# UPCATET Agriculture Botany Sample Paper-6

**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.** Which of the following organelles is present in plant cells but completely absent in typical animal cells?

(A) Mitochondrion

(B) Golgi apparatus

(C) Plastids (chloroplasts, chromoplasts, leucoplasts) and a large central vacuole

(D) Ribosome

**Q2.** In a typical dicotyledonous root, the vascular bundles are characterized as which of the following types?

(A) Conjoint, collateral, and open

(B) Radial and exarch

(C) Conjoint, collateral, and closed

(D) Radial and endarch

**Q3.** The botanical family Poaceae (Gramineae) is of immense agricultural importance. Which of the following diagnostic floral features belongs strictly to this family?

(A) Presence of a persistent calyx and axile placentation

(B) Presence of glumes, lemma, palea, and a pair of lodicules

(C) Papilionaceous corolla with vexillary aestivation

(D) Tricarpellary syncarpous ovary with superior position

**Q4.** During the light reactions of photosynthesis, photolysis of water takes place to evolve oxygen. This critical enzymatic breakdown happens on which specific side or region of the chloroplast membrane?

(A) On the inner side of the thylakoid membrane facing the lumen

(B) On the outer surface of the outer chloroplast membrane

(C) In the stroma matrix surrounding the thylakoids

(D) Inside the intermembrane space between inner and outer envelopes

**Q5.** A distinct type of inflorescence is observed in the genus *Ficus* (such as Fig and Banyan), where a fleshy receptacle forms a hollow cavity with a small apical opening. What is this inflorescence called?

(A) Verticillaster

(B) Cyathium

(C) Hypanthodium

(D) Capitulum

**Q6.** When a plant cell is placed in a hypertonic solution, water moves out of the cell, causing the protoplast to shrink away from the cell wall. Which parameter reaches zero at the exact moment incipient plasmolysis is completed?

(A) Osmotic pressure

(B) Turgor pressure

(C) Water potential

(D) Diffusion pressure deficit

**Q7.** If a crop plant with the heterozygous genotype $AaBb$ is self-pollinated, what proportion of the $F_2$ progeny will exhibit the completely homozygous recessive genotype $aabb$, assuming independent assortment?

(A) $\frac{9}{16}$

(B) $\frac{3}{16}$

(C) $\frac{1}{4}$

(D) $\frac{1}{16}$

**Q8.** Which agricultural crop group is uniquely characterized by the presence of a modified, highly specialized single cotyledon known as the scutellum?

(A) Pulses like Chickpea and Pigeonpea

(B) Oilseeds like Mustard and Linseed

(C) Cereals like Wheat, Maize, and Rice

**Q9.** In structural botany, the specialized modification of a leaf where the lamina becomes highly reduced or absent, and the petiole becomes green, flat, and leaf-like to perform photosynthesis is known as a:

(A) Phylloclade

(B) Cladode

(C) Phyllode

(D) Phyllotaxy

**Q10.** The first stable compound formed during the carbon fixation stage of $C_4$ plants like Maize and Sugarcane is a 4-carbon organic acid. Identify this initial product:

(A) Oxaloacetic acid (OAA)

(B) 3-phosphoglyceric acid (PGA)

(C) Phosphoenolpyruvate (PEP)

(D) Ribulose-1,5-bisphosphate (RuBP)

**Q11.** Which of the following processes during the prophase I stage of meiosis contributes directly to the genetic recombination and variation observed in sexually reproducing agricultural crops?

(A) Synapsis of homologous chromosomes in Zygotene

(B) Condensation of chromatin fibers in Leptotene

(C) Crossing over between non-sister chromatids in Pachytene

(D) Dissolution of the synaptonemal complex in Diplotene

**Q12.** You are examining a plant specimen belonging to the family Solanaceae. Which combination of floral characters would confirm your identification?

(A) Zygomorphic flower, vexillary corolla, diadelphous stamens

(B) Actinomorphic flower, persistent gamosepalous calyx, oblique ovary with swollen placenta

(C) Actinomorphic flower, perianth represented by lodicules, versatile anthers

(D) Zygomorphic flower, epipetalous stamens, parietal placentation

**Q13.** Pneumatophores are specialized, negatively geotropic roots that emerge vertically upward out of muddy soils. These modifications are most commonly found in which category of plants?

(A) Halophytes growing in saline mangrove swamps

(B) Hydrophytes growing in deep freshwater lakes

(C) Xerophytes growing in arid desert sand dunes

(D) Epiphytes growing high up on forest trees

**Q14.** During aerobic respiration, the complete oxidation of one molecule of pyruvic acid within the mitochondrial matrix via the Krebs cycle releases how many molecules of carbon dioxide ($CO_2$)?

