CBSE Class 12 Biology 2024 — Set 3 — Answer Key

English Medium

Time Allowed: 3 Hours

General Instructions:

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

Q.1

The part of the ovule that develops into protective coats of a seed after fertilization in a typical flowering plant is :

(a) embryo sac
(b) nucellus
(c) integuments <<
(d) megaspore

Explanation:

The integuments (inner and outer) of the ovule develop into the seed coat (testa and tegmen) after fertilization.
The embryo sac contains the egg cell;
the nucellus provides nutrition;
the megaspore gives rise to the female gametophyte.

Q.2

A DNA fragment has 2000 nucleotides, out of which 140 are Adenine. How many bases does this DNA segment possess that have triple hydrogen bonds between them ?

(a) 280
(b) 860
(c) 1720 <<
(d) 1860

Explanation:

Total nucleotides in the DNA fragment = 2000 (both strands combined).
A = 140 (given, across both strands).
By Chargaff's rule A = T, so T = 140.
A + T = 280.
Therefore G + C = 2000 - 280 = 1720.
G-C base pairs have triple hydrogen bonds.
The question asks for the number of BASES with triple hydrogen bonds = G + C = 1720.

Correct answer = option (C) 1720.

Q.3

During the 1850s in the pre-industrialisation era in England, the expected effect of natural selection on the number of dark-winged moths as compared to white-winged moths was :

(a) more in number
(b) less in number <<
(c) both were equal in number
(d) both were less in number

Explanation:

In the pre-industrialisation era, tree trunks were light-coloured (covered with lichens).
Dark-winged (melanic) moths were more visible to predators against light-coloured bark and were selectively predated.
Therefore, natural selection favoured white-winged moths, making dark-winged moths LESS in number compared to white-winged moths.

Q.4

In which one of the following floral plants are many embryos formed in the seeds without fertilisation of the egg cell ?

(a) Black pepper
(b) Mustard
(c) Groundnut
(d) Citrus <<

Explanation:

Polyembryony (formation of multiple embryos without fertilisation of the egg cell) is a well-known phenomenon in Citrus (lemon, orange).
Nucellus cells undergo mitosis to form additional embryos by apomixis (nucellar embryony).
Black pepper shows adventive embryony but Citrus is the classic textbook example for polyembryony from seeds.

Q.5

A Snapdragon plant bearing pink colour flowers is crossed with a Snapdragon plant bearing white colour flowers. The expected phenotypic percentage of the offspring is :

(a) 50% Red : 50% White

(b) 25% Red : 50% Pink : 25% White

(c) 50% Pink : 50% White <<

(d) 25% Pink : 50% Red : 25% White

Explanation:

In Snapdragon, flower colour shows incomplete dominance.

Red (RR) × White (rr) gives Pink (Rr) in F1.

Pink (Rr) × White (rr) is a testcross: offspring = 1 Rr (Pink) : 1 rr (White) = 50% Pink : 50% White.

Q.6

In which of the given chromosomal disorders does the individual have tall stature with feminised character ?

(a) Klinefelter's syndrome <<

(b) Down's syndrome

(c) Turner's syndrome

(d) Edwards' syndrome

Explanation:

Klinefelter syndrome (44 + XXY) gives a tall individual with feminised characters (gynaecomastia, sparse body hair) and sterility.

Turner syndrome (45, XO) gives short stature;

Down syndrome is trisomy 21;

Edwards syndrome is trisomy 18.

Q.7

S.L. Miller in 1953, to support the theory of chemical evolution, created conditions in the closed flask that included :

(a) CH_3, O_2, NH_3, H_2O vapour at 1800°C

(b) CH_4, H_2, NH_3, H_2O vapour at 800°C <<

(c) CH_4, CO_2, H_2, H_2O vapour at 1800°C

(d) CH_4, NH_4, SO_2, H_2O vapour at 800°C

Explanation:

Miller's experiment (1953) simulated early Earth conditions: CH4 (methane), H2 (hydrogen), NH3 (ammonia), and H2O vapour at 800°C with electric discharge.

No free oxygen was present.

This produced amino acids and other organic molecules, supporting chemical evolution.

Q.8

In an experiment, E. coli is grown in a medium containing 14NH4Cl. (14N is the light isotope of Nitrogen) followed by growing it for six generations in a medium having heavy isotope of nitrogen (15N). After six generations, their DNA was extracted and subjected to CsCl density gradient centrifugation. Identify the correct density (Light/Hybrid/Heavy) and ratio of the bands of DNA in CsCl density gradient centrifugation.

(a) Hybrid : Heavy, 1 : 16

(b) Light : Heavy, 1 : 31

(c) Hybrid : Heavy, 1 : 31 <<

(d) Light : Heavy, 1 : 05

Explanation:

After 6 generations of growth in 15N medium starting from all-14N DNA: After generation 1: all molecules are Hybrid (14N/15N), ratio = 2 hybrid.

After each subsequent generation, the proportion of Heavy (15N/15N) increases.

After n generations starting from all-hybrid: total molecules = 2^n.

Only 2 molecules remain hybrid (the original two strands); rest are heavy.

After 6 generations: total = 2^6 = 64 molecules.

Hybrid = 2, Heavy = 62.

Ratio Hybrid:Heavy = 2:62 = 1:31.

Answer = Hybrid : Heavy, 1 : 31.

Q.9

Which disease is the patient suffering from who is showing symptoms such as sustained high fever (39°C to 40°C), stomach pain, constipation, headache, loss of appetite and weakness ?

