UPCATET Agriculture Botany Sample Paper-8

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. In the structural organization of specialized halophytic species such as *Rhizophora mangle*, the cortical parenchyma of the negatively geotropic respiratory roots (pneumatophores) undergoes programmed schizogenous intercellular separation. Identify the exact tissue modification and its primary physiological coordination factor:

(A) Lignified sclerenchyma idioblasts maintaining mechanical rigidity under extreme hydrostatic pressure.

(B) Interconnected lacunate aerenchyma channels facilitating downward passive diffusion of atmospheric oxygen.

(C) Suberized exodermis plates preventing the entry of gaseous metabolic inhibitors.

(D) Secondary tylose occlusions blocking vascular reflux during high-tide immersion phases.

Q2. Anatomical investigation of a transverse section of an advanced xerophytic monocotyledonous leaf reveals large, motor-like epidermal units located within the intercostal regions of the upper epidermis. When these cells lose turgor pressure during severe moisture deficit, the leaf rolls tightly inward. Identify these structures:

(A) Trichomes executing localized micro-climate boundary layer insulation.

(B) Bulliform cells acting as mechanical hydropassive levers for leaf rolling.

(C) Velamen membranes facilitating rapid vapor condensation along the lamina surface.

(D) Lithocysts containing dense calcium carbonate crystals acting as structural anchors.

Q3. Consider the unique inflorescence configuration observed in the genus *Ficus* (Moraceae). The highly modified peduncle forms a fleshy, hollow, flask-shaped receptacle enclosing hundreds of minute, uniserial flowers that communicate with the exterior world solely via a tightly guarded terminal ostiole. Identify the precise botanical designation of this inflorescence pattern:

(A) Cyathium mimicking a solitary bisexual entomophilous flower.

(B) Hypanthodium structurally coordinating obligate mutualistic pollination vectors.

(C) Verticillaster executing compressed dichasial cyme transitions.

(D) Coenanthium providing a flattened, open-air platform for anemophilous dispersal.

Q4. In the complex floral mechanical architecture of the Fabaceae family, the two lowermost anterior petals fuse smoothly along their margins to encapsulate the staminal column and the elongated pistil. This specific dynamic unit functions directly as an tensioned spring system for insect-mediated pollination tripping. Identify this petal complex:

(A) Vexillum acting as a broad, colorful dorsal landing vector.

(B) Alae providing bilateral lateral platforms for vector stabilization.

(C) Carina (Keel) providing the elastic packaging envelope holding reproductive organs under tension.

(D) Corona forming an accessory whorl of staminal appendages.

Q5. Analyze the vascular architecture of a typical advanced dicotyledonous root. During early secondary growth phases, the initiation site of the vascular cambium strip follows a distinct undulating pathway. Identify the exact tissue layers responsible for initiating this secondary lateral meristem cylinder:

(A) Exclusively from the internal cells of the endodermis directly bounding the protoxylem poles.

(B) Parenchyma cells located immediately beneath the phloem bundles combined with pericycle tissue segments external to the protoxylem poles.

(C) Cortical collenchyma cells undergoing dedifferentiation in response to localized auxin depletion.

(D) Pith parenchyma elements undergoing rapid anticlinal division lines.

Q6. The asymmetric leaf morphology of certain aquatic macrophytes exhibits distinct heterophylly. The submerged leaves are finely dissected, ribbon-like, and lack a cuticular layer, whereas the floating or emergent leaves are broad, coriaceous, and possess functional stomata. This structural plastic response is primarily driven by which signaling/environmental interface?

(A) Localized abscisic acid synthesis ratios coupled with differential light quality gradients.

(B) Static gibberellin synthesis occurring purely within root apical meristems.

(C) Hydrostatic pressure constraints overriding genetic transcriptional expression.

(D) Rapid calcium-dependent mechanotransduction caused by wind-driven current patterns.

Q7. Microscopic examination of the foliar epidermis of a temperate C4 grass reveals specialized stomatal complexes. Unlike the kidney-shaped guard cells found in dicotyledons, these guard cells display a narrow, elongated central region with bulbous, thin-walled terminal ends, tightly paired with distinct neighboring cells. Identify the morphological classification of these cells:

(A) Reniform guard cells flanked by asymmetric perigene subsidiary units.

(B) Graminaceous (dumbbell-shaped) guard cells flanked by distinct subsidiary cells.

(C) Anomocytic stomatal complexes lack recognizable adjacent cell distinctions.

(D) Actinocytic ring configurations distributing mechanical stress omnidirectionally.

Q8. In the evolutionary modification of cauline structures, certain taxonomic groups develop flattened, leaf-like green stems of limited growth, which consist of only one or two internodes. These structures completely assume the photosynthetic role of reduced, non-functional scale leaves. Select the exact technical term for this stem adaptation:

(A) Phyllode derived from the modification of a petiole or rachis axis.

(B) Cladode characterized by unlimited growth potential with multiple nodes.

(C) Cladophyll / Phylloclade displaying unlimited indeterminate expansion vectors.

(D) Cladophyll (Phylloclade) of limited growth specifically designated as a Cladode.

Q9. A diagnostic floral profile of an economically vital agricultural family reveals an actinomorphic, bisexual structure with a persistent, accrescent calyx. The gynoecium is bicarpellary, syncarpous, with an obliquely placed ovary containing swollen axile placentae bearing numerous ovules. Identify the agricultural family matching this description:

(A) Fabaceae

(B) Solanaceae

(C) Poaceae

(D) Brassicaceae

Q10. The spikelet unit forms the fundamental architecture of the inflorescence within the family Poaceae. In a complex multi-flowered grass spikelet, analyze the spatial arrangement of the basal sterile bracts that subtend the individual fertile floret entities. Identify the exact botanical terms for these outer sterile bracts and the inner specialized fertile bract enclosing the flower:

(A) Glumes acting as basal sterile bracts; Lemma acting as the outer fertile bract.

(B) Palea acting as basal sterile bracts; Glumes acting as inner floral envelopes.

(C) Lodicules acting as protective sterile outer scales; Lemma forming the superior crown.

(D) Spathe acting as a broad enclosing bract; Palea acting as the primary backing plate.