(A) 1

(B) 2

(C) 3

(D) 4

**Q15.** In the structural organization of a typical dicotyledonous leaf, the tissue responsible for maximum photosynthetic activity due to its high density of chloroplasts and orientation toward light is the:

(A) Spongy parenchyma located towards the abaxial surface

(B) Palisade parenchyma located towards the adaxial surface

(C) Vascular bundle sheath cells

(D) Epidermal trichomes and stomatal guard cells

**Q16.** The classic 9 : 3 : 3 : 1 dihybrid phenotypic ratio obtained by Gregor Mendel in his experiments with garden peas is a direct consequence of which fundamental genetic principle?

(A) The Law of Independent Assortment

(B) The Principle of Codominance

(C) The Law of Segregation

(D) The Principle of Incomplete Dominance

**Q17.** Crops belonging to the family Cucurbitaceae (such as pumpkin, bottle gourd, and bitter gourd) are characterized by which specific modification of their vegetative organs for climbing support?

(A) Stem tendrils arising from axillary buds

(B) Leaf tendrils formed by the modification of whole leaves

(C) Root tendrils arising from nodes

(D) Stipular prickles and spines

**Q18.** Stomata open when guard cells become turgid and close when they lose water. According to the widely accepted modern theory, this reversible turgor movement is primarily driven by the active influx and efflux of which ion?

(A) Calcium ions ($Ca^{2+}$)

(B) Potassium ions ($K^{+}$) paired with malate anions

(C) Sodium ions ($Na^{+}$)

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

**Q19.** The phenomenon of "heterophily", where a single plant produces structurally distinct types of leaves on the same individual depending on the environmental growth medium (e.g., air vs. water), is distinctly observed in:

(A) *Ranunculus* (Water buttercup)

(B) *Mangifera indica* (Mango)

(C) *Triticum aestivum* (Wheat)

(D) *Zea mays* (Maize)

**Q20.** The economic part of the cotton plant (*Gossypium* spp.), which belongs to the family Malvaceae, consists of surface fibers used in the textile industry. These valuable fibers are anatomically classified as:

(A) Bast (phloem) fibers from the stem

(B) Sclerenchymatous pericarp cells of the fruit wall

(C) Epidermal prolongations or unicellular hairs of the seed coat

(D) Xylem vessels extracted from the root system

**Q21.** Which type of underground stem modification is structurally compressed, disc-like, and completely enveloped by concentric or overlapping fleshy leaf bases that store reserve food material, as seen in onions?

(A) Rhizome

(B) Corm

(C) Tuber

(D) Bulb

**Q22.** In the family Fabaceae (subfamily Papilionoideae), the corolla shows a characteristic layout. What is the correct numerical distribution and arrangement of petals from the outermost to the innermost layer?

(A) One large standard (vexillum), two lateral wings (alae), and two fused anterior petals (keel)

(B) Five equal petals showing twisted aestivation

(C) Two large standards, one wing, and two free keels

(D) Three upper standard petals and two lower fused wings

**Q23.** During glycolysis, which occurs in the cytosol of all living crop cells, a single molecule of glucose ($6C$) is broken down via a series of enzyme-catalyzed steps into:

(A) One molecule of citric acid ($6C$)

(B) Two molecules of pyruvic acid ($3C$)

(C) Two molecules of acetyl-CoA ($2C$)

(D) One molecule of oxaloacetic acid ($4C$)

**Q24.** Brassicaceae (Cruciferae) is an economically important family containing oilseed mustard. A distinct floral feature of this family is the arrangement of its stamens where there are six stamens total, with two outer shorter and four inner longer ones. This condition is termed:

(A) Didynamous

(B) Tetradynamous

(C) Monadelphous

(D) Polyadelphous

**Q25.** When cells undergo mitotic division to support vegetative growth in the root apical meristems of crops, the exact phase where sister chromatids separate and move toward opposite poles of the spindle fiber setup is:

(A) Prophase

(B) Metaphase

(C) Anaphase

(D) Telophase

## Detailed Solutions

**Q1.**

### Solution

**Concept:** Plant cells possess distinct structural features adapted for rigidity, autotrophic nutrition, and turgor maintenance. Identifying these unique organelles is fundamental to understanding plant physiology, cellular mechanics, and tissue specialization.

**Solution:**

(a) Plant cells are eukaryotic structures characterized by specific distinct components missing in animal cells, notably a rigid cellulose-based cell wall, plastids, and a massive central vacuole.

(b) Plastids are double-membrane bound organelles responsible for manufacturing and storing chemical compounds. They include chloroplasts for photosynthesis, chromoplasts for pigmentation, and leucoplasts for starch storage.

