Rajasthan JET Biology Sample Paper-7

Duration: 40 Minutes **Maximum Marks: 160**

Instructions

- This paper contains **40** Multiple Choice Questions (Single Correct).
- Each correct answer carries **+4 marks**.
- Each incorrect answer carries: **−1 marks**.
- Use of mobile phones, smartwatches, calculators, or any electronic gadgets is strictly prohibited.

Q1. The xylem vessel element differs from the tracheid in which of the following features?

(A) Both lack nuclei at maturity

(B) Tracheids have bordered pits while vessels have simple pits

(C) Vessels have perforated end walls while tracheids have oblique end walls

(D) Both function in transport of minerals only

Q2. In the light-dependent reactions of photosynthesis, the splitting of water molecules occurs at:

(A) Photosystem I (PSI)

(B) Photosystem II (PSII)

(C) Cytochrome b6f complex

(D) ATP synthase

Q3. Which of the following families is characterized by a superior ovary, diadelphous stamens, and lomentum type of fruit?

(A) Brassicaceae

(B) Fabaceae

(C) Rosaceae

(D) Lamiaceae

Q4. The process by which a plant detects and responds to the angle of incoming light is called:

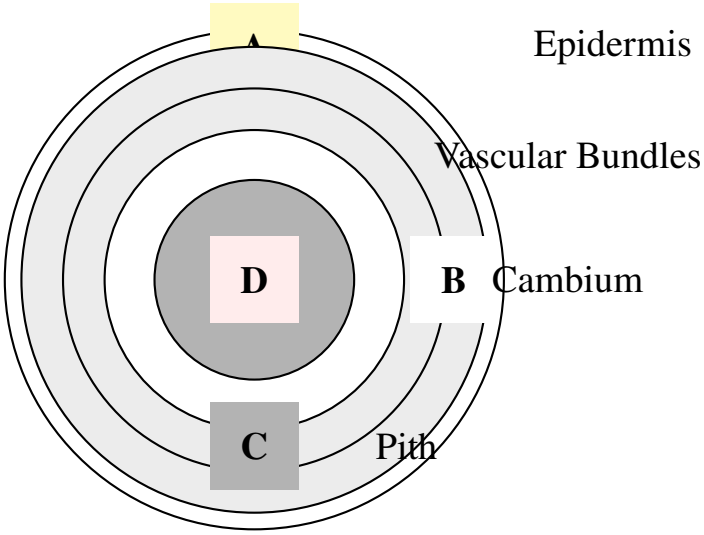
(A) Phototropism

(B) Heliotropism

(C) Nyctinasty

(D) Hyponasty

Q5. The diagram below represents a transverse section of a dicot stem showing different tissues. Which region is responsible for the secondary growth of the stem?



(A) Region A (Epidermis)

(B) Region B (Cambium)

(C) Region C (Cortex)

(D) Region D (Pith)

Q6. The number of ATP molecules produced during the complete oxidation of one glucose molecule in cellular respiration is approximately:

(A) 2 ATP

(B) 12 ATP

(C) 30-32 ATP

(D) 50 ATP

Q7. A test cross between a heterozygous individual (Aa) and a homozygous recessive individual (aa) produces a phenotypic ratio of:

(A) 1:1

(B) 3:1

(C) 9:3:3:1

(D) 9:7

Q8. Ethylene hormone is primarily involved in which of the following physiological processes?

(A) Seed germination

(B) Fruit ripening

(C) Apical dominance

(D) Root elongation

Q9. The phenomenon of nitrogen fixation by plants is achieved through the association with:

(A) Mycorrhizal fungi

(B) Rhizobium bacteria

(C) Azotobacter

(D) Nostoc (cyanobacteria)

Q10. Macronutrients required for plant growth include all of the following EXCEPT:

(A) Nitrogen and Phosphorus

(B) Potassium and Calcium

(C) Magnesium and Sulfur

(D) Iron and Zinc

Q11. In the Krebs cycle (citric acid cycle), the enzyme that catalyzes the first step of carboxylation is:

(A) Citrate synthase

(B) Isocitrate dehydrogenase

(C) Succinate dehydrogenase

(D) Malate dehydrogenase

Q12. The structure produced during mitosis that helps in the separation of chromatids is:

(A) Centriole

(B) Spindle fiber

(C) Centromere

(D) Nucleolus

Q13. Pollen grains develop in which anther tissue?

(A) Epidermis

(B) Endothecium

(C) Connective tissue

(D) Sporogenous tissue

Q14. The primary succession occurs when a community develops:

(A) On a previously occupied area after disturbance

(B) On a newly exposed bare rock area

(C) In a previously existing community

(D) On degraded agricultural land

Q15. In DNA replication, the Okazaki fragments are synthesized on:

(A) The leading strand

(B) The lagging strand

(C) Both strands simultaneously

(D) Only at the replication fork

Q16. Plasmolysis in plant cells demonstrates the principle of:

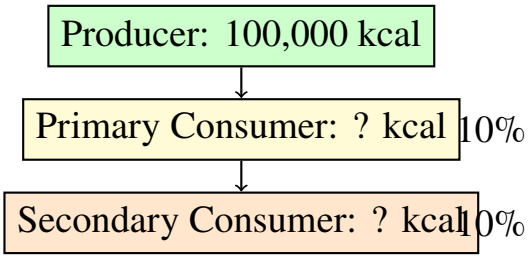
(A) Active transport

(B) Osmosis

(C) Diffusion

(D) Imbibition

Q17. The ecological efficiency (energy transfer) from one trophic level to the next is approximately:



Energy Pyramid

(A) 50%

(B) 25%

(C) 10%

(D) 1%

Q18. The phenomenon by which a plant leaf moves to expose its flat surface perpendicular to the sun's rays is:

(A) Heliotropism

(B) Phototropism

(C) Nyctinasty

(D) Thigmotropism

Q19. PCR (Polymerase Chain Reaction) is used in biotechnology primarily for:

(A) Protein synthesis

(B) DNA amplification

(C) RNA transcription

(D) Cell division

Q20. The seed dispersal mechanism in which seeds are carried by wind is specifically called:

(A) Hydrochory

(B) Anemochory

(C) Zoochory

(D) Autochory

Q21. In the light-independent reactions (Calvin cycle), the enzyme that catalyzes CO_2 fixation is:

(A) Phosphofructokinase

(B) RuBisCO

(C) Aldolase

(D) Hexokinase

Q22. The process of formation of new individuals from vegetative parts without gamete fusion is:

(A) Sexual reproduction

(B) Vegetative reproduction

(C) Regeneration

(D) Fragmentation alone

Q23. Bacterial blight of rice is caused by:

(A) Xanthomonas oryzae pv. oryzae

(B) Pyricularia oryzae

(C) Fusarium oxysporum

(D) Rhizoctonia solani

Q24. The variety of genetic information present in a population is known as:

(A) Genetic drift

(B) Gene flow

(C) Genetic variation

(D) Natural selection

Q25. Stomata primarily regulate the exchange of which gases?

(A) Nitrogen and Oxygen

(B) Carbon dioxide and Oxygen

(C) Oxygen and Nitrogen

(D) Carbon dioxide and Nitrogen

Q26. The parasitic protozoan that causes visceral leishmaniasis (kala-azar) in humans is:

(A) Plasmodium malariae

(B) Leishmania donovani

(C) Entamoeba histolytica

(D) Giardia intestinalis

Q27. The characteristic feature that distinguishes arthropods from other invertebrates is:

(A) Presence of a notochord

(B) Jointed appendages and chitinous exoskeleton

(C) Segmented body without appendages

(D) Presence of a complete digestive system

Q28. In human circulation, the blood vessel that carries deoxygenated blood from the body to the right atrium is:

(A) Pulmonary artery

(B) Pulmonary vein

(C) Superior and inferior vena cava

(D) Aorta

Q29. The hormonal disorder characterized by goiter and metabolic slowdown is caused by deficiency of:

(A) Iodine

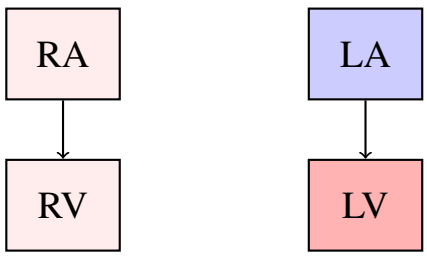
(B) Calcium

(C) Iron

(D) Phosphorus

Q30. The diagram below represents the structure of mammalian heart chambers and major blood vessels. Which chamber pumps oxygenated blood to the body?

RA: Right Atrium LA: Left Atrium



RV: Right Ventricle LV: Left Ventricle (?)