Q11. An agronomist examines the floral morphology of a major pulse crop (*Cajanus cajan*). The androecium consists of ten stamens arranged in a specific spatial formulation where nine filaments are fused together into a basal tube, while the tenth posterior stamen remains entirely free. Identify this precise structural pattern:

(A) Monadelphous configuration typical of the Malvaceae family.

(B) Diadelphous configuration showing a distinct (9) + 1 arrangement.

(C) Polyadelphous bundle groups facilitating synchronous pollen release.

(D) Syngenesious anther columns surrounding a central free style.

Q12. The family Brassicaceae (Cruciferae) displays a highly specialized androecial organization that serves as a primary diagnostic marker during field identification of oilseed crops like *Brassica juncea*. This arrangement comprises six stamens distributed across two distinct concentric whorls. Identify this characteristic spatial pattern:

(A) Didynamous arrangement: two long outer stamens and two short inner ones.

(B) Tetradynamous arrangement: two short outer stamens and four long inner ones.

(C) Monadelphous column: all six filaments fused into a single hollow cylinder.

(D) Gynandrous system: direct fusion of all six filaments with the style axis.

Q13. The systematic classification of agricultural crops often relies on specific fruit typologies. In the family Cucurbitaceae (e.g., *Cucumis sativus*), the characteristic fruit develops from an inferior, tri-carpellary, unilocular ovary with parietal placentation, forming a thick, fleshy berry modified with a hard, unyielding rind. Identify this diagnostic fruit type:

(A) Hesperidium

(B) Pome

(C) Pepo

(D) Amphisarca

Q14. In the family Asteraceae (Compositae), which includes sunflower (*Helianthus annuus*), the individual florets are densely packed onto a common receptacle. The calyx undergoes a radical morphological shift, losing its leaf-like green form and transforming into specialized structures that facilitate wind-mediated seed dispersal. Identify these structures:

(A) Lodicules executing dynamic osmotic floral opening movements.

(B) Pappus consisting of persistent hairy, bristly, or feathery modifications.

(C) Epicalyx providing an extra whorl of defensive armor.

(D) Glumaceous scales shielding the delicate base of the ovaries.

Q15. A deep taxonomic review of agricultural cereal crops within the family Poaceae focuses on the microscopic structural adaptations of the reduced perianth. These tiny, fleshy scales swell by absorbing water rapidly at anthesis, forcing the lemma and palea apart to expose the reproductive organs. Identify these structures:

(A) Colleters

(B) Coleoptiles

(C) Lodicules

(D) Ligules

Q16. During the light-dependent reactions of photosynthesis, the transport of electrons through the Cytochrome b_6f complex drives protons across the thylakoid membrane. Identify the resulting electrochemical gradient layout across the sub-chloroplast compartments that powers ATP Synthase (CF_0CF_1):

(A) High H^+ concentration in the stroma; low H^+ concentration in the thylakoid lumen.

(B) High H^+ concentration in the thylakoid lumen; low H^+ concentration in the stroma.

(C) High H^+ concentration in the intermembrane space; low H^+ concentration in the matrix.

(D) Equal distribution of H^+ ions across both boundaries creating an electrical potential only.

Q17. In C4 plants, such as maize (*Zea mays*), the spatial segregation of carbon fixation steps minimizes photorespiration. Analyze the initial carboxylation reaction. Identify the exact primary carbon dioxide acceptor molecule and the cell type where this first fixation step takes place:

(A) Ribulose-1,5-bisphosphate (RuBP) within the Bundle Sheath cells.

(B) Phosphoenolpyruvate (PEP) within the Mesophyll cells.

(C) Oxaloacetate (OAA) within the Vascular Parenchyma elements.

(D) 3-Phosphoglycerate (3-PGA) within the Kranz Anatomy border layers.

Q18. The physiological process of stomatal closure during severe drought stress is regulated by complex signaling cascades within the guard cells. Upon perception of Abscisic Acid (ABA), specific ion channels are activated, leading to a massive efflux of solutes that drops guard cell turgidity. Identify the key ion channel movement that drives this response:

(A) Activation of inward-rectifying K^+ channels, triggering solute accumulation.

(B) Inhibition of anion channels, preventing chloride and malate leakage.

(C) Activation of outward-rectifying K^+ channels along with anion efflux through anion channels.

(D) Direct ATP-driven pumping of H^+ ions into the guard cell cytoplasm.

Q19. The Krebs cycle (Tricarboxylic Acid cycle) takes place in the mitochondrial matrix. Within this pathway, a single step involves the direct, substrate-level phosphorylation of a nucleoside diphosphate to generate a high-energy triphosphate compound. Identify the specific enzymatic step responsible for this conversion:

(A) Conversion of Isocitrate to α-Ketoglutarate by Isocitrate Dehydrogenase.

(B) Conversion of Succinyl-CoA to Succinate by Succinyl-CoA Synthetase.

(C) Oxidation of Succinate to Fumarate by Succinate Dehydrogenase.

(D) Condensation of Oxaloacetate and Acetyl-CoA by Citrate Synthase.

Q20. Photorespiration (C2 cycle) represents a metabolic pathway that occurs when Rubisco fixes oxygen instead of carbon dioxide. This process depends on the coordinated transport of metabolites across three distinct, physically separated organelles. Identify the correct chronological sequence of these organelles in the pathway:

(A) Chloroplast $\rightarrow$ Mitochondria $\rightarrow$ Peroxisome

(B) Chloroplast $\rightarrow$ Peroxisome $\rightarrow$ Mitochondria

(C) Peroxisome $\rightarrow$ Chloroplast $\rightarrow$ Mitochondria

(D) Mitochondria $\rightarrow$ Peroxisome $\rightarrow$ Chloroplast

Q21. The allocation of photosynthalates from source leaves to sink tissues occurs through phloem sieve tube elements via pressure-flow translocation. Identify the physiological mechanism that drives the active loading of sucrose into the sieve element-companion cell complexes at the source site:

(A) Passive diffusion down a concentration gradient through plasmodesmata connections.

(B) Sucrose-H^+ symport driven by a proton electrochemical gradient generated by plasma membrane H^+-ATPases.

