

UPCATET Biology Sample Paper-8

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. During C₄ photosynthesis, the initial carboxylation event occurs within the mesophyll cytoplasm. If an experimental toxicant completely blocks the enzyme malate dehydrogenase inside the mesophyll chloroplasts, which chemical transport intermediate is primary blocked from migrating across the plasmodesmata into the bundle sheath cells?

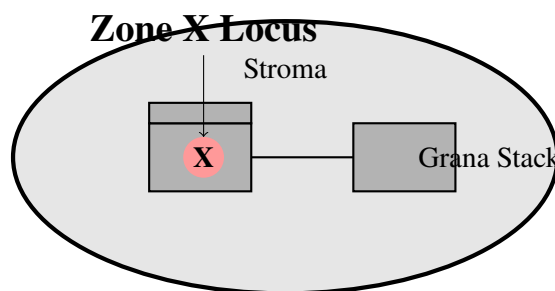
- (A) Oxaloacetate
- (B) Aspartate
- (C) Malate
- (D) Pyruvate

Q2. A mutant line of *Arabidopsis thaliana* displays complete insensitivity to exogenous abscisic acid (ABA) during seed germination. Genetic analysis reveals a loss-of-function mutation in an intracellular receptor. Which signaling component is structurally non-functional?

- (A) PYR/RCAR soluble proteins
- (B) PP2C phosphatases
- (C) SnRK2 protein kinases
- (D) Inward K⁺ channels



- Q3.** The Munch pressure-flow hypothesis relies on hydro-osmotic pressure gradients. If companion cells at a source leaf are treated with a metabolic uncoupler like 2,4-dinitrophenol (DNP), what immediate biophysical alteration occurs inside the local sieve tube elements?
- (A) Drastic drop in hydrostatic pressure
(B) Massive accumulation of sucrose
(C) Inversion of the water potential gradient
(D) Instantaneous callose synthesis
- Q4.** An anatomical transverse section of an unknown woody angiosperm stem reveals specialized cells within the secondary xylem that retain active protoplasts, store abundant starch granules, and stretch radially across the wood. Identify these structures.
- (A) Xylem vessel elements
(B) Libriform fibers
(C) Xylem ray parenchyma
(D) Sieve tube companion cells
- Q5.** A researcher maps the photosynthetic electron transport chain kinetics across different internal components of an isolated spinach chloroplast. Identify the specific sub-organelle structural locus labeled as Zone X in the vector diagram below where the accumulation of protons (H^+) reaches its maximum steady-state concentration during active non-cyclic photophosphorylation:



- (A) Thylakoid Lumen
(B) Chloroplast Stroma



- (C) Outer Intermembrane Space
- (D) Peroxisomal Matrix

Q6. During aerobic plant respiration, the oxidation of one molecule of cytosolic NADH via the malate-aspartate shuttle yields a higher net ATP equivalent than via the glycerol-3-phosphate shuttle. What is the precise enzymatic reason for this difference?

- (A) FAD bypassing Complex I completely
- (B) Direct entry of electrons into Complex IV
- (C) Lack of proton pumping at Complex II
- (D) Coenzyme Q deficiency in the membrane

Q7. The Casparian strip is a physiological barrier in plant roots that forces water from the apoplastic pathway into the symplastic pathway. Which chemical polymer is primary deposited in this specific endodermal structural layer?

- (A) Hemicellulose
- (B) Pectin
- (C) Suberin
- (D) Chitin

Q8. When a mesophytic plant undergoes severe water deficit stress, its stomatal closure mechanism is mediated by a rapid efflux of solute ions. Which primary ion transport sequence occurs across the guard cell plasma membrane?

- (A) Influx of K^+ and Cl^- ions
- (B) Efflux of K^+ and malate anions
- (C) Influx of Ca^{2+} and H^+ ions
- (D) Efflux of water via active reverse osmosis

Q9. An analytical assay of a secondary stem cross-section reveals a ring of dividing cells originating directly from a persistent pericycle layer. Which primary or secondary tissue does this specialized meristematic ring generate?

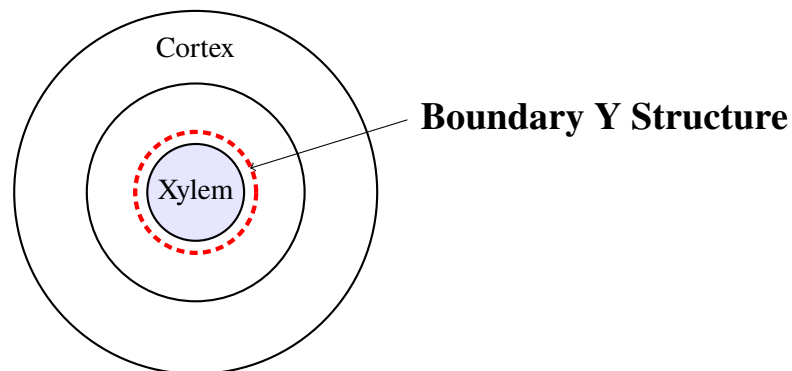


- (A) Interfascicular cambium
- (B) Cork cambium (Phellogen)
- (C) Primary Phloem strands
- (D) Intrafascicular cambium

Q10. The canonical triple response in etiolated dicot seedlings—shortening of the hypocotyl, thickening of the hypocotyl, and pronounced horizontal growth curvature—is induced by hyper-accumulation of which phytohormone?

- (A) Auxin
- (B) Gibberellic Acid
- (C) Ethylene
- (D) Cytokinin

Q11. A plant anatomy workstation tracks water potential kinetics across root tissue zones during active transpiration. Identify the morphological boundary demarcated as Boundary Y in the structural root layout schema below that prevents unrestricted apoplastic water movement into the central vascular cylinder:



- (A) Epidermal hypodermis
- (B) Inner Endodermis
- (C) Exodermis line
- (D) Medullary Ray

Q12. Under low light intensities, the quantum yield of photosynthesis remains constant, but at high intensities, it saturates. If a plant is exposed to excessive light beyond



saturation, photoinhibition occurs due to damage to which core protein component of Photosystem II?

- (A) D1 core protein
- (B) Plastocyanin
- (C) Cytochrome b6f
- (D) P700 reaction center

Q13. A tissue sample from a xerophytic leaf exhibits stomata sunk deep within specialized crypts lined with epidermal trichomes. What is the precise physical mechanism by which this structure minimizes water loss?

- (A) Increasing boundary layer resistance
- (B) Lowering internal leaf temperature
- (C) Blocking blue-light induced opening
- (D) Increasing water vapor pressure deficit

Q14. The enzyme ribulose-1,5-bisphosphate carboxylase-oxygenase (RuBisCO) acts as an oxygenase under high O_2 to CO_2 ratios. What is the immediate direct product of this oxygenase activity that enters the photorespiratory C2 cycle?

- (A) Two molecules of 3-phosphoglycerate
- (B) One molecule of 3-phosphoglycerate and one molecule of 2-phosphoglycolate
- (C) Two molecules of 2-phosphoglycolate
- (D) One molecule of oxaloacetate

Q15. A mutant plant lacks functional ATP synthase complexes within its mitochondrial inner membrane but retains an intact, operational electron transport chain. If this mutant is supplied with pyruvate and oxygen, what will be the state of its oxygen consumption and proton gradient?

- (A) Oxygen consumption stops; proton gradient collapses
- (B) Oxygen consumption continues; proton gradient hyper-accumulates
- (C) Oxygen consumption stops; proton gradient hyper-accumulates



(D) Oxygen consumption continues; proton gradient collapses

Q16. A clinical patient presents with a severe mutation in the parietal cells of the gastric mucosa, rendering their apical H^+/K^+ ATPase pumps completely non-functional. Aside from achlorhydria, which hematological manifestation is most likely to develop over time?

(A) Microcytic iron-deficiency anemia

(B) Megaloblastic pernicious anemia

(C) Polycythemia vera

(D) Hemolytic sickle cell crisis

Q17. During the cardiac cycle, a sudden pharmacological block of the slow voltage-gated L-type Ca^{2+} channels during the ventricular action potential will cause which direct alterations to the electrocardiogram (ECG) and myocardial contractility?

(A) Shortening of the QT interval and decreased contractility

(B) Prolongation of the PR interval and increased contractility

(C) Widening of the QRS complex and no change in contractility

(D) Elevation of the ST segment and hyper-contractility

Q18. A respiratory physiologist measures the oxygen-hemoglobin dissociation curve of an athlete. If the blood PCO_2 , temperature, and 2,3-BPG concentration all increase simultaneously within working skeletal muscle tissue, what occurs to hemoglobin's affinity for O_2 ?

(A) Decreases, shifting the curve to the right

(B) Increases, shifting the curve to the left

(C) Decreases, shifting the curve to the left

(D) Remains unchanged due to strict homeostatic buffering

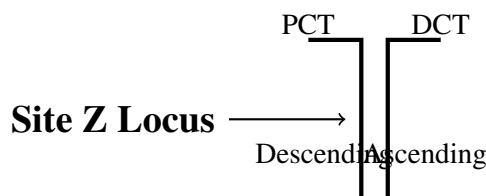
Q19. A neurological injury specifically destroys the cells of the supraoptic and paraventricular nuclei within the hypothalamus. Which direct pathophysiological



syndrome and urinary output profiles will be observed in this patient?

- (A) Syndrome of Inappropriate Antidiuretic Hormone (SIADH); concentrated urine
- (B) Diabetes Insipidus; high volume, highly dilute urine
- (C) Type I Diabetes Mellitus; glycosuria and ketonuria
- (D) Conn's Syndrome; high sodium excretion urine

Q20. A nephron micro-perfusion study measures solute concentrations along the renal tubule structures. Identify the exact anatomical segment labeled as Site Z in the loop architecture below where the luminal fluid becomes progressively hypertonic relative to the surrounding cortical interstitial fluid matrix:



- (A) Thick Ascending Limb
- (B) Thin Descending Limb
- (C) Distal Convolute Tubule
- (D) Cortical Collecting Duct

Q21. During a nerve impulse transmission, the absolute refractory period is a phase where no second action potential can be generated, regardless of stimulus intensity. What is the underlying molecular state of the voltage-gated Na^+ channels during this specific period?

- (A) Closed but capable of activation
- (B) Open and conducting ions freely
- (C) Inactivated due to closure of the inactivation gate (h-gate)
- (D) Hyperpolarized due to slow inactivation gate kinetics

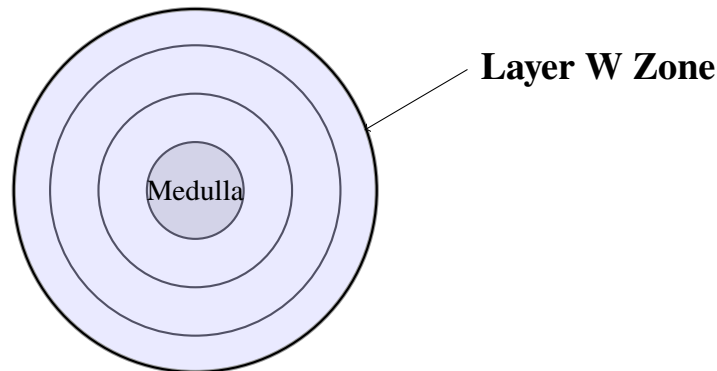


- Q22.** A patient presents with a tumor of the parathyroid gland that autonomously hyper-secretes parathyroid hormone (PTH). What profile of serum calcium, serum phosphate, and osteoclast activity will be detected in blood and bone biopsies?
- (A) Hypocalcemia, hyperphosphatemia, decreased osteoclast activity
 - (B) Hypercalcemia, hypophosphatemia, increased osteoclast activity
 - (C) Hypercalcemia, hyperphosphatemia, decreased osteoclast activity
 - (D) Hypocalcemia, hypophosphatemia, increased osteoclast activity
- Q23.** The pancreatic acinar cells secrete digestive zymogens into the duodenum. Which specific intestinal brush-border enzyme triggers the activation cascade of these proteases by converting trypsinogen into active trypsin?
- (A) Aminopeptidase
 - (B) Enteropeptidase (Enterokinase)
 - (C) Carboxypeptidase
 - (D) Chymotrypsin
- Q24.** During skeletal muscle contraction, the binding of Ca^{2+} ions to a regulatory protein complex causes a conformational shift that exposes the myosin-binding sites on the actin thin filaments. Identify this specific Ca^{2+} -binding subunit.
- (A) Troponin T
 - (B) Troponin I
 - (C) Troponin C
 - (D) Tropomyosin
- Q25.** A chemical warfare agent acts as an irreversible acetylcholinesterase inhibitor at the neuromuscular junctions. What will be the immediate functional consequence on the postsynaptic muscle fiber membrane?
- (A) Persistent depolarization leading to spastic paralysis
 - (B) Hyperpolarization leading to flaccid paralysis



- (C) Immediate cessation of end-plate potentials
- (D) Accelerated degradation of nicotinic receptors

Q26. An endocrine pathology team isolates cells from the adrenal gland cortex to evaluate steroid hormone synthesis pathways. Identify the exact histological layer designated as Layer W in the structural cross-section schematic below that is primarily responsible for the biosynthesis and secretion of aldosterone:



- (A) Zona Fasciculata
 - (B) Zona Reticularis
 - (C) Zona Glomerulosa
 - (D) Adrenal Medulla core
- Q27.** The countercurrent multiplier system in the mammalian kidney establishes an osmotic gradient in the medullary interstitium. Which two specific chemical components contribute most to this high interstitial hyperosmolality deep within the renal medulla?
- (A) Potassium ions and Glucose
 - (B) Sodium chloride and Urea
 - (C) Calcium ions and Albumin
 - (D) Bicarbonate ions and Creatinine
- Q28.** A patient is diagnosed with an autoimmune disease that selectively destroys the myelin-producing Schwann cells in the peripheral nervous system. What will be the direct effect on action potential propagation along these affected peripheral motor axons?



- (A) Accelerated saltatory conduction
- (B) Complete reversal of action potential direction
- (C) Marked deceleration or failure of continuous conduction
- (D) Increased amplitude of the action potential spikes

Q29. During a forced expiration, which specific set of respiratory muscles contract simultaneously to decrease thoracic volume below the functional residual capacity?

- (A) Diaphragm and external intercostals
- (B) Internal intercostals and abdominal muscles
- (C) Scalenes and sternocleidomastoid
- (D) Pectoralis major and serratus anterior

Q30. In a cross between two individuals with genotypes $AaBbCc \times AaBbCc$, assuming complete dominance and independent assortment across all three loci, what precise fraction of the total F1 offspring is expected to exhibit the completely recessive phenotype for all three traits simultaneously?

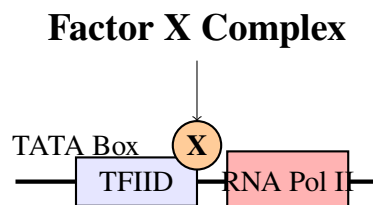
- (A) $1/64$
- (B) $3/64$
- (C) $9/64$
- (D) $1/16$

Q31. During DNA replication in *E. coli*, DNA polymerase III synthesizes the leading strand continuously but requires structural coordination for the lagging strand. If a temperature-sensitive mutation inactivates the *dnaG* gene encoding DNA primase, what structural intermediate will fail to form at the replication fork?

