# CBSE Class 12 Biology 2024 — 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

In which of the following plants are both male and female flowers born on the same plant and the mode of pollination can be geitonogamy or xenogamy ?

(a) Papaya
(b) Date Palm
(c) Maize <<
(d) Spinach

Explanation:

Maize (corn) is monoecious — male (tassel) and female (silk/cob) flowers are on the same plant.
Pollen from the tassel can land on the silk of the same plant (geitonogamy) or a different plant (xenogamy).
Papaya is dioecious (separate male/female plants).
Date Palm is also dioecious.
Spinach is dioecious.

Q.2

Which one of the following hormones is secreted by the human placenta that helps in the maintenance of pregnancy ?

(a) Relaxin
(b) Human Chorionic Gonadotropin <<
(c) Oxytocin
(d) Human Placental Lactogen

Explanation:

Human Chorionic Gonadotropin (hCG) is secreted by the trophoblast/placenta and maintains the corpus luteum, which secretes progesterone to sustain the pregnancy during the first trimester.
Relaxin is secreted by the corpus luteum.
Oxytocin is secreted by the posterior pituitary.
Human Placental Lactogen is produced by the placenta but is involved in metabolic changes, not specifically in maintaining pregnancy through progesterone support.

Q.3

The periodic abstinence by a couple for family planning should be from :

(a) Day 5 to 10 of menstrual cycle

(b) Day 13 to 15 of menstrual cycle

(c) Day 10 to 17 of menstrual cycle <<

(d) Day 16 to 20 of menstrual cycle

Explanation:

In a 28-day menstrual cycle, ovulation typically occurs around day 14.

The ovum survives for about 1–2 days and sperm for up to 3 days.

The fertile period is approximately days 10–17.

Couples using the rhythm/calendar method (periodic abstinence) should abstain from sexual intercourse during this window to avoid pregnancy.

Q.4

Select the incorrect match from the following :

Human Karyotype | Characters

45 + XX | Broad palm with characteristic palm crease

44 + XXY | Overall feminine development

44 + XO | Sterile females as ovaries are rudimentary

44 + XY | Normal male

(a) 45 + XX — Broad palm with characteristic palm crease

(b) 44 + XXY — Overall feminine development <<

(c) 44 + XO — Sterile females as ovaries are rudimentary

(d) 44 + XY — Normal male

Explanation:

Incorrect match is (B) 44+XXY — 'Overall feminine development'.

44+XXY (47,XXY) is Klinefelter syndrome: the individual is phenotypically MALE (masculine development) with some feminine traits (gynaecomastia), NOT 'overall feminine'.

The other matches are correct: 45+XX (trisomy 21, Down — broad palm with palm

crease), 44+XO (Turner — sterile females, rudimentary ovaries), 44+XY (normal male).

Answer: (B).

Q.5

You know that there are twenty different types of naturally occurring amino acids and four different types of bases in the DNA. A combination of 3 such bases code for a specific amino acid. If instead there are 96 different amino acids and 12 different bases in the DNA, then the minimum number of combination of bases required to form a codon is :

(a) 6

(b) 8

(c) 2 <<

(d) 4

Explanation:

With 96 amino acids and 12 bases, the minimum codon length n must satisfy 12^n >= 96.

12^1 = 12 < 96; 12^2 = 144 >= 96.

So minimum n = 2.

Answer: 2 (option C).

Q.6

The type of bond represented by the dotted line in a schematic polynucleotide chain is :

(a) Hydrogen bond

(b) Peptide bond

(c) N-glycosidic linkage <<

(d) Phosphodiester bond

Explanation:

The dotted line in the printed schematic joins the sugar (S) to the nitrogenous base (B) in each nucleotide.

That linkage is the N-glycosidic bond.

The phosphodiester bonds are the solid zig-zag links between P and S that form the backbone.

Hydrogen bonds join bases of two different strands; peptide bonds occur in proteins.

Answer: (C) N-glycosidic linkage.

Q.7

In which of the following conditions/diseases is there a substantial increase in the activity of mast cells observed in the human body ?

(a) Typhoid

(b) Allergy <<

(c) Ascariasis

(d) AIDS

Explanation:

Mast cells are present in connective tissue and contain histamine and other mediators.

During allergic reactions (allergy), allergens bind to IgE antibodies on mast cells, causing degranulation — the mast cells release large amounts of histamine and other chemicals causing allergy symptoms.

Typhoid is caused by Salmonella typhi (bacterial).

Ascariasis is caused by Ascaris lumbricoides (worm).

AIDS involves T-helper cell depletion.

Only allergy involves substantial mast cell hyperactivity.

Q.8

Lactobacillus that sets milk into curd is categorised as :

(a) Cyanobacteria

(b) Archaebacteria

(c) Chemosynthetic bacteria

(d) Heterotrophic bacteria <<

Explanation:

Lactobacillus is a genus of bacteria that ferments lactose in milk to lactic acid, converting milk to curd.

It is heterotrophic — it obtains energy by breaking down organic compounds (lactose).
It is not a cyanobacterium (which are photosynthetic), not archaebacteria, and not chemosynthetic (which use inorganic chemicals for energy).

Q.9

Which one of the following transgenic animals is being used to test the safety of the polio vaccine ?

