

NIOS Class 12 Biology Sample Paper-6

Duration: 180 Minutes

Maximum Marks: 80

Instructions

- This paper contains **43** Questions. The paper is divided into two sections: **Section A – 40** marks, **Section B – 40** marks.
- **Section A** consists of
 - **Q.No. 1 to 16** – Multiple Choice type questions (MCQs) carrying 1 mark each. Select and write the most appropriate option out of the four options given in each of these questions. An internal choice has been provided in some of these questions. You have to attempt only one of the given choices in such questions.
 - **Q. No. 17 to 28** – Objective type questions. Q. No. 17 to 28 carry 02 marks each (with 2 sub- parts of 1 mark each). Attempt these questions as per the instructions given for each of the questions 17 –28.
- **Section B** consists of
 - **Q.No. 29 to 37** – Very Short questions carrying 02 marks each to be answered in the range of 30 to 50 words.
 - **Q.No. 38 to 41** – Short Answer type questions carrying 03 marks each to be answered in the range of 50 to 80 words.
 - **Q.No. 42 and 43** – Long Answer type questions carrying 05 marks each to be answered in the range of 80 to 120 words.
- There is **No Negative marking**.
- Use of mobile phones, smartwatches, calculators, or any electronic gadgets is strictly prohibited.

Section: A

- Q1.** During the Calvin cycle (light-independent reactions) of photosynthesis, atmospheric carbon dioxide is fixed into an organic compound by combining with ribulose biphosphate (RuBP). The enzyme that catalyses this crucial carbon-fixation step is: (1)



- (A) RuBisCO (ribulose biphosphate carboxylase/oxygenase)
- (B) PEP carboxylase
- (C) ATP synthase
- (D) NADP reductase

Q2. In Mendel's experiment, when a cross is made between a pure-breeding round-seeded pea plant (RR) and a pure-breeding wrinkled-seeded pea plant (rr), all the F₁ seeds are round. If these F₁ plants are self-pollinated, the expected phenotypic ratio of round to wrinkled seeds in the F₂ generation is: **(1)**

- (A) 1 : 1
- (B) 2 : 1
- (C) 3 : 1
- (D) 1 : 3

Q3. Cyanobacteria (blue-green algae) are classified under Kingdom Monera rather than Kingdom Plantae because they: **(1)**

- (A) Are prokaryotic and lack a membrane-bound nucleus
- (B) Lack chlorophyll entirely
- (C) Cannot carry out photosynthesis
- (D) Have a cellulose cell wall like true plants

Q4. In a pond ecosystem, the term "primary productivity" refers to the rate at which: **(1)**

- (A) Consumers break down organic matter by respiration
- (B) Decomposers mineralise dead organic matter in the soil
- (C) Tertiary consumers transfer energy to the next trophic level
- (D) Producers synthesise organic matter through photosynthesis

Q5. During aerobic respiration in a plant cell, the Krebs cycle (citric acid cycle) takes place inside the: **(1)**

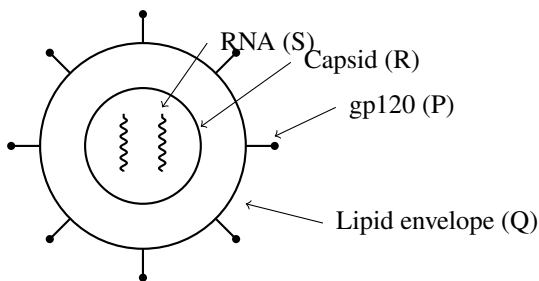


- (A) Cytoplasm (cytosol)
- (B) Inner mitochondrial membrane
- (C) Mitochondrial matrix
- (D) Chloroplast stroma

Q6. In angiosperms (flowering plants), the male gametophyte that carries two male gametes to the embryo sac for fertilisation is the: (1)

- (A) Pollen grain (pollen tube)
- (B) Ovule
- (C) Endosperm
- (D) Megaspore

Q7. The diagram below represents the basic structure of the human immunodeficiency virus (HIV). The outer envelope glycoproteins that help HIV attach to and enter host T-helper cells are labelled as: (1)



- (A) P
- (B) Q
- (C) R
- (D) S

Q8. Which of the following groups of the plant kingdom produces seeds but does **not** bear flowers or fruits? (1)

- (A) Bryophytes (e.g., mosses)
- (B) Pteridophytes (e.g., ferns)



- (C) Gymnosperms (e.g., pine, cycad)
- (D) Angiosperms (e.g., mango, wheat)

Q9. The industrial process that converts atmospheric nitrogen gas and hydrogen gas into ammonia at high temperature and pressure is called: (1)

- (A) Nitrification
- (B) Ammonification
- (C) Denitrification
- (D) Haber process

Q10. Chronic deficiency of iodine in the diet leads to the enlargement of the thyroid gland, a condition commonly known as: (1)

- (A) Anaemia
- (B) Marasmus
- (C) Pellagra
- (D) Goitre

Q11. In molecular biology, the process by which the genetic information encoded in mRNA is used to assemble a specific sequence of amino acids into a polypeptide chain at the ribosome is called: (1)

- (A) Replication
- (B) Transcription
- (C) Translation
- (D) Transduction

Q12. The blood vessel that carries oxygenated blood from the lungs back to the left atrium of the human heart is the: (1)

- (A) Pulmonary artery
- (B) Pulmonary vein



- (C) Aorta
- (D) Superior vena cava

Q13. Sclerenchyma is a type of permanent plant tissue that provides mechanical strength. Its cells are characteristically: **(1)**

- (A) Living, thin-walled, with large intercellular spaces
- (B) Living, with irregularly thickened corners
- (C) Dead, with uniformly thick, lignified walls
- (D) Actively dividing with dense cytoplasm

Q14. In genetic engineering, a plasmid used to carry a foreign gene into a host bacterial cell is called a: **(1)**

- (A) Primer
- (B) Probe
- (C) Ligase
- (D) Vector

Q15. The copper-T is a widely used intrauterine contraceptive device. Its primary mechanism of action is to: **(1)**

- (A) Suppress ovulation by releasing hormones
- (B) Release copper ions that are toxic to sperm and inhibit implantation
- (C) Prevent sperm from entering the cervix physically
- (D) Permanently block the fallopian tubes

Q16. The part of the human brain that is primarily responsible for maintaining balance, posture, and coordination of voluntary muscular movements is the: **(1)**

- (A) Cerebrum
- (B) Cerebellum
- (C) Medulla oblongata
- (D) Hypothalamus



Note: Q. No. 17 to 28 are the objective type questions of 2 marks each.

Q17. Read the passage given below and answer the following questions:

In C_3 plants, the first stable product of carbon fixation in the Calvin cycle is a three-carbon compound called 3-phosphoglyceric acid (3-PGA). However, in C_4 plants such as maize and sugarcane, carbon dioxide is initially fixed in the mesophyll cells into a four-carbon compound called oxaloacetic acid (OAA) by the enzyme PEP carboxylase. The OAA is then converted to malate and transported to the bundle sheath cells, where CO_2 is released and enters the Calvin cycle. (2)

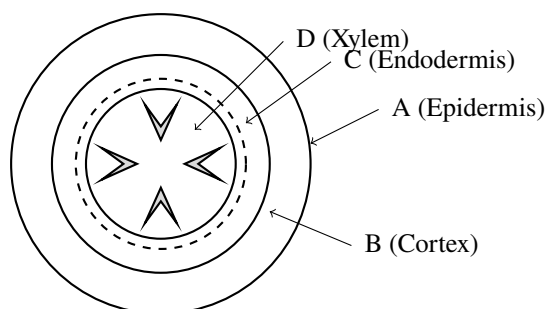
1. Name the first stable product of carbon fixation in C_3 plants.
2. In which cells of a C_4 plant leaf does the initial fixation of CO_2 by PEP carboxylase occur?

Q18. Complete the following sentences using the words given below:

(lichen, symbiotic, heterotrophic, autotrophic, parasitic) (2)

1. A is a composite organism formed by the symbiotic association between a fungus and an alga (or cyanobacterium).
2. In this association, the alga is . (photosynthetic) while the fungus is . and absorbs water and minerals.

Q19. Study the diagram of the internal structure (transverse section) of a typical dicot root given below and answer the questions that follow. (2)



1. Name the tissue labelled D that conducts water and dissolved minerals upward from the root to the shoot.



2. Name the single-cell-thick layer labelled C that regulates the movement of substances between the cortex and the vascular cylinder.

