IISER Biology Sample Paper-10

Duration: 45 Minutes **Maximum Marks: 60**

Instructions

- This paper contains **15** Multiple Choice Questions (Single Correct).
- Each correct answer carries **+4 marks**.
- Each incorrect answer carries: **−1** marks.
- Unattempted questions carry **0** marks.
- Only one option is correct for each question.
- Use of mobile phones, smartwatches, calculators, or any electronic gadgets is strictly prohibited.

Q1. An actively growing plant cell is treated with a drug that specifically inhibits the activity of the enzyme pectinase inhibitor during cell wall synthesis. Which of the following cellular processes will be most directly affected in the developing tissue?

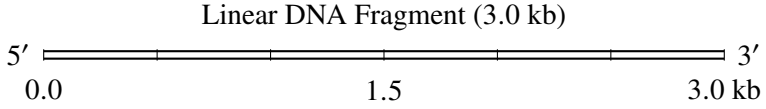
(A) The formation of the primary cell wall matrix.

(B) The enzymatic dissolution of the middle lamella during cell separation.

(C) The orientation of cellulose microfibrils by cortical microtubules.

(D) The fusion of Golgi-derived vesicles at the equatorial plane during cytokinesis.

Q2. A linear 3.0 kb DNA fragment contains two restriction sites for EcoRI and one site for HindIII. When this DNA is completely digested with both enzymes simultaneously, fragments of sizes 1.5 kb, 0.8 kb, 0.5 kb, and 0.2 kb are obtained. Digestion with EcoRI alone yields fragments of 1.5 kb, 1.3 kb, and 0.2 kb. What is the expected fragment pattern when the DNA is digested with HindIII alone?



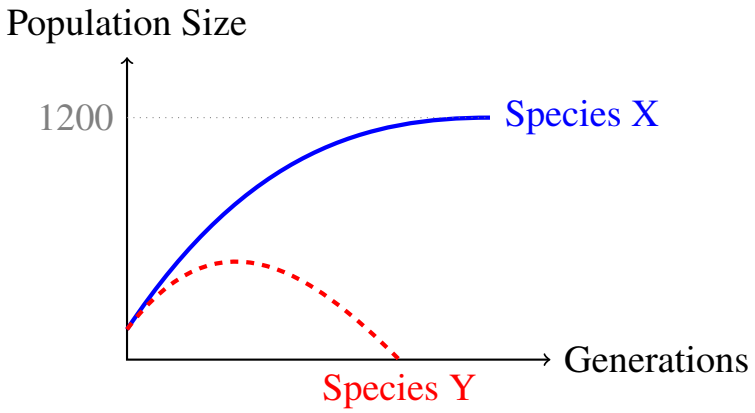
(A) 2.0 kb and 1.0 kb

(B) 2.3 kb and 0.7 kb

(C) 1.7 kb and 1.3 kb

(D) 2.5 kb and 0.5 kb

Q3. In an isolated mountain ecosystem, two species of beetles (Species X and Species Y) feed on the same high-altitude alpine herb. When Species X is present alone, its population stabilizes at 1200 individuals. When Species Y is present alone, its population stabilizes at 800 individuals. When both species are placed together in equal initial numbers, Species X drives Species Y to extinction within 15 generations. However, in a neighboring valley where the alpine herb grows alongside a dense rocky terrain that offers physical hiding spots, both species coexist stably for years. This field observation is a direct real-world demonstration of:



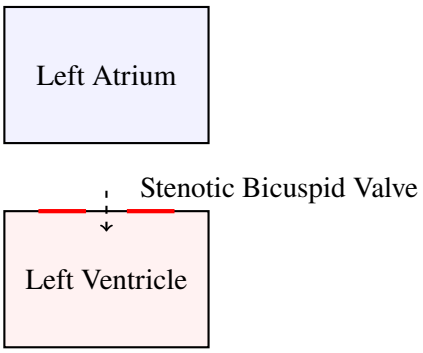
(A) Competitive exclusion rule modified by environmental heterogeneity.

(B) Character displacement leading to sympatric speciation.

(C) Apparent competition driven by a shared specialist predator.

(D) Obligate mutualism dynamic transitioning into commensalism.

