# UPCATET Agriculture Botany Sample Paper-5

**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.** Anatomical investigation of a hyper-xerophytic stress-tolerant crop variant reveals anomalous secondary growth. The master vascular cambium produces anomalous rings of concentric accessory cambia along with highly integrated amphivasal vascular bundles. Identify the diagnostic tissue configuration that characterizes this structure under high salinity constraints.

(A) Interxylary phloem embedded inside secondary xylem

(B) Exogenous continuous deep-seated aerenchyma tissue

(C) Multiseriate continuous mechanical sclerenchyma bundle sheath

(D) Intraxylary phloem associated exclusively with lysigenous cavities

**Q2.** A specialized structural modification is observed in the subterranean anchoring networks of certain halophytic leguminous crops. The secondary roots grow vertically upwards against gravity, developing large aerating intercellular spaces lined with multi-layered suberized structural membranes. Choose the correct morpho-anatomical term and physiological designation for these specific channels.

(A) Negatively geotropic pneumatophores with functional pneumathodes

(B) Positively hydrotropic prop roots containing active lenticels

(C) Velamen-bearing epiphytic root complexes with thick cortical mantles

(D) Coralloid root symbiotic channels tracking deep endodermis

**Q3.** During structural parsing of the family Asteraceae used in forage systems, an agronomic researcher identifies a complex inflorescence structure. The peripheral ray florets exhibit a zygomorphic, ligulate corolla that is strictly pistillate, while the central disc florets are actinomorphic, tubular, and structurally perfect. Identify this highly integrated morphological composition.

(A) Heterogamous capitulum inflorescence

(B) Homogamous cyathium inflorescence

(C) Hypanthodium structural complex

(D) Verticillaster composite system

**Q4.** Transverse sectioning of an unexposed monocotyledonous root complex shows a uniquely thickened internal ring barrier. The tangential and radial cell walls of the endodermal layer are heavily impregnated with highly hydrophobic suberin and lignin complex linkages without any distinct structural breaks except at specific passage point configurations. Identify this structural anatomical component.

(A) Casparian strips within the specialized root endodermis

(B) Trichoblast complexes inside the mechanical exodermis

(C) Intrafascicular pericycle cambium initials

(D) Tyloses blocking the primary metaxylem vessels

**Q5.** The modification of leaves in certain arid-zone pulse crops involves a specialized anatomical structural arrangement where the main petiole becomes highly flattened, green, and blade-like, taking over the complete photosynthetic burden, whereas the true leaflets drop off early during development. Identify this morphological alteration.

(A) Phyllode structure

(B) Phylloclade complex

(C) Cladode modification

(D) Phylloptila system

**Q6.** In the structural cross-section of a high-yield C4 bioenergy grass stem, the vascular bundles are anatomically mapped as closed, collateral, and distributed across the parenchymatous ground tissue without any distinct concentric zone boundaries. Identify the unique mechanical structural layer protecting these bundles from mechanical lodging under high wind velocities.

(A) Sclerenchymatous bundle sheath jacket

(B) Collenchymatous hypodermal cortical ring

(C) Intrafascicular thin-walled cambium initials

(D) Sub-epidermal parenchymatous phelloderm

**Q7.** A deep morphological assay of the family Euphorbiaceae indicates a unique inflorescence configuration. It consists of a cup-shaped involucre mimicking a single flower, containing a single central long-stalked female flower surrounded by numerous scorpioid cymes of single-stamened male flowers. Identify this structural configuration.

(A) Cyathium inflorescence

(B) Coenanthium system

(C) Thyrsus composite array

(D) Corymbose raceme layout

**Q8.** Microscopic examination of the leaf epidermis of a drought-resistant Poaceae pasture grass species reveals specialized, large, wedge-shaped, empty cells located along the intercostal zones of the upper leaf surface. These cells regulate leaf rolling and unrolling dynamics during acute water deficit cycles. Identify these cells.

(A) Bulliform cells (Motor cells)

(B) Lithocyst secretory complexes

(C) Subsidiary guard cell auxiliaries

(D) Trichomes with silicified outer walls

**Q9.** An agronomist analyzes a new pulse crop variant showing an independent vexillary aestivation pattern. The corolla consists of a large posterior standard petal overlapping two lateral wings, which in turn overlap two fused anterior keel petals. Identify the diagnostic botanical family and associated structural sub-class matching this floral blueprint.

(A) Fabaceae (Papilionoideae sub-family)

(B) Solanaceae (Atropoideae sub-family)

(C) Poaceae (Panicoideae sub-family)

(D) Brassicaceae (Brassicoideae sub-family)

**Q10.** A commercial solanaceous crop display reveals an advanced floral layout. The androecium contains exactly five epipetalous stamens with porous anther dehiscence, surrounding a superior, bicarpellary, obligately syncarpous gynoecium placed obliquely on an exceptionally swollen placental matrix. Determine the exact diagnostic floral index constraint for this group.

