UPCATET Biology Sample Paper-5

Duration: 80 Minutes **Maximum Marks: 320**

Instructions

- This paper contains **80** Multiple Choice Questions.
- Each correct answer carries **+4** mark. Incorrect answer: **−1** marks. Only **one** correct option.
- Unattempted questions carry **0** marks.
- Use of mobile phones, smartwatches, or any electronic gadgets is strictly prohibited.

Q1. A complete turn of the DNA double helix in its B-form contains 10 base pairs. If a double-stranded DNA molecule has a length of 340 Å, how many complete turns are present, and what is the total number of hydrogen bonds if adenine constitutes 30% of the total bases?

(A) 100 turns and 200 hydrogen bonds

(B) 100 turns and 240 hydrogen bonds

(C) 10 turns and 220 hydrogen bonds

(D) 100 turns and 220 hydrogen bonds

Q2. An anatomical cross-section of a plant stem shows open vascular bundles arranged in a distinct ring, a well-defined parenchymatous pericycle, and a collenchymatous hypodermis. Which of the following families typically exhibits this specific layout?

(A) Liliaceae

(B) Solanaceae

(C) Poaceae

(D) Orchidaceae

Q3. During cellular respiration, when one molecule of acetyl-CoA undergoes complete oxidation through the citric acid cycle and subsequent oxidative phosphorylation, the net yield of ATP synthesized purely via substrate-level phosphorylation is:

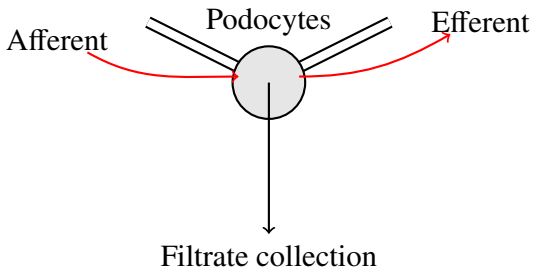
(A) 1 ATP

(B) 2 ATP

(C) 3 ATP

(D) 12 ATP

Q4. Refer to the schematic TikZ model below representing a functional structural unit within the human physiological system:



If the hydrostatic pressure within the capillary network shown above decreases significantly below normal homeostatic levels, which of the following immediate physiological outcomes will occur?

(A) The ultrafiltration rate will dramatically increase due to compensation.

(B) Glomerular filtration rate (GFR) drops, triggering the juxtaglomerular apparatus to release renin.

(C) Podocytes expand to increase mechanical fluid permeability into the capsular space.

(D) Capsular hydrostatic pressure becomes highly negative to pull fluid across.

Q5. Which of the following elements acts as a structural component of the oxygen-evolving complex (OEC) during the light-dependent reactions of oxygenic photosynthesis?

(A) Magnesium and Iron

(B) Manganese, Calcium, and Chlorine

(C) Copper and Zinc

(D) Molybdenum and Boron

Q6. In a multi-enzyme metabolic pathway, an abundance of the end-product binds to an regulatory site of the initial rate-limiting enzyme, distinct from its catalytic active center, altering its tertiary conformation. This mechanism is best classified as:

(A) Competitive inhibition

(B) Allosteric feedback inhibition

(C) Non-reversible denaturing activation

(D) Co-enzyme suicidal inactivation

Q7. Which ecological pyramid can never exhibit an inverted profile in any natural, stable ecosystem due to the fundamental constraints of thermodynamics?

(A) Pyramid of numbers in a tree ecosystem

(B) Pyramid of biomass in a marine ecosystem

(C) Pyramid of energy in all functional ecosystems

(D) Pyramid of biomass in a grassland ecosystem

Q8. A researcher isolates a mutant strain of *Escherichia coli* where the gene encoding the lac repressor protein has a mutation preventing it from binding to lactose or allolactose. What will be the state of the lac operon expression in the presence of both glucose and lactose?

(A) Constitutive high expression

(B) Transitory expression followed by rapid degradation

(C) Completely repressed/minimal basal expression

(D) Expression will alternate in a cyclic manner

Q9. During the human cardiac cycle, the second heart sound ("dub") is generated synchronously with which mechanical valvular event?

(A) Closure of the atrioventricular (mitral and tricuspid) valves

(B) Opening of the atrioventricular valves

(C) Closure of the semilunar valves at the base of aorta and pulmonary artery

(D) Rapid filling phase of the left and right ventricles

Q10. The biological process of nitrogen fixation carried out by the free-living, aerobic bacterium *Azotobacter* requires an absolute anaerobic microenvironment inside the cell to protect the highly sensitive nitrogenase complex. How is this maintained?

(A) By utilizing a unique plant-derived protein called leghaemoglobin

(B) Through extremely high cellular respiration rates that rapidly deplete internal dissolved oxygen

(C) By living exclusively in deep, oxygen-depleted subsoil zones

(D) By creating thick, impermeable calcium carbonate shells around individual cells

Q11. If an angiospermic plant possesses a diploid ($2n$) chromosome number of 24, what will be the corresponding chromosome counts in its leaf cells, microspore mother cells, endosperm cells, and synergid cells respectively?

(A) 24, 24, 36, 12

(B) 24, 12, 36, 12

(C) 12, 24, 36, 24

(D) 24, 24, 24, 12

Q12. Which of the following techniques utilizes a heat-stable DNA polymerase from *Thermus aquaticus* to geometrically amplify specific fragments of target DNA in vitro?

(A) Western Blotting

(B) Southern Hybridization

(C) Polymerase Chain Reaction (PCR)

(D) Sanger Dideoxy Sequencing

Q13. An isolated ecosystem undergoes primary ecological succession on a bare volcanic rock island. Which of the following groups represents the correct chronological sequence of pioneering to subclimax seral stages?

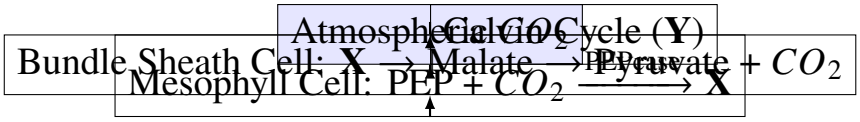
(A) Herbs → Shrubs → Lichens → Mosses

(B) Lichens → Mosses → Herbs → Shrubs

(C) Mosses → Lichens → Shrubs → Herbs

(D) Shrubs → Herbs → Mosses → Lichens

Q14. Consider the given TikZ pathway layout detailing structural carbon fixation transitions in specialized autotrophic plants:



Identify intermediate compound **X** and the primary carboxylating enzyme **Y** active inside the bundle sheath cells of this plant system?

(A) **X** = Oxaloacetic acid (4C); **Y** = RuBisCO

(B) **X** = Phosphoglyceric acid (3C); **Y** = PEP carboxylase

(C) **X** = Malic acid (4C); **Y** = Malate dehydrogenase

(D) **X** = Oxaloacetic acid (4C); **Y** = Pyruvate kinase

Q15. A person exhibits a physiological pathology characterized by a drastically elevated basal metabolic rate (BMR), rapid weight loss despite increased food intake, exophthalmos (protruding eyeballs), and chronic nervousness. This syndrome points towards:

(A) Hypothyroidism (Grave's Disease)

(B) Hyperthyroidism (Grave's Disease)

(C) Hypoadrenalism (Addison's Disease)

(D) Hyperparathyroidism

Q16. The structural component of the bacterial cell wall that distinguishes Gram-positive organisms from Gram-negative organisms, allowing them to retain the primary Crystal Violet-Iodine complex, is:

(A) A thick, highly cross-linked multi-layered peptidoglycan meshwork

(B) An outer lipopolysaccharide asymmetric membrane bilayer

(C) The presence of integral porin transport channels

(D) Large, dense accumulations of cholesterols within the plasma membrane

Q17. In human gametogenesis, the structural block against polyspermy is established immediately after sperm-egg binding via the cortical reaction. This reaction is directly triggered by a rapid, wave-like intracellular surge of which secondary ion messenger?

(A) Sodium (Na^+)

(B) Potassium (K^+)

(C) Calcium (Ca^{2+})

(D) Magnesium (Mg^{2+})

Q18. Which of the following botanical diagnostic features uniquely characterizes members belonging to the family Cruciferae (Brassicaceae)?

(A) Epipetalous stamens with monadelphous anthers

(B) Tetradynamous stamens, cruciform corolla, and a siliqua fruit with a false septum (replum)

(C) Bicarpellary syncarpous ovary with an obliquely placed septum and swollen placenta

(D) Monocarpellary unilocular ovary with marginal placentation

Q19. A transgenic crop known as "Golden Rice" was bioengineered through the insertion of foreign genes from daffodil (*Narcissus pseudonarcissus*) and a soil bacterium (*Pantoea ananatis*) to biosynthesize high levels of which essential nutritional precursor?

(A) Vitamin B12

(B) Essential Lysine amino acids

(C) β-carotene (Pro-vitamin A)

(D) Alpha-linolenic fatty acids

Q20. The biochemical phenomenon known as "wobbling" allows a single tRNA molecule to recognize more than one codon on the mRNA template. This non-standard base pairing flexibility occurs exclusively at which position of the codon-anticodon interaction?

(A) The 5' end base of the mRNA codon

(B) The 3' end base of the mRNA codon

(C) The middle base of both codon and anticodon

(D) The 3' end base of the tRNA anticodon loop

Q21. When the ecological relationship between two distinct co-habiting species benefits one organism significantly while leaving the other completely unaffected (neither helped nor harmed), the dynamic is classified as:

(A) Mutualism

(B) Parasitism

(C) Amensalism

(D) Commensalism

Q22. A sample of double-stranded DNA contains 22% Cytosine bases. According to Chargaff's rules of base equivalence, what is the calculated percentage of Adenine bases present in this DNA genome?

(A) 22%

(B) 44%

(C) 28%

(D) 56%

Q23. Identify the correct structural path taken by a water molecule moving radially from the external soil solution into the central conducting lumen of the root xylem vessels:

(A) Root hair → Cortex → Pericycle → Endodermis → Xylem

(B) Root hair → Epidermis → Endodermis → Cortex → Pericycle → Xylem

(C) Root hair → Cortex → Endodermis → Pericycle → Xylem

(D) Root hair → Pericycle → Endodermis → Cortex → Xylem

Q24. During the structural contraction of skeletal muscle sarcomeres, which of the following bands or zones does not undergo any shortening or structural width reduction?

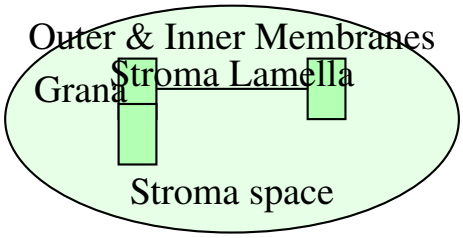
(A) The I-band

(B) The H-zone

(C) The A-band

(D) The distance between two consecutive Z-lines

Q25. Refer to the structural TikZ representation of a specialized eukaryotic cellular organelle below:



Which specific sub-organellar compartment shown in the model houses the enzymatic machinery for the light-independent, carbon-fixing dark reactions (Calvin Cycle)?

(A) The inner thylakoid lumen space

(B) The aqueous stroma matrix

(C) The intermembrane space between bilayers

(D) The localized grana membrane surfaces

Q26. The localized physiological effect of a permanent restriction in the diameter of the human afferent arteriole serving a renal corpuscle would result in:

(A) An extreme rise in the systemic venous return pressure

(B) A severe reduction in the net glomerular hydrostatic filtration force

(C) Massive acute excretion of plasma globulins into the secondary urine bladder

(D) Complete systemic suppression of antidiuretic hormone secretion

Q27. An X-linked recessive genetic condition expresses itself phenotypically with what pattern of inheritance in human families?

(A) Transmitted exclusively from affected fathers directly to all sons

(B) Passed from an affected father through carrier daughters down to fifty percent of grandsons

(C) Expressed with identical frequency in both males and females across generations

(D) Never carried silently by female individuals due to hormonal interactions

Q28. In the industrial production of transgenic therapeutic proteins, a plasmid vector is digested using a restriction endonuclease that generates sticky cohesive ends. To ensure successful directional ligation into the host expression plasmid, the vector must be treated with which modifying enzyme to prevent self-circularization?

(A) DNA Ligase

(B) Alkaline Phosphatase

(C) Reverse Transcriptase

(D) Exonuclease III

Q29. The evolutionary phenomenon where geographically isolated, distinct biological lineages evolve highly similar morphological adaptations in response to comparable ecological selection pressures is named:

(A) Divergent Evolution

(B) Convergent Evolution

(C) Adaptive Radiation

(D) Genetic Drift (Founder Effect)

Q30. Which of the following organic biomolecules acts as the critical structural link between the anaerobic glycolysis pathway and the aerobic tricarboxylic acid (Krebs) cycle within the mitochondria?

(A) Oxaloacetic acid

(B) Acetyl-CoA

(C) Phosphoenolpyruvate

(D) Citric acid

Q31. A physiological condition where an individual's immune cells mistake self-surface antigens for foreign pathogens and launch an destructive inflammatory response against their own joints is seen in:

(A) Osteoarthritis

(B) Gouty Arthritis

(C) Rheumatoid Arthritis

(D) Myasthenia Gravis

Q32. A molecular biologist inserts a target eukaryotic gene into the cloning site of a pBR322 plasmid, successfully disrupting the structural sequence of the tet^R gene. The transformed *E. coli* cells harboring this recombinant plasmid will exhibit which antibiotic resistance phenotype?

(A) Resistant to both ampicillin and tetracycline

(B) Sensitive to both ampicillin and tetracycline

(C) Resistant to ampicillin but sensitive to tetracycline

(D) Sensitive to ampicillin but resistant to tetracycline

Q33. In plant anatomy, the presence of distinct Casparian strips made of water-impermeable suberin depositions is a diagnostic feature characterizing which tissue layer?

(A) Exodermis of older dicot stems

(B) Endodermis of roots

(C) Inner bundle sheath of C3 leaves

(D) Pericycle of monocot roots

Q34. During the standard meiotic cell division cycle, the precise physical crossing over and exchange of non-sister chromatid genetic material takes place during which sub-stage of Prophase I?

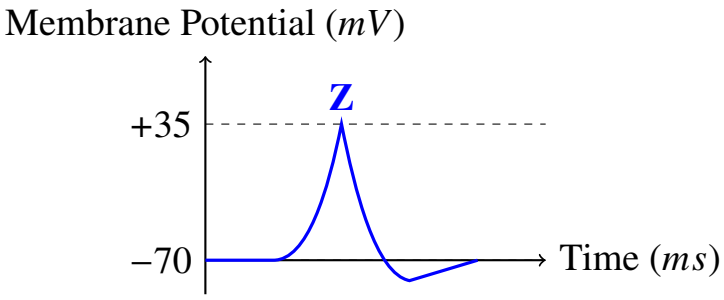
(A) Leptotene

(B) Zygotene

(C) Pachytene

(D) Diplotene

Q35. Refer to the TikZ graphical trace detailing changes in membrane polarization across a functional excitable human cellular membrane tissue over a short span of time:



The rapid physiological ionic shift responsible for driving the electrical curve upward to point **Z** on the action potential trace is driven by:

(A) Massive outward movement of potassium (K^+) ions through voltage-gated channels

(B) Rapid inward influx of sodium (Na^+) ions through voltage-gated channels

(C) Continuous ATP-driven pumping action of the Na^+/K^+ electrogenic pump

(D) Rapid influx of chloride (Cl^-) anions across the synaptic gap

Q36. The active phloem translocation mechanism that drives organic solutes from synthetic source leaves to metabolic sink tissues is explained by the pressure-flow model. This process requires:

(A) Active loading of sugars into sieve tubes at the source, creating a hypertonic environment that draws water in via osmosis, increasing hydrostatic pressure.

(B) Pure physical capillary action within the non-living sieve tube elements.

(C) Negative tension pulled from the roots by transpirational forces.