- (A) Okazaki fragments
- (B) RNA Primers
- (C) Holliday junctions
- (D) Single-stranded binding protein complexes



- Q32.** The tryptophan (*trp*) operon in bacteria is regulated via attenuation based on the structural rate of translation. If the cellular levels of tryptophan are extremely high, what specific physical structure forms within the leader mRNA transcript to arrest transcription prematurely?
- (A) 2-3 hairpin stem loop
(B) 3-4 terminator hairpin loop
(C) 1-2 x-axis pause loop
(D) Poly-A tail configuration
- Q33.** A pedigree chart of a rare metabolic disorder shows that affected males pass the trait to all of their daughters, but none of their sons. Affected females passed the trait to exactly half of their sons and half of their daughters. What is the mode of inheritance?
- (A) Autosomal Dominant
(B) X-linked Recessive
(C) X-linked Dominant
(D) Y-linked (Holandric)
- Q34.** A molecular biology unit maps the assembly of the transcription initiation complex at a eukaryotic promoter locus. Identify the critical enzymatic component labeled as Factor X in the assembly profile below that possesses internal helicase activity and phosphorylates the C-terminal domain (CTD) of RNA Polymerase II to initiate promoter clearance:



- (A) TFIIA
(B) TFIIB
(C) TFIIH



(D) TFIIE

Q35. A point mutation occurs in a structural gene where the codon UUG is converted to UAG. What specific type of mutation has occurred, and what will be its direct impact on the resulting polypeptide chain length?

(A) Missense mutation; single amino acid substitution

(B) Nonsense mutation; premature truncation

(C) Frameshift mutation; completely altered sequence

(D) Silent mutation; no change in length

Q36. During the process of aminoacylation, an aminoacyl-tRNA synthetase couples an amino acid to its cognate tRNA. What is the precise two-step biochemical energetic cost of this accuracy control reaction per single amino acid loaded?

(A) Hydrolysis of 1 ATP to 1 ADP + Pi

(B) Hydrolysis of 1 ATP to 1 AMP + 1 PPi

(C) Hydrolysis of 1 GTP to 1 GDP + Pi

(D) Hydrolysis of 2 ATP to 2 ADP + 2 Pi

Q37. In human genetics, a classic test cross involving two linked genes reveals a recombination frequency of exactly 12.5%. What does this specific numerical percentage represent in terms of mapping distance along the chromosome?

(A) 12.5 centimorgans (cM)

(B) 1.25 centimorgans (cM)

(C) 125 centimorgans (cM)

(D) 25 kilobase pairs (kb)

Q38. The Meselson-Stahl experiment proved that DNA replication is semi-conservative. If *E. coli* cells grown exclusively in ^{15}N media are shifted to light ^{14}N media for exactly three generations of synchronized division, what will be the ratio of hybrid (^{15}N - ^{14}N) DNA molecules to light (^{14}N - ^{14}N) DNA molecules?

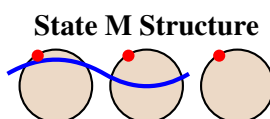


- (A) 1:1
- (B) 1:3
- (C) 1:7
- (D) 0:8

Q39. A patient is diagnosed with Xeroderma Pigmentosum, an autosomal recessive disorder characterized by extreme sensitivity to UV light. This clinical pathology stems from an inherent defect in which specific DNA repair pathway mechanism?

- (A) Base Excision Repair (BER)
- (B) Mismatch Repair (MMR)
- (C) Nucleotide Excision Repair (NER)
- (D) Homologous Recombination (HR)

Q40. A molecular laboratory characterizes chromatin modifications regulating transcription. Identify the nucleosomal configuration tagged as State M in the structural schema below where histone tails undergo massive acetylation, causing a specific biophysical transition that facilitates gene activation:



- (A) Heterochromatin condensation
- (B) Euchromatin decondensation
- (C) Telomeric silencing form
- (D) Barr body inactivation matrix

Q41. The wobble hypothesis states that unconventional base pairing can occur between the third base of a codon and the first base of an anticodon. If the first position of a tRNA anticodon contains the modified purine base Inosine (I), which specific set of bases can it pair with on the mRNA transcript?



- (A) A, U, or C
- (B) G or A only
- (C) U or G only
- (D) C or G only

Q42. During the mitotic cell cycle, the spindle assembly checkpoint (SAC) monitors the attachment of spindle microtubules to chromosomes. Which specific proteinaceous multi-subunit structure assembled on the centromere serves as the primary physical sensing site for this checkpoint mechanism?

- (A) Telomere cap
- (B) Kinetochore
- (C) Synaptonemal complex
- (D) Centrosome matrix

Q43. A cell biology line is treated with Brefeldin A, a drug that specifically inhibits vesicle transport from the endoplasmic reticulum to the Golgi apparatus. What will be the direct cellular structural consequence observed within the Golgi apparatus stacks over time?

- (A) Hyper-elongation of trans-Golgi networks
- (B) Disassembly and collapse of the Golgi stacks into the ER
- (C) Massive accumulation of secretory vesicles at the plasma membrane
- (D) Autophagic engulfment of lysosomes

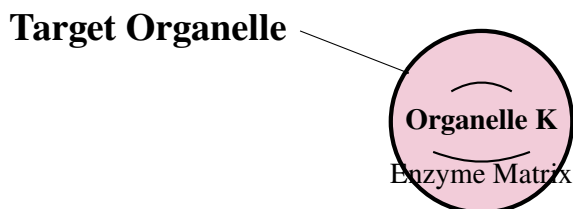
Q44. During Meiosis I, homologous chromosomes pair up and undergo genetic recombination. What is the precise name of the proteinaceous zipper-like structure that holds non-sister chromatids together during the pachytene stage of prophase I?

- (A) Cohesin ring complex
- (B) Synaptonemal Complex
- (C) Condensin module



(D) Chiasmata lattice

- Q45.** A subcellular fraction analysis separates cellular organelles based on density. Identify the biochemical compartment labeled as Organelle K in the structural diagram below that contains high concentrations of acid hydrolases and maintains an internal pH of approximately 4.5 to 5.0 via vacuolar H^+ -ATPase pumps:



- (A) Peroxisome
(B) Glyoxysome
(C) Lysosome
(D) Rough Endoplasmic Reticulum
- Q46.** The fluid mosaic model states that membrane fluidity depends heavily on lipid composition. How does a high concentration of cholesterol affect plasma membrane fluidity at high physiological temperatures versus cold temperatures?
- (A) Increases fluidity at high, decreases at low
(B) Decreases fluidity at high, increases at low
(C) Decreases fluidity at both temperature spectrums
(D) Increases fluidity at both temperature spectrums
- Q47.** A biochemical assay evaluates the enzyme kinetics of an industrial oxidoreductase. If a competitive inhibitor is added to the reaction mixture, what specific quantitative changes will be observed regarding the maximum velocity (V_{max}) and the Michaelis constant (K_m)?
- (A) V_{max} decreases; K_m increases
(B) V_{max} remains unchanged; K_m increases



- (C) V_{max} decreases; K_m remains unchanged
 (D) Both V_{max} and K_m decrease proportionally

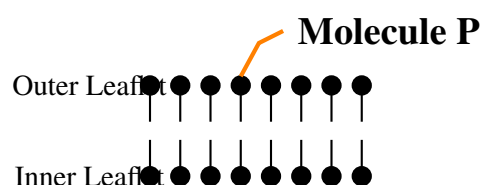
Q48. A mammalian cell line carries a mutation preventing the degradation of Cyclin B during mitosis. At which specific stage of the mitotic cell cycle will these cells become irreversibly arrested?

- (A) G1/S transition boundary
 (B) Metaphase-to-Anaphase transition
 (C) Exit from Anaphase to Telophase
 (D) Cytokinesis cleavage ring formation

Q49. Which specific cytoskeletal filament system possesses an inherent structural polarity, utilizes kinesin and dynein motor proteins for intracellular transport, and forms the core structure of eukaryotic cilia and flagella?

- (A) Actin microfilaments
 (B) Intermediate filaments
 (C) Microtubules
 (D) Spectrin networks

Q50. A cellular structural team models the molecular architecture of the plasma membrane. Identify the specific lipid category indicated as Molecule P in the layout below that is strictly localized to the outer leaflet and plays a central role in cell-to-cell recognition and cell signaling:



- (A) Phosphatidylserine
 (B) Glycolipid (Sphingolipid base)
 (C) Phosphatidylethanolamine



(D) Cholesterol core

Q51. Proteins destined for secretion from the cell must be co-translationally translocated into the lumen of the rough endoplasmic reticulum. Which specific ribonucleoprotein complex binds to the nascent N-terminal hydrophobic signal sequence to halt cytosolic translation and guide the ribosome to the ER membrane?

(A) Signal Recognition Particle (SRP)

(B) Clathrin coat adaptor protein

(C) Sec61 translocon core

(D) Ubiquitin ligase complex

Q52. An ecological field study monitors the energy transfer efficiency across four trophic levels in a pelagic marine ecosystem. If the net primary productivity of the phytoplankton is measured at $10,000 \text{ kcal}/\text{m}^2/\text{year}$, what precise energy yield is expected to be incorporated into the biomass of the tertiary consumers based on Lindeman's trophic efficiency law?

(A) $1,000 \text{ kcal}/\text{m}^2/\text{year}$

(B) $100 \text{ kcal}/\text{m}^2/\text{year}$

(C) $10 \text{ kcal}/\text{m}^2/\text{year}$

(D) $1 \text{ kcal}/\text{m}^2/\text{year}$

Q53. A population of critically endangered mountain pheasants is tracked over a decade. The growth curve displays an initial exponential phase followed by a sharp plateau as it approaches environmental saturation. Which mathematical model best defines this growth trajectory, and what factor limits it?

(A) Geometric growth; intrinsic rate of increase (r)

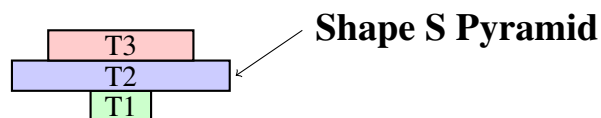
(B) Logistic growth; environmental carrying capacity (K)

(C) Exponential growth; density-independent mortality

(D) J-shaped growth; resource infinite supply



- Q54.** In deep aquatic ecosystems, a specific thermal stratification layer develops during summer months, characterized by a rapid, vertical temperature drop that separates the upper warm mixolimnion from the lower cold hypolimnion. Identify this specific intermediate layer.
- (A) Epilimnion
(B) Thermocline (Mesolimnion)
(C) Benthic zone
(D) Littoral boundary
- Q55.** An environmental management agency profiles a standard ecological pyramid of numbers for an oak forest habitat. Identify the specific structural configuration category labeled as Shape S in the framework below that is generated when a single massive primary producer supports thousands of herbivorous insects and hyper-parasites:



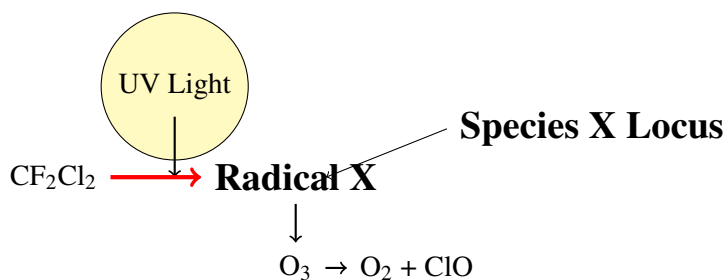
- (A) Upright Pyramid
(B) Inverted Pyramid
(C) Spindle-shaped Pyramid
(D) Completely linear column
- Q56.** Minamata disease, a severe neurological syndrome that occurred in human populations in Japan, was caused by the ingestion of marine organisms that concentrated toxic heavy metal compounds. Which ecological principle and specific chemical variant caused this disaster?
- (A) Eutrophication; Inorganic elemental mercury
(B) Biomagnification; Methylmercury
(C) Bioremediation; Cadmium chloride
(D) Bioaccumulation; Lead arsenate



- Q57.** Under the MacArthur-Wilson Island Biogeography model, which specific configuration of an island will theoretically preserve the highest equilibrium species richness at steady state?
- (A) Small island close to the mainland
 - (B) Large island far from the mainland
 - (C) Small island far from the mainland
 - (D) Large island close to the mainland
- Q58.** Two closely related species of seed-eating finches live sympatrically on an isolated island. Over evolutionary time, their beak sizes diverge significantly to exploit different seed sizes, minimizing competitive overlap. What ecological phenomenon does this shift illustrate?
- (A) Competitive exclusion principle
 - (B) Character displacement
 - (C) Müllerian mimicry
 - (D) Exploitative interference
- Q59.** A pristine wetland ecosystem undergoes a severe pulse of agricultural runoff rich in nitrates and orthophosphates. What is the correct chronological sequence of downstream biological events that leads to a catastrophic fish kill?
- (A) Algal bloom → Increased light penetration → Oxygen hyper-saturation → Fish death
 - (B) Algal bloom → Algal senescence → Bacterial decomposition bloom → Biochemical Oxygen Demand (BOD) spike → Hypoxia → Fish death
 - (C) Bacterial collapse → Oligotrophication → Toxin accumulation → Fish death
 - (D) Macrophyte proliferation → Increased DO → Hyper-respiration → Fish death
- Q60.** An atmospheric monitoring station measures solar radiation interactions with industrial gas vectors. Identify the chemical species labeled as compound X



in the stratospheric reaction cycle schematic below that acts as a free radical catalyst to accelerate the destruction of the protective ozone (O_3) layer:



- (A) Carbon dioxide radical
- (B) Free Chlorine atom (Cl^\bullet)
- (C) Hydroxyl radical (OH^\bullet)
- (D) Nitrous oxide molecule

Q61. A taxonomist isolates a unicellular, eukaryotic organism from a deep hydrothermal vent. The organism possesses a cell wall composed of silica templates with intricate valve ornamentations, lacks flagella except in gametic stages, and stores carbon as chrysolaminarin. To which specific phylum/class under the Protista kingdom does this organism belong?

- (A) Dinoflagellata
- (B) Chrysophyta (Diatoms)
- (C) Euglenophyta
- (D) Rhodophyta

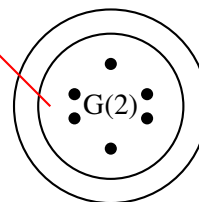
Q62. A botanical survey of an agricultural field identifies a weed with a characteristic modified inflorescence called a *cyathium*, containing a single reduced female flower surrounded by multiple male flowers enclosed within an involucre of bracts. To which plant family does this species belong?

- (A) Solanaceae
- (B) Cruciferae (Brassicaceae)
- (C) Euphorbiaceae
- (D) Fabaceae



- Q63.** An invertebrate specimen collected from a marine benthos displays true bilateral symmetry, a complete digestive tract, a pseudocoelomate body cavity profile, and a tough exterior cuticle layer that undergoes ecdysis. Identify its phylum classification.
- (A) Annelida
 (B) Nematoda
 (C) Platyhelminthes
 (D) Ctenophora
- Q64.** The Five-Kingdom system proposed by Robert Whittaker separates organisms based on structural and nutritional criteria. Which specific combination of characteristics correctly describes the members of Kingdom Fungi?
- (A) Eukaryotic, photosynthetic, cellulosic cell wall
 (B) Prokaryotic, absorptive heterotrophic, chitinous cell wall
 (C) Eukaryotic, absorptive heterotrophic, chitinous cell wall
 (D) Eukaryotic, ingestive heterotrophic, lacking cell walls
- Q65.** A systematic research team maps the floral architecture of economic cash crops. Identify the specific diagnostic layout parameter labeled as Component Z in the floral diagram representation of the Brassicaceae family shown below that denotes the characteristically arrangement of the androecium:

Component Z Arrangement



- (A) Monadelphous configuration
 (B) Tetradynamous stamens (2 + 4 setup)
 (C) Epipetalous placement
 (D) Polyadelphous bundle



- Q66.** A veterinary pathology team examines an endoparasitic fluke isolated from the bile ducts of livestock. The organism presents an unsegmented body, flame cells for excretion, and a highly branched gastrovascular cavity with no anus. Identify this organism's class.
- (A) Cestoda
 - (B) Trematoda
 - (C) Turbellaria
 - (D) Polychaeta
- Q67.** Members of the plant family Solanaceae can be consistently distinguished from members of the Liliaceae family using which specific morphological character criteria?
- (A) Pentamerous flowers and superior ovary vs Trimerous flowers and perianth structures
 - (B) Zygomorphic flowers vs Actinomorphic symmetries
 - (C) Exstipulate leaves vs Stipulate modifications
 - (D) Marginal placentation vs Superficial placentation
- Q68.** Which specific evolutionary innovation distinguishes the chordate subphylum Vertebrata from the primitive Urochordata and Cephalochordata lines during mature adult stages?
- (A) Presence of a dorsal hollow nerve cord
 - (B) Replacement of the embryonic notochord by a cartilaginous or bony vertebral column
 - (C) Development of pharyngeal gill slits for filter feeding
 - (D) Secretion of a tunic coat made of cellulose-like polymers
- Q69.** During megasporogenesis and megagametogenesis in a typical angiosperm, a single functional chalazal megaspore undergoes a sequence of karyokinesis steps to form a mature Polygonum-type embryo sac. What is the exact structural cellular and nuclear count of this sac before fertilization?

