CBSE Class 12 Biology 2026 — Set 1 — 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

Identify the plant in which emasculation is not required for artificial hybridization.

(a) Rice
(b) Wheat
(c) Pea
(d) Papaya <<

Explanation:

Papaya is a dioecious plant (separate male and female plants).
Since female flowers naturally lack stamens, there is no need to remove anthers (emasculation) before artificial hybridization.
Rice, wheat, and pea are bisexual/hermaphrodite plants and require emasculation.

Q.2

Which of the following is not a component of immune system?

(a) Lymphocytes
(b) Plasma Proteins
(c) Red Blood Cells <<
(d) Bone Marrow

Explanation:

Red Blood Cells (erythrocytes) are not part of the immune system.
The immune system components include lymphocytes (B and T cells), plasma proteins (antibodies/immunoglobulins), and bone marrow (which produces immune cells).
RBCs are involved in oxygen transport, not immunity.

Q.3

Select the option that shows correct statements:

(i) Corpus luteum secretes progesterone.
(ii) Only FSH attains a peak level in middle of cycle.
(iii) LH surge induces rupture of graafian follicle.
(iv) Luteal phase of menstrual cycle is also called proliferative phase.

(a) Only (ii) is correct.

(b) (i) and (iii) are correct. <<

(c) Only (iv) is correct.

(d) (ii) and (iv) are correct.

Explanation:

Statement (i) is correct — corpus luteum secretes progesterone.

Statement (iii) is correct — the LH surge (mid-cycle spike) triggers ovulation by inducing rupture of the Graafian follicle.

Statement (ii) is incorrect — both LH and FSH attain peak levels at mid-cycle.

Statement (iv) is incorrect — the proliferative phase corresponds to the follicular phase;

the luteal phase is the secretory phase.

Q.4

Select the mismatched pair:

(a) Mega diversity countries in the world – 12

(b) Genetically different strains of rice in India – Less than 1000 <<

(c) Robert May's estimation on global species diversity – 7 million species worldwide

(d) Zoological parks – Ex-situ conservation

Explanation:

The mismatched pair is option (B).

India has more than 50,000 genetically different strains of rice (not less than 1000).

Mega diversity countries = 12 (correct).

Robert May's estimate = approximately 7 million species (correct).

Zoological parks = ex-situ conservation (correct).

Q.5

Pomato was produced by fusing protoplasts of

(a) Tomato and Potato <<

(b) Pomegranate and Tomato

(c) Pomegranate and Potato

(d) Pomegranate, Potato and Tomato

Explanation:

Pomato is a somatic hybrid produced by somatic hybridization (protoplast fusion) of Tomato (Lycopersicon esculentum) and Potato (Solanum tuberosum).

The name 'Pomato' is derived from Po(tato) + (to)mato.

Q.6

In an ecosystem, different species occupy different levels and vertical distribution of species is found. This is called _____.

(a) Stratification <<

(b) Layering

(c) Fragmentation

(d) Population

Explanation:

Stratification refers to the vertical distribution (layering) of different species in an ecosystem, where each species occupies a specific level or stratum.

For example, in a forest ecosystem, different tree canopy levels host different species.

Q.7

Which of the following sacred groves is found in Meghalaya?

(a) Jaintia hills <<

(b) Bastar

(c) Chanda

(d) Sarguja

Explanation:

Sacred groves (forests traditionally protected by local communities) in Meghalaya include those in the Jaintia hills and Khasi hills.

Bastar and Sarguja are in Chhattisgarh, and Chanda is in Maharashtra.

Q.8

In the following figure, two ways of pairing of two homologous pairs of chromosomes are shown. Which of the following phenomena is expressed?

(a) Linkage of genes

(b) Independent assortment of genes <<

(c) Multiple alleles

(d) Incomplete dominance

Explanation:

The figure shows two homologous chromosome pairs aligning independently at the metaphase plate during meiosis I.

The two different arrangements (combinations) of chromosomes at the plate represent independent assortment of genes (Mendel's Law of Independent Assortment), where each pair segregates independently of the other.

Q.9

Match Column-I with Column-II and choose the correct option:

Column-I:

a. Biolistic gun

b. Chitinase

c. Ti

d. Ca++

Column-II:

i. Bacterial cell

ii. Tumour inducing

iii. Animal cell

iv. Fungal cell

v. Plant cell

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

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

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

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

Explanation:

Biolistic gun (gene gun) is used to introduce DNA into plant cells (v).

Chitinase digests chitin in fungal cell walls (iv).

Ti plasmid (Tumour inducing plasmid from Agrobacterium tumefaciens) is tumour inducing (ii).

Ca++ (calcium ions) are used to create pores in bacterial cell membranes to make them competent for DNA uptake (i).

Hence a-v, b-iv, c-ii, d-i.

Q.10

The idea of use and disuse of organs for evolution of organism was proposed by

(a) Charles Darwin

(b) Thomas Malthus

(c) Hugo De Vries

(d) Lamarck <<

Explanation:

Jean-Baptiste Lamarck proposed the theory of inheritance of acquired characteristics, which included the concept of use and disuse of organs — organs that are used frequently become stronger and larger, while unused organs degenerate.

This forms the basis of Lamarckism.

Q.11

Which of the following statements about plasmids is incorrect?

(a) Plasmids have the ability to replicate within the bacterial cell.

(b) Their replication is controlled by chromosomal DNA. <<

(c) They are autonomously replicating circular extra-chromosomal DNA.

(d) They often carry antibiotic resistant genes.

Explanation:

The incorrect statement is (B).

