CBSE Class 12 Biology 2024 — 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

An angiosperm embryo sac is located within the :

(a) Placenta
(b) Megasporangium
(c) Nucellus <<
(d) Ovary

Explanation:

The embryo sac (female gametophyte) in angiosperms develops within the nucellus of the ovule.

The nucellus is the central tissue of the ovule that surrounds and nourishes the embryo sac.

Q.2

Match the items in Column I with those in Column II and select the correctly matched option from those given below :

Column I (Cross) | Column II (Phenotypic Ratio)
1. Mendelian monohybrid | (i) 1 : 2 : 1 (F2)
2. Mendelian dihybrid | (ii) 1 : 1
3. Incomplete dominance | (iii) 3 : 1 (F2)
4. Test cross (monohybrid) | (iv) 9 : 3 : 3 : 1 (F2)

(a) 1 (ii), 2 (iv), 3 (i), 4 (iii)
(b) 1 (iii), 2 (i), 3 (iv), 4 (ii)
(c) 1 (iii), 2 (iv), 3 (i), 4 (ii) <<
(d) 1 (ii), 2 (i), 3 (iv), 4 (iii)

Explanation:

Mendelian monohybrid cross gives 3:1 ratio in F2 (iii);
Mendelian dihybrid cross gives 9:3:3:1 (iv);
Incomplete dominance gives 1:2:1 in F2 (i) because heterozygotes show intermediate phenotype;
Test cross (monohybrid) gives 1:1 ratio (ii).

So: 1-(iii), 2-(iv), 3-(i), 4-(ii).

Q.3

In humans, the secondary oocyte completes meiotic division when :

(a) it gets implanted in the uterine endometrium.
(b) it is released from the matured Graafian follicle.
(c) it is penetrated by the sperm cell. <<
(d) acrosomal enzymes break down the zona pellucida.

Explanation:

The secondary oocyte is arrested in Meiosis II (metaphase II) at the time of ovulation. It only completes meiosis II (to form the ovum and second polar body) after penetration by the sperm cell.
Fertilization triggers the completion of meiosis II.

Q.4

Which one of the following statements is not true ?

(a) Flippers of whales and dolphins are homologous organs.
(b) Homologous organs have similar anatomical structure, but perform different functions.
(c) Homology indicates common ancestry.
(d) Homologous structures are a result of convergent evolution. <<

Explanation:

Homologous structures result from DIVERGENT evolution — structures with common origin that have evolved to perform different functions in different species.
Convergent evolution produces ANALOGOUS structures (e.g., wings of birds and insects) which look similar but have different origins.
Options A, B, and C are all true statements about homology.

Q.5

A population is in genetic equilibrium/Hardy-Weinberg equilibrium for a gene with two alleles (dominant allele A and recessive allele a). If the frequency of allele A is 0·6, then the frequency of genotype Aa is :

(a) 0·21
(b) 0·42
(c) 0·48 <<
(d) 0·32

Explanation:
Given: frequency of dominant allele A (p) = 0.6, so frequency of recessive allele a (q) = 1 - 0.6 = 0.4.
Frequency of heterozygote Aa = 2pq = 2 × 0.6 × 0.4 = 0.48.
Option C = 0.48.

Q.6
In the double helical structure of DNA molecule, the strands are :

(a) identical and complementary
(b) identical and non-complementary
(c) anti-parallel and complementary <<
(d) anti-parallel and non-complementary

Explanation:
In the Watson-Crick double helix model of DNA, the two strands run in opposite directions (anti-parallel — one 5' to 3', the other 3' to 5') and are complementary to each other (A pairs with T, G pairs with C).
They are NOT identical; they are complementary.

Q.7
In a transcription unit the terminator is located towards the :

(a) 3' end of the template strand
(b) 5' end of the template strand
(c) 5' end of the coding strand
(d) 3' end of the coding strand <<

Explanation:
The terminator lies downstream, towards the 3′ end of the coding strand (the strand with the same polarity as the RNA), option (D).

The promoter lies at the 5′ end of the coding strand.

Note: option (B), the 5′ end of the template strand, describes the same end.

Q.8

A woman with normal vision has a colour blind father. She marries a man with normal vision. The percentage chance of their progeny being colour blind is :

(a) 25% <<

(b) 50%

(c) 75%

(d) 100%

Explanation:

Colour blindness is X-linked recessive.

The woman's father is colour blind (X^b Y), so she is a carrier (X^B X^b).

Her husband has normal vision (X^B Y).

Cross: X^B X^b × X^B Y gives X^B X^B (normal female), X^B X^b (carrier female), X^B Y (normal male), X^b Y (colour blind male).

Colour blind offspring = X^b Y = 1 out of 4 = 25%.

Q.9

The vector for dengue fever is :

(a) Female Aedes mosquito <<

(b) Female Anopheles mosquito

(c) Male Aedes mosquito

(d) Female Culex mosquito

Explanation:

Dengue fever is transmitted by the female Aedes mosquito (specifically Aedes aegypti).

Female mosquitoes are the vectors because only females suck blood (needed for egg development).

Female Anopheles transmits malaria; Female Culex transmits filariasis.

Q.10

Which one of the following pairs is not correctly matched ?

(a) Clostridium butylicum — Butyric acid

(b) Trichoderma polysporum — Cyclosporin A

(c) Monascus purpureus — Citric Acid <<

(d) Streptococcus — Streptokinase

Explanation:

Monascus purpureus is used to produce statins (blood cholesterol lowering agents), not Citric Acid.

Citric acid is produced by Aspergillus niger.

The other pairs are correct: Clostridium butylicum produces butyric acid;

Trichoderma polysporum produces cyclosporin A (immunosuppressant);

Streptococcus produces streptokinase (clot buster).