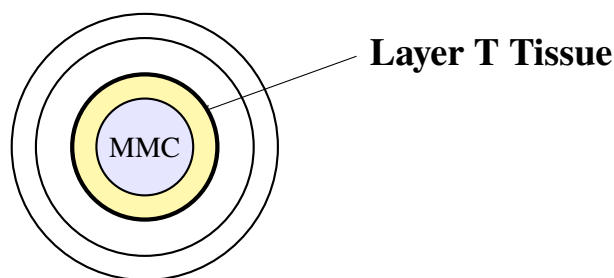


- (A) 8-celled, 8-nucleate
- (B) 7-celled, 8-nucleate
- (C) 8-celled, 7-nucleate
- (D) 3-celled, 3-nucleate

Q70. In human embryology, the process of implantation occurs when the blastocyst hatches from its surrounding protective layer. Identify this specific glycoprotein coat that must be shed to allow the trophoblast to adhere to the uterine endometrium.

- (A) Corona radiata
- (B) Zona pellucida
- (C) Vitelline membrane
- (D) Amniotic fold

Q71. A developmental histology lab evaluates a cross-section of an anther wall during microsporogenesis. Identify the specific nourishing cellular layer marked as Layer T in the layout below that synthesizes sporopollenin precursors and undergoes programmed cell death during pollen maturation:



- (A) Endothecium
- (B) Middle Layers
- (C) Tapetum
- (D) Exothecium

Q72. During the human ovarian cycle, a surge in which specific anterior pituitary hormone triggers the breakdown of the follicular wall, inducing ovulation of the secondary oocyte arrested in Metaphase II?



- (A) Follicle-Stimulating Hormone (FSH)
- (B) Luteinizing Hormone (LH)
- (C) Progesterone
- (D) Human Chorionic Gonadotropin (hCG)

Q73. Double fertilization is a hallmark of angiosperms. If the somatic chromosome number of a corn plant is $2n = 20$, what will be the exact chromosome numbers found within the cells of its primary endosperm nucleus and its embryo, respectively?

- (A) 20 and 30
- (B) 30 and 20
- (C) 10 and 30
- (D) 30 and 10

Q74. A patient seeking family planning options chooses an injectable hormonal contraceptive. What is the primary cellular mechanism by which continuous synthetic progestin administration prevents pregnancy?

- (A) Inducing mechanical tubal occlusion
- (B) Suppressing ovulation via negative feedback on the hypothalamus-pituitary axis
- (C) Destroying mature spermatozoa via chemical spermicidals
- (D) Uprooting the basal layer of the endometrium directly

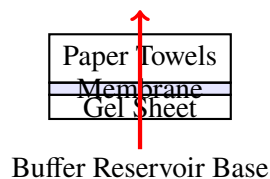
Q75. During mammalian spermatogenesis, the primary spermatocytes enter Meiosis I. How many mature haploid spermatozoa are generated from a single primary spermatocyte after the completion of spermatogenesis?

- (A) One functional spermatozoon and three polar bodies
- (B) Two functional spermatozoa
- (C) Four functional spermatozoa
- (D) Eight functional spermatozoa



- Q76.** In recombinant DNA technology, a cloning vector requires an origin of replication, restriction sites, and selectable markers. If a plasmid vector is engineered with an ampicillin resistance gene and a *lacZ* reporter gene containing a multiple cloning site, what will be the color profile of colonies growing on an X-gal agar plate containing ampicillin if insertion of a target gene is successful?
- (A) Blue colonies with no growth
(B) White colonies with successful growth
(C) Intense blue colonies with successful growth
(D) Fluorescent green colonies
- Q77.** During a standard Polymerase Chain Reaction (PCR) assay run, a technician encounters complete amplification failure. Optimization reveals that the step occurring at approximately 55°C to 60°C was misprogrammed to 85°C. Which kinetic phase was disrupted by this error?
- (A) Template Denaturation phase
(B) Primer Annealing phase
(C) Primer Extension phase
(D) Taq Polymerase activation phase
- Q78.** A molecular diagnostic laboratory uses Southern blotting to identify restriction fragment length polymorphisms (RFLPs). Identify the step labeled as Phase P in the procedural workflow layout below where DNA fragments are horizontally translocated from an agarose gel matrix onto a solid nitrocellulose membrane support:

Phase P Elution



- (A) Electrophoretic Separation step
(B) Capillary Transfer (Blotting) step



- (C) Probe Hybridization cycle
- (D) Autoradiographic Development phase

Q79. Genetically modified Bt cotton crops express crystalline endotoxins isolated from *Bacillus thuringiensis*. Why does this crystalline protoxin remain completely harmless to the host bacterium and human cells but selectively destroy the midgut of specific insect lepidopteran larvae?

- (A) It requires an acidic pH activation loop found in mammalian stomachs
- (B) It requires an alkaline pH environment to be proteolytically cleaved into its active toxin form within the insect gut
- (C) It targets the cellulose component of plant cells exclusively
- (D) It functions as an inhibitor of the eukaryotic cytoplasmic 80S ribosome

Q80. To produce a transgenic animal that secretes a human therapeutic protein into its milk, a molecular biologist must clone the human cDNA sequence directly downstream of which specific promoter control region?

- (A) Ubiquitous CMV viral promoter
- (B) Tissue-specific mammary gland β -casein promoter
- (C) Bacterial lac operon promoter line
- (D) Pancreatic insulin gene promoter segment



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

Concept: During C_4 photosynthesis, plants bypass the energy-wasteful process of photorespiration by physically separating the initial carbon fixation step from the downstream Calvin cycle across two morphologically distinct cell layers: mesophyll cells and bundle sheath cells.

Solution:

Let's trace the biochemical metabolic intermediates of the C_4 dicarboxylic acid pathway:

- (a) In the mesophyll cytoplasm, atmospheric CO_2 is fixed by phosphoenolpyruvate carboxylase (PEP carboxylase) to form the 4-carbon organic acid oxaloacetate (OAA).
- (b) This newly formed oxaloacetate is rapidly transported into the mesophyll chloroplasts. Here, the enzyme **malate dehydrogenase** reduces oxaloacetate into malate using electrons supplied by NADPH.
- (c) Under uninhibited physiological conditions, this malate intermediate acts as the primary chemical vehicle that diffuses across the interconnecting plasmodesmata channels out of the mesophyll layers and into the bundle sheath cells to undergo decarboxylation. Therefore, if a toxicant completely blocks malate dehydrogenase, the synthesis and subsequent migration of malate will be selectively blocked.

Final Answer:

Answer: (C)

[Go Back to Question 1](#)



Q2.

Solution

Concept: Abscisic acid (ABA) is a vital stress-responsive plant phytohormone that maintains seed dormancy and prevents premature germination under unfavorable environmental conditions. The core intracellular ABA signaling cascade is operated via a three-protein component regulatory network.

Solution:

Let's analyze the biochemical architecture of the core ABA signaling pathway:

- (a) The direct upstream intracellular receptors responsible for binding signaling molecules of exogenous or endogenous ABA are the **PYR/RCAR soluble proteins** (Pyrabactin Resistance/Regulatory Components of ABA Receptors).
- (b) In a functional wild-type plant, the binding of ABA to a PYR/RCAR receptor protein induces a conformational transformation that enables the receptor to physically bind and inhibit Type 2C protein phosphatases (PP2Cs).
- (c) The inactivation of PP2C releases its repressive block on downstream SnRK2 protein kinases. The activated SnRK2 kinases can then freely phosphorylate downstream transcription factors and ion channels to execute ABA-mediated physiological responses. A loss-of-function mutation in the intracellular receptor itself signifies that the PYR/RCAR soluble proteins are structurally non-functional.

Final Answer: PYR/RCAR soluble proteins

Answer: (A)

[Go Back to Question 2](#)



Q3.

Solution

Concept: The Munch pressure-flow hypothesis explains translocation through the phloem as a bulk flow mechanism driven by an osmotically generated hydrostatic pressure gradient between a sugar source (e.g., mature leaves) and a sugar sink (e.g., roots or developing fruits).

Solution:

Let's trace the biophysical changes caused by metabolic inhibition at the source:

- (a) Active phloem loading of sucrose from source mesophyll cells into companion cells and sieve tube elements relies on an active, energy-dependent H^+ /sucrose symporter mechanism driven by an H^+ -ATPase proton pump.
- (b) Treating companion cells with a metabolic uncoupler like 2,4-dinitrophenol (DNP) collapses the mitochondrial proton gradient, stopping ATP synthesis. Without ATP, active phloem loading ceases immediately, and sucrose cannot accumulate within the source sieve tube elements.
- (c) As a direct biophysical consequence, solute concentration inside the local sieve tubes drops, raising the solute potential. Water stops moving osmotically into the phloem from the adjacent xylem, which eliminates the local turgor pressure and causes a drastic drop in hydrostatic pressure at the source.

Final Answer:

Answer: (A)

[Go Back to Question 3](#)



Q4.

Solution

Concept: Secondary xylem (wood) in woody angiosperms contains both an axial system (oriented vertically) and a radial system (oriented horizontally). This dual arrangement enables structural support, water conduction, and metabolic storage across the stem.

Solution:

Let's evaluate the anatomical features described in the transverse stem section:

- (a) **Xylem vessel elements:** Highly specialized axial cells that undergo programmed cell death at maturity, losing their protoplast to function as hollow tubes for water transport.
- (b) **Libriform fibers:** Thick-walled, elongated axial cells that lack active protoplasts at maturity, functioning primarily to provide mechanical support.
- (c) **Xylem ray parenchyma:** Living, metabolic cells within the secondary xylem that retain active protoplasts at maturity. These cells are arranged in ribbon-like files that extend radially across the wood perpendicular to the main stem axis. They function as storage depots for starch granules and nutrients, and facilitate the lateral transport of water and metabolic organic solutes across the stem diameter.

Final Answer: Xylem ray parenchyma

Answer: (C)

[Go Back to Question 4](#)



Q5.

Solution

Concept: During non-cyclic photophosphorylation (the light-dependent reactions of photosynthesis), light energy drives an electron transport cascade through Photosystem II (PSII), the cytochrome b_6f complex, and Photosystem I (PSI) embedded within the thylakoid membrane.

Solution:

Let's analyze the spatial translocation of protons (H^+) across sub-organelar zones:

- The energetic transport of electrons through the thylakoid membrane chain is coupled to the active pumping of protons from the chloroplast stroma across into the internal membrane-bound compartment.
- This active accumulation of protons is driven by two main processes: the photolysis (splitting) of water molecules by the oxygen-evolving complex on the inner face of PSII, and the active translocation of protons from the stroma mediated by plastoquinone via the cytochrome b_6f complex.
- Both pathways dump protons directly inside the **Thylakoid Lumen** (Zone X). Because the thylakoid membrane is highly impermeable to passive proton leakage, this continuous pumping creates a steep electrochemical proton gradient (ΔpH), with maximum H^+ concentration inside the lumen. This proton motive force then drives ATP synthesis as protons exit through CF_0CF_1 ATP synthase complexes back into the stroma.

Final Answer:

Answer: (A)

[Go Back to Question 5](#)



Q6.

Solution

Concept: The inner mitochondrial membrane is completely impermeable to hydrophilic molecules, meaning that cytosolic NADH synthesized during glycolysis cannot cross directly into the mitochondrial matrix to donate its electrons to the electron transport chain (ETC). Instead, cells must rely on metabolic shuttle systems to transfer these reducing equivalents.

Solution:

Let's compare the pathways of both shuttle systems:

- (a) **Malate-Aspartate Shuttle:** Operates by reducing cytosolic oxaloacetate to malate, which is transported into the matrix and oxidized back to oxaloacetate, generating matrix NADH. This matrix NADH delivers its electrons directly to Complex I (NADH dehydrogenase). As electrons travel down the ETC from Complex I, protons are pumped at Complexes I, III, and IV, yielding approximately 2.5 ATP molecules per NADH.
- (b) **Glycerol-3-Phosphate Shuttle:** Transfers reducing equivalents from cytosolic NADH to an enzyme embedded on the outer face of the inner mitochondrial membrane, reducing FAD to FADH₂. These electrons are passed directly to coenzyme Q (ubiquinone), completely bypassing Complex I. Because Complex I is bypassed, the system misses the first major proton-pumping site, resulting in a lower proton motive force and a reduced yield of approximately 1.5 ATP molecules.

Final Answer: FAD bypassing Complex I completely

Answer: (A)

[Go Back to Question 6](#)



Q7.

Solution

Concept: Water absorbed by root hairs travels horizontally across the root cortex toward the central vascular cylinder via three distinct pathways: the apoplastic (through non-living cell walls), symplastic (through interconnected plasmodesmata cytoplasm), and transmembrane pathways.

Solution:

Let's analyze the structural modification that regulates this lateral movement at the endodermal boundary:

- (a) The endodermis forms a specialized single layer of tightly packed cells that encloses the central vascular cylinder (stele).
- (b) The radial and transverse cell walls of these endodermal cells are impregnated with a hydrophobic, waxy band known as the Casparian strip.
- (c) The primary chemical constituent deposited within the cell wall matrix to form this waterproof barrier is **suberin** (occasionally accompanied by lignin). The hydrophobic nature of suberin blocks the passive, non-selective movement of water and dissolved mineral ions through the apoplast, forcing all incoming solutions to cross the plasma membrane into the symplast. This allows the plant to selectively filter and regulate nutrient uptake before it enters the xylem.

Final Answer:

Answer: (C)

[Go Back to Question 7](#)



Q8.

Solution

Concept: Stomatal movements are controlled by changes in the turgor pressure of guard cells relative to neighboring epidermal cells. This turgor pressure is dynamically regulated by the active transport of solutes across the plasma membrane and vacuolar membranes of the guard cells.

Solution:

Let's trace the ion transport steps that drive stomatal closure during water deficit stress:

- (a) Under severe water stress, the phytohormone abscisic acid (ABA) accumulates in leaf tissues and binds to receptors on the guard cells. This signaling event triggers an influx of calcium ions into the cytoplasm, which depolarizes the plasma membrane.
- (b) This membrane depolarization opens voltage-gated anion channels, facilitating a rapid efflux of anions—specifically chloride (Cl^-) and **malate**—from the guard cells.
- (c) The loss of negative charge further depolarizes the membrane, activating outward-rectifying potassium channels. This triggers a massive, rapid **efflux of potassium (K^+) ions** down their electrochemical gradient.
- (d) This substantial loss of intracellular ions raises the osmotic water potential (Ψ_s) inside the guard cells. Water then leaves the guard cells via osmosis, causing them to lose turgor pressure, flatten, and close the stomatal pore.

Final Answer: Efflux of K^+ and malate anions

Answer: (B)

[Go Back to Question 8](#)



Q9.

Solution

Concept: During secondary growth in dicotyledonous roots, the plant must develop lateral protection and vascular systems to support expanding tissues and replace the epidermis as the root grows thicker.