(D) Simple passive diffusion down a chemical concentration gradient through plasmodesmata.

Q37. Which of the following organic compounds is a structural polymer made of β-1,4-glycosidic linkages of N-acetylglucosamine units, serving as the primary component of fungal cell walls and arthropod exoskeletons?

(A) Cellulose

(B) Chitin

(C) Peptidoglycan

(D) Glycogen

Q38. An environmental condition characterized by excessive nutrient enrichment of a body of water, leading to algal blooms, severe oxygen depletion, and subsequent collapse of aquatic animal life is defined as:

(A) Biomagnification

(B) Eutrophication

(C) Bioremediation

(D) Thermal inversion

Q39. In human female reproduction, the transient endocrine structure known as the corpus luteum is formed from the remnants of the Graafian follicle post-ovulation. Which hormone does it secrete in large quantities to maintain the uterine lining for potential embryo implantation?

(A) Luteinizing Hormone (LH)

(B) Estrogen

(C) Progesterone

(D) Human Chorionic Gonadotropin (hCG)

Q40. The specific taxonomic category that contains organisms sharing the fewest common structural or genetic features, representing the highest level of classification listed here, is:

(A) Cohort

(B) Family

(C) Order

(D) Division

Q41. During the transcription phase of gene expression in eukaryotic organisms, the initial RNA transcript synthesized by RNA Polymerase II undergoes processing. Which of the following best describes this modification sequence?

(A) Exon removal followed by poly-A tail addition to the 3' end

(B) Addition of a 7-methylguanosine cap to the 5' end, splicing out of introns, and addition of a poly-A tail at the 3' end

(C) Direct attachment of the raw transcript to ribosomes without any processing steps

(D) Splicing of exons only, leaving introns untouched within the mature sequence

Q42. A specific plant hormone promotes cell elongation in coleoptiles, exhibits polar basipetal transport, maintains apical dominance, and induces root initiation in stem cuttings. This hormone is:

(A) Gibberellic acid (GA_3)

(B) Indole-3-acetic acid (Auxin)

(C) Kinetin (Cytokinin)

(D) Abscisic acid (ABA)

Q43. The structural component of human hemoglobin contains four polypeptide subunits. Each subunit is conjugated to a prosthetic heme group containing an iron atom. For effective, reversible binding of molecular oxygen, this iron atom must remain in which oxidation state?

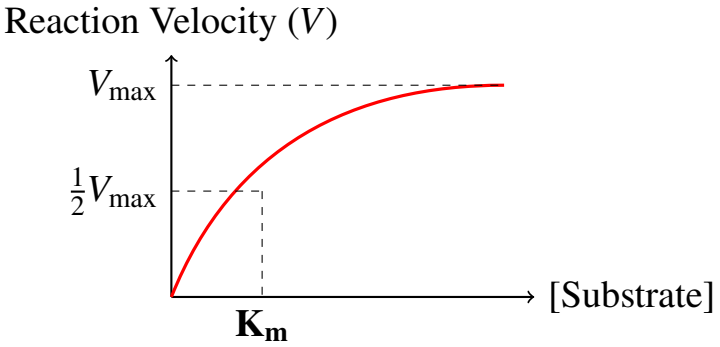
(A) Ferric state (Fe^{3+})

(B) Ferrous state (Fe^{2+})

(C) Elemental state (Fe^{0})

(D) Ferryl state (Fe^{4+})

Q44. Consider the TikZ graphical representation below mapping enzyme-catalyzed reaction kinetics with respect to changing substrate concentration:



If a competitive inhibitor is introduced into this enzymatic assay system, how will the values of V_{max} and the Michaelis constant ($\mathbf{K_m}$) change on the graph?

(A) V_{max} decreases; $\mathbf{K_m}$ remains unchanged

(B) V_{max} remains unchanged; $\mathbf{K_m}$ increases

(C) Both V_{max} and $\mathbf{K_m}$ decrease proportionally

(D) V_{max} increases; $\mathbf{K_m}$ decreases

Q45. Which of the following diseases is caused by a chromosomal numerical aberration resulting from non-disjunction during gametogenesis, leaving the affected individual with a karyotype of 47 chromosomes, specifically $45 + XXY$?

(A) Turner's Syndrome

(B) Down's Syndrome

(C) Klinefelter's Syndrome

(D) Cri-du-chat Syndrome

Q46. The physiological phenomenon where greenhouse gases absorb and re-emit long-wave radiation, heating up the Earth's lower troposphere, is driven primarily by which gas molecule listed below?

(A) Oxygen (O_2)

(B) Nitrogen (N_2)

(C) Carbon dioxide (CO_2) and Methane (CH_4)

(D) Sulfur dioxide (SO_2)

Q47. In flowering plants (angiosperms), the unique process of double fertilization involves which of the following cellular fusions?

(A) One male gamete fuses with the egg cell; the other male gamete fuses with a synergid cell.

(B) One male gamete fuses with the egg cell (syngamy); the second male gamete fuses with the two polar nuclei (triple fusion) to form the primary endosperm nucleus.

(C) Both male gametes fuse with the egg cell simultaneously to form a triploid zygote.

(D) Fusion of the vegetative cell with the antipodal cells within the embryo sac.

Q48. The structural classification of biological organisms into the Five Kingdom system proposed by Robert Whittaker in 1969 was based primarily on which criteria?

(A) Presence or absence of cell wall, and locomotive structural adaptations

(B) Cell structure complexity, body organization, mode of nutrition, reproduction, and phylogenetic relationships

(C) Nucleic acid sequence homology and sequence length of 16S rRNA

(D) Ecological zone distribution and thermal adaptation limits

Q49. A molecular biologist utilizes a specialized type of molecular scissors that recognizes a specific palindromic sequence of nucleotides in double-stranded DNA, cutting the sugar-phosphate backbones at precise sites. This enzyme class is known as:

(A) DNA Polymerases

(B) Topoisomerases

(C) Restriction Endonucleases

(D) Exonucleases

Q50. The transport of carbon dioxide (CO_2) within human blood is managed through multiple physiological mechanisms. The largest percentage of CO_2 (70%) is transported as:

(A) Dissolved gas molecules within blood plasma solution

(B) Carbaminohemoglobin complexes inside red blood cells

(C) Bicarbonate (HCO_3^-) ions formed inside erythrocytes and shifted into plasma

(D) Solid carbo-carbonate precipitates bound to plasma proteins

Q51. Which of the following plant hormones acts as a potent growth inhibitor, promotes seed dormancy, induces stomatal closure during severe water stress, and is synthesized during environmental adversity?

(A) Zeatin

(B) Ethylene

(C) Abscisic acid

(D) Gibberellic acid

Q52. During the structural phase of DNA replication, the topological tension generated by the unwinding of the parental double helix by DNA Helicase is relieved by which enzyme ahead of the replication fork?

(A) DNA Ligase

(B) Single-Stranded Binding Proteins (SSBP)

(C) DNA Topoisomerase (DNA Gyrase)

(D) RNA Primase

Q53. The physiological region of the human brain that serves as the primary homeostatic integration center for regulating core body temperature, osmoregulation, appetite, and governing the endocrine output of the pituitary gland is the:

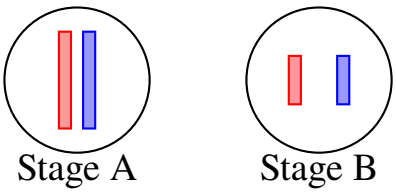
(A) Cerebellum

(B) Medulla Oblongata

(C) Thalamus

(D) Hypothalamus

Q54. Refer to the TikZ diagrammatic presentation below illustrating structural changes in homologous chromosome alignments during cell division stages:



Identify the specific meiotic division phases represented by Stage A and Stage B where homologous pairs align at the equator versus individual sister chromatids separating respectively.

(A) Stage A = Metaphase I; Stage B = Anaphase II

(B) Stage A = Prophase I; Stage B = Metaphase II

(C) Stage A = Anaphase I; Stage B = Telophase I

(D) Stage A = Metaphase II; Stage B = Anaphase I

Q55. In an open, functional terrestrial ecosystem, the total amount of living organic matter (biomass) present at a specific trophic level at any given point in time is defined ecologically as the:

(A) Standing crop

(B) Standing state

(C) Gross primary productivity

(D) Net primary productivity

Q56. A rare genetic cross between a red-flowered plant and a white-flowered plant yields F_1 progeny that display an intermediate pink coloration. When the F_1 individuals are self-pollinated, the F_2 generation shows a phenotypic ratio of 1 Red : 2 Pink : 1 White. This pattern of genetic inheritance is a classic demonstration of:

(A) Codominance

(B) Complete Dominance

(C) Incomplete Dominance

(D) Polygenic Epistasis

Q57. Which of the following biological molecules acts as the primary structure of cell membranes, displaying an amphipathic nature with a hydrophilic polar head group and hydrophobic fatty acid non-polar tails?

(A) Triglycerides

(B) Phospholipids

(C) Glycoproteins

(D) Sphingomyelins

Q58. The commercial production of human insulin via recombinant DNA technology involves inserting the synthetic gene sequences coding for insulin chains A and B separately into expression vectors. Which bacterial host organism is widely used for this industrial synthesis?

(A) *Bacillus thuriengiensis*

(B) *Saccharomyces cerevisiae*

(C) *Escherichia coli*

(D) *Agrobacterium tumefaciens*

Q59. The physiological mechanism of water absorption by plant roots that operates independently of transpirational pull, generating a positive hydrostatic pressure capable of pushing fluid up short distances within the xylem and driving guttation through hydathodes, is termed:

(A) Imbibition force

(B) Root pressure

(C) Capillary tension

(D) Cohesive wall adhesion

Q60. The presence of a persistent, multi-layered endosperm tissue storing rich reserves of oils and proteins in mature seeds is a common botanical characteristic of which of the following crop groups?

(A) Pea, Bean, and Gram seeds

(B) Castor and Maize seeds

(C) Groundnut and Mustard seeds

(D) Orchids and Sunflower seeds

Q61. During the physiological digestion of dietary lipids in the human small intestine, the large hydrophobic fat droplets must first undergo mechanical emulsification before enzymatic hydrolysis. This mechanical breakdown is mediated by:

(A) Pancreatic Lipase

(B) Gastric Pepsinogen

(C) Bile salts (Sodium glycocholate and taurocholate)

(D) Intestinal Enterokinase

Q62. An environmental pollutant that undergoes progressive biological concentration at higher trophic levels along a food chain due to its highly lipophilic nature and resistance to metabolic degradation exhibits the process of:

(A) Eutrophication

(B) Bioaccumulation

(C) Biomagnification

(D) Phytoremediation

Q63. In molecular biology, the sequence of events where genetic information flows unidirectionally from DNA to RNA via transcription, and subsequently from RNA to protein via translation, is termed the Central Dogma. Which of the following biological agents violates this standard directionality?

(A) Cyanobacteria

(B) Retroviruses (e.g., HIV)

(C) Filamentous Ascomycetes

(D) Archaebacteria

Q64. Which of the following unique anatomical features is observed in a cross-section of a C4 leaf, providing a structural adaptation to minimize photorespiratory carbon losses?

(A) Large intercellular spaces in spongy mesophyll

(B) Well-developed palisade parenchymal tissue lining both epidermal faces

(C) Kranz anatomy characterized by prominent bundle sheath cells arranged in a wreath-like manner around vascular bundles

(D) Complete absence of functional stomatal complexes on the abaxial surface

Q65. During the standard cell cycle, the critical checkpoint where the cell commits to undergo DNA synthesis and structural genome replication is located at the transition between which phases?

(A) G_1 phase to S phase

(B) S phase to G_2 phase

(C) G_2 phase to M phase

(D) Metaphase to Anaphase

Q66. A biological tool widely used for the generation of transgenic plants is a soil bacterium nicknamed "the natural genetic engineer." It possesses a large tumor-

inducing (Ti) plasmid capable of integrating a specific T-DNA segment into the host plant genome. This bacterium is:

(A) *Rhizobium leguminosarum*

(B) *Agrobacterium tumefaciens*

(C) *Streptomyces coelicolor*

(D) *Azotobacter chroococcum*

Q67. The human respiratory system uses a specialized chemical complex called surfactant to lower the surface tension within the lungs, preventing alveolar collapse during deep expiration. This surfactant layer is secreted by which cell type?

(A) Alveolar Macrophages (Dust cells)

(B) Type I Alveolar Pneumocytes

(C) Type II Alveolar Pneumocytes

(D) Ciliated goblet cells of the bronchioles

Q68. The floral structural formula $\oplus\ \sigma^{\nearrow}\ K_{(5)}\ C_{(5)}\ A_5\ \underline{G}_{(2)}$ detailing a actinomorphic, bisexual flower with five fused sepals, five fused petals, five epipetalous stamens, and a bicarpellary syncarpous superior ovary is diagnostic for which family?

(A) Fabaceae

(B) Solanaceae

(C) Liliaceae

(D) Brassicaceae

Q69. In human female reproduction, the primary oocyte remains arrested in its meiotic division for years before ovulation occurs. This prolonged developmental arrest happens during which specific stage of cell division?

(A) Metaphase I

(B) Prophase II

(C) Diplotene stage of Meiotic Prophase I

(D) Anaphase I

Q70. An international agreement drafted under the Convention on Biological Diversity to regulate the safe transboundary movement, handling, and use of living modified organisms (LMOs) resulting from modern biotechnology is known as the:

(A) Kyoto Protocol

(B) Montreal Protocol

(C) Cartagena Protocol on Biosafety

(D) Paris Climate Agreement

Q71. The physiological phenomenon where an abundance of oxygen binds to hemoglobin, causing a structural conformation shift that promotes the displacement of carbon dioxide from blood into the lungs, is called the:

(A) Bohr Effect

(B) Haldane Effect

(C) Root Effect

(D) Chloride Shift (Hamburger Phenomenon)

Q72. Which of the following organic structures contains a non-protein organic cofactor that is tightly bound to an enzyme molecule via permanent covalent or non-covalent structural linkages, required for its catalytic function?

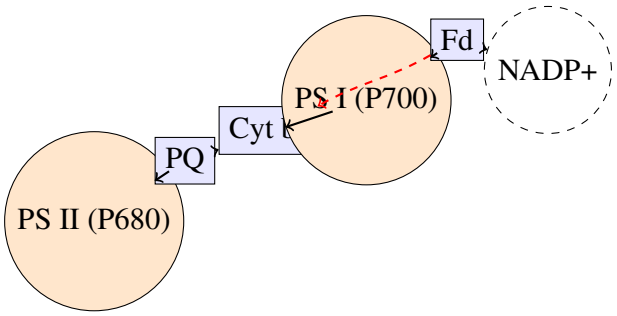
(A) Coenzyme

(B) Apoenzyme

(C) Prosthetic group

(D) Holoenzyme

Q73. Consider the TikZ structural pathway mapping the biochemical details of cyclic versus non-cyclic photophosphorylation in light-dependent photosynthetic mechanisms:



When the dashed red physiological feedback pathway becomes the exclusive operational circuit for electron transport in this system, what will be the net operational biochemical product generated?

(A) Synthesis of both ATP and NADPH

(B) Synthesis of NADPH only

(C) Generation of molecular oxygen (O_2) and ATP

(D) Synthesis of ATP only, without any generation of NADPH or O_2

Q74. The global conservation strategy that focuses resources on protecting specialized geographic regions characterized by exceptionally high levels of species endemism coupled with severe, accelerated threats of habitat destruction defines a:

(A) National Park

(B) Biodiversity Hotspot

(C) Biosphere Reserve

(D) Sacred Grove

Q75. A point mutation occurs in the human β-globin gene, where a single nucleotide substitution changes the codon at position 6 from GAG to GTG. This changes the incorporated amino acid from glutamic acid to valine, causing a structural distortion of erythrocytes under low oxygen tension. This condition is:

(A) Thalassemia

(B) Sickle-Cell Anemia

(C) Phenylketonuria

(D) Hemophilia A

Q76. In human endocrinology, which hormone acts as a physiological antagonist to Parathyroid Hormone (PTH), lowering blood calcium levels by inhibiting bone resorption and reducing renal calcium reabsorption?