(a) Sheep
(b) Goat
(c) Pig
(d) Mice <<

Explanation:

Transgenic mice are widely used in biomedical research.
Specifically, transgenic mice have been developed that carry the gene for the poliovirus receptor, making them susceptible to poliovirus.
These mice are used to test the safety and efficacy of the polio vaccine.
This is the standard NCERT example for transgenic animal use in vaccine testing.

Q.10

Restriction Endonuclease Hind II always cuts DNA molecules at a particular point by recognising a specific sequence of :

(a) Six base pairs <<
(b) Four base pairs
(c) Seven base pairs
(d) Three base pairs

Explanation:

Hind II, the first restriction endonuclease discovered, always cuts DNA at a particular point by recognising a specific sequence of six base pairs (NCERT Class 12, Biotechnology: Principles and Processes).
Option (A).

Q.11

The improved trait that is found in the genetically modified transgenic crop Golden rice is :

(a) High lysine content
(b) Insect resistant
(c) High protein content
(d) High vitamin-A content <<

Explanation:

Golden rice is a transgenic variety of rice (Oryza sativa) developed to biosynthesize beta-carotene (a precursor of vitamin A) in the edible parts of rice.
It was engineered to address vitamin A deficiency.
The genes for beta-carotene biosynthesis (phytoene synthase from daffodil and lycopene beta-cyclase and phytoene desaturase) were introduced.
Hence the improved trait is high vitamin-A content.

Q.12

The rate of formation of new organic matter by consumers, and the biomass available for consumption of herbivores as well as decomposers are referred to as :

(a) Gross primary productivity and Net primary productivity
(b) Net primary productivity and Secondary productivity
(c) Secondary productivity and Net primary productivity <<
(d) Secondary productivity and Gross primary productivity

Explanation:

Secondary productivity is the rate of formation of new organic matter by consumers (heterotrophs).
Net primary productivity (NPP) = Gross primary productivity minus respiration losses — it represents the biomass available for consumption by herbivores and decomposers.
Therefore: rate of formation by consumers = Secondary productivity;
biomass available for herbivores and decomposers = Net primary productivity.

The correct match is 'Secondary productivity and Net primary productivity'.

Q.13

Assertion (A) : The laws of our country permit legal adoption and it is as yet, one of the best methods for childless couples looking for parenthood.

Reason (R) : Emotional, religious and social factors are no deterrents to the legal adoption of orphaned and destitute children in India.

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

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

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

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

Explanation:

Assertion (A) is TRUE — Indian law does permit legal adoption and it is indeed one of the best options for childless couples.

However, Reason (R) is FALSE — emotional, religious and social factors DO act as deterrents to legal adoption in India.

Many couples avoid adopting due to social stigma, religious concerns, and emotional reluctance.

Therefore: A is true, R is false — option (C).

Q.14

Assertion (A) : Linked genes do not show dihybrid F2 ratio 9 : 3 : 3 : 1.

Reason (R) : Linked genes do not undergo independent assortment.

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

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

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

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

Explanation:

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

Linked genes (genes on the same chromosome) do not assort independently (they violate Mendel's Law of Independent Assortment).

Because they do not assort independently, they tend to be inherited together, and therefore the standard dihybrid 9:3:3:1 ratio is not observed in F2.

The reason (failure of independent assortment due to linkage) correctly explains the assertion.

Q.15

Assertion (A) : Agrobacterium tumefaciens is a pathogen of several monocot plants.

Reason (R) : It is able to deliver a piece of DNA known as T-DNA to transform normal plant cells into a tumor.

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

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

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

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

Explanation:

Assertion (A) is FALSE — Agrobacterium tumefaciens is a pathogen of dicot plants (not monocot plants).

It causes crown gall disease in dicots.

Monocots (grasses, cereals) are largely resistant to Agrobacterium.

Reason (R) is TRUE — A.

tumefaciens does deliver T-DNA (from its Ti plasmid) into plant cells, transforming normal cells into tumour cells (crown gall).

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

Q.16

Assertion (A) : Indian Government has set up an organisation known as

GEAC to decide the validity of GM research.

Reason (R) : Genetic modification of organisms has no effect when such organisms are introduced in the ecosystem.

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

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

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

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

Explanation:

Assertion (A) is TRUE — The Indian Government has established the Genetic Engineering Approval Committee (GEAC) to make decisions regarding the validity and safety of GM research and to approve the large-scale use of GMOs.

Reason (R) is FALSE — GM organisms CAN have significant effects on the ecosystem when introduced;

this is precisely why biosafety regulations and bodies like GEAC exist.

Therefore: A is true, R is false — option (C).

Q.17

Identify A, B, C and D in the table given below :

Terms | Part of the plant it represents

Pericarp | A

B | Cotyledon in seed of grass family

Embryonal axis | C

D | Remains of nucellus in a seed

Answer: A = Fruit wall; B = Scutellum; C = Plumule and radicle (embryonal axis = axis connecting plumule and radicle); D = Perisperm

Explanation:

Pericarp is the fruit wall (A).

In seeds of grass family (monocots like wheat, maize), the single cotyledon is called Scutellum (B).