Plasmid replication is autonomous — it is NOT controlled by the chromosomal (bacterial) DNA.
Plasmids have their own origin of replication (ori) and replicate independently.
Statements (A), (C), and (D) are all correct descriptions of plasmids.

Q.12

Which connective tissue connects ovary to pelvic wall and uterus?

(a) Tendons
(b) Ligaments <<
(c) Cartilage
(d) Bone

Explanation:

Ligaments are fibrous connective tissue that connect bone to bone (or organ to organ).
The ovaries are held in position and connected to the pelvic wall and uterus by ligaments (ovarian ligament and suspensory ligament).
Tendons connect muscle to bone; cartilage is a flexible connective tissue.

Q.13

Assertion (A): The population of melanized moths increased in industrial areas after Industrial Revolution.
Reason (R): In Industrial environment lichen covered trees were replaced by soot-covered trees offering better camouflage to dark coloured moths.

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

Explanation:

Both A and R are true and R correctly explains A.
This is the classic industrial melanism example (Biston betularia).

Before industrialization, lichen-covered light trees favoured light-coloured moths.
After industrialization, soot blackened the trees, making dark (melanized) moths better camouflaged and less likely to be eaten by predators — so their population increased.
R is the correct explanation for A.

Q.14

Assertion (A): The milk produced by transgenic cow 'Rosie' was nutritionally more balanced product for human babies than natural cow milk.
Reason (R): It was human protein enriched milk containing human alpha lactalbumin.

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

Explanation:
Both A and R are true and R correctly explains A.
'Rosie' was a transgenic cow that produced human protein-enriched milk containing human alpha-lactalbumin (2.4 g/litre).
Human alpha-lactalbumin is a nutritionally balanced protein for human babies, making the milk more suitable for human infants than normal cow milk.
R correctly explains why A is true.

Q.15

Assertion (A): Flocs are masses of bacteria associated with fungal filaments in secondary treatment of sewage.
Reason (R): Flocs help in digestion of solid waste by anaerobic respiration.

(a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation for Assertion (A).
(b) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation for 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 — flocs are indeed masses of bacteria associated with fungal filaments formed during secondary (biological) treatment of sewage.

Reason (R) is false — flocs reduce BOD (Biochemical Oxygen Demand) through aerobic respiration, not anaerobic respiration.

Anaerobic digestion occurs in anaerobic sludge digesters (a separate step).

Hence A is true but R is false.

Q.16

Assertion (A): In terrestrial ecosystem much larger fraction of energy flows through grazing food chain.

Reason (R): Grazing food chain may be connected to Detritus food chain at some levels.

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

(b) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation for 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 false — in a terrestrial ecosystem, a much larger fraction of energy actually flows through the detritus food chain (decomposers), not the grazing food chain.

Reason (R) is true — the grazing food chain and detritus food chain are indeed interconnected at various levels.

Hence A is false but R is true.

Q.17

(a) Define Humoral immune response.

(b) Name any two types of antibodies found to give humoral immune

response in humans.

Answer: (a) Humoral immune response is the branch of adaptive immunity mediated by B lymphocytes (B cells) that produce and secrete antibodies (immunoglobulins) into body fluids (blood, lymph, mucus) to neutralise antigens. It is also called antibody-mediated immunity.

(b) IgG (Immunoglobulin G) and IgA (Immunoglobulin A). [Also accept: IgM, IgE, IgD]

Explanation:

Humoral immunity involves B cells differentiating into plasma cells that secrete antibodies.

The five classes of antibodies in humans are IgG, IgA, IgM, IgE, and IgD.

IgG is the most abundant;

IgA is found in secretions;

IgM is the first antibody produced in primary response;

IgE is involved in allergy;

IgD is found on B cell surfaces.

Q.18

(a)(i) How does a farmer use dormancy of seed to his advantage?

(a)(ii) Differentiate between pea seed and castor seed.

Answer: (a)(i) Seed dormancy allows seeds to remain viable and stored for long periods without germinating prematurely. Farmers use this to store seeds after harvest and use them for the next sowing season without loss of viability, ensuring a future crop even under unfavourable conditions.

(a)(ii) Pea seed is non-endospermic (exalbuminous) — the food is stored in cotyledons (embryonic leaves). Castor seed is endospermic (albuminous) — the food is stored in the endosperm, which persists in the mature seed.

Explanation:

Dormancy prevents germination in unfavourable conditions and allows farmers to store seeds for future use.

Pea (Pisum sativum) stores nutrients in cotyledons (no persistent endosperm = non-endospermic).

Castor (Ricinus communis) retains endosperm in the mature seed (endospermic).

OR

Q.18

OR (b) Identify the stage of follicle where primary oocyte undergoes first meiotic division. Also mention the products of this division.

Answer: The primary oocyte completes its first meiotic division in the tertiary follicle, which matures into the Graafian follicle just before ovulation.

Products: one large haploid secondary oocyte (receives almost all the cytoplasm) and one tiny first polar body.

Explanation:

The primary oocyte is arrested in prophase I until puberty.

Within the growing tertiary (Graafian) follicle it completes meiosis I, and the unequal division gives a large haploid secondary oocyte and a tiny first polar body.

The secondary oocyte is released at ovulation and completes meiosis II only on fertilization.

Q.19

Study the sequence of bases in a DNA molecule that is shown below and answer the questions.

5' – GAATTC – 3'

3' – CTTAAG – 5'

(a) What are such sequences called? Name the enzyme used that recognises such nucleotide sequences.

(b) How do these enzymes function?

Answer: (a) Such sequences are called palindromic sequences (palindromic nucleotide sequences). The enzyme that recognises this sequence is EcoRI (a restriction endonuclease / restriction enzyme).