(A) Calcitriol (Vitamin D)

(B) Thyrocalcitonin (Calcitonin)

(C) Aldosterone

(D) Glucagon

Q77. The physiological phenomenon where the application of gibberellins induces rapid, elongated stem growth in rosette plants prior to flowering is known as:

(A) Etiolation

(B) Bolting

(C) Vernalization

(D) Photoperiodic induction

Q78. Which of the following cellular components acts as the primary site for the modification, sorting, and packaging of proteins and lipids into secretory vesicles, adding carbohydrate groups to form glycoproteins?

(A) Rough Endoplasmic Reticulum

(B) Peroxisome

(C) Lysosome

(D) Golgi Apparatus

Q79. The human placenta fulfills essential endocrine roles during gestation. Which of the following hormone combinations is secreted exclusively by the placenta to maintain pregnancy?

(A) LH, FSH, and Estrogen

(B) human Chorionic Gonadotropin (hCG), human Placental Lactogen (hPL), Estrogen, and Progesterone

(C) Prolactin, Oxytocin, and Cortisol

(D) Renin, Erythropoietin, and Aldosterone

Q80. The active uptake of ions from the soil solution across the plasma membrane of root epidermal cells against a concentration gradient occurs through which physiological mechanism?

(A) Simple passive diffusion through open porin channels

(B) Facilitated diffusion utilizing passive carrier proteins

(C) Primary active transport driven directly by the hydrolysis of ATP via proton pumps

(D) Mass flow driven purely by the transpirational stream

Detailed Solutions

Q1.

Solution

Concept: The structural dimension of B-form DNA dictates its helical pitch parameters, where each complete turn spans 34 Å and contains exactly 10 base pairs. Quantitative analysis of the constituent nucleotide bases utilizes Chargaff's rules of base equivalence, establishing that the molecular percentage of purines equals pyramides due to selective hydrogen bonding.

Solution:

(a) The length of a single complete helical turn in standard B-DNA is 34 Å. Given a total molecular length of 340 Å, the number of complete turns is calculated by dividing total length by pitch length: 340 Å/34 Å = 10 turns.

(b) Since 1 complete turn contains 10 base pairs, 10 complete turns contain a total of $10 \times 10 = 100$ base pairs, which corresponds to 200 total individual nitrogenous bases.

(c) According to Chargaff's rules, Adenine (A) pairs with Thymine (T) via 2 hydrogen bonds, while Guanine (G) pairs with Cytosine (C) via 3 hydrogen bonds. If Adenine constitutes 30% of the bases (30% of 200 = 60 bases), then Thymine must also constitute 60 bases.

(d) The remaining bases comprise Guanine and Cytosine: $200 - (60 + 60) = 80$ bases. Due to base-pairing equivalence, Guanine accounts for 40 bases and Cytosine accounts for 40 bases, forming 40 G-C base pairs.

(e) The total number of hydrogen bonds is calculated by multiplying the base pairs by their respective bond capacities: $(60 \text{ A-T pairs} \times 2) + (40 \text{ G-C pairs} \times 3) = 120 + 120 = 240$ hydrogen bonds.

Final Answer: 100 turns and 240 hydrogen bonds.

Answer: (B)

Go Back to Question 1

Q2.

Solution

Concept: Plant anatomy serves as a diagnostic tool for taxonomic identification. Dicotyledonous stems display specific structural configurations of ground tissue and vascular cylinders that easily distinguish them from monocotyledonous structures, providing clear markers to isolate plants down to their respective families.

Solution:

(a) The anatomical cross-section describes a typical dicotyledonous stem structure. Key identifying characters include a collenchymatous hypodermis providing mechanical support, a distinct parenchymatous pericycle layer, and a ring-like arrangement of vascular bundles.

(b) The vascular bundles in a dicot stem are conjoint, collateral, and open. The term open indicates the presence of intrafascicular cambium between the xylem and phloem, enabling secondary growth.

(c) Analyzing the given options, Liliaceae, Poaceae, and Orchidaceae are all monocotyledonous families. Monocot stems typically exhibit scattered vascular bundles (atactostele) that are closed, lacking cambium, and feature a sclerenchymatous hypodermis.

(d) Solanaceae is a well-known dicotyledonous family containing economically important crops like potato, tomato, and brinjal. Stems within this family exhibit the classic eustele configuration described in the problem.

(e) Consequently, the presence of open bundles arranged in a ring, a collenchymatous hypodermis, and a well-defined pericycle explicitly points to a member of the Solanaceae family.

Final Answer: Solanaceae.

Answer: (B)

Go Back to Question 2

Q3.

Solution

Concept: During cellular respiration, cells extract chemical energy from metabolic substrates through oxidative stages. Substrate-level phosphorylation represents a direct mechanism of ATP synthesis where a high-energy phosphate group is mechanically transferred from a reactive intermediate directly to ADP, operating independently of the electron transport chain.

Solution:

(a) When one molecule of acetyl-CoA enters the tricarboxylic acid (Krebs) cycle within the mitochondrial matrix, it condenses with oxaloacetic acid to form citric acid, initiating a sequence of enzymatic transformations.

(b) During this cyclic pathway, a single substrate-level phosphorylation event takes place during the conversion of succinyl-CoA to succinic acid. This coupled energetic reaction is mediated by the enzyme succinyl-CoA synthetase.

(c) In this specific reaction step, the cleavage of the high-energy thioester bond of succinyl-CoA provides the free energy required to phosphorylate GDP to GTP (in animal tissues) or ADP directly to ATP (in plants and bacteria).

(d) In human metabolic physiological systems, the synthesized GTP is rapidly converted into ATP by the intracellular enzyme nucleoside diphosphate kinase, yielding exactly 1 net ATP per oxidized acetyl-CoA molecule.

(e) The remaining energy from acetyl-CoA oxidation is captured as reducing equivalents (3 NADH and 1 FADH2), which yield ATP downstream via oxidative phosphorylation rather than substrate-level mechanism.

Final Answer: 1 ATP.

Answer: (A)

Go Back to Question 3

Q4.

Solution

Concept: The renal corpuscle utilizes a precise balance of physical forces to regulate ultrafiltration across the glomerular membrane. Glomerular filtration rate depends heavily on the hydrostatic pressure within the glomerular capillaries, which is maintained homeostatically by the differential diameters of the afferent and efferent arterioles.

Solution:

(a) Glomerular filtration is driven by net filtration pressure (NFP), which is determined by subtracting anti-filtration forces (capsular hydrostatic pressure and blood colloidal osmotic pressure) from the primary driving force, the glomerular hydrostatic pressure.

(b) When a physiological disturbance causes a significant drop in glomerular capillary hydrostatic pressure, the net filtration pressure decreases accordingly. This immediate reduction directly suppresses the volume of fluid filtered into Bowman's capsule per unit time.

(c) A decrease in the glomerular filtration rate (GFR) is sensed immediately by the macula densa cells located in the distal convoluted tubule due to altered delivery of sodium and chloride ions.

(d) The macula densa signals the adjacent juxtaglomerular (JG) cells within the afferent arteriole wall to synthesize and release the proteolytic enzyme renin into the bloodstream, activating the renin-angiotensin-aldosterone system ($RAAS$).

(e) This hormonal cascade causes systemic vasoconstriction and aldosterone release to restore blood volume, systemic blood pressure, and renal perfusion back toward normal homeostatic baselines.

Final Answer: Glomerular filtration rate (GFR) drops, triggering the juxtaglomerular apparatus to release renin.

Answer: (B)

Go Back to Question 4

Q5.

Solution

Concept: During the light-dependent reactions of oxygenic photosynthesis, photolysis of water occurs on the luminal side of the thylakoid membrane. This water-splitting mechanism is executed by a specialized metalloenzyme complex integrated within photosystem II, known structurally as the oxygen-evolving complex (OEC).

Solution:

(a) The oxygen-evolving complex (OEC), or water-splitting complex, plays a vital biological role by converting two molecules of water into one molecule of molecular oxygen, four protons, and four extracted electrons.

(b) Structural and spectroscopic analyses reveal that the core catalytic center of the OEC contains a specialized inorganic multinuclear cluster composed of specific transition metals and essential inorganic ions.

(c) This metallic core is structurally identified as a inorganic cubane cluster containing four manganese atoms and one calcium atom, dynamically bridged by oxygen atoms (Mn_4CaO_5).

(d) In addition to manganese and calcium, chloride anions (Cl^-) are required as cofactor components within the local coordination sphere to stabilize the radical intermediates generated during the stepwise oxidation states.

(e) Therefore, the precise assembly and metabolic activity of the functional water-splitting structural machinery depend strictly on the simultaneous biological availability of manganese, calcium, and chlorine.

Final Answer: Manganese, Calcium, and Chlorine.

Answer: (B)

Go Back to Question 5

Q6.

Solution

Concept: Metabolic pathways are tightly regulated homeostatically to conserve cellular energy and resources. Enzymes pacing these multi-step sequences are frequently modulated by downstream pathway intermediates via non-covalent structural modifications that physically alter active site availability without competitive molecular binding.

Solution:

(a) In many multi-enzyme biosynthetic pathways, the final product accumulates beyond the immediate metabolic demands of the cell, serving as a feedback signal to decelerate the rate of its own synthesis.

(b) To achieve this, the end-product molecule binds specifically to a specialized regulatory site on the initial rate-limiting enzyme of the pathway. This regulatory site is known as an allosteric site.

(c) The allosteric site is spatially distinct from the catalytic active center where the initial substrate binds. Binding of the end-product induces a distinct change in the tertiary and quaternary conformation of the enzyme protein.

(d) This conformational shift modifies the geometry of the catalytic active site, significantly reducing its affinity for the initial substrate, thereby effectively suppressing enzymatic activity.

(e) Because this mechanism involves feedback from a terminal product acting at an alternative structural locus on the enzyme, it is classified as allosteric feedback inhibition.

Final Answer: Allosteric feedback inhibition.

Answer: (B)

Go Back to Question 6

Q7.

Solution

Concept: Ecological pyramids graphically depict the trophic structure and energetic distribution across successive levels of an ecosystem. While structural parameters like organism abundance or standing biomass can vary wildly, energetic transfers remain restricted by inescapable thermodynamic laws.

Solution:

(a) Pyramids of numbers and biomass can display inverted profiles. For instance, a single tree host supporting numerous herbivorous insects displays an inverted number pyramid, and marine systems present inverted biomass profiles due to rapid phytoplankton turnover.

(b) In contrast, the pyramid of energy represents the total rate of energy flow through successive trophic levels. The configuration of this specific pyramid is governed strictly by the laws of thermodynamics.

(c) According to Lindeman's 10% law of energy transfer, only about 10% of the chemical energy fixed at a given trophic level is successfully incorporated into the biomass of the subsequent trophic level.

(d) The remaining 90% of available energy is lost to the environment as metabolic heat during respiration, mechanical movement, and general thermodynamic entropy.

(e) Because energy decreases progressively with each higher step, the energy content at lower levels always exceeds that of higher levels, ensuring the pyramid of energy is always upright.

Final Answer: Pyramid of energy in all functional ecosystems.

Answer: (C)

Go Back to Question 7

Q8.

Solution

Concept: The lac operon of *Escherichia coli* serves as a genetic model for transcriptional regulation in prokaryotes. Operon expression is controlled by an operon-specific repressor protein alongside global catabolite repression pathways responsive to ambient carbohydrate concentrations.

Solution:

(a) The lac repressor, encoded by the regulatory $lacI$ gene, is structurally designed to bind to the operator region, blocking RNA polymerase from initiating transcription of the lac structural genes ($lacZYA$).

(b) Under normal physiological conditions, the inducer molecule (allolactose, an isomer of lactose) binds to the repressor protein, causing a conformational change that forces it to release from the operator, permitting transcription.

(c) The mutant strain possesses a modified repressor protein that can no longer bind to lactose or allolactose. Consequently, the repressor remains permanently bound to the operator region regardless of lactose presence.

(d) Furthermore, when glucose is present in the medium, intracellular cyclic AMP ($cAMP$) levels remain low, keeping the catabolite activator protein (CAP) inactive, which prevents high-level transcriptional activation.

(e) Since the mutant repressor remains bound to the operator site, it physically blocks RNA polymerase. The operon stays completely repressed, exhibiting minimal basal expression.

Final Answer: Completely repressed/minimal basal expression.

Answer: (C)

Go Back to Question 8

Q9.

Solution

Concept: The human cardiac cycle involves a coordinated sequence of muscular contractions, pressure fluctuations, and mechanical valvular events. The characteristic heart sounds heard during auscultation are caused by the vibration of cardiac walls associated with sudden valve closures.

Solution:

(a) The cardiac cycle generates two primary distinct sounds: the first heart sound ("lub") and the second heart sound ("dub"). These sounds mark the major transitions between phases of ventricular activity.

(b) The first heart sound ("lub") occurs during the onset of ventricular systole, when rising intraventricular pressure forces the atrioventricular valves (mitral and tricuspid) to shut to prevent backflow into the atria.

(c) Following ventricular ejection, the ventricles begin to relax, entering a phase called ventricular diastole. As the ventricles relax, intraventricular pressure drops rapidly below the pressure in the major exit arteries.

(d) The higher pressure in the aorta and pulmonary artery pushes blood back toward the heart, catching the cusps and causing the immediate closure of the semilunar valves.

(e) The sudden closure of these semilunar valves at the base of the aorta and pulmonary artery generates the sharp, higher-pitched second heart sound ("dub").

Final Answer: Closure of the semilunar valves at the base of aorta and pulmonary artery.

Answer: (C)

Go Back to Question 9

Q10.

Solution

Concept: Biological nitrogen fixation is catalyzed by the nitrogenase enzyme complex, which breaks the strong triple bond of atmospheric dinitrogen. This enzyme is highly sensitive to molecular oxygen, which irreversibly denatures its essential iron-protein components.

Solution:

(a) *Azotobacter* is a genus of free-living, obligately aerobic bacteria found in soils. Because they require oxygen for their metabolic ATP production, they must maintain an oxygen-free environment within the cell for nitrogenase function.

(b) Unlike symbiotic diazotrophs like *Rhizobium*, which rely on plant-derived leghaemoglobin to bind and transport oxygen away from the nodules, free-living *Azotobacter* must use autonomous protective adaptations.

(c) To resolve this paradox, *Azotobacter* maintains an extraordinarily high rate of cellular respiration. This extreme metabolic rate consumes dissolved oxygen inside the cell faster than it can diffuse inward through the cell membrane.

(d) This process, known as respiratory protection, keeps the internal oxygen concentration near zero, protecting the nitrogenase complex while meeting the heavy ATP demands of nitrogen fixation.

(e) Additionally, these bacteria synthesize a specialized protective protein that binds to the nitrogenase complex under transient oxygen stress, shielding it from conformational damage until anaerobic conditions are re-established.

Final Answer: Through extremely high cellular respiration rates that rapidly deplete internal dissolved oxygen.

Answer: (B)

Go Back to Question 10

Q11.

Solution

Concept: Determining ploidy levels in different angiospermic plant structures depends on understanding whether the tissue develops via mitotic division of somatic lineages or through specific meiotic events within generative organs. Somatic and pre-meiotic tissues carry the diploid chromosome number, whereas post-meiotic gametophytic cells are haploid, and product cells of triple fusion exhibit triploidy.

Solution:

(a) The problem states that the diploid ($2n$) chromosome number of the angiospermic plant is 24, meaning the base haploid set (n) consists of 12 chromosomes.

(b) Leaf cells are standard vegetative somatic structures that develop through regular mitosis. Consequently, they retain the full diploid chromosome complement, which corresponds to exactly 24 chromosomes.