(A) Oblique ovary with axile placentation configuration

(B) Parietal placentation with a functional replum barrier

(C) Marginal placentation along the ventral suture line

(D) Basal placentation tracking a single anatropous ovule

**Q11.** The botanical taxonomy of cereal crops classifies the structural grain configuration as a unique dry, single-seeded, indehiscent fruit variant where the pericarp is completely fused and integrated with the seed coat. Identify the precise systematic name of this fruit type typical of the Poaceae family.

(A) Caryopsis

(B) Siliqua

(C) Pod (Legume)

(D) Schizocarp

**Q12.** A tactical field diagnostic key targets the family Brassicaceae (Cruciferae). The diagnostic structural index tracks an androecium consisting of six stamens

arranged in two distinct whorls: two shorter outer stamens and four longer inner stamens. Select the technical term used to define this specific configuration.

(A) Tetradynamous state

(B) Didynamous configuration

(C) Diadelphous assembly

(D) Polyadelphous structural network

**Q13.** An industrial fiber crop belonging to the family Malvaceae is evaluated for structural fiber matrix density. The floral analysis notes a continuous structural collar of fused staminal filaments forming a long tube around the style, leaving only the capitate stigmas exposed. Identify this technical configuration.

(A) Monadelphous androecium forming a staminal tube

(B) Syngenesious anther cluster with free filaments

(C) Synandrous structural integration across all parts

(D) Gynostegium complex anchoring the pollen masses

**Q14.** During systematic review of high-value cash crop lines, an oilseed variant is found to possess a specialized internal tissue network that secretes a pungent sulfur-containing glucoside compound known as sinigrin, detected via specialized structural idioblasts. Identify the specific family linked with this biochemical marker.

(A) Brassicaceae

(B) Solanaceae

(C) Poaceae

(D) Fabaceae

**Q15.** Taxonomic screening of an essential pasture legume species identifies a highly stable floral structure where the gynoecium consists of a monocarpellary superior ovary containing multiple ovules arranged along a single longitudinal edge line. Choose the correct placentation model characterizing this crop family.

(A) Marginal placentation

(B) Parietal placentation

(C) Free-central placentation

(D) Axile placentation

**Q16.** Under severe temperature stress, the primary enzyme Ribulose-1,5-bisphosphate carboxylase-oxygenase (RuBisCO) in a C3 crop lines alters its structural substrate binding profile, dramatically increasing its affinity for $O_2$ relative to $CO_2$. Calculate the direct net energetic loss ratio in terms of ATP and NADPH utilized by the resulting photorespiratory salvage pathway per single molecule of fixed oxygen.

(A) Loss of fixed carbon without generation of ATP or NADPH

(B) Consumption of 3 ATP and 2 NADPH molecule segments

(C) Production of a surplus net mitochondrial ATP via oxidative links

(D) Complete generation of toxic pyruvate without energetic costs

**Q17.** Biophysical tracking of transmembrane ion transport during stomatal opening movements reveals a highly orchestrated proton pump activity. Identify the specific biochemical sequence that governs the hyper-activation of guard cell turgidity under active blue light conditions.

(A) Active efflux of $H^+$ ions, influx of $K^+$ ions, and synthesis of malate

(B) Passive influx of $H^+$ ions accompanied by massive leakage of $Cl^-$ ions

(C) Accumulation of starch within the chloroplast stroma matrix

(D) Reverse horizontal loading of abscisic acid inside the guard cell cytoplasm

**Q18.** The light-dependent reactions of photosynthesis utilize a specialized Z-scheme electron transport pathway embedded within the thylakoid membranes. If an experimental biochemical blocker halts the photolysis of water at the oxygen-evolving complex (OEC) level, evaluate the direct effect on the primary electron donor matrix of Photosystem II ($P_{680}$).

(A) $P_{680}$ remains locked in a highly oxidized state ($P_{680}^{+}$), arresting further light absorption

(B) $P_{680}$ accelerates electron donation directly to the plastoquinone pool

(C) Photosystem I operates at twice the normal rate via cyclic photophosphorylation

(D) Cyclic proton translocation across the cytochrome $b_6f$ complex increases

**Q19.** A mathematical modeling system tracks transpiration dynamics in a deep-canopy forest crop profile. If the total volumetric water potential ($\psi_w$) of the root cortical cells is measured at $-0.3$ MPa, the xylem fluid potential is at $-0.6$ MPa, and the atmospheric boundary layer potential drops to $-95.0$ MPa, evaluate the driving mechanism and direction of water transport according to the cohesion-tension theory.