(c) The large central vacuole is enveloped by the tonoplast membrane. It maintains turgor pressure against the cell wall, stores water, and regulates cytoplasmic ions, which keeps the herbaceously structured plant erect.

(d) In contrast, animal cells completely lack plastids of any type and contain either small, temporary vacuoles or no vacuoles at all.

(e) Other options like mitochondria (cellular respiration), Golgi apparatus (protein packaging), and ribosomes (protein translation) are ubiquitous eukaryotic housekeeping organelles shared equally by both plant and animal cells.

**Final Answer:** Plastids (chloroplasts, chromoplasts, leucoplasts) and a large central vacuole

**Answer: (C)**

Go Back to Question 1

## Q2.

### Solution

**Concept:** The internal anatomy of primary plant roots exhibits specific tissue arrangements that distinguish them from stems. These anatomical patterns, particularly the configuration of xylem and phloem, reflect adaptation to water absorption.

**Solution:**

(a) Vascular bundles in primary roots are arranged in a radial pattern. This means strands of primary xylem and primary phloem alternate with each other along different radii, separated by parenchymatous conjunctive tissue.

(b) The development of primary xylem in roots is exarch. The first-formed protoxylem elements lie toward the periphery (pericycle), while the later-formed metaxylem elements develop toward the center (pith).

(c) In contrast, stems display a conjoint arrangement where xylem and phloem sit together on the same radius, and their xylem development pattern is endarch (protoxylem located internally).

(d) Dicot roots typically feature diarch to hexarch conditions, meaning they contain two to six distinct xylem bundles, accompanied by a small or inconspicuous central pith region.

(e) Therefore, a primary dicotyledonous root is diagnosed strictly by having radial vascular bundles showing an exarch protoxylem pattern.

**Final Answer:** Radial and exarch

**Answer: (B)**

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## Q3.

### Solution

**Concept:** The family Poaceae (Gramineae) consists of monocotyledonous agricultural crops like rice, wheat, and maize. Their highly modified, reduced floral units are specialized for wind pollination (anemophily), presenting unique taxonomic descriptors.

**Solution:**

(a) The basic unit of inflorescence in Poaceae is the spikelet. Each spikelet is enclosed at its base by two sterile green bracts called the outer and inner glumes.

(b) Every individual flower (floret) within the spikelet is protected by an inferior bract called the lemma (which often bears a needle-like awn) and a superior bracteole called the palea.

(c) The perianth is extremely reduced or represented by two tiny, translucent, fleshy scales known as lodicules. These absorb water to swell and push open the lemma and palea during anthesis.

(d) Other families present completely different features: Solanaceae possesses a persistent calyx with axile placentation, Fabaceae features a papilionaceous corolla, and Liliaceae shows a tricarpellary syncarpous superior ovary.

(e) Thus, the presence of protective glumes, lemma, palea, and lodicules acts as the exclusive diagnostic signature of the grass family.

**Final Answer:** Presence of glumes, lemma, palea, and a pair of lodicules

**Answer: (B)**

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## Q4.

### Solution

**Concept:** The light-dependent reactions of photosynthesis capture solar energy to synthesize $ATP$ and $NADPH$. Understanding the precise sub-organellar localization of water photolysis clarifies the proton gradient generation necessary for chemiosmotic ATP synthesis.

**Solution:**

(a) Photolysis of water, also known as the hill reaction, is catalyzed by an oxygen-evolving complex ($OEC$) closely linked to Photosystem II ($PSII$) embedded within the thylakoid membrane.

(b) The enzymatic active site of the oxygen-evolving manganese complex is physically oriented toward the inner side of the thylakoid membrane, directly facing the thylakoid lumen.

(c) When light hits $PSII$, water molecules undergo split reactions: $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$. The generated electrons fill the electron vacancy created in $PSII$.

(d) The released oxygen gas diffuses out into the atmosphere, while the protons ($H^+$) accumulate directly within the thylakoid lumen, building a high proton concentration gradient.

(e) Because this chemical process deposits protons inside the lumen and not on the outer stroma side, it establishes the transmembrane electrochemical proton motive force needed by ATP synthase.

**Final Answer:** On the inner side of the thylakoid membrane facing the lumen

**Answer: (A)**

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## Q5.

### Solution

**Concept:** Inflorescences describe the spatial arrangement of flowers on the floral axis. Highly specialized, condensed pseudanthial inflorescences have evolved to facilitate mutualistic pollination strategies in specific tree genera like *Ficus*.

**Solution:**

(a) A hypanthodium is a specialized composite inflorescence where the main peduncle modifies into a fleshy, flask-shaped, hollow receptacle containing an internal cavity.

(b) The cavity opens to the exterior environment via a small apical pore called an ostiole, which is guarded by numerous overlapping scale-like bracts.