(c) Microspore mother cells are specialized diploid cells located within the anther microsporangia. Since they have not yet undergone meiotic reduction division to produce microspores, their ploidy remains completely diploid ($2n = 24$).

(d) Endosperm tissue is formed through triple fusion during double fertilization, where one haploid male gamete fuses with the diploid secondary nucleus. This yields a triploid matrix ($3n = 3 \times 12 = 36$).

(e) Synergid cells are component structures of the female gametophyte (embryo sac) generated via meiotic megasporogenesis followed by mitotic embryo sac maturation. They are strictly haploid ($n = 12$).

Final Answer: 24, 24, 36, 12.

Answer: (A)

Go Back to Question 11

Q12.

Solution

Concept: In genetic engineering and biotechnology, multiplying specific target nucleotide sequences requires a technique capable of operating at elevated denaturation temperatures. Using a highly specialized, heat-stable enzyme isolated from thermophilic microorganisms ensures that the catalytic machinery survives consecutive cycles of thermal variation.

Solution:

(a) The Polymerase Chain Reaction (PCR) is an in vitro biochemical technique used to amplify a single or a few copies of a specific DNA segment across several orders of magnitude, generating millions of copies.

(b) A key challenge of automated thermal cycling is that standard DNA polymerases denature and lose functional activity at the high temperatures required to separate double-stranded DNA templates.

(c) This limitation was overcome by isolating a heat-stable DNA polymerase called Taq Polymerase from the thermophilic archaebacterium *Thermus aquaticus*, which thrives in high-temperature hot springs.

(d) The PCR process moves sequentially through three steps: denaturation at high temperature to separate strands, primer annealing at lower temperatures, and extension where Taq polymerase synthesizes the complementary strands.

(e) Other techniques like Western blotting analyze proteins, Southern hybridization identifies specific fragments via probes, and Sanger sequencing determines exact base orders, making PCR the primary tool for targeted geometric amplification.

Final Answer: Polymerase Chain Reaction (PCR).

Answer: (C)

Go Back to Question 12

Q13.

Solution

Concept: Primary ecological succession describes the orderly, predictable process of biotic community assembly over time in a newly formed, completely barren habitat lacking pre-existing organic soil. The structural composition of seral communities changes systematically as pioneering organisms modify the local physical environment.

Solution:

(a) Primary succession on a bare, rocky substrate begins with pioneer communities. Lichens serve as the initial pioneers because they can tolerate extreme desiccation and intense solar radiation while secreting organic acids that chemically weather the rock.

(b) The gradual weathering of rock, combined with the accumulation of decaying lichen organic matter, creates a rudimentary thin layer of soil capable of retaining moisture.

(c) This altered microenvironment allows mosses to colonize the substrate. Mosses form dense mats that trap windblown dust particles, accelerate soil development, and minimize moisture evaporation from the surface.

(d) As the soil layer deepens and becomes rich in organic nutrients, herbaceous plants outcompete the pioneering mosses. These annual and perennial herbs establish wider root systems that stabilize the newly formed soil matrix.

(e) The progressive enrichment and structural stabilization of the soil eventually permit the growth of larger shrubs, which act as a subclimax seral stage before the establishment of a stable forest climax community.

Final Answer: Lichens → Mosses → Herbs → Shrubs.

Answer: (B)

Go Back to Question 13

Q14.

Solution

Concept: Specialized autotrophic plants growing in arid habitats utilize the C_4 photosynthetic pathway to suppress photorespiratory energy losses. Spatial separation of initial carbon capture and subsequent carbohydrate synthesis allows these plants to maintain high internal carbon dioxide concentrations near their primary carboxylating enzymes.

Solution:

(a) In C_4 plants, the initial fixation of atmospheric carbon dioxide occurs inside the mesophyll cells. The primary acceptor molecule is phosphoenolpyruvate (PEP), and the reaction is catalyzed by the enzyme PEP carboxylase.

(b) This carboxylating reaction produces a four-carbon intermediate compound called oxaloacetic acid (OAA), which is represented as intermediate **X** in the provided metabolic diagram.

(c) Oxaloacetic acid is rapidly reduced into malic acid or aspartic acid within the mesophyll cells before being transported through plasmodesmata into the adjacent bundle sheath cells.

(d) Inside the bundle sheath cells, malate undergoes oxidative decarboxylation to yield pyruvate and release a molecule of carbon dioxide, generating a locally concentrated, oxygen-depleted microenvironment around the vascular cylinder.

(e) This released carbon dioxide is then fixed through the standard Calvin cycle (C_3 pathway). The primary carboxylating enzyme active within these bundle sheath cells is RuBisCO, represented as enzyme **Y**.

Final Answer: **X** = Oxaloacetic acid (4C); **Y** = RuBisCO.

Answer: (A)

Go Back to Question 14

Q15.

Solution

Concept: The endocrine system coordinates human metabolic rate, tissue development, and neural sensitivity via regulated hormonal secretions. Pathological conditions arise when homeostatic feedback mechanisms fail, leading to either hypersecretion or hyposecretion of hormones within major endocrine axes.

Solution:

(a) The thyroid gland synthesizes and releases thyroid hormones (thyroxine or T_4, and triiodothyronine or T_3), which act as primary determinants of the basal metabolic rate (BMR) across somatic tissues.

(b) Hypersecretion of these thyroid hormones causes hyperthyroidism. An autoimmune manifestation of this state is Grave's disease, where abnormal antibodies mimic thyroid-stimulating hormone, driving unregulated hormone release.

(c) The excessive circulating levels of T_3 and T_4 drastically accelerate metabolic pathways, resulting in a significantly elevated basal metabolic rate, rapid weight loss, heat intolerance, and chronic nervous system excitability.

(d) A hallmark clinical sign of Grave's disease is exophthalmos, where autoimmune inflammation and fluid accumulation within the retro-orbital connective tissues cause the eyeballs to protrude forward.

(e) In contrast, hypothyroidism reduces metabolic rates, Addison's disease stems from adrenal insufficiency leading to low cortisol, and hyperparathyroidism alters blood calcium levels, confirming hyperthyroidism as the correct underlying pathology.

Final Answer: Hyperthyroidism (Grave's Disease).

Answer: (B)

Go Back to Question 15

Q16.

Solution

Concept: The differential retention of the primary crystal violet-iodine complex during the Gram staining procedure depends directly on the structural layout and chemical composition of the bacterial cell wall envelope, providing a fundamental metric for prokaryotic taxonomic classification.

Solution:

(a) Gram staining differentiates bacteria based on the physical properties of their cell walls. Both cell walls contain peptidoglycan, a polymer composed of alternating N-acetylglucosamine and N-acetylmuramic acid cross-linked by amino acid side chains.

(b) Gram-positive bacteria possess a thick, highly cross-linked multi-layered peptidoglycan meshwork that constitutes up to 90% of the total cell wall envelope weight, alongside teichoic acids.

(c) During the decolorization step using alcohol or acetone, this dense peptidoglycan layer becomes dehydrated, shrinking the cell wall pores and trapping the primary crystal violet-iodine complex inside the cell.

(d) Gram-negative bacteria feature a thin, single-layered peptidoglycan sheet surrounded by an asymmetric outer lipid membrane containing lipopolysaccharides (LPS), which dissolves during decolorization and allows the stain to wash out.

(e) Because the thick, extensively cross-linked peptidoglycan matrix physically prevents the elution of the primary dye complex, Gram-positive cells retain the purple coloration throughout the staining protocol.

Final Answer: A thick, highly cross-linked multi-layered peptidoglycan meshwork.

Answer: (A)

Go Back to Question 16

Q17.

Solution

Concept: Successful fertilization requires mechanisms to prevent polyspermy, which would introduce extra chromosome sets and cause mitotic failure. Binding of the fertilizing sperm to egg surface receptors initiates a signaling cascade that modifies the extracellular matrix to block additional sperm entry.

Solution:

(a) Upon initial contact and binding of the sperm head to the egg plasma membrane, a fast block to polyspermy occurs via a transient depolarization of the oocyte membrane driven by sodium influx.

(b) This initial wave triggers the slow block to polyspermy, known as the cortical reaction. The mechanical trigger for this event is a rapid, wave-like intracellular surge of calcium (Ca^{2+}) ions.

(c) This calcium wave propagates from the site of sperm entry across the entire oocyte cytoplasm, stimulated by phospholipase activation and the subsequent release of calcium from the endoplasmic reticulum.

(d) The elevated cytosolic calcium concentration induces the exocytosis of specialized cortical granules located just beneath the oocyte plasma membrane, releasing proteolytic enzymes into the perivitelline space.

(e) These enzymes cleave egg surface receptors and harden the zona pellucida (or vitelline envelope), creating a permanent physical barrier that prevents any further spermatozoa from binding or penetrating.

Final Answer: Calcium (Ca^{2+}).

Answer: (C)

Go Back to Question 17

Q18.

Solution

Concept: The structural features of floral organs serve as diagnostic keys for classifying angiosperms into specific families. Members of the family Cruciferae (also known as Brassicaceae) display a distinct arrangement of their calyx, corolla, androecium, and gynoecium.

Solution:

(a) The family Cruciferae gets its name from its characteristic corolla layout, where four distinct clawed petals are arranged in an opposite, cross-like orientation known as a cruciform corolla.

(b) The androecium exhibits a tetradynamous configuration consisting of six stamens total, arranged in two separate whorls. The outer whorl contains two short stamens, while the inner whorl houses four long stamens.

(c) The gynoecium is bicarpellary and syncarpous. Although the ovary is initially unilocular, it later becomes bilocular due to the development of a false internal tissue framework called the replum or false septum.

(d) The characteristic fruit that develops from this ovary structure is a dry dehiscent capsule termed a siliqua or silicula, which splits along both sutures from the base upward.

(e) Other options describe alternative families: monadelphous stamens characterize Malvaceae, an obliquely placed ovary septum defines Solanaceae, and marginal placentation in a monocarpellary ovary is typical of Fabaceae.

Final Answer: Tetradynamous stamens, cruciform corolla, and a siliqua fruit with a false septum (replum).

Answer: (B)

Go Back to Question 18

Q19.

Solution

Concept: Recombinant DNA technology allows researchers to introduce complete biosynthetic pathways into staple food crops to address nutrient deficiencies in human populations, a strategy known as nutritional biofortification.

Solution:

(a) Golden Rice is a variety of transgenic rice (*Oryza sativa*) developed to combat vitamin A deficiency, a leading cause of blindness and childhood mortality in developing nations dependent on rice monocultures.

(b) Endosperm tissue in standard rice grains naturally possesses the metabolic precursors for carotenoid production but lacks the active structural enzymes required to complete the biosynthesis within the grain.

(c) To resolve this, scientists inserted foreign genes: phytoene synthase (psy) from the daffodil plant *Narcissus pseudonarcissus* and phytoene desaturase ($crtI$) from the soil bacterium *Pantoea ananatis* (formerly *Erwinia uredovora*).

(d) These introduced genetic sequences express functional enzymes within the grain endosperm, completing the metabolic pathway that converts geranylgeranyl diphosphate into β-carotene.

(e) The accumulated β-carotene imparts a characteristic golden-yellow color to the polished rice grains. When consumed, this compound is cleaved by intestinal enzymes to yield essential functional Vitamin A (retinol).

Final Answer: β-carotene (Pro-vitamin A).

Answer: (C)

Go Back to Question 19

Q20.

Solution

Concept: The translation of genetic information from mRNA into polypeptides relies on specific pairing between mRNA codons and tRNA anticodons. The wobble hypothesis explains how a cell can translate all 61 sense codons using fewer than 61 distinct tRNA species through flexible base-pairing rules.

Solution:

(a) According to the wobble hypothesis proposed by Francis Crick, the base-pairing interactions between the first two positions of the mRNA codon and the last two positions of the tRNA anticodon strictly follow standard Watson-Crick pairing rules (A with U, G with C).

(b) These first two positions ensure high fidelity during translation, maintaining accurate amino acid selection based on the genetic code.

(c) In contrast, the spatial constraints at the third position of the mRNA codon (read in the 5' to 3' direction) and the corresponding first position of the tRNA anticodon are less rigid.

(d) This steric flexibility allows for non-standard, alternative base-pairing alignments (such as Guanine pairing with Uracil, or Hypoxanthine pairing with Uracil, Adenine, or Cytosine) at this final codon position.

(e) This relaxed pairing flexibility at the 3' end base of the mRNA codon allows a single tRNA anticodon to recognize and bind to multiple synonymous codons that differ only in their terminal nucleotide.

Final Answer: The 3' end base of the mRNA codon.

Answer: (B)

Go Back to Question 20

Q21.

Solution

Concept: Population ecology explores the diverse interspecific interactions that arise when two distinct species share a common habitat. These ecological dynamics are classified systematically based on whether the multi-species relationship exerts a positive, negative, or completely neutral physiological effect on each participant organism.

Solution:

(a) In community ecology, an interspecific interaction where one biological species derives a significant survival or nutritional benefit while the co-habiting partner species remains completely unaffected is defined as commensalism.

(b) This neutral condition implies that the host organism experiences absolutely no metabolic drain, structural damage, reproductive disadvantage, or survival benefit from the presence of the commensal individual.

(c) A classic example is the relationship between small orchid plants growing as epiphytes on the branches of large mango trees, where the orchid gains physical support and elevation without stealing nutrients from the tree.

(d) Another manifestation includes barnacles attaching themselves to the skin of migrating whales, where the barnacles receive transportation to plankton-rich waters while the whale remains entirely unbothered and unharmed.

(e) Alternative ecological pairings like mutualism benefit both organisms, parasitism harms the host while helping the parasite, and amensalism results in one species being inhibited or destroyed while the other experiences no net effect.

Final Answer: Commensalism.

Answer: (D)

Go Back to Question 21

Q22.

Solution

Concept: The biochemical architecture of double-stranded DNA molecules conforms to strict quantitative structural regularities determined by base-pairing constraints. Analyzing nucleotide percentages across a total genome requires applying stoichiometric equivalence rules governing the ratios of purine and pyrimidine bases.

Solution:

(a) Erwin Chargaff formulated the rules of base equivalence, stating that in any natural double-stranded DNA molecule, the total concentration of purine bases always equals the total concentration of pyrimidine bases.

(b) This structural equivalence means that the percentage of Adenine (A) is precisely equal to the percentage of Thymine (T), and the percentage of Guanine (G) is precisely equal to the percentage of Cytosine (C).

(c) The given problem states that the DNA genome contains 22% Cytosine bases, which means the complementary pyrimidine base concentration must also equal 22% Guanine ($G = C = 22\%$).

(d) Combining these values accounts for a specific portion of the total genetic composition, yielding a combined Guanine-Cytosine fraction of exactly 44% ($22\% + 22\% = 44\%$).

(e) Deducting this value from the total baseline population leaves 56% allocated to the Adenine-Thymine pairs, which, when divided equally, gives an Adenine concentration of exactly 28% ($56\%/2 = 28\%$).

Final Answer: 28%.

Answer: (C)

Go Back to Question 22

Q23.

Solution

Concept: Plant anatomy dictates the sequential path that soil water and inorganic nutrients must traverse during radial translocation from the external rhizospheric solution into the central conducting elements of the vascular cylinder, moving across distinct cellular layers.

Solution:

(a) Water absorption begins at the interface with the soil matrix, where specialized thin-walled extensions of root epidermal cells, known as root hairs, significantly expand the total surface area available for driving osmosis.

(b) Once inside the root hair, water moves inward across the outermost protective layer, the epidermis, and enters the expansive parenchymatous tissue layer of the cortex via apoplastic or symplastic pathways.

(c) At the innermost boundary of the cortex, the water confronts the endodermis, where suberized Casparian strips block the apoplast, forcing all fluid to enter the symplast to undergo selective filtration.