Embryo axis = the central axis of the embryo bearing plumule at one end and radicle at the other (C).

Perisperm is the persistent nucellus found in seeds like black pepper and beet (D) — it is the remains of nucellus in a seed.

Q.18

Observe the picture given below. Name the naturalist and write the explanation given by him that evolution of life forms had occurred on the basis of this example.

Answer: The naturalist is Jean Baptiste de Lamarck. The picture shows giraffes with progressively longer necks reaching tall trees. Lamarck's theory (use and disuse of organs, inheritance of acquired characters): ancestors of giraffes had short necks; to reach leaves on tall trees they kept stretching their necks, and this acquired elongation was passed on to the offspring. Over generations the long-necked giraffe evolved.

Explanation:

The figure shows giraffes of increasing neck length feeding on taller trees, the classic Lamarckian example.

Lamarck proposed that organs used more become better developed (use and disuse) and that such acquired characters are inherited, so evolution of long necks occurred.

Q.19

Write the basic steps followed in the Assisted Reproductive Technologies (ART) programme to help childless couples. Why is it also known as test tube baby programme ?

Answer: Basic steps in ART (IVF-ET): (1) Ovarian stimulation using hormones to produce multiple ova. (2) Collection of ova from the woman and sperm from the man. (3) Fertilisation of the ovum with sperm outside the body (in vitro) in a laboratory dish. (4) The fertilised egg (zygote) is allowed to develop into an

embryo (up to 8-celled stage). (5) Transfer of the embryo into the uterus of the woman (embryo transfer / ET) for further development. It is called the test tube baby programme because fertilisation takes place outside the body (in a glass dish/test tube in the laboratory), not inside the woman's body.

Explanation:

ART includes techniques like IVF (in vitro fertilisation) and ET (embryo transfer).

The fertilisation occurs in a controlled laboratory environment (in vitro = outside the living body, in a glass vessel), which is why the resulting baby is called a 'test tube baby'.

The embryo is then transferred to the uterus for normal gestation.

Q.20

(a) A farmer while working on his farm was bitten by a poisonous snake. He was rushed to a nearby health centre where the doctor gave him an injection to save his life.

(i) What did the doctor inject and why ?

(ii) Name the kind of immunity provided by this injection.

Answer: (i) The doctor injected anti-venom (antiserum/antitoxin) — preformed antibodies against the snake venom. It was injected because there was no time for the farmer's immune system to produce its own antibodies; the venom acts rapidly and can be fatal. The antiserum provides ready-made antibodies that neutralise the toxin immediately. (ii) The kind of immunity provided is Passive immunity (artificially acquired passive immunity), because the antibodies were produced in another organism (horse/animal) and transferred to the farmer.

Explanation:

Anti-snake venom contains antibodies (IgG) produced in horses immunised with snake venom.

When injected into the patient, these preformed antibodies neutralise the venom — this is passive immunisation.

It provides immediate protection.

Active immunity (where the patient's own immune system produces antibodies) would

take too long in an emergency snakebite situation.

OR

Q.20

(b) Why do organic farmers not recommend complete eradication of insect pests ? Explain giving reason.

Answer: Organic farmers do not recommend complete eradication of insect pests because: (1) Maintaining a small population of pests ensures the presence of their natural predators and parasites (biological control agents) in the ecosystem. If pests are completely eliminated, the natural enemies/biocontrol agents will also disappear due to lack of food. (2) A small pest population helps maintain ecological balance and biodiversity. (3) When pest populations increase again in the future (rebound), the natural predators would not be present to control them, leading to a pest explosion. Thus, a low, controlled level of pests is tolerated so that the ecosystem's natural regulatory mechanisms remain active.

Explanation:

Complete eradication of pests would remove the food source for their natural predators and parasitoids.

This would destabilise the biological control system.

Organic farming relies on natural pest control;

keeping some pests ensures the biological control agents persist in the ecosystem.

Q.21

Study the diagram of a pyramid of biomass given below. Name the two standing crops that could be occupying level ‘A’ and level ‘B’ in it. Name this type of pyramid and the ecosystem in which it is found.

Answer: Level ‘A’ (PC, wider upper bar) = zooplankton; level ‘B’ (PP, narrower lower bar) = phytoplankton. It is an inverted pyramid of biomass, found in an aquatic ecosystem (sea/ocean). Phytoplankton have a small standing crop but a very fast turnover, so their biomass is less than that of the zooplankton feeding on them.

Explanation:

In the printed pyramid the upper bar (A, marked PC, primary consumer) is wider than the lower bar (B, marked PP, primary producer), so the pyramid is inverted.

This occurs in aquatic ecosystems where producers are phytoplankton (small standing crop, rapid turnover) and consumers are zooplankton.

Q.22

Explain the mode of action of contraceptive pills taken by human females. Mention the schedule to be followed for effective outcome.

Answer: Mode of action: Oral contraceptive pills contain synthetic progesterone and/or oestrogen. These hormones inhibit ovulation by suppressing the release of FSH (Follicle Stimulating Hormone) and LH (Luteinising Hormone) from the anterior pituitary through negative feedback. Without the LH surge, ovulation does not occur. They also alter the cervical mucus (making it thick and hostile to sperm) and thin the uterine lining (endometrium), preventing implantation. Schedule: Pills should be taken daily for 21 days starting within 5 days of the menstrual cycle. After a 7-day gap (during which withdrawal bleeding/pseudo-menstruation occurs), the next course is started. This schedule is to be followed regularly every month for effective contraception.