Solution:

Let's trace the origin and function of the meristematic rings involved in secondary growth:

- (a) The vascular cambium forms from a combination of conjunctiva tissue cells located below the phloem strands and cells of the pericycle layer located outside the protoxym poles, creating a wavy meristematic ring that produces secondary xylem and phloem.
- (b) As the root expands radially due to secondary vascular tissue production, the outer cortex and epidermis are stretched and eventually rupture.
- (c) To form a new protective outer layer, cells within the persistent pericycle layer undergo periclinal divisions. This activity creates a continuous cylinder of secondary meristem known as the ****cork cambium (phellogen)****. The cork cambium divides to produce protective cork cells (phellem) toward the outside and secondary cortex (phellogen) toward the inside, forming the periderm.

Final Answer:

Answer: (B)

[Go Back to Question 9](#)



Q10.

Solution

Concept: Gaseous phytohormones regulate a wide range of developmental processes and stress responses in plants. Dicot seedlings germinating in darkness (etiolated) exhibit a highly conserved morphological response designed to protect the fragile shoot apical meristem as it pushes through obstructing soil.

Solution:

Let's evaluate the characteristics of this seedling growth response:

- (a) The diagnostic morphological syndrome described—shortening of the hypocotyl, radial thickening of the stem axis, and a pronounced horizontal growth curvature with an exaggerated apical hook—is known as the ****triple response****.
- (b) This specific triple response is triggered by the hyper-accumulation of the gaseous plant hormone **ethylene**.
- (c) When an etiolated seedling encounters a physical obstacle (like a dense soil clod), the mechanical stress stimulates a rapid spike in ethylene synthesis. The resulting triple response thickens and strengthens the seedling stem, allowing it to navigate around the obstruction without damaging its growing tip.

Final Answer: Ethylene

Answer: (C)

[Go Back to Question 10](#)



Q11.

Solution

Concept: Water absorbed from the soil travels radially inward across root tissue layers toward the central vascular core. The plant uses specialized structural boundaries to regulate solute absorption and prevent the unrestricted backflow of water.

Solution:

Let's identify the structural boundary shown in the diagram:

- (a) The schematic diagram shows a cross-section of a root, displaying concentric tissue layers from the outer cortex to the innermost core containing the xylem vessels.
- (b) Boundary Y marks the interface between the cortical parenchyma and the central stele. This layer is the **Inner Endodermis**.
- (c) The radial and transverse walls of endodermal cells contain hydrophobic Casparian strips made of suberin. This waxy barrier blocks the passive movement of water and dissolved minerals through the apoplast (cell walls), forcing the solution to cross the selective plasma membrane of the endodermal cells into the symplast, providing a regulatory checkpoint before entry into the xylem.

Final Answer: Inner Endodermis

Answer: (B)

[Go Back to Question 11](#)



Q12.

Solution

Concept: Photosynthetic efficiency depends on light availability. At low intensities, light is the limiting factor, and the rate of photosynthesis rises linearly. However, at excessive light intensities beyond the saturation point, the absorbed energy exceeds the capacity of the electron transport chain, causing oxidative stress and photoinhibition.

Solution:

Let's isolate the molecular target damaged during photoinhibition:

- (a) When a plant absorbs excess light energy, the reaction center of Photosystem II (PSII) becomes over-excited. This leads to the hyper-accumulation of highly reactive oxygen species (ROS) inside the thylakoid membrane.
- (b) These reactive oxygen species target and degrade the core **D1 reaction center protein** (PsbA) of PSII.
- (c) The degradation of the D1 core protein disrupts electron transfer from the oxygen-evolving complex to the plastoquinone pool, shutting down non-cyclic electron transport. The plant must then degrade the damaged complex and synthesize new D1 proteins to restore functional photosynthesis.

Final Answer:

Answer: (A)

[Go Back to Question 12](#)



Q13.

Solution

Concept: Xerophytic plants have evolved specialized anatomical adaptations to survive in arid environments by minimizing transpiration while maintaining necessary gas exchange for photosynthesis.

Solution:

Let's analyze the physical mechanism of stomatal crypts and trichomes:

- (a) Transpiration rates depend on the water vapor concentration gradient between the internal spaces of the leaf and the external air layer directly adjacent to the leaf surface.
- (b) When stomata are sunken deep within specialized epidermal cavities (crypts) lined with fine hairs (**trichomes**), air movement across the stomatal pores is restricted.
- (c) This pocket of calm air traps escaping water vapor, creating a microenvironment with high relative humidity outside the pore. Biophysically, this setup significantly increases the **boundary layer resistance** (r_b) to water vapor diffusion. By lowering the water vapor pressure gradient between the leaf interior and the immediate boundary layer, the plant reduces water loss without needing to keep its stomata completely closed.

Final Answer: Increasing boundary layer resistance

Answer: (A)

[Go Back to Question 13](#)



Q14.

Solution

Concept: The enzyme RuBisCO is bifunctional: it can catalyze either the carboxylation or the oxygenation of ribulose-1,5-bisphosphate (RuBP). Under environmental conditions with high $O_2 : CO_2$ ratios (such as high temperatures or drought causing stomatal closure), its oxygenase activity increases, initiating photorespiration.

Solution:

Let's trace the molecular products of this oxygenation reaction:

- During the standard Calvin cycle carboxylation event, a 5-carbon RuBP molecule reacts with a 1-carbon CO_2 molecule to produce an unstable 6-carbon intermediate that splits into two molecules of 3-phosphoglycerate (3-PGA).
- In the oxygenase reaction, a 5-carbon RuBP molecule reacts with an O_2 molecule instead.
- Because no carbon is added, this oxygenation reaction yields **one molecule of 3-phosphoglycerate** (a 3-carbon compound) and **one molecule of 2-phosphoglycolate** (a 2-carbon compound). The 3-PGA molecule enters the Calvin cycle, while the toxic 2-phosphoglycolate must be recycled through the photorespiratory C_2 cycle across chloroplasts, peroxisomes, and mitochondria to salvage its carbon.

Final Answer: One molecule of 3-phosphoglycerate and one molecule of 2-phosphoglycolate

Answer: (B)

[Go Back to Question 14](#)



Q15.

Solution

Concept: During aerobic respiration, oxidative phosphorylation relies on chemiosmotic coupling. The electron transport chain (ETC) transfers electrons from reducing equivalents to oxygen, using this energy to pump protons across the inner mitochondrial membrane into the intermembrane space, creating an electrochemical proton gradient.

Solution:

Let's evaluate the physiological state of the mutant lacking functional ATP synthase:

- (a) The mutant's electron transport chain remains intact and functional. When supplied with pyruvate and oxygen, complexes I, III, and IV continue to transfer electrons and pump protons into the intermembrane space, consuming oxygen to form water.
- (b) Normally, these protons re-enter the mitochondrial matrix through the F_0F_1 ATP synthase complex, dissipating the gradient to synthesize ATP.
- (c) In this mutant, because the ATP synthase complex is non-functional, the primary return pathway for protons is blocked. As the ETC continues to pump protons without an exit route, the **proton gradient hyper-accumulates** across the inner membrane. This extreme gradient increases backpressure, eventually making it harder for the ETC to pump additional protons, though oxygen consumption continues until an equilibrium plateau is reached.

Final Answer: Oxygen consumption continues; proton gradient hyper-accumulates

Answer: (B)

[Go Back to Question 15](#)



Q16.

Solution

Concept: Gastric parietal cells are specialized epithelial cells located within the mucosa of the stomach. They use apical H^+/K^+ ATPase proton pumps to secrete hydrochloric acid (HCl) into the gastric lumen, maintaining the low pH necessary for protein digestion.

Solution:

Let's connect parietal cell dysfunction to its hematological consequences:

- (a) A severe mutation that deactivates the H^+/K^+ ATPase pumps leads to achlorhydria (a lack of gastric acid secretion).
- (b) In addition to pumping protons, gastric parietal cells are responsible for synthesizing and secreting **Intrinsic Factor (IF)**, a glycoprotein essential for nutrient absorption.
- (c) Intrinsic factor binds to dietary vitamin B₁₂ (cobalamin) in the small intestine, protecting it from degradation and allowing it to be absorbed in the terminal ileum. Without functional parietal cells, intrinsic factor secretion ceases, causing a severe vitamin B₁₂ deficiency. Since vitamin B₁₂ is required for DNA synthesis during erythrocyte maturation, its absence disrupts red blood cell production, leading to the development of **megaloblastic pernicious anemia**.

Final Answer: Megaloblastic pernicious anemia

Answer: (B)

[Go Back to Question 16](#)



Q17.

Solution

Concept: The ventricular action potential in myocardial contractile cells features a prolonged depolarization phase, known as the plateau phase (Phase 2), which distinguishes it from skeletal muscle action potentials. This plateau is maintained by a balance between inward calcium currents and outward potassium currents.

Solution:

Let's analyze the effects of blocking slow voltage-gated L-type Ca^{2+} channels:

- (a) During Phase 2, the opening of L-type Ca^{2+} channels allows an inward flux of calcium ions that counteracts the outward flux of potassium ions, delaying repolarization and creating the plateau phase.
- (b) A pharmacological block of these L-type Ca^{2+} channels accelerates repolarization, shortening Phase 2 of the action potential. On an electrocardiogram (ECG), ventricular depolarization and repolarization are represented by the QT interval; thus, shortening the action potential causes a noticeable **shortening of the QT interval**.
- (c) Inside the myocardial cell, the influx of extracellular calcium through L-type channels triggers a larger release of calcium from the sarcoplasmic reticulum via ryanodine receptors (calcium-induced calcium release). Blocking the L-type channels reduces intracellular calcium availability during contraction, resulting in **decreased myocardial contractility** (a negative inotropic effect).

Final Answer: Shortening of the QT interval and decreased contractility

Answer: (A)

[Go Back to Question 17](#)



Q18.

Solution

Concept: The oxygen-hemoglobin dissociation curve illustrates the relationship between the partial pressure of oxygen (PO_2) and the percentage saturation of hemoglobin. The affinity of hemoglobin for oxygen is modulated by local chemical and physical factors within peripheral tissues.

Solution:

Let's evaluate the physiological shifts caused by metabolic activity in working muscle:

- When an athlete's skeletal muscles are actively working, localized metabolic activity accelerates, causing a simultaneous increase in partial pressure of carbon dioxide (PCO_2), hydrogen ion concentration (decreasing pH via lactic acid), local temperature, and the glycolytic intermediate **2,3-bisphosphoglycerate (2,3-BPG)**.
- These factors interact with hemoglobin to stabilize its deoxygenated structural conformation (the T-state). For example, increased H^+ and CO_2 bind to specific amino acid residues on hemoglobin, lowering its oxygen affinity—a phenomenon known as the **Bohr effect**.
- This combined stabilization **decreases hemoglobin's affinity for O_2** , shifting the oxygen-hemoglobin dissociation curve to the **right**. This rightward shift facilitates the unloading of oxygen from hemoglobin into the oxygen-depleted, metabolically active muscle tissues.

Final Answer: Decreases, shifting the curve to the right

Answer: (A)

[Go Back to Question 18](#)



Q19.

Solution

Concept: The hypothalamus regulates systemic fluid balance by synthesizing key neurohypophyseal hormones within specific magnocellular neurosecretory neuron clusters. These hormones are then transported down axonal tracts to the posterior pituitary for release into circulation.

Solution:

Let's analyze the effects of destroying the supraoptic and paraventricular nuclei:

- (a) The supraoptic and paraventricular nuclei are the primary sites for the synthesis of **Antidiuretic Hormone (ADH)**, also known as arginine vasopressin.
- (b) A neurological injury that destroys these nuclei causes a severe deficiency or absolute absence of circulating ADH, resulting in a clinical syndrome known as central **Diabetes Insipidus (DI)**.
- (c) Normally, ADH binds to V_2 receptors in the renal collecting ducts, recruiting aquaporin-2 channels to reabsorb water. Without ADH, the distal tubules and collecting ducts remain impermeable to water, preventing reabsorption. This leaves the kidneys unable to concentrate urine, leading to the excretion of a **high volume of highly dilute urine** (polyuria), which can quickly cause systemic dehydration.

Final Answer: Diabetes Insipidus; high volume, highly dilute urine

Answer: (B)

[Go Back to Question 19](#)



Q20.

Solution

Concept: The loop of Henle establishes an osmotic gradient within the renal medullary interstitium via a countercurrent multiplier mechanism. The two limbs of the loop possess opposing water and solute permeability profiles that continuously alter the tonicity of the tubular fluid.

Solution:

Let's trace the fluid tonicity changes through the segments of the loop:

- (a) Fluid enters the loop of Henle from the proximal convoluted tubule (PCT) with an osmolality of approximately 300 mOsm/kg, which is isotonic relative to the surrounding cortical fluid.
- (b) **Site Z** marks the **Thin Descending Limb** of the loop of Henle. The epithelial cells lining this segment express high levels of constitutive aquaporin-1 water channels, making the membrane highly permeable to water, while remaining largely impermeable to sodium chloride (NaCl) and urea.
- (c) As the tubular fluid flows down Site Z into the deeper, highly concentrated medullary interstitium, water is drawn out of the lumen via osmosis. Because water leaves while solutes remain trapped inside, the luminal fluid becomes **progressively hypertonic**, reaching its maximum concentration (around 1200 mOsm/kg) at the hairpin turn of the loop.

Final Answer:

Answer: (B)

[Go Back to Question 20](#)



Q21.

Solution

Concept: The propagation of an action potential along an excitable neuronal axon is followed by a refractory period, which is divided into an absolute refractory period and a relative refractory period. This timing ensures that nerve impulses travel in a single direction and sets an upper limit on firing frequency.

Solution:

Let's analyze the structural state changes of voltage-gated Na^+ channels during an action potential:

- Voltage-gated Na^+ channels possess two distinct regulatory gates: an extracellular activation gate (m -gate) and an intracellular inactivation gate (h -gate).
- At rest, the activation gate is closed and the inactivation gate is open. When a stimulus depolarizes the membrane to threshold, the activation gates open rapidly, allowing a massive influx of Na^+ ions that drives the depolarization phase.
- At the peak of the action potential, the slow-acting intracellular inactivation gate (h -gate) closes, shutting down Na^+ conductance. During this subsequent depolarization and early repolarization phase, the channels enter a state of absolute refractoriness. Because the inactivation gates are physically closed, no amount of stimulus can reopen the channels to generate a second action potential until the membrane repolarizes and resets the channels back to their resting state.

Final Answer: Inactivated due to closure of the inactivation gate (h-gate)

Answer: (C)

[Go Back to Question 21](#)



Q22.

Solution

Concept: Parathyroid hormone (PTH) is a primary endocrine regulator of calcium and phosphate homeostasis, acting directly on bone and kidney tissues to modulate mineral concentrations in the blood.

Solution:

Let's trace the physiological effects of autonomous PTH hyper-secretion (hyperparathyroidism):

- (a) Elevated PTH binds to receptors on osteoblasts, stimulating them to express RANKL and suppress osteoprotegerin (OPG). This signaling pathway increases the maturation and activation of bone-resorbing **osteoclasts**, leading to accelerated bone demineralization and the release of calcium and phosphate into circulation.
- (b) In the kidneys, PTH enhances calcium reabsorption in the distal convoluted tubule while simultaneously inhibiting phosphate reabsorption in the proximal convoluted tubule by downregulating Na^+/Pi co-transporters.
- (c) This increased renal excretion of phosphate overrides the amount released from bone, causing a net decrease in blood phosphate levels. Therefore, a patient with a PTH-secreting tumor will present with a serum and tissue profile of **hypercalcemia, hypophosphatemia, and increased osteoclast activity**.

Final Answer: Hypercalcemia, hypophosphatemia, increased osteoclast activity

Answer: (B)

[Go Back to Question 22](#)



Q23.

Solution

Concept: The exocrine pancreas secretes digestive enzymes into the duodenum as inactive precursors (zymogens) to prevent autodigestion and damage to the pancreatic duct network. These zymogens must be activated inside the intestinal lumen.