(b) Restriction endonucleases function by recognising specific palindromic

sequences in double-stranded DNA and cutting both strands of the DNA at specific points within or adjacent to the recognition sequence. EcoRI cuts between G and AATTC on each strand, producing staggered cuts that result in sticky ends (single-stranded overhangs).

Explanation:

GAATTC read 5' to 3' on one strand is the same as GAATTC read 5' to 3' on the complementary strand (antiparallel) — this is the hallmark of a palindromic sequence.
EcoRI is a Type II restriction endonuclease isolated from Escherichia coli.
It makes staggered cuts: 5'...G | AATTC...3' and 3'...CTTAA | G...5', generating sticky ends (4-nucleotide single-stranded overhangs).

Q.20

(a) Analyse the following two cases of sex determination in different organisms:

Case I: Males have (XO) sex chromosomes and females have two copies of same sex chromosome (XX).

Case II: Females have two different sex chromosomes (ZW) and males have two copies of same sex chromosome (ZZ).

Identify the type of heterogamety in each case, giving one example of each.

Answer: Case I (XO system): Male heterogamety. Males are XO and produce two types of gametes — X-bearing and O-bearing (no sex chromosome). Example: Grasshopper (Locusta/Gryllus).

Case II (ZW system): Female heterogamety. Females are ZW and produce two types of eggs — Z-bearing and W-bearing. Example: Birds (e.g., hen/pigeon) or Butterflies.

Explanation:

Heterogamety means producing two types of gametes with respect to sex chromosomes.
In XO system (Case I), males (XO) are heterogametic — they produce X-bearing and no-sex-chromosome-bearing sperms.

In ZW system (Case II), females (ZW) are heterogametic — they produce Z-bearing and W-bearing eggs.

This is opposite to the human (XX/XY) system where males are heterogametic.

OR

Q.20

OR (b)(i) Differentiate between a DNA and RNA nucleotide.

(b)(ii) Name the two types of bonds present within a single nucleotide.

Answer: (b)(i) DNA nucleotide: contains deoxyribose sugar, phosphate group, and one of four nitrogenous bases (Adenine, Guanine, Cytosine, Thymine). RNA nucleotide: contains ribose sugar, phosphate group, and one of four nitrogenous bases (Adenine, Guanine, Cytosine, Uracil). Key differences: sugar type (deoxyribose vs ribose) and thymine (DNA) vs uracil (RNA).

(b)(ii) The two types of bonds within a single nucleotide are: (1) N-glycosidic bond — between nitrogenous base and pentose sugar; (2) Phosphoester bond — between phosphate group and pentose sugar.

Explanation:

A nucleotide = nitrogenous base + pentose sugar + phosphate.

The N-glycosidic bond links the base to C1' of the sugar.

The phosphoester bond links the phosphate to C5' (or C3') of the sugar.

These are the two covalent bonds within a mononucleotide.

Q.21

(a) Given below is a pyramid found in an ecosystem, where each bar represents the standing crop available in the trophic level. (See the figure.)

(i) Identify the kind of pyramid and with the help of an example explain the conditions where this kind of pyramid is possible in nature.

(ii) Write any two limitations of ecological pyramids.

Answer: (a)(i) Inverted pyramid of biomass. This occurs in aquatic ecosystems (e.g., a pond or sea), where the biomass of producers (phytoplankton) at any given time is less than the biomass of primary consumers (zooplankton). Although

phytoplankton have a very high reproductive rate and rapid turnover, the standing crop biomass at any instant is lower than that of zooplankton.

(a)(ii) Limitations of ecological pyramids:

1. They do not account for the same species belonging to two or more trophic levels (omnivores).

2. They assume a simple food chain, ignoring the complex food web in nature.

[Also accept: They do not accommodate saprophytes; they give no information about the rate of energy flow (productivity vs standing crop).]

Explanation:

Inverted pyramid of biomass: in aquatic systems, phytoplankton (producers) have small standing biomass but very high turnover rate, while zooplankton accumulate more biomass.

Pyramids of numbers can also be inverted (e.g., a single tree supporting many insects).

Pyramids of energy are always upright.

OR

Q.21

OR (b) In an ecosystem there was loss of biodiversity due to some project in that area.

(i) How will biodiversity be affected? (2 points)

(ii) List two major causes of loss of biodiversity.

Answer: (b)(i) Effects of biodiversity loss:

1. Loss of species leads to destabilisation of ecosystems, reducing their ability to recover from disturbances (reduced resilience).

2. Decline in ecosystem services such as pollination, nutrient cycling, water purification, and productivity.

(Also: disruption of food webs; reduced genetic diversity.)

(b)(ii) Major causes of loss of biodiversity:

1. Habitat loss and fragmentation (e.g., deforestation, urbanisation).

2. Over-exploitation of species (hunting, poaching, over-fishing).

[Also accept: Introduction of invasive alien species; co-extinctions; pollution; climate change.]

Explanation:

The major causes of biodiversity loss are the 'Evil Quartet': habitat loss and fragmentation, over-exploitation, alien species invasions and co-extinctions.

Habitat loss is the single biggest cause.

Q.22

(a) Do all pollen grains remain viable for the same length of time? Support your answer with two suitable examples.

(b) How are pollen grains stored in pollen banks?

Answer: (a) No, pollen grains do not remain viable for the same length of time. Viability varies greatly among species. Examples:

1. Rice and wheat pollen — lose viability within 30 minutes of shedding.

2. Members of Rosaceae, Leguminoseae, Solanaceae — pollen remains viable for months.

(b) Pollen grains are stored in pollen banks in liquid nitrogen at −196°C. This preserves their viability for long periods and they can be used in crop breeding programmes.