(A) Continuous water movement along a decreasing thermodynamic gradient from root to atmosphere

(B) Reverse osmotic pressure pushing water back into the root cortex

(C) Disruption of water columns due to spontaneous cavitation at low potentials

(D) Active metabolic transport mediated by ATP hydrolyzing proteins in the xylem

**Q20.** During mitochondrial respiration in germinating crop seeds, the conversion of succinate to fumarate in the Krebs cycle is catalyzed by a multi-subunit enzyme complex that is also integrated directly into the electron transport chain (ETC). Identify this specific dual-functional respiratory complex.

(A) Complex II (Succinate Dehydrogenase)

(B) Complex I (NADH Dehydrogenase)

(C) Complex III (Cytochrome $bc_1$ complex)

(D) Complex IV (Cytochrome $c$ Oxidase)

**Q21.** An analytical study evaluates the dark fixation efficiency of an elite variety of sugarcane. The initial carboxylation step occurs in the mesophyll cytoplasm,

forming a 4-carbon organic acid which is subsequently transported into the bundle sheath cells for decarboxylation. Identify the primary fixing enzyme and the precise compound that accepts $CO_2$.

(A) PEP carboxylase acting on Phosphoenolpyruvate (PEP)

(B) RuBisCO acting on Ribulose-1,5-bisphosphate

(C) Malate dehydrogenase acting on Oxaloacetate

(D) Pyruvate phosphate dikinase acting on Pyruvate

**Q22.** During microsporogenesis in an elite polyploid crop line, homologous chromosome pairs undergo a highly regulated process of synapsis and reciprocal physical recombination. Identify the precise sub-stage of Prophase-I where the multi-protein synaptonemal complex completely dissolves, leaving the homologous chromosomes connected only at the specific sites of cross-over execution called chiasmata.

(A) Diplotene stage

(B) Pachytene stage

(C) Zygotene stage

(D) Diakinesis stage

**Q23.** A dihybrid plant cross involving two independently assorting locus profiles governing seed coat texture $(R/r)$ and endosperm pigment distribution $(Y/y)$ yields a highly skewed phenotype distribution pattern in the F2 generation. Instead of the expected $9:3:3:1$ segregation ratio, a dominant epistatic gene interaction occurs where the presence of a single dominant allele at one locus completely masks the phenotypic expression of the second locus. Determine the modified phenotypic ratio.

(A) $12:3:1$

(B) $9:7$

(C) $15:1$

(D) $9:3:4$

**Q24.** An advanced cytogenetic assay monitors mitotic cell division arrest in crop root tip cells treated with an alkaloid derivative compound derived from *Colchicum autumnale*. This compound targets the cellular cytoskeleton, preventing spindle fiber formation during division. Identify the molecular target and the specific stage at which the cell division cycle is halted.

(A) Inhibition of tubulin polymerization, arresting cells explicitly at Metaphase

(B) Disruption of actin filaments, preventing Telophase cytokinesis

(C) Destruction of the nuclear lamina framework during early Prophase

(D) Degradation of centromere cohesion proteins during Anaphase transition

**Q25.** A plant breeding experiment evaluates a test cross between an F1 hybrid individual heterozygous at two linked loci ($AaBb$) and a double recessive tester individual ($aabb$). The resulting progeny configuration displays 44% parental phenotype $AB$, 44% parental phenotype $ab$, 6% recombinant phenotype $Ab$, and 6% recombinant phenotype $aB$. Calculate the exact genetic map distance separating these two loci on the chromosome linkage map.

(A) 12 centimorgans (cM)

(B) 6 centimorgans (cM)

(C) 88 centimorgans (cM)

(D) 50 centimorgans (cM)

## Detailed Solutions

**Q1.**

### Solution

**Concept:** Anomalous secondary growth in hyper-xerophytic and halophytic plants often produces accessory cambia that generate integrated amphivasal (leptocentric) vascular bundles. In these bundles, the phloem is entirely encircled by xylem elements, frequently leaving pockets of phloem structurally surrounded by secondary xylem tissue.

**Solution:**

In hyper-xerophytic and extreme stress-tolerant crop variants showing anomalous cambial activity, the development of successive concentric rings of accessory cambia yields unique structural layouts. The resulting integrated amphivasal vascular bundles display a configuration where the phloem stands centrally encircled by xylem components. Under microscopic analysis, this manifests as islands or strands of phloem tissue embedded directly within the thick secondary xylem mass, technically referred to as interxylary (or included) phloem. This architectural configuration provides mechanical stability and safeguards essential nutrient translocation channels under high salinity and extreme osmotic stress constraints.