(A) Right atrium

(B) Left atrium

(C) Right ventricle

(D) Left ventricle

Q31. The red hairy caterpillar (Amsacta moorei) is a major pest of:

(A) Cotton and groundnut

(B) Sugarcane and rice

(C) Vegetables only

(D) Wheat and barley

Q32. In the human excretory system, the functional unit responsible for urine formation is:

(A) Bowman's capsule

(B) Nephron

(C) Collecting duct

(D) Glomerulus

Q33. The reflex action does not involve the cerebrum because:

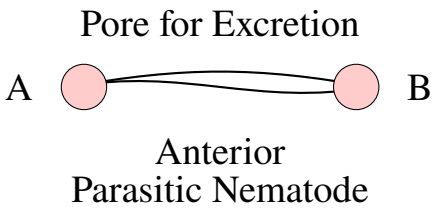
(A) It requires faster response

(B) It is a voluntary action

(C) It requires conscious decision

(D) It involves only the limbic system

Q34. The organism shown in the diagram below represents a parasitic roundworm. The structure marked is used for:



(A) Sensory reception

(B) Attachment to host

(C) Excretion of nitrogenous wastes

(D) Reproduction

Q35. The structural protein present in the cell membrane is:

(A) Keratin

(B) Spectrin

(C) Collagen

(D) Elastin

Q36. The lymphoid tissue that produces antibodies is:

(A) Thymus gland

(B) Bone marrow

(C) Plasma cells

(D) Spleen

Q37. The vitamin required for blood clotting is:

(A) Vitamin A

(B) Vitamin B12

(C) Vitamin C

(D) Vitamin K

Q38. Biological magnification refers to:

(A) Increase in DDT concentration in higher trophic levels

(B) Decrease in population size

(C) Increase in biodiversity

(D) Increase in photosynthesis

Q39. The pancreatic enzyme that breaks down fats into fatty acids and glycerol is:

(A) Amylase

(B) Trypsin

(C) Lipase

(D) Chymotrypsin

Q40. Osmoregulation in freshwater fishes is maintained by:

(A) Drinking large quantities of water

(B) Producing dilute urine

(C) Active uptake of salts through gills

(D) All of the above

Detailed Solutions

Q1.

Solution

Concept:

Xylem tissue is specialized for water and mineral transport in plants. Within xylem, two main types of conducting cells exist: vessel elements and tracheids. These structures differ significantly in their morphology and functioning, reflecting their evolutionary development and efficiency in water transport.

Solution:

(a) Both vessel elements and tracheids are dead, hollow cells at maturity, lacking nuclei and cytoplasm, allowing free flow of water.

(b) Tracheids possess bordered pits (pits with an overarching arch or border), which regulate water flow and prevent embolism (air entry).

(c) Vessel elements have simple pits (pits without borders), which allow more rapid water movement between adjacent vessel members.

(d) The key structural difference is that vessel elements have perforated end walls (end walls with large holes or perforations), allowing direct connection between adjacent vessel members.

(e) Tracheids, in contrast, have oblique end walls with bordered pits but no perforations, requiring water to pass through pits rather than through open apertures.

(f) This difference means vessel elements provide lower resistance to water flow and are more efficient in water transport than tracheids.

(g) Both structures function in transport of water and dissolved minerals, not minerals alone.

(h) Vessels evolved later than tracheids and represent an evolutionary refinement for more efficient xylem transport in flowering plants.

Final Answer: Vessels have perforated end walls while tracheids have oblique end walls.

Answer: (C)

Go Back to Question 1

Q2.

Solution

Concept:

Photosynthesis's light-dependent reactions are catalyzed by pigment-protein complexes embedded in the thylakoid membrane. Water splitting (photolysis) is a crucial step that replenishes electrons and generates oxygen, representing one of the most important reactions on Earth. This process occurs at a specific photosystem.

Solution:

(a) The light-dependent reactions involve two major photosystems: Photosystem II (PSII) and Photosystem I (PSI), named in the order of their discovery, not their sequence in the electron transport chain.

(b) Water splitting occurs at PSII, specifically at the oxygen-evolving complex containing manganese ions.

(c) At PSII, light energy excites P680 (the chlorophyll reaction center of PSII), enabling it to transfer electrons to the electron transport chain.

(d) Water molecules are split at the oxygen-evolving complex: $2H_2O \rightarrow O_2 + 4H_+ + 4e$

(e) The electrons released from water splitting are used to regenerate P680, making continuous light absorption possible.

(f) PSI is downstream in the electron flow and is involved in the reduction of $NADP_+$ to NADPH, not water splitting.

(g) The cytochrome b6f complex transfers electrons between PSII and PSI but does not split water.

(h) ATP synthase uses the proton gradient to synthesize ATP but is not involved in water splitting.

(i) The oxygen produced from water splitting is released as a byproduct, which is essential for aerobic life on Earth.

Final Answer: Water splitting occurs at Photosystem II (PSII).

Answer: (B)

Go Back to Question 2

Q3.

Solution

Concept:

Plant families within the order Rosales are diverse in their floral and fruit characteristics. The family Fabaceae (legumes) is distinguished by specific morphological features including unique stamen arrangements and characteristic fruit types. Understanding these diagnostic characters is essential for plant taxonomy.

Solution:

(a) Fabaceae (the pea family) is characterized by several distinctive features that define the family.

(b) A superior ovary is positioned above the insertion of other floral parts and is typical of Fabaceae flowers.

(c) Diadelphous stamens are a characteristic feature of Fabaceae, where the ten stamens are arranged in two groups: nine stamens fused together and one stamen free.

(d) This stamen arrangement is particularly evident in legume flowers and reflects the family's evolutionary history and pollination mechanisms.

(e) The lomentum is a modified legume fruit that is segmented, breaking at constrictions between seeds, characteristic of some Fabaceae members.

(f) Brassicaceae (the mustard family) has tetramerous flowers and siliqua/silicula type fruits, not lomentum.

(g) Rosaceae has perigynous or epigynous flowers with numerous stamens and diverse fruit types, not the diadelphous condition.

(h) Lamiaceae (the mint family) has didynamous stamens and a superior ovary but produces nutlets, not legume-type fruits.

(i) The combination of superior ovary, diadelphous stamens, and lomentum fruit is diagnostic for Fabaceae.

Final Answer: The family is Fabaceae.

Answer: (B)

Go Back to Question 3

Q4.

Solution

Concept:

Plant movements in response to directional stimuli (tropisms) are fundamental to plant ecology and survival. These movements are mediated by differential growth on opposite sides of the plant organ, controlled by hormones and environmental signals. Different tropisms respond to different types of stimuli.

Solution:

(a) Phototropism is the directional growth response toward light, where the stem exhibits positive phototropism and roots exhibit negative phototropism.

(b) However, the specific detection and response to the angle of incoming light from a fixed direction is defined as phototropism in the broader sense.

(c) The question asks specifically about response to the angle of incoming light, which describes the ability of a plant to orient itself relative to a light source.

(d) Phototropism involves the lateral redistribution of auxin (a growth hormone) on the shaded side of the stem, causing asymmetric growth toward light.

(e) Heliotropism involves the tracking of the sun's movement across the sky during the day, particularly in flowers and young leaves.

(f) Nyctinasty (or sleep movements) involves non-directional leaf movements in response to darkness, not light angle perception.

(g) Hyponasty refers to differential growth between the upper and lower surfaces of a leaf, causing the leaf to curve downward.

(h) The process described is phototropism, specifically the directional response to unilateral light.

(i) This response is mediated by blue light receptors (phototropins) that detect light direction and trigger auxin redistribution.

Final Answer: The process is phototropism.

Answer: (A)

Go Back to Question 4

Q5.

Solution

Concept:

The internal anatomy of a dicot stem reveals a highly organized arrangement of tissues adapted for support, transport, and growth. Secondary growth, which increases the girth of the stem, depends on a specialized meristematic tissue. Understanding which tissue mediates this growth is fundamental to plant developmental biology.

Solution:

(a) Secondary growth refers to the increase in diameter (girth) of the stem, distinct from primary growth which increases length.

(b) The cambium (Region B in the diagram) is a lateral meristematic tissue located between the xylem and phloem in dicot stems.

(c) The vascular cambium (often simply called cambium) produces new xylem cells toward the inside and new phloem cells toward the outside.

(d) This activity causes the stem to increase in diameter, with new xylem forming annual rings of wood and new phloem pushing the older phloem outward.

(e) The epidermis (Region A) provides a protective outer layer but does not contribute to secondary growth.

(f) The cortex (Region C) is a region of thin-walled parenchyma cells that provides some structural support but does not actively produce secondary growth.

(g) The pith (Region D) is a central storage and structural tissue but does not contribute to secondary growth.

(h) The cork cambium (phellogen) may also develop in the cortex and produces cork tissue, contributing to secondary growth of the outer layers.

(i) However, the primary agent of secondary growth is the vascular cambium, making Region B the correct answer.

Final Answer: The cambium (Region B) is responsible for secondary growth.