Explanation:

Pollen viability depends on the species and environmental conditions.

Short-lived pollen (rice, wheat) must be used immediately;

long-lived pollen (legumes, rosaceae) can be stored.

Liquid nitrogen (cryopreservation) is the standard method for pollen banking — the ultra-low temperature halts all metabolic activity, preserving viability.

Q.23

(a) What is pedigree analysis? Mention its importance in human genetics. (2 pts.)

(b) Analyse the following pedigree and write the:

(i) Pattern of inheritance.

(ii) Give one example of a disease showing such an inheritance pattern.

Answer: (a) Pedigree analysis is the study of the pattern of inheritance of a trait in several generations of a family using a conventional set of symbols (squares for males, circles for females, shaded symbols for affected individuals). Importance in human genetics: (1) It helps to determine whether a trait is dominant or recessive, autosomal or sex-linked. (2) It is used in genetic counselling to predict the probability of a genetic disorder appearing in offspring.

(b)(i) Two unaffected parents have an affected daughter (and affected sons), and the trait skips a generation (unaffected carrier couple in the second generation has an affected son), so it is autosomal recessive inheritance.

(b)(ii) Example: Phenylketonuria (PKU), or Sickle cell anaemia, or Cystic fibrosis. [Accept any correct autosomal recessive disease.]

Explanation:

In autosomal recessive pedigrees, affected individuals often have unaffected carrier parents.

The trait may skip generations.

Males and females are equally likely to be affected.

Common examples include PKU, albinism, sickle cell anaemia, cystic fibrosis.

Q.24

(a) How is Hardy-Weinberg expression $(p^2 + 2pq + q^2) = 1$ derived?

(b) List any two factors that disturb the genetic equilibrium.

Answer: (a) Derivation: Let p = frequency of dominant allele A, q = frequency of recessive allele a. Since there are only two alleles, p + q = 1. The frequency of genotypes in the next generation (assuming random mating, large population, no selection, no mutation, no gene flow) is determined by the binomial expansion of $(p + q)^2$:

$(p + q)^2 = p^2 + 2pq + q^2 = 1$

where p^2 = frequency of AA (homozygous dominant), 2pq = frequency of Aa (heterozygous), q^2 = frequency of aa (homozygous recessive).

This demonstrates that allele and genotype frequencies remain constant from generation to generation (genetic equilibrium).

(b) Two factors that disturb genetic equilibrium:

1. Natural selection (selection pressure favouring or eliminating certain alleles)
2. Genetic drift (random changes in allele frequencies in small populations)

[Also accept: mutation, gene flow/migration, non-random mating, recombination]

Explanation:

Hardy-Weinberg principle (1908) states that allele and genotype frequencies in a large, randomly mating population remain constant in the absence of evolutionary influences.

The expression $p^2 + 2pq + q^2 = 1$ is derived from $(p + q)^2 = 1$.

Violations of the five assumptions (large population, random mating, no mutation, no selection, no gene flow) disturb this equilibrium.

Q.25

Draw a neat diagram of megasporangium of an angiosperm and label any six parts.

Answer: Diagram of megasporangium (ovule) should show and label any six of the following parts:

1. Funicle (stalk)
2. Hilum (junction of funicle and ovule body)
3. Integuments (outer integument and inner integument)
4. Micropyle (opening at one end)
5. Nucellus (mass of parenchymatous cells)
6. Embryo sac (female gametophyte)
7. Chalaza (base region)
8. Egg cell (one of three cells at micropylar end)
9. Synergids (flanking egg cell)
10. Antipodal cells (three cells at chalazal end)
11. Secondary nucleus (central cell with two polar nuclei fused)

Explanation:

The megasporangium is the ovule in angiosperms.

It consists of the nucellus (megasporangium proper) surrounded by integuments (usually two in angiosperms) with a micropyle at one end and chalaza at the other.

The mature embryo sac (Polygonum type) contains 7 cells and 8 nuclei: 3 antipodals, 2 synergids, 1 egg cell, and 1 central cell with 2 polar nuclei.

Q.26

(a) Mention the scientific name of the source plant and the part from which opioids are extracted.

(b) How are morphine and heroin related? Mention the effect each one of them has on human body.

Answer: (a) Scientific name: Papaver somniferum (poppy plant). Opioids are extracted from the latex of the unripe seed capsule (pod).

(b) Morphine and heroin: Heroin (diacetylmorphine) is a chemically modified derivative of morphine — it is synthesised by acetylation of morphine. Heroin is therefore derived from morphine.

Effects on human body:

- Morphine: Acts as a strong pain killer (analgesic) by binding to opioid receptors in the CNS. Slows down body functions; produces euphoria and relief from pain.
- Heroin: More potent than morphine; rapidly produces euphoria and is highly addictive. Causes CNS depression (slows down breathing, heart rate). Leads to physical and psychological dependence.

Explanation:

Opioids include opium, morphine, heroin, and codeine — all derived from Papaver somniferum.

Heroin = diacetylmorphine (morphine + 2 acetyl groups).

Both are CNS depressants.

Morphine is used medically for pain relief;

heroin has no accepted medical use and is a Schedule I narcotic due to high abuse potential.

Q.27

A farmer grew two varieties of corn crop in field A and B. He grew normal corn crops in field A and GM corn crops in field B. He observed that corn borers attacked only in field A. To control it, spores of Bt were sprayed on field A.

(a) Name the gene in the spores responsible for control of pest.

(b) What effect will the spores of Bt have on insect pest?