Solution:

Let's isolate the specific biochemical trigger that initiates this activation cascade:

- (a) Pancreatic juice containing zymogens like trypsinogen, chymotrypsinogen, and procarboxypeptidase enters the duodenum via the pancreatic duct.
- (b) The mucosal lining of the duodenum contains a specialized brush-border enzyme called **enteropeptidase (or enterokinase)**.
- (c) Enteropeptidase specifically cleaves a hexapeptide fragment from the amino terminus of inactive trypsinogen, converting it into its active form, **trypsin**. Once activated, trypsin acts as a master protease, autocatalytically activating remaining trypsinogen molecules and cleaving other zymogens like chymotrypsinogen into active chymotrypsin to initiate protein digestion.

Final Answer: Enteropeptidase (Enterokinase)

Answer: (B)

[Go Back to Question 23](#)



Q24.

Solution

Concept: Skeletal muscle contraction operates via a sliding filament mechanism regulated by intracellular calcium concentrations. The thin actin filaments are associated with a regulatory complex composed of tropomyosin and troponin.

Solution:

Let's evaluate the functions of the specific subunits within the troponin complex:

- (a) In a resting muscle fiber, intracellular calcium levels are low, and the long protein strand tropomyosin physically covers the myosin-binding sites on the actin filament, preventing cross-bridge formation.
- (b) When an action potential depolarizes the muscle membrane, calcium ions (Ca^{2+}) are released from the sarcoplasmic reticulum into the sarcoplasm.
- (c) These free Ca^{2+} ions bind directly to **Troponin C**, the specialized calcium-binding subunit of the heterotrimeric troponin complex. This binding induces a conformational shift that pulls tropomyosin away from the myosin-binding sites, allowing the myosin heads to bind to actin and initiate the contraction cycle.

Final Answer:

[Go Back to Question 24](#)



Q25.

Solution

Concept: Neuromuscular junction transmission relies on the rapid breakdown of neurotransmitters to ensure controlled skeletal muscle contraction and relaxation cycles.

Solution:

Let's analyze the effects of an irreversible acetylcholinesterase (AChE) inhibitor:

- (a) When an action potential reaches the motor neuron terminal, acetylcholine (ACh) is released into the synaptic cleft, where it binds to nicotinic receptors on the postsynaptic muscle end-plate, triggering depolarization.
- (b) Under normal conditions, AChE rapidly hydrolyzes ACh into choline and acetate, terminating the signal and allowing the muscle membrane to repolarize.
- (c) An irreversible inhibitor blocks AChE activity, causing ACh to accumulate within the synaptic cleft. This leads to continuous binding and activation of nicotinic receptors, resulting in **persistent depolarization** of the postsynaptic muscle membrane. This continuous activation prevents the muscle from repolarizing to fire subsequent action potentials, causing initial fasciculations followed by **spastic paralysis**.

Final Answer: Persistent depolarization leading to spastic paralysis

Answer: (A)

[Go Back to Question 25](#)



Q26.

Solution

Concept: The adrenal gland is an endocrine organ divided into an inner medulla and an outer cortex. The adrenal cortex is structured into three distinct histological zones, each containing specialized enzymes to synthesize specific corticosteroid hormones.

Solution:

Let's map the histological zones of the adrenal cortex from the outside in:

- (a) **Zona Glomerulosa (Layer W):** The outermost thin cellular layer located directly beneath the adrenal capsule. It expresses aldosterone synthase, making it uniquely responsible for the biosynthesis and secretion of mineralocorticoids, primarily **aldosterone**, which regulates systemic blood pressure and fluid balance.
- (b) **Zona Fasciculata:** The thick middle layer composed of parallel cords of lipid-rich cells, primarily responsible for secreting glucocorticoids such as cortisol.
- (c) **Zona Reticularis:** The innermost layer of the cortex adjacent to the medulla, primarily responsible for producing weak adrenal androgens like dehydroepiandrosterone (DHEA).

Final Answer:

Answer: (C)

[Go Back to Question 26](#)

Q27.

Solution

Concept: The kidneys maintain systemic fluid homeostasis by concentrating urine through a countercurrent multiplier system. This system establishes a steep osmotic gradient in the medullary interstitium that rises from 300 mOsm/kg near the cortex to roughly 1200 mOsm/kg deep in the inner medulla.

Solution:

Let's identify the chemical solutes that generate this high medullary interstitial hyperosmolality:

- (a) **Sodium Chloride (NaCl):** Actively transported out of the thick ascending limb of the loop of Henle into the surrounding interstitium via $\text{Na}^+/\text{K}^+/\text{2Cl}^-$ co-transporters (NKCC2). Because this segment is impermeable to water, NaCl accumulates in the medullary interstitium, accounting for roughly half of its total hyperosmolality.
- (b) **Urea:** Contributes the remaining portion of the medullary osmotic gradient through a recycling process. ADH activates urea transporters (UT-A1) in the inner medullary collecting ducts, allowing urea to diffuse down its concentration gradient into the deep medullary interstitium, where it traps water and drives further concentration of the urine.

Final Answer:

Answer: (B)

[Go Back to Question 27](#)



Q28.

Solution

Concept: Myelin is a lipid-rich sheath produced by specialized glial cells—Schwann cells in the peripheral nervous system (PNS) and oligodendrocytes in the central nervous system (CNS). This insulation wraps around axons to facilitate rapid, energy-efficient signal propagation.

Solution:

Let's evaluate the biophysical effects of demyelination on action potential propagation:

- (a) In a healthy, myelinated peripheral axon, the myelin sheath prevents ion leakage across the membrane, forcing the action potential to jump from one unmyelinated node of Ranvier to the next—a process known as saltatory conduction.
- (b) An autoimmune disease that destroys Schwann cells leads to segmental demyelination along peripheral motor axons.
- (c) Without myelin insulation, the membrane capacitance increases and resistance drops, causing ions to leak across the exposed membrane. This leakage dissipates the local current, preventing it from depolarizing adjacent axonal segments to threshold. As a result, the nerve impulse experiences ****marked deceleration or absolute failure of continuous conduction****, leading to muscle weakness or sensory loss.

Final Answer: Marked deceleration or failure of continuous conduction

Answer: (C)

[Go Back to Question 28](#)



Q29.

Solution

Concept: Normal resting expiration is a passive process that relies on the elastic recoil of the lungs and chest wall to expel air as the diaphragm and external intercostal muscles relax. However, forced expiration requires active muscular contraction to decrease thoracic volume below the functional residual capacity (FRC).

Solution:

Let's identify the specific muscle groups recruited during forced expiration:

- (a) To drive air out of the lungs against resistance or below resting volumes, the body must actively compress the thoracic cavity.
- (b) This compression is driven by two primary muscle groups: the **internal intercostal muscles** and the **abdominal muscles** (including the rectus abdominis, transverse abdominis, and internal/external obliques).
- (c) Contraction of the internal intercostals pulls the ribs downward and inward, compressing the rib cage. Simultaneously, contraction of the abdominal muscles compresses the abdominal contents, pushing the diaphragm upward into the thoracic cavity. This combined action rapidly reduces thoracic volume, increasing intrapulmonary pressure to force air out of the lungs.

Final Answer: Internal intercostals and abdominal muscles

Answer: (B)

[Go Back to Question 29](#)



Q30.

Solution

Concept: Mendelian genetics states that when alleles at multiple distinct loci assort independently during gametogenesis, the probability of an offspring inheriting a specific combination of phenotypes can be calculated by multiplying the individual probabilities for each trait.

Solution:

Let's calculate the phenotypic probability for each independent locus in the cross $AaBbCc \times AaBbCc$:

- (a) **Locus 1 ($Aa \times Aa$):** The probability of producing an offspring displaying the completely recessive phenotype (aa) is $\frac{1}{4}$.
- (b) **Locus 2 ($Bb \times Bb$):** The probability of producing an offspring displaying the completely recessive phenotype (bb) is $\frac{1}{4}$.
- (c) **Locus 3 ($Cc \times Cc$):** The probability of producing an offspring displaying the completely recessive phenotype (cc) is $\frac{1}{4}$.
- (d) Since these three loci assort independently, we multiply their individual probabilities to find the fraction of offspring that will express the recessive phenotype for all three traits simultaneously ($aabbcc$):

$$\text{Total Probability} = \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} = \frac{1}{64}$$

Final Answer: 1/64

Answer: (A)

[Go Back to Question 30](#)



Q31.

Solution

Concept: DNA polymerases require a pre-existing 3'-OH group to initiate the synthesis of a new DNA strand. During replication, this required primer strand is synthesized by a specialized RNA polymerase known as DNA primase.

Solution:

Let's evaluate the structural consequences of a mutation in the *dnaG* gene:

- (a) The *dnaG* gene in *E. coli* encodes DNA primase, the enzyme responsible for synthesizing short RNA sequences complementary to the single-stranded DNA template.
- (b) These short **RNA Primers** provide the essential 3'-OH primers needed for DNA Polymerase III to begin elongation. On the lagging strand, primase must repeatedly synthesize new primers to initiate each Okazaki fragment.
- (c) If a temperature-sensitive mutation inactivates DNA primase, the replication machinery cannot generate these vital **RNA Primers**. Without them, DNA polymerase III cannot initiate elongation at the replication fork, preventing the formation of Okazaki fragments and halting lagging strand synthesis.

Final Answer: RNA Primers

Answer: (B)

[Go Back to Question 31](#)



Q32.

Solution

Concept: The bacterial tryptophan (*trp*) operon is regulated by a dual control system: a repressor protein that blocks transcription initiation and an attenuation mechanism that regulates transcription elongation based on intracellular tryptophan concentrations.

Solution:

Let's trace the structural conformations of the leader mRNA during attenuation:

- (a) The *trp* operon leader transcript contains a specialized attenuator region with four distinct sequence segments (1, 2, 3, and 4) capable of base-pairing into alternative hairpin structures.
- (b) When intracellular tryptophan levels are high, the ribosome translates the leader peptide rapidly, covering region 2 before region 3 is transcribed.
- (c) As RNA polymerase continues, region 3 base-pairs with the newly transcribed region 4, forming a stable **3-4 terminator hairpin loop**. This structure is followed by a run of uracil residues, acting as a Rho-independent transcription terminator. This hairpin physically disrupts the transcription complex, causing RNA polymerase to fall off the DNA template and arresting transcription prematurely before the structural genes of the operon can be copied.

Final Answer: 3-4 terminator hairpin loop

Answer: (B)

[Go Back to Question 32](#)



Q33.

Solution

Concept: Pedigree analysis evaluates the transmission patterns of a phenotypic trait across generations to determine its underlying mode of genetic inheritance.

Solution:

Let's analyze the transmission rules described in the pedigree profile:

- (a) **Affected Males:** Pass the metabolic trait to 100% of their daughters but 0% of their sons. Because sons inherit their single Y chromosome from their father, the absolute absence of transmission from father to son rules out Y-linked or autosomal inheritance. Since daughters must inherit their father's single X chromosome, this perfect transmission to all daughters indicates the mutant allele is carried on the X chromosome.
- (b) **Affected Females:** Pass the trait to exactly half (50%) of their sons and half (50%) of their daughters. This matches the segregation pattern of a heterozygous maternal carrier ($X^D X^d$) passing an X chromosome allele to her offspring.
- (c) Because the presence of a single mutant allele is sufficient to express the phenotype in both hemizygous males and heterozygous females, the mode of inheritance is defined as ****X-linked Dominant****.

Final Answer: X-linked Dominant

Answer: (C)

[Go Back to Question 33](#)



Q34.

Solution

Concept: Transcription initiation in eukaryotes requires the sequential assembly of general transcription factors (GTFs) along with RNA Polymerase II at the core promoter locus to form a functional pre-initiation complex (PIC).

Solution:

Let's identify the enzymatic functions of the specified transcription factor:

- (a) The schematic profile illustrates the transcription factors assembled at the TATA box promoter, including TFIID and RNA Polymerase II. Factor X represents the multi-subunit complex **TFIIH**, which is the final general transcription factor recruited to the pre-initiation complex.
- (b) TFIIH contains two subunits with ATP-dependent **helicase activity** (XPB and XPD) that unwind the double-stranded genomic DNA at the start site, creating the transcription bubble.
- (c) Additionally, TFIIH possesses a kinase subunit that phosphorylates specific serine residues within the **C-terminal domain (CTD)** of RNA Polymerase II. This phosphorylation event alters the enzyme's conformation, releasing it from the transcription factors bound at the promoter and allowing it to begin elongation (promoter clearance).

Final Answer:

Answer: (C)

[Go Back to Question 34](#)



Q35.

Solution

Concept: The genetic code is translated sequentially in triplets of nucleotide bases called codons. A point mutation is a molecular alteration involving the substitution of a single nucleotide base within a genetic sequence.

Solution:

Let's analyze the molecular consequences of the specified codon alteration:

- The original codon sequence is 5'-UUG-3', which translates to the amino acid Leucine.
- A single point mutation transitions the central Uracil (U) to an Adenine (A), converting the codon to 5'-UAG-3'.
- Out of the 64 possible codons in the standard genetic code, three (UAA, UAG, and UGA) do not code for any amino acid; instead, they serve as translation termination signals. UAG is specifically known as the amber stop codon.
- Because a sense codon coding for an amino acid is mutated into a translation termination signal, this is classified as a **nonsense mutation**. When the ribosome encounters this new UAG triplet during translation, it binds a release factor instead of an aminoacyl-tRNA, leading to the ****premature truncation**** of the elongating polypeptide chain.

Final Answer: Nonsense mutation; premature truncation

Answer: (B)

[Go Back to Question 35](#)



Q36.

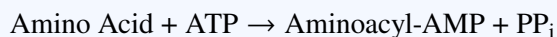
Solution

Concept: Aminoacylation (tRNA charging) is the metabolic activation step of translation wherein an aminoacyl-tRNA synthetase enzyme covalently couples a specific amino acid to its corresponding cognate tRNA vehicle, establishing the genetic fidelity of protein synthesis.

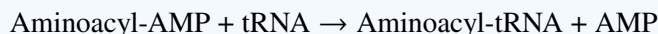
Solution:

Let's break down the two-step biochemical reaction sequence catalyzed by the synthetase:

- (a) **Step 1 (Activation):** The aminoacyl-tRNA synthetase binds one molecule of free amino acid and one molecule of ATP. The enzyme hydrolyzes the high-energy bond between the α - and β -phosphates of ATP, driving the coupling of adenosine monophosphate (AMP) to the carboxyl group of the amino acid. This step produces an activated aminoacyl-AMP intermediate and releases an inorganic pyrophosphate (PP_i) molecule:



- (b) **Step 2 (Transfer):** Without leaving the active site, the aminoacyl group is transferred from the AMP carrier to either the 2'- or 3'-hydroxyl group of the ribose sugar attached to the terminal adenosine nucleotide at the 3' acceptor stem of the tRNA molecule. This releases free AMP:



- (c) **Net Energetic Expenditure:** To drive this continuous forward metabolic pathway, the released inorganic pyrophosphate (PP_i) is rapidly broken down into two inorganic orthophosphates ($2 P_i$) by ubiquitous pyrophosphatase enzymes. Consequently, the loading of a single amino acid requires the complete **hydrolysis of 1 ATP to 1 AMP + 1 PP_i **, which is energetically equivalent to expending two high-energy phosphate bonds.

Final Answer: Hydrolysis of 1 ATP to 1 AMP + 1 PP_i

Answer: (B)

[Go Back to Question 36](#)



Q37.

Solution

Concept: Genetic linkage mapping calculates the relative structural positions of genes arranged along a single chromosome. Because crossing over occurs randomly during prophase I of meiosis, the physical distance between two linked loci determines the mathematical probability that a recombination event will separate their alleles.

