UPCATET Agriculture Botany Sample Paper-7

Duration: 20 Minutes **Maximum Marks: 100**

Instructions

- This paper contains **25** 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 a high-resolution microscopic investigation of a multi-layered anomalous anomalous secondary growth specimen in an advanced xerophytic woody liana, an investigator observes a persistent, bidirectional concentric vascular cambium ring. If the primary anomalous activity produces interxylary phloem nests embedded completely within secondary xylem, identify the precise structural mechanism preventing the mechanical collapse of these deep-seated soft phloem tissues under extreme administrative hydrostatic wood pressures:

(A) Lignification of the surrounding tangential paratracheal parenchyma cells forming a rigid protective sclerotic sheath.

(B) Continuous active suberization of the radial ray initial cell derivatives bordering the phloem nests.

(C) Development of localized inner tylosoids derived from neighboring unlignified libriform fibers.

(D) Programmed mechanical compression offset by high turgor pressure sustained exclusively through active companion cell proton pumps.

Q2. A plant morphologist analyzes the modified structural configurations of an unknown sub-tropical forage legume. The specimen reveals a specialized aerial, multi-nodal horizontally crawling axis where every alternative node produces a modified photosynthetic laminar expansion that is morphologically a modified stipule, while the true leaf blade is completely reduced to a decompound tendril. Identify the correct anatomical classification of this architecture:

(A) Phyllode architecture with compensating adventitious cauline nodal meristems.

(B) Stipular phylloclade configuration optimizing atmospheric moisture interception.

(C) Metamorphosed runner axis exhibiting specialized pseudolamina stipular dominance.

(D) Cladode specialization exhibiting absolute suppression of the terminal bud.

Q3. A pollination biologist evaluates the mechanical acoustics of a wild Solanaceae accession adapted for buzz pollination (sonication). The floral design reveals an asymmetric connivent anther cone where individual anthers are not fused but are held rigidly in a tight cylindrical column exclusively via specialized interlocking, microscopic marginal epidermal hairs (trichomes). When a female bumblebee (*Bombus* sp.) lands and vibrates her thoracic muscles at a specific resonant frequency (240 Hz), it induces immediate fluidization of the dry, powdery pollen mass inside the thecae. Identify the structural configuration and exit mechanism responsible for the directional "explosive" projection of pollen grains onto the bee's ventral abdomen:

(A) Longitudinal sutural splitting triggered by an immediate drop in filament turgor pressure.

(B) Apical poricidal dehiscence combined with a restrictive internal structural valve that opens only under critical vibrational acceleration.

(C) Basal valvular explosive dehiscence driven by the rapid desiccation of the endothecial cell layer walls.

(D) Circumscissile operculum shedding mediated by mechanical resonance breaking the middle lamella line.

Q4. A comparative histological examination of the root-stem transition zone (hypocotyledonary region) in a dicotyledonous crop seed reveals a complex shifting pattern of vascular strands. If the root exhibits an exarch, radial actinostelic arrangement with 8 protoxylem poles, while the epicotyl transitions into an endarch, collateral eustele, what precise developmental re-orientation occurs to the xylem vectors within this localized anatomical domain?

(A) Absolute disintegration of primary exarch components followed by de novo differentiation of secondary bundles.

(B) Inversion and 180° longitudinal rotation of individual metaxylem tracheary elements accompanied by radial splitting.

(C) Bifurcation of protoxylem strands along the tangential plane followed by outward radial migration and internal inversion.

(D) Lateral migration, branching, and a 180° chordal twisting of the protoxylem elements relative to the position of metaxylem.

Q5. The structural configuration of the grass spikelet inflorescence contains highly modified bracts and bracteoles. During anthesis, the rapid swelling of specific hyaline, vascularized/non-vascularized scale-like structures located at the base of the floret forces the overlapping lemma and palea apart to expose the reproductive organs. Evaluate the anatomical identity of these structural cushions:

(A) Glumes acting as turgor-sensitive hydrostatic hinge lines.

(B) Lodicules executing continuous localized endosmosis driven by rapid potassium ion accumulation.

(C) Prophylls performing parenchymatous expansion via direct mechanical pressure of the elongating rachilla.

(D) Trichomes localized at the pulvinus executing rapid losing of cell wall microfibrils.

Q6. An agricultural anatomist extracts the mechanical tissue of a wind-exposed hydrophytic emergent crop plant. The cross-section reveals a specialized mechanical tissue type that shows selective asymmetric primary non-lignified cell wall thickenings restricted entirely to the tangential walls while leaving the radial walls extremely thin, containing high pectin content along with functional chloroplasts. Classify this tissue precisely:

(A) Angular collenchyma optimizing multidirectional torsional shear stress resistance.

(B) Lamellar (plate) collenchyma offering structural elasticity and photosynthetic capacity.

(C) Lacunate collenchyma specialized for maximizing internal gas diffusion channels.

(D) Brachysclereid networks undergoing secondary unlignified wall reinforcement phases.

Q7. The root anatomy of certain deep-water marshland monocot crops exhibits a specialized developmental shift in the cortex where organized files of parenchymatous cells undergo lysigenous programmed cell death. What is the precise regulatory triggering factor and anatomical consequence of this structural modification?

(A) High carbon dioxide toxicity causing physical dissolution of middle lamella via pectinase activation.

(B) Ethylene accumulation under hypoxic stress inducing targeted cellulolytic breakdown resulting in cortical aerenchyma.

(C) Abscisic acid surge inducing mechanical collapse of the exodermis to promote exosmosis.

(D) Auxin depletion causing cellular atrophy within the pericycle layer resulting in cortical lacunae.

Q8. The foliar morphology of certain highly adapted drought-resistant cereal crops shows specialized longitudinal bands of enlarged, hygroscopic, wedge-shaped epidermal cells positioned within the intercostal regions of the adaxial epidermis. Under acute atmospheric vapor pressure deficit, these cells undergo rapid changes to alter leaf architecture. Identify the mechanism and the ultimate physical transformation:

(A) Guard cells losing turgor, causing the leaf blade to expand flat to maximize heat dissipation.

(B) Bulliform cells undergoing rapid turgor loss, inducing upward inward rolling of the leaf blade to minimize transpirational surface area.

(C) Subsidiary cells absorbing water rapidly, inducing mechanical twisting of the petiole vector.

(D) Trichomes collapsing inward, triggering the complete shedding of the distal half of the laminar sheet.

Q9. A systematist performs an analytical evaluation of the floral morphology of a high-value industrial crop species belonging to the family Fabaceae (Subfamily: Papilionoideae). The floral formula shows a characteristic diadelphous condition. However, a wild mutant accession displays an anomalous $A_{(5)+(4)+1}$ configuration instead of the standard $A_{(9)+1}$. What is the exact taxonomic impact and morphological interpretation of this variation?

(A) Shift in family classification toward Mimosoideae due to increased polyadelphous resemblance.

(B) Preservation of the Papilionoideae classification as the structural identity of the vexillary stamen remains independent.

(C) Reclassification into Caesalpinioideae due to the structural modification of the odd stamen.