Answer: (B)

Go Back to Question 5

Q6.

Solution

Concept:

Cellular respiration is the process by which cells extract energy from glucose by breaking chemical bonds and transferring that energy to ATP molecules. The complete oxidation of one glucose molecule yields significantly different amounts of ATP depending on the efficiency of the respiration and whether oxygen is available.

Solution:

(a) Glycolysis produces 2 ATP (net) and 2 NADH per glucose molecule in the cytoplasm.

(b) The pyruvate decarboxylation (linking reaction) produces 2 NADH but no direct ATP.

(c) The Krebs cycle (citric acid cycle) produces 2 GTP (equivalent to 2 ATP) and 6 NADH and 2 $FADH_2$ per glucose.

(d) The electron transport chain oxidizes NADH and $FADH_2$, with each NADH producing approximately 2.5 ATP and each $FADH_2$ producing approximately 1.5 ATP.

(e) The complete calculation: 2 (glycolysis) + 2 (Krebs) + (10 NADH × 2.5) + (2 $FADH_2$ × 1.5) = 2 + 2 + 25 + 3 = 32 ATP.

(f) However, due to the cost of transporting NADH across the mitochondrial membrane and variations in efficiency, the actual yield is often cited as 30-32 ATP per glucose.

(g) Earlier textbooks cited 38 ATP or 36 ATP, but current understanding recognizes the lower efficiency due to various transport costs.

(h) The value of 30-32 ATP represents the most accurate estimation for typical aerobic respiration in animal cells.

Final Answer: Approximately 30-32 ATP molecules are produced.

Answer: (C)

Go Back to Question 6

Q7.

Solution

Concept:

The test cross is a specific type of genetic cross used to determine the genotype of an individual exhibiting a dominant phenotype. By crossing an individual of unknown genotype with a homozygous recessive individual, the phenotypic ratio of offspring reveals the parental genotype.

Solution:

(a) A test cross involves crossing an individual with a dominant phenotype with a homozygous recessive individual.

(b) If the dominant individual has genotype Aa, the cross is Aa × aa.

(c) Using a Punnett square: Aa produces A and a gametes in 1:1 ratio; aa produces only a gametes.

(d) The offspring genotypes are: Aa (expressing dominant phenotype) and aa (expressing recessive phenotype) in a 1:1 ratio.

(e) The phenotypic ratio is therefore 1:1 (one dominant : one recessive).

(f) If the heterozygous individual were crossed with another heterozygote (Aa × Aa), the ratio would be 3:1.

(g) The test cross 1:1 ratio is particularly useful because it directly reflects the gametes produced by the heterozygous parent.

(h) The 9:3:3:1 ratio applies to dihybrid crosses involving two genes.

(i) The 9:7 ratio is observed in some modified dihybrid crosses with epistasis.

(j) The test cross is a fundamental technique in classical genetics for determining genotypes.

Final Answer: The phenotypic ratio is 1:1.

Answer: (A)

Go Back to Question 7

Q8.

Solution

Concept:

Ethylene is a gaseous plant hormone with diverse physiological roles, distinct from other plant hormones that regulate growth and development. This hormone is particularly important in fruit maturation and senescence, reflecting its evolutionary role in seed dispersal and plant reproduction.

Solution:

(a) Ethylene (C_2H_4) is a simple hydrocarbon gas that acts as a plant hormone despite its chemical simplicity.

(b) Ethylene is primarily known for promoting fruit ripening, where it triggers the development of fruit color, softening of fruit flesh, and production of aromatic compounds.

(c) During ripening, ethylene acts through a signal transduction pathway that activates transcription factors regulating ripening-related gene expression.

(d) Ethylene also promotes senescence (aging) of leaves and flowers, making them age faster and preparing them for abscission (shedding).

(e) Ethylene can promote leaf and flower senescence but inhibits stem and root elongation, so it does not promote root elongation.

(f) Seed germination is primarily promoted by gibberellins (especially in overcoming dormancy), not ethylene.

(g) Apical dominance is primarily maintained by auxins, not ethylene.

(h) Ethylene is also involved in the triple response to mechanical stress, causing seedlings to thicken and curve when encountering obstacles.

(i) The association between ethylene and fruit ripening is so strong that ethylene is commercially used to ripen bananas and other fruits.

Final Answer: Ethylene is primarily involved in fruit ripening.

Answer: (B)

Go Back to Question 8

Q9.

Solution

Concept:

Nitrogen is an essential macronutrient for plant growth as it is a component of proteins, nucleic acids, and chlorophyll. However, atmospheric nitrogen (N_2) is not directly available to plants because it is unreactive. Specific microorganisms can convert atmospheric nitrogen into bioavailable forms through nitrogen fixation.

Solution:

(a) Nitrogen fixation is the conversion of atmospheric nitrogen (N_2) into ammonia (NH_3) and ammonium (NH_4^+), forms that plants can utilize.

(b) Rhizobium bacteria are nitrogen-fixing bacteria that form nodules on the roots of legume plants (family Fabaceae).

(c) Within these root nodules, Rhizobium bacteria convert atmospheric nitrogen into ammonia using the enzyme nitrogenase.

(d) The plant provides carbohydrates to the bacteria, while the bacteria provide fixed nitrogen to the plant, creating a mutualistic symbiotic relationship.

(e) Azotobacter is a free-living nitrogen-fixing bacterium that can fix nitrogen independently but is not typically associated with legume roots.

(f) Nostoc and other cyanobacteria can also fix nitrogen and are important in aquatic and terrestrial ecosystems.

(g) Mycorrhizal fungi enhance nutrient uptake, particularly phosphorus, but do not fix atmospheric nitrogen.

(h) The most important agricultural association for nitrogen fixation is between Rhizobium and legume plants, enabling sustainable agriculture without synthetic nitrogen fertilizers.

(i) This symbiosis is so significant that legumes are often included in crop rotation to replenish soil nitrogen.

Final Answer: Nitrogen fixation is achieved through Rhizobium bacteria.

Answer: (B)

Go Back to Question 9

Q10.

Solution

Concept:

Plant nutrients are classified into two categories: macronutrients (required in relatively large amounts) and micronutrients (required in smaller amounts but essential for specific metabolic functions). Understanding which elements are macronutrients versus micronutrients is important for diagnosing nutrient deficiencies.

Solution:

(a) Macronutrients include carbon, hydrogen, and oxygen (obtained from air and water) and six mineral macronutrients: nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur.

(b) Nitrogen is essential for proteins, nucleic acids, and chlorophyll synthesis.

(c) Phosphorus is essential for energy transfer (ATP, ADP) and nucleic acid synthesis.

(d) Potassium is essential for enzyme activation, osmotic regulation, and various metabolic processes.

(e) Calcium is essential for cell wall structure, membrane stability, and signal transduction.

(f) Magnesium is the central atom of chlorophyll and is essential for photosynthesis.

(g) Sulfur is essential for protein synthesis (in amino acids methionine and cysteine).

(h) Micronutrients include iron (Fe), manganese (Mn), zinc (Zn), boron (B), copper (Cu), and molybdenum (Mo).

(i) Iron is essential for chlorophyll formation and electron transport in photosynthesis and respiration.

(j) Zinc is essential for enzyme function and protein synthesis.

(k) Therefore, iron and zinc are micronutrients, not macronutrients, making this the correct answer.

Final Answer: Iron and Zinc are NOT macronutrients (they are micronutrients).

Answer: (D)

Go Back to Question 10

Q11.

Solution

Concept:

The Krebs cycle is a series of chemical reactions catalyzed by specific enzymes that oxidize acetyl-CoA to CO_2, generating NADH and $FADH_2$ for the electron transport chain. The first step, catalyzed by citrate synthase, combines acetyl-CoA with oxaloacetate to form citrate.

Solution:

(a) The Krebs cycle (also called the citric acid cycle or tricarboxylic acid cycle) is the central metabolic pathway for oxidizing acetyl groups.

(b) Citrate synthase catalyzes the condensation of acetyl-CoA (a 2-carbon molecule) with oxaloacetate (a 4-carbon molecule) to form citrate (a 6-carbon molecule).

(c) This is the first committed step of the cycle and is an energy-requiring reaction, using the high-energy thioester bond of acetyl-CoA.

(d) Isocitrate dehydrogenase catalyzes the oxidative decarboxylation of isocitrate, producing -ketoglutarate, NADH, and CO_2.

(e) Succinate dehydrogenase catalyzes the oxidation of succinate to fumarate, producing $FADH_2$.

(f) Malate dehydrogenase catalyzes the oxidation of malate to oxaloacetate, regenerating oxaloacetate for the next cycle turn.

(g) Citrate synthase is often the rate-limiting enzyme of the Krebs cycle because its product (citrate) is the first irreversible intermediate.