Q20. Fill in the blanks: (2)

1. The segment of DNA that contains the information to code for a specific protein or a functional RNA molecule is called a
2. Alternative forms of the same gene, which occupy the same position (locus) on homologous chromosomes, are called

Q21. Match the items in Column I with the most appropriate items in Column II: (2)

Column I	Column II
(a) Cerebrum	(i) Controls involuntary actions such as breathing and heartbeat
(b) Cerebellum	(ii) Centre for thinking, memory, and voluntary actions
(c) Medulla oblongata	(iii) Regulates body temperature, hunger, and thirst
(d) Hypothalamus	(iv) Maintains body balance and coordinates muscular movements

Q22. Fill in the blanks: (2)

1. The interaction between two species in which both partners benefit from the association is called
2. The maximum number of individuals of a species that a given habitat can sustainably support over time is called its

Q23. Write TRUE (T) for the correct statement and FALSE (F) for the incorrect statement: (2)

1. In human males, spermatogenesis occurs in the seminiferous tubules of the testes under the influence of testosterone.
2. The placenta is an organ that connects the developing embryo to the father’s bloodstream and supplies nutrients.



Q24. Match the items in Column I with the most appropriate items in Column II: (2)

Column I	Column II
(a) Parenchyma	(i) Dead cells with thick, lignified walls; provides mechanical support
(b) Collenchyma	(ii) Thin-walled living cells; stores food and provides turgidity
(c) Sclerenchyma	(iii) Living cells with unevenly thickened corners; provides flexibility
(d) Meristematic tissue	(iv) Actively dividing cells at growing tips; responsible for growth

Q25. Fill in the blanks: (2)

1. The process by which soil bacteria decompose proteins and amino acids in dead organic matter, releasing ammonia (NH₃), is called
2. Free-living soil bacteria such as *Azotobacter* that fix atmospheric nitrogen independently (without a plant host) are called nitrogen fixers.

Q26. Match the items in Column I with the most appropriate items in Column II: (2)

Column I	Column II
(a) Vitamin A deficiency	(i) Rickets (soft, deformed bones)
(b) Vitamin D deficiency	(ii) Beri-beri (nerve and heart damage)
(c) Vitamin B ₁ deficiency	(iii) Night blindness (impaired dim-light vision)
(d) Vitamin C deficiency	(iv) Scurvy (bleeding gums, poor wound healing)

Q27. Write TRUE (T) for the correct statement and FALSE (F) for the incorrect statement: (2)

1. Vaccination (active immunisation) works by introducing weakened or killed pathogens into the body to stimulate the immune system to produce memory cells and antibodies.



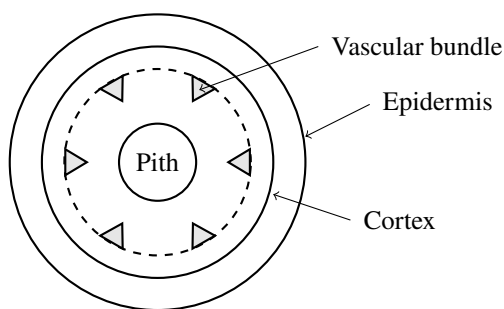
2. Transgenic organisms are those whose genetic material has been altered by inserting a gene from a different species using recombinant DNA technology.

Q28. Match the items in Column I with the most appropriate items in Column II: (2)

Column I	Column II
(a) DNA polymerase	(i) Transfers specific amino acids to the ribosome during translation
(b) RNA polymerase	(ii) Catalyses the synthesis of a new DNA strand during replication
(c) tRNA	(iii) Site of protein synthesis (translation)
(d) Ribosome	(iv) Catalyses the synthesis of mRNA from a DNA template

Section: B

Q29. With the help of a labelled diagram, describe the internal structure of a typical dicot stem in transverse section, identifying the epidermis, cortex, vascular bundles, and pith. (2)



Q30. Define the term ‘double fertilisation’ in angiosperms and state the two products formed as a result of this process. (2)

Q31. (i) Define the terms ‘food chain’ and ‘food web’, and state one key difference between them.

OR



(ii) What is meant by ‘biogeochemical cycle’? Name any two such cycles that are essential for sustaining life on Earth. (2)

Q32. (i) State two characteristic features of phylum Chordata, giving one example of a cold-blooded (poikilothermic) chordate. (2)

OR

(ii) State two characteristic features of phylum Arthropoda, giving one example. (2)

Q33. The overall balanced equation for photosynthesis shows that 6 molecules of CO₂ and 6 molecules of H₂O produce 1 molecule of glucose (C₆H₁₂O₆). If a plant fixes 18 molecules of CO₂ during photosynthesis, calculate the number of glucose molecules produced and the number of water molecules consumed. (2)

Q34. In garden pea, the allele for yellow seed colour (Y) is dominant over the allele for green seed colour (y). A heterozygous yellow-seeded plant (Yy) is crossed with a green-seeded plant (yy). Using a Punnett square, work out the genotypic and phenotypic ratio of the offspring. (2)

	Y	y
y	Yy	yy
y	Yy	yy

Q35. (i) Name the hormone secreted by the islets of Langerhans in the pancreas that lowers blood glucose levels, and briefly explain its mechanism of action. (2)

OR

(ii) Name the hormone secreted by the thyroid gland and briefly explain one of its major functions in the human body. (2)

Q36. Define ‘malnutrition’. Name the disease caused by severe protein-energy deficiency in young children characterised by extreme emaciation and wasting (2)



of body tissues. (2)

Q37. Differentiate between arteries and veins with respect to (a) wall thickness and (b) direction of blood flow, giving one example of each. (2)

Q38. Define the following terms with one example each:

A. Vaccine

B. Passive immunity

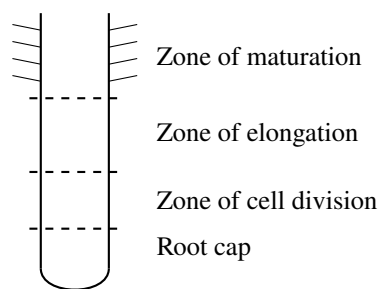
C. Allergen (3)

Q39. (i) With the help of a simple diagram, describe the structure of a DNA molecule, mentioning the two strands, sugar-phosphate backbone, and base pairing rules.

OR

(ii) Describe the process of DNA replication, mentioning the role of the enzyme DNA polymerase and the concept of semi-conservative replication. (3)

Q40. With the help of a labelled diagram, describe the zones of a root tip (root cap, zone of cell division, zone of elongation, and zone of maturation) and state one function of each zone. (3)



Q41. (i) Explain the causes, symptoms, and prevention of protein-energy malnutrition (Kwashiorkor and Marasmus) in children.

OR

(ii) Explain the harmful effects of drug addiction on human health and list two measures for its prevention. (3)



- Q42.** (i) (a) State Mendel's law of segregation.
(b) In a cross between two heterozygous black-coated guinea pigs ($Bb \times Bb$), where black (B) is dominant over white (b), work out the genotypic and phenotypic ratios of the offspring using a Punnett square. Draw the Punnett square.

OR

- (ii) (a) Define the terms 'codominance' and 'incomplete dominance' with one example each.
(b) In a cross between a red-flowered snapdragon plant (RR) and a white-flowered snapdragon plant (rr), the F_1 offspring are all pink (Rr). If two F_1 pink plants are crossed, work out the phenotypic ratio of the F_2 generation. (5)

- Q43.** (i) Describe the process of photosynthesis in detail, covering the light-dependent reactions (site, inputs, outputs) and the light-independent reactions (Calvin cycle – site, inputs, outputs). Include a simple labelled diagram of the chloroplast showing where each stage occurs.

OR

- (ii) Describe the five-kingdom system of classification proposed by R. H. Whittaker, mentioning the basis of classification and one distinguishing feature and one example organism for each kingdom. (5)



Detailed Solutions**Q1.****Solution**

Concept: In the Calvin cycle, the enzyme RuBisCO (ribulose biphosphate carboxylase/oxygenase) catalyses the fixation of atmospheric CO₂ by combining it with the five-carbon acceptor molecule RuBP, producing two molecules of the three-carbon compound 3-PGA.

Step 1: The Calvin cycle operates in the stroma of the chloroplast and begins with CO₂ fixation, in which each molecule of CO₂ is attached to a molecule of RuBP (a 5-carbon sugar phosphate).

Step 2: This reaction is exclusively catalysed by the enzyme RuBisCO, which is considered the most abundant protein on Earth and is the key regulatory enzyme of the Calvin cycle.