(c) Three types of flowers are arranged on the inner wall of this cavity: male flowers near the ostiole, fertile female flowers at the base, and sterile female gall flowers in between.

(d) This structure is intricately linked to an obligate mutualism with chalcid wasps (like *Blastophaga*), which enter through the ostiole to oviposit and complete pollination.

(e) Other mixed or specialized inflorescences include the verticillaster found in Lamiaceae (Labiatæ), the cyathium found in *Euphorbia*, and the capitulum head characteristic of Asteraceae.

**Final Answer:** Hypanthodium

**Answer: (C)**

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## Q6.

### Solution

**Concept:** Plant water relations rely on thermodynamic parameters like water potential ($\Psi_w$), osmotic pressure ($\pi$), and turgor pressure ($\Psi_p$). Plasmolysis highlights how external osmotic gradients modulate physical pressures inside cell walls.

**Solution:**

(a) When a living plant cell is placed into a hypertonic environment, water exits via exosmosis, causing an initial drop in cellular volume without membrane detachment, a state termed incipient plasmolysis.

(b) Turgor pressure ($\Psi_p$) is the hydrostatic pressure exerted by the protoplast pushing outward against the rigid cell wall, providing structural mechanical support.

(c) As the protoplast contracts away from the cell wall during incipient plasmolysis, the wall ceases to experience outward mechanical stress, causing turgor pressure to fall exactly to zero.

(d) At this zero-turgor milestone, the overall internal water potential of the cell becomes entirely equal to its internal solute/osmotic potential ($\Psi_w = \Psi_s$).

(e) Diffusion pressure deficit ($DPD$), which represents the cell's net suction pressure ($DPD = OP - TP$), reaches its maximum equivalent value to osmotic pressure since $TP$ becomes zero.

**Final Answer:** Turgor pressure

**Answer: (B)**

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## Q7.

### Solution

**Concept:** Mendelian dihybrid inheritance analyzes how two independent gene pairs segregate during gametogenesis. Calculating specific genotypic frequencies among progeny utilizes basic probability laws combined with independent chromosomal alignment.

**Solution:**

(a) In a dihybrid cross where a parent possessing the heterozygous genotype $AaBb$ undergoes self-pollination ($AaBb \times AaBb$), each locus segregates independently according to Mendel's second law.

(b) For the $A$ locus, the probability of obtaining a homozygous recessive genotype ($aa$) from an $Aa \times Aa$ monohybrid cross cross-section is exactly $\frac{1}{4}$.

(c) Similarly, for the $B$ locus, the probability of obtaining a homozygous recessive genotype ($bb$) from an $Bb \times Bb$ cross-section is exactly $\frac{1}{4}$.

(d) Because the assortment events at the two loci are independent, the joint probability of both events occurring simultaneously is calculated using the multiplication rule of probability.

(e) Multiplying these individual probabilities ($\frac{1}{4} \times \frac{1}{4}$) yields a final proportion of $\frac{1}{16}$ for the double homozygous recessive $aabb$ genotype within the total $F_2$ population.

**Final Answer:** $1_{\frac{}{16}}$

**Answer: (D)**

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## Q8.

### Solution

**Concept:** Seed architecture provides fundamental criteria for separating monocotyledonous crops from dicotyledonous ones. The scutellum represents a highly evolved embryological structure specialized for nutrient trans-shipment in grass grains.

**Solution:**

(a) Monocotyledonous grains belonging to the family Poaceae (such as wheat, maize, barley, and rice) possess a single, large, shield-shaped cotyledon termed the scutellum.

(b) The scutellum is positioned laterally relative to the embryonal axis and does not serve as a primary long-term macronutrient storage organ itself like dicot cotyledons.

(c) Instead, it acts as an absorptive interface, synthesizing hydrolytic enzymes to break down dense starch reserves stored in the adjacent large endosperm tissue during germination.

(d) Dicotyledonous agricultural crops, including pulses (Fabaceae) and oilseeds (Brassicaceae), possess two prominent cotyledons that store reserves directly and lack an asymmetric scutellum.

(e) Therefore, the presence of a specialized scutellum structurally indicates a monocotyledonous cereal grain, establishing it as a key diagnostic feature of these grass crops.

**Final Answer:** Cereals like Wheat, Maize, and Rice

**Answer: (C)**

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## Q9.

### Solution

**Concept:** Plants adapt morphologically to balance survival and carbon assimilation in challenging ecological niches. Leaf modifications demonstrate how standard petioles can shift functionality when environmental pressures limit typical lamina growth.

**Solution:**

(a) A phyllode is a specialized vegetative modification where the primary leaf blade (lamina) is reduced, short-lived, or completely absent, and the petiole or rachis flattens out to look leaf-like.