(c) How has corn plants of field B developed resistance against this pest? Explain.

Answer: (a) The gene responsible is the cry gene (crystal protein gene / Bt toxin gene), specifically cry IAb or cry IAc for corn borer control. [Accept: cry gene / Bt cry gene]

(b) Effect of Bt spores on insect pest: The Bt bacterium (Bacillus thuringiensis) spores contain crystal (Cry) proteins. When ingested by the insect larvae, the alkaline pH of the larval midgut activates the pro-toxin (inactive Cry protein) into active toxin. The active toxin binds to the midgut epithelial cells, creating pores/holes in the cell membrane, causing cell swelling, lysis and death. The insect larva stops feeding and dies.

(c) Field B corn (GM crop) has developed resistance by incorporating the Bt cry gene into its own genome (transgenic plant). The plant cells synthesise the Cry protein (delta-endotoxin) themselves. When the corn borer ingests the plant tissue, it ingests the Cry protein, which is activated in the insect gut and causes death as described above. The plant is thus protected from within.

Explanation:

Bacillus thuringiensis produces insecticidal crystal proteins (Cry proteins / delta-endotoxins) encoded by cry genes.

In GM crops (Bt crops), the cry gene is incorporated into the plant genome so the plant produces the toxin in all its tissues, giving inherent pest resistance.

The toxin is harmless to mammals (requires the alkaline insect gut pH for activation) but lethal to lepidopteran pests.

Q.28

Observe the given picture carefully. A mixture of DNA with fragments ranging from 100 base pairs to 1800 base pairs were separated by electrophoresis on agarose gel with the following arrangement. (See the figure.)

(a) What result will be obtained in staining with ethidium bromide? Explain with reasons.

(b) The above setup was modified as shown below and a band with 100 base pairs was obtained at X. What changes were made to the previous design to get a band at 'X'. Why did the band appear at 'X'?

Answer: (a) No bands will be seen on staining with ethidium bromide. In the given arrangement the wells are at the positive (+) electrode end. DNA is negatively charged and moves towards the anode (+), so the fragments move away from the wells and out of the gel instead of into it, and no separated bands form.

(b) The polarity was reversed: the wells were placed at the negative (−) electrode (cathode) end and the positive electrode at the opposite end. DNA then migrates through the gel from the wells towards the + electrode. The 100 bp fragment is the smallest, so it moves fastest and farthest, and its band appears at X, the position farthest from the wells.

Explanation:

DNA is negatively charged and migrates towards the positive electrode through the agarose matrix;

smaller fragments move faster and farther.

With wells at the + end the DNA runs backwards out of the gel, so no bands are seen.

Placing the wells at the − end gives the normal run, with the smallest (100 bp) fragment farthest from the wells at X.

Ethidium bromide stains DNA bands, which fluoresce orange under UV.

Q.29

The diagram below shows the distribution of two barnacle species, Chthamalus and Balanus on a rocky sea shore. When Balanus is

experimentally removed, Chthamalus expands its range in lower intertidal zone. (See the figure.)

(a) Identify and define the ecological phenomenon demonstrated by this observation.

Answer: (a) The ecological phenomenon demonstrated is Interspecific Competition (specifically, competitive exclusion / resource competition between two species).

Definition: Interspecific competition is the competition between individuals of different species for the same limited resources (food, space, light, etc.) in the same habitat. In this case, Balanus competitively excludes Chthamalus from the lower intertidal zone by occupying that space. When Balanus is removed, Chthamalus can expand its realised niche to cover its fundamental niche.

Explanation:

This is Connell's barnacle experiment.

In the figure Balanus outcompetes Chthamalus for space in the middle intertidal zone, while Chthamalus thrives in the upper zone where Balanus dessicates.

When Balanus is removed, Chthamalus expands its range, showing that competition from Balanus was restricting it.

This is interspecific competition, which can lead to competitive exclusion.

OR

Q.29

OR (a) State the principle that explains the elimination of one species.

Answer: The principle that explains the elimination of one species is the Competitive Exclusion Principle (also called Gause's Principle): Two species competing for the same limited resources cannot coexist indefinitely — the competitively inferior species will eventually be eliminated/excluded, while the superior competitor will survive. The losing species either goes locally extinct or is forced to use a different resource (niche differentiation).

Explanation:

Gause's competitive exclusion principle (1934): No two species with identical ecological requirements (same niche) can coexist in the same habitat.

One will always outcompete and exclude the other.

Demonstrated experimentally with Paramecium aurelia and P. caudatum competing for the same food.

Q.29(b)

[Case-based Q29] (b) Two different species can compete for the same resource. Give another example of it.

Answer: Another example of interspecific competition for the same resource: flamingos and resident fishes in shallow South American lakes compete for zooplankton as their common food. [Other acceptable examples: Abingdon tortoise driven to extinction by goats introduced on Abingdon island (competing for the same plant food); lions and leopards competing for the same prey; different bird species competing for the same insects.]

Explanation:

Interspecific competition occurs when two species share a resource that is in limited supply.

The example from NCERT: Abingdon tortoise became extinct within a decade after goats were introduced on Abingdon island — both competed for the same plant food.

Another NCERT example: flamingos and fish competing for zooplankton in shallow South American lakes.

Q.29(c)

[Case-based Q29] (c) How do species avoid competition in nature? Explain with an example.

Answer: Species avoid competition through resource partitioning — they divide or share the available resources so that direct competition is minimised. Each species specialises in using a slightly different part of the resource (niche differentiation).