Step 3: PEP carboxylase is a different enzyme involved in the initial CO₂ fixation step of C₄ plants (not the Calvin cycle itself), ATP synthase generates ATP during the light reactions, and NADP reductase reduces NADP⁺ to NADPH.

Why other options are wrong:

- **Option B:** PEP carboxylase fixes CO₂ in C₄ mesophyll cells, not in the Calvin cycle.
- **Option C:** ATP synthase synthesises ATP during the light-dependent reactions on the thylakoid membrane.
- **Option D:** NADP reductase (ferredoxin-NADP⁺ reductase) reduces NADP⁺ at the end of Photosystem I.

Final Answer: RuBisCO (Option A)

Answer: (A)

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Q2.

Solution

Concept: Mendel's law of segregation states that the two alleles of a gene separate from each other during gamete formation so that each gamete carries only one allele. When two heterozygous individuals are crossed, the resulting offspring show a 3 : 1 phenotypic ratio of dominant to recessive traits.

Step 1: The cross RR (round) \times rr (wrinkled) produces all Rr (heterozygous round) offspring in the F₁ generation, because R is dominant over r.

Step 2: When F₁ plants (Rr) are self-pollinated, each parent produces two types of gametes (R and r) in equal proportion.

Step 3: Combining gametes in a Punnett square: RR (1) + Rr (2) + rr (1), giving a genotypic ratio of 1:2:1 and a phenotypic ratio of 3 round : 1 wrinkled.

Why other options are wrong:

- **Option A (1:1):** This ratio results from a test cross (Rr \times rr), not a self-cross of heterozygotes.
- **Option B (2:1):** No standard Mendelian cross produces this phenotypic ratio for simple dominance.
- **Option D (1:3):** This would mean recessive phenotype is more common, which contradicts dominance.

Final Answer: (Option C)

Answer: (C)

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Q3.

Solution

Concept: The five-kingdom classification separates organisms primarily on the basis of cell structure (prokaryotic vs. eukaryotic), mode of nutrition, and body organisation. All members of Kingdom Monera are prokaryotic, meaning they lack a membrane-bound nucleus and other membrane-bound organelles.

Step 1: Cyanobacteria are photosynthetic organisms that possess chlorophyll and can carry out oxygenic photosynthesis, which is why they were historically called “blue-green algae.”

Step 2: Despite being photosynthetic, cyanobacteria are prokaryotic – their DNA lies free in the cytoplasm without a nuclear membrane, and they lack membrane-bound organelles such as chloroplasts and mitochondria.

Step 3: Kingdom Plantae exclusively contains eukaryotic organisms with membrane-bound nuclei and chloroplasts, so cyanobacteria are placed under Kingdom Monera on the basis of their prokaryotic cell structure.

Why other options are wrong:

- **Option B:** Cyanobacteria do possess chlorophyll (chlorophyll *a*); they are photosynthetic.
- **Option C:** Cyanobacteria actively carry out photosynthesis.
- **Option D:** Cyanobacteria do not have a cellulose cell wall like true plants; their wall contains peptidoglycan.

Final Answer: Prokaryotic, lack a membrane-bound nucleus (Option A)

Answer: (A)

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Q4.

Solution

Concept: Primary productivity is the rate at which producers (autotrophs such as green plants, algae, and cyanobacteria) convert light energy into chemical energy by synthesising organic compounds through photosynthesis.

Step 1: In any ecosystem, primary productivity is measured as the amount of organic matter (biomass) produced per unit area per unit time by the autotrophic organisms.

Step 2: Gross primary productivity (GPP) is the total rate of photosynthesis, and net primary productivity (NPP) is GPP minus the organic matter consumed by the producers themselves through respiration.

Step 3: The other options describe consumer respiration, decomposition, and energy transfer at higher trophic levels – none of which define primary productivity.

Why other options are wrong:

- **Option A:** This describes secondary productivity or consumer metabolism, not primary productivity.
- **Option B:** This describes decomposition or mineralisation by decomposers.
- **Option C:** This describes energy flow at the tertiary consumer level, not production.

Final Answer: Producers synthesise organic matter through photosynthesis (Option D)

Answer: (D)

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Q5.

Solution

Concept: Aerobic respiration occurs in multiple stages at specific cellular locations: glycolysis in the cytoplasm, the Krebs cycle in the mitochondrial matrix, and the electron transport chain on the inner mitochondrial membrane.

Step 1: After glycolysis converts glucose to pyruvate in the cytoplasm, pyruvate enters the mitochondrion and is converted to acetyl-CoA, which then enters the Krebs cycle.

Step 2: The Krebs cycle operates in the mitochondrial matrix, the fluid-filled interior compartment of the mitochondrion, where acetyl-CoA is completely oxidised to CO_2 , generating NADH, FADH_2 , and GTP.

Step 3: The inner mitochondrial membrane is the site of the electron transport chain and oxidative phosphorylation, not the Krebs cycle itself.

Why other options are wrong:

- **Option A:** The cytoplasm is the site of glycolysis, not the Krebs cycle.
- **Option B:** The inner mitochondrial membrane houses the electron transport chain.
- **Option D:** The chloroplast stroma is where the Calvin cycle of photosynthesis occurs.

Final Answer: Mitochondrial matrix (Option C)

Answer: (C)

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Q6.

Solution

Concept: In angiosperms, the male gametophyte is the pollen grain. After landing on the stigma, it germinates to form a pollen tube that carries two male gametes (sperm nuclei) down through the style to the embryo sac for double fertilisation.

Step 1: The microspore mother cell in the anther undergoes meiosis to produce four microspores, each of which develops into a pollen grain – the immature male gametophyte.

Step 2: The mature pollen grain contains a generative cell (which divides to form two sperm cells) and a tube cell. Upon germination, the pollen tube grows through the style and delivers both sperm to the embryo sac.

Step 3: The ovule contains the female gametophyte (embryo sac), the endosperm is a product of fertilisation, and the megaspore is a precursor of the female gametophyte – none of these is the male gametophyte.

Why other options are wrong:

- **Option B:** The ovule is a structure that contains the female gametophyte, not the male.
- **Option C:** The endosperm forms after triple fusion; it is not a gametophyte.
- **Option D:** The megaspore develops into the female gametophyte (embryo sac).

Final Answer: (Option A)

Answer: (A)

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Q7.

Solution

Concept: HIV (human immunodeficiency virus) is an enveloped retrovirus. Its outer lipid envelope is studded with glycoprotein spikes, particularly gp120, which specifically binds to the CD4 receptor on helper T-cells, enabling the virus to attach to and infect these immune cells.

Step 1: The outermost projecting knob-like structures on the HIV particle are the gp120 glycoproteins, which are labelled as P in the given diagram.

Step 2: These gp120 molecules recognise and bind to the CD4 protein on the surface of T-helper lymphocytes, which is the first essential step in HIV infection.

Step 3: Q represents the lipid envelope (the outer membrane derived from the host cell), R represents the protein capsid that encloses the viral genome, and S represents the two single-stranded RNA molecules that constitute the HIV genome.

Why other options are wrong:

- **Option B (Q):** Q is the lipid envelope, a membrane layer, not the glycoprotein spike.
- **Option C (R):** R is the capsid, the inner protein shell, not an attachment protein.
- **Option D (S):** S is the RNA genome inside the capsid.

Final Answer: P (gp120) (Option A)

Answer: (A)

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Q8.

Solution

Concept: The plant kingdom is broadly divided into non-seed-bearing plants (bryophytes, pteridophytes) and seed-bearing plants (gymnosperms, angiosperms). Gymnosperms produce seeds but lack true flowers and fruits, while angiosperms produce seeds enclosed within fruits developed from flowers.

Step 1: Bryophytes (mosses) are non-vascular plants that reproduce through spores, not seeds, and require water for fertilisation.

Step 2: Pteridophytes (ferns) are vascular plants that also reproduce through spores and do not produce seeds.

Step 3: Gymnosperms (e.g., pine, cycad) are seed-bearing plants in which the seeds develop on the surface of cone scales (megasporophylls) without being enclosed within a fruit – they bear neither flowers nor fruits in the strict botanical sense.

Step 4: Angiosperms (flowering plants) produce seeds enclosed within fruits that develop from the ovary wall of a flower.

Why other options are wrong:

- **Option A:** Bryophytes do not produce seeds at all.
- **Option B:** Pteridophytes reproduce by spores, not seeds.
- **Option D:** Angiosperms produce both flowers and fruits.