(C) Facilitated antiport exchange swapping sodium ions for sucrose molecules.

(D) Dynamic hydrostatic suction generated by transpiration tension within the xylem vessels.

Q22. During the first meiotic division of gametogenesis, homologous chromosomes pair up and undergo genetic recombination. Identify the specific sub-stage of

Prophase I where the assembly of the synaptonemal complex is fully completed, and crossing over takes place between non-sister chromatids:

(A) Leptotene

(B) Zygotene

(C) Pachytene

(D) Diplotene

Q23. Consider a genetic cross involving two linked genes, A and B, in an agricultural crop. An individual heterozygous for both genes ($AaBb$) in the coupling (cis) phase is test-crossed with a double homozygous recessive ($aabb$) individual. If the recombination frequency between these two loci is exactly 16%, determine the expected percentage of recombinant progeny ($Aabb$ and $aaBb$ combined) in the resulting generation:

(A) 8%

(B) 16%

(C) 32%

(D) 84%

Q24. Mendelian inheritance patterns can be modified by epistatic interactions between different loci. In a cross involving two independent gene pairs governing grain color, a phenotypic ratio of 15 : 1 is observed in the F_2 generation. Identify the specific genetic mechanism responsible for this ratio:

(A) Complementary Gene Action (9 : 7)

(B) Duplicate Dominant Epistasis (15 : 1)

(C) Recessive Epistasis (9 : 3 : 4)

(D) Inhibitory Gene Interplay (13 : 3)

Q25. In plant cell biology, the formation of the new cell wall during cytokinesis is directed by a highly organized, transient cytoskeletal and vesicular structure. This structure forms along the equatorial plane of the dividing cell after the chromosomes have separated. Identify this structure:

(A) Tonoplast

(B) Phragmoplast

(C) Plasmodesmata

(D) Axoneme

Detailed Solutions

Q1.

Solution

Concept: Pneumatophores are specialized, negatively geotropic breathing roots developed by mangrove species (such as *Rhizophora mangle* and *Avicennia germinans*) inhabiting anaerobic, waterlogged halophytic environments. To facilitate gas exchange, the cortical parenchyma cells undergo programmed cell separation (schizogeny), creating an extensive system of internal air spaces called lacunate aerenchyma channels.

Solution:

In specialized halophytic coastal environments, the substrate is highly saline and chronically hypoxic or anaerobic. To survive, mangrove species like *Rhizophora mangle* develop specialized aerial roots called pneumatophores that grow vertically upward (negatively geotropic) out of the mud and water into the atmosphere.

The internal anatomy of these breathing roots is modified to optimize gas transport: the cortical parenchyma cells undergo highly regulated, programmed schizogenous intercellular separation. Instead of remaining tightly packed, the cell walls separate along their middle lamellae, creating an integrated network of large internal air cavities known as lacunate aerenchyma channels. These hollow, interconnected structural pipelines act as low-resistance conduits that facilitate the passive downward diffusion of atmospheric oxygen from the external lenticels to the submerged, actively respiring root tissues, sustaining cellular respiration under waterlogged conditions.

Final Answer: $\boxed{\text{Interconnected lacunate aerenchyma channels facilitating downward passive diffusion of atmospheric oxygen.}}$

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

Go Back to Question 1

Q2.

Solution

Concept: Bulliform cells (motor cells) are large, bubble-shaped, hygroscopic epidermal cells arranged in longitudinal bands along the intercostal regions of the adaxial (upper) epidermis in xerophytic monocot leaves (particularly grasses). Under severe moisture deficits, these cells rapidly lose turgor pressure and shrink, causing the leaf lamina to roll tightly inward to minimize transpirational surface area.

Solution:

The leaf anatomy of drought-resistant monocotyledonous crops and grasses reveals specialized evolutionary adaptations within the adaxial epidermis. Positioned in bands between the vascular bundles (the intercostal regions) are groups of exceptionally large, thin-walled, highly vacuolated epidermal units called **bulliform cells**.

These cells act as dynamic, water-sensitive hydrostatic switches:

- When water is abundant, the bulliform cells absorb moisture, become highly turgid, and exert lateral mechanical pressure that keeps the leaf blade expanded flat to maximize light interception.
- When the plant experiences severe atmospheric vapor pressure deficits or soil water scarcity, these thin-walled cells lose water faster than neighboring epidermal cells, causing a sudden drop in turgor pressure.
- As they shrink and collapse inward, they function as mechanical hydropassive levers, pulling the margins of the leaf blade together and causing it to roll tightly inward. This structural transformation shelters the stomata within a humid micro-climate, reducing transpirational water loss.

Final Answer: $\boxed{\text{Bulliform cells acting as mechanical hydropassive levers for leaf rolling.}}$

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

Go Back to Question 2

Q3.

Solution

Concept: A hypanthodium is a highly specialized inflorescence characteristic of the genus *Ficus* (Moraceae). The main peduncle modifies into a fleshy, hollow, flask-shaped or globose receptacle that encloses hundreds of minute uniserial flowers on its inner wall, communicating with the exterior environment exclusively through a small, bract-covered terminal opening called an ostiole.

Solution:

Let's analyze the morphological properties of the inflorescence architecture found in the genus *Ficus* (such as the common fig or banyan tree):

(a) **Receptacle Modification:** The central axis or peduncle does not remain flat or elongated; instead, it grows fleshy and curves completely inward to form a hollow, flask-shaped capsule.

(b) **Flower Distribution:** Hundreds of tiny, simplified, unisexual flowers (male, female, and sterile gall flowers) line the interior walls of this closed chamber.

(c) **External Communication:** The interior cavity is isolated from the outside world except for a tiny, narrow terminal pore called the **ostiole**, which is tightly guarded by overlapping scales or bracts.

This unique structural design is botanically designated as a **hypanthodium**. It functions as a specialized reproductive chamber that coordinates an obligate mutualistic pollination vector with tiny chalcid wasps (Agaonidae), which enter through the ostiole to lay eggs and transfer pollen.

Final Answer: $\boxed{\text{Hypanthodium structurally coordinating obligate mutualistic pollination vectors.}}$

Answer: (B)

Go Back to Question 3

Q4.