Q.11

Which one of the following is not a feature of plasmids ?

(a) Circular

(b) Self-replicating

(c) Single stranded <<

(d) Extra-chromosomal

Explanation:

Plasmids are double-stranded (not single-stranded) circular DNA molecules.

They are extra-chromosomal (separate from the main chromosome), self-replicating, and usually circular.

'Single stranded' is NOT a feature of plasmids.

Q.12

The pyramid of biomass in sea is generally inverted because in sea :

(a) Biomass of fishes exceeds that of phytoplankton. <<

(b) Number of phytoplanktons is more.

(c) Number of phytoplanktons is less.

(d) Large fishes feed on small fishes.

Explanation:

Phytoplankton in the sea have a small standing crop but a very high turnover, and they are grazed continuously.

The total biomass of fishes (and zooplankton) at any time therefore exceeds that of phytoplankton, so the pyramid of biomass is inverted.

Answer: (A) Biomass of fishes exceeds that of phytoplankton.

The number of phytoplankton is not the reason for inversion of the biomass pyramid.

Q.13

Assertion (A) : RNA is unstable and can mutate at a faster rate.

Reason (R) : The presence of 2' OH group in every nucleotide of RNA makes it labile and easily degradable.

(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 statements are true.

RNA is indeed less stable than DNA because of the 2'-OH group on ribose sugar, which makes it susceptible to hydrolysis (labile and easily degradable).

This instability is the reason RNA can be chemically degraded more easily, and viruses with RNA genomes (e.g., influenza) mutate faster.

The Reason correctly explains the Assertion.

Q.14

Assertion (A) : Virus-infected cells produce interferons.

Reason (R) : Interferons can cause inflammation of virus-infected cells.

(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 — virus-infected cells do produce interferons (antiviral proteins).
However, Reason R is false — interferons do NOT cause inflammation of virus-infected cells.
Instead, interferons protect non-infected neighboring cells by inducing antiviral state and activating immune cells (NK cells, macrophages).
They do not cause inflammation.

Q.15

Assertion (A) : Specific enzymes are used to degrade the cell wall in organisms to isolate the DNA from the cell.

Reason (R) : Fungal cell wall is degraded by the enzyme cellulase.

(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 — specific enzymes ARE used to degrade cell walls in DNA isolation (lysozyme for bacteria, cellulase for plants, chitinase for fungi).
However, Reason R is false — fungal cell wall is made of chitin, so it is degraded by CHITINASE, not cellulase.
Cellulase degrades cellulose (plant cell walls).

Hence A is true but R is false.

Q.16

Assertion (A) : Loss of biodiversity can occur due to overexploitation of resources.

Reason (R) : Introduction of Clarias gariepinus in Indian rivers has led to a decline in native Indian fishes.

(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 statements are true.

Assertion A is correct — overexploitation of resources does lead to loss of biodiversity.

Reason R is also correct — Clarias gariepinus (African catfish) introduced in Indian rivers has led to decline of native fish species.

However, the Reason (introduction of alien species) does not explain Assertion A (overexploitation) — these are two different causes of biodiversity loss.

Hence both are true but R does not explain A.

Q.17

(a) Name any two copper releasing intra-uterine devices. State two reasons that make them effective contraceptives.

Answer: Copper releasing IUDs: (1) CuT (Copper-T), (2) Cu7 (Copper-7) / Multiload 375. Two reasons for effectiveness: (i) Copper ions released suppress sperm motility and fertilising capacity of sperms. (ii) IUDs make the uterus unsuitable for implantation and also make the cervical mucus hostile to sperms.

Explanation:

Copper-releasing IUDs release Cu2+ ions continuously.

These ions are spermicidal (suppress sperm motility and fertilizing capacity) and also create an environment in the uterus that is hostile to implantation.

They are highly effective, long-acting reversible contraceptives.

OR

Q.17

(b) Name any two outbreeding devices that flowering plants have developed and explain how they help in encouraging cross-pollination.

Answer: Two outbreeding devices: (1) Dichogamy — anthers and stigma mature at different times (e.g., protandry in sunflower, protogyny in some plants), preventing self-pollination. (2) Self-incompatibility — a genetic mechanism that prevents pollen germination on the same plant's stigma. Other valid devices include heterostyly (different lengths of style and stamens) and unisexuality (monoecious or dioecious flowers). These devices prevent self-pollination and promote cross-pollination.

Explanation:

Flowering plants have evolved several outbreeding devices to prevent inbreeding and promote cross-pollination, which increases genetic variation.

Dichogamy (temporal separation), self-incompatibility (genetic barrier), and heterostyly (morphological barrier) all encourage pollen from one flower to fertilise another genetically different flower.

Q.18

Although Haemophilia and sickle cell anemia are two blood related Mendelian disorders, yet, they differ in their pattern of inheritance. State any two differences.

Answer: Differences: (1) Haemophilia is X-linked recessive disorder (gene on X chromosome), while Sickle cell anaemia is autosomal recessive (gene on chromosome 11). (2) Haemophilia predominantly affects males (females are

usually carriers), while Sickle cell anaemia affects both males and females equally. (3) In haemophilia, heterozygous females are carriers but phenotypically normal; in sickle cell anaemia, heterozygous individuals show sickle cell trait (incomplete dominance/codominance).

Explanation:

Haemophilia is caused by mutation in gene on X chromosome (Factor VIII or IX gene); sickle cell anaemia by mutation in beta-globin gene on chromosome 11.

Their modes of inheritance (X-linked vs autosomal) lead to different patterns in pedigree analysis.