**Final Answer:** Interxylary phloem embedded inside secondary xylem

**Answer: (A)**

Go Back to Question 1

## Q2.

### Solution

**Concept:** Halophytic plants growing in waterlogged, saline, or hypoxic anaerobic substrates modify their root networks to develop specialized negatively geotropic (aerating) structures called pneumatophores. These roots grow vertically upwards to capture atmospheric oxygen via specialized porous structures known as pneumathodes or lenticels.

**Solution:**

When subterranean anchoring networks face gas-exchange limitations in swampy or saline mangrove environments, they develop specialized structural adaptations:

- The roots exhibit negative geotropism, growing vertically upward out of the water or mud into the air.
- They develop an internal architectural layout with prominent aerenchymatous spaces lined by suberized structural membranes to minimize moisture loss while optimizing gas diffusion.
- Atmospheric oxygen enters through specialized breathing pores called pneumathodes.

Thus, these specialized upward-growing structures are designated as negatively geotropic pneumatophores featuring functional pneumathodes.

**Final Answer:** Negatively geotropic pneumatophores with functional pneumathodes

**Answer: (A)**

Go Back to Question 2

## Q3.

### Solution

**Concept:** In the family Asteraceae, the composite inflorescence is structured as a head or capitulum. When the peripheral ray florets differ morphologically and sexually from the central disc florets, the capitulum is classified as heterogamous.

**Solution:**

Let's analyze the structural components of the described Asteraceae inflorescence:

(a) **Peripheral Ray Florets:** Exhibit a zygomorphic, strap-like (ligulate) corolla and are strictly pistillate (female) or neutral.

(b) **Central Disc Florets:** Exhibit an actinomorphic, tubular corolla and are structurally perfect (bisexual/hermaphrodite).

Because the head contains two distinct morphological and sexual types of florets, it is designated as a heterogamous capitulum. Conversely, a homogamous capitulum contains only one type of floret throughout the entire disk profile.

**Final Answer:** Heterogamous capitulum inflorescence

**Answer: (A)**

Go Back to Question 3

## Q4.

### Solution

**Concept:** The endodermis of monocotyledonous roots forms a highly specialized physiological barrier characterized by radial and inner tangential cell wall thickenings impregnated with hydrophobic suberin and lignin bands, known as Casparian strips.

**Solution:**

Transverse sectioning of a primary monocotyledon root uncovers a continuous, highly specialized cellular ring layer called the endodermis. The radial and tangential walls of these cells undergo heavy deposition of hydrophobic suberin polymers and rigid lignin complexes. These band-like structural blockages are known as Casparian strips. They block the passive, non-selective apoplastic movement of water and solutes, forcing solutions to transition into the selective symplastic path through specialized thin-walled passage cells to enter the central metaxylem stream.

**Final Answer:** Casparian strips within the specialized root endodermis

**Answer: (A)**

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## Q5.

### Solution

**Concept:** A phyllode is a specialized modification of the leaf petiole or rachis, which becomes flattened, green, and leaf-like to conduct photosynthesis, while the true lamina or leaflets drop off early to minimize transpirational water loss in arid environments.

**Solution:**

In many xerophytic plants and specific arid-zone pulse or legume variants, leaves adapt structurally to limit transpiration:

- The true compound leaflets are caducous, meaning they drop off early during developmental stages.
- The main petiole or rachis compensates by flattening, expanding into a green blade-like profile, and assuming the complete photosynthetic role.

This precise anatomical modification of a petiole mimicking a leaf blade is called a phyllode (commonly observed in taxa like *Acacia auriculiformis*). It is distinct from a phylloclade or cladode, which represent photosynthetic modifications of stem structures.

**Final Answer:** Phyllode structure

**Answer: (A)**

Go Back to Question 5

## Q6.

### Solution

**Concept:** In monocotyledonous stems (such as high-yield $C_4$ bioenergy grasses), the vascular bundles are closed, collateral, and scattered throughout the ground tissue. Each bundle is individually enclosed and reinforced by a specialized jacket of thick-walled mechanical tissue called a sclerenchymatous bundle sheath.

**Solution:**

Anatomical mapping of a typical monocotyledonous stem reveals vascular bundles that lack cambium (closed) and are distributed extensively across the parenchymatous ground tissue. To prevent mechanical structural lodging, buckling, or snapping caused by high wind velocities, each individual vascular bundle is surrounded by a highly protective, thick-walled jacket. This structural reinforcement layer is composed of dead, lignified mechanical cells known as the sclerenchymatous bundle sheath.

**Final Answer:** Sclerenchymatous bundle sheath jacket

**Answer: (A)**

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## Q7.

### Solution

**Concept:** A cyathium is a highly specialized pseudanthial inflorescence characteristic of the genus *Euphorbia* (Euphorbiaceae), where a cup-shaped involucre enclosing multiple single-stamened male florets surrounds a solitary, centrally positioned, long-stalked female floret.