(b) This green, expanded petiole takes over the primary role of photosynthesis, reducing water loss through transpiration, a feature common in xerophytic species like *Acacia auriculiformis*.

(c) It must be distinguished from a phylloclade, which is an entire modified stem structure that becomes green and fleshy with limited or unlimited growth, as seen in cacti like *Opuntia*.

(d) A cladode is a specific subtype of phylloclade consisting of a stem branch with only one or two internodes that functions like a leaf, seen in *Asparagus*.

(e) Since the question specifically identifies a modification of the leaf petiole rather than a stem axis, the correct anatomical term is a phyllode.

**Final Answer:** Phyllode

**Answer: (C)**

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## Q10.

### Solution

**Concept:** The $C_4$ photosynthetic pathway is an evolutionary adaptation that minimizes photorespiration in tropical crops. It relies on a two-step spatial separation of carbon capture between mesophyll and bundle sheath cells.

**Solution:**

(a) In $C_4$ plants like maize, sugarcane, and sorghum, initial carbon fixation happens in the cytoplasm of mesophyll cells, catalyzed by the enzyme phosphoenolpyruvate carboxylase ($PEPCase$).

(b) The primary gaseous substrate, carbon dioxide ($CO_2$, as bicarbonate ions), reacts directly with the 3-carbon acceptor molecule phosphoenolpyruvate ($PEP$).

(c) This carboxylation reaction produces oxaloacetic acid ($OAA$), a 4-carbon dicarboxylic organic acid, which serves as the very first stable chemical product of the pathway.

(d) $OAA$ is quickly converted into malic acid or aspartic acid before moving through plasmodesmata into the bundle sheath cells for decarboxylation and entry into the Calvin cycle.

(e) In contrast, $C_3$ plants use $RuBP$ as an acceptor to form 3-phosphoglyceric acid ($PGA$), making $OAA$ the defining initial chemical compound of $C_4$ crop physiology.

**Final Answer:** Oxaloacetic acid (OAA)

**Answer: (A)**

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## Q11.

### Solution

**Concept:** Meiosis is a specialized form of cell division that reduces the chromosome number by half, producing genetically distinct haploid gametes. Prophase I is the most complex stage, featuring distinct sub-phases critical for introducing genetic variation in sexually reproducing plants.

**Solution:**

(a) Prophase I of meiosis progress through five successive sub-stages: leptotene, zygotene, pachytene, diplotene, and diakinesis. Each phase involves unique chromosomal behaviors and setups.

(b) During the pachytene substage, homologous chromosomes are tightly paired via the synaptonemal complex formed in zygotene. This structure allows the non-sister chromatids of homologous pairs to physically interact.

(c) Recombination nodules appear at this stage, containing the enzyme recombinase which facilitates crossing over, the physical exchange of genetic material between non-sister chromatids.

(d) This breakage and reciprocal swapping of corresponding DNA segments break parental linkage groups, producing novel combinations of maternal and paternal alleles along the chromosome lengths.

(e) Consequently, when gametes fuse during fertilization, the offspring inherit these unique genomic combinations, providing the raw genetic variation essential for crop adaptation, breeding selection, and evolution.

**Final Answer:** Crossing over between non-sister chromatids in Pachytene

**Answer: (C)**

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## Q12.

### Solution

**Concept:** Floral taxonomy relies on specific morphological combinations to accurately diagnose families. The family Solanaceae, often called the potato family, displays distinctive vegetative and reproductive traits essential for economic crop identification.

**Solution:**

(a) Flowers in the family Solanaceae are typically actinomorphic, meaning they exhibit radial symmetry and can be divided into equal halves along multiple vertical planes passing through the center.

(b) The calyx features five sepals that are fused (gamosepalous). A key diagnostic marker for this family is that this calyx is persistent, remaining attached and growing along with the developing fruit.

(c) The androecium consists of five epipetalous stamens, meaning the filaments are physically attached directly to the petals, with anthers often dehiscing via apical pores or longitudinal slits.

(d) The gynoecium is bicarpellary and syncarpous with a superior ovary. Crucially, the ovary is placed obliquely relative to the flower axis, and the placenta is highly swollen with numerous ovules.

(e) Other options describe different families; for instance, zygomorphic flowers with vexillary corollas belong exclusively to Fabaceae, while reduced perianths with versatile anthers characterize the Poaceae family.

**Final Answer:** Actinomorphic flower, persistent gamosepalous calyx, oblique ovary with swollen placenta

**Answer: (B)**

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## Q13.

### Solution

**Concept:** Plants residing in waterlogged, anaerobic environments develop distinct morphological and anatomical adaptations to secure atmospheric oxygen. Pneumatophores represent modified root structures adapted to survive severe root-zone hypoxia.