(D) Transition toward a pseudo-monadelphous state inducing complete regular symmetry (actinomorphy).

Q10. You are analyzing a diagnostic field key for differentiating critical agricultural weeds and crops belonging to the family Solanaceae versus Scrophulariaceae (or Plantaginaceae). Which specific set of combined embryological and morphological criteria provides an absolute distinction between these closely aligned tubiflorous families?

(A) Presence of regular actinomorphic flowers with epipetalous stamens in Scrophulariaceae vs zygomorphic flowers in Solanaceae.

(B) Obliquely placed ovary with swollen axile placentation containing numerous ovules in Solanaceae vs medianly placed ovary in Scrophulariaceae.

(C) Presence of parietal placentation with persistent calyx in Scrophulariaceae vs free central placentation in Solanaceae.

(D) Monothecous anthers with valvar dehiscence in Solanaceae vs dithecous anthers with poricidal dehiscence in Scrophulariaceae.

Q11. The agronomically vital crop family Brassicaceae (Cruciferae) displays a highly specialized and characteristic diagnostic feature within its gynoecium structure. The ovary is originally unilocular but subsequently becomes bilocular due to the development of a structural framework. Identify this structure and its exact developmental origin:

(A) Caruncula, arising as an outgrowth from the micropylar integument surface.

(B) Replum, which is a false septum developing as an ingrowth from the parietal placentae.

(C) Obturator, developing from the local ovarian wall tissue to guide pollen tubes.

(D) Integumentary tapetum, originating from the inner chalazal zone line layers.

Q12. Consider the technical morphological characteristics of the spikelet architecture within the family Poaceae. If a specific feed grain crop exhibits a pair of sterile glumes that completely enclose two sub-tending florets where the lower floret is strictly staminate with a deeply bifid palea, and the upper floret is hermaphrodite with a completely awned lemma, evaluate the tribal grouping classification under which this crop falls:

(A) Tribe Aveneae, characterized by large glumes exceeding the lowest floret with dorsal awns.

(B) Tribe Oryzeae, characterized by six functional stamens and highly compressed multi-glume reduction.

(C) Tribe Triticeae, characterized by sessile spikelets inserted alternately on opposite sides of a continuous rachis.

(D) Tribe Andropogoneae, characterized by paired heterogamous spikelets on an articulate rachis line.

Q13. An industrial oilseed crop belonging to the family Asteraceae (Compositae) is evaluated for its floral development. The inflorescence consists of a dense capitulum wrapped by an involucre of bracts. Microscopic dissection of individual disc florets reveals a unique staminal configuration where the anthers are completely fused longitudinally into a hollow cylinder surrounding the style, while the filaments remain completely free from each other. Identify this specific condition:

(A) Synandrous condition with basal gynostegial attachment lines.

(B) Syngenesious condition facilitating a specialized brush-mechanism for pollen presentation.

(C) Gynandrous condition leading to direct internal auto-pollination vectors.

(D) Monadelphous condition with modified epipetalous tracking networks.

Q14. A breeder works with an essential condiment crop belonging to the family Apiaceae (Umbelliferae). The fruit type is a highly diagnostic schizocarp called a cremocarp. During complete maturity and mechanical processing, this fruit splits cleanly into two single-seeded units which remain suspended dynamically from a central axis. Identify the technical terms for the units and the supporting structure:

(A) Regma units suspended by a derived placental operculum.

(B) Mericarps suspended securely from a bifurcated carpophore axis.

(C) Carcerulus components supported by a persistent gynobasic style stalk.

(D) Lomentum segments attached directly to an extended persistent replum.

Q15. The diagnostic tribal classification of the family Cucurbitaceae utilizes modifications of the tendril system and staminal configurations. If a cultivated gourds variety exhibits a uniquely modified staminal complex where all 5 stamens are completely fused throughout both their filaments and highly contorted, S-shaped anthers into a single central column, classify this precise state:

(A) Synandrium condition typical of advanced Cyclantherae or modified Cucurbiteae tribes.

(B) Syngenesious condition with distinct bithecous separation zones.

(C) Monadelphous column containing straight anthers typical of primitive Fevilleae.

(D) Gynostegium unit mimicking the highly advanced Orchidaceae configurations.

Q16. During a laboratory simulation of photosynthetic electron flow under intense abiotic stress, a researcher treats a C3 cereal crop with an experimental inhibitor that specifically blocks the proton pumping activity of the Cytochrome b_6f complex without directly intercepting light absorption at PSII or PSI. Evaluate the precise immediate stoichiometric consequence of this inhibition on the chloroplast matrix:

(A) Absolute and immediate cessation of cyclic photophosphorylation, while non-cyclic ATP production increases to compensate.

(B) Complete collapse of the transthylakoid proton motive force (Δp), preventing ATP synthesis while linear electron flow to $NADP^+$ briefly continues before being halted by acceptor side limitation.

(C) Instantaneous reversal of the Oxygen Evolving Complex (OEC) operational vector, causing internal consumption of oxygen.

(D) Hyper-acidification of the stroma resulting in the rapid activation of the Calvin-Benson cycle enzymes.

Q17. A physiological study of stomatal dynamics under acute soil moisture deficit examines the operational mechanics of the guard cell plasma membrane. When systemic Abscisic Acid (ABA) binds to its intracellular receptors (PYR/PYL/RCAR), it initiates a signaling cascade that halts the activity of the plasma membrane H^+-ATPase. Identify the subsequent downstream ion channel movements that cause immediate stomatal closure:

(A) Hyperpolarization of the membrane triggering rapid inward-rectifying K^+ channels (KAT1) activation.

(B) Depolarization of the membrane activating outward-rectifying anion channels (SLAC1), leading to efflux of Cl^- and malate, followed by massive sustained K^+ efflux.

(C) Rapid active pumping of Ca^{2+} ions out of the cytosol into the apoplast, causing immediate cell wall relaxation.

(D) Activation of inward H^+/K^+ symporters, rapidly increasing guard cell inner osmotic potential.

Q18. The primary carboxylation enzyme Rubisco exhibits a competitive oxygenation activity leading to the photorespiratory (C_2) cycle. If an agricultural biochemist applies a chemical agent that selectively inhibits the functional activity of the mitochondrial enzyme glycine decarboxylase (GDC) complex in a C3 legume crop, what is the exact downstream metabolic roadblock that directly impairs the Calvin cycle?

(A) Complete accumulation of phosphoglycolate in the chloroplast, which directly stabilizes Rubisco in its active conformation.

(B) Failure to regenerate glutamate from glutamine within the peroxisome matrix space.

(C) Depletion of the cellular pool of glycerate, preventing the synthesis of 3-phosphoglycerate (3-PGA) via the salvage pathway, alongside massive accumulation of toxic glycine.

(D) Overproduction of serine, which acts as a powerful competitive inhibitor of fructose-1,6-bisphosphatase.

