IISER Biology Sample Paper-2

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. A population of a sexually reproducing annual plant species exists in a stable environment. A researcher measures the selection coefficient (s) against individuals with extremely high or extremely low heights over several generations and finds it to be significantly greater than zero. If a sudden, persistent environmental shift occurs that favors taller plants, which of the following graphs correctly represents the change in phenotypic variance (V_P) and mean phenotype (μ) over time?

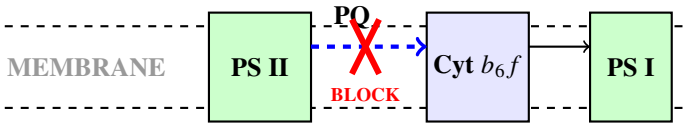
(A) V_P decreases immediately and permanently; μ increases linearly.

(B) V_P transiently increases before decreasing; μ shifts towards a higher value.

(C) V_P remains absolutely constant; μ shifts towards a higher value.

(D) V_P decreases continuously; μ undergoes a cyclical fluctuation.

Q2. During standard non-cyclic photophosphorylation in chloroplasts, a specific herbicide blocks electron transfer at the plastoquinone (PQ) site of the cytochrome b_6f complex. Which of the following consequences will be observed in the chloroplast immediately after the application of this herbicide?



(A) The rate of O_2 evolution will increase due to accumulation of oxidized P_{680}.

(B) The pH of the thylakoid lumen will decrease significantly compared to the stroma.

(C) $NADP^+$ reduction will cease, while ATP synthesis via the $CF_0 - CF_1$ complex will continue unabated.

(D) The non-photochemical quenching of chlorophyll fluorescence will increase due to the accumulation of reduced plastoquinone.

Q3. A researcher fragments healthy mammalian liver cells and isolates different subcellular fractions using differential centrifugation. Fraction X shows a high rate of oxygen consumption accompanied by H_2O_2 accumulation, but contains no trace of cytochromes or $F_0 - F_1$ ATPase complexes. Fraction X most likely consists of:

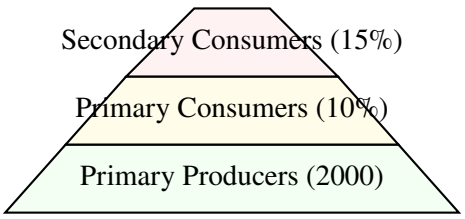
(A) Peroxisomes

(B) Lysosomes

(C) Rough endoplasmic reticulum

(D) Inner mitochondrial membrane vesicles

Q4. In a specific marine ecosystem, the trophic efficiency between primary producers and primary consumers is measured to be 10%, while the trophic efficiency between primary consumers and secondary consumers is 15%. If the net primary productivity of this ecosystem is 2000 g C m^{-2} yr^{-1}, what is the estimated net secondary productivity of the secondary consumers?



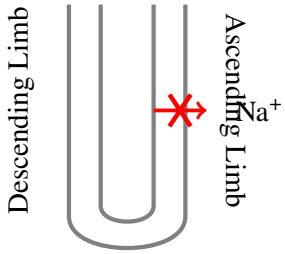
(A) 20 g C m^{-2} yr^{-1}

(B) 30 g C m^{-2} yr^{-1}

(C) 3 g C m^{-2} yr^{-1}

(D) 300 g C m^{-2} yr^{-1}

Q5. An experimental drug blocks the active transport of sodium ions out of the ascending limb of the loop of Henle in mammalian kidneys. What will be the direct effect of this drug on the urine concentration mechanism?



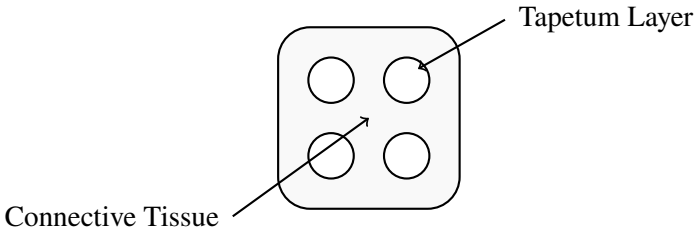
(A) The medullary osmotic gradient will be abolished, resulting in the production of large volumes of dilute urine.

(B) Water reabsorption in the descending limb will increase, producing highly concentrated urine.

(C) The collecting duct will become hyper-permeable to water independent of ADH levels.

(D) Passive urea recycling into the medullary interstitium will increase to compensate for the lost sodium gradient.

Q6. A mutation in a specific plant species results in a non-functional tapetum during microsporogenesis. Which of the following phenotypic outcomes is most likely to be observed in this mutant plant?