Solution

Concept: In the papilionaceous corolla of the family Fabaceae, the five petals are highly differentiated. The two lowermost anterior petals are fused along their margins to form a boat-shaped structural unit called the carina (keel), which encapsulates the staminal column and pistil under mechanical tension, serving as a spring-loaded tripping platform for insect pollinators.

Solution:

The specialized floral architecture of the family Fabaceae (sub-family Papilionoideae) is adapted for specific insect-mediated pollination mechanisms (such as the banner-keel or tripping mechanism). The corolla features a distinct zygomorphic arrangement of five petals:

- **Vexillum (Standard):** A single, large, rear dorsal petal that acts as a visual advertisement to attract flying insects.
- **Alae (Wings):** Two lateral petals that extend outward, providing horizontal landing platforms for insect vectors.
- **Carina (Keel):** The two lowermost anterior petals, which fuse smoothly along their lower edges to form a rigid, boat-shaped structure.

This **carina (keel) complex** encapsulates the ten stamens and the elongated style. The reproductive organs are held inside the keel under mechanical tension. When a heavy insect landing on the wing petals exerts downward force, it trips the keel complex, causing the stamens and stigma to spring out explosively against the insect's ventral abdomen, ensuring effective pollen transfer.

Final Answer: $\boxed{\text{Carina (Keel) providing the elastic packaging envelope holding reproductive organs under tension.}}$

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

Go Back to Question 4

Q5.

Solution

Concept: The vascular cambium in a typical dicotyledonous root is secondary in origin. It is initiated from two distinct tissue zones: the parenchyma cells located immediately beneath (internal to) the primary phloem strands, and the pericycle tissue segments located directly outside (external to) the protoxylem poles, creating an initially wavy or undulating meristematic ring.

Solution:

In the primary state of an advanced dicotyledonous root, the vascular bundles are arranged radially, with alternating patches of primary xylem and primary phloem separated by parenchymatous connective tissue. The primary xylem exhibits an exarch configuration, meaning the protoxylem poles point outward toward the pericycle.

When secondary growth begins, a continuous lateral meristematic cylinder (the vascular cambium) must be established:

(a) First, ordinary parenchyma cells located immediately beneath the primary phloem patches undergo dedifferentiation, becoming actively dividing meristematic cells. This forms separate strips of cambium internal to the phloem.

(b) Shortly after, the pericycle cells located directly external to the outward-pointing protoxylem poles also undergo dedifferentiation and begin dividing.

(c) These newly formed meristematic segments join together to form a continuous, wavy, undulating loop that snakes inside the phloem patches and outside the xylem poles.

As the segments beneath the phloem produce secondary xylem inward faster than the pericycle segments, this undulating loop is pushed outward, eventually forming a uniform, concentric meristematic cylinder.

Final Answer: $\boxed{\text{Parenchyma cells located immediately beneath the phloem bundles combined with pericycle tissue segments external to the protoxylem poles.}}$

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

Go Back to Question 5

Q6.

Solution

Concept: Heterophylly in amphibious or aquatic macrophytes represents a form of developmental plasticity where a single plant produces distinctly different leaf phenotypes depending on the microenvironment. This structural shift is primarily regulated by the plant hormone abscisic acid (ABA), whose levels change in response to environmental cues like light quality gradients and water immersion.

Solution:

Many aquatic macrophytes exhibit heterophylly, producing highly specialized leaf forms on the same individual plant body based on whether the nodes develop submerged or in the aerial environment:

- **Submerged Leaves:** Developed under water, these leaves are finely dissected, capillary, or ribbon-like to minimize drag from water currents and maximize the surface-area-to-volume ratio for dissolved gas and nutrient absorption. They lack a protective waxy cuticle and functional stomata.
- **Floating/Emergent Leaves:** Developed at or above the water surface, these leaves are broad, flat, and coriaceous (leathery) to optimize light capture, and they possess a thick cuticle and functional stomata for gas exchange.

This developmental plasticity is controlled by a biochemical interface: submergence alters the red to far-red light quality gradient and limits gas exchange, which suppresses endogenous **abscisic acid (ABA)** synthesis. When shoots breach the water surface, exposure to full atmospheric air and altered light qualities triggers a rise in internal ABA levels, activating transcription factors that shift leaf primordia development from the dissected aquatic form to the broad aerial phenotype.

Final Answer: Localized abscisic acid synthesis ratios coupled with differential light quality gradients.

Answer: (A)

Go Back to Question 6

Q7.

Solution

Concept: Graminaceous stomata, unique to the family Poaceae (grasses) and certain related monocots, feature specialized dumbbell-shaped guard cells. These cells consist of a narrow, thick-walled central region flanked by thin-walled, bulbous terminal ends, and they are closely associated with distinct, triangular or dome-shaped neighboring subsidiary cells.

Solution:

Let's examine the cellular architecture of the foliar epidermis in temperate C4 grass lineages:

- In typical dicot leaves, the stomatal complex features reniform (kidney-shaped) guard cells with uniformly distributed microfibrils that curve outward when turgid.
- In contrast, members of the grass family (Poaceae) exhibit a specialized **graminaceous** stomatal morphology. The guard cells are elongated and **dumbbell-shaped**, consisting of a narrow, rigid central region with heavily thickened primary cell walls, flanked on either end by bulbous, thin-walled terminal loops.
- These dumbbell-shaped guard cells are closely associated with a pair of distinct, specialized epidermal cells known as **subsidiary cells** positioned parallel to them.

When turgor pressure increases, the thin-walled bulbous ends absorb water and swell rapidly, pushing against each other and pulling the rigid, parallel central sections apart to open a wide, linear stomatal pore.

Final Answer: $\boxed{\text{Graminaceous (dumbbell-shaped) guard cells flanked by distinct subsidiary cells.}}$

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

Go Back to Question 7

Q8.

Solution

Concept: A cladode is a specialized, green, photosynthetic stem modification characterized by limited growth, typically consisting of only one or two internodes. It assumes the functional role of a leaf when the true leaves are reduced to non-functional scales or spines, distinguishing it from an indeterminate phylloclade.