Q.19

Identify A, B, C and D in the following table :

Scientific name of the plant | Drug | Effect on the human body/human system

(a) Papaver somniferum | A | Depressant/slows down body function

(b) Cannabis sativa | Cannabinoids | B

(c) Erythroxylum coca | C | D

Answer: A = Opiates / Morphine (opium, heroin) — derived from Papaver somniferum (opium poppy); B = Cannabinoids cause hallucination / alter thought, feeling and perception (alter mind/cause euphoria); C = Cocaine; D = Stimulant / acts on central nervous system, causes euphoria and increased energy, interferes with dopamine transport.

Explanation:

Papaver somniferum (opium poppy) yields opiates including morphine and heroin — depressants that slow down CNS activity.

Cannabis sativa yields cannabinoids (THC) that cause hallucinations and altered perception.

Erythroxylum coca yields cocaine, a stimulant that interferes with dopamine reuptake and causes intense euphoria.

Q.20

Write the role of ‘ori’ and restriction site in the cloning vector pBR322.

Answer: ori (origin of replication): This is the sequence where DNA replication initiates. Any foreign DNA ligated to pBR322 at the restriction site will be replicated using this ori, allowing amplification of the recombinant DNA in the host cell. Restriction site: pBR322 has several restriction enzyme recognition sites (e.g., EcoRI, BamHI, SalI) located within the ampicillin resistance (ampR) or tetracycline resistance (tetR) genes. Foreign DNA is inserted at these sites. Insertion into tetR allows insertional inactivation to identify recombinants (transformed bacteria with insert will be tetracycline-sensitive but ampicillin-resistant).

Explanation:

pBR322 is a commonly used cloning vector.

It contains two antibiotic resistance genes (ampR and tetR) which serve as selectable markers.

The ori allows autonomous replication.

Restriction sites within antibiotic resistance genes allow insertional inactivation for recombinant selection.

Q.21

How is the rate of decomposition affected by the nature of detritus and temperature ?

Answer: Nature of detritus: (i) Detritus rich in lignin and chitin decomposes slowly. (ii) Detritus rich in cellulose decomposes at intermediate rate. (iii) Detritus rich in nitrogen and water-soluble compounds (sugars, amino acids) decomposes rapidly. Chemical composition (C:N ratio, lignin content) determines decomposition rate. Temperature: Higher temperature (within optimal range) increases decomposition rate because it increases the metabolic activity of decomposers (bacteria and fungi). Extremely high or low temperatures reduce decomposition rate. Warm and moist conditions favour rapid decomposition.

Explanation:

Decomposition is primarily carried out by microbial decomposers.

Temperature affects the enzymatic activity of these microbes — optimum temperatures speed up decomposition.

The chemical nature of organic matter determines how easily microbes can break it down.

Recalcitrant compounds like lignin resist decomposition.

Q.22

(a) Why is IVF (In Vitro Fertilisation) so named ? State its importance.

(b) Distinguish between GIFT and ZIFT.

Answer: (a) IVF is named 'In Vitro Fertilisation' because fertilisation occurs outside the body (in vitro = in glass, i.e., in lab conditions, typically in a petri dish) rather than inside the fallopian tube (in vivo). Importance: It helps couples who cannot conceive naturally (e.g., due to blocked fallopian tubes, low sperm count) to have children. The embryo (usually at 8-cell stage) is then transferred to the uterus (Embryo Transfer / ET). (b) GIFT (Gamete Intra Fallopian Transfer): Transfer of an ovum collected from a donor into the fallopian tube of a recipient female. Fertilisation occurs inside the fallopian tube. ZIFT (Zygote Intra Fallopian Transfer): The zygote (or early embryo up to 8 cells) formed by IVF is transferred into the fallopian tube. Key difference: In GIFT, gametes (unfertilised eggs) are transferred; in ZIFT, the fertilised egg (zygote) is transferred into the fallopian tube.

Explanation:

IVF-ET is an assisted reproductive technology (ART).

GIFT involves transfer of gametes to fallopian tube;

ZIFT involves transfer of zygote to fallopian tube.

Both aim to assist infertile couples.

Q.23

(a) (i) Write the karyotype and the genetic disorder of an individual who has

developed from a zygote formed from an ‘XX’ egg fertilised by a ‘Y’ sperm.
(ii) Mention any two symptoms of this genetic disorder.
(iii) Write the possible reason that leads to the formation of this ‘XX’ egg.

Answer: (i) Karyotype 44 + XXY (47, XXY); the disorder is Klinefelter's syndrome. (ii) Symptoms: individual is phenotypically male but has an overall masculine development with feminine traits such as gynaecomastia (breast development); small testes, sterility; tall stature, sparse body hair. (iii) The ‘XX’ egg forms by non-disjunction of the sex chromosomes during meiosis in oogenesis: the two X chromosomes (or the two X chromatids) fail to separate, so the egg receives both X chromosomes instead of one.

Explanation:

An XX egg (24 chromosomes: 22 + XX) fertilised by a Y sperm gives 44 + XXY, Klinefelter's syndrome.

The extra X comes from the mother through failure of X chromosomes to separate (non-disjunction) during egg formation.

OR

Q.23

(b) In case of any dispute, a very small sample of tissue or even a drop of blood can help us to determine the paternity of a child. Provide a scientific explanation to substantiate the statement.

Answer: DNA fingerprinting (DNA profiling) is the scientific basis for paternity determination. Each individual has a unique DNA sequence. The technique involves: (1) Isolation of DNA from the tissue/blood sample. (2) DNA is cut with restriction endonucleases to produce fragments. (3) Fragments are separated by gel electrophoresis. (4) Southern blotting transfers DNA to nylon membrane. (5) Hybridisation with radioactive/fluorescent probes that bind to Variable Number Tandem Repeats (VNTRs) / satellite DNA. (6) Autoradiography reveals a unique banding pattern (DNA fingerprint). Since a child inherits half its DNA from the father and half from the mother, the child's DNA fingerprint will show bands matching both parents. Paternity can be confirmed if the child's bands not

matching the mother are found in the alleged father's profile.