**Solution:**

Let's break down the unique morphological configuration presented by this Euphorbiaceae variant:

- **Involucre:** A structural cup-formed perimeter formed by fused bracts that mimics a single actinomorphic flower.
- **Male Florets:** Represented by numerous reduced, naked, single-stamened flowers arranged in scorpioid cymes inside the cup.
- **Female Floret:** A solitary, centrally located, trilocular, long-stalked (pedicellate) pistillate flower that eventually hangs outside the cup.

This highly integrated, deceptive floral assembly is technically termed a cyathium inflorescence.

**Final Answer:** Cyathium inflorescence

**Answer: (A)**

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## Q8.

### Solution

**Concept:** Bulliform cells (or motor cells) are large, bubble-shaped, highly vacuolated epidermal cells found on the upper surface of many grass leaves. They regulate leaf rolling and unrolling configurations in response to changes in turgor pressure during drought stress.

**Solution:**

In drought-resistant Poaceae pasture grasses, the upper leaf epidermis features specialized groups of large, wedge-shaped, empty cells known as bulliform cells or motor cells.

- Under adequate water availability, these cells become fully turgid, keeping the leaf blade flattened and exposed to sunlight.
- During acute water deficits, these cells lose turgor pressure and go flaccid. This loss of turgor causes the leaf blade to roll inward, hiding the stomata-bearing surface to drastically minimize transpirational water loss.

**Final Answer:** Bulliform cells (Motor cells)

**Answer: (A)**

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## Q9.

### Solution

**Concept:** Vexillary (or papilionaceous) aestivation is a diagnostic floral arrangement unique to the sub-family Papilionoideae (Fabaceae), characterized by a large posterior standard petal overlapping two lateral wings, which enclose two fused anterior keel petals.

**Solution:**

The structural blueprint of the described corolla follows a strict descendingly imbricate arrangement known as vexillary aestivation:

(a) **Vexillum (Standard):** The largest, outermost posterior petal that overlaps the adjacent lateral petals.

(b) **Alae (Wings):** Two lateral, independent petals that in turn overlap the innermost pair.

(c) **Carina (Keel):** Two anterior petals that are fused along their lower edge to form a boat-shaped structure enclosing the essential reproductive organs.

This specific floral architecture is the definitive taxonomic marker for the sub-family Papilionoideae within the Fabaceae family.

**Final Answer:** Fabaceae (Papilionoideae sub-family)

**Answer: (A)**

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## Q10.

### Solution

**Concept:** A defining anatomical identifier of the family Solanaceae is an oblique ovary configuration paired with a highly swollen, expanded placental matrix bearing numerous ovules under an axile placentation model.

**Solution:**

Let's review the diagnostic floral index constraints given for this solanaceous group:

- The androecium consists of five epipetalous stamens that frequently dehisce via apical pores.
- The gynoecium is bicarpellary and syncarpous with a superior ovary.
- Crucially, the median carpellary plane is positioned obliquely at roughly a 45° angle relative to the mother axis, rather than remaining strictly anterior-posterior.

This anatomical shift is paired with an exceptionally swollen placenta that projects outward into the ovarian locules, sustaining an axile placentation layout.

**Final Answer:** Oblique ovary with axile placentation configuration

**Answer: (A)**

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## Q11.

### Solution

**Concept:** A caryopsis is a specialized simple, dry, indehiscent, single-seeded fruit where the pericarp (fruit wall) is completely fused with the testa (seed coat), characteristic of members of the grass family (Poaceae).

**Solution:**

In the systemic taxonomy of cereal crops (such as wheat, maize, rice, and forage grasses of the family Poaceae), the structural grain represents a fruit rather than a naked seed. This fruit develops from a monocarpellary, superior, unilocular ovary. During maturation, the outer fruit wall layers (the pericarp) completely fuse with the underlying seed coat (the testa) into a single unified membrane. The precise technical term for this dry, single-seeded, completely fused indehiscent fruit variant is a caryopsis.

**Final Answer:** Caryopsis

**Answer: (A)**

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## Q12.

### Solution

**Concept:** The tetradynamous state is an androecium configuration characterized by six stamens arranged in two distinct whorls: an outer whorl of two short stamens and an inner whorl of four long stamens. This condition is a key diagnostic feature of the family Brassicaceae.

**Solution:**

A morphological analysis of the family Brassicaceae (Cruciferae) reveals a distinct staminal arrangement:

- Total number of stamens = 6.
- Outer whorl = 2 shorter stamens positioned laterally.
- Inner whorl = 4 longer stamens positioned antero-posteriorly.