Explanation:

Oral contraceptive pills work primarily by preventing ovulation through hormonal negative feedback.

The 21-day course followed by a 7-day break is the standard schedule as described in NCERT Biology Class 12, Chapter 4 (Reproductive Health).

Q.23

(a) Name and write two characteristics of the type of DNA that forms the basis of DNA fingerprinting technique.

(b) Mention any two applications of this technique.

Answer: (a) The DNA used in DNA fingerprinting is Satellite DNA (also called Variable Number Tandem Repeats / VNTRs or microsatellites/minisatellites). Two

characteristics: (1) It consists of short, repetitive sequences (tandem repeats) of DNA that are highly variable between individuals. (2) The number of repeating units (copy number) varies greatly from person to person, making it highly polymorphic (unique to each individual). (b) Two applications of DNA fingerprinting: (1) Forensic science: Identifying criminals/suspects from biological samples (blood, hair, semen) left at crime scenes. (2) Paternity/maternity testing: To determine biological parentage in disputed cases of parenthood.

Explanation:

DNA fingerprinting, developed by Alec Jeffreys, is based on the polymorphism of VNTRs (Variable Number Tandem Repeats).

These sequences are hypervariable — the number of repeats differs between individuals.

Other applications include identifying disaster/accident victims, studying evolutionary relationships, and wildlife forensics.

Q.24

(a) Explain the significance of the experiment carried out by S.L. Miller. Name the scientists whose hypothesis prompted him to carry out this experiment.

(b) How does meteorite analysis favour this hypothesis ?

Answer: (a) S.L. Miller's experiment (1953) demonstrated that organic molecules essential for life (amino acids, sugars, etc.) can be synthesised abiotically from inorganic substances under simulated primitive Earth conditions. He created an apparatus with a mixture of methane ($CH_4$), ammonia ($NH_3$), hydrogen ($H_2$), and water vapour, subjected to electric sparks (simulating lightning). After a week, amino acids and other organic compounds were detected. Significance: It provided experimental support for chemical evolution and the origin of life from non-living matter. The scientists whose hypothesis prompted him were Oparin (A.I. Oparin, Russian) and Haldane (J.B.S. Haldane, British), who independently proposed the 'primordial soup' theory of the origin of life. (b) Analysis of meteorites (especially carbonaceous chondrites like the Murchison meteorite) has revealed

the presence of amino acids and other organic molecules. This supports the hypothesis that organic compounds can form spontaneously under abiotic conditions (as in primitive Earth or space), favouring the Oparin-Haldane hypothesis of chemical evolution.

Explanation:

Miller's experiment recreated the conditions of early Earth and showed spontaneous synthesis of amino acids.

The Murchison meteorite contained over 90 amino acids, many not found in living organisms, suggesting that organic molecules can form without biological processes — supporting chemical evolution hypothesis.

Q.25

Identify A, B, C, D, E and F in the table given below :

Name of Human Disease | Causative Organism | Symptoms
Pneumonia | Streptococcus | A
Typhoid | B | High fever, weakness, headache, stomach pain
Common Cold | Rhino virus | C
Ringworm | D | Dry scaly lesions on body parts, redness, itching
Ascariasis | Ascaris | E
F | Entamoeba histolytica | Constipation, cramps, stools with mucous and blood clots

Answer: A = Fever, cough, difficulty in breathing, lips and fingernails turning greyish/blue (cyanosis), chest pain; B = Salmonella typhi; C = Nasal congestion/discharge, sore throat, hoarseness, cough, headache, tiredness; D = Microsporum / Trichophyton / Epidermophyton (fungi); E = Internal bleeding, muscular pain, fever, anaemia, blockage of intestinal passage; F = Amoebiasis (Amoebic dysentery)

Explanation:

A: Pneumonia symptoms include fever, chills, cough with sputum, difficulty breathing,

chest pain.

B: Typhoid is caused by Salmonella typhi.

C: Common cold (rhinovirus) causes nasal symptoms, sore throat, mild fever.

D: Ringworm is caused by fungi — Microsporum, Trichophyton, or Epidermophyton.

E: Ascariasis (Ascaris lumbricoides) causes internal bleeding, muscular pain, fever, anaemia.

F: Amoebiasis (caused by Entamoeba histolytica) presents with constipation, cramps, and bloody/mucousy stools.

Q.26

In a family, the father, the daughter and the son are colour blind, whereas the mother has normal vision. Do you think the son and the daughter have inherited the disease from their father ? Work out a cross to justify your answer.

Answer: Colour blindness is X-linked recessive. Let X^B = normal allele, X^b = colour blind allele. Father (colour blind): X^b Y. Mother (normal vision, but she must be a carrier since daughter is colour blind): X^B X^b. Cross: X^b Y (father) × X^B X^b (mother). Offspring: X^B X^b (normal female/carrier), X^b X^b (colour blind female), X^B Y (normal male), X^b Y (colour blind male). The daughter (X^b X^b) received one X^b from the father and one X^b from the mother (carrier). The son (X^b Y) received X^b from the mother and Y from the father. Therefore: The daughter inherited the colour blind allele from BOTH parents (one from father, one from mother). The son inherited his colour blind allele ONLY from the mother (his Y chromosome came from father). Conclusion: The son did NOT inherit colour blindness from his father — he inherited it from his mother. The daughter inherited it from both parents. The father's X^b went only to daughters (not to sons).