Explanation:

DNA fingerprinting exploits the highly polymorphic nature of satellite DNA/VNTRs which are unique to each individual (except identical twins).

This technique, developed by Alec Jeffreys, is used in forensic science and paternity testing.

Q.24

(a) Explain the process by which amino acid gets attached to the tRNA molecule during translation process.

(b) How does the translation process get terminated ?

(c) Expand UTR. Where are they located ?

Answer: (a) Amino acyl-tRNA synthetase (aminoacyl-tRNA synthetase): Each amino acid is activated by reacting with ATP to form aminoacyl-AMP (amino acid adenylate), releasing pyrophosphate. The activated amino acid is then transferred to the 3'-OH end of the specific tRNA molecule (at CCA-3' end), forming aminoacyl-tRNA. This reaction is catalysed by specific aminoacyl-tRNA synthetase enzymes (one for each amino acid). Energy from ATP hydrolysis is used. (b) Termination: When a stop codon (UAA, UAG, or UGA) on the mRNA reaches the A site of the ribosome, no tRNA can recognise these codons (no aminoacyl-tRNA for stop codons). Instead, release factors (proteins) bind to the stop codon, causing hydrolysis of the peptidyl-tRNA bond, releasing the completed polypeptide chain and disassembly of the ribosome. (c) UTR = Untranslated Region. They are located at both ends of the mRNA — 5' UTR (5' untranslated region) is upstream (before) the start codon, and 3' UTR (3' untranslated region) is downstream (after) the stop codon. They are present in the mRNA but are not translated into protein.

Explanation:

Aminoacyl-tRNA synthetases are the enzymes that 'charge' tRNAs.

UTRs are important for mRNA stability, translation efficiency, and regulation.

Stop codons are recognised by protein release factors, not tRNAs.

Q.25

(a) Differentiate between humoral immune response and cell-mediated immune response.

(b) Draw a schematic diagram of an antibody molecule and label any four parts.

Answer: (a) Differences between Humoral and Cell-mediated immune response:
Humoral Immune Response: (i) Mediated by B-lymphocytes (B-cells). (ii) Involves production of antibodies (immunoglobulins) by plasma cells. (iii) Effective against extracellular pathogens (bacteria, free viruses, toxins). (iv) Memory B cells provide long-term immunity.
Cell-mediated Immune Response (CMI): (i) Mediated by T-lymphocytes (T-cells), specifically cytotoxic T-cells (Tc cells). (ii) Does not involve antibody production. (iii) Effective against intracellular pathogens (viruses inside cells), cancer cells, and transplanted organs. (iv) Involves direct killing of infected/abnormal cells.
(b) Antibody (Immunoglobulin) structure — 4 parts to label: (1) Heavy chain (H chain) — two identical heavy polypeptide chains. (2) Light chain (L chain) — two identical light polypeptide chains. (3) Variable region (Fab region / antigen-binding site) — located at the tips of the Y-structure; antigen binding occurs here. (4) Constant region (Fc region) — the stem of the Y; determines class of antibody and mediates effector functions. Also acceptable: disulfide bonds, hinge region.

Explanation:

Humoral immunity is antibody-mediated (B cell-mediated); CMI is T cell-mediated.

An antibody (IgG) is a Y-shaped molecule with two heavy and two light chains held by disulfide bonds.

The variable regions form the antigen-binding sites.

Q.26

The picture given below shows :

(a) Roots of a typical control tobacco crop plant (infected).

(b) Transgenic tobacco plant showing healthy roots even after deliberate infection by nematode.

Explain how this transformation was achieved in the tobacco plant.

Answer: The tobacco plant was made resistant to the nematode Meloidogyne incognita using RNA interference (RNAi) technology. Process: (1) A nematode-specific gene (e.g., a parasitism gene such as that encoding a protein essential for nematode survival) was identified. (2) Both sense (5'→3') and antisense (3'→5') copies of the nematode-specific gene were cloned into a vector in a manner that they could be expressed in the plant. (3) The sense and antisense RNA strands produced in the plant cell are complementary to each other and form double-stranded RNA (dsRNA). (4) This dsRNA triggers RNA interference (RNAi) — the cellular mechanism that uses small interfering RNA (siRNA) to silence gene expression by degrading the specific complementary mRNA of the nematode. (5) When the nematode feeds on the transgenic plant, the siRNA from the plant enters the nematode cells and silences the nematode's essential gene, killing or neutralising the nematode. Result: The transgenic tobacco plant shows healthy roots even after deliberate nematode infection.

Explanation:

RNA interference (RNAi) is post-transcriptional silencing of a gene by double-stranded RNA complementary to its mRNA.

Sense and antisense RNAs of a nematode-specific gene were expressed in the tobacco roots (introduced by Agrobacterium vectors);

they form dsRNA that silences the nematode's essential gene, so the parasite cannot survive in the transgenic plant.

Q.27

Given below is a pie chart representing global diversity of vertebrates.

(See the figure.)

(a) Redraw the pie chart identifying the groups ‘A’, ‘B’, ‘C’ and ‘D’ in their respective positions.

(b) Mention two examples of recently extinct animals.

Answer: (a) The pie chart has Fishes (about half) and four smaller sectors. In order of size and position: A = Mammals (smallest sector, about 9%), B = Birds (largest of the four, about 17%), C = Reptiles (about 14%), D = Amphibians (about 10%). Redraw the circle with Fishes as the large half and label A–D accordingly. (b) Recently extinct animals: Dodo (Mauritius) and Thylacine/Tasmanian tiger; also Quagga and Steller's sea cow.

Explanation:

The pie shows relative numbers of vertebrate species: fishes are the most diverse group (about half);

among the other groups birds and reptiles each exceed amphibians and mammals.