(a) Pneumonia
(b) Malaria
(c) Typhoid <<
(d) Amoebiasis

Explanation:

Typhoid fever (caused by Salmonella typhi) presents with sustained high fever (39-40°C), stomach pain, constipation, headache, loss of appetite, and weakness.
Malaria causes intermittent fever with chills.
Pneumonia causes respiratory symptoms.
Amoebiasis causes dysentery.

Q.10

Which native plasmid did Stanley Cohen and Herbert Boyer use for the construction of the first recombinant DNA ?

(a) Salmonella typhimurium <<
(b) Streptococcus pneumoniae
(c) Escherichia coli
(d) Haemophilus influenzae

Explanation:

NCERT: the first recombinant DNA was made by linking a gene encoding antibiotic resistance with a native plasmid of Salmonella typhimurium (Stanley Cohen and Herbert Boyer, 1972).
Option (A).

Q.11

Which one of the following represents the correct annealing of primers to the

DNA to be amplified in the PCR ?

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

Explanation:
Each primer must anneal antiparallel to its template strand, one on each strand, with the 3′ ends pointing towards each other so that DNA polymerase extends them across the target region.
Only figure (B) shows this;
in (A), (C) and (D) a primer lies parallel to its template strand.

Q.12

The population growth curve applicable for a population growing in a geometric fashion, when the resources are not limiting in the habitat will be :

(a) Flat horizontal line (constant population density)
(b) Straight rising line (linear growth)
(c) Upward-curving J-shaped curve (exponential growth) <<
(d) S-shaped curve levelling off (logistic growth)

Explanation:
With unlimited resources a population grows geometrically (exponentially), dN/dt = rN, giving a J-shaped curve that rises ever more steeply — graph (C).
(D) is logistic growth with a carrying capacity; (B) is linear, not geometric.

Q.13

Assertion (A) : Primary transcripts in eukaryotes are subjected to splicing to remove the introns.
Reason (R) : Primary transcripts contain both exons and introns and the introns are non-functional in eukaryotes.

(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 is true: primary transcripts (hnRNA) in eukaryotes undergo splicing to remove intron sequences.
Reason is true and correctly explains the assertion: primary transcripts contain both exons (coding) and introns (non-coding/non-functional sequences), and splicing removes introns so the mature mRNA contains only exons.

Q.14

Assertion (A) : The chronic use of alcohol by a person leads to cirrhosis.
Reason (R) : Alcohol addiction at times becomes the cause of mental and financial distress to the entire family of the addicted person.

(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 is true: chronic alcohol use causes liver cirrhosis (fibrosis/scarring of liver).
Reason is also true: alcohol addiction causes mental and financial distress to the family.
However, the Reason does not explain WHY chronic alcohol use causes cirrhosis (it describes social consequences, not the biological mechanism).
Hence both are true but R is not the correct explanation of A.

Q.15

Assertion (A) : The zygote gives rise to heart-shaped embryo and

subsequently proembryo in most angiosperms.

Reason (R) : The zygote is present at the micropylar end of the embryo sac and develops into an embryo.

(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 is false: in most angiosperms, the zygote first develops into a proembryo (globular stage), then torpedo shape, then heart-shaped embryo — NOT heart-shaped first then proembryo;

the sequence is reversed in the assertion.

Reason is true: the zygote is indeed located at the micropylar end of the embryo sac and does develop into an embryo.

Hence A is false, R is true — option (D).

Q.16

Assertion (A) : The stirrer facilitates the even mixing of oxygen availability in a bioreactor.

Reason (R) : Stirred-tank bioreactors generally have a flat base.

(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 is true: the stirrer (impeller) in a bioreactor ensures uniform mixing of nutrients and oxygen throughout the vessel.

Reason is false: stirred-tank bioreactors do NOT generally have a flat base;
they typically have a curved/rounded base (and a cylindrical body) to facilitate mixing and avoid dead zones.
Hence A is true, R is false — option (C).

Q.17

Oral contraceptives are widely accepted for controlling the increasing rate of population. Name the two important components of oral contraceptives. Why is 'Saheli' considered a preferred contraceptive by women ?

Answer: The two important components of oral contraceptives are: (1) Synthetic oestrogen (progestogen-oestrogen combination) and (2) Synthetic progesterone (progestins/progestogens).

Saheli (centchroman) is preferred by women because: it is a non-steroidal oral contraceptive (unlike conventional pills which contain steroidal hormones). It is taken once a week (not daily), has very few side effects, high contraceptive efficacy, and does not disrupt the normal hormonal balance as severely as steroidal contraceptives.

Explanation:
Oral contraceptive pills typically contain synthetic oestrogen and progestogen (combined pill) or progestogen alone (mini-pill).
They prevent ovulation and alter uterine conditions.
Saheli, developed by CDRI Lucknow, contains centchroman (ormeloxifene), a selective oestrogen receptor modulator — it is non-steroidal, taken once weekly after initial daily dosing, and has minimal side effects.

Q.18

What is a vaccine ? Write the basis on which it acts when administered in the body.

Answer: A vaccine is a biological preparation containing weakened/killed pathogens (or their antigens/toxoids) that is introduced into the body to stimulate

immunity without causing disease.

Basis of action: When a vaccine is administered, the immune system recognises the antigens as foreign and mounts a primary immune response — producing specific antibodies and memory B-cells and memory T-cells. On subsequent exposure to the actual pathogen, the memory cells rapidly mount a stronger and faster secondary immune response (anamnestic response), neutralising the pathogen before it can cause disease. This is based on the principle of immunological memory.