(h) The enzyme is regulated by feedback inhibition from products (citrate, NADH, ATP) and by feedforward activation from substrates.

(i) Therefore, the enzyme that catalyzes the first step of carboxylation (combining acetyl-CoA with oxaloacetate) is citrate synthase.

Final Answer: The enzyme is citrate synthase.

Answer: (A)

Go Back to Question 11

Q12.

Solution

Concept:

Mitosis is the process of nuclear division that produces two genetically identical daughter nuclei. The spindle fiber apparatus is a structure composed of microtubules that is essential for organizing and separating chromosomes during cell division.

Solution:

(a) The centromere is a specialized region of the chromosome where sister chromatids are held together and where kinetochore proteins assemble.

(b) The centromere itself is not a structure that separates chromatids; rather, it is the attachment point where spindle fibers attach.

(c) Centrioles are cylindrical structures composed of microtubules that organize the spindle apparatus in animal cells. They are not directly involved in chromatid separation.

(d) The spindle fiber (or spindle apparatus) consists of microtubules that form two main categories: kinetochore microtubules and polar microtubules.

(e) Kinetochore microtubules attach to the kinetochores (at the centromeres) of chromosomes and pull sister chromatids toward opposite poles during anaphase.

(f) Polar microtubules extend from the spindle poles and help push the poles apart, contributing to spindle elongation and cell elongation during telophase.

(g) The spindle fibers are the structures that actually pull the separated chromatids (now called chromosomes) to opposite poles of the cell.

(h) The nucleolus is involved in ribosome synthesis and breaks down during prophase but is not involved in chromatid separation.

(i) Therefore, the spindle fiber is the structure most directly responsible for separating chromatids during mitosis.

Final Answer: The spindle fiber separates chromatids.

Answer: (B)

Go Back to Question 12

Q13.

Solution

Concept:

Pollen development is a complex process involving mitosis and differentiation. The site where pollen grains develop is a specialized tissue within the anther structure. Understanding the histology of the anther is essential to understanding pollen formation.

Solution:

(a) The anther is the male reproductive organ of the flower, consisting of pollen sacs (microsporangia) containing developing pollen.

(b) The epidermis of the anther provides a protective outer layer but does not develop pollen.

(c) The endothecium is a layer of cells beneath the epidermis that assists in anther dehiscence (opening) but does not develop pollen.

(d) The connective tissue (vascular tissue) is the central region that provides vascular supply to the anther but does not develop pollen.

(e) The sporogenous tissue (also called pollen sacs or microsporangia) is the tissue that contains microspore mother cells (pollen mother cells).

(f) Microspore mother cells undergo meiosis to produce four haploid microspores, which subsequently develop into pollen grains.

(g) Pollen grains develop from microspores through mitotic divisions and differentiation, with each microspore producing a pollen grain.

(h) Therefore, sporogenous tissue is the tissue responsible for pollen development as it contains the dividing cells that eventually become pollen.

(i) The sporogenous tissue is lined by tapetum, a nutritive layer that provides nutrients for developing pollen grains.

Final Answer: Pollen develops in sporogenous tissue.

Answer: (D)

Go Back to Question 13

Q14.

Solution

Concept:

Ecological succession refers to the process of community change over time. Primary and secondary succession represent different starting points for community development, with distinct environmental conditions and timescales. Understanding the difference between these processes is fundamental to ecology.

Solution:

(a) Primary succession occurs on bare substrate that has never been colonized by organisms, such as newly exposed rock from glacial retreat or volcanic eruptions.

(b) Secondary succession occurs on previously occupied areas where an existing community has been disturbed or removed, such as after fire, deforestation, or abandonment of agricultural land.

(c) In primary succession, pioneer species such as lichens and mosses colonize bare rock, breaking down the substrate and creating soil.

(d) In secondary succession, soil already exists (or can be rapidly restored), allowing faster community recovery and establishment of more complex communities.

(e) Degraded agricultural land shows secondary succession because soil structure, seed bank, and residual vegetation support recovery.

(f) Primary succession on bare rock is much slower than secondary succession because soil formation from weathered rock is a time-consuming process.

(g) The presence of existing soil is the key distinguishing feature: primary succession occurs on newly exposed bare substrate without soil; secondary succession occurs on soil-covered sites.

(h) A previously existing community is not the defining feature of secondary succession; rather, it is the presence of soil that allows faster community development.

Final Answer: Primary succession occurs on newly exposed bare rock.

Answer: (B)

Go Back to Question 14

Q15.

Solution

Concept:

DNA replication is a semi-conservative process where each strand of the parent DNA molecule serves as a template for a new complementary strand. The replication machinery synthesizes DNA in the 5' to 3' direction, creating an asymmetry in synthesis between the two strands.

Solution:

(a) DNA replication proceeds bidirectionally from the origin of replication, creating two replication forks moving in opposite directions.

(b) The leading strand is synthesized continuously in the 5' to 3' direction toward the replication fork, requiring only one RNA primer.

(c) The lagging strand is synthesized discontinuously (in segments called Okazaki fragments) in the 5' to 3' direction, but the overall direction is away from the replication fork.

(d) Each Okazaki fragment on the lagging strand is approximately 1,000-2,000 nucleotides long in prokaryotes and 100-200 nucleotides long in eukaryotes.

(e) Each Okazaki fragment requires its own RNA primer synthesized by primase to initiate synthesis.

(f) DNA polymerase III synthesizes each Okazaki fragment in the 5' to 3' direction, but the segments are arranged 3' to 5' along the lagging strand template.

(g) After synthesis, RNA primers are removed and replaced with DNA, and adjacent Okazaki fragments are joined by DNA ligase.

(h) The leading strand requires continuous synthesis (not Okazaki fragments) due to its orientation relative to the replication fork.

(i) Therefore, Okazaki fragments are synthesized on the lagging strand because this strand's template runs in a direction requiring discontinuous synthesis.

Final Answer: Okazaki fragments are synthesized on the lagging strand.

Answer: (B)

Go Back to Question 15

Q16.

Solution

Concept:

Plant cells maintain water balance through osmotic regulation. When plant cells are placed in a hypertonic external solution, water moves out of the cell, causing the cytoplasm to separate from the cell wall. This phenomenon, called plasmolysis, demonstrates the principles of osmosis and solute potential.

Solution:

(a) Active transport is the movement of substances against a concentration gradient using ATP energy; plasmolysis is driven by osmosis, not active transport.

(b) Osmosis is the movement of water molecules across a semi-permeable membrane from regions of higher water potential (lower solute concentration) to regions of lower water potential (higher solute concentration).

(c) In plasmolysis, the external solution is hypertonic (higher solute concentration) compared to the cell sap, causing water to move out of the cell.

(d) As water leaves the cell, the cell's internal pressure (turgor pressure) decreases, and the cytoplasm shrinks away from the cell wall.

(e) This separation of the cytoplasm from the cell wall is the defining characteristic of plasmolysis.

(f) The cell wall remains rigid and does not move because it is composed of cellulose and other structural polymers that do not stretch under these conditions.

(g) Diffusion involves the movement of solutes, not water, and does not specifically explain plasmolysis.

(h) Imbibition is the absorption of water by dry seeds, not the osmotic movement of water out of cells.

(i) Plasmolysis is a direct demonstration of osmosis because it shows water movement in response to solute concentration differences across a semi-permeable membrane (the cell membrane).

Final Answer: Plasmolysis demonstrates osmosis.

Answer: (B)

Go Back to Question 16

Q17.

Solution

Concept:

Ecosystems function as energy-transforming systems where energy flows from the sun through living organisms. Not all energy is retained at each trophic level; much is lost to heat and respiration. Understanding energy transfer efficiency is crucial to predicting ecosystem productivity and food web structure.

Solution:

(a) Producers (plants) capture approximately 1-5% of incident solar radiation, converting it into chemical energy stored in organic molecules.

(b) When primary consumers eat producers, only approximately 10% of the producer's energy is incorporated into the primary consumer's biomass.

(c) The remaining 90% of energy is lost through respiration (producing heat), feces (indigestible material), and urine (soluble wastes).

(d) This 10% transfer efficiency is approximate and can range from 5-20% depending on the specific organisms and environmental conditions.

(e) Each subsequent trophic level receives approximately 10% of the energy of the trophic level below it.

(f) Therefore: Secondary consumers receive approximately 10% of primary consumer energy, and tertiary consumers receive approximately 10% of secondary consumer energy.

(g) This decreasing energy availability explains why top predators are always rare in ecosystems and food chains typically have only 3-5 trophic levels.

(h) The diagram shows the energy available at each level, illustrating the 10% transfer efficiency between consecutive trophic levels.

(i) This principle is sometimes called the "10% law" and was described by Lindeman in 1942, becoming a fundamental concept in ecology.

Final Answer: Ecological efficiency is approximately 10%.