Final Answer: (Option C)

Answer:

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Q9.

Solution

Concept: While biological nitrogen fixation is carried out by microorganisms, the industrial conversion of atmospheric nitrogen (N_2) and hydrogen (H_2) into ammonia (NH_3) at high temperature ($\sim 400\text{--}500^\circ\text{C}$) and high pressure (~ 200 atm) using an iron catalyst is called the Haber process (Haber–Bosch process).

Step 1: The Haber process was developed by Fritz Haber and Carl Bosch and is the principal industrial method for manufacturing ammonia, which is then used to produce fertilisers, explosives, and other chemicals.

Step 2: Nitrification is a biological process carried out by bacteria (*Nitrosomonas* and *Nitrobacter*) that convert ammonia to nitrate in the soil. Ammonification is the release of ammonia from decomposing organic matter. Denitrification converts nitrate back to N_2 gas.

Why other options are wrong:

- **Option A:** Nitrification converts NH_3 to NO_3^- biologically, not N_2 to NH_3 industrially.
- **Option B:** Ammonification is the biological breakdown of organic nitrogen into NH_3 .
- **Option C:** Denitrification converts nitrate to N_2 gas – the reverse of fixation.

Final Answer: (Option D)

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Q10.

Solution

Concept: Iodine is an essential trace element required for the synthesis of thyroid hormones (thyroxine, T_4 , and triiodothyronine, T_3). Chronic dietary deficiency of iodine causes the thyroid gland to enlarge in an attempt to compensate for reduced hormone production, a condition called goitre.

Step 1: The thyroid gland uses dietary iodine to synthesise thyroxine (T_4). When iodine intake is chronically insufficient, the gland cannot produce adequate thyroxine.

Step 2: In response, the pituitary gland secretes more thyroid-stimulating hormone (TSH), which stimulates the thyroid to grow and absorb more iodine from the blood. This excessive stimulation causes visible enlargement of the thyroid – goitre.

Step 3: Goitre can be prevented by consuming iodised salt regularly.

Why other options are wrong:

- **Option A:** Anaemia results from iron or B_{12} deficiency, not iodine.
- **Option B:** Marasmus results from total calorie-protein deficiency.
- **Option C:** Pellagra results from niacin (Vitamin B_3) deficiency.

Final Answer: (Option D)

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Q11.

Solution

Concept: The central dogma of molecular biology describes the flow of genetic information: DNA → RNA (transcription) → Protein (translation). Translation is the specific step in which the nucleotide sequence of mRNA is decoded at the ribosome to produce a polypeptide chain.

Step 1: Replication is the synthesis of a new copy of DNA from an existing DNA template, producing two identical DNA molecules.

Step 2: Transcription is the synthesis of mRNA from a DNA template strand by RNA polymerase.

Step 3: Translation is the process occurring at ribosomes where the mRNA codon sequence directs the sequential addition of specific amino acids (brought by tRNA) to form a polypeptide chain.

Why other options are wrong:

- **Option A:** Replication copies DNA to DNA, not mRNA to protein.
- **Option B:** Transcription copies DNA to mRNA, not mRNA to protein.
- **Option D:** Transduction is a mechanism of bacterial gene transfer via bacteriophages.

Final Answer: Translation (Option C)

Answer: (C)

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Q12.

Solution

Concept: In human circulation, the pulmonary circuit carries deoxygenated blood from the heart to the lungs and returns oxygenated blood to the heart. The pulmonary veins are the only veins in the body that carry oxygenated blood.

Step 1: The right ventricle pumps deoxygenated blood to the lungs through the pulmonary arteries (which are the only arteries carrying deoxygenated blood).

Step 2: In the lungs, gas exchange occurs: CO_2 is released and O_2 is absorbed. The now oxygenated blood returns to the heart via four pulmonary veins, which empty into the left atrium.

Step 3: From the left atrium, blood passes to the left ventricle and is pumped out through the aorta to the entire body.

Why other options are wrong:

- **Option A:** The pulmonary artery carries deoxygenated blood from the heart to the lungs.
- **Option C:** The aorta carries oxygenated blood away from the heart to the body, not from lungs to heart.
- **Option D:** The superior vena cava carries deoxygenated blood from the upper body to the right atrium.

Final Answer: (Option B)

Answer: (B)

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Q13.

Solution

Concept: Sclerenchyma is a type of simple permanent tissue in plants that provides mechanical support and rigidity. Its cells are characteristically dead at maturity, with uniformly thick, heavily lignified secondary cell walls that make them extremely hard and inflexible.

Step 1: Sclerenchyma cells deposit layers of lignin in their secondary cell walls during maturation, making the walls extremely thick, hard, and impermeable.

Step 2: Because of this heavy lignification, the cells lose their protoplasm and become dead at maturity, but they continue to provide mechanical strength as a rigid skeleton within the plant body.

Step 3: Sclerenchyma is found in the hard shells of nuts, in fibres of jute and hemp, and in the gritty texture of pear fruit (stone cells).

Why other options are wrong:

- **Option A:** This describes parenchyma – living, thin-walled cells with intercellular spaces.
- **Option B:** This describes collenchyma – living cells with unevenly thickened corners.
- **Option D:** This describes meristematic tissue – actively dividing cells at growing tips.

Final Answer: Dead, with uniformly thick, lignified walls (Option C)

Answer: (C)

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Q14.

Solution

Concept: In genetic engineering, a vector is a DNA molecule used as a vehicle to carry and introduce a foreign gene (gene of interest) into a host cell. Plasmids – small, circular, extrachromosomal DNA molecules found in bacteria – are the most commonly used vectors.

Step 1: A plasmid is cut open using a restriction endonuclease at a specific site, and the foreign gene (also cut with the same enzyme) is inserted into the plasmid.

Step 2: DNA ligase seals the foreign gene into the plasmid, creating a recombinant plasmid (recombinant DNA).

Step 3: This recombinant plasmid (vector) is then introduced into a host bacterial cell through transformation, where the foreign gene can be expressed to produce the desired protein.

Why other options are wrong:

- **Option A:** A primer is a short nucleotide sequence used to initiate DNA synthesis during PCR, not a carrier of genes.
- **Option B:** A probe is a labelled nucleic acid fragment used to detect a specific DNA/RNA sequence, not to carry genes.
- **Option C:** Ligase is an enzyme that joins DNA fragments – it is a tool, not a carrier molecule.

Final Answer: (Option D)

Answer: (D)

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Q15.

Solution

Concept: Intrauterine contraceptive devices (IUCDs) such as Copper-T are placed inside the uterus. The copper ions released by the device create a hostile environment for sperm (spermicidal effect) and also alter the uterine lining to inhibit implantation of any fertilised egg.

Step 1: Copper-T is a small T-shaped plastic device wound with copper wire. Once inserted into the uterus, it continuously releases small amounts of copper ions into the uterine fluid.

Step 2: These copper ions have a direct toxic (spermicidal) effect on sperm, reducing their motility and viability. Additionally, the copper ions induce a mild inflammatory response in the uterine lining, which makes the endometrium hostile to implantation.

Step 3: Copper-T does not suppress ovulation (that is a hormonal method), does not physically block the cervix (that is a barrier method), and does not permanently block the tubes (that is sterilisation).

Why other options are wrong:

- **Option A:** Ovulation suppression is the mechanism of oral contraceptive pills, not Copper-T.
- **Option C:** Physical cervical blockage is the mechanism of barrier methods like diaphragms.
- **Option D:** Permanent tubal blockage describes surgical sterilisation (tubectomy).

Final Answer: Releases copper ions toxic to sperm; inhibits implantation (Option B)

Answer: (B)

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Q16.

Solution

Concept: The human brain has three major regions: the cerebrum (higher mental functions), the cerebellum (balance and motor coordination), and the medulla oblongata (involuntary vital functions). The cerebellum, located at the posterior base of the brain, specifically coordinates voluntary muscular movements and maintains body posture and equilibrium.

Step 1: The cerebrum is the largest part of the brain and is the centre for conscious thought, intelligence, memory, sensory perception, and voluntary motor commands – but it does not directly maintain balance.

Step 2: The cerebellum receives proprioceptive information from muscles, joints, and the inner ear, and uses this to fine-tune and coordinate the timing, force, and extent of voluntary movements, ensuring smooth, balanced, and precise motion.