This 2 + 4 structural setup, defined by two distinct length profiles and whorls, is technically termed a tetradynamous configuration. It differs from a didynamous setup, which consists of four stamens total (two long and two short).

**Final Answer:** Tetradynamous state

**Answer: (A)**

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## Q13.

### Solution

**Concept:** A monadelphous androecium is a structural configuration where the filaments of all stamens are fused together into a single continuous collar or staminal tube surrounding the style, while leaving the anthers free at the apex. This is a definitive floral feature of the family Malvaceae.

**Solution:**

In industrial fiber lines and species belonging to the family Malvaceae (such as cotton and hibiscus), the androecium undergoes significant structural fusion:

- The individual filaments of numerous stamens fuse laterally to form a single hollow cylinder known as a staminal tube or collar.
- This tube encloses the elongated style of the gynoecium, while the single-celled (monothecous), reniform anthers remain free along its upper section and apex.

This configuration of stamens fused into a single bundle or column is termed a monadelphous androecium.

**Final Answer:** Monadelphous androecium forming a staminal tube

**Answer: (A)**

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## Q14.

### Solution

**Concept:** The production of pungent, sulfur-containing glucosinolates (such as sinigrin) stored within specialized idioblastic cells called myrosin cells (or mustard oil glands) is a classic chemotaxonomic marker for the family Brassicaceae.

**Solution:**

The presence of specialized secretory idioblasts containing glucosinolate compounds alongside the enzyme myrosinase serves as a definitive biochemical and structural fingerprint for the family Brassicaceae (Cruciferae). When plant tissues are crushed or attacked, these specialized idioblasts rupture, allowing the enzyme to hydrolyze sinigrin into pungent, volatile isothiocyanates (mustard oils). This system functions as a chemical defense mechanism against herbivores and pathogens.

**Final Answer:** Brassicaceae

**Answer: (A)**

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## Q15.

### Solution

**Concept:** Marginal placentation is defined by a monocarpellary, unilocular superior ovary where ovules are arranged in two alternating rows along the ventral suture line, a structural characteristic of the family Fabaceae (Leguminosae).

**Solution:**

In the systematic screening of pasture and grain legumes (family Fabaceae), the gynoecium displays a highly consistent architectural layout:

- The ovary is superior, unilocular, and derived from a single carpel (monocarpellary).
- The placenta develops as an elongated ridge along the ventral suture line where the margins of the carpellary leaf fuse.
- The ovules are attached along this vertical margin line in two alternating rows.

This configuration is known as marginal placentation and gives rise to the classic legume pod fruit.

**Final Answer:** Marginal placentation

**Answer: (A)**

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## Q16.

### Solution

**Concept:** The photorespiratory ($C_2$) salvage pathway is an energetically costly process triggered when RuBisCO acts as an oxygenase. For every single molecule of $O_2$ fixed, the metabolic salvage cycle spanning chloroplasts, peroxisomes, and mitochondria directly consumes a net total of 3 ATP and 2 NADPH equivalent units.

**Solution:**

When elevated temperatures cause RuBisCO to function as an oxygenase rather than a carboxylase, it adds $O_2$ to Ribulose-1,5-bisphosphate (RuBP), producing one molecule of 3-phosphoglycerate (3-PGA) and one molecule of 2-phosphoglycolate. To salvage the carbon trapped in phosphoglycolate, the plant runs the photorespiratory carbon oxidation (PCO) cycle across three separate organelles:

(a) The structural recovery pathway releases one molecule of $CO_2$ for every two molecules of glycolate processed in the mitochondria.

(b) Re-assimilating the ammonia ($NH_4^+$) released during glycine decarboxylation and converting glycerate back into 3-PGA requires a direct input of energy.

(c) Summing the energetic costs of the structural salvage pathway reveals a net consumption of 3 ATP and 2 NADPH molecules per single molecule of fixed oxygen, without generating any new chemical energy.

**Final Answer:** Consumption of 3 ATP and 2 NADPH molecule segments

**Answer: (B)**

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## Q17.

### Solution

**Concept:** Stomatal opening is driven by a light-activated plasma membrane $H^+$-ATPase proton pump. This creates an electrochemical gradient that drives the active influx of $K^+$ ions and accumulation of malate, increasing turgor pressure within the guard cells.

**Solution:**

Biophysical tracking shows that when blue light strikes guard cell photoreceptors, it stimulates a plasma membrane-bound $H^+$-ATPase proton pump. The biochemical sequence proceeds as follows:

(a) **Proton Efflux:** The pump actively expels hydrogen ($H^+$) ions out of the guard cell cytoplasm into the surrounding apoplast, hyperpolarizing the plasma membrane.

(b) **Potassium Influx:** This negative membrane potential drives the passive, rapid influx of potassium ($K^+$) ions into the cell through inward-rectifying channels.