Example: MacArthur (1958) showed that five species of warblers (Dendroica spp.) coexist on the same spruce tree by occupying and foraging in different zones of the tree canopy (top, middle, base, outer branches, inner branches). Each species has a distinct microhabitat, so they are not in direct competition for exactly the same space/food, allowing coexistence.

Explanation:

Resource partitioning allows competitive coexistence.

When closely related species live in the same area, they evolve to use different resources or use the same resource at different times/places/ways.

This leads to character displacement (morphological differences that reduce competition).

The warbler example is the classic NCERT illustration of this principle.

Q.30

A student performed some crosses in plants and represented the result in the form of bar graphs as shown below. Each graph displays the phenotypic proportion of the progeny. Study the graphs and answer the questions : (See the figure.)

(a) What can you infer about the genotype of parents in crosses I and II ?

Answer: Cross I: all 500 progeny are tall and none is dwarf, so the tall trait is dominant and at least one parent is homozygous dominant (for example TT × TT, TT × tt or TT × Tt).

Cross II: 375 tall : 125 dwarf is a 3 : 1 ratio, so both parents are heterozygous (Tt × Tt).

Explanation:

Bar graph values: Cross I = 500 tall, 0 dwarf;

Cross II = 375 tall, 125 dwarf (3 : 1);

Cross III = 250 tall, 250 dwarf (1 : 1).

All-dominant progeny means a homozygous dominant parent is involved.

A 3 : 1 ratio comes only from Tt × Tt.

OR

Q.30

OR (a) Which genetic cross is represented by these crosses?

Answer: Cross I: monohybrid cross between a homozygous tall plant and a homozygous dwarf plant (TT × tt), giving all tall progeny (F1) — all progeny show the dominant trait.

Cross II: monohybrid cross between two heterozygotes (Tt × Tt, F1 × F1) giving a 3 : 1 phenotypic ratio.

Cross III: test cross (Tt × tt) giving a 1 : 1 ratio.

Explanation:

Cross I (500 tall : 0 dwarf) is a cross of pure parents with F1 all dominant, cross II (375 : 125 = 3 : 1) is the F1 self-cross (monohybrid cross), and cross III (250 : 250 = 1 : 1) is a test cross.

Q.30(b)

[Case-based Q30] (b) Looking at bar graph of cross III, identify the type of cross performed and its importance in genetics.

Answer: Cross III bar graph shows 250 tall : 250 dwarf — a 1:1 phenotypic ratio.

Type of cross: Test Cross (Aa × aa) — crossing a heterozygous dominant plant with a homozygous recessive plant.

Importance in genetics: (1) A test cross is used to determine the genotype of an organism showing dominant phenotype — whether it is homozygous (AA) or heterozygous (Aa). A 1:1 result proves the plant is heterozygous (Aa). (2) It demonstrates and verifies Mendel's Law of Segregation — that alleles separate during gamete formation.

Explanation:

The bar graph shows Cross III as 250 tall : 250 dwarf, a 1 : 1 ratio.

A test cross (heterozygote × homozygous recessive, Tt × tt) gives this ratio and reveals the unknown genotype of a plant with the dominant phenotype.

Q.30(c)

[Case-based Q30] (c) What conclusion can you draw from the results of bar graphs of crosses I and II? Name the genetic principle illustrated.

Answer: Cross I (all tall) shows that tall is dominant over dwarf: the dominant allele masks the recessive allele in the heterozygote. Cross II (375 : 125 = 3 : 1) shows that the recessive dwarf trait reappears in one-fourth of the progeny, so the two alleles of a gene separate (segregate) during gamete formation and are not blended.

Genetic principle illustrated: Mendel's Law of Segregation (together with the Law of Dominance).

Explanation:

All-tall progeny shows dominance.

The 3 : 1 ratio of Cross II with the reappearance of dwarf plants shows segregation of alleles at gamete formation (Mendel's first law).

Q.31

(a) Trace the events from fertilization till implantation of blastocyst in human female. Also mention the site where fertilization takes place.

Answer: Site of fertilization: ampullary–isthmic junction of the fallopian tube (oviduct).

Events from fertilization to implantation:

1. Fertilization: Sperm penetrates the secondary oocyte at the ampullary–isthmic junction; this triggers completion of meiosis II by the oocyte, producing the ovum and second polar body. The sperm and egg nuclei fuse to form the zygote (diploid, 46 chromosomes).

2. Cleavage: The zygote undergoes rapid mitotic divisions (cleavage) without growth, producing 2, 4, 8, 16 cells — called blastomeres. The 8-16 cell stage is the morula (solid ball of cells).

3. Morula: The morula moves through the fallopian tube towards the uterus.

4. Blastocyst formation: The morula develops into a blastocyst — a hollow ball of cells with an inner cell mass (embryoblast) and an outer layer (trophoblast), surrounding a fluid-filled cavity (blastocoel).

5. Implantation: The blastocyst reaches the uterus (approximately 6–7 days after fertilization). The trophoblast attaches to the endometrium (uterine wall), and the blastocyst embeds into the endometrium — this is implantation.

Explanation:

The entire journey from fertilization to implantation takes about 6–7 days in humans.

Key stages: zygote →

cleavage →

2-cell →

4-cell →

morula →

blastocyst →

implantation in endometrium.

The trophoblast secretes enzymes to help the blastocyst embed.

Human chorionic gonadotropin (hCG) begins to be secreted by the trophoblast after implantation, maintaining the corpus luteum and preventing menstruation.

OR

Q.31

OR (b)(i) Case studies of some couples are given below. They were not able to have kids even though the parents were not taking any precautions. They also do not wish to adopt a child or take the help of donors. Study these cases and suggest an appropriate Assisted Reproductive Technology that could help them.