Q19. An evaluation of respiratory mechanics in flooding-tolerant versus flooding-sensitive crop cultivars shows a distinct reliance on alternative metabolic pathways. During deep prolonged waterlogging, a sensitive cultivar exhibits an immediate drop in its energy charge because its pyruvate metabolism shifts entirely to lactic acid fermentation. Why does this cause metabolic death compared to a tolerant cultivar executing ethanolic fermentation?

(A) Lactic acid fermentation yields 0 net ATP molecules per glucose molecule, whereas ethanolic fermentation yields 36 ATP.

(B) Intracellular lactic acid accumulation drops the cytosolic pH (cytoplasmic acidosis), which directly inhibits key glycolytic enzymes like phosphofructokinase, halting all energy production.

(C) Ethanol acts as a required structural stabilizer for the mitochondrial outer membrane during hypoxic stress conditions.

(D) Lactic acid directly blocks the active transport of sucrose through the symplastic phloem loading sieve element complexes.

Q20. A researcher measures phloem transport kinetics in a transgenic sugar beet line. The active phloem loading mechanism of sucrose into the sieve element-companion cell (SE-CC) complexes is driven by a sucrose-H^+ symporter (SUC2/SUT1). If the researcher introduces a highly specific uncoupler that permeabilizes the companion cell plasma membrane exclusively to protons (H^+), evaluate the structural and physical outcome on the translocation dynamics:

(A) Mass flow rate increases substantially due to the elimination of the frictional resistance of protons inside the sieve tube.

(B) The proton gradient across the companion cell membrane is dissipated, completely stopping active sucrose loading, which drops the hydrostatic pressure at the source and stops long-distance transport.

(C) Sucrose accumulation inside the source leaves shifts to a purely passive down-gradient acceleration, drastically increasing sink delivery.

(D) Water potential inside the sieve elements drops to highly negative values, causing explosive structural rupture of the sieve plates.

Q21. A physiological experiment investigates the phenomenon of "solarization" and photoinhibition in high-yielding crop leaves exposed to extreme, chilling-temperature stress under full sunlight conditions. The tracking data reveals a severe drop in the quantum yield of Photosystem II (F_v/F_m). What is the precise molecular site of damage and the accompanying protective non-photochemical quenching (NPQ) mechanism activated under these conditions?

(A) Irreversible cleavage of the P700 reaction center chlorophyll molecule; protected by the rapid conversion of neoxanthin to lutein.

(B) Targeted proteolytic degradation of the D1 core reaction center protein of PSII; protected by the enzymatic conversion of violaxanthin to zeaxanthin via the xanthophyll cycle.

(C) Disassembly of the Oxygen Evolving Complex manganese cluster; protected by the continuous de-epoxidation of alpha-carotene.

(D) Sudden physical detachment of the Light Harvesting Complex II (LHCII) from the thylakoid membrane; protected by cyclic electron flow around the NDH complex.

Q22. A cytogeneticist examines a mutant line of tetraploid forage grass displaying highly irregular chromosome segregation during microsporogenesis. Fine-structure immunofluorescence imaging reveals that a specific mutation completely disrupts the functional assembly of the kinetochore-associated motor protein complex during late diakinesis. Which exact stage of the meiotic cycle will display an immediate structural arrest?

(A) Synapsis initiation during the zygotene stage, preventing homologous alignment.

(B) Congression of bivalents to the metaphase plate and subsequent stable bipolar orientation during Meiosis I.

(C) Nucleolar reconstitution during the telophase-I stage transitions.

(D) Terminalization of chiasmata during the transition from pachytene to diplotene.

Q23. In an advanced genetic mapping experiment involving an elite cross of a self-pollinated pulse crop, an investigator analyzes the recombination frequencies between three linked loci controlling seed yield components: A (pod length), B (ovule number), and C (testa thickness). If the observed double crossover frequency is exactly 0.002, while the expected double crossover frequency calculated from individual map distances is 0.010, compute the Coefficient of Coincidence (C) and the degree of Interference (I) operating within this chromosomal interval:

(A) $C = 5.00$, $I = -4.00$; demonstrating powerful localized negative crossover interference.

(B) $C = 0.20$, $I = 0.80$; demonstrating that the presence of a first crossover strongly inhibits the formation of a second nearby crossover.

(C) $C = 0.02$, $I = 0.98$; showing absolute structural independence of chromosomal arms.

(D) $C = 1.00$, $I = 0.00$; indicating complete absence of any mechanical tension along the synaptonemal complex.

Q24. A molecular genetics group investigates the inheritance of chloroplastic herbicide resistance in an agronomically valuable F1 hybrid population of an oilseed crop. When a resistant maternal parent is crossed with a susceptible paternal parent, 100% of the offspring display complete resistance. However, in reciprocal crosses, a rare 0.5% of the F1 progeny derived from a susceptible maternal parent unexpectedly show partial resistance. Identify the most probable cytological explanation for this leakiness:

(A) Spontaneous nuclear reverse mutations operating at high-frequency locus hotspots.

(B) Occasional paternal leakage of plastids via low-frequency transmission of paternal cytoplasm during male gametophyte pollen tube fertilization events.

(C) Epistatic suppression of nuclear genes by specialized cytoplasmic long non-coding RNA molecules.

(D) Genomic imprinting causing complete transcriptional silencing of paternal alleles.

Q25. A plant cell biologist applies a highly specialized chemical compound to an actively dividing root apical meristem culture. This compound specifically blocks the synthesis and structural polymerization of the trans-Golgi network-derived polysaccharide matrices without affecting nuclear division or spindle microtubule disassembly. Evaluate which specific structural feature of plant cell division is directly prevented from forming:

(A) The astral microtubule arrays responsible for centering the nuclear mass.

(B) The contractile actin-myosin ring responsible for executing cell cleavage furrow pinching.

(C) The phragmoplast-guided cell plate formation and expansion from the center to the periphery during cytokinesis.

(D) The kinetochore attachment plates required for chromatid separation along the axis.

Detailed Solutions

Q1.

Solution

Concept: Interxylary phloem nests (included phloem) represent soft, unlignified tissues deeply embedded within a rigid matrix of secondary xylem. To prevent these vital nutrient-conducting channels from mechanically collapsing under intense hydrostatic and radial growth pressures, the surrounding parenchymatous tissue undergoes a targeted structural modification, transforming into a thick, protective, highly lignified sclerotic matrix.

Solution:

In the multi-layered anomalous secondary growth of advanced xerophytic woody lianas, strands of soft phloem tissue become entirely surrounded by secondary xylem, forming interxylary phloem nests. As the concentric vascular cambium actively produces new layers, these internal nests are subjected to immense mechanical, administrative, and hydrostatic wood pressures.

To prevent the physical collapse of these non-lignified sieve tubes and companion cells, the plant utilizes a specialized structural defense mechanism: the tangential paratracheal parenchyma cells immediately bordering these phloem nests undergo a secondary differentiation phase. This involves heavy sclerification and the deposition of secondary lignified walls, creating a rigid, protective sclerotic sheath or jacket. This structural reinforcement acts as a mechanical shield that neutralizes compressive stresses while allowing the embedded phloem to maintain regular internal translocation dynamics under extreme pressure.