Explanation:

In X-linked inheritance, a father passes his X chromosome only to daughters and his Y chromosome to sons.

Therefore a colour-blind father cannot pass colour blindness to his sons.

The colour-blind son must have received his X^b from his carrier mother.

The colour-blind daughter received X^b from both parents.

Q.27

(a) (i) What are transgenic animals ?

(ii) Name the first transgenic cow and state its importance.

Answer: (i) Transgenic animals are animals that have had their DNA experimentally manipulated so that a foreign gene (transgene) is stably integrated into their genome and expressed. They carry functional recombinant DNA in every cell. (ii) The first transgenic cow was Rosie. Its importance: Rosie produced human protein-enriched milk containing human alpha-lactalbumin (a nutritionally balanced protein for human babies). The milk contained 2.4 grams of human alpha-lactalbumin per litre, making it more suitable for human infants than normal cow milk.

Explanation:

Rosie was the first transgenic cow, developed to produce milk with human alpha-lactalbumin, a nutritionally important whey protein for newborn babies.

This is a standard NCERT example of transgenic animals used for production of biological products.

OR

Q.27

(b) (i) Explain the convention for naming EcoRI.

(ii) With the help of an illustration only, show the action of EcoRI on a DNA Polynucleotide.

Answer: (i) Naming convention for EcoRI: E = genus name Escherichia; co = species name coli; R = strain name RY13 (the strain from which it was isolated); I = the order/number in which the enzyme was isolated from that organism (first enzyme isolated = I). So EcoRI stands for: E. coli (strain RY13), first restriction endonuclease. (ii) EcoRI recognises the palindromic sequence 5'-GAATTC-3' / 3'-CTTAAG-5' and cuts between G and A on both strands, producing sticky ends: 5'-G + AATTC-3' (top strand cut between G^AATTC); the resulting sticky ends

are: 5'-...G  3' and 5'-AATTC...-3' (i.e., 5'-AATT overhang sticky ends).

Explanation:

The naming of restriction enzymes follows the convention: first letter = genus, next two = species, next = strain, Roman numeral = order of discovery.

EcoRI: Escherichia coli, strain RY13, first enzyme.

EcoRI cuts 5'-G|AATTC-3' leaving 4-base 5' sticky (cohesive) ends.

Q.28

(a) Explain how it is ensured that the orchid Ophrys is pollinated by a specific species of bee.

(b) Describe co-evolution with the help of this example.

Answer: (a) The orchid Ophrys ensures pollination by a specific bee species through sexual deceit/floral mimicry. One petal of the Ophrys flower has evolved to look exactly like the female of a specific bee species (in shape, colour, texture, and scent). The male bee is attracted to the flower, thinking it is a female bee, and attempts to 'pseudocopulate' (mate) with the flower. During this process, pollen (pollinia) get attached to the body of the bee. When the bee visits another Ophrys flower (again deceived), it transfers the pollen, achieving pollination. This mimicry is so precise that only the specific bee species is attracted. (b) Co-evolution: The Ophrys-bee relationship is an example of co-evolution — the mutual evolutionary influence of two species on each other over time. As the bee evolved its shape and pheromones, the orchid also evolved matching features. Each species acts as a selective agent on the other. The orchid evolved features that mimic the specific bee, and the bee's behaviour/appearance influenced the orchid's floral evolution. This reciprocal adaptation is co-evolution.

Explanation:

Ophrys is a classic NCERT example of pollination through deceit (pseudocopulation).

The flower mimics the female bee so accurately (including chemical signals) that the male bee is fooled.

This is a case of mutualistic co-evolution where each species has influenced the

other's evolution.

Q.29(a)

Read the following passage and answer the questions that follow.

Isn't it incredible that India's land area is only 2·4 per cent of the world's total land area whereas its share of the global species diversity is an impressive 8·1 per cent ! However, in these estimates of species, prokaryotes do not figure anywhere.

Biologists are always keen on collecting data with respect to species diversity observed in different regions of the world. The data collected based on the survey conducted for species richness of groups of mammals in three different regions of the world is shown in the bar graph given below :

(See the figure.)

(a) Why is the species richness maximum in Region III in the bar graph ?

Answer: Species richness is maximum in Region III because Region III is likely a tropical region (located near the equator). Tropics have maximum species richness due to: (1) Greater solar energy availability leading to higher productivity; (2) Relatively stable and undisturbed environment over millions of years allowing for more time for species diversification and evolution; (3) Less seasonal variation — more constant climate allows species to be more specialised and niche partitioning is more pronounced; (4) Higher habitat heterogeneity supporting more species.

Explanation:

Tropical regions consistently show the highest species richness (biodiversity).

Temperate/polar regions (Region I) have lower richness.

The latitudinal gradient of biodiversity is a well-established ecological pattern — species richness increases from poles to tropics.