(d) After clearing this regulatory checkpoint, the filtered fluid moves radially into the underlying pericycle layer, which forms the outer perimeter of the stele and plays a key role in root branching.

(e) From the pericycle, the water enters the dead, hollow conducting elements of the root xylem vessels, where negative transpirational pull transports it upward through the shoot system.

Final Answer: Root hair → Cortex → Endodermis → Pericycle → Xylem.

Answer: (C)

Go Back to Question 23

Q24.

Solution

Concept: The mechanical contraction of human skeletal muscle tissue is explained by the sliding filament model, where interdigitating thin actin and thick myosin structural protein filaments slide past one another without undergoing any individual conformational shortening.

Solution:

(a) A functional sarcomere represents the repeating structural unit of myofibrils, bounded at both ends by dark lines called Z-lines, which anchor the thin actin filaments.

(b) During a nerve-induced muscle contraction, myosin cross-bridges repeatedly bind to actin, pulling the thin filaments inward toward the center of the sarcomere, which shortens the distance between consecutive Z-lines.

(c) As the actin filaments slide deeper into the central region, the light-colored I-bands, which contain exclusively thin actin filaments, decrease in total width and can disappear entirely during maximum structural contraction.

(d) Similarly, the H-zone, located at the center of the dark band where thin filaments do not overlap thick filaments in a relaxed state, shortens as actin moves inward.

(e) However, the dark A-band corresponds to the total physical length of the thick myosin filaments. Because these thick filaments do not change their length, the total width of the A-band remains completely constant.

Final Answer: The A-band.

Answer: (C)

Go Back to Question 24

Q25.

Solution

Concept: Eukaryotic plant cells partition photosynthetic reactions across distinct sub-organellar compartments inside the chloroplast. This spatial segregation isolates the light-dependent generation of chemical energy from the enzymatic fixation of carbon dioxide into carbohydrates.
Solution:

(a) The chloroplast is wrapped in a double-membrane envelope that encloses a complex internal structural system. Photosynthesis occurs in two distinct, interconnected metabolic phases: the light-dependent reactions and the dark reactions.

(b) The light reactions take place on the specialized membranes of the thylakoids and grana, where embedded chlorophyll pigments absorb light energy to produce ATP and $NADPH$.

(c) The dark reactions, also known as the Calvin cycle, are light-independent but rely on the chemical energy carriers (ATP and $NADPH$) produced during the light-dependent phase to fix carbon.

(d) The enzymatic machinery required for this carbon fixation phase, including the key carboxylating enzyme RuBisCO, is located in the fluid-filled matrix surrounding the thylakoids, called the stroma.

(e) Alternative sub-organellar compartments like the thylakoid lumen accumulate protons, the intermembrane space separates the outer and inner bilayers, and the grana host light-harvesting complexes, confirming the stroma as the site of dark reactions.

Final Answer: The aqueous stroma matrix.

Answer: (B)

Go Back to Question 25

Q26.

Solution

Concept: Renal physiology relies on maintaining a precise hydrostatic pressure gradient across the glomerular capillary network to drive ultrafiltration. Modulating the vascular diameter of the arterioles leading into or out of the renal corpuscle directly alters this filtration pressure.

Solution:

(a) The blood vessels supplying a renal corpuscle include a wide afferent arteriole that introduces blood into the glomerulus and a narrower efferent arteriole that directs blood away from it.

(b) This physical diameter difference creates a high homeostatic resistance that maintains an elevated hydrostatic pressure inside the glomerular capillaries, driving the separation of plasma filtrate into Bowman's capsule.

(c) If a pathological condition permanently constricts the diameter of the afferent arteriole, the volume of blood entering the capillary network per unit time will drop significantly.

(d) This decrease in blood flow lowers the net hydrostatic pressure within the glomerulus, reducing the primary driving force for filtration and causing a drop in the glomerular filtration rate (GFR).

(e) Other options are incorrect: a reduction in GFR decreases venous return pressure, large plasma proteins like globulins remain too large to pass the filtration barrier, and low pressure stimulates antidiuretic hormone release to conserve fluid.

Final Answer: A severe reduction in the net glomerular hydrostatic filtration force.

Answer: (B)

Go Back to Question 26

Q27.

Solution

Concept: Human transmission genetics traces the inheritance patterns of phenotypic traits associated with mutant alleles located on sex chromosomes. Traits linked to the X chromosome express themselves differently in males and females due to differences in chromosomal composition.

Solution:

(a) Human females possess two X chromosomes (XX), whereas human males carry one X and one Y chromosome (XY). A male is hemizygous for X-linked genes, meaning he expresses whatever allele is present on his single X chromosome.

(b) If a genetic condition is caused by an X-linked recessive allele, an affected father will pass his mutated X chromosome to all of his daughters, making them carriers if they inherit a normal allele from their mother.

(c) This affected father cannot pass the condition to his sons, because he contributes only his Y chromosome to his male offspring, excluding vertical male-to-male transmission of X-linked traits.

(d) When a carrier daughter reproduces with an unaffected male, she has a 50% chance of passing her mutated X chromosome to her children, leading to a phenotypic expression rate of fifty percent among her sons.

(e) This multi-generational transmission pattern, where a trait passes from an affected male through a carrier female to his grandsons, is known as criss-cross inheritance.

Final Answer: Passed from an affected father through carrier daughters down to fifty percent of grandsons.

Answer: (B)

Go Back to Question 27

Q28.

Solution

Concept: In molecular cloning, preparing plasmid vectors requires modifying terminal nucleotide groups to optimize ligation efficiency. When restriction endonucleases cut a vector, treating the exposed ends prevents the plasmid from closing back on itself without inserting the foreign gene.

Solution:

(a) Digesting a circular plasmid vector with a single restriction endonuclease breaks the phosphodiester backbone, creating linear DNA fragments with matching, complementary sticky ends at both terminals.

(b) During a cloning ligation reaction, these matching sticky ends can easily pair with each other, causing the vector to self-circularize and re-ligate without incorporating the target eukaryotic insert.

(c) To prevent this self-ligation, the linearized plasmid vector is treated with an enzyme called Alkaline Phosphatase before mixing it with the target gene insert.

(d) Alkaline Phosphatase catalyzes the removal of the essential 5' phosphate groups from both ends of the linear vector DNA molecule, leaving unreactive 5' hydroxyl groups exposed.

(e) Since DNA ligase requires a 5' phosphate group to catalyze phosphodiester bond formation, self-circularization is blocked, forcing directional ligation to occur with the 5' phosphorylated ends of the insert DNA.

Final Answer: Alkaline Phosphatase.

Answer: (B)

Go Back to Question 28

Q29.

Solution

Concept: Evolutionary biology studies how environmental selection forces shape the morphological, physiological, and behavioral profiles of organisms over generations, leading to predictable patterns of adaptation across independent biological lineages.

Solution:

(a) When geographically isolated and phylogenetically distinct biological lineages encounter similar ecological niches and selection pressures, they often evolve similar phenotypic adaptations independently, a process called convergent evolution.

(b) This evolutionary pattern results in analogical structures that perform similar functions and look alike superficially, despite having different embryonic origins and underlying genetic frameworks.

(c) A classic example is the streamlined body shape of dolphins (mammals) and sharks (chondrichthyan fish), both adapted for high-speed swimming in marine environments.

(d) Alternative concepts like divergent evolution describe related lineages developing different traits, adaptive radiation involves a single ancestral species diversifying into multiple specialized forms, and genetic drift refers to random allele frequency shifts.

(e) Because convergent evolution is driven by similar environmental pressures acting on unrelated organisms, it leads to independent lineages developing similar morphological solutions.

Final Answer: Convergent Evolution.

Answer: (B)

Go Back to Question 29

Q30.

Solution

Concept: Cellular respiration links anaerobic cytoplasmic pathways with aerobic mitochondrial pathways to optimize ATP synthesis from organic substrates. Connecting these pathways requires converting the final product of glycolysis into a substrate that can enter the citric acid cycle.

Solution:

(a) Metabolic breakdown begins in the cytoplasm with glycolysis, an anaerobic pathway where a six-carbon glucose molecule is broken down through a series of steps into two molecules of three-carbon pyruvate.

(b) Under aerobic conditions, this pyruvate is transported across the double-membrane envelope of the mitochondrion into the inner matrix to undergo oxidative decarboxylation.

(c) Inside the mitochondrial matrix, the multi-enzyme pyruvate dehydrogenase complex catalyzes the decarboxylation of pyruvate, releasing carbon dioxide and generating a two-carbon acetyl group.

(d) This acetyl group is co-valently linked to Coenzyme A to form Acetyl-CoA, which serves as the primary substrate for entry into the aerobic tricarboxylic acid (TCA) cycle.

(e) Inside the cycle, Acetyl-CoA condenses with four-carbon oxaloacetic acid to form six-carbon citric acid, making Acetyl-CoA the critical structural link between cytoplasmic glycolysis and mitochondrial respiration.

Final Answer: Acetyl-CoA.

Answer: (B)

Go Back to Question 30

Q31.

Solution

Concept: Human clinical pathology includes various musculoskeletal and neuromuscular disorders. Correctly diagnosing these conditions requires identifying whether the underlying physiological cause stems from chemical degradation, metabolic deposition, structural wear, or a targeted autoimmune inflammatory response.

Solution:

(a) Rheumatoid arthritis is a systemic autoimmune disease where the body's immune system mistakenly identifies the self-antigens of the synovial membrane within joints as foreign threats.

(b) This mismatch triggers an immune response where lymphocytes infiltrate the joint space, releasing inflammatory cytokines that cause chronic inflammation and dangerous swelling of the synovial lining.

(c) Over time, this inflammation leads to the formation of pannus, an abnormal tissue layer that invades and destroys the underlying articular cartilage and bone, causing joint deformity.

(d) In contrast, osteoarthritis is a degenerative structural wear-and-tear condition of aging cartilage, gouty arthritis is caused by the metabolic deposition of uric acid crystals, and myasthenia gravis is a neuromuscular autoimmune disease affecting acetylcholine receptors.

(e) Therefore, a pathology where immune cells directly launch an inflammatory attack against the self-surface antigens of an individual's own joints is classified specifically as rheumatoid arthritis.

Final Answer: Rheumatoid Arthritis.

Answer: (C)

Go Back to Question 31

Q32.

Solution

Concept: Genetic engineering relies on plasmid vectors containing selectable markers, such as antibiotic resistance genes, to identify recombinant clones. Inserting a foreign gene into a restriction site located within one of these markers disrupts its function, a process called insertional inactivation.

Solution:

(a) The standard cloning vector pBR322 contains two distinct genes that confer antibiotic resistance to its host cell: the ampicillin resistance gene (amp^R) and the tetracycline resistance gene (tet^R).

(b) When a researcher cuts the plasmid and inserts a target eukaryotic gene specifically into a restriction site located inside the structural sequence of the tet^R gene, the continuity of that gene is completely broken.

(c) This insertional inactivation prevents the host cell from transcribing and translating a functional protein for tetracycline resistance, causing the recombinant plasmid to lose its protective capability against that specific antibiotic.

(d) Because the ampicillin resistance gene (amp^R) remains untouched during this cloning step, host cells carrying the recombinant plasmid continue to produce the enzyme needed to survive in the presence of ampicillin.

(e) Consequently, transformed bacterial cells containing this recombinant plasmid display a distinct phenotype, showing resistance to ampicillin but sensitivity to tetracycline.

Final Answer: Resistant to ampicillin but sensitive to tetracycline.

Answer: (C)

Go Back to Question 32

Q33.

Solution

Concept: Plant anatomy relies on specialized structural modifications within tissue layers to regulate the radial movement of water and dissolved minerals, preventing backflow and ensuring selective filtration before nutrients enter the vascular cylinder.

Solution:

(a) The endodermis represents the innermost cellular boundary of the root cortex, forming a tightly packed, single-layered ring of barrel-shaped cells that completely encloses the vascular cylinder.

(b) The radial and transverse walls of these endodermal cells feature localized bands of a water-impermeable, waxy material called suberin, which are known as Casparian strips.

(c) As soil water moves inward through the root tissues via the apoplastic pathway, traveling along cell walls and intercellular spaces, it encounters this suberized barrier at the endodermal interface.

(d) The hydrophobic Casparian strips block any further apoplastic fluid movement, forcing the water and minerals to cross the plasma membrane and enter the living symplastic pathway.

(e) This structural block allows the endodermal cells to act as a physiological checkpoint, filtering solutes before they can pass into the pericycle and enter the conducting lumen of the root xylem.

Final Answer: Endodermis of roots.

Answer: (B)

Go Back to Question 33

Q34.

Solution

Concept: Meiotic cell division reduces the chromosome number by half while introducing genetic diversity. This variation is achieved through the precise pairing, physical crossing over, and reciprocal exchange of genetic material during Prophase I.

Solution:

(a) Prophase I of meiosis is a long, complex stage divided into five distinct sub-stages: leptotene, zygotene, pachytene, diplotene, and diakinesis, each marked by specific chromosomal behaviors.

(b) During the initial leptotene stage, chromatin fibers condense, and during the subsequent zygotene stage, homologous chromosomes pair up side-by-side to form bivalents through synapsis.

(c) Once synapsis is complete, the cells enter the pachytene stage, where the paired homologous chromosomes shorten, thicken, and clearly show a four-chromatid tetrad configuration.

(d) During this pachytene stage, non-sister chromatids of the homologous pairs form physical connections where recombination nodules facilitate crossing over and the exchange of genetic segments.

(e) Following this phase, the diplotene stage is marked by the dissolution of the synaptonemal complex and the appearance of X-shaped chiasmata, confirming that pachytene is the stage where crossing over occurs.

Final Answer: Pachytene.

Answer: (C)

Go Back to Question 34

Q35.

Solution

Concept: Neurophysiology depends on rapid, transient shifts in membrane potential called action potentials to transmit signals along excitable cells, driven by the sequential opening and closing of voltage-gated ion channels.

Solution:

(a) An excitable human cell maintains a steady resting membrane potential, typically around $-70\,\text{mV}$, due to the selective permeability of the plasma membrane and the continuous action of the sodium-potassium pump.

(b) When an electrical stimulus reaches the threshold level, it triggers a conformational change in the voltage-gated sodium channels embedded in the cell membrane, causing them to open rapidly.

(c) Because sodium ions (Na^+) are highly concentrated outside the cell and the interior carries a negative charge, opening these channels creates a strong electrochemical gradient that drives a massive influx of sodium into the cytoplasm.

(d) This rapid influx of positive ions neutralizes the internal negative charge and drives the membrane potential upward past zero toward a peak value of approximately $+35\,\text{mV}$, a phase known as depolarization.

(e) This rapid upward shift matches point **Z** on the action potential trace, whereas the subsequent downward curve is driven by the outward movement of potassium ions during repolarization.

Final Answer: Rapid inward influx of sodium (Na^+) ions through voltage-gated channels.

Answer: (B)

Go Back to Question 35

Q36.

Solution

Concept: Plant physiology explains the long-distance translocation of organic nutrients through phloem tissue using the pressure-flow (mass-flow) model, which relies on a hydrostatic pressure gradient established between source and sink tissues.

Solution:

(a) Translocation begins at source tissues, such as mature leaves, where photosynthetic cells produce large quantities of sugars that are actively loaded into the sieve tube elements with the help of companion cells.

(b) This active accumulation of sugars increases the solute concentration inside the sieve tubes, lowering the water potential and creating a hypertonic environment at the source end of the phloem.

(c) In response to this gradient, water moves osmotically from the adjacent xylem vessels into the hypertonic sieve tubes, causing a significant increase in local hydrostatic pressure.

(d) Meanwhile, at metabolic sink tissues like roots or developing fruits, sugars are actively unloaded from the phloem, which lowers the solute concentration and causes water to move back out into the xylem.

(e) The resulting high pressure at the source and low pressure at the sink create a mass-flow gradient that drives organic fluids through the interconnected sieve tube system.