Solution:

Let's correlate recombination frequency with genetic map units:

- (a) Recombination frequency (RF) is calculated as the total percentage of recombinant offspring relative to the entire population produced in a classic genetic test cross:

$$\text{RF} = \frac{\text{Number of Recombinant Offspring}}{\text{Total Offspring}} \times 100\%$$

- (b) In genetic mapping, the standard arbitrary unit of physical chromosome distance is named the **centimorgan (cM)**, or map unit (mu), in honor of geneticist Thomas Hunt Morgan.
- (c) By definition, a recombination frequency of exactly 1% equals a genetic mapping distance of 1 centimorgan (cM). Therefore, a measured recombination frequency of exactly 12.5% corresponds linearly to a chromosomal mapping distance of **12.5 centimorgans (cM)**.

Final Answer: 12.5 centimorgans (cM)

Answer: (A)

[Go Back to Question 37](#)



Q38.

Solution

Concept: The Meselson-Stahl experiment demonstrated that DNA replication follows a semi-conservative mechanism. During every round of replication, the two complementary strands of a parent DNA double helix separate, and each individual strand serves as a template for the synthesis of a newly engineered daughter strand.

Solution:

Let's trace the isotopic composition of the DNA molecules across three generations of synchronized division:

- (a) **Generation 0 (Parental):** Cells are grown exclusively in heavy ^{15}N medium, meaning 100% of the DNA molecules consist of two heavy strands (^{15}N - ^{15}N).
- (b) **Generation 1:** Cells divide once in light ^{14}N medium. The two parent heavy strands separate and act as templates for light strands. This results in $2^1 = 2$ DNA molecules, both of which are **hybrid** (^{15}N - ^{14}N) density molecules.
- (c) **Generation 2:** The 2 hybrid DNA molecules divide again in light ^{14}N medium, yielding $2^2 = 4$ total molecules. The two original heavy strands form 2 hybrid (^{15}N - ^{14}N) molecules, while the two light strands form 2 **light** (^{14}N - ^{14}N) molecules.
- (d) **Generation 3:** The 4 DNA molecules divide a third time in ^{14}N medium, resulting in $2^3 = 8$ total double-stranded DNA molecules. The two original ^{15}N strands are still present, conserved within 2 hybrid (^{15}N - ^{14}N) DNA molecules. The remaining 6 molecules are made entirely of light nitrogen, forming light (^{14}N - ^{14}N) DNA molecules.
- (e) **Ratio Determination:** Let's find the ratio of hybrid to light DNA molecules in this third generation:

$$\text{Ratio} = \frac{\text{Hybrid Molecules}}{\text{Light Molecules}} = \frac{2}{6} = \frac{1}{3}$$

Final Answer:

Answer: (B)

[Go Back to Question 38](#)



Q39.

Solution

Concept: Eukaryotic organisms use multiple DNA repair pathways to correct structural damage caused by environmental mutagens, ensuring genomic stability across cell divisions.

Solution:

Let's isolate the molecular mechanism affected in Xeroderma Pigmentosum:

- (a) Exposure to ultraviolet (UV) radiation from sunlight causes covalent bonds to form between adjacent pyrimidine bases, creating distorting DNA lesions such as cyclobutane pyrimidine dimers (CPDs) or 6-4 photoproducts.
- (b) In healthy cells, these bulky, helix-distorting lesions are recognized and repaired by the **Nucleotide Excision Repair (NER)** pathway. The NER mechanism uses multi-protein complexes to unwind the DNA, cleave a short single-stranded fragment containing the lesion, and fill the gap via DNA polymerase and ligase.
- (c) Xeroderma Pigmentosum (XP) is caused by an inherited autosomal recessive loss-of-function mutation in genes encoding core enzymes of this pathway (such as XPA through XPG). This genetic defect renders the **Nucleotide Excision Repair** pathway non-functional, leaving cells unable to fix UV-induced dimers and leading to skin malignancies.

Final Answer: Nucleotide Excision Repair (NER)

Answer: (C)

[Go Back to Question 39](#)



Q40.

Solution

Concept: Eukaryotic genomic DNA is packed into chromatin around histone protein octamers to form repeating nucleosome units. The structural density of this chromatin can be altered by covalent modifications to the amino-terminal histone tails, shifting the DNA between transcriptionally active and inactive states.

Solution:

Let's evaluate the structural transition associated with State M:

- (a) Histone tails contain positively charged lysine residues that form tight ionic bonds with the negatively charged phosphate backbone of DNA, holding the chromatin in a condensed, tightly packed structure.
- (b) When histone acetyltransferase (HAT) enzymes add acetyl groups to these lysine tails (as shown in State M), the positive charge is neutralized. This weakens the ionic attraction between the histones and the DNA strand.
- (c) This biophysical change causes the nucleosomes to loosen and unfold, driving a transition into a relaxed, open conformation known as **euchromatin decondensation**. This uncoiled state increases the accessibility of the DNA template to RNA polymerase and transcription factors, facilitating gene activation.

Final Answer:

Answer: (B)

[Go Back to Question 40](#)



Q41.

Solution

Concept: Francis Crick's wobble hypothesis explains why cells do not require 61 unique tRNA species to decode the 61 codons that specify amino acids. It states that while the first two positions of a codon require strict Watson-Crick base pairing (A-U and G-C), the base pairing rules at the third position of the mRNA codon (matching the first position of the tRNA anticodon) are more flexible.

Solution:

Let's analyze the pairing capacity of the modified purine base Inosine (I):

- (a) Inosine is formed through the post-transcriptional deamination of Adenine within the anticodon loops of certain tRNAs.
- (b) Structurally, Inosine contains the purine base hypoxanthine. Due to its unique arrangement of hydrogen bond donors and acceptors, Inosine can form stable hydrogen bonds with multiple different bases without disrupting the geometry of the RNA double helix.
- (c) Specifically, an Inosine located at the critical 5' first position of a tRNA anticodon can form non-standard wobble base pairs with three different nucleotide bases at the 3' third position of an mRNA codon: **Adenine (A), Uracil (U), or Cytosine (C)**. It cannot pair with Guanine (G) due to steric and electrostatic repulsion.

Final Answer: A, U, or C

Answer: (A)

[Go Back to Question 41](#)



Q42.

Solution

Concept: To prevent chromosomal instability and aneuploidy, the eukaryotic cell cycle relies on strict quality control surveillance systems. The spindle assembly checkpoint (SAC) operates during mitosis to halt cell cycle progression until all duplicated chromosomes are properly aligned along the metaphase plate.

Solution:

Let's isolate the structural sensing complex where this checkpoint operates:

- (a) The centromere is a highly specialized, condensed region of genomic DNA that acts as a structural platform for chromosome segregation.
- (b) During prophase and prometaphase, a multi-protein, disk-shaped macromolecular complex called the **kinetochore** assembles directly onto this centromeric DNA platform.
- (c) The kinetochore serves as the primary physical anchoring site for incoming spindle microtubules. Additionally, unattached kinetochores act as the sensor for the spindle assembly checkpoint, recruiting signaling proteins (such as Mad2 and BubR1) to generate a wait-anaphase signal until proper, bi-oriented microtubule attachment is achieved.

Final Answer:

Answer: (B)

[Go Back to Question 42](#)



Q43.

Solution

Concept: The intracellular endomembrane system relies on vesicle budding and fusion pathways to move proteins and lipids between the endoplasmic reticulum (ER) and the distinct cis, medial, and trans cisternae stacks of the Golgi apparatus.

Solution:

Let's analyze the cellular effects of Brefeldin A treatment:

- (a) Brefeldin A (BFA) is a lactone antiviral metabolite that specifically inhibits Guanine Nucleotide Exchange Factors (GEF) required to activate Arf1 GTPase. This inhibition prevents the assembly of COP-I protein coats on budding membranes.
- (b) Because COP-I vesicles mediate retrograde transport, blocking this pathway disrupts the dynamic equilibrium of membrane recycling within the endomembrane network.
- (c) Without functional coat proteins, forward anterograde transport balances tilt completely. Over time, this disruption leads to the ****disassembly and collapse of the Golgi stacks****, as the Golgi membrane fuses back into the endoplasmic reticulum, causing the organelle to disappear as a distinct structure.

Final Answer: Disassembly and collapse of the Golgi stacks into the ER

Answer: (B)

[Go Back to Question 43](#)



Q44.

Solution

Concept: Meiosis I is characterized by the pairing, alignment, and segregation of homologous chromosomes. During prophase I, homologous chromosomes progress through five distinct sub-stages: leptotene, zygotene, pachytene, diplotene, and diakinesis.

Solution:

Let's trace the structural components that hold homologous chromosomes together:

- (a) During the zygotene stage, homologous chromosomes begin to align side-by-side in a process called synapsis.
- (b) This alignment is stabilized by the assembly of a highly organized, proteinaceous zipper-like structure called the **Synaptonemal Complex**.
- (c) During the **pachytene stage**, this complex is fully formed, holding the non-sister chromatids of the homologous chromosomes together. This tight physical association provides the structural framework necessary for specialized enzyme complexes to execute genetic recombination (crossing over). The complex breaks down later during the diplotene stage, leaving the chromosomes connected only at points of cross-over called chiasmata.

Final Answer:

Answer: (B)

[Go Back to Question 44](#)



Q45.

Solution

Concept: Eukaryotic cells contain specialized, membrane-bound organelles designed to isolate biochemical pathways, maintaining internal microenvironments with distinct pH values and enzyme compositions tailored to specific cellular functions.

Solution:

Let's analyze the properties of Organelle K from the description:

- (a) Organelle K is a spherical membrane-bound vesicle filled with a dense matrix of hydrolytic enzymes.
- (b) This compartment maintains an acidic internal pH of approximately 4.5 to 5.0, driven by active vacuolar H^+ -ATPase proton pumps embedded within its membrane.
- (c) This low pH is the optimal environment for its internal **acid hydrolases** (including proteases, nucleases, and lipases) to break down macromolecules. This description uniquely identifies the **lysosome**, which serves as the primary recycling and degradation center of the cell, digesting worn-out organelles, internalized pathogens, and macromolecules.

Final Answer:

Answer: (C)

[Go Back to Question 45](#)



Q46.

Solution

Concept: The fluid mosaic model describes the plasma membrane as a dynamic lipid bilayer embedded with mobile proteins. Membrane fluidity must be tightly regulated within a narrow physiological range to preserve structural integrity, support transporter function, and facilitate signal transduction.

Solution:

Let's analyze how cholesterol acts as a bidirectional fluidity buffer across temperature extremes:

- (a) **At High Physiological Temperatures (around 37°C):** The lipid bilayer becomes highly mobile and fluid. Because cholesterol contains a rigid steroid ring system, it inserts between the hydrophobic fatty acid tails of phospholipids, restricting their lateral movement and **decreasing membrane fluidity**, which helps stabilize the bilayer structure.
- (b) **At Low Temperatures:** Phospholipids tend to pack tightly together, transitioning into a rigid, crystalline gel state. The presence of bulky cholesterol molecules disrupts this tight, orderly packing, preventing the fatty acid chains from solidifying. This structural disruption **increases membrane fluidity** at low temperatures, keeping the membrane functional in the cold.

Final Answer: Decreases fluidity at high, increases at low

Answer: (B)

[Go Back to Question 46](#)



Q47.

Solution

Concept: Enzyme inhibitors reduce the catalytic activity of enzymes. They can be classified into competitive, non-competitive, or uncompetitive modes of inhibition based on their structural interactions with the enzyme's active site and substrate-binding configurations.

Solution:

Let's evaluate the Michaelis-Menten kinetic parameters under competitive inhibition:

- (a) A competitive inhibitor shares structural similarity with the natural substrate, allowing it to compete directly for binding at the enzyme's active site.
- (b) **Impact on V_{\max} :** If the substrate concentration is increased to extremely high levels, the substrate molecules outcompete the inhibitor for active site access. At saturation, the maximum catalytic rate is fully restored, meaning the maximum velocity (V_{\max} remains unchanged).
- (c) **Impact on K_m :** Because the inhibitor interferes with substrate binding at lower concentrations, a higher concentration of substrate is required to reach half of the maximum velocity. This shift reflects an apparent decrease in binding affinity, which mathematically increases the Michaelis constant (K_m).

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

Answer: (B)

[Go Back to Question 47](#)



Q48.

Solution

Concept: Cell cycle progression is driven by the cyclical activation and inactivation of Cyclin-Dependent Kinases (CDKs) bound to regulatory cyclin subunits. Cell cycle checkpoints ensure these cyclins are degraded at specific times to keep cell division moving in one direction.

Solution:

Let's analyze the consequences of preventing Cyclin B degradation:

- (a) Entry into mitosis is driven by the activation of the Mitosis-Promoting Factor (MPF), a protein complex composed of CDK1 and **Cyclin B**.
- (b) During metaphase, once all chromosomes are properly aligned along the spindle equator, the spindle assembly checkpoint is satisfied. This activates the Anaphase-Promoting Complex/Cyclosome (APC/C), a specialized ubiquitin ligase.
- (c) The APC/C tags Cyclin B with ubiquitin, targeting it for destruction by the 26S proteasome. The degradation of Cyclin B inactivates CDK1, a drop that is required for the cell to exit mitosis. If Cyclin B cannot be degraded, MPF remains active, locking the cell in a state of continuous mitotic spindle stability and causing an irreversible arrest at the **Metaphase-to-Anaphase transition**.

Final Answer: Metaphase-to-Anaphase transition

Answer: (B)

[Go Back to Question 48](#)



Q49.

Solution

Concept: The eukaryotic cytoskeleton is a dynamic structural network composed of three principal filament systems: actin microfilaments, intermediate filaments, and microtubules. Each filament system possesses distinct physical structures and structural components adapted to specific cellular roles.

Solution:

Let's evaluate the characteristics of the specified cytoskeletal system:

- (a) **Microtubules:** Hollow, rigid cylindrical tubes measuring approximately 25 nm in diameter, assembled from alternating polymers of α - and β -tubulin dimers.
- (b) **Structural Polarity:** Microtubules possess an inherent structural polarity, with a fast-growing plus end and a slower-growing minus end. This polarity allows them to act as directional tracks for molecular motor proteins: **kinesins** generally move toward the plus end, while **dyneins** move toward the minus end.
- (c) **Ciliary Core:** Microtubules assemble into a characteristic "9 + 2" arrangement of axonemes to form the structural core of eukaryotic cilia and flagella, driving cellular motility through dynein-mediated sliding.

Final Answer:

Answer: (C)

[Go Back to Question 49](#)



Q50.

Solution

Concept: The plasma membrane lipid bilayer is highly asymmetric; the lipid composition of the outer leaflet facing the extracellular matrix differs significantly from the composition of the inner leaflet facing the cytoplasm.

Solution:

Let's analyze the properties and distribution of the specified membrane lipid:

- (a) Phosphatidylserine and phosphatidylethanolamine are aminophospholipids that are actively sequestered into the inner cytoplasmic leaflet by flippase enzymes under normal physiological conditions.
- (b) **Molecule P** features a hydrophobic lipid base anchored within the outer leaflet, extended with a complex, branching hydrophilic carbohydrate chain that projects out into the extracellular space.
- (c) This structural profile defines a **glycolipid** (often built on a sphingolipid base). Glycolipids are found exclusively on the outer leaflet of the plasma membrane, where their carbohydrate chains form part of the protective cellular glycocalyx. This layer plays roles in cell-to-cell recognition, tissue histocompatibility, and intercellular signaling pathways.

Final Answer: Glycolipid (Sphingolipid base)

Answer: (B)

[Go Back to Question 50](#)



Q51.

Solution

Concept: Proteins destined for secretion, incorporation into the plasma membrane, or localization within lysosomes must be targeted to the rough endoplasmic reticulum (RER) during translation. This targeting process relies on specific signal sequences and cytosolic recognition machinery.