Final Answer: $\boxed{\text{Lignification of the surrounding tangential paratracheal parenchyma cells forming a rigid protective sclerotic sheath.}}$

Answer: (A)

Go Back to Question 1

Q2.

Solution

Concept: In specific climbing and creeping legumes, extreme foliar modifications occur to optimize atmospheric resource capture and mechanical climbing efficiency. When the true leaf lamina becomes entirely metamorphosed into a branched climbing tendril, the flanking stipules expand into large, green, photosynthetic leaf-like structures termed pseudolaminae (stipular dominance) along a horizontally crawling runner axis.

Solution:

Let's break down the morpho-anatomical attributes of the sub-tropical forage legume specimen:

- **Axis Configuration:** A multi-nodal, horizontally crawling aerial axis is classified morphologically as a runner or stoloniferous system.
- **True Leaf Modification:** The true leaf blade undergoes a complete evolutionary modification, becoming a decompound tendril optimized solely for mechanical anchoring and support.
- **Stipular Compensation:** To offset the absolute loss of typical photosynthetic leaf area, the vegetative stipules at alternative nodes expand into large, green, flattened laminar structures.

This precise anatomical arrangement exhibits pseudolamina stipular dominance modifying a classic runner framework. It is morphologically distinct from a phyllode (which involves a modified, flattened petiole) or a phylloclade/cladode (which represent modified, flattened photosynthetic stem branches).

Final Answer: Metamorphosed runner axis exhibiting specialized pseudolamina stipular dominance.

Answer: (C)

Go Back to Question 2

Q3.

Solution

Concept: Buzz pollination (sonication) relies on anther specialization where pollen grains are released exclusively through small pores at the apex (poricidal dehiscence). In many sonicating species, individual anthers form a functional cone held together by microscopic marginal trichomes, utilizing an internal restrictive valve that releases localized fluidised pollen masses only when exposed to a specific vibrational frequency.

Solution:

Let's examine the biomechanical and structural properties of the sonication mechanism in this wild Solanaceae accession:

(a) **Anther Column Assembly:** The anthers are not morphologically fused via parenchymatous tissue (which would be syngenesious), but are instead held in a tight, connivent column via microscopic interlocking marginal epidermal hairs (trichomes).

(b) **Dehiscence Type:** The exit mechanism is strictly apical and poricidal, meaning the pollen must escape through small terminal pores at the apex of the anther column.

(c) **Gating Mechanism:** Inside each theca, a specialized internal structural valve or barrier keeps the dry, powdery pollen mass contained.

(d) **Resonant Fluidization:** When a visiting bumblebee vibrates her thoracic muscles at 240 Hz, this mechanical resonance induces immediate fluidization of the pollen mass. The vibrational acceleration forces the internal structural valve open, resulting in a highly directional, explosive expulsion of pollen grains directly onto the bee's ventral abdomen.

Final Answer: Apical poricidal dehiscence combined with a restrictive internal structural valve that opens only under critical vibrational acceleration.

Answer: (B)

Go Back to Question 3

Q4.

Solution

Concept: The root-stem transition zone (hypocotyl region) requires a complete re-orientation of primary vascular tissues. It bridges an exarch, radial root arrangement (where protoxylem points outward and metaxylem points inward) with an endarch, collateral stem arrangement (where protoxylem points inward and metaxylem points outward) through a sequence of lateral migration, radial bifurcation, and a 180° chordal twisting of xylem components.

Solution:

Let's analyze the developmental geometry of the vascular strands within the hypocotyl transition zone:

- **Root Configuration:** Exarch and radial. The protoxylem elements are situated on the periphery (outward), and the metaxylem elements develop toward the center (inward).
- **Stem/Epicotyl Configuration:** Endarch and collateral. The protoxylem points toward the center (inward), while the metaxylem points toward the periphery (outward).

To transition smoothly between these opposite structural configurations, the individual primary vascular bundles must alter their orientations. As the strands travel longitudinally upward through the hypocotyl, the primary xylem vectors undergo a coordinated re-orientation: the strands shift laterally, branch or bifurcate, and experience a progressive 180° chordal twisting. This rotational inversion re-positions the early-forming protoxylem elements internally relative to the later-forming metaxylem, changing the orientation from exarch to endarch.

Final Answer: $\boxed{\text{Lateral migration, branching, and a 180° chordal twisting of the protoxylem elements relative to the position of metaxylem.}}$

$\boxed{\textbf{Answer: (D)}}$

Go Back to Question 4

Q5.

Solution

Concept: Lodicules are highly modified, small, hyaline scale-like structural remnants of the perianth located at the base of the grass (Poaceae) floret. During anthesis, they act as turgor-sensitive hydrostatic cushions that swell rapidly via solute accumulation, pushing the overlapping lemma and palea apart to expose the reproductive organs.

Solution:

In the grass spikelet inflorescence, anthesis requires a mechanical opening of the protecting bracts. This process is driven by the lodicules:

- Lodicules are situated directly at the base of the floret, adjacent to the ovary and the enclosing lemma and palea.
- At the onset of anthesis, a rapid accumulation of potassium (K^+) ions occurs within these cells, dramatically dropping their solute potential.
- This ion surge triggers immediate, localized endosmosis, causing the lodicules to swell into turgid hydrostatic cushions.
- The physical expansion of these swollen structures exerts strong mechanical outward leverage, forcing the lemma and palea apart so that the stamens and stigmas can emerge for pollination.

Final Answer: Lodicules executing continuous localized endosmosis driven by rapid potassium ion accumulation.

Answer: (B)

Go Back to Question 5

Q6.

Solution

Concept: Lamellar (or plate) collenchyma is a living mechanical tissue characterized by primary, non-lignified, pectin-rich cell wall thickenings deposited selectively along the tangential walls, while the radial walls remain unthickened and thin.

Solution:

Collenchyma is a living, primary mechanical tissue that provides flexibility and tensile strength to wind-exposed, growing plant organs. It features non-uniform, non-lignified cell wall thickenings composed primarily of cellulose and high levels of hydrophilic pectin. Based on the spatial pattern of these wall depositions, it is classified into distinct categories:

- **Angular Collenchyma:** Thickening is localized primarily at the intercellular corners where multiple cell walls meet.
- **Lacunate Collenchyma:** Thickening is distributed around prominent intercellular spaces.
- **Lamellar (Plate) Collenchyma:** Thickening is deposited heavily and selectively along the inner and outer tangential walls, appearing as parallel plates or bands in cross-section, while leaving the radial walls thin.

Because these cells remain living and contain functional chloroplasts, lamellar collenchyma provides structural elasticity while maintaining a functional photosynthetic capacity.

Final Answer: $\boxed{\text{Lamellar (plate) collenchyma offering structural elasticity and photosynthetic capacity.}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 6

Q7.

Solution

Concept: Under waterlogged or hypoxic conditions, roots produce and trap gas molecules. The accumulation of gas stimulates programmed cell death (PCD) in specific files of the root cortex, leading to the cellulolytic breakdown of cell walls and forming large gas-diffusion channels called lysigenous aerenchyma.