Final Answer: Active loading of sugars into sieve tubes at the source, creating a hypertonic environment that draws water in via osmosis, increasing hydrostatic pressure.

Answer: (A)

Go Back to Question 36

Q37.

Solution

Concept: Biochemistry classifies structural polysaccharides based on their specific monomer subunits and the glycosidic bonds that connect them into complex polymeric structures, which provide mechanical strength to various organisms.

Solution:

(a) Chitin is a tough, long-chain structural homopolymer composed of repeating units of an amino sugar derivative known as N-acetylglucosamine (NAG).

(b) These monomeric units are linked together by strong β-1,4-glycosidic bonds, forming linear chains that pack closely to provide high tensile strength and structural rigidity.

(c) In nature, this polymer serves as the primary component of fungal cell walls and forms the protective, unyielding exoskeleton of arthropods, including insects and crustaceans.

(d) In comparison, cellulose is a polymer made of plain glucose units found in plant walls, peptidoglycan contains cross-linked peptides in bacterial walls, and glycogen serves as a branched glucose storage molecule in animals.

(e) Thus, a polymer made of β-1,4-glycosidic linkages of N-acetylglucosamine units that builds fungal walls and arthropod exoskeletons is identified as chitin.

Final Answer: Chitin.

Answer: (B)

Go Back to Question 37

Q38.

Solution

Concept: Environmental biology tracks how chemical and nutrient inputs impact aquatic ecosystems, where overloading a body of water with nutrients can disrupt ecological balance and lead to a collapse of aquatic life.

Solution:

(a) Eutrophication is the natural or accelerated aging of a water body caused by excessive nutrient enrichment, primarily from agricultural runoff containing nitrogen and phosphorus.

(b) This sudden influx of nutrients stimulates the rapid growth of primary producers, leading to massive surface accumulations of algae known as algal blooms.

(c) These dense algal mats block sunlight from reaching submerged plants, halting underwater photosynthesis and causing deeper vegetation to die off.

(d) As the short-lived algae die, aerobic decomposers like bacteria multiply rapidly to break down the organic matter, consuming large amounts of dissolved oxygen in the process.

(e) This high bacterial activity depletes the water's oxygen levels, creating hypoxic conditions that lead to the widespread suffocation and death of fish and other aquatic animals.

Final Answer: Eutrophication.

Answer: (B)

Go Back to Question 38

Q39.

Solution

Concept: Human reproductive endocrinology coordinates the menstrual cycle and early pregnancy using a sequence of hormones produced by temporary endocrine structures in the ovaries and the pituitary gland.

Solution:

(a) During the human female reproductive cycle, a surge of luteinizing hormone (LH) from the anterior pituitary triggers ovulation, causing a mature Graafian follicle to rupture and release an oocyte.

(b) After ovulation, the remaining granulosa and theca cells of the ruptured follicle undergo structural changes to form a temporary endocrine gland called the corpus luteum.

(c) This corpus luteum synthesizes and secretes large quantities of progesterone, along with smaller amounts of estrogen, during the luteal phase of the cycle.

(d) Progesterone stimulates the vascularization and glandular development of the endometrium, preparing the uterine lining to receive and support a potentially implanted embryo.

(e) If fertilization does not occur, the corpus luteum degenerates into the scar-like corpus albicans, causing progesterone levels to drop and triggering menstruation.

Final Answer: Progesterone.

Answer: (C)

Go Back to Question 39

Q40.

Solution

Concept: Taxonomy organizes living organisms using a hierarchical classification system where groups are arranged based on shared structural, anatomical, and genetic features, moving from specific to broad categories.

Solution:

(a) The standard taxonomic hierarchy consists of several major levels arranged in descending order: Kingdom, Division (or Phylum), Class, Order, Family, Genus, and Species.

(b) At the lowest level, a species consists of individuals that are highly similar and capable of interbreeding, meaning they share the highest percentage of common evolutionary and structural traits.

(c) As you move up the taxonomic hierarchy to broader categories, each higher level includes a more diverse group of organisms that share fewer traits.

(d) Among the choices provided, a Division (equivalent to a Phylum in animal classification) sits highest in the taxonomic hierarchy, above Order, Cohort, and Family.

(e) Consequently, organisms grouped together at the Division level display the fewest shared characteristics and the greatest overall genetic diversity compared to the other listed categories.

Final Answer: Division.

Answer: (D)

Go Back to Question 40

Q41.

Solution

Concept: Eukaryotic gene expression requires extensive post-transcriptional modification of the primary RNA transcript within the nucleus. This processing converts unstable pre-mRNA containing non-coding sequences into a stable, functional mature mRNA molecule ready for ribosomal translation.

Solution:

(a) In eukaryotic transcription, RNA Polymerase II synthesizes an initial raw transcript known as heterogeneous nuclear RNA (hnRNA), which contains both coding exons and non-coding introns.

(b) To transform this unstable hnRNA into mature mRNA, the molecule must undergo three distinct co-transcriptional and post-transcriptional modifications inside the nucleus.

(c) The first processing step is capping, where an unusual nucleotide, 7-methylguanosine, is attached to the 5' end of the transcript to protect it from exonuclease degradation.

(d) Next, the molecule undergoes splicing, a precise biochemical process managed by spliceosomes that removes non-coding introns and splices the coding exons together.

(e) Finally, tailing occurs at the 3' end, where a polyadenylate polymerase enzyme adds a string of approximately 200 to 300 adenylate residues, forming a stable poly-A tail.

Final Answer: Addition of a 7-methylguanosine cap to the 5' end, splicing out of introns, and addition of a poly-A tail at the 3' end.

Answer: (B)

Go Back to Question 41

Q42.

Solution

Concept: Plant growth and development are coordinated by chemical messengers known as phytohormones. Each class of hormone displays a unique combination of physiological actions, transport mechanisms, and tissue-specific patterns of cellular regulation.

Solution:

(a) Auxins represent a primary class of plant growth regulators, with Indole-3-acetic acid (IAA) serving as the principal naturally occurring form synthesized in actively growing apices.

(b) This hormone exhibits strict polar basipetal transport, meaning it moves downward from the apical shoots toward the roots through a dedicated system of cellular influx and efflux carriers.

(c) A primary physiological role of auxin is promoting cell elongation in coleoptiles and stems by stimulating proton pumps to loosen the structural integrity of the primary cell wall.

(d) Auxin also maintains apical dominance, where high concentrations near the shoot apex inhibit the growth of lateral buds, keeping the plant growing upward.

(e) In agricultural practices, synthetic or natural auxins are regularly applied to induce rapid root initiation in stem cuttings, facilitating vegetative propagation.

Final Answer: Indole-3-acetic acid (Auxin).

Answer: (B)

Go Back to Question 42

Q43.

Solution

Concept: The respiratory physiology of human blood depends on the structural conformation of hemoglobin. Reversibly binding and releasing molecular oxygen requires maintaining the iron atom within the prosthetic heme group in a specific chemical oxidation state.

Solution:

(a) A human hemoglobin molecule is a quaternary protein composed of four polypeptide chains, each containing an integrated non-protein prosthetic group known as a heme ring.

(b) At the center of each heme ring sits a single iron atom coordinated by nitrogen atoms, which acts as the direct binding site for molecular oxygen.

(c) For effective, reversible oxygenation to occur, this central iron atom must remain strictly in the reduced ferrous state (Fe^{2+}).

(d) When hemoglobin binds oxygen to form oxyhemoglobin, the iron atom shares electrons temporarily without undergoing chemical oxidation, allowing it to release the oxygen easily at the tissues.

(e) If the iron atom is oxidized to the ferric state (Fe^{3+}), it forms an abnormal molecule called methemoglobin, which cannot bind molecular oxygen and disrupts respiratory transport.

Final Answer: Ferrous state (Fe^{2+}).

Answer: (B)

Go Back to Question 43

Q44.

Solution

Concept: Enzyme kinetics tracks how inhibitors alter the catalytic efficiency of an enzyme assay by analyzing changes in maximum reaction velocity (V_{max}) and the Michaelis constant ($\mathbf{K_m}$), which measures substrate binding affinity.

Solution:

(a) A competitive inhibitor possesses a three-dimensional structural conformation that closely resembles the normal substrate molecule, allowing it to compete directly for the catalytic active site.

(b) Because the inhibitor and substrate compete for the same site, increasing the concentration of the substrate can outcompete the inhibitor, completely reversing its inhibitory effect.

(c) Since high substrate concentrations can completely saturate the enzyme, the maximum reaction velocity (V_{max}) achievable by the enzymatic assay remains completely unchanged.

(d) However, because the inhibitor blocks a portion of the active sites at lower substrate levels, a higher concentration of substrate is required to reach half of the maximum velocity.

(e) This requirement means that the Michaelis constant ($\mathbf{K_m}$) increases, shifting the corresponding point on the kinetic graph to the right while leaving the horizontal V_{max} asymptote steady.

Final Answer: V_{max} remains unchanged; $\mathbf{K_m}$ increases.

Answer: (B)

Go Back to Question 44

Q45.

Solution

Concept: Human cytogenetics investigates chromosomal numerical aberrations that occur when chromosomes fail to separate correctly during gametogenesis. This failure results in aneuploid zygotes with altered structural and reproductive phenotypes.

Solution:

(a) During normal meiosis, homologous chromosomes or sister chromatids separate evenly into daughter gametes, a physiological process known as disjunction.

(b) If non-disjunction occurs, a pair of chromosomes fails to separate, producing a gamete with an extra chromosome that results in a trisomic zygote upon fertilization.

(c) Klinefelter's syndrome is a classic chromosomal aberration caused by non-disjunction, leaving the affected individual with a total count of 47 chromosomes instead of the standard 46.

(d) The specific genetic layout for this syndrome is designated as $45 + XXY$, meaning the individual possesses a standard set of autosomes combined with an abnormal sex chromosome triplet.

(e) Phenotypically, these individuals develop as sterile males with distinct features, including weak muscular development, elongated limbs, and gynecomastia due to the altered hormonal balance.

Final Answer: Klinefelter's Syndrome.

Answer: (C)

Go Back to Question 45

Q46.

Solution

Concept: Environmental science analyzes the greenhouse effect, where specific atmospheric trace gases trap thermal energy. These molecules absorb long-wave infrared radiation re-emitted from the Earth's surface and radiate it back, heating the lower troposphere.

Solution:

(a) Solar radiation passes through the atmosphere and warms the Earth's surface, which then re-emits this energy back toward space as longer-wave infrared radiation.

(b) Main atmospheric gases like Nitrogen (N_2) and Oxygen (O_2) do not absorb this infrared wavelength due to their symmetric diatomic molecular structure.

(c) In contrast, greenhouse gases possess asymmetric structures that allow them to absorb these infrared photons, trapping thermal energy within the troposphere.

(d) Carbon dioxide (CO_2) is the most significant greenhouse gas contributor, accounting for roughly 60% of human-driven global warming due to massive fossil fuel combustion.

(e) Methane (CH_4) acts as another potent greenhouse molecule, contributing nearly 20% of the total warming effect through agricultural activities and anaerobic decomposition.

Final Answer: Carbon dioxide (CO_2) and Methane (CH_4).

Answer: (C)

Go Back to Question 46

Q47.

Solution

Concept: The reproductive biology of angiosperms features a highly specialized double fertilization process within the embryo sac, where two distinct fertilization events occur simultaneously to initiate seed development.

Solution:

(a) After a pollen tube successfully penetrates the female embryo sac through the micropylar opening, it releases two haploid male gametes into the cytoplasm of a helper synergid cell.

(b) The first male gamete moves toward the egg cell and fuses with its nucleus, an event called syngamy that produces a diploid ($2n$) zygote destined to form the embryo.

(c) Meanwhile, the second male gamete travels to the center of the embryo sac and fuses with the two haploid polar nuclei located inside the large central cell.

(d) This second fusion event involves three haploid nuclei and is known as triple fusion, which produces a triploid ($3n$) cell called the primary endosperm nucleus (PEN).

(e) Together, syngamy and triple fusion constitute the process of double fertilization, a diagnostic feature unique to flowering plants that ensures nutrient-rich endosperm tissue develops alongside the embryo.

Final Answer: One male gamete fuses with the egg cell (syngamy); the second male gamete fuses with the two polar nuclei (triple fusion) to form the primary endosperm nucleus.

Answer: (B)

Go Back to Question 47

Q48.

Solution

Concept: Biological taxonomy organizes the diversity of life by grouping organisms based on shared evolutionary history and structural traits. Modern classification systems rely on multi-criteria analysis rather than simple superficial features.

Solution:

(a) Early historical classification systems relied on basic superficial traits, such as grouping organisms by their habitat or whether they possessed red blood cells.

(b) In 1969, Robert H. Whittaker advanced biological taxonomy by proposing the Five Kingdom classification system, which grouped organisms into Monera, Protista, Fungi, Plantae, and Animalia.

(c) This system was built on several core structural criteria, starting with cell structure complexity to clearly separate prokaryotic and eukaryotic organisms.

(d) It also evaluated thallus or body organization to distinguish unicellular life forms from complex multicellular configurations.

(e) Additionally, the system incorporated the mode of nutrition, reproductive mechanisms, and evolutionary or phylogenetic relationships to create a comprehensive taxonomic framework.

Final Answer: Cell structure complexity, body organization, mode of nutrition, reproduction, and phylogenetic relationships.

Answer: (B)

Go Back to Question 48

Q49.

Solution

Concept: Biotechnology utilizes specialized bacterial enzymes to manipulate genetic material in vitro. These molecular tools find, bind to, and cleave specific nucleotide configurations along double-stranded DNA molecules.

Solution:

(a) Restriction endonucleases are a specialized class of bacterial enzymes that function as molecular scissors within recombinant DNA technology.

(b) These enzymes scan a double-stranded DNA molecule until they locate a specific, matching sequence of nucleotides known as a restriction recognition site.

(c) These recognition sites are typically palindromic, meaning the sequence of base pairs reads identical on both complementary strands when oriented in the 5' to 3' direction.

(d) Upon binding to this palindromic site, the enzyme cleaves the phosphodiester bonds of the sugar-phosphate backbone on both strands at precise nucleotide locations.

(e) This cleavage results in either blunt ends or protruding single-stranded cohesive terminals called sticky ends, which are invaluable for pasting genes into plasmid vectors.

Final Answer: Restriction Endonucleases.

Answer: (C)

Go Back to Question 49

Q50.

Solution

Concept: Human respiratory physiology manages the transport of metabolic waste from peripheral tissues back to the lungs using multiple chemical pathways within the bloodstream to maintain homeostatic acid-base balance.

Solution:

(a) Carbon dioxide (CO_2) generated by cellular metabolism diffuses out of tissue cells and enters the surrounding capillary network, where it is transported in three distinct forms.

(b) A small fraction, roughly 7%, remains physically dissolved within the blood plasma solution, while about 23% binds directly to hemoglobin to form carbaminohemoglobin.

(c) The largest portion, approximately 70%, is converted and transported through a highly efficient chemical pathway that takes place inside red blood cells.

(d) Inside the erythrocytes, the enzyme carbonic anhydrase rapidly converts dissolved carbon dioxide and water into carbonic acid, which quickly dissociates into hydrogen and bicarbonate ions (HCO_3^-).

(e) These bicarbonate ions then diffuse out of the red blood cells into the blood plasma via an antiport exchange mechanism called the chloride shift, traveling safely in the plasma to the lungs.

Final Answer: Bicarbonate (HCO_3^-) ions formed inside erythrocytes and shifted into plasma.

Answer: (C)

Go Back to Question 50

Q51.

Solution

Concept: Plant development is closely regulated by phytohormones that respond to environmental changes. Under adverse conditions, specific growth inhibitors are synthesized to protect tissues by conserving resources, inducing structural defenses, and delaying metabolic activities.