Step 3: The medulla oblongata controls involuntary functions such as breathing rate, heart rate, and blood pressure. The hypothalamus regulates body temperature, hunger, thirst, and hormonal release.

Why other options are wrong:

- **Option A:** The cerebrum handles thinking and voluntary command, not balance coordination.
- **Option C:** The medulla oblongata controls involuntary vital reflexes, not balance.
- **Option D:** The hypothalamus regulates homeostatic functions and the endocrine system.

Final Answer: (Option B)

Answer: (B)

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Q17.

Solution

Concept: C_3 and C_4 plants differ in the initial product and cellular location of carbon fixation. In C_3 plants, the Calvin cycle directly fixes CO_2 into the three-carbon compound 3-PGA using RuBisCO. In C_4 plants, a preliminary fixation step using PEP carboxylase occurs in mesophyll cells.

Step 1: The passage clearly states that “the first stable product of carbon fixation in the Calvin cycle is a three-carbon compound called 3-phosphoglyceric acid (3-PGA).” Therefore, the answer to sub-part 1 is **3-phosphoglyceric acid (3-PGA)**.

Step 2: The passage states that “in C_4 plants . . . carbon dioxide is initially fixed in the **mesophyll cells** into a four-carbon compound . . . by the enzyme PEP carboxylase.” Therefore, the answer to sub-part 2 is **mesophyll cells**.

Final Answer:

1. 3-phosphoglyceric acid (3-PGA)
2. Mesophyll cells

Answer: (See above)

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Q18.

Solution

Concept: A lichen is a composite organism formed by a mutually beneficial (symbiotic) partnership between a fungus (the mycobiont) and an alga or cyanobacterium (the photobiont). In this association, the alga provides food through photosynthesis (autotrophic) while the fungus provides shelter, absorbs water and minerals, and is heterotrophic.

Step 1: A **lichen** is a composite organism formed by the symbiotic association between a fungus and an alga or cyanobacterium.

Step 2: In this association, the alga is **autotrophic** (photosynthetic – it makes food using sunlight) while the fungus is **heterotrophic** (it cannot make its own food and depends on the alga for organic nutrients, while providing water and minerals in return).

Final Answer:

1. lichen
2. autotrophic; heterotrophic

Answer: (See above)

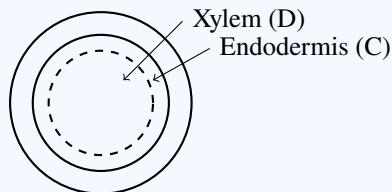
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Q19.

Solution

Concept: In a transverse section of a typical dicot root, the vascular cylinder contains the conducting tissues. Xylem (labelled D) conducts water and dissolved minerals upward. The endodermis (labelled C) is a single-cell-thick barrier layer with Casparian strips that regulates the radial movement of water and solutes between the cortex and the vascular cylinder.



Step 1: Tissue D (xylem) is the primary water-conducting tissue of the plant. It consists of tracheids and vessels, which are dead, hollow cells forming continuous tubes that transport water and dissolved minerals from the root upward to stems and leaves via the transpiration pull.

Step 2: Layer C (endodermis) is a single layer of barrel-shaped cells encircling the vascular cylinder. Its cell walls contain a waxy, waterproof band called the Casparian strip, which forces all water and dissolved substances to pass through the endodermal cell membranes (symplastic pathway), thereby regulating which substances enter the vascular tissue.

Final Answer:

1. Xylem
2. Endodermis

Answer: (See above)

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Q20.

Solution

Concept: In genetics, a gene is a functional unit of heredity – a specific segment of DNA that codes for a protein or functional RNA. Alleles are the different versions (variants) of the same gene that arise by mutation and occupy the same locus on homologous chromosomes.

Step 1: A **gene** is defined as a segment of DNA that carries the complete information required to code for a specific polypeptide (protein) or a functional RNA molecule such as rRNA or tRNA. Genes are the basic units of inheritance.

Step 2: **Alleles** are the alternative forms of the same gene. For example, the gene for seed colour in pea plants has two alleles: Y (yellow) and y (green). Alleles occupy the same position (locus) on a pair of homologous chromosomes.

Final Answer:

1. gene
2. alleles

Answer: (See above)

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Q21.

Solution

Concept: The human brain has functionally specialised regions. The cerebrum handles higher mental functions, the cerebellum coordinates balance and movement, the medulla oblongata controls vital involuntary functions, and the hypothalamus regulates homeostasis and endocrine activity.

Step 1: The cerebrum is the largest brain region; its cortex is the centre for thinking, memory, reasoning, language, and voluntary actions, matching pair (a)–(ii).

Step 2: The cerebellum, located at the back of the brain below the cerebrum, coordinates the precision of voluntary muscular movements and maintains body balance and posture, matching pair (b)–(iv).

Step 3: The medulla oblongata, located at the base of the brainstem, controls involuntary vital functions such as breathing rate, heartbeat, and blood pressure, matching pair (c)–(i).

Step 4: The hypothalamus, situated below the thalamus, regulates body temperature, hunger, thirst, sleep, and controls the pituitary gland, matching pair (d)–(iii).

Final Answer: (a)–(ii), (b)–(iv), (c)–(i), (d)–(iii)

Answer: (See above)

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Q22.

Solution

Concept: Species interactions in an ecosystem include mutualism (both benefit), commensalism (one benefits, other unaffected), parasitism (one benefits, other harmed), and competition (both harmed). The carrying capacity (K) represents the upper limit of population size that the resources of a habitat can sustain indefinitely.

Step 1: Mutualism is a type of interspecific interaction in which both participating species derive benefit. For example, the relationship between Rhizobium bacteria (which fix nitrogen) and leguminous plants (which provide carbohydrates) is mutualistic.

Step 2: Carrying capacity (denoted K) is the maximum population size of a species that a given environment can sustain over an extended period without degradation of the habitat, determined by limiting factors such as food, water, space, and shelter.

Final Answer:

1. mutualism
2. carrying capacity

Answer: (See above)

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Q23.

Solution

Concept: Spermatogenesis is the process of sperm cell formation in the seminiferous tubules of the testes, regulated by the male sex hormone testosterone (secreted by Leydig cells). The placenta connects the developing embryo to the mother's (not the father's) uterine wall and mediates nutrient and gas exchange.

Step 1: Spermatogenesis indeed occurs in the seminiferous tubules, where spermatogonia undergo meiosis and differentiation to produce mature spermatozoa. Testosterone, produced by Leydig cells under the influence of LH, stimulates and maintains this process. Therefore, statement 1 is **True (T)**.

Step 2: The placenta is an organ formed during pregnancy that connects the developing embryo/foetus to the **mother's** uterine wall (not the father's bloodstream). It facilitates the exchange of nutrients, oxygen, and waste between maternal and foetal blood. Therefore, the claim that it connects to the "father's bloodstream" is factually incorrect, making statement 2 **False (F)**.

Final Answer:

1. True (T)
2. False (F)

Answer: (See above)

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Q24.

Solution

Concept: Plant tissues are classified as meristematic (undifferentiated, dividing) or permanent (differentiated). The three main simple permanent tissues – parenchyma, collenchyma, and sclerenchyma – differ in cell wall structure, cell viability at maturity, and function.

Step 1: Parenchyma consists of thin-walled, living cells with large vacuoles and intercellular spaces. It stores food and water and provides turgidity, matching pair (a)–(ii).

Step 2: Collenchyma consists of living cells with unevenly (irregularly) thickened corners due to pectin and cellulose deposition, providing flexible support to young stems and petioles, matching pair (b)–(iii).

Step 3: Sclerenchyma consists of dead cells with uniformly thick, heavily lignified walls, providing rigid mechanical support to mature plant parts, matching pair (c)–(i).

Step 4: Meristematic tissue consists of small, actively dividing cells with dense cytoplasm and thin walls, found at growing tips (root and shoot apices), responsible for primary growth, matching pair (d)–(iv).

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

Answer: (See above)

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Q25.

Solution

Concept: In the nitrogen cycle, organic nitrogen in dead organisms is converted to ammonia through ammonification by decomposing bacteria and fungi. Free-living (non-symbiotic) nitrogen-fixing bacteria such as *Azotobacter* and *Clostridium* convert atmospheric N_2 to ammonia independently, without requiring a plant host.

Step 1: Ammonification is the process by which soil bacteria and fungi decompose proteins, amino acids, and nucleic acids in dead organic matter (plant litter, animal remains, excreta), releasing ammonia (NH_3) or ammonium ions (NH_4^+) into the soil.