Solution:

In deep-water or waterlogged marshland monocot crops, flooding restricts the diffusion of oxygen into the soil, creating an anaerobic environment. This hypoxic stress triggers a specific signaling cascade within the root tissue:

(a) Due to slow diffusion in water, the plant hormone **ethylene** accumulates rapidly within the submerged root tissues.

(b) This high internal concentration of ethylene acts as a key regulatory signaling factor that triggers localized, targeted lysigenous programmed cell death (PCD) within the parenchymatous files of the root cortex.

(c) The signaling pathway activates cellulolytic enzymes (such as cellulases and pectinases) that degrade and dissolve the primary cell walls.

(d) This cellular breakdown leaves behind large, open, interconnected intercellular spaces known as **cortical aerenchyma**. These structural channels allow oxygen to flow via internal longitudinal systems from the aerial parts down to the submerged root tips.

Final Answer: $\boxed{\text{Ethylene accumulation under hypoxic stress inducing targeted cellulolytic breakdown resulting in cortical aerenchyma.}}$

Answer: (B)

Go Back to Question 7

Q8.

Solution

Concept: Bulliform cells (motor cells) are large, bubble-shaped, hygroscopic epidermal cells situated in longitudinal bands along the adaxial surface of grass leaves. Under high atmospheric vapor pressure deficits (drought stress), they lose turgor pressure faster than neighboring cells, causing the leaf blade to roll inward to protect the stomata.

Solution:

The foliar epidermis of many arid-adapted grass species (Poaceae) features specialized rows of large, thin-walled, highly vacuolated, wedge-shaped cells called **bulliform cells** or motor cells. These cells function as turgor-sensitive mechanical switches:

- Under conditions of high water availability, these hygroscopic cells absorb water and expand, keeping the leaf blade unrolled and flat to maximize light interception.
- Under acute atmospheric vapor pressure deficits or drought stress, transpirational water loss causes these cells to rapidly lose turgor pressure and shrink.
- As they lose volume and go flaccid, it creates a mechanical pulling force that rolls the leaf blade upward and inward along the midrib. This architectural adjustment reduces the exposed transpirational surface area, traps a humid micro-climate over the adaxial stomatal pores, and protects the plant from excessive desiccation.

Final Answer: Bulliform cells undergoing rapid turgor loss, inducing upward inward rolling of the leaf blade to minimize transpirational surface area.

Answer: (B)

Go Back to Question 8

Q9.

Solution

Concept: The diadelphous condition in the sub-family Papilionoideae (Fabaceae) is typically characterized by ten stamens arranged in two distinct groups ($A_{(9)+1}$). A variation in the fusion pattern that splits the fused bundle into two sub-groups while keeping the single vexillary stamen free ($A_{(5)+(4)+1}$) does not alter the underlying taxonomic classification, because the independent vexillary stamen preserves the diagnostic diadelphous blueprint.

Solution:

In the standard floral morphology of the sub-family Papilionoideae (Fabaceae), the androecium displays a diadelphous state where 9 staminal filaments fuse together to form a basal staminal tube, while the 10th posterior stamen (the vexillary stamen) remains entirely free and independent ($A_{(9)+1}$).

If a mutant accession exhibits a structural modification resulting in an $A_{(5)+(4)+1}$ configuration, the 9 previously unified stamens are split into two smaller fused bundles of 5 and 4 filaments, respectively. However, because the single posterior vexillary stamen remains completely free from both bundles, the androecium maintains its underlying diadelphous blueprint (stamens split into fused groups plus an independent stamen). This modification represents an intra-family structural variation that does not alter the primary family classification, preserving its assignment within the Papilionoideae.

Final Answer: $\boxed{\text{Preservation of the Papilionoideae classification as the structural identity of the vexillary stamen remains independent.}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 9

Q10.

Solution

Concept: The families Solanaceae and Scrophulariaceae can be distinguished by their gynoecium anatomy. Solanaceae features an obliquely oriented bicarpellary ovary with a swollen placental matrix and axile placentation, whereas Scrophulariaceae features a straight, medianly oriented ovary.

Solution:

While both Solanaceae and Scrophulariaceae (or Plantaginaceae) belong to the order Lamiales/Solanales and share characteristics like sympetalous corollas and epipetalous stamens, they can be distinguished by specific morphological and anatomical markers:

- **Solanaceae:** The flowers are typically actinomorphic (regular). The gynoecium consists of a superior, bicarpellary ovary that is placed **obliquely** at an angle of roughly 45° relative to the mother axis. The placenta is highly swollen and prominent, bearing numerous ovules arranged in an axile placentation pattern.

- **Scrophulariaceae:** The flowers are predominantly zygomorphic (bilaterally symmetrical). The superior, bicarpellary ovary is oriented **medianly** (aligned straight along the antero-posterior plane of the flower) without the characteristic oblique tilt or exceptionally swollen placenta seen in Solanaceae.

Therefore, assessing the oblique orientation of the ovary alongside the characteristics of the placental matrix provides a reliable anatomical distinction between these two families.

Final Answer: Obliquely placed ovary with swollen axile placentation containing numerous ovules in Solanaceae vs medianly placed ovary in Scrophulariaceae.

Answer: (B)

Go Back to Question 10

Q11.

Solution

Concept: The gynoecium of the family Brassicaceae is initially unilocular but becomes bilocular during development due to the formation of a false internal septum called the replum, which develops as an inward growth from the parietal placentae.

Solution:

In the diagnostic floral layout of the family Brassicaceae (Cruciferae), the gynoecium is bicarpellary, syncarpous, and superior. During early ontogenetic development, the ovary contains a single internal cavity (unilocular state) with ovules attached along the outer walls via parietal placentation. As development progresses, a specialized structural framework forms within the ovary: a false partition or septum grows inward from the opposing parietal placentae, dividing the single cavity into two chambers (bilocular state). This specialized false septum is technically termed the **replum**. When the mature fruit (a siliqua or silicula) undergoes dehiscent splitting, the outer fruit walls open from the base upward, leaving the seeds attached to the persistent, frame-like replum.

Final Answer: Replum, which is a false septum developing as an ingrowth from the parietal placentae.

Answer: (B)

Go Back to Question 11

Q12.

Solution

Concept: The tribe Aveneae within the grass family (Poaceae) is characterized by spikelet architectures where the elongated sterile glumes are large enough to completely enclose or exceed the subtended florets, which frequently feature lemmas with distinct dorsal awns.

Solution:

Let's evaluate the structural features of the grass spikelet architecture provided:

- **Glume Characteristics:** A pair of large, persistent sterile glumes completely encloses the internal florets.
- **Floret Composition:** The spikelet contains two distinct florets. The lower floret is strictly staminate (male) and features a deeply bifid (cleft) palea structural configuration. The upper floret is hermaphrodite (perfect) and displays a prominently awned lemma.

This diagnostic combination—where the empty outer glumes are larger than or completely wrap around the florets, paired with awned lemmas and dimorphic florets—is a key taxonomic characteristic of the tribe **Aveneae** (commonly represented by genera like *Avena*). This structural setup differs from the Triticeae (which feature alternate sessile spikelets along a rigid rachis) or the Oryzeae (which feature highly reduced glumes and six stamens).