NCERT examples of recent extinctions: Dodo, Quagga, Thylacine, Steller's sea cow.

Q.28

Predation is referred to as a detrimental interaction. Explain any three positive roles, supported by an example each, that a predator plays in an ecosystem.

Answer: Three positive roles of predators in an ecosystem:

(1) Maintaining prey population size / preventing overpopulation: Predators keep prey populations in check, preventing overgrazing or resource depletion. Example: Lions preying on herbivores (zebras, wildebeest) in savannah prevent overgrazing of grasslands.

(2) Maintaining species diversity: By preying on competitively dominant species (keystone predation), predators prevent any one prey species from dominating and outcompeting others, thus maintaining biodiversity. Example: The sea star Pisaster (a keystone predator) in intertidal zones preys on mussels, preventing mussels from outcompeting other species and maintaining diversity.

(3) Acting as a biological control agent: Predators can control pest populations

naturally, reducing the need for pesticides. Example: Gambusia fish introduced in ponds/water bodies to control mosquito larvae populations (biological control of mosquitoes).
Other valid roles: (4) Prey evolution — predation drives prey adaptations (faster running, cryptic colouration), promoting evolution.

Explanation:
While predation is harmful to the prey (−/+ interaction), it plays important positive ecological roles — population regulation, maintaining diversity, and driving evolution. The keystone predator concept (Paine's sea star experiment) is a classic example.

Q.29(a)

Read the following passage and answer the questions that follow.

Spermatogenesis is an important primary sex characteristic in humans and all other vertebrates. The process is coordinated and controlled under the influence of hormones. It starts with the onset of puberty in humans and thereafter continues. The primordial cells within the embryonic testis which differentiate into spermatogonia are the precursors of the sperms. These are located at the outer walls of the seminiferous tubules where the process of spermatogenesis proceeds.

(a) State the site of action of FSH in the testes and describe its action thereafter.

Answer: Site of action of FSH: Sertoli cells (within the seminiferous tubules). Action: FSH stimulates Sertoli cells to secrete androgen-binding protein (ABP). ABP binds testosterone and concentrates it in the seminiferous tubules, maintaining a high local concentration of testosterone needed for spermatogenesis. FSH also stimulates Sertoli cells to secrete inhibin (which provides negative feedback on FSH secretion from the anterior pituitary) and various other factors that support the development of sperm cells.

Explanation:

FSH (Follicle Stimulating Hormone) from the anterior pituitary acts on Sertoli cells in the seminiferous tubules to promote spermatogenesis by stimulating ABP production. This maintains the androgen-rich microenvironment essential for sperm development.

OR

Q.29(a)

(Case Study — Spermatogenesis) (a) OR: Describe the role of LH in the process of spermatogenesis.

Answer: LH (Luteinizing Hormone) acts on Leydig cells (interstitial cells) located in the connective tissue between the seminiferous tubules in the testes. LH stimulates Leydig cells to synthesise and secrete androgens (primarily testosterone). Testosterone, in turn, is essential for: (i) Stimulating the process of spermatogenesis — the proliferation and differentiation of spermatogonia into spermatozoa. (ii) Maintaining the secondary sexual characteristics of males. Thus, LH indirectly promotes spermatogenesis by stimulating testosterone production from Leydig cells.

Explanation:

LH acts on Leydig cells (not Sertoli cells) to stimulate testosterone synthesis.
Testosterone is the key hormone that drives spermatogenesis.
LH is sometimes called ICSH (Interstitial Cell Stimulating Hormone) in males.

Q.29(b)

(Case Study — Spermatogenesis) (b) Name the cells and their products which undergo the following during the process of spermatogenesis:

(i) Mitosis and Differentiation

(ii) Meiosis I and Meiosis II

Answer: (i) Mitosis and Differentiation: Spermatogonia (diploid, 2n) — primary germ cells located on the outer wall of seminiferous tubules — undergo mitosis to increase in number, and some differentiate into primary spermatocytes (2n). (ii) Meiosis I: Primary spermatocytes (2n) undergo Meiosis I to produce secondary

spermatocytes (n, haploid). Meiosis II: Secondary spermatocytes (n) undergo Meiosis II to produce spermatids (n). Spermatids then undergo spermiogenesis (differentiation without further division) to form spermatozoa.

Explanation:
Spermatogenesis stages: Spermatogonia (2n) →
[mitosis] →
Primary spermatocytes (2n) →
[Meiosis I] →
Secondary spermatocytes (n) →
[Meiosis II] →
Spermatids (n) →
[spermiogenesis] →
Spermatozoa (n).

Q.29(c)

(Case Study — Spermatogenesis) (c) Name the accessory ducts that the sperms travel through from seminiferous tubules to reach the epididymis.

Answer: The sperms travel from the seminiferous tubules through the following accessory ducts to reach the epididymis: (1) Rete testis — a network of channels within the testis. (2) Vasa efferentia (efferent ductules) — connect the rete testis to the epididymis. The sequence is: Seminiferous tubules → Rete testis → Vasa efferentia → Epididymis.

Explanation:
After spermatogenesis, sperms are immotile and are transported via the rete testis and vasa efferentia to the epididymis, where they undergo maturation and gain motility. The epididymis then connects to the vas deferens.

Q.30(a)

Read the following passage and answer the questions that follow.

In 1981, the health workers of United States of America had become aware

of the increased frequency of Kaposi's sarcoma, cancer of the skin and blood vessels and another disease pneumocystis pneumonia, a respiratory infection caused by a protozoan. Both these diseases were very rare in the general population, but occurred frequently in more severely "immunosuppressed" individuals. This led to the recognition of the immune system disorder that was named Acquired Immune Deficiency Syndrome (AIDS).