Step 2: Bacteria such as *Azotobacter* (aerobic) and *Clostridium* (anaerobic) are examples of **free-living** (non-symbiotic) nitrogen fixers. Unlike *Rhizobium*, they do not require a leguminous plant host and can fix atmospheric N_2 independently in the soil.

Final Answer:

1. ammonification
2. free-living (non-symbiotic)

Answer: (See above)

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Q26.

Solution

Concept: Each vitamin has a specific biochemical role, and its chronic dietary deficiency produces a characteristic deficiency disease with identifiable symptoms.

Step 1: Vitamin A (retinol) is essential for the synthesis of rhodopsin in retinal rod cells. Its deficiency causes night blindness (impaired ability to see in dim light), matching pair (a)–(iii).

Step 2: Vitamin D (calciferol) is required for the proper absorption of calcium and phosphorus from the intestine and their deposition in bones. Its deficiency causes rickets in children, characterised by soft, weak, deformed bones, matching pair (b)–(i).

Step 3: Vitamin B₁ (thiamine) is a coenzyme in carbohydrate metabolism. Its deficiency causes beri-beri, characterised by peripheral nerve damage, muscle weakness, and heart problems, matching pair (c)–(ii).

Step 4: Vitamin C (ascorbic acid) is essential for collagen synthesis. Its deficiency causes scurvy, characterised by bleeding gums, loose teeth, poor wound healing, and subcutaneous haemorrhages, matching pair (d)–(iv).

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

Answer: (See above)

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Q27.

Solution

Concept: Vaccination is a form of active immunisation that introduces a weakened, killed, or subunit form of a pathogen to stimulate the body's own immune system to produce antibodies and memory cells. Transgenic organisms are those whose genome has been altered by the insertion of a gene from another species using genetic engineering techniques.

Step 1: Vaccination works by exposing the immune system to an antigen (from a weakened or killed pathogen or a purified protein) without causing the disease. The immune system responds by producing specific antibodies and, crucially, memory B-cells and T-cells that provide long-lasting immunity. Statement 1 is **True (T)**.

Step 2: Transgenic organisms are indeed organisms whose genetic material has been deliberately modified by introducing a gene from a different species using recombinant DNA technology. Examples include Bt cotton (containing a gene from *Bacillus thuringiensis*) and transgenic mice used in research. Statement 2 is **True (T)**.

Final Answer:

1. True (T)
2. True (T)

Answer: (See above)

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Q28.

Solution

Concept: Gene expression and molecular inheritance involve specific enzymes and molecules at each step: DNA polymerase for replication, RNA polymerase for transcription, tRNA for amino acid delivery during translation, and ribosomes as the structural site of translation.

Step 1: DNA polymerase is the enzyme that catalyses the synthesis of a new DNA strand complementary to the template strand during DNA replication, matching pair (a)–(ii).

Step 2: RNA polymerase is the enzyme that reads the DNA template strand and synthesises a complementary mRNA molecule during transcription, matching pair (b)–(iv).

Step 3: tRNA (transfer RNA) is a small, cloverleaf-shaped RNA molecule that carries a specific amino acid to the ribosome and matches its anticodon to the corresponding mRNA codon during translation, matching pair (c)–(i).

Step 4: The ribosome is a cellular organelle composed of rRNA and proteins that serves as the physical site where mRNA is read and protein synthesis (translation) occurs, matching pair (d)–(iii).

Final Answer: (a)–(ii), (b)–(iv), (c)–(i), (d)–(iii)

Answer: (See above)

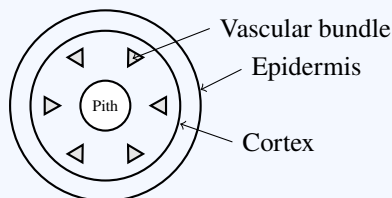
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Q29.

Solution

Concept: A transverse section of a typical dicot stem shows concentric rings of tissues from outside to inside: epidermis, cortex (with hypodermis), endodermis, vascular bundles (arranged in a ring, conjoint, collateral, open type), and a central pith.



Step 1: The **epidermis** is the outermost single layer of cells, often covered with a waxy cuticle, providing protection against water loss and mechanical injury.

Step 2: The **cortex** lies between the epidermis and the vascular bundles. It may contain collenchyma (hypodermis) and parenchyma, providing storage and some mechanical support.

Step 3: The **vascular bundles** in a dicot stem are arranged in a ring. Each bundle is conjoint, collateral, and open (with cambium between xylem and phloem), enabling secondary growth.

Step 4: The **pith** occupies the central region and consists of large parenchyma cells that store food and water.

Final Answer: Dicot stem T.S. shows epidermis (protection), cortex (storage/support), ring-arranged vascular bundles (transport), and central pith (storage).

Answer: (See above)

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Q30.

Solution

Concept: Double fertilisation is a unique feature of angiosperms in which the two male gametes delivered by the pollen tube fuse with two different cells of the embryo sac, producing both the embryo and the endosperm in a single event.

Step 1: After the pollen tube enters the embryo sac through the micropyle, it releases two male gametes (sperm cells).

Step 2: The first male gamete fuses with the egg cell (female gamete) in a process called **syngamy**, forming a diploid ($2n$) zygote, which later develops into the embryo.

Step 3: The second male gamete simultaneously fuses with the two polar nuclei (or the secondary nucleus) in the central cell in a process called **triple fusion**, forming a triploid ($3n$) primary endosperm nucleus, which develops into the endosperm – a nutritive tissue that nourishes the developing embryo.

Step 4: Since two fusion events occur simultaneously (syngamy + triple fusion), the entire process is called double fertilisation.

Final Answer: Double fertilisation involves two fusions: (1) syngamy (sperm + egg → zygote/embryo) and (2) triple fusion (sperm + 2 polar nuclei → endosperm).

Answer: (See above)

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Q31.

Solution

Concept: Energy flow through an ecosystem can be represented as food chains (single linear pathways) or food webs (interconnected networks of food chains). Biogeochemical cycles describe the circular movement of essential chemical elements through the biotic and abiotic components of the environment.

Alternative (i):

Step 1: A **food chain** is a single, linear sequence of organisms in which food energy is transferred from one trophic level to the next through repeated eating and being eaten. Example: Grass → Deer → Tiger.

Step 2: A **food web** is a complex, interconnected network of multiple food chains in an ecosystem, reflecting the fact that most organisms feed on more than one type of food and are eaten by more than one predator.

Step 3: The key difference is that a food chain shows a single linear pathway, while a food web shows multiple, interlinking pathways, providing a more realistic picture of energy flow in an ecosystem.

Alternative (ii):

Step 1: A **biogeochemical cycle** is the pathway by which a chemical element (such as carbon, nitrogen, or water) moves cyclically between the living (biotic) and non-living (abiotic) components of the environment.

Step 2: Two essential biogeochemical cycles are: (a) the **carbon cycle**, which circulates carbon through the atmosphere, living organisms, and geological deposits; and (b) the **nitrogen cycle**, which converts atmospheric nitrogen into biologically usable forms and back.

Final Answer: (i) Food chain is a single linear energy pathway; food web is an interconnected network; (ii) Biogeochemical cycle is the cyclic movement of elements (e.g., carbon cycle, nitrogen cycle).

Answer: (See above)

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Q32.

Solution

Concept: Animal classification groups organisms into phyla based on shared body plans and structural features. Phylum Chordata is characterised by a notochord, dorsal nerve cord, and pharyngeal gill slits. Phylum Arthropoda is the largest animal phylum, characterised by a chitinous exoskeleton and jointed appendages.

Alternative (i) – Phylum Chordata:

Step 1: Two characteristic features: (a) Presence of a notochord (a flexible, rod-shaped support structure) at some stage of life; (b) A dorsal, hollow, tubular nerve cord (spinal cord in vertebrates).

Step 2: Example of a cold-blooded (poikilothermic) chordate: Frog (*Rana*) – an amphibian whose body temperature varies with the environment.

Alternative (ii) – Phylum Arthropoda:

Step 1: Two characteristic features: (a) Body covered by a hard, chitinous exoskeleton that is periodically moulted; (b) Jointed legs (appendages) that allow flexible movement.

Step 2: Example: Cockroach (*Periplaneta americana*) – an insect with three pairs of jointed legs and a chitinous body covering.

Final Answer: (i) Chordata: notochord + dorsal nerve cord; e.g., frog; (ii) Arthropoda: chitinous exoskeleton + jointed legs; e.g., cockroach.