Final Answer: Tribe Aveneae, characterized by large glumes exceeding the lowest floret with dorsal awns.

Answer: (A)

Go Back to Question 12

Q13.

Solution

Concept: The syngenesious condition is an androecium configuration unique to the family Asteraceae where the anthers are completely fused longitudinally into a rigid hollow cylinder surrounding the style, while the underlying filaments remain free and distinct.

Solution:

In the floral analysis of members of the family Asteraceae (Compositae), the central disc florets display a highly specialized staminal arrangement:

- The androecium consists of exactly five epipetalous stamens.
- **Anther Fusion:** The five anthers are completely fused together along their lateral edges (longitudinally), forming a hollow, rigid cylinder or sleeve.
- **Filament Separation:** The underlying supporting filaments remain completely separate and free from one another, anchoring independently to the inner corolla wall.

This condition is termed **syngenesious**. It facilitates a specialized push- or brush-mechanism for pollen presentation: as the immature style elongates through the center of the hollow anther tube, its outer hairs brush the internally dehisced pollen grains upward out of the cylinder, exposing them to visiting pollinators.

Final Answer: $\boxed{\text{Syngenesious condition facilitating a specialized brush-mechanism for pollen presentation.}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 13

Q14.

Solution

Concept: The characteristic fruit of the family Apiaceae is a cremocarp, a type of dry schizocarp derived from a bicarpellary inferior ovary. At maturity, it splits along the midline into two single-seeded units called mericarps, which remain temporarily suspended from a central slender axis known as a bifurcated carpophore.

Solution:

Let's analyze the structural disassembly of the fruit type typical of the condiment family Apiaceae (Umbelliferae):

- The fruit is an inferior, dry schizocarp known as a **cremocarp**.
- Upon reaching complete structural maturity, the fruit splits longitudinally along a central dividing plane (the commissure).
- The two individual splitting segments, each containing a single seed, are called **mericarps**.
- Instead of falling away immediately, these mericarps remain suspended in the air from a central, specialized, slender, thread-like structural stalk. This supporting framework is derived from the elongated receptacle axis and is called a **bifurcated carpophore**.

Final Answer: $\boxed{\text{Mericarps suspended securely from a bifurcated carpophore axis.}}$

Answer: (B)

Go Back to Question 14

Q15.

Solution

Concept: A synandrium is an advanced androecium modification found in certain tribes of the family Cucurbitaceae, where all five stamens undergo complete structural integration, fusing along both their filaments and highly contorted, S-shaped anthers into a single central column.

Solution:

In the family Cucurbitaceae, the androecium undergoes various degrees of structural fusion, moving from five free stamens to progressive stages of cohesion:

- The standard configuration often features a 2 + 2 + 1 arrangement, where four stamens fuse in pairs by their filaments, leaving one stamen free.
- In advanced cultivated gourd accessions or members of specialized tribes (such as Cyclantherae or advanced Cucurbiteae), the fusion reaches its maximum expression. All five stamens are completely unified.
- This fusion joins both the length of the filaments and the highly convoluted, folded, or S-shaped anther lobes into a single, central column.

This complete structural integration across all staminal parts is termed a **synandrium**. It differs from a syngenesious condition (where only anthers are fused) or a monadelphous condition (where only filaments are fused).

Final Answer: $\boxed{\text{Synandrium condition typical of advanced Cyclantherae or modified Cucurbiteae tribes.}}$

$\boxed{\textbf{Answer: (A)}}$

Go Back to Question 15

Q16.

Solution

Concept: The Cytochrome b_6f complex acts as a key proton pump within the thylakoid membrane, linking Photosystem II and Photosystem I. Inhibiting its proton-pumping function stops the accumulation of protons inside the lumen, dissipating the transthylakoid proton motive force (Δp) and halting ATP synthesis, even while linear electron transport to $NADP^+$ briefly continues.

Solution:

In the light-dependent reactions of photosynthesis, linear electron flow transfers electrons from water through Photosystem II, the plastoquinone pool, the Cytochrome b_6f complex, plastocyanin, Photosystem I, and ferredoxin to reduce $NADP^+$ to NADPH. Simultaneously, the Cytochrome b_6f complex uses electron energy to pump protons (H^+) from the stroma into the internal thylakoid lumen:

(a) This accumulation of protons creates a large electrochemical gradient across the membrane, known as the **tranthylakoid proton motive force (Δp)**, which drives ATP synthesis via the CF_0CF_1 ATP synthase complex.

(b) If an inhibitor selectively blocks only the proton-pumping activity of the Cytochrome b_6f complex, protons are no longer moved into the lumen, causing the proton motive force to dissipate.

(c) Without this gradient, ATP synthesis stops immediately, disrupting both cyclic and non-cyclic photophosphorylation.

(d) Meanwhile, because light absorption at the photosystems is not directly blocked, linear electron transport can briefly continue moving remaining electrons to $NADP^+$. However, it soon halts as a lack of ATP stops the Calvin-Benson cycle, leading to an **acceptor-side limitation** due to a depleted pool of oxidized $NADP^+$.

Final Answer: Complete collapse of the transthylakoid proton motive force (Δp), preventing ATP synthesis while linear electron flow to $NADP^+$ briefly continues before being halted by acceptor-side limitation.

Answer: (B)

Go Back to Question 16

Q17.

Solution

Concept: Abscisic Acid (ABA)-mediated stomatal closure is driven by an intracellular signaling cascade that inhibits the plasma membrane H^+-ATPase pump and activates outward-rectifying anion channels (SLAC1). The resulting efflux of malate and Cl^- depolarizes the membrane, driving a massive, sustained efflux of K^+ ions that lowers cell turgor.

Solution:

When a plant experiences acute soil moisture deficits, the hormone Abscisic Acid (ABA) binds to its intracellular PYR/PYL/RCAR receptor complexes. This interaction initiates a downstream protein kinase signaling cascade that governs guard cell osmoregulation:

(a) The cascade inhibits the plasma membrane H^+-ATPase proton pump, stopping the active efflux of protons.

(b) Simultaneously, it opens calcium-permeable channels, causing an influx of Ca^{2+} into the cytosol, which triggers the release of additional calcium from internal stores.

(c) This rise in cytosolic calcium, paired with the proton pump inhibition, activates **outward-rectifying anion channels** such as SLAC1 (Slow Anion Channel 1). This allows accumulated anions—primarily chloride (Cl^-) and malate—to flow rapidly out of the cell into the apoplast.

(d) The loss of negative charges **depolarizes** the plasma membrane. This depolarization shifts the membrane potential past the threshold required to activate inward-rectifying channels, opening **outward-rectifying K^+ channels** instead.

(e) Potassium (K^+) ions rush out of the cell down their electrochemical gradient. The massive loss of ions increases the water potential (ψ_w) inside the guard cells, causing water to flow out into the surrounding apoplast, which lowers cell turgor and closes the stomatal pore.