(c) **Anion Accumulation and Malate Synthesis:** To balance the positive charge, chloride ($Cl^-$) ions are taken up, and starch is broken down down into phosphoenolpyruvate to synthesize malate anions.

(d) **Osmotic Swelling:** The high accumulation of $K^+$ and malate lowers the internal solute potential ($\psi_s$), causing water to rush inward down an osmotic gradient, which increases guard cell turgidity and opens the pore.

**Final Answer:** Active efflux of $H^+$ ions, influx of $K^+$ ions, and synthesis of malate

**Answer: (A)**

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## Q18.

### Solution

**Concept:** During non-cyclic photophosphorylation, the oxygen-evolving complex (OEC) splits water to resupply electrons to the oxidized reaction center of Photosystem II ($P^+_{680}$). Blocking this photolysis step locks $P_{680}$ in its oxidized state, halting the electron transport chain.

**Solution:**

In the thylakoid light-dependent Z-scheme network, absorption of a photon excites the Photosystem II reaction center, which ejects an electron to become oxidized $P^+_{680}$. Under normal physiological conditions, the oxygen-evolving complex (OEC) photolyses water ($2H_2O \rightarrow O_2 + 4H^+ + 4e^-$) and transfers these electrons to reduce $P^+_{680}$ back to its ground state ($P_{680}$), preparing it for subsequent excitation. If a biochemical blocker halts water photolysis at the OEC level, $P^+_{680}$ cannot receive replacement electrons. Consequently, it remains locked in its oxidized state ($P^+_{680}$), arresting further linear electron transport and light absorption.

**Final Answer:** $P_{680}$ remains locked in a highly oxidized state ($P^+_{680}$), arresting further light absorption.

**Answer: (A)**

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## Q19.

### Solution

**Concept:** According to the cohesion-tension theory, transpirational water movement is a passive process driven by a continuous, decreasing thermodynamic water potential gradient ($\psi_w$) extending from the soil through the plant roots and xylem up to the atmosphere.

**Solution:**

Let's analyze the given water potential values ($\psi_w$) across the forest canopy continuum:

$$\psi_{\text{root cortex}} = -0.3 \text{ MPa}$$

$$\psi_{\text{xylem fluid}} = -0.6 \text{ MPa}$$

$$\psi_{\text{atmosphere}} = -95.0 \text{ MPa}$$

Water moves spontaneously down a thermodynamic gradient from a region of higher water potential (less negative) to a region of lower water potential (more negative). Comparing these values:

$$-0.3 \text{ MPa} > -0.6 \text{ MPa} > -95.0 \text{ MPa}$$

This arrangement forms a continuous, steeply decreasing gradient from the root cortex through the xylem tissues out into the dry atmospheric boundary layer. This gradient provides the driving force for passive water transport via cohesive water columns, as described by the cohesion-tension theory.

**Final Answer:** Continuous water movement along a decreasing thermodynamic gradient from root to atmosphere

**Answer: (A)**

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## Q20.

### Solution

**Concept:** Succinate dehydrogenase (Complex II) is a dual-functional enzyme that participates in both the citric acid cycle (converting succinate to fumarate) and the mitochondrial electron transport chain by transferring electrons to the ubiquinone pool.

**Solution:**

During mitochondrial cellular respiration in germinating seeds, the conversion of succinate into fumarate within the matrix of the Krebs cycle is catalyzed by the enzyme succinate dehydrogenase. This enzyme complex is unique because it is the only membrane-bound enzyme of the citric acid cycle; it is embedded directly within the inner mitochondrial membrane. In this position, it functions simultaneously as Complex II of the respiratory electron transport chain (ETC), direct-loading electrons extracted from succinate oxidation via $FADH_2$ directly into the lipid-soluble ubiquinone (coenzyme Q) pool.

**Final Answer:** Complex II (Succinate Dehydrogenase)

**Answer: (A)**

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## Q21.

### Solution

**Concept:** In $C_4$ plants like sugarcane, the initial carbon fixation step occurs in the mesophyll cell cytoplasm, where the enzyme phosphoenolpyruvate (PEP) carboxylase fixes atmospheric $CO_2$ (in the form of $HCO_3^-$) onto the 3-carbon acceptor molecule phosphoenolpyruvate (PEP).

**Solution:**

The dark fixation chemistry of elite $C_4$ bioenergy crops like sugarcane relies on spatial separation between two cell types to minimize photorespiration:

(a) **Mesophyll Cytoplasm:** The initial carboxylation step occurs here. The primary enzyme involved is phosphoenolpyruvate carboxylase (**PEP carboxylase**), which has a high affinity for carbon dioxide and is insensitive to oxygen.