Explanation:

Vaccines work on the principle of immunological memory.

The primary vaccination creates memory lymphocytes.

When the real pathogen is encountered later, these memory cells trigger a rapid, amplified secondary immune response (higher antibody titres), providing protection.

Q.19

Consider the given data of a hypothetical small portion of mRNA that codes for a functional polypeptide chain and answer the questions that follow :

mRNA 5′ – UCAUUACCACGAUUCUUUAAAAGA – 3′

(a) How many amino acids will be formed from the given codons, if substitution of ‘U’ by ‘C’ takes place at the 5th codon ? Explain your answer.

(b) Write the number of amino acids that would be in the polypeptide synthesised by a similar mRNA as above, where in the fourth codon instead of ‘C’ there is ‘U’. Justify your answer.

Answer: Codons (5′→3′): UCA UUA CCA CGA UUC UUU AAA AGA (8 codons, no stop codon).

(a) The 5th codon is UUC. Replacing U by C gives CUC (Leu) or UCC (Ser). Neither is a stop codon, so translation continues through all 8 codons: 8 amino acids (a missense change, chain length unchanged).

(b) The 4th codon is CGA (Arg). Replacing C by U gives UGA, which is a stop

codon (nonsense mutation). Translation terminates at the 4th codon, so only the first 3 codons (UCA, UUA, CCA) are translated: 3 amino acids.

Explanation:

Reading frame: UCA-UUA-CCA-CGA-UUC-UUU-AAA-AGA.

(a) UUC to CUC/UCC is a missense change, so 8 amino acids.

(b) CGA to UGA creates a premature stop codon at position 4, so the polypeptide has 3 amino acids.

Q.20

With reference to the set-ups (A, B and C) given below, of the electrophoretic separation of a mixture of DNA fragments of varied lengths, answer the questions that follow :

(a) In which one of the two Set-ups, A or B, would you see the DNA fragments separated and why ? Justify your answer.

(b) In Set-up C, which one of the two, I / II, are the bands of longer fragments of DNA ? Justify your answer.

Answer: (a) DNA fragments would be separated in Set-up A (not Set-up B). In Set-up A, the wells containing DNA are positioned near the CATHODE (negative electrode) at the top, and the ANODE (positive electrode) is at the bottom. DNA is negatively charged (due to its phosphate backbone) and migrates toward the positive electrode (anode). Therefore, in Set-up A the DNA travels downward through the gel, away from the wells, and fragments of different sizes are separated by size. In Set-up B, the wells are positioned near the ANODE (positive electrode) at the top and the cathode is at the bottom — DNA would be repelled back toward the wells and no useful separation would occur. (b) In Set-up C, Band I (the upper band, closer to the well/negative electrode) represents the LONGER DNA fragments. Longer fragments experience greater resistance moving through the agarose matrix and therefore migrate more slowly, travelling a shorter distance from the wells. Shorter fragments migrate faster and end up lower (Band II, farther from the well).

Explanation:

DNA is negatively charged (phosphate backbone) and moves towards the anode.

In Set-up A the wells are at the cathode end and the anode is at the bottom, so the fragments migrate into the gel and separate by size.

In Set-up B the wells are at the anode end, so DNA would not move into the gel.

In Set-up C, longer fragments move more slowly through the gel matrix and stay nearer the well (band I);

shorter fragments travel farther (band II).

Q.21

(a) Write important features of 'humus' formed during the decomposition cycle in a terrestrial ecosystem.

Answer: Important characteristics of humus:

1. Humus is a dark-coloured amorphous substance formed by microbial decomposition of dead organic matter.

2. It is highly resistant to further microbial decomposition (recalcitrant/resistant to decomposition).

3. It is colloidal in nature and serves as a reservoir of nutrients.

4. It improves soil structure, water-holding capacity, and aeration.

5. It releases nutrients (minerals) slowly upon further decomposition (mineralisation).

Explanation:

Humus is the end product of humification during decomposition.

It is dark, amorphous, resistant to further decomposition, nutrient-rich, and improves soil fertility.

It is the stable organic component of soil formed from partially decomposed plant and animal matter.

OR

Q.21

(b) (i) Graphically represent the relationship between species richness and area on a log-log scale for bats and fishes.

(ii) Write the equation for the relationship as on a logarithmic scale.

Answer: (i) On a log scale the species–area relationship is a straight line. Plot log S (species richness) on the Y-axis against log A (area) on the X-axis; both bats and fishes give a straight line with a positive slope Z. The line cuts the Y-axis at log C.

(ii) S = C A^Z, so on a logarithmic scale: log S = log C + Z log A

where S = species richness, A = area, Z = slope of the line (regression coefficient), C = Y-intercept.

Explanation:

The power law S = C A^Z becomes the straight line log S = log C + Z log A on a log-log plot.

The slope Z is typically 0.1 to 0.2 for regions of different sizes within a continent.

Q.22

Draw a longitudinal section of pistil of a flower showing growth of the pollen tube. Label the part :

(a) through which the pollen tube moves down.

(b) the cell wherein the pollen tube releases its contents.

Answer: Labelled diagram: stigma (pollen grain germinating on it), style, ovary, ovule with micropyle and embryo sac (egg apparatus = egg cell + 2 synergids, central cell with polar nuclei, antipodals); the pollen tube is drawn growing down through the style and entering the ovule through the micropyle.