Solution:

Let's trace the molecular steps of co-translational targeting:

- (a) As a secretory protein is translated by a cytosolic ribosome, its N-terminus emerges first, carrying a short, hydrophobic amino acid sequence known as the signal peptide.
- (b) This hydrophobic sequence is recognized and bound by the ****Signal Recognition Particle (SRP)****, a specialized cytosolic ribonucleoprotein complex containing a 7SL RNA core and six protein subunits.
- (c) Upon binding the signal peptide, the SRP alters its conformation to temporarily halt translation. The SRP-ribosome complex then migrates to the RER membrane, where the SRP binds to its matching membrane receptor, delivering the ribosome to the Sec61 translocon pore to resume translation directly into the RER lumen.

Final Answer: Signal Recognition Particle (SRP)

Answer: (A)

[Go Back to Question 51](#)



Q52.

Solution

Concept: Lindeman's ten percent law of trophic efficiency states that during the transfer of organic energy from one trophic level to the next higher level within an ecosystem, only a small fraction of the fixed energy is incorporated into net biomass. The remaining energy is lost as metabolic heat during respiration, excretion, or through unconsumed organic matter.

Solution:

Let's calculate the step-by-step energy transfer across the marine trophic levels:

(a) According to Lindeman's law, the efficiency of energy transfer between sequential trophic levels is approximately 10%.

(b) **Trophic Level 1 (Primary Producers - Phytoplankton):** The net primary productivity is given as:

$$T1 = 10,000 \text{ kcal/m}^2/\text{year}$$

(c) **Trophic Level 2 (Primary Consumers - Zooplankton):** Ingest and assimilate 10% of the primary producer energy:

$$T2 = 10,000 \times 0.10 = 1,000 \text{ kcal/m}^2/\text{year}$$

(d) **Trophic Level 3 (Secondary Consumers - Small Fish):** Ingest and assimilate 10% of the primary consumer energy:

$$T3 = 1,000 \times 0.10 = 100 \text{ kcal/m}^2/\text{year}$$

(e) **Trophic Level 4 (Tertiary Consumers - Apex Predators):** Ingest and assimilate 10% of the secondary consumer energy:

$$T4 = 100 \times 0.10 = 1 \text{ kcal/m}^2/\text{year}$$

Final Answer:

Answer: (D)

[Go Back to Question 52](#)



Q53.

Solution

Concept: Ecosystem populations exhibit characteristic growth curves that reflect the availability of local resources and the presence of density-dependent limiting factors.

Solution:

Let's analyze the mathematical characteristics of the pheasant population growth curve:

- (a) A population tracking model that begins with a rapid, exponential increase in numbers when resources are abundant, but slows down and levels off into a stable plateau as resources become limited, generates a characteristic S-shaped curve.
- (b) This mathematical growth trajectory is defined as **logistic growth**.
- (c) The upper growth plateau reflects the **environmental carrying capacity (K)**, which is the maximum population size an environment can sustainably support based on limiting factors like food availability, nesting space, and predation pressure.

Final Answer: Logistic growth; environmental carrying capacity (K)

Answer: (B)

[Go Back to Question 53](#)

Q54.

Solution

Concept: Deep aquatic ecosystems (such as temperate lakes) undergo seasonal thermal stratification due to differences in water density at different temperatures, creating distinct, horizontal water layers during the summer months.

Solution:

Let's identify the stratified layers from the top surface to the bottom:

- (a) **Epilimnion (or Mixolimnion):** The upper, warm, low-density water layer that is continuously mixed by wind and exposed to solar radiation.
- (b) **Hypolimnion:** The deep, cold, high-density water layer that remains isolated from surface interactions, maintaining low oxygen levels and cold temperatures.
- (c) **Thermocline (or Mesolimnion):** The distinct, intermediate boundary layer situated between the epilimnion and hypolimnion. This layer is characterized by a rapid, sharp vertical temperature drop with increasing depth, acting as a thermal barrier that prevents mixing between the surface and deep water layers during the summer.

Final Answer: Thermocline (Mesolimnion)

Answer: (B)

[Go Back to Question 54](#)



Q55.

Solution

Concept: Ecological pyramids are graphical models that illustrate the structural relationships across sequential trophic levels (T1, T2, T3) within an ecosystem. They can depict total biomass, energy transfer, or individual organism counts (pyramids of numbers).

Solution:

Let's analyze the geometric shape of the pyramid of numbers in an oak forest:

- (a) **Trophic Level 1 (Primary Producers):** Composed of a single, massive oak tree. Because this is a count of individuals, the base of the pyramid is extremely narrow (1 single producer organism).
- (b) **Trophic Level 2 (Primary Consumers):** This single tree supports thousands of herbivorous insects, creating an exceptionally wide middle tier.
- (c) **Trophic Level 3 (Secondary Consumers):** Composed of carnivorous birds or hyper-parasites that prey on the insects. Their individual numbers are lower than the insect population, narrowing the top tier.
- (d) This specific geometric profile—narrow at the base, very broad in the middle, and tapering again at the apex—is classified as a ****spindle-shaped pyramid****.

Final Answer: Spindle-shaped Pyramid

Answer: (C)

[Go Back to Question 55](#)



Q56.

Solution

Concept: Chemical pollution can cause severe ecological damage when persistent toxins enter a food web, accumulating within organisms and increasing in concentration at higher trophic levels.

Solution:

Let's isolate the ecological principle and chemical culprit behind Minamata disease:

- (a) Minamata disease was caused by the industrial discharge of wastewater containing high levels of mercury compounds into Minamata Bay, Japan.
- (b) In the aquatic sediments, anaerobic bacteria converted this inorganic mercury into a highly lipophilic organic form: **methylmercury**.
- (c) This methylmercury was rapidly absorbed by phytoplankton and passed up the aquatic food chain. Because consumers break down organic compounds faster than they can excrete this lipophilic toxin, its concentration increased at each sequential trophic level. This process is known as **biomagnification**, and it led to toxic concentrations in predatory fish and humans.

Final Answer: Biomagnification; Methylmercury

Answer: (B)

[Go Back to Question 56](#)



Q57.

Solution

Concept: The MacArthur-Wilson Island Biogeography model predicts the equilibrium species richness (S^*) of an isolated habitat island based on a dynamic balance between two competing factors: the rate of new species immigration (I) and the rate of established species extinction (E).

Solution:

Let's evaluate how island size and distance from the mainland modulate immigration and extinction rates:

- (a) **Distance Factor (Immigration):** Islands situated close to a source mainland experience significantly higher species immigration rates (I) because dispersing organisms can cross the short geographic barrier more easily. Farther islands have lower immigration rates.
- (b) **Size Factor (Extinction):** Large islands provide a greater area with more diverse ecological niches and larger resource pools. This allows for larger individual population sizes, which reduces the risk of accidental extinctions and lowers the overall extinction rate (E). Small islands have higher extinction rates.
- (c) Therefore, a **large island close to the mainland** combines a high immigration rate with a low extinction rate, resulting in the highest theoretical equilibrium species richness at steady state.

Final Answer:

Answer: (D)

[Go Back to Question 57](#)



Q58.

Solution

Concept: The competitive exclusion principle states that two distinct species competing for the exact same limiting resource cannot coexist stably if their ecological niches overlap completely. To survive in sympatry, competing species often undergo evolutionary adaptations to partition resources.

Solution:

Let's isolate the evolutionary and ecological process described:

- (a) When the two finch species live sympatrically on the same island, intense competition for food drives natural selection to favor individuals that exploit different resources.
- (b) Over generations, directional selection drives a divergence in their physical traits, such as beak size, allowing them to specialize in different seed sizes. This divergence minimizes competitive overlap, an evolutionary shift known as **character displacement**. When these same species live apart in allopatric populations, their beak sizes remain similar because they are not under pressure to partition resources.

Final Answer:

Answer: (B)

[Go Back to Question 58](#)



Q59.

Solution

Concept: Eutrophication is an ecological syndrome that occurs when an aquatic ecosystem becomes overloaded with artificial or natural nutrients, triggering a cascade of biological changes that can collapse local food webs.

Solution:

Let's trace the chronological steps of this ecological collapse:

- (a) **Nutrient Influx:** High levels of nitrates and orthophosphates from agricultural runoff enter the wetland, triggering rapid growth of primary producers, known as an **algal bloom**.
- (b) **Light and Space Limitation:** The dense layer of algae blocks sunlight from reaching submerged aquatic plants, causing them to die. As nutrients are exhausted, the massive algal population dies off as well (**algal senescence**).
- (c) **Decomposition Spike:** Aerobic heterotrophic bacteria proliferate rapidly to decompose this large amount of dead organic matter. This bacterial bloom creates a sharp spike in the **Biochemical Oxygen Demand (BOD)**.
- (d) **Anoxia and Mortality:** These decomposers consume dissolved oxygen (DO) faster than it can dissolve into the water from the atmosphere, plunging the ecosystem into severe **hypoxia**. Deprived of oxygen, fish and other aquatic organisms suffocate, leading to a large-scale fish kill.

Final Answer:

Algal bloom → Algal senescence → Bacterial decomposition bloom → Biochemical Oxygen Demand (BOD) spike → Hypoxia → Fish death

Answer: (B)[Go Back to Question 59](#)

Q60.

Solution

Concept: The stratospheric ozone layer (O₃) protects life on Earth by absorbing harmful ultraviolet (UV) radiation. This protective layer can be broken down by synthetic chemical pollutants, such as chlorofluorocarbons (CFCs), through free radical catalytic cycles.

Solution:

Let's trace the chemical steps of ozone destruction shown in the diagram:

- CFC molecules like dichlorodifluoromethane (CF₂Cl₂) drift up into the stratosphere, where they are exposed to high-energy solar UV light.
- This UV radiation breaks a carbon-chlorine bond, releasing a highly reactive **free Chlorine atom (Cl[•])**, which acts as **Radical X**.
- This free chlorine radical attacks an ozone molecule, stripping away an oxygen atom to form chlorine monoxide (ClO) and an oxygen molecule (O₂):



The ClO molecule then reacts with free oxygen atoms to regenerate the chlorine radical, allowing a single chlorine atom to catalyze the destruction of thousands of ozone molecules.

Final Answer: Free Chlorine atom (Cl[•])

Answer: (B)

[Go Back to Question 60](#)

Q61.

Solution

Concept: The kingdom Protista includes a highly diverse array of unicellular eukaryotic microorganisms. These protists are classified into distinct taxonomic phyla based on cell wall composition, locomotor organelles, and photosynthetic storage products.

Solution:

Let's evaluate the diagnostic features of the isolated organism:

- Cell Wall Structure:** The presence of a rigid, glass-like cell wall composed of silica (SiO₂) nested into two overlapping halves (valves) is a defining feature of **Diatoms**.
- Locomotion and Storage:** Diatoms lack flagella except during specialized male gametic stages, and they store surplus photosynthetic carbon as the carbohydrate polymer **chrysolaminarin** (along with lipids). This set of characteristics places them within the phylum **Chrysophyta** (specifically the class Bacillariophyceae).

Final Answer: Chrysophyta (Diatoms)

Answer: (B)

[Go Back to Question 61](#)



Q62.

Solution

Concept: Angiosperm taxonomy relies on identifying unique floral and inflorescence modifications to distinguish and classify plants into their respective families.

Solution:

Let's analyze the characteristics of the specified inflorescence modification:

- (a) A **cyathium** is a highly specialized, condensed inflorescence that superficially resembles a single flower. It consists of a cup-like involucre formed by fused protective bracts, often lined with nectar glands.
- (b) Inside this cup sits a single reduced female flower (consisting of a lone pistil on a long stalk) surrounded by multiple male flowers, each reduced to a single stamen.
- (c) This unique cyathium inflorescence is a diagnostic evolutionary feature of the genus *Euphorbia*, placing this weed within the family *Euphorbiaceae*.

Final Answer:

Answer: (C)

[Go Back to Question 62](#)

Q63.

Solution

Concept: Invertebrate taxa are grouped into distinct phyla based on basic body plans, including embryonic tissue layers, body symmetry, the presence and type of coelom (body cavity), and developmental processes like ecdysis.

Solution:

Let's evaluate the anatomical features of the marine specimen:

- (a) **Symmetry and Gut:** True bilateral symmetry and a complete digestive tract (with a separate mouth and anus) are shared by most advanced triploblastic phyla.
- (b) **Body Cavity:** A pseudocoelomate profile indicates a body cavity that is not completely lined by mesoderm-derived tissue.
- (c) **Cuticle and Ecdysis:** The presence of a tough, non-cellular outer cuticle layer that must be periodically shed or molted (**ecdysis**) to allow growth places this organism within the superphylum Ecdysozoa. The combination of a pseudocoelom, a complete gut, and a molting cuticle is a defining feature of the phylum *Nematoda* (roundworms).

Final Answer:

Answer: (B)

[Go Back to Question 63](#)



Q64.

Solution

Concept: Robert Whittaker's Five-Kingdom system classifies living organisms into Monera, Protista, Fungi, Plantae, and Animalia based on cellular structure (prokaryotic vs. eukaryotic), body organization, and primary mode of nutrition.

Solution:

Let's evaluate the defining biological characteristics of Kingdom Fungi:

- (a) **Cellular Structure:** Fungi are true **eukaryotic** organisms containing membrane-bound nuclei and complex organelles, ruling out prokaryotic groups like Monera.
- (b) **Mode of Nutrition:** Fungi lack chlorophyll and cannot perform photosynthesis, ruling out Plantae. Instead, they are heterotrophs that secure energy via an **absorptive heterotrophic** strategy: they secrete extracellular digestive enzymes into their surroundings to break down organic matter, then absorb the liquefied nutrients through their cell walls.
- (c) **Cell Wall Composition:** Unlike plant cell walls made of cellulose, fungal cell walls are reinforced with **chitin**, a tough polymer of N-acetylglucosamine.

Final Answer: Eukaryotic, absorptive heterotrophic, chitinous cell wall

Answer: (C)

[Go Back to Question 64](#)

Q65.

Solution

Concept: Floral diagrams are graphical models that illustrate the structural layout, symmetry, and arrangement of floral organs within a specific plant family. They map the calyx (sepals), corolla (petals), androecium (stamens), and gynoecium (carpels) from the outside in.

Solution:

Let's analyze the androecium arrangement shown in the Brassicaceae floral diagram:

- (a) The diagram depicts a central bicarpellary syncarpous gynoecium, G(2), surrounded by the stamens of the androecium, labeled as Component Z.
- (b) Looking at Component Z, there are 6 stamens in total, arranged in two distinct whorls. The outer whorl contains 2 short stamens, while the inner whorl contains 4 long stamens.
- (c) This specific 2 + 4 setup is a diagnostic feature of the Brassicaceae (mustard) family, known as a **tetradynamous** stamen configuration.

Final Answer: Tetradynamous stamens (2+4 setup)

Answer: (B)

[Go Back to Question 65](#)



Q66.

Solution

Concept: The phylum Platyhelminthes (flatworms) includes triploblastic, acoelomate invertebrates with flattened bodies. This phylum is divided into multiple distinct classes based on lifestyle (free-living vs. parasitic) and structural adaptations.

Solution:

Let's evaluate the anatomical features of the parasitic fluke:

- (a) The specimen is an endoparasite with an unsegmented body and a incomplete, branched gastrovascular cavity that lacks an anus. This rules out Cestoda (tapeworms), which have segmented bodies (proglottids) and lack a digestive tract entirely.
- (b) The presence of specialized **flame cells** (protonephridia) is a shared excretory feature across flatworms.
- (c) Parasitic flatworms that infect internal organs (like the liver and bile ducts of livestock) and possess specialized suckers for attachment belong to the class **Trematoda** (commonly referred to as flukes).

Final Answer: Trematoda

Answer: (B)

[Go Back to Question 66](#)



Q67.

Solution

Concept: Angiosperm taxonomy uses key vegetative and floral characteristics to distinguish between dicotyledonous families (such as Solanaceae) and monocotyledonous families (such as Liliaceae).