(b) **Substrate Acceptor:** The compound that acts as the initial gaseous carbon acceptor is the 3-carbon molecule **phosphoenolpyruvate (PEP)**. This reaction forms oxaloacetate (OAA), a 4-carbon organic acid.

(c) This OAA is reduced to malate and transported into the bundle sheath cells for decarboxylation, releasing a high concentration of $CO_2$ directly around RuBisCO.

**Final Answer:** PEP carboxylase acting on Phosphoenolpyruvate (PEP)

**Answer: (A)**

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## Q22.

### Solution

**Concept:** During Prophase I of meiosis, the diplotene stage is characterized by the dissolution of the multi-protein synaptonemal complex, causing homologous chromosomes to pull apart except at chiasmata where crossovers occurred.

**Solution:**

Let's trace the progressive sub-stages of meiotic Prophase-I during microsporogenesis:

- **Zygotene:** Homologous chromosomes begin pairing up side-by-side via assembly of the synaptonemal complex (synapsis).
- **Pachytene:** Synapsis is complete, and reciprocal physical crossing-over takes place between non-sister chromatids.
- **Diplotene:** The multi-protein synaptonemal complex degrades and dissolves. This causes the paired homologous chromosomes to separate slightly, remaining held together only at the exact physical cross-over nodes, which are termed chiasmata.
- **Diakinesis:** Chiasmata shift toward the chromosome ends via terminalization.

**Final Answer:** Diplotene stage

**Answer: (A)**

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## Q23.

### Solution

**Concept:** Dominant epistasis is a gene interaction where a dominant allele at one locus masks the phenotypic expression of alleles at a second, independently assorting locus, altering the classic $9:3:3:1$ dihybrid $F_2$ ratio into a modified $12:3:1$ ratio.

**Solution:**

In a classic Mendelian dihybrid cross involving independent assortment, the expected $F_2$ phenotypic segregation ratio is $9:3:3:1$, corresponding to the genotypic distributions:

$$9\,R\_Y\_ : 3\,R\_yy : 3\,rrY\_ : 1\,rryy$$

When a dominant epistatic interaction occurs, a single dominant allele at one locus (let's assume locus $R$) masks the expression of the alleles at the second locus ($Y/y$).

- Any individual carrying at least one dominant $R$ allele ($R\_Y\_$ and $R\_yy$) will express the same dominant epistatic phenotype.
- Combining these classes yields: $9 + 3 = 12$.
- The remaining classes express their typical phenotypes: 3 for the recessive-dominant combination ($rrY\_$) and 1 for the double homozygous recessive individual ($rryy$).

This modifies the phenotypic distribution pattern into a $12:3:1$ ratio.

**Final Answer:** $\boxed{12:3:1}$

**Answer: (A)**

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## Q24.

### Solution

**Concept:** Colchicine is an anti-mitotic alkaloid derived from *Colchicum autumnale* that binds to tubulin dimers, inhibiting microtubule polymerization and preventing spindle fiber formation. This arrests dividing cells at the metaphase stage.

**Solution:**

When dividing plant root tip cells are treated with colchicine, the chemical targets the cellular cytoskeleton.

- It binds specifically to free tubulin dimers, preventing them from polymerizing into functional microtubules.
- Without functional microtubules, mitotic spindle fibers cannot form or attach to the kinetochores of duplicated chromosomes.
- As a result, the condensed chromosomes cannot align along the equatorial plate or separate toward opposite poles, locking the cell division cycle at the metaphase stage (often called a C-metaphase). This mechanism is widely used in plant breeding to induce polyploidy.

**Final Answer:** Inhibition of tubulin polymerization, arresting cells explicitly at Metaphase

**Answer: (A)**

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## Q25.

### Solution

**Concept:** Genetic map distance between two linked loci on a chromosome is calculated from a test cross by determining the total recombination frequency, where 1% recombination frequency equals 1 centimorgan (cM).

**Solution:**

Let's calculate the map distance separating the two linked loci step-by-step:

(a) Identify the recombinant progeny classes resulting from the test cross ($AaBb \times aabb$):

$$\text{Recombinant Class 1 } (Ab) = 6\%$$

$$\text{Recombinant Class 2 } (aB) = 6\%$$

(b) Calculate the total recombination frequency by summing the percentages of these recombinant phenotypes:

$$\text{Total Recombination Frequency} = 6\% + 6\% = 12\%$$

(c) According to genetic mapping principles established by Sturtevant, 1% recombination frequency corresponds directly to 1 genetic map unit or centimorgan (cM).

Therefore, a total recombination rate of 12% indicates that the two loci are separated by a genetic map distance of 12 cM.

**Final Answer:** 12 centimorgans (cM)

**Answer: (A)**

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# Answer Key

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