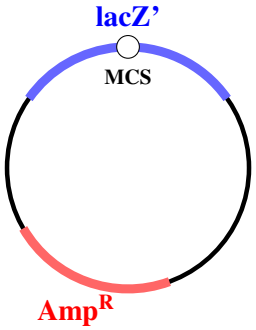
(A) The pollen grains will form normal exine but lack an intine layer.

(B) Megaspores will fail to undergo meiosis, leading to obligate apomixis.

(C) Microspores will degenerate before completing development due to lack of nourishment and sporopollenin precursors.

(D) The endothecium will undergo excessive periclinal divisions, leading to giant pollen grains.

Q7. In a laboratory experiment, a student performs a standard blue-white screening using a pUC19 vector containing an ampicillin resistance gene and the lacZ' gene. The foreign DNA fragment is successfully ligated into the multiple cloning site (MCS) located within lacZ'. If the competent *E. coli* cells are transformed and plated on a medium containing ampicillin, X-gal, and IPTG, which of the following observations indicates a successful recombinant colony?



(A) Colonies that grow and turn blue because lacZ' expression is enhanced by the insert.

(B) Colonies that grow and remain white because insertion disrupts the lacZ' open reading frame.

(C) No colony growth at all because the insert inactivates the ampicillin resistance promoter.

(D) Colonies that grow and turn yellow due to the metabolic breakdown of IPTG by the recombinant plasmid.

Q8. In a classic pulse-chase experiment designed to track the secretion of a glycoprotein in pancreatic acinar cells, radioactive amino acids (^{3}H-Leucine) are added for 3 minutes (pulse) and then replaced with an excess of non-radioactive leucine (chase). If the cells are analyzed after a 40-minute chase period, where would the majority of the radioactive signal be expected to localize?

(A) Rough Endoplasmic Reticulum

(B) Cis-Golgi network

(C) Secretory vesicles fused with or near the plasma membrane

(D) Nucleolus and nuclear envelope

Q9. In an experimental model, human uterine endometrium is analyzed during the mid-luteal phase of a normal menstrual cycle. Which of the following sets of physiological conditions correctly characterizes this specific phase?

(A) Peak levels of LH, low levels of progesterone, high mitotic activity in endometrial glands.

(B) Regressed corpus luteum, rising estradiol, sloughing off of the functionalis layer.

(C) Peak levels of progesterone, high secretory activity in endometrial glands, maximal vascularization.

(D) Low levels of FSH, undetectable progesterone, proliferation of the spiral arteries driven by hCG.

Q10. A standard testcross of a dihybrid individual ($AaBb \times aabb$) yields the following offspring phenotypes:

- AB : 415
- ab : 385
- Ab : 105
- aB : 95

Based on these data, what is the map distance between locus A and locus B, and what was the linkage configuration in the dihybrid parent?

$$\begin{array}{cc} A & B \\ \hline \multicolumn{2}{c}{\longleftarrow \text{ Distance = ? } \longrightarrow} \\ \hline a & b \end{array}$$

(A) 20 cM; Cis configuration (AB/ab)

(B) 20 cM; Trans configuration (Ab/aB)

(C) 10 cM; Cis configuration (AB/ab)

(D) 40 cM; Trans configuration (Ab/aB)

Q11. A physiologist isolates a mammalian skeletal muscle fiber and exposes it to a solution containing a high concentration of a drug that selectively blocks the

ryanodine receptors (RyR) on the sarcoplasmic reticulum. If the motor nerve supplying this muscle fiber is stimulated electrically with a supra-threshold voltage, what will be the immediate mechanical response of the muscle?

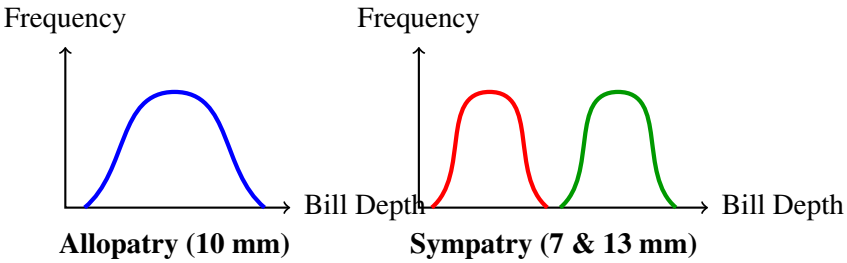
(A) The muscle will enter a state of sustained, irreversible tetanus.

(B) Action potentials will propagate along the sarcolemma, but no contraction will occur.

(C) A single normal twitch will occur, but subsequent relaxation will be infinitely prolonged.

(D) Intracellular calcium levels will spike instantly, causing a rapid twitch independent of ATP availability.