Solution:

Let's compare the diagnostic morphological criteria of both families:

- (a) **Solanaceae (Dicot Family):** Characterized by ****pentamerous flowers**** (parts arranged in multiples of five) with an actinomorphic symmetry, a corolla of fused petals, and a ****superior ovary**** with swollen axile placentation. Their leaves are typically exstipulate.
- (b) **Liliaceae (Monocot Family):** Characterized by ****trimerous flowers**** (parts arranged in multiples of three). Instead of distinct sepals and petals, they possess a undifferentiated ****perianth**** composed of six tepals arranged in two whorls of three, along with a superior ovary.
- (c) Comparing these options, flower merosity (pentamerous vs. trimerous) and the presence of a perianth structure are reliable criteria for distinguishing Solanaceae from Liliaceae.

Final Answer:

Pentamerous flowers and superior ovary vs Trimerous flowers and perianth structures

Answer: (A)[Go Back to Question 67](#)

Q68.

Solution

Concept: The phylum Chordata is defined by four core anatomical features that appear at some stage of development: a dorsal hollow nerve cord, a notochord, pharyngeal gill slits, and a post-anal tail. This phylum is divided into three subphyla: Urochordata, Cephalochordata, and Vertebrata.

Solution:

Let's isolate the evolutionary adaptation unique to the subphylum Vertebrata:

- (a) All three subphyla share the basic chordate hallmarks during their embryonic or larval stages. For example, Urochordates possess a notochord only in their free-swimming larval tail, while Cephalochordates retain a prominent notochord throughout adulthood.
- (b) The major evolutionary innovation that separates Vertebrata from these primitive non-vertebrate chordates is that the flexible, embryonic notochord is systematically replaced during development by a segmented, ****cartilaginous or bony vertebral column**** (backbone). This structure provides an internalized skeleton that supports a larger body plan and protects the dorsal nerve cord.

Final Answer:

Replacement of the embryonic notochord by a cartilaginous or bony vertebral column

Answer: (B)[Go Back to Question 68](#)

Q69.

Solution

Concept: Angiosperm reproduction relies on megagametogenesis inside the ovule to transform a functional megaspore into a mature female gametophyte (embryo sac) capable of undergoing double fertilization.

Solution:

Let's trace the nuclear divisions that form a standard Polygonum-type embryo sac:

- (a) A single functional chalazal megaspore undergoes three sequential rounds of free nuclear mitotic divisions (karyokinesis) without immediate cell wall formation. This process yields an intermediate structure containing $2^3 = 8$ haploid nuclei.
- (b) These 8 nuclei then organize themselves spatially within the sac: three move to the chalazal end, three move to the micropylar end, and two remain in the center.
- (c) **Cell Wall Formation (Cytokinesis):** Cell walls form around six of these nuclei. The three nuclei at the chalazal end become individual antipodal cells. At the micropylar end, two nuclei form flanking synergid cells and one forms the functional egg cell (the egg apparatus). The remaining two central nuclei, known as polar nuclei, stay together within the large single **central cell**.
- (d) Counting the individual compartments reveals that the mature embryo sac contains 7 distinct cells (3 antipodals + 2 synergids + 1 egg + 1 central cell) housing a total of 8 separate nuclei, making it a **7-celled, 8-nucleate** structure before fertilization.

Final Answer: 7-celled, 8-nucleate

Answer: (B)

[Go Back to Question 69](#)



Q70.

Solution

Concept: Implantation marks the definitive structural attachment of a mammalian embryo to the maternal uterine wall. Before this adhesion can happen, the free-floating blastocyst must break out of its dense protective outer shell in a process known as hatching.

Solution:

Let's trace the cellular coatings surrounding the early embryo:

- (a) During ovulation, the secondary oocyte is released surrounded by an outer layer of granulosa cells called the corona radiata and an inner translucent glycoprotein matrix.
- (b) This inner acellular matrix is the **zona pellucida**. It acts as a critical species-specific barrier during fertilization and physically prevents the sticky dividing blastomeres from implanting prematurely in the fallopian tube walls during early cleavage divisions.
- (c) Around day 5 to 6 post-fertilization, as the blastocyst reaches the uterine cavity and expands, it secretes specialized proteolytic enzymes (such as trypsins) that degrade this shell. The embryo then emerges through a breach in the **zona pellucida** (hatching), exposing its outer layer of trophoblast cells so they can bind directly to the receptive maternal uterine endometrium.

Final Answer:

Answer: (B)

[Go Back to Question 70](#)



Q71.

Solution

Concept: Microsporogenesis occurs within the four pollen sacs (microsporangia) of a fertile plant anther. The developing microspore mother cells (MMC) are enclosed by a specialized, four-layered protective and nourishing cell wall.

Solution:

Let's analyze the layered anatomy of the anther wall from the outermost boundary inward:

- (a) **Epidermis (Exothecium):** The single outermost protective structural layer.
- (b) **Endothecium:** A fibrous sub-epidermal layer that develops cell wall thickenings to help the anther split open (dehisce) at maturity.
- (c) **Middle Layers:** One to three transient cellular sheets that generally collapse during early microspore development.
- (d) **Layer T (Tapetum):** The innermost specialized layer immediately surrounding the sporogenous tissue. The cells of the **tapetum** are rich in cytoplasm and often multinucleate, acting as a crucial nurse tissue. They synthesize key lipids, proteins, and precursors for **sporopollenin** (the incredibly durable polymer that forms the outer exine wall of pollen grains). Once microspore development is complete, the tapetum undergoes programmed cell death to release its contents into the anther cavity.

Final Answer: Tapetum

Answer: (C)

[Go Back to Question 71](#)



Q72.

Solution

Concept: The human ovarian cycle is regulated by coordinated hormonal feedback loops between the hypothalamus, the anterior pituitary gland, and the ovaries. This pathway controls both follicle maturation and the release of the female gamete.

Solution:

Let's trace the hormonal triggers that drive ovulation:

- (a) During the follicular phase, developing ovarian follicles secrete rising amounts of estradiol. When these estrogen levels cross a sustained high threshold near the midpoint of the cycle, they trigger a shift from negative feedback to positive feedback on the anterior pituitary gland.
- (b) This positive feedback loop causes a rapid, sharp release of **Luteinizing Hormone (LH)**, creating a mid-cycle hormonal spike known as the LH surge.
- (c) This **Luteinizing Hormone (LH)** surge activates proteolytic enzymes (like collagenases and plasminogen activators) that degrade the structural matrix of the preovulatory follicle wall. This degradation causes the follicle to rupture and release the secondary oocyte—which is stably arrested in Metaphase II of meiosis—into the fallopian tube.

Final Answer: Luteinizing Hormone (LH)

Answer: (B)

[Go Back to Question 72](#)



Q73.

Solution

Concept: Angiosperms undergo double fertilization, a specialized reproductive mechanism where two male gametes (sperm cells) enter the female embryo sac to fuse with separate maternal target cells.

Solution:

Let's calculate the ploidy levels and chromosome counts based on the somatic numbers given:

- (a) The corn plant has a somatic chromosome count of $2n = 20$. This means its haploid gametic chromosome count is:

$$n = \frac{20}{2} = 10$$

- (b) **Embryo Formation:** One haploid male gamete ($n = 10$) fertilizes a haploid female egg cell ($n = 10$) to form a diploid zygote ($2n$). This zygote develops into the embryo, maintaining a chromosome count of:

$$2n = 20$$

- (c) **Primary Endosperm Nucleus (PEN) Formation:** The second haploid male gamete ($n = 10$) migrates to the center of the embryo sac and fuses with the diploid central cell, which contains two fused polar nuclei ($2n = 20$). This triple fusion event creates a ****triploid**** ($3n$) primary endosperm nucleus. Its final chromosome count is calculated as:

$$3n = 3 \times 10 = 30$$

Final Answer:

Answer: (B)

[Go Back to Question 73](#)



Q74.

Solution

Concept: Hormonal contraceptives use synthetic analogs of ovarian steroids to alter the endocrine feedback loops of the hypothalamic-pituitary-gonadal (HPG) axis, blocking the physiological signals required for conception.

Solution:

Let's analyze the cellular and systemic mechanisms of continuous progestin action:

- (a) Injectable contraceptives provide a steady, continuous release of a synthetic progestin compound into the bloodstream.
- (b) This continuous level acts on the hypothalamus and anterior pituitary gland via a ****negative feedback loop****. It suppresses the pulse-like release of Gonadotropin-Releasing Hormone (GnRH), which in turn suppresses the secretion of Follicle-Stimulating Hormone (FSH) and Luteinizing Hormone (LH).
- (c) Without the necessary rising levels of FSH, ovarian follicles fail to mature properly, and the absence of a mid-cycle LH surge prevents ovulation entirely. Therefore, ****suppressing ovulation via negative feedback**** serves as the primary mechanism for preventing pregnancy, supported by secondary effects like thickening the cervical mucus to block sperm penetration.

Final Answer: Suppressing ovulation via negative feedback on the hypothalamus-pituitary axis

Answer: (B)

[Go Back to Question 74](#)



Q75.

Solution

Concept: Spermatogenesis is the highly coordinated sequence of meiotic divisions and morphological transformations that occurs within the seminiferous tubules of the testes, turning diploid germ cells into mature haploid male gametes.

Solution:

Let's trace the cell divisions starting from a single primary spermatocyte:

- (a) A diploid spermatogonium undergoes mitotic duplication and differentiation to form a large, diploid **primary spermatocyte** ($2n$).
- (b) This single primary spermatocyte undergoes **Meiosis I** (the reductional division), dividing into two equal, haploid secondary spermatocytes (n).
- (c) Both secondary spermatocytes immediately enter **Meiosis II** (the equational division). Each divides to yield two haploid spermatids, producing a total of four structural spermatids (n) from the original cell.
- (d) These four non-motile spermatids then go through a differentiation process called spermiogenesis, shedding excess cytoplasm and developing flagella. This process transforms them into **four functional, mature spermatozoa** without any loss of cells, unlike the asymmetrical divisions of oogenesis which produce polar bodies.

Final Answer: Four functional spermatozoa

Answer: (C)

[Go Back to Question 75](#)



Q76.

Solution

Concept: Blue-white screening is a molecular technique used to quickly identify successful bacterial transformation and recombinant gene cloning. It relies on the biochemical principle of α -complementation within the reporter enzyme β -galactosidase.

Solution:

Let's evaluate the screening outcomes based on the layout of the plasmid vector:

- (a) The plasmid vector carries an ampicillin resistance marker (Amp^R) and a functional *lacZ* gene segment containing a multiple cloning site (MCS).
- (b) **Non-Recombinant Plasmids (Unsuccessful Insertion):** If the plasmid recircularizes without taking up the target gene, the *lacZ* reporter gene remains intact. When grown on an agar plate containing X-gal, the expressed β -galactosidase enzyme hydrolyzes the X-gal substrate, forming an insoluble indigo dye that turns these colonies intense blue.
- (c) **Recombinant Plasmids (Successful Insertion):** When the target foreign gene is successfully ligated into the multiple cloning site, it physically disrupts the reading frame of the *lacZ* sequence, a process called insertional inactivation. Because the cells can no longer produce functional β -galactosidase, they cannot cleave X-gal, causing the recombinant colonies to remain **white**. The ampicillin resistance gene stays intact, ensuring these white colonies grow successfully in the presence of the antibiotic.

Final Answer: White colonies with successful growth

Answer: (B)

[Go Back to Question 76](#)



Q77.

Solution

Concept: The Polymerase Chain Reaction (PCR) is an *in vitro* enzymatic technique used to amplify specific target DNA sequences through repeated thermal cycles. A standard cycle consists of three distinct, temperature-dependent kinetic phases.

Solution:

Let's analyze the thermal parameters of a standard PCR cycle:

- (a) **Denaturation Phase (approx. 94°C – 95°C):** High temperatures break the hydrogen bonds between complementary base pairs, separating double-stranded DNA into single-stranded templates.
- (b) **Annealing Phase (approx. 55°C – 60°C):** The temperature is lowered to allow synthetic oligonucleotide primers to find and bind to their complementary sequences on the single-stranded target DNA.
- (c) **Extension Phase (approx. 72°C):** The temperature is raised slightly to the optimal working range of a thermostable DNA polymerase (like *Taq*), which extends the primers by adding complementary dNTPs.
- (d) ****Impact of the Error:**** If the system is misprogrammed to run at 85°C during the 55°C – 60°C window, the thermal kinetic energy remains too high for hydrogen bonds to form between the primers and the template strands. This high temperature completely prevents the ****primer annealing phase****, causing the amplification run to fail.

Final Answer:

Answer: (B)

[Go Back to Question 77](#)



Q78.

Solution

Concept: Southern blotting is a classic molecular laboratory method used to detect the presence, size, and abundance of specific DNA sequences within a complex genomic sample.

Solution:

Let's evaluate the sequential steps of the Southern blotting workflow:

- (a) **Separation:** DNA fragments are first separated by size using agarose gel electrophoresis.
- (b) **Phase P (Transfer):** Because agarose gels are fragile and the DNA molecules can easily diffuse out, the separated bands must be moved onto a durable, solid support for analysis. The gel is placed into a transfer setup, where a buffer reservoir uses capillary action to draw liquid upward through the gel and a **nitrocellulose or nylon membrane**, into a stack of dry paper towels. This upward fluid flow carries the DNA fragments out of the gel matrix and binds them firmly onto the membrane in the exact same pattern. This phase is known as the **capillary transfer (blotting) step**.
- (c) **Hybridization and Detection:** The membrane is then incubated with a labeled single-stranded probe and visualized using autoradiography.

Final Answer: Capillary Transfer (Blotting) step

Answer: (B)

[Go Back to Question 78](#)



Q79.

Solution

Concept: Transgenic Bt crops are engineered to express insecticidal crystal (Cry) proteins derived from the soil bacterium *Bacillus thuringiensis*. These proteins protect the plant by selectively targeting specific insect pests while remaining safe for other organisms.

Solution:

Let's analyze the biochemical activation mechanism of the Bt toxin:

- (a) The *Bacillus thuringiensis* bacterium synthesizes these proteins as inactive, crystalline protoxins. Because the toxin is synthesized in this inactive state, it is entirely harmless to the host bacterium itself.
- (b) When an insect larva (such as a lepidopteran caterpillar) eats the transgenic plant tissue, it ingests these crystalline protoxins. The midgut of these specific target larvae maintains a highly **alkaline pH environment** ($\text{pH} > 9.0$).
- (c) This highly alkaline environment dissolves the protein crystals. Specialized alkaline-stable proteases within the insect gut then enzymatically clip the protoxin, turning it into an active, functional toxin. This active form binds to specific cadherin-like receptors on the midgut epithelial cells, creating pores that cause osmotic lysis and kill the insect. Humans and other mammals are unaffected because their digestive tracts are highly acidic, which denatures the protein rather than activating it, and they lack the matching surface receptors.

Final Answer:

It requires an alkaline pH environment to be proteolytically cleaved into its active toxin form within the insect gut

Answer: (B)

[Go Back to Question 79](#)



Q80.

Solution

Concept: Transgenic molecular pharming involves engineering animals to synthesize valuable human therapeutic proteins within specific tissues. This strategy relies on reusing existing cellular pathways to simplify protein purification and ensure proper post-translational modifications.

Solution:

Let's evaluate the promoter control configurations for tissue-specific expression:

- (a) A promoter is a regulatory region of DNA that determines where, when, and how efficiently a downstream gene is transcribed into RNA by a cell's transcription machinery.
- (b) If a cloned human cDNA sequence is placed under the control of a strong, non-specific promoter (like the cytomegalovirus CMV promoter), the protein will be expressed ubiquitously across all tissues, which can cause systemic toxicity in the animal.
- (c) To direct expression specifically into milk for easy, non-invasive harvesting, the gene must be linked to a promoter that is active only in the mammary glands during lactation. Linking the target sequence to the **tissue-specific mammary gland β -casein promoter** ensures that the therapeutic protein is synthesized and secreted exclusively into the animal's milk.

Final Answer: Tissue-specific mammary gland β -casein promoter

Answer: (B)

[Go Back to Question 80](#)



Answer Key

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