Solution:

Let's distinguish between the closely related morphological modifications of stem and leaf axes:

(a) **Phyllode:** A modification of the leaf assembly, where the petiole or rachis flattens out into a green, photosynthetic structure while the true lamina is reduced (commonly seen in *Acacia ampliceps*).

(b) **Phylloclade (Cladophyll):** A modified, green, leaf-like stem axis that displays **unlimited or indeterminate growth** with multiple nodes and internodes, often found in xerophytes like *Opuntia*.

(c) **Cladode:** A specialized form of a phylloclade that is structurally restricted to **limited or determinate growth**. It typically consists of only a single node and one or two internodes (as seen in *Ruscus* or *Asparagus*). The true leaves are reduced to minute scales, and this compressed stem segment carries out all primary photosynthetic functions.

Final Answer: $\boxed{\text{Cladophyll (Phylloclade) of limited growth specifically designated as a Cladode.}}$

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

Go Back to Question 8

Q9.

Solution

Concept: The family Solanaceae is characterized by a unique combination of floral traits: actinomorphic symmetry, a persistent and accrescent calyx that remains and grows around the fruit, and a syncarpous, bicarpellary gynoecium containing an obliquely oriented ovary with highly swollen axile placentae.

Solution:

Let's analyze the diagnostic characteristics provided in the floral profile:

- **Symmetry and Sexuality:** The flowers are radially symmetrical (actinomorphic) and bisexual.
- **Calyx Modification:** The calyx is persistent and often **accrescent**, meaning it continues to grow after fertilization to enclose the developing fruit (as seen in the papery husks of *Physalis* or the persistent cap of *Solanum melongena*).
- **Gynoecium Anatomy:** The ovary is superior, syncarpous, and formed by two carpels (bicarpellary). Crucially, the ovary is placed **obliquely** at an angle of approximately 45° relative to the posterior-anterior axis of the flower. Inside the chambers, the placenta is exceptionally **swollen** and thick, bearing numerous ovules arranged in an axile placentation pattern.

This precise combination of anatomical and morphological traits is the classic diagnostic blueprint for the nightshade family, **Solanaceae**.

Final Answer: $\boxed{\text{Solanaceae}}$

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

Go Back to Question 9

Q10.

Solution

Concept: The spikelet is the basic unit of the grass (Poaceae) inflorescence. At its base, the spikelet axis (rachilla) bears two empty, sterile bracts called glumes. Above the glumes are one or more florets, each enclosed by an outer fertile bract called the lemma and an inner backing scale called the palea.

Solution:

Let's look at the structural hierarchy and botanical terminology of a grass spikelet within the family Poaceae:

(a) **Basal Sterile Layer:** At the very base of the spikelet unit, attached directly to the rachilla, sits a pair of empty, non-flowering protective bracts. These outer sterile bracts are called the **glumes** (typically divided into a lower first glume and an upper second glume).

(b) **Fertile Bract Layers:** Above the glumes are one or more individual reproductive units called florets. Each floret is enclosed by a pair of specialized bracts:

- The lower, outer, larger bract that faces away from the axis and often bears a stiff bristle (awn) is called the **lemma**. This is the primary outer fertile bract.
- The upper, inner, smaller, two-keeled scale that faces the axis and folds over the flower is called the **palea**.

Together, the lemma and palea enclose the true flower, which consists of reduced perianth scales (lodicules), stamens, and a pistil.

Final Answer: $\boxed{\text{Glumes acting as basal sterile bracts; Lemma acting as the outer fertile bract.}}$

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

Go Back to Question 10

Q11.

Solution

Concept: The diadelphous condition is a specialized staminal arrangement characteristic of the sub-family Papilionoideae (Fabaceae), where the staminal filaments are fused into two distinct groups or bundles. In major pulse crops like *Cajanus cajan* (pigeon pea), this manifests as a (9) + 1 configuration.

Solution:

In the floral analysis of the pulse crop *Cajanus cajan* (pigeon pea), which belongs to the family Fabaceae, the androecium contains exactly ten stamens. The filaments of these stamens are modified into a specific spatial layout:

- Nine of the ten staminal filaments fuse along their lateral margins to form a split, hollow basal cylinder or staminal sheet that surrounds the central ovary.
- The tenth stamen—the posterior or vexillary stamen situated closest to the standard petal—remains completely free, distinct, and separate from the fused bundle.

This configuration, where the stamens are split into two distinct groups, is termed **diadelphous** and is written in floral formulas as $A_{(9)+1}$. It differs from a monadelphous configuration (where all filaments fuse into a single tube, as in Malvaceae) or a syngenesious condition (where only the anthers fuse, as in Asteraceae).

Final Answer: $\boxed{\text{Diadelphous configuration showing a distinct (9) + 1 arrangement.}}$

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

Go Back to Question 11

Q12.

Solution

Concept: A tetradynamous arrangement is a characteristic androecial feature of the family Brassicaceae (Cruciferae) consisting of six stamens split between two whorls: an outer whorl of two short stamens and an inner whorl of four long stamens.
Solution:

In the field identification of cruciferous oilseed crops like *Brassica juncea* (mustard), the androecium provides a key diagnostic marker. The flower contains six functional stamens that are organized into two concentric whorls based on their filament lengths and positions:

- **Outer Whorl:** Consists of exactly **two short stamens** positioned laterally on either side of the flower.
- **Inner Whorl:** Consists of **four long stamens** arranged in pairs along the anterior and posterior planes.

This specific spatial pattern (2 + 4) is termed a **tetradynamous** arrangement. It is distinct from a didynamous arrangement (which features two long and two short stamens, common in Lamiaceae and Scrophulariaceae) and serves as a primary marker for the Brassicaceae family.
Final Answer: $\boxed{\text{Tetradynamous arrangement: two short outer stamens and four long inner ones.}}$

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

Go Back to Question 12

Q13.

Solution

Concept: A pepo is a specialized, inferior fleshy berry characteristic of the family Cucurbitaceae. It develops from a tri-carpellary, syncarpous, inferior ovary with parietal placentation, and it features a thick, fleshy mesocarp and endocarp surrounded by a hard, leathery outer rind derived from the receptacle and exocarp tissue.