Q4. During human cardiac cycle analysis, a patient is found to have a stenotic (narrowed) bicuspid valve. Which of the following direct hemodynamic consequences will be observed in this patient during ventricular diastole?



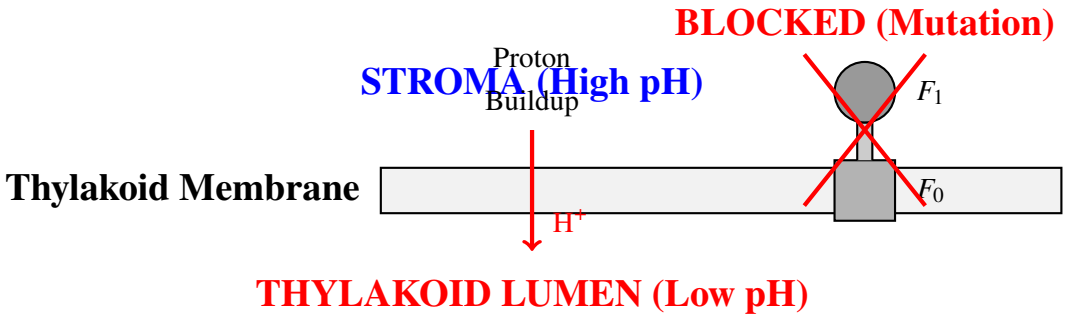
(A) Significantly elevated hydrostatic pressure in the left atrium and pulmonary veins.

(B) A rapid drop in systolic blood pressure within the aorta during ventricular ejection.

(C) Hypertrophy of the right ventricular myocardium due to volume overload.

(D) Decreased duration of the isovolumetric ventricular relaxation phase.

Q5. A mutant strain of *Arabidopsis thaliana* exhibits a loss-of-function mutation in the gene encoding the regulatory subunit of the chloroplast ATP synthase enzyme. When this plant is shifted from darkness to continuous moderate sunlight, which of the following immediate physiological changes will be recorded in its thylakoids?



(A) Accumulation of protons inside the thylakoid lumen leading to an unusually low internal pH.

(B) An immediate cessation of cyclic and non-cyclic electron transport through Photosystem I and II.

(C) Failure to photolyze water molecules at the oxygen-evolving complex.

(D) Rapid acceleration of carbon dioxide fixation rates in the stroma.

Q6. A team of botanists discovers a new vascular plant species in a tropical rainforest. Morphological analysis reveals that the plant possesses a dominant, independent, branched sporophyte generation with well-developed xylem vessels. The gametophyte is small, free-living, photosynthetic, and lacks vascular tissue. Water is absolutely essential for flagellated sperm to reach the archegonia. To which of the following plant groups does this unique specimen belong?

(A) Bryophyta

(B) Pteridophyta

(C) Gymnosperms

(D) Angiosperms

Q7. In human males, a rare genetic condition leads to the complete absence of functional LH (Luteinizing Hormone) receptors on the surface of Leydig cells, while FSH receptors on Sertoli cells function perfectly. What will be the precise endocrinological and physiological profile of an adult individual with this condition?

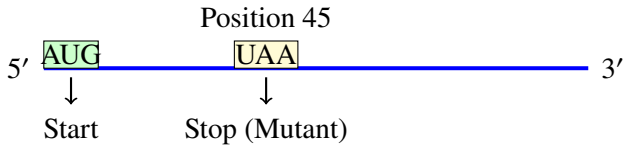
(A) Elevated blood testosterone levels, normal spermatogenesis, and typical male secondary sexual traits.

(B) Low blood testosterone levels, completely arrested spermatogenesis, and failure to develop secondary sexual traits.

(C) High blood LH levels, normal testosterone levels, and hyper-activated spermatogenesis.

(D) Normal blood LH levels, low FSH levels, and normal secondary sexual traits but complete sterility.

Q8. A researcher sequences a 120 base pair open reading frame of a functional bacterial mRNA. The researcher induces a single-base substitution mutation precisely at the 45th nucleotide from the 5′ end, changing a 5′-UAC-3’ codon to a 5′-UAA-3’ codon. What will be the maximum length of the polypeptide chain translated from this mutated mRNA?