(a) The part through which the pollen tube moves down is the style (its transmitting tissue / stylar canal).

(b) The cell in which the pollen tube releases its contents (the two male gametes) is the synergid.

Explanation:

The pollen tube grows from the stigma through the style to the ovary, enters the ovule through the micropyle and discharges the two male gametes into one synergid;

one gamete fuses with the egg cell and the other with the polar nuclei (double

fertilisation).

Q.23

Explain the IUI and IUT methods of assisted reproductive technologies.

Answer: IUI (Intrauterine Insemination):

In IUI, the semen (from the husband or a healthy donor) is collected, processed/washed to remove seminal plasma, and the motile sperms are introduced directly into the uterus of the female through the cervix using a catheter. The woman may be given hormonal stimulation to produce eggs. The sperms then travel to the fallopian tube where fertilisation can occur. This method is used when the male partner has low sperm count or poor motility, or when the cervical environment is hostile.

IUT (Intrauterine Transfer):

In IUT, embryos with more than 8 blastomeres are transferred into the uterus. The embryo is developed in vitro (outside the body) from IVF (in vitro fertilisation) and then transferred into the uterine cavity. Embryos with fewer than 8 blastomeres can be transferred into the fallopian tube (ZIFT — Zygote Intrafallopian Transfer). IUT ensures the embryo implants in the uterine wall.

Explanation:

ART methods: IUI — sperm introduced into uterus (bypasses cervical barrier);
IUT — embryo (>8 blastomeres from IVF) transferred to uterus.
GIFT = gamete intrafallopian transfer;
ZIFT = zygote/early embryo to fallopian tube (<8 blastomeres).

Q.24

Three crosses were carried out in pea plants with respect to flower colour violet/white (V/v) and flower position axial/terminal (A/a). Study in the table the crosses ‘a’, ‘b’ and ‘c’ where parental phenotypes and their F1 progeny phenotypes are given.

(a) Violet, axial × white, axial → 6/16 white, axial; 2/16 white, terminal; 6/16

violet, axial; 2/16 violet, axial

(b) Violet, axial × white, terminal → 1/4 violet, axial; 1/4 violet, terminal; 1/4 white, axial; 1/4 white, terminal

(c) Violet, axial × violet, axial → 3/4 violet, axial; 1/4 white, axial

Find the genotypes of each of the parental pairs of crosses ‘a’, ‘b’ and ‘c’.

Answer: Cross (a): VvAa × vvAa. Colour violet : white = 8 : 8 = 1 : 1 (Vv × vv); position axial : terminal = 12 : 4 = 3 : 1 (Aa × Aa). (The last class is printed “2/16 violet, axial”; it is read as violet, terminal, which is what the 6 : 2 : 6 : 2 ratio requires.)

Cross (b): VvAa × vvaa. Colour 1 : 1 (Vv × vv); position 1 : 1 (Aa × aa).

Cross (c): VvAA × VvAA (or VvAA × VvAa). Colour 3 : 1 (Vv × Vv); all offspring axial, so at least one parent is AA and the other AA or Aa.

Explanation:

Treat each gene separately.

Cross (a): 1:1 colour and 3:1 position gives VvAa × vvAa.

Cross (b): 1:1:1:1 is a test cross, VvAa × vvaa.

Cross (c): 3:1 colour and no terminal offspring gives Vv × Vv with AA in at least one parent.

Q.25

A population of snakes lived in a desert with brown sand. Study the drawings given below showing the change in the population from time one to time two over time and answer the questions that follow. Brown snakes and Grey snakes are represented by alleles A/a (Dominant/recessive).

Population-one → Population-two (Migration of Birds)

(a) If the frequency of the recessive trait is 9% in population-one, work out the frequency of homozygous dominant and heterozygous dominant snakes.

(b) Name the mechanism of evolution that must have operated so that population-two evolved from population-one.

Answer: (a) Using Hardy-Weinberg equilibrium:

Frequency of recessive trait (aa) = q^2 = 9% = 0.09

q = $\sqrt{0.09}$ = 0.3

p = 1 - q = 1 - 0.3 = 0.7

Frequency of homozygous dominant (AA) = $p^2 = (0.7)^2 = 0.49 = 49\%$

Frequency of heterozygous dominant (Aa) = $2pq = 2 \times 0.7 \times 0.3 = 0.42 = 42\%$

(b) The mechanism of evolution that operated is NATURAL SELECTION. Birds migrated and preferentially preyed on grey (recessive, aa) snakes which were more visible against the brown sand background. This reduced the frequency of the recessive allele (a) in population-two. Brown snakes (AA and Aa) had better camouflage and higher survival/reproductive success. This is an example of directional natural selection.

Explanation:

Hardy-Weinberg: $q^2 = 0.09$, q = 0.3, p = 0.7.

AA = $p^2 = 0.49$; Aa = 2pq = 0.42.

Bird migration caused selective predation on visible grey snakes → natural selection (directional) changed allele frequencies, shifting to more brown snakes in population-two.

Q.26

(a) (i) List two major reasons for using cow-dung in a biogas plant instead of using domestic sewage.

(ii) Mention one use of the unspent slurry of the biogas plant.

Answer: (i) Two major reasons for using cow-dung instead of domestic sewage in a biogas plant:

1. Cow-dung is rich in methanogenic bacteria (Methanobacterium) that are essential for producing methane (biogas). Domestic sewage may not have sufficient/consistent populations of these anaerobic methanogens.

2. Cow-dung has a suitable C:N ratio and consistency for efficient fermentation/digestion in the biogas digester. Domestic sewage has variable and

often unfavourable composition.