Solution:

(a) Abscisic acid (ABA) is a major plant growth regulator that plays a vital role in mediating responses to environmental stresses, earning it the designation of the stress hormone.

(b) When a plant encounters water deficits or severe drought, aba synthesis increases rapidly within the roots and leaves to coordinate protective physiological adjustments.

(c) This hormone travels to the guard cells of the stomatal complex, where it triggers an efflux of potassium ions and a subsequent loss of turgor pressure, forcing stomatal closure to minimize transpirational water loss.

(d) Additionally, aba acts as a powerful growth inhibitor by counteracting the actions of growth-promoting hormones like gibberellins, thereby maintaining seed and bud dormancy during unfavorable seasons.

(e) By preventing premature germination and reducing metabolic expenditure during winter or dry spells, this hormone ensures that the plant conserves resources until favorable growth conditions return.

Final Answer: Abscisic acid.

Answer: (C)

Go Back to Question 51

Q52.

Solution

Concept: During replication, the separation of complementary polynucleotide strands creates structural alterations further down the molecule. Specialized enzymes must manage these topological changes ahead of the replication fork to prevent the process from stalling.

Solution:

(a) As the enzyme DNA helicase travels along a double-stranded DNA molecule, it breaks the hydrogen bonds between complementary base pairs to separate the template strands.

(b) This unwinding action causes the downstream parental DNA double helix to twist tighter, creating severe positive supercoiling and intense topological strain ahead of the moving replication fork.

(c) To prevent this strain from warping the helix and halting replication, DNA topoisomerase (also known as DNA gyrase in prokaryotic systems) binds to the stressed DNA segment.

(d) The topoisomerase relieves this tension by cutting either one or both strands of the phosphodiester backbone, allowing the DNA to untwist and rotate into a relaxed state.

(e) Once the supercoiling tension is removed, the enzyme reseals the broken phosphodiester bonds, restoring structural continuity and allowing the replication fork to advance without interruption.

Final Answer: DNA Topoisomerase (DNA Gyrase).

Answer: (C)

Go Back to Question 52

Q53.

Solution

Concept: The human central nervous system contains specialized regions dedicated to maintaining homeostasis. These integration centers process sensory feedback from the body to manage metabolic, behavioral, and neuroendocrine systems.

Solution:

(a) The hypothalamus is a small but vital structural region located at the base of the forebrain, sitting directly below the thalamus and forming the floor of the third ventricle.

(b) This neural structure serves as the primary homeostatic integration center of the body, monitoring chemical, thermal, and osmotic changes in the blood flowing through its capillaries.

(c) It acts as the body's central thermostat, initiating physiological responses like sweating or shivering to maintain core body temperature within a narrow, healthy range.

(d) Specialized osmoreceptors inside the hypothalamus detect blood concentration changes, triggering thirst behaviors and releasing antidiuretic hormone to coordinate precise renal water conservation.

(e) Furthermore, the hypothalamus connects the nervous and endocrine systems by secreting releasing and inhibiting hormones that directly regulate the hormone production of the adjacent pituitary gland.

Final Answer: Hypothalamus.

Answer: (D)

Go Back to Question 53

Q54.

Solution

Concept: Meiotic cell division consists of two sequential nuclear divisions that reduce the chromosome number. Tracking the alignment, configuration, and separation of genetic structures helps differentiate the specific stages of meiosis I and meiosis II.

Solution:

(a) Meiosis I focuses on separating homologous chromosome pairs, whereas meiosis II focuses on separating individual sister chromatids, mirroring the structural mechanics seen during standard mitosis.

(b) In Stage A of the diagram, homologous chromosomes pair up and align side-by-side along the equatorial plate of the spindle apparatus, forming a distinct double-row layout.

(c) This specific configuration where homologous pairs align together at the center of the cell is the defining characteristic of metaphase I.

(d) In Stage B, the homologous pairs have already separated, and a haploid set of individual chromosomes aligns along a single metaphase plate before their sister chromatids split.

(e) When these individual chromatids separate and move toward opposite poles of the spindle apparatus, the cell enters anaphase II, making metaphase I and anaphase II the correct stages.

Final Answer: Stage A = Metaphase I; Stage B = Anaphase II.

Answer: (A)

Go Back to Question 54

Q55.

Solution

Concept: Ecosystem ecology utilizes quantitative metrics to measure the structural components and energy content of communities, allowing researchers to evaluate the productivity and efficiency of individual feeding levels.

Solution:

(a) Every feeding level within a food chain, known as a trophic level, contains a measurable quantity of organic material that shifts as energy flows through the ecosystem.

(b) The total mass of living organic matter or the total number of organisms present at a specific trophic level at any single given point in time is called the standing crop.

(c) This parameter can be measured either as fresh biomass weight or as dry organic weight, with dry weight providing a more accurate measure of actual energy content.

(d) It is important to distinguish this from the standing state, which measures the amount of non-living inorganic nutrients, such as nitrogen and phosphorus, present in the soil or water at any time.

(e) Therefore, while productivities measure the rate of biomass production over time, the actual amount of living tissue present at a given moment is defined as the standing crop.

Final Answer: Standing crop.

Answer: (A)

Go Back to Question 55

Q56.

Solution

Concept: Mendelian genetics describes how alleles interact within an organism. While complete dominance hides recessive traits in hybrids, other allelic combinations blend their traits, altering the standard ratios in subsequent generations.

Solution:

(a) When a homozygous red-flowered plant (RR) is crossed with a homozygous white-flowered plant (rr), each parent contributes a single allele to create a heterozygous F_1 generation (Rr).

(b) Instead of showing the dominant red trait, these F_1 hybrids display an intermediate pink color because the red allele cannot produce enough pigment to completely mask the white allele.

(c) This blending of traits in a heterozygote, creating a phenotype intermediate between both homozygous parents, is the classic definition of incomplete dominance.

(d) When these pink F_1 individuals (Rr) are self-pollinated, their alleles segregate evenly during gamete formation to produce a predictable mix of offspring in the F_2 generation.

(e) This cross yields a genotypic and phenotypic ratio of 1 red (RR), 2 pink (Rr), and 1 white (rr), matching the 1:2:1 ratio characteristic of incomplete dominance.

Final Answer: Incomplete Dominance.

Answer: (C)

Go Back to Question 56

Q57.

Solution

Concept: Cellular biology depends on a stable boundary membrane to separate the cytoplasm from the external environment. The architecture of this bilayer relies on structural lipids that possess dual chemical affinities.

Solution:

(a) The plasma membrane and internal organelle boundaries are built around a fluid matrix composed primarily of a specialized class of compound lipids called phospholipids.

(b) A phospholipid molecule consists of a glycerol backbone attached to two long-chain fatty acid tails and a highly polar phosphate group modified by an alcohol.

(c) This unique chemical composition gives the molecule an amphipathic nature, meaning it contains two regions with completely opposite physical properties and fluid affinities.

(d) The modified phosphate head group is charged and polar, making it hydrophilic and allowing it to face outward toward the aqueous environments inside and outside the cell.

(e) Conversely, the long hydrocarbon chains of the fatty acid tails are uncharged and non-polar, making them hydrophobic and causing them to face inward away from water.

Final Answer: Phospholipids.

Answer: (B)

Go Back to Question 57

Q58.

Solution

Concept: Industrial biotechnology utilizes recombinant host systems to synthesize therapeutic human proteins. Choosing an optimal bacterial host requires compatible expression vectors and rapid growth dynamics for large-scale production.

Solution:

(a) Human insulin is a peptide hormone composed of two separate amino acid chains, designated as chain A and chain B, which are linked together by strong disulfide bonds.

(b) To manufacture this hormone commercially without relying on animal tissue, genetic engineers developed a method to synthesize the individual polypeptide chains inside a microbial host.

(c) Synthetic gene sequences matching human insulin chains A and B are inserted separately into expression vectors, typically plasmids containing a beta-galactosidase promoter sequence.

(d) The standard model bacterium Escherichia coli ($E.coli$) serves as the primary host organism for this industrial process due to its well-mapped genetics and rapid replication rate.

(e) After the modified $E.coli$ strains express the individual A and B peptides, the chains are extracted, purified, and chemically joined together in vitro to form functional recombinant human insulin.

Final Answer: *Escherichia coli.*

Answer: (C)

Go Back to Question 58

Q59.

Solution

Concept: Plant vascular physiology coordinates water movement using multiple driving mechanisms. While daytime transport relies heavily on leaf evaporation, an independent active transport process can generate upward fluid movement at night.

Solution:

(a) During the night and early morning when stomata are closed and transpiration is low, root epidermal cells continue to actively pump mineral ions from the soil into the vascular stele.

(b) This active ion accumulation lowers the water potential within the root xylem, establishing an osmotic gradient that draws water from the surrounding cortex into the central vascular cylinder.

(c) As water flows into the confined space of the xylem vessels, it generates a positive hydrostatic pressure known as root pressure that pushes fluid upward through the stem.

(d) In short, herbaceous plants, this positive pressure can drive liquid water out through specialized marginal leaf openings called hydathodes, a physiological phenomenon known as guttation.

(e) While transpirational pull creates a negative tension that pulls water upward, root pressure provides a positive pushing force that operates independently of evaporation.

Final Answer: Root pressure.

Answer: (B)

Go Back to Question 59

Q60.

Solution

Concept: Seed anatomy classifies angiosperm seeds based on whether the endosperm tissue persists into maturity or is completely consumed by the developing embryo during early development.

Solution:

(a) During double fertilization, the triple fusion event creates a triploid endosperm nucleus that divides rapidly to form a nutrient-rich tissue dedicated to supporting the embryo.

(b) In non-endospermous (or exalbuminous) seeds like peas, beans, and grams, the developing embryo completely absorbs the endosperm before the seed reaches maturity, storing its resources in large cotyledons instead.

(c) In contrast, endospermous (or albuminous) seeds retain a distinct, multi-layered endosperm that acts as the primary storage site for nutrients in the mature seed.

(d) Castor and maize seeds are classic examples of endospermous seeds, where the mature structures contain an endosperm packed with rich reserves of carbohydrates, oils, and proteins.

(e) When these seeds germinate, the embryo secretes enzymes to break down the stored endosperm reserves, fueling early seedling development until the plant can begin photosynthesis.

Final Answer: Castor and Maize seeds.

Answer: (B)

Go Back to Question 60

Q61.

Solution

Concept: The digestion of large dietary lipids inside the human gastrointestinal tract requires structural modifications before enzyme action can begin. Because lipids are hydrophobic, they must be broken down mechanically into smaller droplets to expand their total surface area.

Solution:

(a) Dietary lipids enter the small intestine as large, unmanageable fat globules that cannot blend with the surrounding aqueous digestive fluids, severely limiting the efficiency of water-soluble enzymes.

(b) To overcome this physical barrier, the liver synthesizes a specialized lipid fluid called bile, which is stored in the gallbladder and secreted directly into the duodenum.

(c) Bile contains no digestive enzymes but is rich in amphipathic organic components known as bile salts, primarily sodium glycocholate and sodium taurocholate.

(d) These bile salts align themselves around the large fat aggregates, reducing their surface tension and breaking them mechanically into tiny droplets, a physiological process termed emulsification.

(e) By creating these stable, microscopic emulsion droplets, bile salts drastically increase the surface area available for pancreatic lipases to bind and efficiently catalyze chemical hydrolysis.

Final Answer: Bile salts (Sodium glycocholate and taurocholate).

Answer: (C)

Go Back to Question 61

Q62.

Solution

Concept: Ecotoxicology tracks the behavior of chemical pollutants as they move through trophic networks. Persistent substances that resist metabolic degradation accumulate inside living tissues, changing in concentration at progressive levels.

Solution:

(a) Certain heavy metals and chemical pollutants exhibit highly lipophilic properties, meaning they dissolve readily in fats but are completely insoluble in water.

(b) When an organism absorbs these lipid-soluble compounds from its surroundings, it cannot metabolize or excrete them, forcing the substances to accumulate inside its fatty tissues.

(c) As energy transfers upward from one feeding tier to the next, consumers must ingest massive quantities of biomass from lower trophic levels to sustain themselves.

(d) Because the toxic compounds remain trapped within that consumed biomass, they are passed directly up the food chain, concentrating step-by-step within the bodies of apex predators.

(e) This progressive increase in the concentration of a persistent, non-biodegradable toxic pollutant at higher trophic levels of a food web is defined as biomagnification.

Final Answer: Biomagnification.

Answer: (C)

Go Back to Question 62

Q63.

Solution

Concept: The standard framework of molecular biology dictates that genetic instructions flow in a fixed direction from nucleic acid code to functional proteins. However, specialized biological agents possess unique enzymes that flip this pathway.

Solution:

(a) The central dogma of molecular biology outlines the standard unidirectional flow of genetic instruction, where DNA serves as a template to transcribe RNA, which is then translated into a protein.

(b) Cellular organisms, including cyanobacteria, filamentous ascomycetes, and archaebacteria, strictly preserve this default directional path during their regular growth and gene expression cycles.

(c) Certain unique biological agents known as retroviruses possess genomes composed entirely of single-stranded RNA molecules rather than double-stranded DNA.

(d) Upon entering a host cell, a retrovirus introduces a specialized enzyme called reverse transcriptase to copy its viral RNA template directly into a complementary DNA strand.

(e) This biochemical backward transcription directly violates the standard rules of the central dogma, allowing the newly synthesized viral DNA to integrate into the host genome.

Final Answer: Retroviruses (e.g., HIV).

Answer: (B)

Go Back to Question 63

Q64.

Solution

Concept: Specialized autotrophic plants have evolved specific anatomical modifications in their leaf tissues to optimize carbon fixation under hot climates, establishing structural adaptations that suppress photorespiration.

Solution:

(a) Plants that utilize the alternative C4 photosynthetic pathway must partition their carbon-fixing reactions into different cellular compartments to prevent oxygen from interfering with enzymes.

(b) A cross-section of a C4 leaf reveals a highly specialized anatomical pattern known as Kranz anatomy, derived from the German word for wreath or crown.

(c) In this layout, prominent, large bundle sheath cells form a tightly packed, concentric ring around the central conducting vascular bundles of the leaf.

(d) These specialized bundle sheath cells contain large chloroplasts that lack grana and possess thick, gas-impermeable cell walls designed to trap accumulated carbon dioxide inside.

(e) This structural design allows mesophyll cells to capture carbon first and pump it directly into the bundle sheath cells, maintaining a high local concentration of carbon dioxide.

Final Answer: Kranz anatomy characterized by prominent bundle sheath cells arranged in a wreath-like manner around vascular bundles.

Answer: (C)

Go Back to Question 64

Q65.

Solution

Concept: The eukaryotic cell cycle is tightly coordinated by a system of internal monitoring points. These molecular checkpoints evaluate cellular health and resource abundance before committing to irreversible division steps.

Solution:

(a) The eukaryotic cell cycle consists of an organized sequence of events divided into interphase, which handles growth and replication, and the short mitotic M phase, which manages division.

(b) Interphase is split into three successive periods: the first gap (G_1) phase, the synthesis (S) phase, and the second gap (G_2) phase.

(c) During the G_1 phase, the cell undergoes rapid transcription and translation to manufacture essential structural proteins, duplicate internal organelles, and expand its volume.

(d) Near the end of this period, the cell encounters a critical regulatory checkpoint that monitors metabolic fitness, nutrient levels, and the overall integrity of its genomic DNA.

(e) Once a cell clears this control gate and transitions from G_1 into the S phase, it commits irreversibly to duplicating its genome and finishing the division cycle.

Final Answer: G_1 phase to S phase.

Answer: (A)

Go Back to Question 65

Q66.

Solution

Concept: Plant biotechnology exploits natural horizontal gene transfer mechanisms found in soil microorganisms to introduce foreign traits. These bacteria contain plasmids that can insert specific DNA sequences into a plant host.