(A) 14 amino acids

(B) 15 amino acids

(C) 39 amino acids

(D) 40 amino acids

Q9. In an analytical cell biology experiment, a suspension of healthy mammalian cells is treated with a metabolic poison that permeabilizes the inner mitochondrial membrane specifically to hydrogen ions (H^+), rendering it completely leaky to protons. Which of the following biochemical outcomes will be observed in these treated cells?

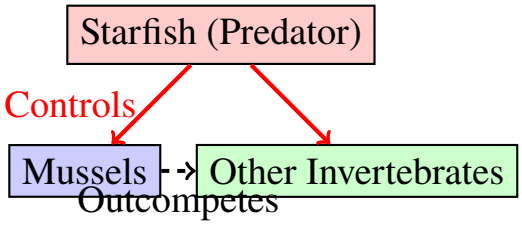
(A) Oxygen consumption will stop immediately as the electron transport chain shuts down.

(B) The rate of the citric acid cycle within the matrix will slow down drastically due to feedback inhibition.

(C) Oxygen consumption will continue or increase, but ATP production via oxidative phosphorylation will drop to zero.

(D) The cytosolic concentration of NADH will drop sharply as it can no longer be oxidized.

Q10. In a classic marine ecology study, the removal of a starfish species (*Pisaster ochraceus*) from a rocky intertidal community led to the rapid population explosion of a mussel species (*Mytilus californianus*), which subsequently outcompeted and eliminated almost all other invertebrates and algae from the rock faces. In this ecosystem context, the starfish is best classified as a:



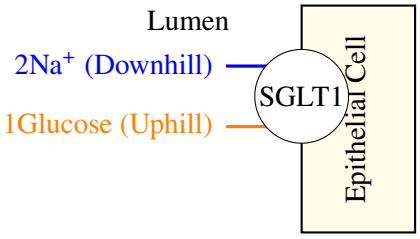
(A) Dominant species due to its high relative biomass.

(B) Keystone species that maintains community diversity.

(C) Pioneer species that initiates secondary ecological succession.

(D) Primary consumer that regulates nutrient cycling rates.

Q11. The active transport of glucose across the apical membrane of intestinal epithelial cells occurs via the SGLT1 cotransporter, which moves two Na^+ ions along with one glucose molecule into the cell. The intracellular concentration of glucose is significantly higher than the extracellular concentration in the intestinal lumen. What is the primary source of energy that directly drives this uphill movement of glucose?



(A) Hydrolysis of ATP molecules directly by the SGLT1 cotransporter protein.

(B) The electrochemical gradient of sodium ions maintained by the basolateral Na^+/K^+ ATPase pump.

(C) A high proton motive force built across the apical plasma membrane.

(D) The facilitated diffusion of potassium ions out of the cell through leak channels.

Q12. During the light-independent reactions of photosynthesis (Calvin cycle), the enzyme RuBisCO catalyzes the carboxylation of Ribulose-1,5-bisphosphate (RuBP). If a plant is exposed to an atmosphere containing radioactively labeled carbon dioxide ($^{14}CO_2$) for a fraction of a second during active photosynthesis, which of the following carbon positions will first show the radioactive label?

(A) The C-1 position of 3-phosphoglycerate (3-PGA).

(B) The C-3 position of 3-phosphoglycerate (3-PGA).

(C) The C-1 position of Ribulose-1,5-bisphosphate.

(D) The C-6 position of glucose-6-phosphate.

Q13. In a standard dihybrid cross between two plants heterozygous for two independently assorting traits ($AaBb \times AaBb$), a student notices that the phenotypic ratio in the offspring deviates significantly from the expected 9 : 3 : 3 : 1 ratio. Instead, the observed ratio is 9 : 7 for the dominant vs recessive phenotype combinations. Which of the following genetic phenomena best explains this observation?

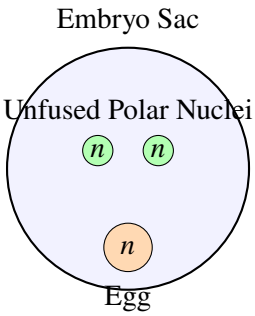
(A) Incomplete dominance between the alleles of both loci.

(B) Complementary gene interaction where both dominant alleles are needed to express the trait.

(C) Tight physical linkage between gene locus A and gene locus B on the same chromosome.

(D) Duplicate gene action where a single dominant allele at either locus can express the trait.