(ii) One use of unspent slurry from biogas plant:
The spent/unspent slurry is used as biofertiliser/manure for agricultural fields — it is rich in nitrogen and phosphorus and improves soil fertility.

Explanation:
Biogas plants: cow dung preferred due to methanogens and C:N ratio.
Slurry (spent material) is nutrient-rich and used as organic manure/biofertiliser.

OR

Q.26

(b) Name the bioactive molecule and its microbial source generally used by physicians to treat the patients for :
(i) Myocardial infarction
(ii) High blood cholesterol level
(iii) Organ transplantation

Answer: (i) Myocardial infarction:
Bioactive molecule: Streptokinase (a clot-buster/thrombolytic agent)
Microbial source: Streptococcus bacterium

(ii) High blood cholesterol level:
Bioactive molecule: Statins (e.g., lovastatin/compactin — HMG-CoA reductase inhibitors)
Microbial source: Monascus purpureus (a yeast/fungus)

(iii) Organ transplantation:
Bioactive molecule: Cyclosporin A (immunosuppressant)
Microbial source: Trichoderma polysporum (a fungus)

Explanation:

Bioactive molecules from microbes: Streptokinase (Streptococcus) dissolves blood clots in MI;

Statins (Monascus purpureus) inhibit cholesterol synthesis;

Cyclosporin A (Trichoderma polysporum) suppresses immune response to prevent transplant rejection.

Q.27

(a) Give the scientific name of the bacteria widely used in biotechnology to create a GM cotton crop resistant to bollworm attacks.

(b) Explain how GM cotton crop is able to resist insect attacks.

Answer: (a) Scientific name: Bacillus thuringiensis (Bt)

(b) Mechanism of resistance in GM Bt cotton:

1. The Cry (crystal) protein genes from Bacillus thuringiensis are introduced into the cotton plant's genome via Agrobacterium tumefaciens-mediated transformation.

2. The Bt cotton plant produces Cry proteins (Bt toxins/delta-endotoxins) in its tissues.

3. When the bollworm (Helicoverpa armigera) larva eats the cotton plant, it ingests the Cry protein.

4. In the alkaline midgut of the insect larva, the Cry protein (protoxin) is solubilised and activated by gut proteases into the active toxin.

5. The active toxin binds to specific receptors on the epithelial cells of the midgut, creating pores that cause cell lysis and ultimately death of the larva.

6. Mammalian guts are acidic, so the protoxin is not activated and Bt cotton is safe for humans and animals.

Explanation:

Bt cotton expresses Cry proteins from Bacillus thuringiensis.

The insecticidal crystal proteins are pro-toxins activated by the alkaline pH of insect gut, bind gut receptors, create pores →

osmotic lysis →
insect death.
Safe for mammals (acidic gut doesn't activate the toxin).

Q.28

Describe how fig tree and wasp relationship is a spectacular example of mutualism.

Answer: The fig tree (Ficus) and fig wasp (Blastophaga) have a highly specific obligate mutualistic relationship:

1. The fig tree produces a specialised structure called a syconium (a hollow inflorescence with flowers inside).
2. The female fig wasp enters the syconium through a narrow opening (ostiole) to lay her eggs. While entering, she pollinates the female flowers with pollen she carries from the previous fig she visited.
3. Inside the syconium, the wasp lays eggs in some flowers (which become galls for larval development) while pollinating other flowers that produce seeds.
4. Male wasps hatch first, mate with females, and then bore exit holes in the syconium wall.
5. Female wasps emerge through these holes, carrying pollen from the male flowers, and fly to a new fig syconium to complete the cycle.

Benefit to both:
- Fig tree: gets cross-pollinated; seeds are produced.
- Wasp: gets a protected site to lay eggs and a food source (galled ovules) for larvae.
Neither can reproduce without the other — an obligate mutualism.

Explanation:
Fig-wasp mutualism: wasps pollinate fig flowers while using syconium for egg-laying/larval development.
Both depend on each other absolutely — fig cannot be pollinated without wasp;

wasp cannot reproduce without fig.

Classic obligate mutualism example in NCERT Biology Class 12.

Q.29(a)

Read the passage given below and answer the questions that follow.

In recombinant DNA technology, restriction enzymes are used as they recognize and cut DNA within a specific recognition sequence. BamH I is one such restriction enzyme which binds at the recognition sequence 5' G-G-A-T-C-C 3' and cleaves this sequence between G and G on each strand, whereas Alu I binds at the recognition sequence 5' A-G-C-T 3' and cleaves these sequences between G and C on each strand.

DNA strand:

5' C C G T A G C T A T C A G C T G G 3'

| | | | | | | | | | | | | | | | |

3' G G C A T C G A T A G T C G A C C 5'

(a) If Alu I is used to cut the given DNA strand, how many DNA fragments would be formed ? Write the sequence of each fragment formed with its polarity.

Answer: Alu I recognises 5′-AGCT-3′ and cuts between G and C. In the given DNA, AGCT occurs twice (positions 5–8 and 12–15 of the top strand), so there are 2 cut sites and 3 fragments (all with blunt ends):

Fragment 1: 5′ CCGTAG 3′ / 3′ GGCATC 5′

Fragment 2: 5′ CTATCAG 3′ / 3′ GATAGTC 5′

Fragment 3: 5′ CTGG 3′ / 3′ GACC 5′

Explanation:

AGCT is palindromic, so Alu I cuts between G and C on both strands at the same position and leaves blunt ends.