**Solution:**

(a) In saline mangrove swamps and coastal regions, the waterlogged mud is completely saturated, preventing normal atmospheric air from diffusing into the underground soil layers.

(b) Because root tissues require oxygen for aerobic respiration to generate metabolic energy, typical underground roots face suffocation and die under these highly anaerobic conditions.

(c) To overcome this, certain halophytes develop specialized, negatively geotropic lateral roots called pneumatophores or respiratory roots that grow vertically upward out of the mud.

(d) These exposed root projections feature numerous microscopic breathing pores known as lenticels or pneumathodes across their outer bark surfaces.

(e) These pores allow gas exchange, pulling oxygen from the air and transporting it down through internal aerenchyma tissue to sustain the submerged root system.

**Final Answer:** Halophytes growing in saline mangrove swamps

**Answer: (A)**

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## Q14.

### Solution

**Concept:** Aerobic respiration breaks down organic substrates completely into inorganic end products through consecutive pathway stages. Tracking carbon atoms through the Krebs cycle clarifies metabolic efficiency and gas exchange stoichiometry.

**Solution:**

(a) Pyruvic acid, a 3-carbon intermediate generated in the cytosol via glycolysis, enters the mitochondrial matrix to undergo complete oxidative decarboxylation.

(b) Before entering the cyclic pathway, pyruvic acid loses its first carbon as a carbon dioxide molecule via the pyruvate dehydrogenase complex, producing a 2-carbon acetyl-CoA unit.

(c) This acetyl-CoA molecule then condenses with 4-carbon oxaloacetic acid to form 6-carbon citric acid, officially initiating the Krebs tricarboxylic acid cycle.

(d) During the cycle, citric acid undergoes two successive decarboxylation steps: first converting to alpha-ketoglutarate, and then converting to succinyl-CoA, releasing two more carbon dioxide molecules.

(e) Summing these steps, all three carbon atoms originally present in the pyruvic acid substrate are fully released as three distinct molecules of carbon dioxide during mitochondrial processing.

**Final Answer:** 3

**Answer: (C)**

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## Q15.

### Solution

**Concept:** The internal anatomy of a dorsiventral leaf is organized to optimize sunlight interception and gas exchange. Understanding the separation of mesophyll tissues explains why specific cellular layers dominate photosynthetic productivity.

**Solution:**

(a) A typical dicotyledonous leaf shows a distinct dorsiventral layout, meaning its upper (adaxial) surface looks and functions differently from its lower (abaxial) surface.

(b) The ground tissue between the upper and lower epidermal layers is called the mesophyll, which is structurally differentiated into palisade parenchyma and spongy parenchyma.

(c) The palisade parenchyma is situated directly beneath the adaxial epidermis. It consists of elongated, columnar cells arranged vertically parallel to each other.

(d) These palisade cells contain a significantly higher density of chloroplasts compared to spongy cells and are positioned perpendicularly to intercept maximum incoming solar radiation.

(e) In contrast, the spongy parenchyma sits below the palisade layer, featuring loosely arranged, irregular cells with large intercellular air spaces designed primarily to facilitate gas diffusion.

**Final Answer:** Palisade parenchyma located towards the adaxial surface

**Answer: (B)**

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## Q16.

### Solution

**Concept:** Mendelian genetics uses mathematical probabilities derived from chromosomal alignments during meiosis to explain heritage ratios. The dihybrid phenotypic ratio reflects how separate non-allelic gene pairs behave relative to each other.

**Solution:**

(a) When Gregor Mendel crossed homozygous dominant round yellow peas with homozygous recessive wrinkled green peas, all $F_1$ individuals expressed the uniform dihybrid dominant phenotype.

(b) Upon self-pollinating these $F_1$ hybrids, four distinct phenotypic classes emerged in the $F_2$ generation in a characteristic $9 : 3 : 3 : 1$ distribution frequency.

(c) This specific distribution proves that the inheritance of the gene regulating seed shape operates independently of the gene regulating seed color.

(d) Mechanistically, during metaphase I of meiosis, maternal and paternal homologous chromosome pairs align randomly at the spindle equator, allowing alleles to separate cleanly.

(e) This independent alignment means the allele a gamete receives for one gene does not influence or restrict the allele received for another gene, validating the Law of Independent Assortment.

**Final Answer:** The Law of Independent Assortment

**Answer: (A)**

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## Q17.

### Solution

**Concept:** Climbing plants modify vegetative organs to secure mechanical support and reach sunlight. Identifying the precise anatomical origin of these climbing structures helps distinguish convergent adaptations across different crop families.

**Solution:**

(a) Members of the family Cucurbitaceae, such as pumpkins, gourds, and cucumbers, possess weak, herbaceous stems that cannot stand upright without external structural support.