Q14. In flowering plants, the process of double fertilization is a defining evolutionary feature. If a pollen grain with a generative cell nucleus of ploidy n fertilizes an embryo sac where the central cell failed to undergo karyogamy of its polar nuclei (meaning the two polar nuclei remain separate but close together), what will be the respective ploidy levels of the resulting zygote and the endosperm nucleus?



(A) Zygote: $2n$, Endosperm: $3n$

(B) Zygote: $3n$, Endosperm: $4n$

(C) Zygote: $2n$, Endosperm: $4n$

(D) Zygote: n, Endosperm: $2n$

Q15. A patient presents with severe dehydration. Blood analysis shows abnormally high plasma osmolarity and very low blood volume. Under normal physiological homeostatic feedback mechanisms, which of the following sets of hormonal responses will be triggered to restore balance?

(A) Increased secretion of Antidiuretic Hormone (ADH) and increased secretion of Aldosterone.

(B) Decreased secretion of Antidiuretic Hormone (ADH) and increased secretion of Atrial Natriuretic Peptide (ANP).

(C) Increased secretion of Atrial Natriuretic Peptide (ANP) and decreased secretion of Renin.

(D) Decreased secretion of Aldosterone and increased secretion of Angiotensin II.

Detailed Solutions

Q1.

Solution

Concept: The plant cell wall expands dynamically during growth. The primary cell wall consists of cellulose microfibrils embedded in a gel-like matrix of hemicellulose and pectin. Pectin components are structurally modified by endogenous enzymes to control wall extensibility. A pectinase inhibitor blocks the breakdown of pectin, preventing cell wall relaxation and modification necessary for growth and subsequent tissue separation.

Solution: Step 1: Analyze the chemical composition of the plant extracellular matrix. The middle lamella functions as the cementing layer between adjacent plant cells and is primarily composed of calcium and magnesium pectates.
Step 2: Understand the role of the enzyme pectinase. Pectinases break down these pectin networks, which is a required physiological process during cell growth, fruit ripening, and cell separation.
Step 3: Evaluate the effect of a pectinase inhibitor. Under normal conditions, an inhibitor regulates the timing of pectin degradation. Blocking this inhibitor means pectinase remains unrestricted, or preventing its regulation disrupts the controlled dissolution of the middle lamella.
Step 4: Connect the experimental treatment to the options. Inhibiting the regulator directly alters the stability and enzymatic dissolution of the middle lamella during cell separation phases rather than altering cellulose synthesis or Golgi vesicle fusion during cytokinesis.

Final Answer: The enzymatic dissolution of the middle lamella during cell separation.

Answer: (B)

Go Back to Question 1

Q2.

Solution

Concept: Restriction endonuclease mapping involves determining the relative positions of enzyme cleavage sites on a DNA fragment by analyzing the sizes of fragments generated from single and double digestions. The total length of the linear fragments must consistently sum up to the total size of the original linear DNA piece, which is 3.0 kb.

Solution: Step 1: Examine the EcoRI single digestion data. It yields fragments of 1.5 kb, 1.3 kb, and 0.2 kb. Summing these gives 1.5 + 1.3 + 0.2 = 3.0 kb. This confirms there are two EcoRI sites.

Step 2: Examine the double digestion data. The fragments are 1.5 kb, 0.8 kb, 0.5 kb, and 0.2 kb. Comparing this to the EcoRI digest shows that the 1.5 kb and 0.2 kb fragments remain completely intact.

Step 3: Deduce which fragment is cleaved by HindIII. The 1.3 kb fragment from the EcoRI digest is missing in the double digest. Instead, we see new fragments of 0.8 kb and 0.5 kb. Since 0.8 + 0.5 = 1.3 kb, the single HindIII site must lie within this 1.3 kb EcoRI fragment.

Step 4: Determine the absolute position of the HindIII site. The ordering of EcoRI fragments can be 1.5 – 0.2 – 1.3 or 0.2 – 1.5 – 1.3. If the configuration is 1.5 – 0.2 – 0.8 – 0.5, then digesting with HindIII alone splits the molecule at position 1.5 + 0.2 + 0.8 = 2.5 kb. This generates a 2.5 kb fragment and a 0.5 kb fragment.

Final Answer: 2.5 kb and 0.5 kb

Answer: (D)

Go Back to Question 2

Q3.