The strand has two AGCT sites, so two cuts and three fragments.

Q.29(b)

(b) Which one of the two restriction enzymes BamH I or Alu I will preferably be used on the same given DNA strand to make a recombinant DNA molecule and why ?

Answer: Alu I. The given strand has no BamH I recognition site (GGATCC) but contains Alu I sites (AGCT), so only Alu I can cut this DNA; it cuts in the middle of the site and gives blunt ends. Note: this answer is unconfirmed.

Explanation:

Check the strand for each recognition sequence: BamH I needs 5′-GGATCC-3′, which does not occur;

Alu I needs 5′-AGCT-3′, which occurs twice.

An enzyme can be used only if its site is present, so Alu I is the one to use on this strand.

Note: this answer is unconfirmed.

Q.29(c)

(c) After binding to the two strands of the double helix DNA, where specifically does the restriction enzyme act to cut the two strands of DNA ? Write the specific term used for the specific nucleotide sequences of DNA recognised by a restriction endonuclease.

Answer: After binding to the recognition sequence on the double-stranded DNA, the restriction enzyme cuts the DNA at specific phosphodiester bonds within or near its recognition sequence — it cleaves the sugar-phosphate backbone of each strand.

The specific term for the specific nucleotide sequences of DNA recognised by a restriction endonuclease is: PALINDROMIC SEQUENCES (or palindromic recognition sequences). These are sequences that read the same on both strands in the 5' to 3' direction. For example, BamH I recognises 5' GGATCC 3' on one strand and 3' CCTAGG 5' (which is 5' GGATCC 3') on the complementary strand.

Explanation:

Restriction enzymes cut phosphodiester bonds at specific positions within or flanking the palindromic recognition sequence.

Palindromic sequences read the same on both strands 5'→3'.

This is the canonical recognition sequence property of Type II restriction endonucleases.

OR

Q.29(c)

(c) OR: Write the specific sequence of DNA segment recognised by the restriction endonuclease EcoRI.

Answer: The specific recognition sequence of EcoRI is:

5' G A A T T C 3'

3' C T T A A G 5'

EcoRI cuts between G and A on each strand:

5' G↓A A T T C 3'

3' C T T A A↑G 5'

This generates 5' overhang sticky ends:

5' G AATTC 3'

3' CTTAA G 5'

The 5' overhang sequence is 5'-AATT-3' (4-nucleotide sticky end).

Explanation:

EcoRI recognition sequence: 5'-GAATTC-3' (palindromic).

Cuts between G and A, generating 4-nucleotide 5' sticky ends (AATT).

This is the first restriction endonuclease used in recombinant DNA technology.

Q.30(a)

Study the figures given below that depict the comparative age distribution of human populations in Sweden and Rwanda. (International Data Base 2003) and answer the questions that follow : (See the figure.)

(a) What can be inferred from the very broad base of Rwanda's age pyramid

? Support your answer with the data provided in the figure.

Answer: A very broad base shows that Rwanda has a very large proportion of young (pre-reproductive) individuals, i.e. a high birth rate, so the population is expanding rapidly. Data from the figure: age 0–4 is 8.2% of males and 8.2% of females, 5–9 is 6.9% and 7.0%, 10–14 is 6.5% and 6.6%, while older groups are tiny (55–59: 0.8% and 1.0%; 85+: 0.0% and 0.1%). As these many young people reach reproductive age, the population will keep growing.

Explanation:

A pyramid with a wide base tapering to a narrow apex is an expanding pyramid: high birth rate and a large young population, as the percentages for the 0–14 groups (about 6.5–8.2%) compared with the 55+ groups (about 1% or less) show.

Q.30(b)

(b) Sweden has an age distribution that is approximately of the same width near its base as at the apex. What does this indicate ?

Answer: Sweden's age distribution being approximately the same width from base to apex indicates a STABLE population. The birth rate approximately equals the death rate, leading to zero or near-zero population growth. The roughly equal distribution across age groups means that roughly equal numbers of people are being born and dying, maintaining a stable population size.

Explanation:

Uniform width from base to apex in an age pyramid = stable/stationary population where birth rate ≈ death rate.

No net growth or decline.

Typical of developed countries with demographic transition completed.

Q.30(c)

(c) Name the type of age pyramid shown above for Sweden.

Answer: The type of age pyramid shown for Sweden is the BELL-SHAPED (or urn-shaped/stationary) pyramid — also called a STABLE age pyramid or

STATIONARY pyramid. It indicates a population with approximately equal birth and death rates and a stable (neither growing nor declining) population.

Explanation:

Sweden's pyramid = bell-shaped/urn-shaped = stationary/stable population.

Birth rate ≈ death rate.

Characteristic of post-demographic transition countries.

OR

Q.30(c)

(c) OR: Name the type of age pyramid shown above for Rwanda.

Answer: The type of age pyramid shown for Rwanda is the EXPANDING (or triangular/pyramidal) age pyramid. It has a broad base and narrow apex, indicating high birth rates, high proportion of young population, and rapid population growth.

Explanation:

Rwanda's pyramid = expanding/triangular pyramid.

Broad base = high birth rate, many young people.

Narrow apex = high mortality in older groups.

Indicates rapid population growth, typical of developing countries.

Q.31(a)

(a) (i) Explain any four devices that flowering plants have developed to encourage cross-pollination.

(ii) Why do plants discourage self-pollination ? State any one reason.