Solution:

In systematic botany, the fruits of the gourd and cucumber family (Cucurbitaceae) follow a uniform structural blueprint:

(a) **Ovary Origin:** The fruit develops from an inferior, syncarpous ovary formed by three fused carpels (tri-carpellary). The ovary is unilocular but often appears multilocular due to the deeply intrusive, curved parietal placentae that bear numerous seeds.

(b) **Structural Modifications:** The inner wall layers (mesocarp and endocarp) develop into a fleshy, moist pulp.

(c) **Rind Modification:** The outer wall layer (exocarp) fuses with the surrounding floral receptacle tissue to form a tough, leathery, or hard outer shell called a **rind** that resists compression and desiccation.

This specific modification of an inferior berry is termed a **pepo**. It is distinct from a hesperidium (a superior citrus berry with a leathery rind containing juice-filled hairs) or a pome (an accessory fruit derived from a semi-inferior ovary, typical of Rosaceae).

Final Answer: $\boxed{\text{Pepo}}$

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

Go Back to Question 13

Q14.

Solution

Concept: The pappus is a highly modified calyx characteristic of the family Asteraceae (Compositae). In individual florets, the typical green sepals are reduced or transformed into persistent bristles, hairs, scales, or feathery plumes that remain attached to the apex of the mature fruit (cypsela), acting as a parachute to facilitate wind dispersal.

Solution:

In the dense capitulum inflorescence of the family Asteraceae, individual disc and ray florets are tightly packed together. Because the florets are protected by an outer whorl of green bracts (the involucre), the individual calyx of each floret is freed from its typical defensive role and undergoes a major evolutionary modification:

- Instead of developing into green, leaf-like sepals, the calyx is reduced and transformed into a structure called a **pappus**.
- This pappus can consist of a ring of fine, hair-like bristles, stiff awns, scales, or feathery plumes situated at the apex of the ovary.
- As the ovary matures into a single-seeded, dry inferior fruit (a cypsela), the pappus remains attached to its crown. It acts as an aerodynamic parachute, increasing drag and catching air currents to facilitate long-distance wind dispersal (anemochory).

Final Answer: $\boxed{\text{Pappus consisting of persistent hairy, bristly, or feathery modifications.}}$

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

Go Back to Question 14

Q15.

Solution

Concept: Lodicules are small, fleshy, hyaline scale-like structures located at the base of the grass floret (Poaceae), representing a highly reduced perianth. At anthesis, they absorb water rapidly via localized endosmosis and swell into turgid cushions, forcing the lemma and palea apart to expose the stamens and stigmas for pollination.

Solution:

In the highly reduced and wind-pollinated grass spikelet (family Poaceae), traditional showy petals and sepals are absent. Instead, the perianth is represented by two minute, translucent, scale-like structures situated at the base of the flower, directly outside the stamens and ovary. These structures are called **lodicules**.

During the onset of anthesis, the lodicules drive the opening of the floret:

(a) A rapid accumulation of solutes (primarily potassium ions) occurs within the lodicule cells, lowering their osmotic potential.

(b) This ion surge drives localized endosmosis, causing water to rush into the cells.

(c) The lodicules swell into turgid hydrostatic cushions.

(d) This physical expansion exerts a strong outward mechanical force against the tightly closed lemma and palea bracts, pushing them apart. This opens the floret, allowing the long filaments to elongate and expose the anthers and feathery stigmas to the wind.

Final Answer: $\boxed{\text{Lodicules}}$

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

Go Back to Question 15

Q16.

Solution

Concept: During the photosynthetic light reactions, linear and cyclic electron flow through the thylakoid membrane drives the translocation of protons from the stroma into the thylakoid lumen. This establishes an electrochemical proton gradient characterized by a high H^+ concentration inside the lumen and a low H^+ concentration in the stroma, which powers the CF_0CF_1 ATP Synthase.

Solution:

In the light-dependent stage of photosynthesis, light absorption by Photosystem II (PSII) and Photosystem I (PSI) drives a continuous flow of electrons along the thylakoid membrane:

(a) As electrons pass through the plastoquinone pool and the **Cytochrome b_6f complex**, the energy released is used to actively translocate protons (H^+) from the stroma across the membrane into the internal **thylakoid lumen**.

(b) Concurrently, the photolysis of water molecules by the Oxygen Evolving Complex (OEC) on the inner face of PSII releases additional protons directly into the lumen, while the reduction of $NADP^+$ to NADPH consumes protons on the stromal side.

(c) This coordinated movement establishes a steep electrochemical gradient, or proton motive force, across the thylakoid membrane, characterized by a **high H^+ concentration inside the thylakoid lumen** and a **low H^+ concentration in the external stroma**.

(d) This concentration gradient drives protons back out into the stroma through the channel of the CF_0CF_1 ATP Synthase complex, driving the phosphorylation of ADP to produce ATP.

Final Answer: $\boxed{\text{High } H^+ \text{ concentration in the thylakoid lumen; low } H^+ \text{ concentration in the stroma.}}$

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

Go Back to Question 16

Q17.

Solution

Concept: In C4 plants (such as maize), the primary carbon dioxide fixation step is spatially segregated from the Calvin cycle to reduce photorespiration. This initial carboxylation reaction occurs in the cytosol of mesophyll cells, where the enzyme PEP carboxylase fixes atmospheric HCO_3^- onto the primary 3-carbon acceptor molecule, phosphoenolpyruvate (PEP), to form the 4-carbon acid oxaloacetate (OAA).

Solution:

[Image of C4 photosynthesis pathway]

C4 plants utilize a specialized internal leaf structure known as Kranz anatomy to spatially segregate initial carbon capture from the regular Calvin-Benson cycle, effectively eliminating the oxygenation activity of Rubisco.