In 1983, virologists working in the USA and France had identified a causative agent for 'AIDS', now known as Human Immunodeficiency Virus (HIV). 'HIV' follows a set path to attack the human body to cause the disease.

(a) Name the group of cells the HIV attacks after gaining entry into the human body and write the various events that occur within this cell.

Answer: HIV attacks Helper T-lymphocytes (T4 cells / CD4+ T cells / T-helper cells). Events within the T-helper cell: (1) HIV enters the T-helper cell by binding its surface protein (gp120) to CD4 receptors. (2) Inside the cell, the viral RNA genome is released. (3) Reverse transcriptase enzyme (carried by the virus) converts viral RNA into viral DNA (reverse transcription). (4) Viral DNA integrates into the host cell's chromosomal DNA, becoming a 'provirus'. (5) The provirus uses the host cell's machinery to produce new viral RNA and viral proteins. (6) New virus particles are assembled and bud off from the cell surface. (7) Over time, large numbers of T-helper cells are destroyed, leading to progressive immune deficiency.

Explanation:

HIV's primary target is CD4+ T-helper cells.

As these are destroyed, the immune system becomes progressively weaker, making the patient susceptible to opportunistic infections.

HIV is a retrovirus — it uses reverse transcriptase to convert RNA to DNA.

Q.30(b)

(Case Study — AIDS) (b) Write the expanded form of the diagnostic test used for detecting AIDS. Write the possible treatment available for the disease at present.

Answer: Diagnostic test: ELISA — Enzyme Linked Immuno Sorbent Assay. It detects antibodies against HIV in the blood. (Western blot test is used for confirmation.) Treatment: There is no complete cure for AIDS. Current treatment: Anti-Retroviral Therapy (ART) using a combination of antiretroviral drugs (highly active antiretroviral therapy — HAART). These drugs inhibit viral enzymes such as reverse transcriptase, integrase, and protease, reducing viral load and slowing disease progression. Treatment is lifelong and manages the disease but does not eliminate the virus.

Explanation:

ELISA is the standard screening test for HIV/AIDS.

ART (antiretroviral therapy) has transformed AIDS from a fatal disease to a manageable chronic condition.

Drugs like zidovudine (AZT) inhibit reverse transcriptase.

Q.30(c)

(Case Study — AIDS) (c) Mention any two steps suggested by WHO for preventing the spread of this disease.

Answer: Two WHO-suggested steps for preventing AIDS spread: (1) Safe sex practices — use of condoms; avoiding multiple sexual partners and unprotected sexual contact. (2) Use of sterile/disposable needles and syringes — avoid sharing needles among intravenous drug users; ensure blood is screened before transfusion. Other valid steps: (3) Free blood testing and counselling. (4) Awareness and education programs. (5) Preventing mother-to-child transmission (PMTCT) through ART during pregnancy.

Explanation:

HIV is transmitted through sexual contact, contaminated blood/needles, and mother-to-child (vertical transmission).

WHO's prevention strategies address all these routes of transmission.

OR

Q.30(c)

(c) "A patient suffering from AIDS does not die of this disease but from some other infection." Justify the statement.

Answer: Justification: HIV (Human Immunodeficiency Virus) attacks and progressively destroys the Helper T-lymphocytes (CD4+ T cells) — the key coordinators of the immune response. As CD4+ T cell count falls drastically (below 200 cells/μL), the patient's immune system becomes severely compromised (immunodeficient). In this immunosuppressed state, the patient becomes highly susceptible to opportunistic infections — infections caused by microorganisms that would not normally cause disease in a healthy person with a functioning immune system. These opportunistic infections (e.g., Pneumocystis jirovecii pneumonia, Toxoplasma encephalitis, Candida infections, Mycobacterium avium complex, CMV retinitis, or secondary infections by bacteria and fungi) are the actual cause of death in AIDS patients. The virus itself does not directly kill the patient; rather, it destroys immune cells, leaving the patient defenceless against infections that a healthy immune system would easily fight off.

Explanation:

This is the key concept of AIDS pathogenesis — immunodeficiency leads to susceptibility to opportunistic infections.

The same principle was what alerted doctors in 1981: rare infections (Kaposi's sarcoma, Pneumocystis pneumonia) appearing in otherwise apparently healthy individuals pointed to immune system failure.

Q.31(a)

(a) (i) Explain the process of double fertilization in an angiosperm starting

from the germination of pollen grains on the stigma, mentioning the ploidy of the end products formed at the end. State the role of synergids during the course of the process.

(ii) Why does the development of endosperm precede that of the embryo ?

Answer: (i) Double Fertilization Process: Step 1 — Pollen grain germinates on the stigma, forming a pollen tube (germination requires compatible stigma conditions). Step 2 — The pollen tube grows through the style, guided chemotropically toward the ovule. Step 3 — The pollen tube enters the ovule through the micropyle. Step 4 — The tube nucleus degenerates. The pollen tube releases two male gametes (n) into the embryo sac. Step 5 — One male gamete (n) fuses with the egg cell (n) → syngamy → forms zygote (2n) [diploid]. Step 6 — The other male gamete (n) fuses with the two polar nuclei (n + n, in secondary nucleus/central cell 2n) → triple fusion → forms primary endosperm nucleus (PEN) (3n) [triploid]. End products: Zygote (2n/diploid) → develops into embryo; Primary Endosperm Nucleus (3n/triploid) → develops into endosperm. Role of Synergids: (1) They secrete chemotropic substances that guide the pollen tube toward the embryo sac through the micropyle. (2) The pollen tube enters one of the synergids (usually the one degenerating), which ruptures to release the male gametes into the embryo sac.