Solution

Concept: Gause's Principle of Competitive Exclusion states that two species competing for the exact same limiting resource cannot coexist stably if their ecological niches are identical; the electronically more efficient competitor will eliminate the other. However, environmental heterogeneity, structural complexity, or spatial refuges can disrupt this outcome by creating microhabitats that support coexistence.

Solution: Step 1: Identify the dynamic in the first isolated system. Species X and Species Y share an identical niche by feeding on the same high-altitude herb. In a homogenous environment, Species X completely drives Species Y to extinction within 15 generations due to competitive exclusion.
Step 2: Analyze the neighboring valley environment. This ecosystem contains rocky terrain that provides physical hiding spots or spatial refuges. This structural complexity introduces environmental heterogeneity into the system.
Step 3: Interpret the physiological outcome of heterogeneity. The physical refuges allow Species Y to avoid direct, continuous competitive pressure from Species X, altering the realized niches and allowing both beetle species to coexist stably over time.
Step 4: Select the correct ecological framework. This scenario illustrates Gause's competitive exclusion rule being modified or mitigated by environmental heterogeneity.

Final Answer: Competitive exclusion rule modified by environmental heterogeneity.

Answer: (A)

Go Back to Question 3

Q4.

Solution

Concept: The bicuspid (mitral) valve separates the left atrium from the left ventricle. Mitral valve stenosis refers to the narrowing of this valvular orifice, which restricts blood flow from the left atrium into the left ventricle during ventricular diastole, the period when the ventricle relaxes and fills with blood.

Solution: Step 1: Define ventricular diastole. During this phase, the ventricles relax, the aortic and pulmonary semilunar valves close, and the atrioventricular valves (tricuspid and bicuspid) open to allow blood to flow from the atria into the ventricles.
Step 2: Model the effect of stenosis. A narrowed bicuspid valve presents high resistance to blood flow. To move blood across this restricted opening, the left atrium must generate higher pressures during atrial contraction.
Step 3: Determine upstream structural consequences. Because blood cannot drain efficiently from the left atrium into the left ventricle, blood backs up into the upstream vessels. This leads to a significant increase in hydrostatic pressure within the left atrium and the pulmonary veins.
Step 4: Evaluate downstream choices. Aortic systolic pressure is affected during ventricular systole, not diastole. Right ventricular hypertrophy occurs due to pulmonary hypertension over an extended period, but the immediate upstream hemodynamic issue is elevated left atrial pressure.

Final Answer: Significantly elevated hydrostatic pressure in the left atrium and pulmonary veins.

Answer: (A)

Go Back to Question 4

Q5.

Solution

Concept: Photophosphorylation relies on Chemiosmotic Coupling. As electrons move through Photosystem II and Photosystem I, protons (H^+) are actively pumped from the stroma into the thylakoid lumen, creating an electrochemical proton gradient. The chloroplast ATP synthase complex allows these protons to flow back down their gradient into the stroma, using that kinetic energy to synthesize ATP from ADP and inorganic phosphate.

Solution: Step 1: Analyze the nature of the mutation. The plant has a loss-of-function mutation in the regulatory subunit of the chloroplast ATP synthase, rendering the channel non-functional or blocked.
Step 2: Trace the effects of continuous moderate sunlight. Light illumination triggers the light-dependent reactions. Photolysis of water at the oxygen-evolving complex and the operation of the cytochrome b_6f complex continue to pump protons into the thylakoid lumen.
Step 3: Identify the kinetic bottleneck. Because the ATP synthase complex is blocked, protons that accumulate in the lumen cannot exit back into the stroma.
Step 4: Conclude the immediate biochemical outcome. The continuous inward pumping combined with zero outward efflux causes an extreme accumulation of protons inside the thylakoid lumen, resulting in an abnormally low internal pH.

Final Answer: Accumulation of protons inside the thylakoid lumen leading to an unusually low internal pH.

Answer: (A)

Go Back to Question 5

Q6.

Solution

Concept: Different plant groups exhibit distinct evolutionary adaptations regarding alternation of generations, vascular tissue development, and reproductive dependence on water. Analyzing these characteristics systematically isolates the taxonomic group.