Answer: (C)

Go Back to Question 17

Q18.

Solution

Concept:

Plant leaf movements can be classified into different types based on their stimuli and mechanisms. Heliotropism involves the tracking of the sun's position across the sky during the day, representing an adaptive behavior that maximizes light capture and heat absorption.

Solution:

(a) Heliotropism (also called heliotropic movement) is the diurnal (daily) tracking of the sun's path across the sky by leaves or flowers.

(b) In the morning, the leaf/flower is oriented toward the eastern sky where the sun rises, and as the day progresses, it rotates to face the moving sun.

(c) This movement is accomplished through differential growth (asymmetric cell elongation) or turgor pressure changes in the pulvinus (a specialized region at the leaf base).

(d) The adaptive value of heliotropism includes maximizing photosynthetic light capture and thermoregulation (warming the flower to attract pollinators).

(e) Heliotropism is exhibited by young leaves and many flowers, including sunflowers, which have given the phenomenon its common name.

(f) Phototropism is the directional growth response toward light (typically toward a unidirectional light source), not tracking the sun's movement.

(g) Nyctinasty refers to non-directional leaf movements in response to darkness, such as the folding of leaflets at night (sleep movements).

(h) Thigmotropism is the response to touch or mechanical stimuli, not light.

(i) The specific characteristic of exposing the flat leaf surface perpendicular to the sun's rays is a hallmark of heliotropism, maximizing light interception.

Final Answer: This phenomenon is heliotropism.

Answer: (A)

Go Back to Question 18

Q19.

Solution

Concept:

PCR (Polymerase Chain Reaction) is a molecular biology technique that has revolutionized genetics, forensics, diagnostics, and research. This technique amplifies specific DNA sequences to detectable levels through repeated cycles of heating and cooling, allowing analysis of minute amounts of DNA.

Solution:

(a) PCR is a DNA amplification technique, not a protein synthesis method. Proteins are synthesized through translation, which does not involve PCR.

(b) PCR specifically amplifies DNA sequences by creating millions of copies of a target DNA segment from a minimal starting amount (even a single DNA molecule).

(c) The PCR process involves three main steps repeated in cycles: (1) denaturation at high temperature (94-95°C) separates DNA strands, (2) annealing at lower temperature (50-65°C) allows primers to bind, and (3) extension at 72°C allows DNA polymerase to synthesize new DNA.

(d) Each cycle doubles the amount of target DNA, resulting in exponential amplification: after 30 cycles, a single DNA molecule is amplified to approximately 1 billion copies.

(e) RNA transcription is a different process where RNA polymerase creates RNA from a DNA template; PCR does not directly accomplish transcription.

(f) Cell division is a biological process; PCR is an in vitro laboratory technique that occurs in a test tube.

(g) PCR applications include: forensic identification, disease diagnosis, genetic fingerprinting, cloning, and preparation of DNA for sequencing.

(h) The DNA polymerase used in PCR (usually Taq polymerase from Thermus aquaticus) must be heat-stable because it is exposed to repeated heating to high temperatures.

Final Answer: PCR is primarily used for DNA amplification.

Answer: (B)

Go Back to Question 19

Q20.

Solution

Concept:

Seed dispersal is the movement of seeds away from the parent plant, ensuring genetic diversity, reducing competition, and allowing colonization of new habitats. Different plants have evolved specialized structures and mechanisms for dispersing seeds using various abiotic and biotic vectors.

Solution:

(a) Seed dispersal mechanisms are classified based on the dispersal agent: wind, water, animals, or by the plant itself.

(b) Anemochory (from Greek: anemo = wind, chory = dispersal) is the dispersal of seeds by wind action.

(c) Plants with wind-dispersed seeds typically have adaptations such as wings, hairs, or pappi (hair-like structures) that catch wind currents.

(d) Examples include the winged seeds of maple and ash trees, the pappus (modified calyx forming a parachute) of dandelion and thistle seeds, and the light, fluffy seeds of milkweed.

(e) Hydrochory is the dispersal of seeds by water, adapted for aquatic and wetland plants.

(f) Zoochory is the dispersal of seeds by animals, including attachment to fur, feathers, or digestive passage through the animal.

(g) Autochory (also called autochorous dispersal) is the dispersal of seeds by the plant itself, through mechanical ejection mechanisms.

(h) The specific term for wind dispersal is anemochory, making this the correct answer to the question.

(i) Wind dispersal allows seeds to travel great distances and colonize new areas without dependence on animal vectors.

Final Answer: Wind dispersal is called anemochory.

Answer: (B)

Go Back to Question 20

Q21.

Solution

Concept:

The Calvin cycle (light-independent reactions) is the portion of photosynthesis that converts CO_2 and water into glucose. This process requires ATP and NADPH from the light-dependent reactions. The first enzyme in the Calvin cycle catalyzes the carboxylation of a five-carbon sugar, a critical and highly regulated step.

Solution:

(a) The Calvin cycle occurs in the stroma of the chloroplast and does not require light directly (hence "light-independent").

(b) The cycle begins with the carboxylation of ribulose-1,5-bisphosphate (RuBP), a five-carbon sugar, using atmospheric CO_2.

(c) The enzyme ribulose-1,5-bisphosphate carboxylase/oxygenase (RuBisCO) catalyzes this carboxylation reaction.

(d) RuBisCO is the most abundant protein on Earth and is responsible for fixing the vast majority of atmospheric CO_2 into organic molecules.

(e) The carboxylation of RuBP produces an unstable six-carbon intermediate that immediately splits into two molecules of 3-phosphoglycerate (3-PG).

(f) Phosphofructokinase (PFK) is an enzyme of glycolysis, not the Calvin cycle.

(g) Aldolase is an enzyme of glycolysis and the pentose phosphate pathway, not the Calvin cycle.

(h) Hexokinase is an enzyme of glycolysis, not the Calvin cycle.

(i) RuBisCO is the correct enzyme that catalyzes CO_2 fixation in the Calvin cycle, making this the definitive answer.

(j) RuBisCO is also unique because it has oxygenase activity in addition to carboxylase activity, which can lead to photorespiration if CO_2 levels are low.

Final Answer: The enzyme is RuBisCO.

Answer: (B)

Go Back to Question 21

Q22.

Solution

Concept:

Asexual reproduction produces offspring genetically identical to the parent through mitotic division, avoiding meiosis and gamete fusion. This process allows rapid population increase and colonization of new habitats without dependence on finding a compatible mate.

Solution:

(a) Sexual reproduction involves the fusion of two gametes (sperm and egg), creating genetic variation through recombination.

(b) Vegetative (or asexual) reproduction produces offspring from non-gametic tissues without meiosis or gamete fusion, creating clones genetically identical to the parent.

(c) Vegetative reproduction includes mechanisms such as fragmentation (breaking into pieces that grow into new organisms), budding (growth of a new individual from parent tissue), and vegetative propagation from tubers, runners, or other vegetative structures.

(d) Regeneration is the regrowth of lost body parts, which is different from vegetative reproduction (though some organisms can regenerate entire individuals from small fragments).

(e) Fragmentation alone is only one type of vegetative reproduction; other types exist (budding, spore production, vegetative growth).

(f) Vegetative reproduction encompasses all asexual reproductive processes, including fragmentation, budding, spore formation, rhizoid formation, and stoloniferous growth.

(g) The advantages of vegetative reproduction include rapid population growth, no energy expenditure for mating behavior, and preservation of successful genotypes.

(h) The disadvantage is the lack of genetic diversity, which can reduce the population's ability to adapt to environmental changes.

(i) Vegetative reproduction is particularly important in plants but occurs in some animal groups as well.

Final Answer: The process is vegetative reproduction.

Answer: (B)

Go Back to Question 22

Q23.

Solution

Concept:

Bacterial diseases of crops are significant agricultural problems causing substantial yield losses. These diseases are caused by Gram-negative or Gram-positive bacteria that typically enter through natural openings or wounds. Rice is susceptible to several bacterial diseases, with bacterial blight being a major concern in South Asia.

Solution:

(a) Bacterial blight of rice is a major disease in India, Bangladesh, and other Asian rice-growing regions.

(b) The causal agent is Xanthomonas oryzae pv. oryzae (also written as X. oryzae pv. oryzae), a Gram-negative bacterium.

(c) The bacteria enter rice leaves through the vascular tissue after entering through water stomata or wounded tissues.

(d) Symptoms include elongated necrotic lesions on leaves that progress from the leaf margin inward, with a characteristic yellow halo around the lesion in advanced stages.

(e) The disease is particularly severe in warm, wet conditions with high humidity, which promote bacterial multiplication and spread.

(f) Pyricularia oryzae causes rice blast, a fungal disease characterized by diamond-shaped lesions on rice leaves and panicles.

(g) Fusarium oxysporum causes various wilt diseases in crops but is not the primary rice pathogen.