Case I – Female – Normal Reports

Male – Normal sperms but no connection between epididymis and vas deferens.

Case II – Female – Normal eggs but Fallopian tube blocked.

Male – Normal sperms. Male reports are normal.

Case III – Female – Normal Reports.

Male – Low sperm count with less motility.

(b)(ii) Copper releasing intrauterine devices are very effective and popular contraceptive devices. Name any two copper releasing IUDs. Write two reasons that make them effective contraceptives.

Answer: (b)(i) ART recommendations:

Case I (no connection between epididymis and vas deferens — sperm cannot be ejaculated): ICSI (Intracytoplasmic Sperm Injection). Sperms are retrieved directly from the epididymis (PESA) and injected directly into the egg in the laboratory.

Case II (blocked fallopian tube — natural fertilization and transport impossible): IVF-ET (In Vitro Fertilisation – Embryo Transfer) / Test Tube Baby technique. Eggs are retrieved from the ovary, fertilised in vitro with husband's sperms, and the embryo is transferred to the uterus.

Case III (low sperm count and motility): ICSI (Intracytoplasmic Sperm Injection) or IUI (Intrauterine Insemination). In ICSI, a single healthy sperm is injected into the egg. IUI involves washing and concentrating the sperms and injecting them into the uterus.

(b)(ii) Two copper-releasing IUDs: CuT (Copper-T) and Cu7 (Copper-7). [Also accept: Multiload 375, Nova-T]

Two reasons they are effective contraceptives:

1. Copper ions released suppress sperm motility and fertilising capacity of sperms.
2. They make the uterus unsuitable for implantation (alter the uterine environment).

Explanation:

ART includes IVF (in vitro fertilisation), GIFT (gamete intrafallopian transfer), ZIFT (zygote intrafallopian transfer), IUI (intrauterine insemination), and ICSI.

Copper IUDs work by: (1) Cu2+ ions are toxic to sperms and inhibit their motility/fertility;

(2) they create a hostile uterine environment preventing implantation.
They do NOT prevent ovulation.

Q.32

(a)(i) Watson and Crick's discovery of double helical structure was based on which two findings. Also mention the name of the scientists associated with these findings.

(a)(ii) Write down the salient features of double helix structure of DNA (any three points).

Answer: (a)(i) Two key findings that Watson and Crick used:

1. X-ray diffraction data of DNA — provided by Rosalind Franklin and Maurice Wilkins. Franklin's X-ray photograph (Photo 51) showed that DNA is a helical molecule with a consistent diameter and repeated structural units.
2. Chargaff's Rules — established by Erwin Chargaff. The molar ratios of purines equal pyrimidines in DNA: A = T and G = C. This implied specific base pairing.

(a)(ii) Three salient features of the double helix structure of DNA:

1. DNA consists of two polynucleotide chains wound around a common axis in an anti-parallel manner (one chain runs 5'→3' and the other runs 3'→5').
2. The sugar-phosphate backbone is on the outside, and the nitrogenous bases are on the inside, facing each other.
3. The two strands are complementary and held together by hydrogen bonds between specific base pairs: Adenine pairs with Thymine (2 H-bonds) and Guanine pairs with Cytosine (3 H-bonds) — following Chargaff's rules.

[Also accept: The helix makes one complete turn every 3.4 nm (34 Å) with 10 base pairs per turn; pitch = 3.4 nm, diameter = 2 nm; the two strands are coiled in right-handed (B-form) manner.]

Explanation:

Watson and Crick's 1953 model of DNA used: (1) Franklin/Wilkins X-ray crystallography showing helical structure, 3.4 Å per base pair, 34 Å per turn;
(2) Chargaff's rules showing A=T and G=C.

The model explained DNA replication through complementary base pairing.

Key features: antiparallel strands, complementary base pairing, major and minor grooves, right-handed helix.

OR

Q.32

OR (b) Given below is a stretch of DNA showing the coding strand of structural gene of transcription unit.

5' - ATG ACC GTA TTT TCT GTA GTG CCC GTA CTT CAG GCA TTA 3'

(i) Write the corresponding template strand and m-RNA strand that will be transcribed along with its polarity.

(ii) If GUA of transcribed mRNA is an intron, then depict the sequence involved in formation of mRNA / mature / processed hnRNA strand:

(1) In a bacterium

(2) In humans

(iii) How many amino acids the resulting polypeptide will have after the process of translation in humans?

Answer: (b)(i) Coding strand (given): 5' - ATG ACC GTA TTT TCT GTA GTG CCC GTA CTT CAG GCA TTA - 3'

Template strand: 3' - TAC TGG CAT AAA AGA CAT CAC GGG CAT GAA GTC CGT AAT - 5'

(written 5'→3': 5' - TAA TGC CTG AAG TAC GGG CAC TAC AGA AAA TAC GGT CAT - 3')

mRNA (same as the coding strand with U in place of T): 5' - AUG ACC GUA UUU UCU GUA GUG CCC GUA CUU CAG GCA UUA - 3'

(b)(ii)(1) In a bacterium there is no splicing (no introns), so the mRNA stays unchanged: 5' - AUG ACC GUA UUU UCU GUA GUG CCC GUA CUU CAG GCA UUA - 3'

(b)(ii)(2) In humans the intron GUA is spliced out wherever it occurs (three times) and the exons are joined: 5' - AUG ACC UUU UCU GUG CCC CUU CAG GCA UUA - 3'

(b)(iii) The mature human mRNA has 10 codons (AUG ACC UUU UCU GUG CCC CUU CAG GCA UUA) and no stop codon, so the polypeptide has 10 amino acids.