OR

Q.29(a)

(Case Study — OR variant) Why is the species richness minimum in Region I in the bar graph ?

Answer: Species richness is minimum in Region I because Region I represents a temperate or polar/high-latitude region. The reasons for minimum species richness include: (1) Harsh climatic conditions (low temperatures, frost, snow) that are unfavourable for most organisms; (2) High seasonality — extreme variation in temperature and light across seasons limits the number of species that can survive; (3) Less solar energy and lower net primary productivity; (4) Less evolutionary time compared to tropics for species to diversify (many high-latitude areas were covered by glaciers during ice ages and are relatively recently colonised).

Explanation:

The latitudinal diversity gradient shows decreasing species richness from tropics (Region III) to polar regions (Region I).

Harsh conditions and high seasonality at higher latitudes support fewer species.

Q.29(b)

Plants and animals do not have uniform diversity in the world but show rather uneven distribution. Mention what this kind of diversity is referred to as.

Answer: Latitudinal gradient in species diversity: species richness is not uniform but decreases from the equator (tropics) towards the poles, so the tropics have the most species and temperate and polar regions fewer.

Explanation:

The uneven distribution of biodiversity across the world, with richness highest in the tropics and declining towards the poles, is called the latitudinal gradient of diversity.

Q.29(c)

Why is it that prokaryotes do not have an estimated number of their species diversity as seen in plants and animals ? Explain.

Answer: Prokaryotes (bacteria and archaea) do not have an estimated number for their species diversity because: (1) Vast majority of prokaryotes cannot be cultured in the laboratory using standard techniques — estimates suggest that less than 1% of microbial species can be cultured, making identification and counting impossible by conventional methods. (2) Prokaryotes lack clear morphological differences (morphologically simple), making species identification and delineation difficult using traditional taxonomy. (3) Horizontal gene transfer is common among prokaryotes, blurring the species boundaries. (4) The sheer number and ubiquity of prokaryotes — found in extreme environments, soil, ocean depths — makes comprehensive surveys practically impossible. (5) The species concept itself is difficult to apply to asexually reproducing prokaryotes.

Explanation:

The difficulty in estimating prokaryote diversity is primarily because most cannot be cultured in the lab (the 'great plate count anomaly').

Modern metagenomic studies are beginning to reveal the true extent of prokaryotic diversity, which far exceeds what can be cultured traditionally.

Q.30(a)

Study the diagram given below that shows the steps involved in the procedure of selecting transformed bacteria and answer the questions that follow.

(a) Identify the colony that has got transformed. Justify your answer.

Answer: Colony 4 is the transformed (recombinant) colony. In plate M it grows, but after replica plating it does not appear on plate N (agar with tetracycline and ampicillin). Foreign DNA inserted into the tetracycline-resistance gene inactivates it (insertional inactivation), so this recombinant colony cannot grow on tetracycline, while colonies 1, 2, 3 and 5 grow on both antibiotics and carry the

non-recombinant plasmid.

Explanation:

Replica plating compares plate M with plate N.

Colonies 1, 2, 3 and 5 appear on plate N, so both resistance genes are intact (non-recombinant).

Colony 4 is missing on plate N: it carries recombinant DNA inserted in an antibiotic-resistance gene (insertional inactivation), so it is the transformed (recombinant) colony.

Q.30(b)

What are the sites in a plasmid called where ampicillin and tetracycline resistance genes are inserted ? State their role in genetic engineering.

Answer: The sites are called cloning sites (recognition sites for restriction enzymes, e.g. BamHI in tetR and PstI in ampR of pBR322). Role: the vector is cut at these sites and the foreign DNA is ligated into them. Insertion inactivates the antibiotic-resistance gene (insertional inactivation), so recombinants lose that resistance and can be told apart from non-recombinants on antibiotic plates.

Explanation:

Cloning sites are unique restriction sites in the plasmid into which foreign DNA is inserted.

Because they lie inside the resistance genes, successful insertion inactivates the gene, which allows selection of recombinants.

Q.30(c)

Name two enzymes playing an important role in genetic engineering.

Answer: Two enzymes important in genetic engineering: (1) Restriction endonucleases (restriction enzymes) — cut DNA at specific palindromic sequences to generate fragments for cloning. (2) DNA ligase — joins/seals the phosphodiester bonds between the insert DNA and vector DNA to create recombinant DNA.

Explanation:

Restriction enzymes act as 'molecular scissors' to cut DNA, while DNA ligase acts as 'molecular glue' to join DNA fragments.

Other important enzymes include DNA polymerase, reverse transcriptase, etc., but restriction endonucleases and DNA ligase are the two most fundamental.

OR

Q.30(c)

(Case Study — OR variant) State the role of beta-galactosidase in insertional inactivation.