(ii) Development of endosperm precedes embryo because: The developing embryo requires a nutrient source (food) for its growth and differentiation. Endosperm develops first to provide nourishment and energy to the embryo during its development. The endosperm acts as a food reserve (stores starch, proteins, fats) for the developing embryo.

Explanation:

Double fertilization is unique to angiosperms — one syngamy producing diploid zygote and one triple fusion producing triploid endosperm.

Synergids guide the pollen tube.

Endosperm-first ensures the embryo has nutritional support from the start.

Q.31(b)

(b) (i) Mention the site where fertilisation of the ovum occurs in a human female. Explain the process of fertilization and mention how polyspermy is prevented.
(ii) Name the embryonic stage that gets implanted in the uterus. Explain the process of implantation in a human female.

Answer: (i) Site: Ampullary region of the fallopian tube (oviduct). Process of Fertilization: (1) After ovulation, the secondary oocyte (arrested in metaphase II) enters the fallopian tube. (2) A sperm reaches the egg. Capacitation of sperm occurs in the female reproductive tract. (3) Acrosomal reaction — the sperm releases acrosomal enzymes (hyaluronidase, acrosin) that digest the zona pellucida, allowing sperm to penetrate. (4) Sperm fuses with the egg plasma membrane; sperm nucleus enters the egg. (5) This triggers completion of Meiosis II of the secondary oocyte, producing the mature ovum and second polar body. (6) The male and female pronuclei fuse → zygote (2n) is formed. Prevention of Polyspermy: (1) Fast block (membrane potential change, within seconds) — the egg membrane depolarises immediately after sperm entry, preventing additional sperms from fusing. (2) Slow/Cortical block — cortical granules beneath the egg membrane fuse with the plasma membrane (cortical reaction), releasing enzymes that harden the zona pellucida, making it impenetrable to additional sperms (zona reaction). (ii) Embryonic stage: Blastocyst. Implantation: (1) The blastocyst reaches the uterus (~6-7 days after fertilization). (2) The zona pellucida breaks down (hatching). (3) The outer layer of the blastocyst (trophoblast) attaches to the uterine endometrium (usually the posterior wall of the uterine cavity). (4) Trophoblast cells proliferate and invade the endometrial stroma, embedding the blastocyst completely. (5) Uterine endometrium proliferates and covers the blastocyst — this completes implantation. The blastocyst is now implanted in the uterine wall.

Explanation:

Fertilization in humans occurs in the ampulla of the fallopian tube.

Polyspermy is prevented by fast (membrane depolarization) and slow (cortical

reaction/zona reaction) blocks.

The blastocyst implants in the endometrium ~7 days post-fertilization.

Q.32(a)

(a) (i) Compare the pattern of inheritance of flower colour in garden pea plant (violet/white) with snapdragon plant (red/white) on the basis of the following:

(1) F1 phenotypic expression;

(2) expected phenotypic and genotypic expression of F2 generation;

(3) the conclusion you reached at the end of the comparison made.

(ii) List any two characteristics of pattern of inheritance of human blood group ABO.

Answer: (i) Comparison:

Garden Pea (Pisum sativum) — violet/white:

(1) F1 phenotype: All violet flowers (Vv) — dominant phenotype expressed (complete dominance).

(2) F2: Phenotypic ratio = 3 violet : 1 white; Genotypic ratio = 1 VV : 2 Vv : 1 vv.

(3) Conclusion: Garden pea shows complete dominance — one allele completely masks the expression of the other; no blending.

Snapdragon (Antirrhinum majus) — red/white:

(1) F1 phenotype: All pink flowers (Rr) — intermediate/blended phenotype (incomplete dominance).

(2) F2: Phenotypic ratio = 1 red (RR) : 2 pink (Rr) : 1 white (rr); Genotypic ratio = 1 RR : 2 Rr : 1 rr.

(3) Conclusion: Snapdragon shows incomplete dominance — neither allele is completely dominant; the heterozygote shows an intermediate phenotype. Unlike complete dominance, the phenotypic and genotypic ratios are the same (1:2:1).

Overall conclusion: The two plants differ in their dominance relationships — complete dominance in garden pea vs. incomplete dominance in snapdragon. In complete dominance, F2 phenotypic ratio (3:1) differs from genotypic ratio (1:2:1);

in incomplete dominance, they are the same (1:2:1).

(ii) Characteristics of ABO blood group inheritance: (1) Codominance — both IA and IB alleles are expressed in the heterozygote (type AB blood); neither dominates the other. (2) Multiple allelism — the ABO locus has three alleles (IA, IB, and i) in the human population, though any individual carries only two. The i allele is recessive to both IA and IB.

Explanation:
Complete vs.
incomplete dominance is a classic comparison.
In garden pea, F1 is violet (complete dominance, 3:1 in F2).
In snapdragon, F1 is pink (incomplete dominance, 1:2:1 in F2).
ABO system exemplifies both codominance and multiple allelism.

Q.32(b)

(b) (i) Draw a schematic, self-explanatory labelled diagram of lac operon in 'switched on' condition.
(ii) Why is regulation of lac operon referred to as negative regulation ?

Answer: (i) Lac operon in switched ON condition (when lactose is present / inducer is present): The diagram should show: — Regulatory gene (i) → mRNA → Repressor protein (inactive/allolactose-bound form). — CAP site (upstream). — Promoter (P). — Operator (O) — UNBLOCKED (repressor not bound, so RNA polymerase can proceed). — Structural genes: lacZ (codes for beta-galactosidase), lacY (codes for permease), lacA (codes for transacetylase). — RNA polymerase binding at promoter and transcribing all three structural genes. — Allolactose (inducer, derived from lactose) bound to repressor, inactivating it so it CANNOT bind the operator. Label: DNA → regulatory gene (i) | CAP site | Promoter (P) | Operator (O) [open] | lacZ | lacY | lacA → mRNA → beta-galactosidase + permease + transacetylase.
(ii) The regulation of lac operon is called NEGATIVE regulation because: The repressor protein normally (in the absence of inducer/lactose) binds to the

operator and BLOCKS transcription (negative control = repressor blocks gene expression). When the inducer (allolactose, derived from lactose) is present, it binds to the repressor and inactivates it, preventing the repressor from binding the operator, allowing transcription to proceed. The default state of the operon is OFF (repressor active, blocking); genes are switched ON only when the repressor is inactivated by the inducer. The control is 'negative' because the regulator (repressor) negatively controls gene expression.