Let's trace the initial steps of this pathway:

- **Cellular Location:** Atmospheric carbon dioxide enters the leaf through the stomata and dissolves into the intercellular spaces of the **mesophyll cells**.
- **Primary Acceptor and Enzyme:** Inside the cytosol of these mesophyll cells, the enzyme **phosphoenolpyruvate carboxylase (PEPC)** catalyzes the primary carboxylation step. PEPC has a high affinity for inorganic carbon (HCO_3^-) and shows no competitive binding with oxygen. It fixes the carbon onto the primary 3-carbon acceptor molecule, **phosphoenolpyruvate (PEP)**.
- **Primary Product:** This reaction yields the 4-carbon organic acid oxaloacetate (OAA), which is rapidly converted into malate or aspartate before being transported into the adjacent bundle sheath cells for decarboxylation and subsequent refixation by Rubisco.

Final Answer: $\boxed{\text{Phosphoenolpyruvate (PEP) within the Mesophyll cells.}}$

Answer: (B)

Go Back to Question 17

Q18.

Solution

Concept: Stomatal closure induced by Abscisic Acid (ABA) is driven by a signaling cascade that depolarizes the guard cell plasma membrane. This depolarization activates outward-rectifying potassium (K^+) channels and anion channels, driving a massive efflux of potassium, chloride, and malate solutes that drops cell turgor.

Solution:

When plants experience drought stress, the hormone Abscisic Acid (ABA) binds to its receptors within guard cells, triggering a downstream signaling cascade that alters membrane transport:

(a) The ABA signaling network inhibits the plasma membrane H^+-ATPase proton pumps, stopping the active efflux of protons.

(b) Simultaneously, it activates anion channels (such as SLAC1), allowing accumulated anions like chloride (Cl^-) and malate to flow out of the cell into the apoplast. 3. This loss of negative charges **depolarizes** the plasma membrane.

(c) This change in membrane potential activates **outward-rectifying K^+ channels** (such as GORK), while inward-rectifying channels are deactivated.

(d) Potassium (K^+) ions rush out of the guard cells down their electrochemical gradient. The massive loss of both anions and cations increases the internal water potential (ψ_w), causing water to leave the guard cells via osmosis. The cells lose turgor and go flaccid, closing the stomatal pore.

Final Answer: $\boxed{\text{Activation of outward-rectifying } K^+ \text{ channels along with anion efflux through anion channels.}}$

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

Go Back to Question 18

Q19.

Solution

Concept: The single step in the mitochondrial Krebs cycle that directly executes substrate-level phosphorylation is the conversion of Succinyl-CoA to Succinate, catalyzed by the enzyme Succinyl-CoA synthetase (Succinate thiokinase). This reaction couples the cleavage of a high-energy thioester bond to the phosphorylation of GDP or ADP to generate GTP or ATP.

Solution:

The Krebs cycle consists of a series of redox and decarboxylation steps that oxidize acetyl groups to generate reducing equivalents (NADH and $FADH_2$). Out of these metabolic steps, only a single reaction directly captures chemical energy via substrate-level phosphorylation without relying on the electron transport chain:

- The intermediate **Succinyl-CoA** contains a high-energy thioester bond linking the succinyl group to Coenzyme A.
- The enzyme **Succinyl-CoA synthetase** (also known as Succinate thiokinase) catalyzes the cleavage of this thioester bond.
- The energy released from breaking this bond is directly coupled to the phosphorylation of a nucleoside diphosphate (ADP or GDP) from an inorganic phosphate (P_i) pool, generating a high-energy nucleoside triphosphate (**ATP or GTP**) while forming **Succinate**.

The remaining options either involve oxidative decarboxylations that yield NADH (such as Isocitrate Dehydrogenase) or the reduction of membrane-bound electron carriers (such as Succinate Dehydrogenase yielding $FADH_2$).

Final Answer: $\boxed{\text{Conversion of Succinyl-CoA to Succinate by Succinyl-CoA Synthetase.}}$

Answer: (B)

Go Back to Question 19

Q20.

Solution

Concept: The photorespiratory (C_2) salvage pathway requires the coordinated transport of metabolites across three distinct organelles in a strict, sequential order: Chloroplast → Peroxisome → Mitochondria → Peroxisome → Chloroplast.

Solution:

When Rubisco functions as an oxygenase, it fixes oxygen onto ribulose-1,5-bisphosphate to form one molecule of 3-phosphoglycerate and one molecule of 2-phosphoglycolate. Because phosphoglycolate is a toxic metabolic inhibitor, the plant must salvage its carbon through the photorespiratory cycle, which moves through three separate organelles in a specific sequence:

(a) **Chloroplast:** The 2-phosphoglycolate is dephosphorylated into glycolate inside the chloroplast. Glycolate then exits the chloroplast via specialized transport proteins.

(b) **Peroxisome:** Glycolate enters the adjacent peroxisome, where it is oxidized to glyoxylate and then transaminated to form the amino acid glycine. Glycine is then exported from the peroxisome.

(c) **Mitochondria:** Glycine enters the mitochondrial matrix, where the glycine decarboxylase complex converts two molecules of glycine into one molecule of serine, releasing CO_2 and NH_4^+.

To complete the salvage loop, serine travels back into the **peroxisome** to be converted into glycerate, which finally re-enters the **chloroplast** to be phosphorylated into 3-PGA for the Calvin cycle. Thus, the initial chronological flow of carbon metabolites moves from the Chloroplast to the Peroxisome and then to the Mitochondria.

Final Answer: $\boxed{\text{Chloroplast} \rightarrow \text{Peroxisome} \rightarrow \text{Mitochondria}}$

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

Go Back to Question 20

Q21.

Solution

Concept: Active phloem loading of sucrose into the sieve element-companion cell (SE-CC) complexes at source leaves is driven by an apoplastic mechanism. Plasma membrane H^+-ATPases actively pump protons into the cell wall apoplast, establishing an electrochemical proton gradient that powers sucrose-H^+ symporters to transport sucrose against its concentration gradient.

Solution:

According to the pressure-flow model of phloem translocation, photosynthalates must be loaded into the sieve element-companion cell (SE-CC) complexes of source leaves at high concentrations to drive osmotic water influx and generate hydrostatic pressure. In species that utilize the apoplastic loading pathway, this process is an active, energy-dependent mechanism:

(a) Companion cells utilize ATP-driven **plasma membrane H^+-ATPases** to actively pump protons (H^+) out of the cytoplasm into the surrounding cell wall space (the apoplast).