(b) To climb, these plants develop specialized, coiled, thread-like structures called tendrils that are sensitive to touch and wrap tightly around nearby supports.

(c) Anatomically, these tendrils develop from the modification of axillary buds situated in the leaf axils, confirming they are modified stem structures.

(d) This origin is verified by their position and branching patterns, distinguishing them from leaf tendrils seen in wild peas, where the leaf blade or leaflet modifies into a tendril.

(e) Because these structures originate from axillary buds, they share structural homology with regular vegetative branches, serving as an outstanding example of stem modification for climbing.

**Final Answer:** Stem tendrils arising from axillary buds

**Answer: (A)**

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## Q18.

### Solution

**Concept:** Stomatal movements are regulated by changes in the turgidity of guard cells. The modern active potassium transport theory explains the biochemical and electrochemical gradients driving these osmotic adjustments.

**Solution:**

(a) According to Levitt's widely accepted active potassium ion influx theory, stomatal opening initiates with the active excretion of hydrogen ions out of guard cells into adjacent epidermal cells.

(b) This proton pumping requires ATP energy and creates a negative electrical potential inside the guard cells, which triggers a rapid influx of external potassium ions.

(c) Simultaneously, starch undergoes breakdown to form malic acid, which dissociates into malate anions and protons. The malate anions neutralize the incoming potassium ions.

(d) The high concentration of potassium and malate ions inside the vacuoles reduces the osmotic and water potential of the guard cells below that of neighboring cells.

**Final Answer:** Potassium ions ($K^+$) paired with malate anions

**Answer: (B)**

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## Q19.

### Solution

**Concept:** Phenotypic plasticity allows plants to alter their vegetative anatomy in response to localized environmental changes. Heterophily exemplifies this adaptation, where a single plant develops distinct leaf shapes across different growth conditions.

**Solution:**

(a) Heterophily is the occurrence of structurally distinct leaf shapes on different parts of the same plant axis, driven by developmental stages or environmental surroundings.

(b) In environmental heterophily, aquatic or amphibious plants exhibit different leaf morphologies depending on whether the nodes develop submerged under water or exposed to open air.

(c) *Ranunculus aquatilis* (the water buttercup) shows this adaptation clearly. Its submerged leaves are highly dissected into linear segments to minimize water-current damage and maximize gas absorption.

(d) Conversely, its floating or aerial leaves develop broad, rounded, slightly lobed laminae structured to intercept maximum sunlight and facilitate atmospheric transpiration.

(e) Other terrestrial crops like wheat, maize, and mango do not encounter these dual environmental media during standard growth and maintain uniform leaf shapes throughout their vegetative phases.

**Final Answer:** *Ranunculus* (Water buttercup)

**Answer: (A)**

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## Q20.

### Solution

**Concept:** Agricultural fibers originate from diverse anatomical tissues across economic crop groups. Dissecting the seed coat morphology of the genus *Gossypium* explains the commercial distinction of cotton fibers.

**Solution:**

(a) The economic product harvested from the cotton plant does not consist of internal vascular bundle fibers or supportive stem tissues, unlike bast fibers gathered from jute or hemp.

(b) Instead, upon fertilization, the single-celled epidermal layers of the developing seed coat undergo significant outer elongation to form long, lint-like trichomes.

(c) These surface fibers are composed of nearly pure cellulose and develop as long unicellular extensions from the outer integument layer of the ovule.

(d) As the fruit (cotton boll) matures and splits open, these elongated hairs dry out, flattening into twisted, interlocking structures suitable for textile spinning.

(e) Therefore, cotton fibers are anatomically classified as epidermal prolongations of the seed coat, distinguishing them from mechanical sclerenchyma or phloem-derived fibers.

**Final Answer:** Epidermal prolongations or unicellular hairs of the seed coat

**Answer: (C)**

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## Q21.

### Solution

**Concept:** Underground stem modifications allow perennial agricultural plants to survive unfavorable climatic periods, store reserve carbohydrates, and carry out vegetative propagation. Recognizing the distinct structural anatomy of a bulb helps differentiate it from other subterranean storage organs.

**Solution:**

(a) A bulb represents a highly specialized, condensed underground stem modification where the main stem axis is reduced to a small, flattened, disc-like structure.

(b) The upper surface of this disc-like stem bears a central terminal bud and numerous surrounding axillary buds, while its lower surface produces a cluster of adventitious roots.

(c) The primary characteristic of a bulb is that this small, flattened stem is completely covered and surrounded by concentric layers of fleshy scale leaves or leaf bases.

(d) These fleshy scale leaves serve as the primary storage tissue, accumulating substantial quantities of water and reserve carbohydrates, as typified by the culinary onion (*Allium cepa*).