Final Answer: Depolarization of the membrane activates outward-rectifying anion channels (SLAC1), leading to efflux of Cl^- and malate, followed by massive sustained K^+ efflux.

Answer: (B)

Go Back to Question 17

Q18.

Solution

Concept: Inhibiting the mitochondrial glycine decarboxylase (GDC) complex blocks the photorespiratory salvage pathway. This stops the conversion of glycine to serine, preventing the regeneration of glycerate and depleting the pool of 3-phosphoglycerate (3-PGA) available for the Calvin cycle, while causing a toxic accumulation of glycine.

Solution:

When Rubisco fixes oxygen instead of carbon dioxide, it produces 2-phosphoglycolate, which must be salvaged through the photorespiratory (C_2) cycle spanning the chloroplasts, peroxisomes, and mitochondria:

(a) Inside the peroxisome, glycolate is converted to glycine, which is then transported into the mitochondrial matrix.

(b) Under normal conditions, the **glycine decarboxylase (GDC)** complex processes two molecules of glycine to synthesize one molecule of serine, releasing CO_2 and NH_4^+ in the process.

(c) If a chemical agent selectively inhibits GDC activity, the photorespiratory salvage pathway is blocked in the mitochondria. This creates a severe metabolic bottleneck: the plant can no longer convert glycine into serine.

(d) This block leads to a rapid, massive accumulation of toxic levels of glycine within the mitochondria and peroxisomes.

(e) Consequently, the downstream steps that convert serine back into glycerate are halted. Without a supply of glycerate, the chloroplast cannot regenerate **3-phosphoglycerate (3-PGA)** through the salvage pathway. This depletes the total pool of intermediates available for the Calvin-Benson cycle, impairing photosynthetic carbon assimilation.

Final Answer: Depletion of the cellular pool of glycerate, preventing the synthesis of 3-phosphoglycerate (3-PGA) via the salvage pathway, alongside massive accumulation of toxic glycine.

Answer: (C)

Go Back to Question 18

Q19.

Solution

Concept: Under prolonged waterlogging or anaerobic conditions, a shift to lactic acid fermentation can cause cytoplasmic acidosis. The accumulation of lactic acid drops the cytosolic pH, which directly inhibits key pH-sensitive glycolytic enzymes like phosphofructokinase, halting all anaerobic energy production and leading to cell death.

Solution:

When flooding or waterlogging limits oxygen availability, plants must rely on glycolysis and anaerobic fermentation pathways to generate ATP, since oxidative phosphorylation is stalled in the mitochondria. Both lactic acid and ethanolic fermentation pathways regenerate the oxidized cofactor NAD^+ needed to keep glycolysis running, yielding a net total of 2 ATP molecules per molecule of glucose:

- **Ethanolic Fermentation (Tolerant Cultivars):** Pyruvate is converted to acetaldehyde by pyruvate decarboxylase and then reduced to ethanol by alcohol dehydrogenase. Ethanol is relatively non-toxic to plant cells at typical physiological concentrations and can diffuse passively across lipid membranes out of the cell into the surrounding water.

- **Lactic Acid Fermentation (Sensitive Cultivars):** Pyruvate is reduced directly to lactic acid by lactate dehydrogenase. Because lactic acid cannot easily leave the cell, it accumulates within the cytosol. This accumulation releases free protons, causing a sharp drop in cytosolic pH, a condition known as **cytoplasmic acidosis**.

- This drop in pH directly inhibits key regulatory enzymes of glycolysis, particularly **phosphofructokinase (PFK)**, which is highly sensitive to acidic environments. Inhibiting PFK halts glycolysis, shutting down all anaerobic ATP production and leading to metabolic cell death.

Final Answer: $\boxed{\text{Intracellular lactic acid accumulation drops the cytosolic pH (cytoplasmic acidosis), which directly inhibits key glycolytic enzymes like phosphofructokinase, halting all energy production.}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 19

Q20.

Solution

Concept: Active phloem loading of sucrose into the sieve element-companion cell (SE-CC) complex relies on an electrochemical proton gradient generated by a plasma membrane H^+-ATPase. Introducing an uncoupler that permeabilizes the membrane to protons dissipates this gradient, stopping active sucrose transport, lowering the hydrostatic pressure at the source, and halting long-distance mass flow.

Solution:

According to the pressure-flow model of phloem translocation, long-distance transport of sugars through the sieve tube network is driven by a hydrostatic pressure gradient between source and sink tissues:

(a) At the source, companion cells use a plasma membrane H^+-ATPase to actively pump protons out into the cell wall space (apoplast), establishing a steep electrochemical proton gradient ($\Delta\mu_{H^+}$).

(b) A sucrose-H^+ symporter (SUC2/SUT1) uses the energy of this proton gradient to transport sucrose against its concentration gradient from the apoplast into the SE-CC complex.

(c) This high concentration of sucrose lowers the solute potential (ψ_s) inside the sieve elements, causing water to flow inward via osmosis. This influx of water generates a high **hydrostatic turgor pressure** at the source, which pushes the phloem sap toward low-pressure sink tissues.

(d) If an uncoupler permeabilizes the companion cell plasma membrane exclusively to protons, H^+ ions leak passively back across the membrane, **dissipating the proton gradient** without requiring active transport.

(e) Without this electrochemical gradient, the sucrose-H^+ symporter stops functioning, halting active phloem loading. As sugar accumulation stops, water no longer moves into the sieve elements, causing the hydrostatic pressure at the source to drop and halting long-distance transport.

Final Answer: $\boxed{\text{The proton gradient across the companion cell membrane is dissipated, completely stopping active sucrose loading, which drops the hydrostatic pressure at the source and stops long-distance transport.}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 20

Q21.

Solution

Concept: Photoinhibition under combined excess light and chilling stress targets the D1 core reaction center protein of Photosystem II for proteolytic degradation. To protect the photosynthetic apparatus from further damage, plants activate a non-photochemical quenching (NPQ) mechanism called the xanthophyll cycle, where the enzyme violaxanthin de-epoxidase converts violaxanthin into zeaxanthin to safely dissipate excess energy as heat.

Solution:

When high-yielding crop leaves are exposed to full sunlight under chilling temperatures, the low temperature slows down the enzymatic reactions of the Calvin-Benson cycle. This creates a metabolic bottleneck where the plant cannot use the absorbed light energy for carbon fixation, leading to an excess of excitation energy within the thylakoid membranes:

- **Molecular Site of Damage:** This excess energy leads to photoinhibition, where the primary target of damage is the **D1 core reaction center protein** of Photosystem II (PSII). Excess excitation energy drives the production of reactive oxygen species (ROS) within the reaction center, leading to the targeted proteolytic degradation of the D1 protein and causing a sharp drop in the maximum quantum yield of PSII (F_v/F_m).
- **Protective NPQ Mechanism:** To minimize further damage, plants activate non-photochemical quenching (NPQ) through the **xanthophyll cycle** within the light-harvesting complexes. The excess light and resulting low lumen pH activate the enzyme violaxanthin de-epoxidase, which converts the diepoxide carotenoid violaxanthin into the intermediate antheraxanthin and finally into the epoxide-free **zeaxanthin**. Zeaxanthin binds to the light-harvesting complex proteins, where it intercepts excess excitation energy from singlet chlorophyll molecules and safely dissipates it as heat, protecting the thylakoid membrane from further photo-oxidative stress.