Explanation:

The mRNA is complementary to the template strand and identical to the coding strand with U for T.

Bacterial mRNA is not spliced.

In eukaryotes the three GUA introns (positions 7–9, 16–18 and 25–27 of the mRNA) are removed and the exons joined, leaving 10 codons: AUG(Met) ACC(Thr) UUU(Phe) UCU(Ser) GUG(Val) CCC(Pro) CUU(Leu) CAG(Gln) GCA(Ala) UUA(Leu) = 10 amino acids.

Note: this answer is unconfirmed.

Q.33

(a)(i) Name the protozoan species that is responsible for causing the most serious and even fatal malarial disease.

(a)(ii) Name the host in which the parasite completes its sexual stages and explain the changes taking place.

(a)(iii) How does the parasite damage the human body after entering the blood stream?

(a)(iv) Suggest two effective preventive measures to control the spread of this disease in endemic regions.

Answer: (a)(i) Plasmodium falciparum — responsible for malignant/falciparum malaria (the most serious and fatal form).

(a)(ii) Sexual reproduction of Plasmodium occurs in the female Anopheles mosquito (definitive host).

Changes in mosquito: When a mosquito bites an infected person, it ingests RBCs containing gametocytes (male microgametocytes and female macrogametocytes). In the mosquito's gut: (1) Gametocytes develop into gametes — microgametes (from microgametocytes) and macrogametes (from macrogametocytes). (2) Fertilization occurs in the mosquito gut forming a zygote. (3) Zygote develops into

an ookinete, then an oocyst (in the gut wall). (4) Oocyst undergoes multiple mitotic divisions to produce thousands of sporozoites. (5) Sporozoites migrate to the salivary glands of the mosquito. When the mosquito bites a human, sporozoites are injected with saliva.

(a)(iii) After entering the blood stream, Plasmodium invades RBCs (erythrocytes). Inside RBCs, the parasites multiply and periodically rupture the RBCs — releasing merozoites and toxins (including haemozoin). This causes: periodic fever and chills (every 48 or 72 hours depending on species); anaemia (destruction of RBCs); in P. falciparum, infected RBCs become sticky and can block capillaries in the brain (cerebral malaria), leading to coma/death; organ damage (liver, spleen enlargement).

(a)(iv) Two preventive measures:
1. Vector control — eliminate mosquito breeding sites by draining stagnant water, using larvicides (e.g., Bacillus thuringiensis israelensis), or introducing biological control agents (e.g., Gambusia fish).
2. Personal protection — use of mosquito nets (insecticide-treated bednets/ITNs), insect repellents, and protective clothing to prevent mosquito bites.

Explanation:
Malaria is caused by Plasmodium (P.
vivax, P.
falciparum, P.
malariae, P.
ovale).
P.
falciparum causes the most severe, cerebral malaria.
Life cycle: sporozoites (injected by mosquito) →
liver cells (exo-erythrocytic schizogony) →
merozoites →
RBCs (erythrocytic schizogony) →

gametocytes →
mosquito (sexual cycle / sporogony).
Haemozoin is the toxic pigment released when RBCs rupture, causing fever.
Prevention = mosquito control + personal protection + chemoprophylaxis.

OR

Q.33

OR (b)(i) What are bio-fertilizers?

(b)(ii) Name the different types of microorganisms used as bio-fertilizers in organic farming and explain how each contributes to soil fertility.

(b)(iii) Write two advantages of using bio-fertilizers over chemical fertilizers.

Answer: (b)(i) Bio-fertilizers are organisms (microorganisms — bacteria, fungi, cyanobacteria) that enrich the nutrient quality of soil naturally. They fix atmospheric nitrogen or solubilize phosphates, making nutrients available to plants without the use of chemical fertilisers.

(b)(ii) Types of microorganisms used as bio-fertilizers:

1. Bacteria:
   - Rhizobium: forms symbiotic associations in root nodules of leguminous plants; fixes atmospheric N2 into ammonia/ammonium ions usable by the plant, enriching soil nitrogen.
   - Azospirillum and Azotobacter: free-living nitrogen-fixing bacteria in soil; fix atmospheric nitrogen and enrich soil nitrogen content.
2. Cyanobacteria (Blue-green algae):
   - Anabaena, Nostoc, Oscillatoria: free-living or symbiotic (Anabaena in Azolla — water fern). Fix atmospheric nitrogen; used extensively in rice paddy fields to enrich soil nitrogen. Contribute organic matter on decomposition.
3. Fungi (Mycorrhiza):
   - Glomus and other mycorrhizal fungi form symbiotic associations with plant roots. They help absorb phosphorus and other nutrients (especially from poor soils), increase the root surface area for water/mineral absorption, and provide

resistance to root-borne pathogens.

(b)(iii) Two advantages of bio-fertilizers over chemical fertilizers:

1. Eco-friendly / environmentally safe — they do not cause soil/water pollution or disrupt soil microbiota, unlike chemical fertilisers which cause eutrophication and soil acidification.

2. Cost-effective and sustainable — bio-fertilizers are cheaper to produce and renew naturally; they improve long-term soil fertility and structure rather than depleting it.

Explanation:

Bio-fertilizers include nitrogen-fixing microbes (Rhizobium, Azotobacter, Azospirillum, cyanobacteria) and phosphate-solubilising microbes and mycorrhizal fungi.

Chemical fertilisers, while immediately effective, cause long-term problems: soil degradation, water pollution (nitrate/phosphate runoff →

eutrophication), loss of beneficial soil microbiota, and greenhouse gas emissions (N_2O from nitrification/denitrification).