(e) This layout contrasts sharply with a rhizome (a horizontally growing elongated stem), a corm (a solid, vertically swollen fleshy stem base), or a stem tuber (a swollen, starch-storing terminal branch tip).

**Final Answer:** Bulb

**Answer: (D)**

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## Q22.

### Solution

**Concept:** The subfamily Papilionoideae within the family Fabaceae is characterized by a unique, highly specialized irregular corolla setup adapted for insect pollination. This floral architecture follows a strict structural hierarchy and arrangement.

**Solution:**

(a) The corolla of papilionaceous flowers consists of five distinct petals arranged in a characteristic layout called descending imbricate or vexillary aestivation.

(b) The largest, outermost petal is situated posteriorly and is called the standard or vexillum, which overlaps the two adjacent lateral petals.

(c) These two middle lateral petals are free from one another, positioned symmetrically, and are structurally known as the wings or alae.

(d) The two smallest, anterior, innermost petals are located at the base and are fused along their margins to form a boat-shaped unit known as the keel or carina.

(e) This keel structure physically encloses and protects the essential reproductive organs, including the ten stamens (frequently showing a diadelphous 9 + 1 grouping) and the single monocarpellary gynoecium.

**Final Answer:** One large standard (vexillum), two lateral wings (alae), and two fused anterior petals (keel)

**Answer: (A)**

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## Q23.

### Solution

**Concept:** Glycolysis, or the Embden-Meyerhof-Parnas pathway, represents the universal initial stage of cellular respiration. This sequence converts hexose sugars into simpler metabolic intermediates, supplying energy substrates for subsequent mitochondrial oxidation.

**Solution:**

(a) Glycolysis takes place entirely within the aqueous environment of the cytosol and operates under both aerobic and anaerobic conditions without requiring molecular oxygen.

(b) The pathway begins with a single molecule of the six-carbon monosaccharide glucose ($C_6H_{12}O_6$), which undergoes a series of ten consecutive enzyme-catalyzed reactions.

(c) The initial regulatory steps consume two molecules of adenosine triphosphate ($ATP$) to phosphorylate and destabilize the sugar ring into fructose-1,6-bisphosphate.

(d) This intermediate is then split into two distinct three-carbon triose phosphate isomers, which are ultimately converted through energy-yielding oxidations into pyruvic acid ($CH_3COCOOH$).

(e) The net biochemical harvest of this complete cytosolic pathway yields two molecules of three-carbon pyruvic acid, two molecules of $NADH$, and a net gain of two $ATP$ molecules.

**Final Answer:** Two molecules of pyruvic acid ($3C$)

**Answer: (B)**

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## Q24.

### Solution

**Concept:** The family Brassicaceae displays highly regularized reproductive traits used in taxonomic classification. Stamen length variations within individual flowers provide reliable morphologic configurations to determine diagnostic profiles.

**Solution:**

(a) Flowers belonging to the mustard family Brassicaceae typically exhibit a cruciform corolla containing four diagonally arranged petals and an androecium consisting of six distinct stamens.

(b) The configuration of these six stamens follows a specific arrangement regarding length and position, a condition botanically designated as tetradynamous.

(c) In this layout, the two outer stamens possess shorter filaments and are positioned laterally opposite each other relative to the floral axis.

(d) The remaining four inner stamens possess significantly longer filaments and are arranged in two median pairs, surrounding the central syncarpous gynoecium.

(e) This condition differs from a didynamous setup (four stamens total: two long, two short, as in Lamiaceae) or a monadelphous system (all filaments fused into a single column, as in Malvaceae).

**Final Answer:** Tetradynamous

**Answer: (B)**

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## Q25.

### Solution

**Concept:** Mitosis preserves genetic continuity by ensuring that replicated chromosomes separate equally into two daughter nuclei. Identifying specific chromosome configurations helps distinguish the chronological stages of the mitotic cycle.

**Solution:**

(a) Mitosis progresses through four continuous, coordinated nuclear stages to distribute genetic material: prophase, metaphase, anaphase, and telophase.

(b) During metaphase, replicated chromosomes achieve maximum condensation and align perfectly along the equatorial metaphase plate, with spindle fibers attached to their kinetochores.

(c) Anaphase initiates abruptly when the protein linkages binding sister chromatids together at their centromeres are enzymatically cleaved.

(d) Once separated, each chromatid is considered an individual daughter chromosome and is rapidly pulled toward opposite poles of the spindle apparatus.

(e) This poleward migration is driven by the shortening of kinetochore microtubules, causing the separating chromosomes to assume characteristic "V", "J", or "I" shapes depending on their centromere positions.

**Final Answer:** Anaphase

**Answer: (C)**

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# Answer Key

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