Answer: (See above)

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Q33.

Solution

Concept: The overall balanced equation for photosynthesis is: $6\text{CO}_2 + 6\text{H}_2\text{O} \xrightarrow{\text{light}} \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$. This stoichiometry shows that 6 molecules of CO_2 produce 1 molecule of glucose and consume 6 molecules of water.

Step 1: From the equation, 6 molecules of CO_2 yield 1 molecule of glucose. Therefore, the ratio is: 1 glucose per 6 CO_2 .

Step 2: If 18 molecules of CO_2 are fixed:

Glucose molecules produced = $\frac{18}{6} = 3$ molecules of glucose.

Step 3: From the same equation, 6 molecules of H_2O are consumed per 6 molecules of CO_2 (i.e., 1:1 ratio of CO_2 to H_2O). Therefore:

Water molecules consumed = 18 molecules of H_2O .

Final Answer: 3 glucose molecules produced; 18 water molecules consumed.

Answer: (See above)

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Q34.

Solution

Concept: A test cross (heterozygous × homozygous recessive) is used to determine the genotype of an organism showing the dominant phenotype. In this cross, the expected offspring ratio is 1:1 genotypically and phenotypically.

	Y	y
y	Yy	yy
y	Yy	yy

Step 1: The heterozygous yellow parent (Yy) produces two types of gametes: Y and y, in equal proportion. The homozygous green parent (yy) produces only one type of gamete: y.

Step 2: Combining gametes in the Punnett square yields: Yy (yellow), yy (green), Yy (yellow), yy (green).

Step 3: Genotypic ratio: 2 Yy : 2 yy = **1 Yy : 1 yy**.

Step 4: Phenotypic ratio: Since Y is dominant, Yy is yellow and yy is green, giving **1 yellow : 1 green**.

Final Answer: Genotypic ratio: 1 Yy : 1 yy; Phenotypic ratio: 1 yellow : 1 green.

Answer: (See above)

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Q35.

Solution

Concept: The endocrine system uses chemical messengers (hormones) to regulate body functions. Insulin, produced by beta cells of the islets of Langerhans in the pancreas, lowers blood glucose. Thyroxine, produced by the thyroid gland, regulates metabolic rate.

Alternative (i):

Step 1: The hormone **insulin** is secreted by the beta (β) cells of the islets of Langerhans in the pancreas when blood glucose levels rise (e.g., after a meal).

Step 2: Insulin lowers blood glucose by: (a) stimulating body cells (especially muscle and adipose tissue) to take up glucose from the blood; (b) promoting the conversion of glucose to glycogen (glycogenesis) in the liver and muscles for storage; (c) enhancing the use of glucose for cellular respiration.

Alternative (ii):

Step 1: The thyroid gland secretes the hormone **thyroxine** (T_4), which requires iodine for its synthesis.

Step 2: Thyroxine regulates the basal metabolic rate (BMR) of the body – it controls how fast cells use energy from nutrients, thereby affecting growth, development, body temperature, and overall energy expenditure.

Final Answer: (i) Insulin lowers blood glucose by promoting glucose uptake and glycogen storage; (ii) Thyroxine regulates the basal metabolic rate.

Answer: (See above)

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Q36.

Solution

Concept: Malnutrition refers to a condition resulting from an inadequate, unbalanced, or excessive intake of nutrients. Protein-energy malnutrition (PEM) in children manifests in two major forms: Kwashiorkor (primarily protein deficiency) and Marasmus (total calorie-protein deficiency).

Step 1: Malnutrition is defined as a nutritional disorder caused by an insufficient, excessive, or unbalanced intake of one or more essential nutrients, leading to adverse effects on body growth, development, and functioning.

Step 2: Marasmus is the disease caused by severe deficiency of both total calories and protein in young children. It is characterised by extreme emaciation (severe wasting of muscles and subcutaneous fat), giving the child an “old man” appearance, along with a very low body weight, dry and wrinkled skin, and extreme weakness.

Step 3: Kwashiorkor, by contrast, is primarily caused by severe protein deficiency (with relatively adequate calorie intake) and is characterised by oedema (swelling), a distended abdomen, and skin lesions.

Final Answer: Malnutrition is a condition due to deficient or unbalanced nutrient intake. Marasmus is characterised by extreme emaciation due to severe protein-energy deficiency.

Answer: (See above)

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Q37.

Solution

Concept: Arteries and veins are blood vessels with distinct structural features suited to their function. Arteries carry blood away from the heart under high pressure, requiring thick, elastic walls. Veins return blood to the heart under lower pressure and have thinner walls with valves to prevent backflow.

Step 1 – Wall thickness: **Arteries** have thick, muscular, and elastic walls to withstand and absorb the high pressure of blood pumped directly from the heart. **Veins** have thinner walls with less muscle and elastic tissue because the blood pressure in veins is much lower.

Step 2 – Direction of blood flow: **Arteries** carry blood *away from the heart* to the body organs. **Veins** carry blood *toward the heart* from the body organs.

Step 3 – Examples: Aorta is the largest artery (carries oxygenated blood from the left ventricle to the body). Superior vena cava is a major vein (carries deoxygenated blood from the upper body back to the right atrium).

Final Answer: Arteries: thick walls, carry blood away from heart (e.g., aorta). Veins: thin walls, carry blood toward heart (e.g., vena cava).

Answer: (See above)

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Q38.

Solution

Concept: The immune system protects the body from pathogens using various mechanisms. Vaccines stimulate active immunity, passive immunity involves receiving pre-formed antibodies, and allergens are substances that trigger inappropriate immune responses (allergies) in sensitive individuals.

Step 1 – Vaccine: A **vaccine** is a biological preparation containing weakened, killed, or subunit forms of a pathogen (or its toxin) that, when administered, stimulates the body's immune system to produce antibodies and memory cells without causing the disease. Example: BCG vaccine (against tuberculosis).

Step 2 – Passive immunity: **Passive immunity** is the type of immunity acquired by receiving pre-formed antibodies from an external source, rather than producing them through one's own immune response. It provides immediate but short-lived protection. Example: Transfer of maternal antibodies (IgG) to the foetus through the placenta, or antibodies in mother's milk (colostrum).

Step 3 – Allergen: An **allergen** is a normally harmless substance from the environment that triggers an exaggerated immune response (hypersensitivity or allergy) in certain genetically predisposed individuals. Example: Pollen grains causing hay fever (allergic rhinitis).

Final Answer: Vaccine: weakened/killed pathogen preparation for active immunity (e.g., BCG); Passive immunity: receiving pre-formed antibodies (e.g., maternal antibodies); Allergen: substance causing allergy (e.g., pollen).

Answer: (See above)

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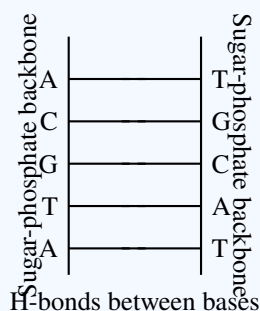


Q39.

Solution

Concept: DNA is a double-stranded helical molecule with a sugar-phosphate backbone and complementary base pairs (A-T, G-C). DNA replication is semi-conservative, meaning each new DNA molecule contains one original strand and one newly synthesised strand, with DNA polymerase catalysing the synthesis.

Alternative (i) – DNA Structure:



Step 1: DNA consists of two polynucleotide strands running antiparallel to each other (5' to 3' and 3' to 5'), wound around a common axis in a right-handed double helix.

Step 2: Each strand has a sugar-phosphate backbone (alternating deoxyribose sugar and phosphate groups) with nitrogenous bases projecting inward.

Step 3: The two strands are held together by hydrogen bonds between complementary base pairs: Adenine pairs with Thymine (2 H-bonds), and Guanine pairs with Cytosine (3 H-bonds).

Solution

Alternative (ii) – DNA Replication:

Step 1: DNA replication begins when the enzyme helicase unwinds and separates the two strands of the parent DNA molecule at specific origins of replication, creating a replication fork.

Step 2: The enzyme **DNA polymerase** then moves along each exposed template strand and synthesises a new complementary strand by adding nucleotides one by one, following the base pairing rules (A with T, G with C), always in the 5' to 3' direction.

Step 3: The result is two identical DNA molecules, each consisting of one original (parental) strand and one newly synthesised strand. This pattern is called **semi-conservative replication**, as demonstrated by Meselson and Stahl's experiment.