Answer: In insertional inactivation (blue-white screening): The lacZ gene (encoding beta-galactosidase) is present in the multiple cloning site (MCS) of certain vectors (like pUC19). When foreign DNA is inserted into the MCS, it disrupts the lacZ gene, inactivating it — the bacteria can no longer produce functional beta-galactosidase. Role: (1) Colonies with intact lacZ (non-recombinant plasmid) produce functional beta-galactosidase, which converts the substrate X-gal (5-bromo-4-chloro-3-indolyl-beta-D-galactopyranoside) into a blue coloured product — colonies appear BLUE. (2) Colonies with disrupted lacZ (recombinant plasmid with insert) cannot produce functional beta-galactosidase, so X-gal is not cleaved — colonies appear WHITE. White colonies = recombinants (insertional inactivation of lacZ). Blue colonies = non-recombinants.

Explanation:

Blue-white screening is a rapid method to identify recombinant clones.

Beta-galactosidase (lacZ product) cleaves X-gal to give a blue colour.

Insertion of foreign DNA into lacZ disrupts the enzyme production, giving white colonies — these are the desired recombinants.

Q.31(a)

(a) (i) Explain the development of male gametophyte in an angiosperm.

(ii) Draw a labelled diagram of a three-celled male gametophyte.

Answer: (i) Development of male gametophyte in angiosperms: The pollen grain

(microspore) is the first cell of the male gametophyte. The microspore undergoes mitotic division (pollen mitosis I) to form a small generative cell and a large vegetative (tube) cell — this is the 2-celled stage (bicellular pollen grain). The generative cell is enclosed within the vegetative cell. The generative cell undergoes one more mitotic division (pollen mitosis II) — either before pollen is shed (in 3-celled pollen) or after germination in the pollen tube — to produce two male gametes (non-motile sperms). The vegetative cell forms the pollen tube. The fully developed male gametophyte is a 3-celled structure: one vegetative cell (tube cell) and two male gametes (sperms). (ii) Three-celled male gametophyte diagram: Should show a pollen grain with: outer exine wall, inner intine wall, vegetative nucleus (large) in the vegetative cell cytoplasm, generative cell divided into two male gametes (two small cells), germ pore.

Explanation:

Male gametophyte development: microspore →
mitosis I →
2-celled pollen (vegetative cell + generative cell) →
mitosis II of generative cell →
3-celled pollen (vegetative cell + 2 male gametes).
This is the standard NCERT description from Chapter 2 (Sexual Reproduction in Flowering Plants).

Q.31(b)

(b) (i) Draw a diagrammatic sectional view of ovary of human female and label the following : (1) Blood vessels (2) Primary follicle (3) Tertiary follicle (4) Ovum

(ii) At which stage of life are primary follicles formed in a human female ?

(iii) Explain the events (both hormonal and structural) that occur at the time of ovulation till the onset of the next menstrual cycle.

Answer: (i) Diagram: sectional view of the ovary showing germinal epithelium, stroma with blood vessels, primary follicle (oocyte with a single layer of granulosa cells), tertiary (Graafian) follicle with antrum and secondary oocyte, the released

ovum and the corpus luteum, with the four parts labelled. (ii) Primary follicles are formed during foetal life (before birth); each has a primary oocyte arrested in prophase I. At birth there are about 2 million; at puberty only 60,000–80,000 remain in each ovary. (iii) At ovulation (day 14), a surge of LH (and FSH) ruptures the Graafian follicle and releases the secondary oocyte. The remaining follicular cells become the corpus luteum under LH, which secretes progesterone (and some oestrogen) to maintain the thick, vascular endometrium. If there is no fertilisation, the corpus luteum degenerates (corpus albicans) around day 24–26; progesterone and oestrogen fall, the endometrium breaks down and menstruation begins (day 1 of the next cycle); FSH rises again to start new follicle growth.

Explanation:

Primary follicles form before birth;
their number falls to about 60,000–80,000 per ovary at puberty (NCERT).
After ovulation the corpus luteum secretes progesterone;
without fertilisation it degenerates and the endometrium is shed.

Q.32(a)

(a) Stability, as one of the properties of genetic material, was very evident in one of the very early experiments in genetics. Name the scientist and describe his experiment. State the conclusion he arrived at.

Answer: The scientist is Frederick Griffith (1928). Experiment: Griffith worked with two strains of Streptococcus pneumoniae (pneumococcus): (1) S strain (smooth) — virulent, has polysaccharide capsule, causes pneumonia, forms smooth colonies. (2) R strain (rough) — non-virulent, no capsule, forms rough colonies. He performed four sets of experiments in mice: (1) Injection of live S strain → mice died. (2) Injection of live R strain → mice lived. (3) Injection of heat-killed S strain → mice lived. (4) Injection of heat-killed S strain + live R strain → mice died, and live S strain bacteria were recovered from dead mice. Conclusion: Some chemical substance (the 'transforming principle') from the heat-killed S strain was transferred to the R strain and transformed it into a virulent S strain. This

transformation was heritable — the transformed S characteristics were passed to subsequent generations of bacteria. Griffith concluded that the 'transforming principle' was a stable genetic material that could be transferred between bacteria and cause permanent, heritable changes. (Later, Avery, MacLeod and McCarty (1944) identified the transforming principle as DNA.)

Explanation:

Griffith's transformation experiment demonstrated that genetic material is stable and can be transferred between organisms to cause heritable changes.

The stability of the S strain characteristics (capsule formation) after transformation showed the stable nature of genetic material.

Q.32(b)

(b) A tall pea plant bearing violet flowers with unknown genotype is given. Find the genotype by working out different crosses only by selfing the plants. Write the genotypic and phenotypic ratios of each cross shown by you.