Solution:

(a) Agrobacterium tumefaciens is a widespread, Gram-negative soil bacterium that naturally infects wounded plant tissues, inducing the formation of crown gall tumors.

(b) This organism contains a large extra-chromosomal circular molecule known as the Ti, or tumor-inducing, plasmid, which functions as a natural vehicle for genetic transfer.

(c) During an infection, the bacterium cuts a specific segment of this plasmid, called the T-DNA, and transfers it directly into the nucleus of the host plant cell.

(d) This T-DNA integrates into the nuclear genome of the plant, forcing the host cells to proliferate into tumors and manufacture specialized nutrient compounds called opines.

(e) By replacing the tumor-causing genes of the T-DNA with desired foreign genes, biotechnologists use this bacterium as a vector to create transgenic crops.

Final Answer: *Agrobacterium tumefaciens*.

Answer: (B)

Go Back to Question 66

Q67.

Solution

Concept: The mechanical efficiency of human respiration depends on lowering the cohesive forces of water molecules within the respiratory zone. Specialized epithelial cells line the air sacs to secrete a tension-reducing fluid.

Solution:

(a) The human lungs contain millions of microscopic, spherical air sacs called alveoli, which are lined by a thin layer of fluid that creates a high internal surface tension.

(b) This surface tension exerts an inward physical force that threatens to collapse the tiny alveoli during expiration, which would make inflating them again extremely difficult.

(c) To maintain lung volume, the alveolar epithelium is composed of two distinct cell types: flat Type I pneumocytes and large, cuboidal Type II pneumocytes.

(d) The Type II alveolar pneumocytes synthesize and secrete pulmonary surfactant, a specialized complex made of dipalmitoylphosphatidylcholine lipids and specific proteins.

(e) This surfactant molecules spread across the fluid film, disrupting the cohesive forces between water molecules to lower surface tension and prevent alveolar collapse during exhalation.

Final Answer: Type II Alveolar Pneumocytes.

Answer: (C)

Go Back to Question 67

Q68.

Solution

Concept: Floral formulas use standard symbolic notations to capture the structural organization, symmetry, and numerical relationships of different flower organs, serving as a reliable tool for identifying plant families.

Solution:

(a) The floral formula begins with the symbol $\oplus$, which indicates actinomorphic symmetry, meaning the flower can be divided into identical halves along any radial plane.

(b) The next symbol shows a combined male and female icon, indicating a bisexual flower that contains both functional stamens and carpels within the same structure.

(c) The notation $K_{(5)}$ represents a calyx made of five sepals that are fused together, while $C_{(5)}$ describes a corolla composed of five fused petals.

(d) The expression A_5 denotes an androecium with five separate stamens, and the structural arc linking C and A indicates that these filaments are fused directly to the petals.

(e) Finally, $\underline{G}_{(2)}$ shows a syncarpous gynoecium with two fused carpels, where the underline marks a superior ovary, matching the definitive traits of the Solanaceae family.

Final Answer: Solanaceae.

Answer: (B)

Go Back to Question 68

Q69.

Solution

Concept: Human oogenesis follows a discontinuous developmental timeline, where female germ cells begin their initial cell divisions during embryonic life but halt the process for years before completing maturation.

Solution:

(a) During female embryonic development, primordial germ cells differentiate into millions of diploid oogonia, which undergo mitosis before converting into primary oocytes.

(b) These primary oocytes enter the first meiotic division within the fetal ovaries, duplicating their DNA and initiating the complex stages of prophase I.

(c) However, instead of proceeding through the complete division cycle, the primary oocytes halt their development during the late prophase I stage.

(d) This prolonged developmental pause occurs specifically at the diplotene stage, where homologous chromosomes remain bound together at crossing-over points called chiasmata.

(e) The oocytes remain locked in this inactive diplotene state for years until puberty, when monthly surges of luteinizing hormone stimulate individual oocytes to resume meiosis.

Final Answer: Diplotene stage of Meiotic Prophase I.

Answer: (C)

Go Back to Question 69

Q70.

Solution

Concept: Global environmental governance relies on international agreements to regulate modern biotechnology, ensuring that the cross-border movement of bioengineered products does not endanger native biological diversity.

Solution:

(a) The rapid advancement of genetic engineering created a need for international safety regulations to govern the transport and handling of modified plants, animals, and microbes.

(b) To address these ecological concerns, nations drafted a specialized agreement under the framework of the global Convention on Biological Diversity.

(c) This treaty is known as the Cartagena Protocol on Biosafety, which was adopted in 2000 and focused on protecting natural ecosystems from modern biotechnology risks.

(d) The protocol sets clear guidelines for the safe transboundary movement, handling, and open environmental use of living modified organisms (LMOs).

(e) It enforces an advance informed agreement procedure, ensuring that importing nations receive detailed scientific data to assess ecological risks before permitting entry.

Final Answer: Cartagena Protocol on Biosafety.

Answer: (C)

Go Back to Question 70

Q71.

Solution

Concept: Gas transport in human blood depends on complex biochemical shifts within hemoglobin molecules. The binding of one gas at respiratory surfaces can dynamically alter hemoglobin structural conformation and its affinity for other bound gases.

Solution:

(a) In the pulmonary capillaries, the blood encounters a highly oxygenated environment where partial pressure of oxygen is elevated and partial pressure of carbon dioxide is low.

(b) When molecular oxygen binds progressively to the iron centers of hemoglobin, it induces an allosteric structural change that converts the molecule from a low-affinity state to a high-affinity state.

(c) This structural shift acts as a physiological trigger that dramatically lowers the binding affinity of hemoglobin for carbon dioxide molecules and protons.

(d) Consequently, carbaminohemoglobin dissociates rapidly, displacing the bound carbon dioxide from the protein chains into the alveoli so it can be exhaled from the respiratory tract.

(e) This specific physiological phenomenon, where high oxygen binding promotes the unloading of carbon dioxide in the lungs, is known as the Haldane effect, which optimizes maternal and systemic gas exchange.

Final Answer: Haldane Effect.

Answer: (B)

Go Back to Question 71

Q72.

Solution

Concept: Enzyme chemistry classifies catalytic systems based on their structural components. While some proteins are active alone, complex enzymes require non-protein chemical additions bound via specific linkages to become functional.

Solution:

(a) A complete, catalytically active enzyme system consisting of both a protein structure and its required non-protein components is termed a holoenzyme.

(b) The purely protein portion of this multi-component molecule is called the apoenzyme, which remains completely inactive until it pairs with its corresponding cofactor.

(c) These necessary non-protein components, or cofactors, are divided into inorganic metal ions and organic chemical groups based on their molecular structures.

(d) When an organic cofactor interacts with an apoenzyme only transiently during catalysis, it is classified as a loose coenzyme.

(e) However, when a non-protein organic cofactor is permanently and tightly bound to the apoenzyme structure via strong covalent or non-covalent links, it is defined as a prosthetic group.

Final Answer: Prosthetic group.

Answer: (C)

Go Back to Question 72

Q73.

Solution

Concept: The light-dependent reactions of photosynthesis manage energy conversions using distinct electron pathways. Restricting the circuit to a looping feedback route alters the final profile of high-energy chemical compounds produced.

Solution:

(a) During standard non-cyclic photophosphorylation, electrons flow linearly from water through photosystem II, the cytochrome complex, and photosystem I to reduce terminal electron acceptors.

(b) This linear path creates a proton gradient across the thylakoid membrane that drives adenosine triphosphate synthesis while simultaneously generating reducing power in the form of reduced nicotinamide adenine dinucleotide phosphate.

(c) When the dashed red feedback pathway is operational, energized electrons leaving photosystem I bypass the enzyme ferredoxin-NADP+ reductase completely.

(d) Instead, ferredoxin diverts these high-energy electrons backward into the plastoquinone pool and the cytochrome b6f complex, establishing a closed looping circuit.

(e) This cyclic electron transport chain continues to pump protons into the thylakoid lumen to power adenosine triphosphate production, but it produces absolutely no reduced nicotinamide adenine dinucleotide phosphate or molecular oxygen.

Final Answer: Synthesis of ATP only, without any generation of NADPH or O_2.

Answer: (D)

Go Back to Question 73

Q74.

Solution

Concept: Global conservation biology prioritizes geographic areas based on specific ecological metrics. Protecting areas facing immediate destruction requires identifying regions with concentrated groups of unique species.

Solution:

(a) Conservation scientists cannot safeguard every wilderness area simultaneously, requiring a data-driven strategy to allocate limited resources to areas under extreme ecological strain.

(b) This strategic approach targets specific geographical zones that exhibit exceptionally high levels of species endemism, meaning many native species live nowhere else on Earth.

(c) To qualify for this specific status, a region must harbor at least fifteen hundred unique species of vascular plants as endemic residents.

(d) Additionally, the habitat must face severe, accelerated threats of destruction, having lost at least seventy percent of its original primary native vegetation.

(e) This combination of extraordinary species concentration and critical habitat endangerment defines a biodiversity hotspot, a concept originally introduced to guide global preservation priorities.

Final Answer: Biodiversity Hotspot.

Answer: (B)

Go Back to Question 74

Q75.

Solution

Concept: Human genetic disorders can stem from minor alterations within a single nucleotide sequence. Changing a single base pair alters the genetic code, leading to abnormal protein structures and cellular defects.

Solution:

(a) The molecular basis of this hereditary blood condition lies in a precise point mutation affecting the gene that codes for the beta-globin polypeptide chains of hemoglobin.

(a) A single nucleotide substitution swaps a thymine base for an adenine base, altering the messenger RNA codon at the sixth position from GAG to GTG.

(b) This point mutation changes the translation output, substituting a hydrophobic valine residue for the normal hydrophilic glutamic acid residue at that specific position.

(c) Under low oxygen concentrations, this abnormal hemoglobin polymerizes into long structural fibers that distort erythrocyte shapes into rigid, crescent outlines.

(d) These crescent-shaped red blood cells block capillary beds and rupture prematurely, causing the classic symptoms associated with sickle-cell anemia.

Final Answer: Sickle-Cell Anemia.

Answer: (B)

Go Back to Question 75

Q2.

Solution

Concept: Human endocrine regulation uses antagonistic hormone pairs to maintain constant blood solute levels. When ion concentrations deviate, specific glands release counter-acting hormones to restore equilibrium.

Solution:

(a) Blood calcium homeostasis is vital for muscle contraction, nerve conduction, and structural bone maintenance, requiring precise hormonal oversight.

(b) When extracellular calcium levels fall below normal, the parathyroid glands secrete parathyroid hormone to stimulate bone resorption and maximize renal calcium retention.

(c) Conversely, when plasma calcium concentrations rise too high, the parafollicular cells of the thyroid gland synthesize and secrete a peptide hormone called thyrocalcitonin.

(d) Thyrocalcitonin acts as a direct physiological antagonist to parathyroid hormone, working rapidly to lower circulating calcium levels back to a baseline state.

(e) It achieves this reduction by inhibiting the bone-resorbing activity of osteoclasts and increasing the excretion of excess calcium ions through renal filtration pathways.

Final Answer: Thyrocalcitonin (Calcitonin).

Answer: (B)

Go Back to Question 76

Q3.

Solution

Concept: Phytohormones regulate distinct architectural transitions during a plant's lifecycle. Certain growth regulators can trigger dramatic stem elongation in compact varieties before they enter reproductive phases.

Solution:

(a) Rosette plants maintain a compact growth habit characterized by extremely shortened internodes, keeping leaves bunched close to the ground during regular vegetative growth.

(b) Under natural field conditions, these species require specific environmental cues, such as long photoperiods or cold winters, to transition into their reproductive stages.

(c) When a rosette plant receives these natural cues, its internal tissues produce high concentrations of gibberellins to induce rapid stem growth.

(d) This dramatic elongation of the internodes right before flowering can be induced artificially by applying exogenous gibberellic acid, a process known as bolting.

(e) This rapid growth elevates the developing flowers high above the vegetative leaves, optimizing pollen dispersal and success during subsequent reproductive stages.

Final Answer: Bolting.

Answer: (B)

Go Back to Question 77

Q4.

Solution

Concept: Eukaryotic endomembrane systems use compartmentalized organelles to process macromolecules. Once ribosomes finish initial polypeptide assembly, separate structures modify and route these products to their final destinations.

Solution:

(a) Nascent polypeptide chains synthesized by ribosomes move first into the lumen of the rough endoplasmic reticulum for initial folding and basic modifications.

(b) These immature proteins are then packed into transport vesicles that travel to the cis-face of the Golgi apparatus, where they fuse with the membrane.

(c) As these molecules move through the successive cisternae of the Golgi complex, specialized enzymes modify them by attaching complex carbohydrate chains to form glycoproteins.

(d) The Golgi apparatus acts as the central shipping hub of the cell, sorting, tagging, and packaging these refined molecules into specific secretory vesicles.

(a) These completed vesicles buds off from the trans-face of the complex, routing enzymes to lysosomes or directing structural proteins to the plasma membrane for exocytosis.

Final Answer: Golgi Apparatus.

Answer: (D)

Go Back to Question 78

Q5.

Solution

Concept: Gestation requires specialized continuous hormonal support to prevent uterine contractions and maintain the endometrial lining. The placenta takes over these endocrine responsibilities during pregnancy.

Solution:

(a) During early human pregnancy, the corpus luteum inside the ovary secretes the initial progesterone required to maintain a receptive, thick uterine environment.

(b) As development proceeds and embryonic structures expand, the placenta develops into a fully functional endocrine organ that assumes control over gestational hormones.

(c) The placenta synthesizes and secretes a unique combination of hormones, including human chorionic gonadotropin, human placental lactogen, estrogen, and progesterone.

(d) Human chorionic gonadotropin sustains early luteal function, while human placental lactogen coordinates maternal metabolic adjustments to ensure a steady supply of nutrients to the fetus.

(e) This specific combination of hormones works together to maintain the pregnancy, support fetal development, and prepare maternal breast tissues for milk production.

Final Answer: human Chorionic Gonadotropin (hCG), human Placental Lactogen (hPL), Estrogen, and Progesterone.

Answer: (B)

Go Back to Question 79

Q6.

Solution

Concept: Mineral nutrition in plants depends on moving dissolved inorganic ions from the soil into root tissues. Moving these particles against an existing concentration gradient requires specialized membrane transport proteins and cellular energy.

Solution:

(a) The concentration of inorganic mineral ions dissolved in soil water is typically much lower than the ion concentration found inside root epidermal cell cytoplasm.

(b) Because of this concentration gradient, minerals cannot enter root tissues via simple passive diffusion; they must be transported across the hydrophobic plasma membrane.

(c) To move these charged ions inward against their gradient, transmembrane proton pumps utilize chemical energy by hydrolyzing adenosine triphosphate molecules.

(d) This active pumping of protons out of the cell establishes a strong electrochemical gradient that drives the inward transport of essential minerals through specialized carrier proteins.

(e) This energy-dependent accumulation mechanism is classified as primary active transport, allowing roots to gather vital nutrients even from nutrient-poor soil solutions.

Final Answer: Primary active transport driven directly by the hydrolysis of ATP via proton pumps.

Answer: (C)

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Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	B	2	B	3	A	4	B	5	B
6	B	7	C	8	C	9	C	10	B
11	A	12	C	13	B	14	A	15	B
16	A	17	C	18	B	19	C	20	B
21	D	22	C	23	C	24	C	25	B
26	B	27	B	28	B	29	B	30	B
31	C	32	C	33	B	34	C	35	B
36	A	37	B	38	B	39	C	40	D
41	B	42	B	43	B	44	B	45	C
46	C	47	B	48	B	49	C	50	C
51	C	52	C	53	D	54	A	55	A
56	C	57	B	58	C	59	B	60	B
61	C	62	C	63	B	64	C	65	A
66	B	67	C	68	B	69	C	70	C
71	B	72	C	73	D	74	B	75	B
76	B	77	B	78	D	79	B	80	C