Explanation:

Lac operon is the classic example of negative regulation in prokaryotes.

In the absence of lactose, the active repressor blocks RNA polymerase.

In the presence of lactose (as allolactose), the repressor is inactivated, enabling transcription of structural genes for lactose metabolism enzymes.

Q.33(a)

(a) (i) Why should a cell be made competent to take up an alien DNA ? How can a bacterial cell be made competent using calcium ions ? Explain.

(ii) (1) State the importance of gel electrophoresis in biotechnology.

(2) Explain the principle on which this technique works.

(3) Mention why ethidium bromide is used in this technique.

Answer: (i) Why competence is needed: The bacterial cell wall and membrane act as a barrier to entry of foreign/alien DNA. A cell must be made 'competent' (capable of taking up exogenous DNA) because the DNA molecule is large, negatively charged, and hydrophilic — it cannot simply pass through the hydrophobic lipid bilayer of the cell membrane. Making the cell competent creates temporary pores/channels in the cell membrane to allow DNA uptake. Making bacterial cells competent using Ca2+ ions: Bacterial cells (e.g., E. coli) are treated with ice-cold CaCl2 solution. Calcium ions (Ca2+) facilitate binding of the negatively charged DNA to the positively charged cell surface, neutralising charge repulsion. The cells are then given a brief heat shock (42°C for ~90 seconds), which is thought to cause the cell membrane to become more fluid/porous,

allowing DNA to enter. The cells are then cooled rapidly on ice. This process allows the bacterial cells to take up recombinant plasmid DNA from the surrounding medium.

(ii) (1) Importance of gel electrophoresis in biotechnology: It is used to separate DNA fragments (restriction fragments) by size after restriction enzyme digestion. It is essential for: (a) analysing restriction digests to confirm cloning; (b) isolating specific DNA fragments for cloning or analysis; (c) DNA fingerprinting; (d) genotyping; (e) checking PCR products. It allows visualisation, separation, and isolation of DNA fragments of known sizes using a DNA ladder. (2) Principle: DNA molecules are negatively charged (due to phosphate groups). When placed in an electric field (anode +, cathode −), DNA migrates towards the positive electrode (anode). Smaller fragments migrate faster and travel farther through the gel matrix (agarose); larger fragments migrate more slowly and remain closer to the wells. The agarose gel acts as a molecular sieve — separation is based on size (molecular weight) and charge. (3) Ethidium bromide (EtBr) use: Ethidium bromide is a fluorescent dye that intercalates (inserts) between the stacked base pairs of double-stranded DNA. When the gel is exposed to UV light, the EtBr-DNA complexes fluoresce bright orange, making the DNA bands visible. This allows detection and visualisation of DNA bands in the gel.

Explanation:

Competent cells are essential for transformation.

Ca2+ + heat shock is the standard chemical transformation method for E. coli.

Gel electrophoresis separates DNA by size under electric field;

EtBr is a DNA intercalating fluorescent dye used for band visualisation under UV.

Q.33(b)

(b) Bt cotton, the genetically modified crop, has greatly helped the cotton farmers to increase their crop yield.

(i) How was Bt cotton plant made resistant to bollworm ? Explain.

(ii) Describe the mechanism that leads to the death of bollworms feeding on

Bt cotton plants.

Answer: (i) How Bt cotton was made resistant to bollworm: (1) The cry genes (crystal protein genes) from the bacterium Bacillus thuringiensis (Bt) were identified — specifically cry1Ac and cry2Ab genes which produce proteins toxic to bollworm (Helicoverpa armigera / Heliothis virescens). (2) These cry genes were cloned into a suitable Ti plasmid vector (or other Agrobacterium-based vectors or direct gene gun method). (3) The recombinant vector was introduced into Agrobacterium tumefaciens, which was then used to infect cotton plant cells (or direct transformation). (4) The cry gene was integrated into the cotton plant's nuclear genome. (5) Transgenic cotton plants (Bt cotton) were selected that express the cry protein (Bt toxin / delta-endotoxin) in their cells, particularly in leaves and bolls.

(ii) Mechanism of death of bollworms: (1) The Bt toxin (delta-endotoxin) is produced in the Bt cotton plant as an inactive protoxin (pro-crystal protein). (2) When a bollworm (caterpillar of Helicoverpa) feeds on Bt cotton leaves, it ingests the inactive Bt protoxin. (3) In the alkaline pH (basic environment) of the bollworm's gut, the protoxin is solubilised and activated by proteolytic enzymes (gut proteases) to form the active toxin. (4) The active toxin binds to specific receptors on the epithelial cells of the midgut of the insect. (5) The toxin creates pores/holes in the midgut cell membrane, causing cell lysis and membrane disruption. (6) The gut cells swell and lyse (burst), causing the gut to rupture. (7) The insect stops feeding, becomes paralysed, and dies due to the destruction of the midgut epithelium.

Explanation:

Bt toxin (cry protein) is an insecticidal protein produced by Bacillus thuringiensis.

It is specific to insects with the right gut pH and receptor.

The toxin is inactive in the plant (as protoxin) but becomes active in the insect gut.

The mechanism involves receptor binding and pore formation leading to cell lysis.