Answer: (i) Four devices for encouraging cross-pollination:

1. Dichogamy: Anthers and stigma of the same flower mature at different times — if anthers mature first it is called protandry (e.g. sunflower); if stigma matures first it is called protogyny (e.g. Mirabilis). This prevents self-pollination.

2. Herkogamy: Physical barrier/separation between anther and stigma in the same flower (e.g. in Calotropis, the stigma is positioned away from the anthers; or mechanical barriers).

3. Self-incompatibility (Self-sterility): Genetic mechanism where pollen from the same plant is rejected by the stigma — the pollen fails to germinate or the pollen tube fails to grow if it lands on the same plant's stigma (e.g. Petunia).
4. Dioecism: Male and female flowers are present on separate plants (dioecious plants), so cross-pollination is obligatory (e.g. Papaya, Cannabis).
(Other valid answers: Emasculation trigger, unisexuality/monoecism, pollen releasing agents)

(ii) Plants discourage self-pollination because:
Self-pollination leads to inbreeding, which reduces genetic variation. Lack of genetic diversity makes the population less adaptable to changing environmental conditions and more vulnerable to diseases and pests. Cross-pollination promotes genetic recombination, maintaining/increasing genetic variability and producing more vigorous offspring (hybrid vigour/heterosis).

Explanation:
Cross-pollination mechanisms: dichogamy (different maturation times), herkogamy (physical separation), self-incompatibility (genetic rejection of own pollen), dioecy (separate sexes on separate plants).
Self-pollination reduces genetic diversity — inbreeding depression.

Q.31(b)

(b) Explain the ovarian and uterine events taking place along with the role of pituitary and ovarian hormones, during menstrual cycle in a normal human female under the following phases :
(i) Follicular phase/proliferative phase
(ii) Luteal phase/secretory phase
(iii) Menstrual phase

Answer: (i) Follicular phase/Proliferative phase (Day 5-13):
Ovarian events: Under influence of FSH (from anterior pituitary), primary follicles in the ovary develop into Graafian follicles. The follicle grows and produces

increasing amounts of oestrogen.
Hormonal role: Rising oestrogen level causes a positive feedback on the anterior pituitary, leading to LH surge (and FSH surge) around day 13-14.
Uterine events: Oestrogen stimulates proliferation (thickening) of the endometrium (uterine lining) — hence called proliferative phase. The endometrium increases in thickness with blood vessels.

(ii) Luteal phase/Secretory phase (Day 15-28):
Ovarian events: After ovulation (triggered by LH surge on ~day 14), the ruptured Graafian follicle transforms into the corpus luteum. The corpus luteum secretes large amounts of progesterone and some oestrogen.
Hormonal role: Progesterone maintains and prepares the endometrium for implantation. High progesterone + oestrogen suppress FSH and LH (negative feedback).
Uterine events: The endometrium undergoes secretory changes — uterine glands become coiled and secrete glycogen-rich fluid. The endometrium thickens further in preparation for implantation of a fertilised egg.

(iii) Menstrual phase (Day 1-5):
Ovarian events: If fertilisation does not occur, the corpus luteum degenerates (becomes corpus albicans), causing a sharp fall in progesterone and oestrogen levels.
Hormonal role: The fall in progesterone and oestrogen removes the inhibition of FSH/LH; FSH begins to rise again, starting a new cycle.
Uterine events: The fall in progesterone causes vasoconstriction of uterine blood vessels, leading to breakdown and shedding of the endometrial lining along with blood — this is menstruation. Approximately 50-80 mL of blood is lost over 3-5 days.

Explanation:

Menstrual cycle: FSH →
follicle growth →
oestrogen →
endometrial proliferation →
LH surge →
ovulation →
corpus luteum →
progesterone →
secretory endometrium.
No fertilisation →
corpus luteum degenerates →
progesterone drops →
menstruation →
new cycle begins.

Q.32(a)

(a) “The influence of both the alleles in a heterozygous state is clearly expressed in codominance.” Explain with the help of inheritance of ABO blood group in humans.

Answer: ABO blood group is controlled by one gene (I) with three alleles: I^A, I^B and i. I^A produces antigen A and I^B produces antigen B on the red blood cells; i produces no antigen. I^A and I^B are both dominant over i, but neither is dominant over the other.

In the heterozygote I^A I^B both alleles are fully expressed: both antigen A and antigen B are present, giving blood group AB. This is codominance.

Blood group A: I^A I^A or I^A i; blood group B: I^B I^B or I^B i; blood group AB: I^A I^B; blood group O: ii.

Three alleles of one gene also illustrate multiple allelism.

Explanation:

Codominance: both alleles of the heterozygote I^A I^B are expressed (antigens A and B together, group AB).

I^A and I^B are dominant over i.

Q.32(b)

(b) “A group of genes are regulated and expressed together as a unit in lac operon.”

(i) Explain the mechanism of switching ‘on’ of the structural genes of lac operon.

(ii) “Regulation of lac operon” is referred to be negatively regulated.” Justify giving a reason.

Answer: (i) Switching ON mechanism of lac operon:

The lac operon consists of: Promoter (P), Operator (O), and three structural genes (lacZ, lacY, lacA) encoding β-galactosidase, permease, and transacetylase respectively. There is also a regulator gene (lacI) that produces a repressor protein.

In the ABSENCE of lactose (inducer):

- The lacI gene constitutively produces the repressor protein.
- The repressor binds to the operator region, blocking RNA polymerase from transcribing the structural genes.
- The operon is switched OFF.