(h) Rhizoctonia solani causes sheath blight and other diseases in rice and other crops.

(i) Management of bacterial blight includes use of resistant varieties, proper sanitation, and avoidance of overhead irrigation that promotes bacterial spread through water splash.

Final Answer: Bacterial blight is caused by Xanthomonas oryzae pv. oryzae.

Answer: (A)

Go Back to Question 23

Q24.

Solution

Concept:

Genetic variation refers to the difference in allele frequencies and genetic composition within a population. This variation is the raw material for evolution and is essential for populations to adapt to environmental changes and maintain evolutionary fitness.

Solution:

(a) Genetic drift is the random change in allele frequencies in a population from one generation to the next, particularly important in small populations.

(b) Gene flow (also called migration) is the movement of alleles from one population to another through individual movement and interbreeding.

(c) Genetic variation is the presence of different alleles and genotypes within a population, resulting from mutation, recombination, and gene flow.

(d) Natural selection is the differential survival and reproduction of organisms based on their traits, leading to changes in allele frequencies over time.

(e) Genetic variation within a population is the diversity of genetic material present, measured by the number of alleles, genotype frequencies, and heterozygosity.

(f) A population with high genetic variation has many different alleles at each locus, allowing greater potential for adaptation to environmental changes.

(g) Genetic variation is essential for: (1) Populations to respond to selection pressure, (2) Maintenance of fitness and disease resistance, (3) Adaptation to environmental changes, (4) Long-term survival of populations.

(h) Genetic variation arises from mutation (the ultimate source of new alleles), sexual reproduction (recombination and segregation), and gene flow between populations.

Final Answer: The variety of genetic information is genetic variation.

Answer: (C)

Go Back to Question 24

Q25.

Solution

Concept:

Stomata are highly specialized structures that regulate gas exchange in plants. These pores are under strict physiological control, responding to various environmental and endogenous signals. The gases exchanged through stomata are intimately linked to photosynthesis and respiration.

Solution:

(a) Stomata (singular: stoma) are pores in the leaf epidermis, typically located on the lower surface (abaxial side) in most dicots.

(b) Each stomate is surrounded by two specialized guard cells that control the opening and closing of the pore.

(c) The primary function of stomata is to allow gas exchange while minimizing water loss through transpiration.

(d) Carbon dioxide (CO_2) enters through stomata for photosynthesis, while oxygen (O_2) is released as a photosynthetic byproduct.

(e) Stomata open during the day when light is available for photosynthesis, allowing CO_2 influx.

(f) Stomata close at night when photosynthesis is not occurring, reducing water loss when light is unavailable.

(g) Nitrogen and oxygen are not the primary gases exchanged through stomata in the context of photosynthesis.

(h) While both carbon dioxide and nitrogen are important plant nutrients, nitrogen is primarily absorbed from soil as nitrate or ammonium ions, not as a gas through stomata.

(i) Therefore, stomata regulate the exchange of carbon dioxide and oxygen, the gases directly involved in photosynthesis and respiration.

Final Answer: Stomata regulate carbon dioxide and oxygen exchange.

Answer: (B)

Go Back to Question 25

Q26.

Solution

Concept:

Parasitic protozoans cause significant human diseases, each with specific etiological agents, transmission mechanisms, and pathogenesis. Visceral leishmaniasis (kala-azar) is a severe systemic infection endemic in India and other tropical and subtropical regions.

Solution:

(a) Leishmaniasis is caused by parasitic protozoans of the genus Leishmania, with different species causing different forms of the disease.

(b) Leishmania donovani causes visceral leishmaniasis (kala-azar), a systemic infection affecting the spleen, liver, and bone marrow.

(c) The term "kala-azar" is Hindi for "black fever," referring to the darkening of the skin that can occur during the disease.

(d) Visceral leishmaniasis is transmitted by the female phlebotomine sandfly, which ingests parasites while taking a blood meal on infected individuals.

(e) Symptoms include prolonged fever, weight loss, splenomegaly (enlarged spleen), hepatomegaly (enlarged liver), and anemia.

(f) Untreated visceral leishmaniasis is fatal in the majority of cases, but effective treatment with antimony compounds or amphotericin B exists.

(g) Plasmodium malariae causes a type of malaria (quartan malaria with fever every 72 hours), not visceral leishmaniasis.

(h) Entamoeba histolytica causes amoebic dysentery and liver abscess (amoebic hepatitis), not visceral leishmaniasis.

(i) Giardia intestinalis causes acute diarrhea and chronic malabsorption, not visceral leishmaniasis.

(j) India is endemic for visceral leishmaniasis, with the disease primarily found in Bihar, Uttar Pradesh, and adjacent regions.

Final Answer: Visceral leishmaniasis is caused by Leishmania donovani.

Answer: (B)

Go Back to Question 26

Q27.

Solution

Concept:

Arthropods constitute the largest and most diverse animal phylum, with over one million described species. The defining characteristics of arthropods have enabled their remarkable adaptive radiation and colonization of nearly every terrestrial and aquatic habitat on Earth.

Solution:

(a) Arthropods are characterized by a segmented body plan, jointed appendages (legs, antennae, mouthparts), and a chitinous exoskeleton.

(b) The jointed appendages (derived from the Greek "arthro" = joint, "poda" = foot) are the defining feature that distinguishes arthropods from other invertebrates.

(c) These jointed appendages are highly specialized for various functions: locomotion, sensory reception, feeding, and reproduction.

(d) The chitinous exoskeleton is composed of layers of chitin, a polysaccharide, and protein, providing rigidity and structural support while remaining relatively lightweight.

(e) The exoskeleton is shed periodically during molting (ecdysis) to allow growth, as the rigid exoskeleton does not expand.

(f) The segmentation in arthropods is less obvious than in annelids because adjacent segments often fuse to form body regions (tagmata) such as head, thorax, and abdomen in insects.

(g) A notochord is present in chordates, not arthropods.

(h) A complete digestive system is present in many invertebrates, not unique to arthropods.

(i) The combination of jointed appendages and a chitinous exoskeleton provides arthropods with superior mobility and protection compared to other invertebrates.

(j) These features, along with a well-developed nervous system and diverse sensory receptors, explain arthropod success.

Final Answer: Jointed appendages and chitinous exoskeleton are characteristic.

Answer: (B)

Go Back to Question 27

Q28.

Solution

Concept:

The human circulatory system is a closed system where blood is transported through arteries, capillaries, and veins. Different vessels carry blood with different oxygen content: oxygenated blood flows from the lungs to the heart and body, while deoxygenated blood returns to the heart and lungs.

Solution:

(a) The superior vena cava drains blood from the head, neck, and upper body, while the inferior vena cava drains blood from the lower body and abdominal organs.

(b) Together, these two major veins deliver deoxygenated blood from the entire body to the right atrium of the heart.

(c) The pulmonary artery carries deoxygenated blood from the right ventricle to the lungs for oxygenation.

(d) The pulmonary veins (typically four: two left and two right) carry oxygenated blood from the lungs to the left atrium.

(e) The aorta carries oxygenated blood from the left ventricle to the entire body.

(f) The systemic circulation begins at the aorta and ends at the vena cava, distributing oxygenated blood and collecting deoxygenated blood.

(g) The pulmonary circulation is the circuit between the heart and lungs, where blood is reoxygenated.

(h) The superior and inferior vena cava are the correct vessels that carry deoxygenated blood from the body to the right atrium.

(i) This arrangement ensures that deoxygenated blood reaches the lungs for reoxygenation before being pumped to the body again.

Final Answer: The superior and inferior vena cava carry deoxygenated blood.

Answer: (C)

Go Back to Question 28

Q29.

Solution

Concept:

The thyroid gland produces thyroid hormones (T3 and T4) that regulate metabolism throughout the body. Iodine is an essential element for thyroid hormone synthesis, and its deficiency leads to a characteristic enlargement of the thyroid gland and metabolic dysfunction.

Solution:

(a) Thyroid hormones (triiodothyronine, T3, and thyroxine, T4) contain iodine atoms essential for their structure and function.

(b) Iodine is obtained from the diet (iodized salt, seafood, dairy products) and is concentrated in the thyroid gland.

(c) Each T4 molecule contains four iodine atoms, while each T3 molecule contains three iodine atoms.

(d) Without adequate iodine, the thyroid cannot synthesize sufficient thyroid hormones, leading to hypothyroidism.

(e) Goiter is the enlargement of the thyroid gland, which occurs when the gland attempts to increase hormone production despite iodine deficiency by increasing the number of hormone-producing follicles.

(f) Metabolic slowdown occurs because thyroid hormones increase metabolic rate. Deficiency causes a decrease in metabolic rate, resulting in weight gain, fatigue, and cold sensitivity.

(g) Cretinism (now called congenital hypothyroidism) occurs when severe iodine deficiency affects fetal development, causing intellectual disability if untreated.