Solution: Step 1: Evaluate the vascular tissue criteria. The plant possesses well-developed vascular tissue including xylem vessels. This completely rules out Bryophyta, which are non-vascular plants lacking true xylem and phloem.
Step 2: Evaluate the alternation of generations. The plant features a dominant, independent, branched sporophyte and a small, free-living, photosynthetic gametophyte. This independent nature of both generations is a characteristic feature of vascular cryptogams.
Step 3: Evaluate the reproductive constraints. Water is strictly required for flagellated sperm to swim to the archegonia for fertilization. This rules out Gymnosperms and Angiosperms, which utilize pollen tubes for siphonogamous fertilization and do not require external liquid water for sperm motility.
Step 4: Combine the findings. A dominant vascular sporophyte combined with a free-living gametophyte and zoidogamous reproduction matches the characteristics of Pteridophyta.

Final Answer: Pteridophyta

Answer: (B)

Go Back to Question 6

Q7.

Solution

Concept: Male reproductive endocrinology depends on two main gonadotropins secreted by the anterior pituitary: Luteinizing Hormone (LH) and Follicle-Stimulating Hormone (FSH). LH targets Leydig cells to stimulate testosterone synthesis, while FSH targets Sertoli cells to support spermatogenesis. Both signals are mandatory for normal male fertility and secondary sexual development.

Solution: Step 1: Assess the impact of missing functional LH receptors on Leydig cells. Without functional receptors, Leydig cells cannot respond to circulating LH. Consequently, they fail to produce and secrete testosterone.
Step 2: Determine systemic testosterone levels. Circulating blood testosterone levels drop significantly, reaching near-zero values.
Step 3: Analyze secondary sexual characteristics. Testosterone is required for the development and maintenance of male secondary sexual traits. Low testosterone levels mean these characteristics will fail to develop normally.
Step 4: Evaluate spermatogenesis. Although FSH receptors on Sertoli cells work fine, high local concentrations of testosterone provided by Leydig cells are necessary for FSH to successfully drive spermatogenesis. In the complete absence of testosterone action, spermatogenesis is arrested, leading to sterility.

Final Answer: Low blood testosterone levels, completely arrested spermatogenesis, and failure to develop secondary sexual traits.

Answer: (B)

Go Back to Question 7

Q8.

Solution

Concept: Translation of an mRNA transcript involves reading triplet nucleotides (codons) sequentially from the 5′ end to the 3′ end, starting from an initiation codon (typically 5′-AUG-3') and continuing until a termination codon (5′-UAA-3', 5′-UAG-3', or 5′-UGA-3') is encountered. A nonsense mutation introduces a premature stop codon, terminating translation early.

Solution: Step 1: Determine the position of the mutated codon. The mutation occurs at the 45th nucleotide. Since each codon consists of exactly 3 nucleotides, we divide the position by 3 to find the codon index:

$$\text{Codon Number} = \frac{45}{3} = 15$$

This means the 15th codon has been changed from 5′-UAC-3' to the stop codon 5′-UAA-3'.
Step 2: Analyze the translation process. The ribosome reads codons 1 through 14 normally, incorporating 14 amino acids into the growing polypeptide chain.
Step 3: Evaluate the stop codon interaction. When the ribosome reaches the 15th codon, it encounters 5′-UAA-3'. Release factors bind to the ribosome, causing the translation complex to dissociate and releasing the completed polypeptide. No amino acid is added for the stop codon itself.
Step 4: Calculate final polypeptide length. The maximum length of the functional polypeptide is exactly 14 amino acids.

Final Answer: 14 amino acids

Answer: (A)

Go Back to Question 8

Q9.

Solution

Concept: Oxidative phosphorylation depends on a proton gradient across the inner mitochondrial membrane. The electron transport chain (ETC) transfers electrons from NADH and $FADH_2$ to molecular oxygen, using the released energy to pump protons into the intermembrane space. This chemical energy is harnessed by ATP synthase to generate ATP.