Final Answer: Targeted proteolytic degradation of the D1 core reaction center protein of PSII; protected by the enzymatic conversion of violaxanthin to zeaxanthin via the xanthophyll cycle.

Answer: (B)

Go Back to Question 21

Q22.

Solution

Concept: Kinetochore-associated motor proteins (such as CENP-E and dynein/kinesin variants) are required during late prophase and early metaphase to drive the chromosome congression movement toward the spindle equator and establish stable, bipolar attachments. Disruption of these motor proteins halts the meiotic cycle at the transition to Metaphase I.

Solution:

During microsporogenesis, the first meiotic division requires an organized sequence of chromosome movements to ensure accurate segregation. Let's trace the impact of a mutation that disrupts kinetochore-associated motor proteins during late diakinesis:

- At diakinesis, the bivalents (paired homologous chromosomes) are highly condensed, the nucleolus breaks down, and the nuclear envelope begins to fragment, allowing spindle microtubules to interact with the chromosomes.
- Kinetochores are specialized multi-protein structures assembled on the centromere of each chromosome. They serve as attachment sites for spindle microtubules and house specialized motor proteins.
- These kinetochore-associated motor proteins are responsible for **congression**: they use ATP hydrolysis to move along spindle microtubules, pulling and guiding the bivalents toward the center of the cell (the metaphase plate).
- They are also required to monitor and stabilize **bipolar orientation**, ensuring that the two homologous centromeres are oriented toward opposite poles of the spindle.
- If these motor complexes fail to assemble properly during late diakinesis, the bivalents cannot move to the equator or establish stable attachments, halting the meiotic cycle before the cell can transition into Metaphase I.

Final Answer: Congression of bivalents to the metaphase plate and subsequent stable bipolar orientation during Meiosis I.

Answer: (B)

Go Back to Question 22

Q23.

Solution

Concept: The Coefficient of Coincidence (C) is calculated as the ratio of the observed double crossover frequency to the expected double crossover frequency (C = Observed DCO/Expected DCO). Crossover Interference (I) represents the degree to which a first crossover event inhibits a second nearby crossover along the chromosome, calculated as $I = 1 - C$.

Solution:

Let's compute the mapping parameters step-by-step using the provided crossover frequencies:

(a) Identify the given parameters from the trihybrid pulse crop mapping experiment:

$$\text{Observed Double Crossover Frequency } (\text{DCO}_{\text{obs}}) = 0.002$$

$$\text{Expected Double Crossover Frequency } (\text{DCO}_{\text{exp}}) = 0.010$$

(b) Compute the Coefficient of Coincidence (C), which measures the ratio of actual double recombinants to the number expected under independent conditions:

$$C = \frac{\text{DCO}_{\text{obs}}}{\text{DCO}_{\text{exp}}} = \frac{0.002}{0.010} = 0.20$$

(c) Compute the degree of chromosomal Interference (I):

$$I = 1 - C = 1 - 0.20 = 0.80$$

A positive interference value ($I = 0.80$) indicates that the formation of a first crossover event along this chromosomal interval mechanically or structurally inhibits the formation of a second crossover nearby, allowing only 20% of the expected double crossover events to occur.

Final Answer: $\boxed{C = 0.20,\ I = 0.80\text{; demonstrating that the presence of a first crossover strongly inhibits the formation of a second nearby crossover.}}$

Answer: (B)

Go Back to Question 23

Q24.

Solution

Concept: Chloroplastic traits typically exhibit maternal inheritance due to the preferential transmission of maternal cytoplasm during fertilization. However, low-frequency deviations from strict maternal inheritance can occur due to paternal leakage, where paternal plastids are occasionally transmitted via the male gametophyte pollen tube.

Solution:

Let's analyze the inheritance patterns of chloroplastic herbicide resistance in this oilseed hybrid population:

- **Primary Cross:** Resistant Maternal (Res^+) × Susceptible Paternal (Sus^-) → Yields 100% resistant offspring. This outcome aligns with strict maternal (cytoplasmic) inheritance, as chloroplasts are typically provided by the egg cell.
- **Reciprocal Cross:** Susceptible Maternal (Sus^-) × Resistant Paternal (Res^+) → Expected to yield 100% susceptible offspring. However, a rare 0.5% of the progeny unexpectedly display partial resistance.

Chloroplast genes are housed within the plastid genome (ptDNA). During angiosperm fertilization, the generative or vegetative cells of the male gametophyte (pollen tube) exclude plastids during asymmetric division, or degrade them prior to syngamy, leading to maternal inheritance. However, in many plant lines, this exclusion mechanism is leaky. Occasional **paternal leakage** allows a small number of paternal plastids to enter the egg cell cytoplasm during fertilization. If the paternal parent carries the chloroplastic resistance gene, this leakage enables a small fraction of the F_1 offspring to inherit the trait from the male parent.

Final Answer: $\boxed{\text{Occasional paternal leakage of plastids via low-frequency transmission of paternal cytoplasm during male gametophyte pollen tube fertilization events.}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 24

Q25.

Solution

Concept: Cytokinesis in higher plants is driven by the phragmoplast, a structural framework of microtubules and actin filaments that guides trans-Golgi network-derived vesicles to the cell center. These vesicles fuse to form the cell plate, which expands outward from the center to the periphery to construct the new primary cell wall.

Solution:

Let's analyze the cell biology of plant cytokinesis and the impact of the applied chemical blocker:

- During late anaphase and telophase, plant cells assemble a specialized structural framework called the **phragmoplast**, composed of remaining spindle microtubules and actin filaments oriented perpendicular to the division plane.
- The phragmoplast functions as a mechanical trackway, guiding secretory vesicles derived from the **trans-Golgi network** toward the equatorial plane.
- These vesicles carry non-cellulosic cell wall matrix polysaccharides, such as pectins and hemicelluloses.
- At the center of the cell, these vesicles fuse together to initiate a flat, membrane-bound structure called the **cell plate**.
- As more vesicles travel along the phragmoplast tracks and fuse, the cell plate expands outward from the center toward the periphery of the cell until it fuses with the existing parental plasma membrane and cell wall, dividing the cytoplasm.
- If a chemical compound blocks the synthesis and structural polymerization of these Golgi-derived polysaccharide matrices, vesicles cannot carry the necessary building blocks to the equator. Consequently, while nuclear division and spindle disassembly proceed normally, the cell is directly prevented from forming and expanding the cell plate, halting cytokinesis.

Final Answer: $\boxed{\text{The phragmoplast-guided cell plate formation and expansion from the center to the periphery during cytokinesis.}}$

Answer: (C)

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Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	A	2	C	3	B	4	D	5	B
6	B	7	B	8	B	9	B	10	B
11	B	12	A	13	B	14	B	15	A
16	B	17	B	18	C	19	B	20	B
21	B	22	B	23	B	24	B	25	C