(h) Calcium deficiency causes hyperparathyroidism, not goiter.

(i) Iron deficiency causes anemia, not goiter.

(j) Phosphorus deficiency causes rickets, not goiter.

(k) Iodine supplementation programs have successfully prevented goiter and cretinism in many countries, making iodized salt a public health success.

Final Answer: Goiter and metabolic slowdown result from iodine deficiency.

Answer: (A)

Go Back to Question 29

Q30.

Solution

Concept:

The mammalian heart is a four-chambered organ with specialized regions for blood collection and pumping. Each chamber has distinct functions and receives blood from specific vessels. Understanding the chamber-specific functions is essential to comprehending cardiac physiology.

Solution:

(a) The right atrium receives deoxygenated blood from the body through the superior and inferior vena cava.

(b) The left atrium receives oxygenated blood from the lungs through the pulmonary veins.

(c) The right ventricle pumps deoxygenated blood to the lungs through the pulmonary artery.

(d) The left ventricle is the largest and most muscular chamber, pumping oxygenated blood to the entire body through the aorta.

(e) The diagram shows the left ventricle (LV) with a question mark, indicating it is the chamber being asked about.

(f) The left ventricle's thick muscular walls allow it to generate sufficient pressure to pump oxygenated blood throughout the entire systemic circulation.

(g) The left ventricle receives oxygenated blood from the left atrium and contracts powerfully to eject this blood into the aorta.

(h) This systemic circulation delivers oxygen to all body tissues and returns deoxygenated blood to the right atrium.

(i) The left ventricle is the only structure capable of generating the pressure necessary to distribute oxygenated blood throughout the entire body.

Final Answer: The left ventricle pumps oxygenated blood to the body.

Answer: (D)

Go Back to Question 30

Q31.

Solution

Concept:

Agricultural pests include both insects and non-insect invertebrates that cause significant crop damage. The red hairy caterpillar is a major pest of various crops in India, particularly during the rainy season. Understanding pest biology is essential for developing effective management strategies.

Solution:

(a) The red hairy caterpillar (Amsacta moorei, also called the hairy caterpillar) is the larval stage of the Erebid moth.

(b) This pest causes damage primarily during the monsoon season (kharif) when the larvae feed voraciously on crop leaves.

(c) Groundnut (peanut) is a major crop affected by the red hairy caterpillar, which can completely defoliate the plant.

(d) Cotton is also highly susceptible to this pest, with larvae feeding on leaves and occasionally on cotton bolls.

(e) The larvae are gregarious (live in groups), moving in large masses from field to field, making them visually conspicuous and distinctive.

(f) Control measures include hand-picking of egg masses and larvae, cultural practices such as deep ploughing to destroy pupae, and chemical insecticides when necessary.

(g) Sugarcane and rice are susceptible to different pest complexes, though the hairy caterpillar can occasionally be found on these crops.

(h) Vegetables are damaged by various caterpillars, but the red hairy caterpillar has a preference for legumes and cotton.

(i) Wheat and barley are rabi crops and are generally not affected by this pest, which is primarily active in the rainy season.

(j) The combination of cotton and groundnut susceptibility makes these the primary hosts for the red hairy caterpillar in India.

Final Answer: The red hairy caterpillar is a pest of cotton and groundnut.

Answer: (A)

Go Back to Question 31

Q32.

Solution

Concept:

The kidney is the primary organ of the urinary system, responsible for filtering blood and producing urine. The functional unit of the kidney is the nephron, a microscopic structure capable of ultrafiltration and selective reabsorption of useful substances.

Solution:

(a) The nephron is the functional unit of the kidney, consisting of a renal corpuscle (Bowman's capsule and glomerulus) and a renal tubule.

(b) Each kidney contains approximately one million nephrons, allowing for continuous and efficient blood filtration.

(c) Bowman's capsule is a cup-like structure that surrounds the glomerulus and collects the filtrate produced by ultrafiltration.

(d) The glomerulus is a network of specialized capillaries where ultrafiltration occurs, driven by blood pressure and the selective permeability of the glomerular filtration barrier.

(e) The collecting duct is a structure that receives and concentrates urine from the distal convoluted tubule, adjusting water reabsorption based on ADH (antidiuretic hormone).

(f) The nephron performs three main functions: (1) ultrafiltration in the Bowman's capsule/glomerulus, (2) selective reabsorption in the proximal convoluted tubule, and (3) collection and concentration in the collecting duct.

(g) Water, glucose, amino acids, ions, and urea are filtered from the blood into the Bowman's capsule.

(h) Useful substances (glucose, amino acids, ions, and some water) are selectively reabsorbed in the proximal convoluted tubule, returning to the blood through peritubular capillaries.

(i) The remaining fluid (urine) contains primarily urea, excess water, and other waste products.

(j) Therefore, the nephron, as the functional unit, is responsible for the entire process of urine formation.

Final Answer: The nephron is the functional unit of urine formation.

Answer: (B)

Go Back to Question 32

Q33.

Solution

Concept:

Reflex actions are rapid, involuntary responses to stimuli that occur without conscious processing. The reflex arc is a neural pathway that bypasses the brain, allowing for immediate response when speed is essential for survival. This represents an important distinction between reflexive and conscious behavior.

Solution:

(a) A reflex action is an automatic response to a stimulus that occurs without conscious deliberation or involvement of the cerebrum.

(b) The reflex arc is a neural pathway consisting of a sensory receptor, sensory neuron, synapse in the spinal cord, motor neuron, and effector.

(c) When a stimulus is detected, the sensory neuron transmits the signal directly to an interneuron in the spinal cord, which synapses with a motor neuron.

(d) The motor neuron carries the signal directly to the appropriate muscle, causing a rapid response without waiting for signals from the brain.

(e) This short pathway is advantageous because reflex responses are much faster than conscious responses, which require processing in the brain and decision-making.

(f) The classic example is the withdrawal reflex: touching a hot surface triggers immediate withdrawal of the hand before you even consciously feel pain.

(g) A voluntary action requires cerebral processing, conscious decision-making, and signals from the cerebral cortex through pyramidal tracts.

(h) The reflex action bypasses this slower pathway, allowing the body to protect itself immediately upon detecting danger.

(i) Therefore, reflex actions do not involve the cerebrum because they require faster response than is possible with conscious decision-making and brain processing.

(j) Signals from the reflex are still sent to the brain (via sensory neurons that continue upward), where you become aware of the stimulus and the response after it has already occurred.

Final Answer: Reflex actions require faster response than brain processing allows.

Answer: (A)

Go Back to Question 33

Q34.

Solution

Concept:

Parasitic nematodes are elongated, unsegmented worms that parasitize humans and animals. These organisms have specialized structures adapted to their parasitic lifestyle. Understanding nematode anatomy is essential to diagnosing infections and understanding the mechanism of parasitism.

Solution:

(a) The organisms shown in the diagram are parasitic roundworms (nematodes) with anterior (front) and posterior (rear) ends marked.

(b) The structures marked at the anterior and posterior ends are likely sensory organs (amphids and phasmids, respectively) used for chemoreception and sensing the environment.

(c) However, the diagram specifically shows structures marked as pores for excretion, indicating that these are excretory pores.

(d) In nematodes, the excretory system consists of one or more excretory pores through which nitrogenous wastes are excreted.

(e) Some nematodes have anterior excretory pores (openings in the pharyngeal region), while others have posterior excretory pores or lateral excretory pores.

(f) The excretory pores are used specifically for excretion of nitrogenous wastes and sometimes urine.

(g) Sensory reception occurs through amphids and phasmids, specialized sensory organs distinct from excretory pores.

(h) Attachment to the host occurs through specialized structures like hooks or teeth in the anterior end (buccal capsule), not through the pores shown.

(i) Reproduction involves specialized reproductive organs located in the body cavity, not the pores shown.

(j) Therefore, the structures shown are used for excretion of nitrogenous wastes.

Final Answer: The structures are used for excretion of nitrogenous wastes.

Answer: (C)

Go Back to Question 34

Q35.

Solution

Concept:

The cell membrane (plasma membrane) is composed of a phospholipid bilayer embedded with proteins and cholesterol. Proteins in the membrane have various functions: some are structural, some are enzymatic, and some are involved in transport. Understanding membrane structure is fundamental to cell biology.

Solution:

(a) The cell membrane contains two main categories of proteins: integral (transmembrane) proteins and peripheral proteins.

(b) Spectrin is a cytoplasmic protein that binds to the inner surface of the cell membrane and provides structural support to the cell.

(c) Spectrin forms a network beneath the membrane in red blood cells, helping maintain cell shape and mechanical flexibility.

(d) This is why spectrin is often called a "skeleton" protein—it provides structural integrity to the cell.