Solution: Step 1: Understand the mechanism of an uncoupling agent. A poison that permeabilizes the inner mitochondrial membrane to protons allows H^+ ions to leak freely back into the matrix, bypassing ATP synthase.
Step 2: Determine the state of the proton gradient. This continuous leakage completely dissipates the proton motive force (ΔpH and electrical potential drop to zero). Without a proton gradient, ATP synthase cannot produce ATP.
Step 3: Analyze the behavior of the electron transport chain. The ETC itself is not directly inhibited by the proton leak. In fact, because it no longer has to pump protons against a steep electrochemical gradient, electron transport and oxygen consumption run uninhibitedly and often accelerate.
Step 4: Conclude the overall cellular effect. Oxygen consumption continues at high rates, but cellular ATP production via oxidative phosphorylation drops to zero.

Final Answer: Oxygen consumption will continue or increase, but ATP production via oxidative phosphorylation will drop to zero.

Answer: (C)

Go Back to Question 9

Q10.

Solution

Concept: Ecosystem structure is maintained by complex biotic interactions. A keystone species is a species that has a disproportionately large effect on its natural environment relative to its abundance or biomass. Eliminating a keystone predator typically collapses community diversity by allowing a dominant prey species to monopolize limited resources.

Solution: Step 1: Review the experimental observations. The removal of the apex predator starfish (*Pisaster ochraceus*) results in a rapid population explosion of its primary prey, the mussel (*Mytilus californianus*).
Step 2: Evaluate the secondary consequences. The unchecked mussel population monopolizes the available space on the rocky substrate, outcompeting and eliminating other invertebrates and benthic algae.
Step 3: Connect to community ecology terms. The total biodiversity of the intertidal zone drops significantly following the removal of the starfish. This shows that the starfish plays a central role in maintaining community structure by keeping the dominant competitor in check.
Step 4: Distinguish between terms. It is not a dominant species because it does not make up the majority of the community biomass, but rather exerts strong top-down regulatory control, defining it as a classic keystone species.

Final Answer: Keystone species that maintains community diversity.

Answer: (B)

Go Back to Question 10

Q11.

Solution

Concept: Active transport mechanisms are categorized as primary or secondary. Primary active transport hydrolyzes ATP directly to move solutes. Secondary active transport uses the electrochemical gradient of an ion, created by a primary active transport pump elsewhere, to drive the uphill movement of a target molecule.

Solution: Step 1: Identify the transport mechanism of SGLT1. SGLT1 is a symporter that couples the transport of glucose against its concentration gradient to the movement of Na^+ ions down their electrochemical gradient.
Step 2: Determine if SGLT1 hydrolyzes ATP. The SGLT1 cotransporter protein does not have an ATP catalytic domain and does not hydrolyze ATP directly during the transport cycle.
Step 3: Trace the origin of the sodium gradient. The low intracellular sodium concentration and negative membrane potential required for this process are established by the Na^+/K^+ ATPase pump located on the basolateral membrane of the epithelial cell.
Step 4: Conclude the primary source of energy. The direct energy source driving the uphill accumulation of glucose is the sodium electrochemical gradient, which is maintained by primary active transport via the basolateral pump.

Final Answer: The electrochemical gradient of sodium ions maintained by the basolateral Na^+/K^+ ATPase pump.

Answer: (B)

Go Back to Question 11

Q12.

Solution

Concept: The Calvin cycle (light-independent reactions) fixes inorganic carbon dioxide into organic molecules. The key carbon fixation step is catalyzed by the enzyme Ribulose-1,5-bisphosphate carboxylase-oxygenase (RuBisCO), which adds a CO_2 molecule to a five-carbon sugar acceptor.

Solution: Step 1: Trace the carboxylation step. RuBisCO combines one molecule of carbon dioxide (CO_2) with one molecule of Ribulose-1,5-bisphosphate (RuBP, a 5-carbon compound).
Step 2: Identify the unstable intermediate. This reaction initially forms an unstable 6-carbon intermediate compound.
Step 3: Track the cleavage of the intermediate. The unstable 6-carbon intermediate is immediately cleaved into two molecules of 3-phosphoglycerate (3-PGA, a 3-carbon compound).
Step 4: Locate the radioactively labeled carbon atom. The incoming chemical group ($^{14}CO_2$) is attached directly to the C-2 position of RuBP, which becomes the carboxyl group (C-1 position) of one of the newly formed 3-phosphoglycerate molecules.

Final Answer: The C-1 position of 3-phosphoglycerate (3-PGA).

Answer: (A)

Go Back to Question 12

Q13.