(b) This active pumping establishes a steep electrochemical proton gradient (Δp) across the plasma membrane, characterized by a low pH and positive electrical potential in the apoplast relative to the cytoplasm.

(c) A specialized transmembrane transport protein, the **sucrose-H^+ symporter** (such as SUC2 or SUT1), uses the energy released as protons flow back down their electrochemical gradient into the cell to co-transport sucrose molecules into the SE-CC complex against a steep concentration gradient.

Final Answer: Sucrose–H^+ symport driven by a proton electrochemical gradient generated by plasma membrane H^+-ATPases.

Answer: (B)

Go Back to Question 21

Q22.

Solution

Concept: During Prophase I of meiosis, the alignment and physical pairing of homologous chromosomes occurs across distinct sub-stages. The assembly of the synaptonemal complex is completed, and genetic crossing over occurs between non-sister chromatids, during the pachytene stage.

Solution:

Let's review the developmental sequence of the sub-stages of Prophase I during meiotic cell division:

- **Leptotene:** Chromosomes begin to condense and become visible as thin threads within the nucleus.
- **Zygotene:** Homologous chromosomes begin to align and pair up side-by-side in a process called synapsis. The ladder-like protein framework known as the synaptonemal complex begins to assemble between them.
- **Pachytene:** Synapsis is fully stabilized, and the assembly of the **synaptonemal complex is completed**. During this stage, the paired homologous chromosomes form tetrads, and recombination nodules appear. This is the precise stage where **crossing over** occurs—the physical breakage and reciprocal exchange of genetic material between non-sister chromatids.
- **Diplotene:** The synaptonemal complex degrades, allowing the homologous chromosomes to separate slightly. They remain held together only at the cross-over points, called chiasmata.

Final Answer: $\boxed{\text{Pachytene}}$

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

Go Back to Question 22

Q23.

Solution

Concept: In a genetic test-cross involving two linked genes in the coupling (cis) phase, the recombination frequency between the two loci directly corresponds to the total percentage of recombinant phenotypes produced in the offspring generation.

Solution:

Let's calculate the expected phenotypic proportions step-by-step:

(a) **Determine Gene Configuration:** The heterozygous parent ($AaBb$) is in the **coupling (cis) phase**, which means the dominant alleles are on one chromosome and the recessive alleles are on the homologous chromosome. The parental gamete types are $\underline{AB}$ and $\underline{ab}$.

(b) **Identify Recombinant Gametes:** Recombination (crossing over) between these two loci produces recombinant gametes carrying mixed allele combinations: $\underline{Ab}$ and $\underline{aB}$.

(c) **Apply Recombination Frequency:** The problem states that the recombination frequency between loci A and B is exactly **16%**. By definition, the recombination frequency represents the total percentage of recombinant gametes produced by the heterozygote parent.

(d) **Analyze Test-Cross Progeny:** In a test-cross with a homozygous recessive individual ($aabb$), the tester parent provides only recessive alleles ($\underline{ab}$), allowing the genetic contribution of the heterozygous parent's gametes to be directly expressed in the phenotypes of the offspring:

- Parental Progeny ($AaBb$ and $aabb$) will account for $100\% - 16\% = 84\%$ of the total population.
- Recombinant Progeny (**$Aabb$ and $aaBb$ combined**) will account for exactly the remaining **16%** of the total population (with each individual recombinant phenotype making up 8%).

Final Answer: $\boxed{16\%}$

Answer: (B)

Go Back to Question 23

Q24.

Solution

Concept: A classical dihybrid cross involving independent assortment typically yields a $9:3:3:1$ phenotypic ratio in the F_2 generation. Modifications to this ratio occur through epistatic gene interactions; a modified ratio of $15:1$ indicates duplicate dominant epistasis, where a dominant allele at either of the two independent loci produces the same dominant phenotype.

Solution:

Let's analyze the genetic basis of the modified Mendelian dihybrid ratio:

- Under standard Mendelian conditions with independent assortment and no gene interaction, an F_2 generation displays a ratio of $9:3:3:1$, representing the phenotypic classes $A\_B\_$ (9), A_bb (3), $aaB\_$ (3), and $aabb$ (1).
- In this crop grain color cross, the observed F_2 phenotypic ratio shifts to **$15:1$**. This tells us that the first three phenotypic classes ($9+3+3=15$) all produce an identical dominant grain color, while only the double homozygous recessive class ($aabb$, 1) produces the alternative recessive phenotype.
- This interaction occurs through **duplicate dominant epistasis**. In this system, two independent loci govern the same trait, and a dominant allele at **either** locus (A or B) is sufficient to catalyze the biochemical pathway that produces the dominant phenotype. Only the complete absence of dominant alleles ($aabb$) results in the recessive form.

Final Answer: $\boxed{\text{Duplicate Dominant Epistasis } (15:1)}$

Answer: (B)

Go Back to Question 24

Q25.

Solution

Concept: The phragmoplast is a specialized, temporary plant cell structure composed of microtubules, actin filaments, and vesicle networks that assembles along the equatorial plane during late anaphase and telophase. It guides trans-Golgi network-derived secretory vesicles to the center of the dividing cell, where they fuse to construct the new cell plate during cytokinesis.

Solution:

In plant cell biology, cytokinesis cannot occur via a simple contractile cleavage furrow due to the presence of a rigid cell wall. Instead, plant cells construct a new cell wall from the inside out:

- During late anaphase and telophase, after the sister chromatids have separated to opposite poles, a complex cytoskeletal framework called the **phragmoplast** forms along the equatorial plane.
- The phragmoplast is composed of parallel arrays of microtubules and actin filaments derived from the remaining mitotic spindle.
- This framework acts as a structural trackway that directs secretory vesicles from the **trans-Golgi network** toward the center of the cell. These vesicles carry cell wall components such as pectins and hemicelluloses.
- At the equator, the vesicles fuse together to form a disk-like structure called the **cell plate**. The phragmoplast grows and moves outward toward the periphery, guiding further vesicle fusion until the expanding cell plate meets and fuses with the original parental cell wall, completing cytokinesis.

Final Answer: $\boxed{\text{Phragmoplast}}$

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

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Answer Key

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