(e) Keratin is an intermediate filament protein found in the cytoplasm, providing structural support but not specifically associated with the cell membrane.

(f) Collagen is an extracellular matrix protein found outside cells, providing structural support to tissues but not in the cell membrane.

(g) Elastin is an extracellular matrix protein providing elasticity to tissues but not in the cell membrane.

(h) While many membrane proteins (like integrins, cadherins) contribute to cell structure, spectrin specifically provides the structural protein scaffold beneath the membrane.

(i) In red blood cells (RBCs), spectrin is essential: mutations in spectrin genes cause hereditary spherocytosis, a condition affecting RBC shape and function.

(j) Therefore, spectrin is the structural protein present in the cell membrane.

Final Answer: The structural protein is spectrin.

Answer: (B)

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Q36.

Solution

Concept:

The immune system consists of lymphoid tissues that produce and house cells responsible for immune defense. Different lymphoid tissues have different roles: some produce immune cells, while others are sites of immune cell maturation or activation. Understanding lymphoid tissues is essential to immunology.

Solution:

(a) Plasma cells (differentiated B cells) produce antibodies and are the effector cells of the humoral immune response.

(b) However, plasma cells are located in lymphoid tissues; they are not the tissue itself that produces antibodies.

(c) The spleen is a lymphoid organ that filters blood, removes pathogens, and houses B and T lymphocytes; it contributes to antibody production by housing plasma cells.

(d) Bone marrow is the primary lymphoid tissue that produces all blood cells, including B lymphocytes and some T lymphocyte precursors.

(e) The thymus gland is a primary lymphoid tissue where T cells mature and become immunocompetent, not where they produce antibodies.

(f) Secondary lymphoid tissues (spleen, lymph nodes, gut-associated lymphoid tissue) are sites where immune responses occur, with B cells differentiating into plasma cells that produce antibodies.

(g) Lymph nodes are secondary lymphoid tissues where B and T cells interact with antigens and with each other, leading to immune responses and antibody production.

(h) The spleen, as a secondary lymphoid organ, filters blood and houses B cells that differentiate into antibody-producing plasma cells in response to antigens.

(i) Therefore, multiple lymphoid tissues contribute to antibody production, but the spleen and lymph nodes are the sites where plasma cells (antibody-producing cells) are generated.

Final Answer: The spleen produces antibodies through plasma cells.

Answer: (D)

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Q37.

Solution

Concept:

Vitamins are essential organic compounds required for numerous physiological functions. Fat-soluble vitamins are absorbed with dietary fat and can accumulate in tissues, while water-soluble vitamins are not stored and must be consumed regularly. Blood clotting requires the participation of specific vitamin-dependent factors.

Solution:

(a) Blood clotting involves a cascade of enzymatic reactions where various clotting factors interact to form a blood clot.

(b) Vitamin K is a fat-soluble vitamin essential for the synthesis of several clotting factors: II (prothrombin), VII, IX, and X.

(c) These factors undergo gamma-carboxylation (addition of carboxyl groups to glutamic acid residues), a post-translational modification that requires vitamin K as a cofactor.

(d) Without adequate vitamin K, these clotting factors cannot be properly activated, leading to prolonged bleeding times and increased risk of bleeding.

(e) Vitamin K deficiency can occur due to dietary insufficiency, malabsorption of fat-soluble vitamins, or use of antibiotics that destroy gut bacteria that produce vitamin K.

(f) Warfarin, a commonly used anticoagulant drug, works by inhibiting vitamin K-dependent clotting factor synthesis, prolonging bleeding time therapeutically.

(g) Vitamin A is involved in vision and immune function, not blood clotting.

(h) Vitamin B12 is involved in DNA synthesis and neurological function, not blood clotting.

(i) Vitamin C (ascorbic acid) is involved in collagen synthesis and is required for wound healing but is not directly involved in blood clotting.

(j) Vitamin K is uniquely essential for blood clotting factor synthesis.

Final Answer: Vitamin K is required for blood clotting.

Answer: (D)

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Q38.

Solution

Concept:

Ecological efficiency and energy transfer in food webs are subject to physical and biological constraints. Bioaccumulation and biomagnification represent the accumulation of substances through food chains, with significant implications for environmental toxicology and conservation.

Solution:

(a) Bioaccumulation is the accumulation of a substance in an organism over time, with the concentration increasing with repeated exposure.

(b) Biomagnification (or biological magnification) is the increase in concentration of a substance as it passes through successive trophic levels in a food chain.

(c) DDT (dichlorodiphenyltrichloroethane) is a pesticide that exhibits both bioaccumulation and biomagnification.

(d) DDT is fat-soluble (lipophilic) and resistant to degradation, so it accumulates in body tissues and is passed along food chains with increasing concentration.

(e) At the top of the food chain, predatory birds and mammals can accumulate DDT to concentrations millions of times higher than in the environment or in producers.

(f) This high concentration of DDT interferes with calcium metabolism in birds, causing eggshell thinning and preventing successful reproduction.

(g) Populations of peregrine falcons, eagles, and other raptors were severely damaged by DDT-induced eggshell thinning before DDT was banned.

(h) Biomagnification is specific to persistent, fat-soluble compounds and does not occur with all pollutants (particularly water-soluble ones that are more readily excreted).

(i) Decrease in population size is a consequence of biomagnification but is not the definition of the phenomenon.

(j) Increase in biodiversity or photosynthesis are not effects of biomagnification.

Final Answer: Biological magnification refers to increased DDT concentration in higher trophic levels.

Answer: (A)

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Q39.

Solution

Concept:

Lipid digestion is a complex process involving mechanical emulsification, enzymatic breakdown, and formation of micelles. Different enzymes are involved, each with specific substrates and locations of action within the digestive tract.

Solution:

(a) Lipase is an enzyme that catalyzes the hydrolysis of lipid molecules (fats and oils) into fatty acids and glycerol.

(b) Pancreatic lipase is produced by the pancreas and is the major enzyme responsible for dietary lipid digestion in the small intestine.

(c) Pancreatic lipase requires colipase (a pancreatic cofactor) for efficient function in the presence of bile salts.

(d) The reaction catalyzed by lipase: Triglycerides $\rightarrow$ Diglycerides + Fatty acids, or complete hydrolysis producing Glycerol + 3 Fatty acids.

(e) Lipase action is preceded by bile salt emulsification of lipids, which increases the surface area available for enzymatic attack.

(f) Amylase is an enzyme that catalyzes the hydrolysis of carbohydrates (starch), not lipids.

(g) Trypsin is a serine protease that catalyzes protein digestion, not lipid digestion.

(h) Chymotrypsin is another serine protease involved in protein digestion, not lipid digestion.

(i) The products of lipase action (fatty acids and glycerol) are used for energy and can be absorbed through the intestinal epithelium.

(j) Therefore, lipase is the pancreatic enzyme that breaks down fats into fatty acids and glycerol.

Final Answer: The enzyme is lipase.

Answer: (C)

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Q40.

Solution

Concept:

Osmoregulation is the physiological process by which organisms maintain osmotic balance and prevent excessive water loss or uptake. Different organisms have evolved specialized mechanisms suited to their environment. Freshwater and saltwater organisms face opposite osmoregulatory challenges.

Solution:

(a) Freshwater fishes face the problem of hypotonic external environment: water constantly enters the body through osmosis.

(b) Saltwater fishes face the opposite problem: the external environment is hypertonic, and water constantly leaves the body.

(c) To maintain osmotic balance, freshwater fishes produce dilute urine with a low solute concentration, excreting excess water.

(d) Freshwater fishes also actively uptake salts through their gills using active transport, retaining essential ions while diluting urine.

(e) Freshwater fishes do NOT drink large quantities of water; in fact, they must restrict water intake to avoid excessive dilution of body fluids.

(f) The kidneys of freshwater fishes are adapted to produce large volumes of dilute urine, and the gills actively reabsorb ions from the environment.

(g) Drinking large quantities of water would worsen the osmoregulatory challenge by increasing the water load that must be excreted.

(h) Active uptake of salts through gills is a major mechanism for maintaining ion balance and is essential for freshwater fish osmoregulation.

(i) The combination of producing dilute urine and actively uptaking salts through the gills represents the integrated osmoregulatory strategy of freshwater fishes.

(j) Therefore, "all of the above" is not the correct answer because freshwater fishes specifically do NOT drink large quantities of water.

Final Answer: Freshwater fishes produce dilute urine and actively uptake salts.

Answer: (C)

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Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	C	2	B	3	B	4	A	5	B
6	C	7	A	8	B	9	B	10	D
11	A	12	B	13	D	14	B	15	B
16	B	17	C	18	A	19	B	20	B
21	B	22	B	23	A	24	C	25	B
26	B	27	B	28	C	29	A	30	D
31	A	32	B	33	A	34	C	35	B
36	D	37	D	38	A	39	C	40	C