Final Answer: (i) DNA is a double helix with sugar-phosphate backbones and A-T, G-C base pairs; (ii) DNA replication is semi-conservative – DNA polymerase builds a new strand on each parent template.

Answer: (See above)

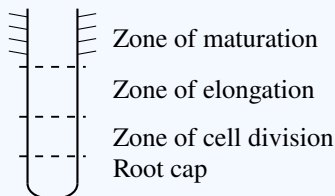
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Q40.

Solution

Concept: The growing tip of a root shows distinct longitudinal zones, each with a specific structural organisation and function: root cap (protection), zone of cell division (meristematic activity), zone of elongation (cell lengthening), and zone of maturation (cell differentiation and root hair formation).



Step 1: The **root cap** is a thimble-shaped covering of loose cells at the very tip of the root. Its function is to protect the delicate apical meristem as the root pushes through abrasive soil particles and to secrete mucilage that lubricates the root’s path.

Step 2: The **zone of cell division** (meristematic zone) lies just above the root cap and contains small, thin-walled, actively dividing cells of the apical meristem. Its function is to produce new cells that will eventually form all the other root tissues.

Step 3: The **zone of elongation** lies above the meristematic zone. Here, the newly formed cells absorb water, their vacuoles enlarge, and the cells elongate significantly, pushing the root tip deeper into the soil.

Step 4: The **zone of maturation** (differentiation zone) is the uppermost zone, where elongated cells differentiate into specialised tissues. Epidermal cells develop tubular extensions called root hairs, which greatly increase the surface area for absorption of water and minerals.

Final Answer: Root cap (protection), zone of cell division (new cell production), zone of elongation (cell growth and root extension), zone of maturation (differentiation and root hair formation for absorption).

Answer: (See above)

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Q41.

Solution

Concept: Protein-energy malnutrition (PEM) is a major nutritional disorder in developing countries, manifesting as Kwashiorkor (primarily protein deficiency) and Marasmus (total calorie-protein deficiency). Drug addiction causes severe physical, mental, and social harm and can be prevented through awareness, counselling, and strict regulation.

Alternative (i) – Protein-Energy Malnutrition:

Step 1: Kwashiorkor is caused by severe deficiency of protein in the diet (with relatively adequate calorie intake). Symptoms include oedema (swelling of hands, feet, and face), a distended abdomen, skin lesions, thin and discoloured hair, and an enlarged liver. It commonly affects children after weaning.

Step 2: Marasmus is caused by severe deficiency of both total calories and protein. Symptoms include extreme emaciation, wasting of muscles and fat, very low body weight (below 60% of normal), dry and wrinkled skin, and a wizened (old) facial appearance. It typically affects infants below one year of age.

Step 3: Prevention includes promoting breastfeeding, ensuring adequate protein and calorie intake through balanced meals, nutritional supplementation programmes, and public health education.

Alternative (ii) – Drug Addiction:

Step 1: Drug addiction causes serious damage to the liver, kidneys, brain, and cardiovascular system. It impairs mental functioning, leading to depression, anxiety, hallucinations, and poor judgement. Social consequences include loss of employment, family disruption, and criminal behaviour.

Step 2: Two preventive measures: (a) Education and awareness campaigns in schools and communities about the dangers of drug abuse; (b) Strict enforcement of laws against the production, sale, and use of illicit drugs, combined with counselling and rehabilitation services.

Final Answer: (i) Kwashiorkor: protein deficiency (oedema, distended abdomen); Marasmus: total calorie-protein deficiency (extreme emaciation); (ii) Drug addiction damages organs and mental health; prevention through education and law enforcement.

Answer: (See above)

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Q42.

Solution

Concept: Mendel’s law of segregation states that the two alleles of a gene separate during gamete formation, so each gamete carries only one allele. Codominance occurs when both alleles are fully expressed simultaneously in the heterozygote. Incomplete dominance occurs when the heterozygote shows an intermediate (blended) phenotype.

Alternative (i):

Step 1 (a): Mendel’s law of segregation (also called the law of purity of gametes) states that during the formation of gametes, the two alleles of a gene pair separate (segregate) from each other so that each gamete receives only one allele. At fertilisation, the alleles recombine randomly.

Step 2 (b): Cross: Bb × Bb (both parents are heterozygous black).

	B	b
B	BB	Bb
b	Bb	bb

Step 3: Genotypic ratio: 1 BB : 2 Bb : 1 bb. Phenotypic ratio: 3 black (BB + Bb) : 1 white (bb).

Solution

Alternative (ii):

Step 1 (a): Codominance occurs when both alleles in a heterozygote are fully and independently expressed, producing a phenotype that shows both parental traits simultaneously (e.g., AB blood group in humans, where both A and B antigens are expressed on RBCs).

Step 2 (a): Incomplete dominance occurs when neither allele is completely dominant, and the heterozygote shows an intermediate (blended) phenotype between the two homozygous phenotypes (e.g., red × white snapdragon producing pink F₁).

Step 3 (b): Cross: Rr (pink) × Rr (pink). Offspring: 1 RR (red) : 2 Rr (pink) : 1 rr (white). Phenotypic ratio = **1 red : 2 pink : 1 white**.

Final Answer: (i)(a) Law of segregation: alleles separate during gamete formation; (b) Bb × Bb gives 3 black : 1 white; (ii)(a) Codominance: both alleles fully expressed (AB blood); incomplete dominance: intermediate phenotype (pink snapdragon); (b) F₂ ratio: 1 red : 2 pink : 1 white.

Answer: (See above)

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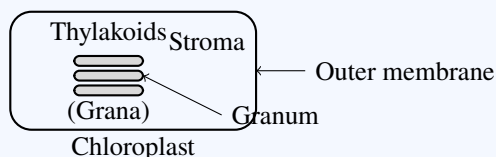


Q43.

Solution

Concept: Photosynthesis is the process by which green plants convert light energy, CO₂, and water into glucose and oxygen, occurring in two stages within the chloroplast. Whittaker’s five-kingdom classification organises all living organisms into Monera, Protista, Fungi, Plantae, and Animalia based on cell structure, mode of nutrition, and body organisation.

Alternative (i) – Photosynthesis:



Step 1 – Light-dependent reactions: These occur on the **thylakoid membranes** (grana). Inputs: light energy, water (H₂O). Chlorophyll absorbs light, water is split (photolysis), and the products are ATP, NADPH, and O₂ (released as a by-product).

Step 2 – Light-independent reactions (Calvin cycle): These occur in the **stroma**. Inputs: CO₂, ATP, and NADPH (from the light reactions). The enzyme RuBisCO fixes CO₂ into 3-PGA, which is reduced using ATP and NADPH to eventually form glucose (C₆H₁₂O₆).

Step 3: Overall equation: $6\text{CO}_2 + 6\text{H}_2\text{O} \xrightarrow{\text{light, chlorophyll}} \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$.

Solution

Alternative (ii) – Whittaker’s Five-Kingdom Classification:

Basis: Cell structure (prokaryotic/eukaryotic), mode of nutrition (autotrophic/heterotrophic/saprophytic), body organisation (unicellular/multicellular), and phylogenetic relationships.

Step 1 – Kingdom Monera: Prokaryotic, unicellular organisms without a membrane-bound nucleus. Example: *Escherichia coli* (bacterium).

Step 2 – Kingdom Protista: Eukaryotic, mostly unicellular organisms that do not fit into the other kingdoms. Example: *Amoeba*.

Step 3 – Kingdom Fungi: Eukaryotic, heterotrophic (saprophytic or parasitic) organisms with a cell wall made of chitin. Example: *Rhizopus* (bread mould).

Step 4 – Kingdom Plantae: Eukaryotic, multicellular, autotrophic (photosynthetic) organisms with a cellulose cell wall. Example: Mango tree (*Mangifera indica*).

Step 5 – Kingdom Animalia: Eukaryotic, multicellular, heterotrophic organisms that lack a cell wall and are capable of locomotion. Example: Housefly (*Musca domestica*).

Final Answer: (i) Photosynthesis: light reactions on thylakoids produce ATP, NADPH, O₂; Calvin cycle in stroma fixes CO₂ into glucose; (ii) Five kingdoms: Monera (bacteria), Protista (Amoeba), Fungi (Rhizopus), Plantae (mango), Animalia (housefly).

Answer: (See above)

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Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	A	2	C	3	A	4	D	5	C
6	A	7	A	8	C	9	D	10	D
11	C	12	B	13	C	14	D	15	B
16	B								