Answer: Tall (T) is dominant over dwarf (t) and violet (V) over white (v). A tall, violet plant can be TTVV, TTVv, TtVV or TtVv. Self the plant and observe the progeny:

1. TTVV selfed: all tall violet; genotypes all TTVV (1 : 0).
2. TTVv selfed: 3 tall violet : 1 tall white; genotypic 1 TTVV : 2 TTVv : 1 TTvv.
3. TtVV selfed: 3 tall violet : 1 dwarf violet; genotypic 1 TTVV : 2 TtVV : 1 ttVV.
4. TtVv selfed: 9 tall violet : 3 tall white : 3 dwarf violet : 1 dwarf white; genotypic 1 TTVV : 2 TTVv : 2 TtVV : 4 TtVv : 1 TTvv : 2 Ttvv : 1 ttVV : 2 ttVv : 1 ttvv.

The phenotypic ratio of the selfed progeny therefore identifies the genotype of the parent plant.

Explanation:

Selfing a plant heterozygous for one gene gives 3 : 1, for both genes 9 : 3 : 3 : 1, and a homozygous plant breeds true.

Matching the observed ratio to these outcomes reveals the unknown genotype.

Q.33(a)

(a) (i) Name and explain the property present in normal cells but is lost in cancer cells.

(ii) All normal human cells have genes that may become cancerous under certain conditions. Name them and explain how.

(iii) State the role of the following techniques in detection and diagnosis of cancer : (1) Biopsy and Histopathology (2) Magnetic Resonance Imaging

Answer: (i) The property present in normal cells but lost in cancer cells is Contact inhibition. Normal cells stop dividing when they come in contact with each other (they stop proliferating when they form a monolayer). Cancer cells lose this property — they do not stop dividing on contact and continue to grow in an uncontrolled manner, piling up on each other and forming tumours. (ii) All normal human cells have proto-oncogenes. These are normal genes that regulate cell growth and division. Under certain conditions (exposure to mutagens like radiation, chemicals, viruses), proto-oncogenes may undergo mutation or be over-expressed, converting them into oncogenes. Oncogenes cause uncontrolled cell proliferation and transformation of normal cells into cancer cells. (iii) Role of diagnostic techniques: (1) Biopsy and Histopathology: In biopsy, a piece of the suspected tumour tissue is surgically removed and examined under a microscope (histopathology/histological staining). This determines whether the cells are cancerous (malignant) or non-cancerous (benign), the type of cancer cells, and the stage of cancer. It is the gold standard for cancer diagnosis. (2) Magnetic Resonance Imaging (MRI): Uses strong magnetic fields and radio waves (non-ionising) to create detailed images of internal body structures. MRI is useful for detecting tumours in soft tissues (brain, spinal cord, muscles), determining tumour size, location, and extent of spread. It provides high-resolution images without radiation exposure.

Explanation:

Contact inhibition loss is the hallmark of cancer cells.

Proto-oncogenes (like ras, myc) code for growth factors and cell cycle regulators;

mutations convert them to oncogenes driving uncontrolled proliferation.
Biopsy gives tissue confirmation;
MRI gives structural/anatomical information about tumour extent.

Q.33(b)

(b) Large quantities of sewage are generated every day in cities as well as in towns and are treated in Sewage Treatment Plants (STPs) to make them less polluting. Given below is the flow diagram of stages of STP: Primary effluent passed into large aeration tanks → Effluent passed into settling tanks to form sediment.

(i) (1) Why is primary effluent passed into large aeration tanks ? (2) What is the sediment formed, referred to as ? Mention its significance. (3) Explain the final step in the settling tank before the treated effluent is released into water bodies.
(ii) Name any two organisms commonly used as biofertilisers, belonging to different kingdoms. Write how each one acts as a biofertiliser.

Answer: (i)(1) The primary effluent is passed into large aeration tanks and constantly agitated so that useful aerobic heterotrophic microbes grow vigorously into flocs (masses of bacteria with fungal filaments). They consume the organic matter, which reduces the BOD of the effluent. (i)(2) The sediment is called activated sludge. Significance: a small part is pumped back into the aeration tank as inoculum; the remaining major part goes to large anaerobic sludge digesters, where anaerobic bacteria digest it and release biogas (methane, $CO_2$, $H_2S$). (i)(3) In the settling tank the flocs settle as sediment (activated sludge) and the clarified effluent, whose BOD is now much reduced, is passed out and released into natural water bodies such as rivers and streams. (ii) Rhizobium (Kingdom Monera): lives in root nodules of leguminous plants and fixes atmospheric nitrogen into ammonia for the plant. Mycorrhiza, e.g. Glomus (Kingdom Fungi): its hyphae form a symbiotic association with roots, absorb phosphorus and water from the soil and pass them to the plant.

Explanation:

Secondary treatment: aeration tank flocs reduce BOD;

settling gives activated sludge, partly recycled and partly digested anaerobically to biogas;

the BOD-reduced effluent is released into water bodies (NCERT).

Biofertilisers: Rhizobium (bacterium) fixes N2;

Glomus (fungus) improves phosphorus and water uptake.