophages act as a 'HIV factory', producing new virus particles continuously without dying. Step 2 — The newly produced viruses also infect T-helper cells (CD4+ T lymphocytes / TH cells), which are the key coordinators of the immune response. HIV binds to the CD4 surface receptor on TH cells and enters them. Step 3 — Inside TH cells, the same replication cycle occurs. Over months to years, HIV progressively destroys CD4+ T lymphocytes. The count of TH cells decreases dramatically (a healthy person has ~1000 CD4+ cells/μL; AIDS patient < 200 cells/μL). Step 4 — Without TH cells: B cells cannot produce adequate antibodies (humoral immunity compromised); cytotoxic T cells (TC) are not

properly activated (cell-mediated immunity compromised); NK cells are not activated; macrophage activity declines. The person becomes severely immunocompromised and susceptible to opportunistic infections (Pneumocystis jirovecii pneumonia, Toxoplasmosis, Candida, Mycobacterium, CMV, Kaposi's sarcoma, etc.) that a healthy immune system would easily control. This immunodeficiency stage is called AIDS.

(iii) Two major modes of HIV/AIDS transmission: (1) Sexual transmission — Unprotected sexual contact (vaginal, anal, oral) with an infected person; HIV is present in semen and vaginal secretions. (2) Blood-to-blood transmission — Sharing contaminated needles/syringes (intravenous drug users); receiving infected blood transfusions; needle stick injuries in healthcare workers. Other valid modes: Mother-to-child (vertical) transmission — during childbirth (perinatal) or through breast milk.

Explanation:

HIV targets CD4+ TH cells (and macrophages), progressively destroying the immune coordination cells.

Without TH cells, both humoral and cell-mediated immunity fail, leading to AIDS and susceptibility to opportunistic infections.

Transmission routes: sexual, blood (needles/transfusion), and perinatal.

OR

Q.33

(b) (i) Why are microbes considered effective biocontrol agents in sustainable agriculture ?

(ii) Explain the role of the following as biocontrol agents naming the pests or diseases they help to control :

(1) A Bacterium

(2) A Fungus

(3) Virus

Answer: (i) Microbes are considered effective biocontrol agents in sustainable agriculture because: (a) They are specific — they target only specific

pests/pathogens without harming non-target organisms (unlike chemical pesticides which kill indiscriminately). (b) Biodegradable and environmentally safe — they naturally degrade and do not persist in the environment or accumulate in food chains (no biomagnification). (c) Reduce chemical pesticide use — decrease pollution, soil degradation, and health hazards associated with chemical pesticides. (d) Sustainable — they can reproduce and persist in the environment, providing long-term pest control. (e) Do not lead to pesticide resistance in the same way chemical pesticides do.

(ii) Biocontrol agents: (1) Bacterium — Bacillus thuringiensis (Bt): Used against lepidopteran insects (butterfly/moth larvae — caterpillars), coleopteran beetles, and dipteran mosquito larvae. Bt produces Cry proteins (Cry toxins, encoded by cry genes) during sporulation. When ingested by insect larvae, the alkaline pH of the insect gut solubilizes the Cry protein, which is activated by gut proteases. The activated toxin inserts into the midgut epithelial cells, creating pores that disrupt ion balance → cell lysis → larval death. Used in Bt cotton (against bollworm), Bt corn (against corn borer), and Bt sprays for organic farming. (2) Fungus — Trichoderma species (e.g., Trichoderma viride, T. harzianum): Used as a biocontrol agent against soil-borne plant pathogens (fungal diseases) such as Fusarium root rot, Pythium damping-off, Rhizoctonia blight. Trichoderma is a free-living fungus that colonizes plant roots, produces antibiotics and lytic enzymes (chitinases, glucanases) that degrade the cell walls of pathogenic fungi, and also competes with pathogens for nutrients and space. Another example: Beauveria bassiana — entomopathogenic fungus used against whiteflies, aphids, thrips. (3) Virus — Baculoviruses (Nuclear Polyhedrosis Viruses, NPV): Used as bioinsecticides against specific insect pests such as Helicoverpa (cotton bollworm), Spodoptera (armyworm), Lymantria (gypsy moth). Baculoviruses are highly host-specific — they infect and kill target insects without harming mammals, birds, fish, plants, or other beneficial insects (like honeybees and predatory insects). They are particularly suitable for integrated pest management (IPM). The Autographa californica NPV (AcMNPV) is widely used.

Explanation:

The three classic microbial biocontrol agents: Bacillus thuringiensis (Bt) — bacteria targeting insect larvae via Cry toxins;

Trichoderma — fungus targeting soil pathogens;

Baculoviruses/NPV — viruses targeting specific insect pests.

All are selective, safe, and biodegradable.