Solution

Concept: Gene interactions can modify classic Mendelian dihybrid ratios. When two heterozygous loci are crossed ($AaBb \times AaBb$), the expected independent assortment phenotypic ratio is $9:3:3:1$. Deviations from this ratio indicate epistasis, where one gene locus alters or masks the phenotypic expression of another locus.

Solution: Step 1: Analyze the observed phenotypic ratio. The student observes a modified ratio of $9:7$ instead of the typical $9:3:3:1$.
Step 2: Group the Mendelian classes. A $9:7$ ratio is derived by combining the classical phenotypic classes:

$$9:(3+3+1)=9:7$$

The 9 class represents individuals with at least one dominant allele at both loci ($A\_B\_$), while the 7 class represents all other genetic combinations (A_bb, $aaB\_$, and $aabb$).
Step 3: Define the biochemical mechanism. This pattern indicates that a dominant allele at both independent gene loci is strictly required to express the final dominant phenotype. If either gene is homozygous recessive (aa or bb), the biochemical pathway is blocked, resulting in the recessive phenotype.
Step 4: Identify the genetic phenomenon. This mechanism defines complementary gene interaction.

Final Answer: Complementary gene interaction where both dominant alleles are needed to express the trait.

Answer: (B)

Go Back to Question 13

Q14.

Solution

Concept: Double fertilization is a characteristic feature of angiosperms. It involves two distinct fusion events: one sperm cell fertilizes the haploid egg cell to form a diploid zygote, while a second sperm cell fuses with the central cell nuclei to form the endosperm tissue.

Solution: Step 1: Determine the ploidy of the male gametes. The pollen grain generative cell divides to produce two male gametes (sperm cells), each containing a haploid nucleus (n).
Step 2: Calculate the ploidy of the zygote. One haploid sperm cell (n) fuses with the haploid egg cell nucleus (n) inside the embryo sac. This fertilization event results in a diploid zygote ($2n$):

$$\text{Zygote} = n + n = 2n$$

Step 3: Analyze the aberrant central cell condition. In this specific embryo sac, the central cell failed to undergo karyogamy, meaning its two polar nuclei remain separate but adjacent. Each polar nucleus retains its individual haploid (n) ploidy level.
Step 4: Calculate the ploidy of the resulting endosperm nucleus. The second haploid sperm cell (n) enters the central cell and fuses simultaneously with both separate polar nuclei ($n + n$). The resulting fusion nucleus combines all three genomes:

$$\text{Endosperm} = n \text{ (sperm)} + n \text{ (polar 1)} + n \text{ (polar 2)} = 3n$$

Thus, the ploidy of the endosperm remains $3n$.

Final Answer: Zygote: $2n$, Endosperm: $3n$

Answer: (A)

Go Back to Question 14

Q15.

Solution

Concept: Osmoregulation and blood volume homeostasis are maintained by coordinated endocrine feedback loops involving the hypothalamus, posterior pituitary, and the renin-angiotensin-aldosterone system (RAAS). These systems respond to changes in plasma osmolarity, blood pressure, and total fluid volume.

Solution: Step 1: Analyze the physiological state of the patient. The patient exhibits severe dehydration, high plasma osmolarity, and low total blood volume.
Step 2: Trace the hypothalamic response. Osmoreceptors in the hypothalamus detect high plasma osmolarity. This stimulates the posterior pituitary gland to increase the secretion of Antidiuretic Hormone (ADH, or vasopressin), which increases water reabsorption in the renal collecting ducts.
Step 3: Trace the renal volume response. Low blood volume and reduced renal perfusion pressure are sensed by the juxtaglomerular apparatus in the kidneys, triggering the release of renin. Renin converts angiotensinogen to angiotensin I, which is processed into angiotensin II.
Step 4: Evaluate downstream mineralocorticoid effects. Angiotensin II stimulates the adrenal cortex to increase the secretion of aldosterone. Aldosterone promotes sodium and water reabsorption in the distal convoluted tubules, helping to rebuild blood volume. Thus, both ADH and aldosterone secretion increase.

Final Answer: Increased secretion of Antidiuretic Hormone (ADH) and increased secretion of Aldosterone.

Answer: (A)

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Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	B	2	D	3	A	4	A	5	A
6	B	7	B	8	A	9	C	10	B
11	B	12	A	13	B	14	A	15	A