Switching ON (in PRESENCE of lactose):

1. Lactose (allolactose, the actual inducer) enters the cell.
2. Allolactose (an isomer of lactose formed by β-galactosidase) acts as the inducer.
3. Allolactose binds to the repressor protein, causing a conformational change in the repressor.
4. The changed repressor can no longer bind to the operator.
5. The operator is now free; RNA polymerase can bind to the promoter and transcribe the structural genes (lacZ, lacY, lacA).
6. The three enzymes are produced: β-galactosidase breaks down lactose;

permease transports lactose into the cell; transacetylase acetylates lactose.
Thus, the presence of lactose induces (switches on) the expression of structural genes.

(ii) Negative regulation:
The lac operon regulation is called NEGATIVE regulation because in the normal (default) state, the operon is switched OFF by the repressor protein (a negative regulator). The repressor actively prevents transcription by binding to the operator. Regulation requires the removal of the repressor (by the inducer allolactose) to allow transcription. Since the regulator acts as a REPRESSOR (negative effector) that turns OFF gene expression — and the default state is OFF — this is called negative regulation.

Explanation:
lac operon: switched ON when allolactose (inducer) binds repressor →
repressor leaves operator →
RNA polymerase transcribes structural genes.
Negative regulation = default OFF state, repressor prevents transcription;
inducer relieves repression.
Classic Jacob-Monod model.

Q.33(a)

(a) (i) Describe the life cycle of Plasmodium from the time it enters the human body till a female Anopheles mosquito bites an infected person.
(ii) Mention the two events of Plasmodium life cycle that occur within the female Anopheles body.

Answer: (i) Life cycle of Plasmodium in the human body:
1. Entry: Sporozoites (infective stage) are injected into the human blood by a female Anopheles mosquito during a blood meal.
2. Liver stage (Pre-erythrocytic/Exo-erythrocytic schizogony): Sporozoites travel through blood to the liver. In liver cells (hepatocytes), they undergo asexual multiplication — each sporozoite divides to produce thousands of merozoites (liver

schizogony).

3. Erythrocytic stage: Merozoites are released into the blood and invade Red Blood Cells (RBCs). Inside RBCs, merozoites develop into trophozoites (ring stage) → schizonts → multiple merozoites. The RBC ruptures (haemolysis), releasing merozoites, which infect more RBCs. This cycle repeats every 48-72 hours causing recurring fever (called haemozoin-induced fever — toxic haemozoin from haemoglobin breakdown triggers fever).

4. Gametocyte formation: Some merozoites inside RBCs develop into male (micro) and female (macro) gametocytes instead of schizonts.

5. Transmission: When a female Anopheles mosquito bites an infected person, it ingests these gametocytes along with blood.

(ii) Two events of Plasmodium life cycle occurring within the female Anopheles body:

1. Gametogenesis and Fertilisation: Micro and macrogametocytes develop into microgametes and macrogametes in the mosquito gut; microgamete fertilises macrogamete to form a diploid zygote (ookinete).

2. Sporogony: The ookinete penetrates the midgut wall of the mosquito and develops into an oocyst. Inside the oocyst, the zygote undergoes meiosis and multiple mitoses to produce thousands of sporozoites. The oocyst ruptures, releasing sporozoites that migrate to the salivary glands — ready to be injected into the next human host.

Explanation:

Plasmodium life cycle in humans: sporozoites →
liver (exo-erythrocytic schizogony →
merozoites) →
RBCs (erythrocytic schizogony →
merozoites →
gametocytes) →
mosquito ingests gametocytes.
In mosquito: gametocyte →

gametes →
fertilisation →
zygote →
ookinete →
oocyst →
sporozoites (sporogony) →
salivary glands.

Q.33(b)

(b) (i) Write two differences between malignant tumor and benign tumor.
(ii) Explain any three diagnostic techniques for the detection of cancer.

Answer: (i) Differences between malignant and benign tumors:

Feature	Malignant Tumor	Benign Tumor
Invasiveness	Invades and destroys adjacent normal tissues	Remains localised; does not invade surrounding tissue
Metastasis	Undergoes metastasis — cancer cells spread to distant organs via blood/lymph to form secondary tumors	Does NOT metastasise; remains at original site

(ii) Three diagnostic techniques for cancer detection:

1. Biopsy and histopathological study: A small piece of suspected tumour tissue is excised and stained for histological examination under microscope. Pathologists look for abnormal cell morphology, loss of differentiation, and increased mitotic figures. This is the gold standard for cancer diagnosis.

2. Imaging techniques (Radiography/CT/MRI): X-rays, CT (Computed Tomography) scans, and MRI (Magnetic Resonance Imaging) are used to detect tumours in internal organs. CT scans use X-rays from multiple angles processed by computer; MRI uses radio waves and magnetic fields to produce detailed soft-tissue images. These detect the location and size of tumours.

3. Blood tests / Molecular diagnosis: Blood tests for tumour markers (e.g. PSA for prostate cancer, CEA for colorectal cancer). Molecular techniques such as PCR (Polymerase Chain Reaction) and FISH (Fluorescence In Situ Hybridisation) can detect specific gene mutations, chromosomal abnormalities, or overexpression of oncogenes/suppressor genes associated with cancer.

Explanation:

Cancer diagnosis: biopsy (gold standard — histology), imaging (X-ray/CT/MRI — location/size), molecular/blood tests (tumour markers, PCR, FISH — genetic/molecular markers).

Malignant vs benign: malignant invades + metastasises; benign stays localised.