Q12. During a field study on an island, a researcher identifies two closely related species of seed-eating finches. When species X exists alone on an isolated island, its bill depth averages 10 mm. When species Y exists alone on a different island, its bill depth also averages 10 mm. However, on a third island where both species X and Y coexist sympatrically, species X has an average bill depth of 13 mm and species Y has an average bill depth of 7 mm. This phenomenon is a classic example of:



(A) Competitive exclusion

(B) Character displacement driven by directional selection

(C) Convergent evolution driven by stabilizing selection

(D) Apparent competition mediated by a shared predator

Q13. A vascular plant is grown in a controlled environment. If the ambient relative humidity is suddenly dropped from 80% to 20% while keeping soil moisture constant, which of the following sequences of events describes the initial, short-term physiological response of the plant?

(A) Transpiration rate decreases instantly → Leaf turgor pressure increases → Stomata open wider.

(B) Water potential gradient between leaf and air increases → Transpiration rate spikes transiently → Leaf turgor drops → ABA accumulation triggers stomatal closure.

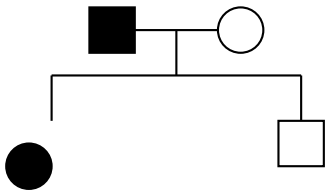
(C) Root pressure increases to match air demand → Guttation begins → Stomata close mechanically due to high guard cell turgor.

(D) Xylem cavitation occurs instantly throughout the stem → Phloem transport reverses direction → Stomata open to dissipate heat.

Q14. An investigator is studying a rare genetic disorder that exhibits a distinct inheritance pattern. Analysis of a large, multi-generational family pedigree reveals the following features:

- The trait affects both males and females.
- An affected male always passes the trait to all of his daughters, but to none of his sons.
- Affected females who are heterozygous pass the trait to approximately 50% of their offspring, regardless of sex.

What is the most likely mode of inheritance for this disorder?



(A) Autosomal dominant

(B) X-linked recessive

(C) X-linked dominant

(D) Y-linked (Holandric)

Q15. Three distinct organisms are analyzed for their biological characteristics:

- Organism 1: Lacks a true cell wall, possesses a cell membrane containing branched-chain lipids with ether linkages, and produces methane under strictly anaerobic conditions.
- Organism 2: Possesses a cell wall containing peptidoglycan, undergoes oxygenic photosynthesis using chlorophyll a, and fixes atmospheric nitrogen in specialized cells called heterocysts.
- Organism 3: Lacks a cell wall entirely, passes through a 0.22 μm filter, and causes pleuropneumonia-like diseases in animals.

To which taxonomic domains or groups do these organisms belong?

(A) 1: Archaea; 2: Cyanobacteria; 3: Mycoplasma

(B) 1: Eubacteria; 2: Green Algae; 3: Chlamydia

(C) 1: Archaea; 2: Bryophytes; 3: Viruses

(D) 1: Protista; 2: Cyanobacteria; 3: Viroids

Detailed Solutions

Q1.

Solution

Concept: Stabilizing selection operates in a constant, invariant environment by weeding out extreme phenotypes, thereby reducing phenotypic variance (V_P) without changing the mean phenotype (μ). When an environmental shift occurs, the mode of selection changes from stabilizing to directional selection. Directional selection favors an extreme phenotype, which alters the population mean over generations.

Solution: Step 1: Initially, the stable environment exerts stabilizing selection against both extreme phenotypic heights ($s > 0$). This keeps the mean height (μ) constant and maintains a low, stable phenotypic variance (V_P).

Step 2: When a sudden, persistent environmental shift occurs favoring taller plants, directional selection begins to operate on the population.

Step 3: In the initial phases of directional selection, previously rare or intermediate alleles that contribute to increased height begin to increase in frequency. As these alleles change in frequency toward an intermediate state, the genetic and phenotypic variance (V_P) transiently increases.

Step 4: As selection continues over generations, the favored tall alleles move toward fixation, which eventually reduces the phenotypic variance (V_P) to a low level again.

Step 5: Concurrently, the mean phenotype (μ) shifts systematically and progressively over time toward a higher value representing the newly favored taller height.

Final Answer: V_P transiently increases before decreasing; μ shifts towards a higher value.

Answer: (B)

Go Back to Question 1

Q2.

Solution

Concept: Non-cyclic photophosphorylation relies on a continuous chain of electron transfer from Photosystem II (PS II) to Photosystem I (PS I). Plastoquinone (PQ) carries electrons from PS II to the cytochrome b_6f complex while pumping protons from the stroma into the thylakoid lumen. Blocking this step breaks the electron transport chain, directly disrupting the electrochemical proton gradient and downstream reduction processes.

Solution: Step 1: The herbicide binds to the plastoquinone docking site of the cytochrome b_6f complex, completely arresting electron transfer from reduced PQ (PQH_2) to cytochrome b_6f.

Step 2: Since electrons can no longer move past PQ, the upstream components of the chain, including the primary electron acceptor pheophytin and the reaction center P_{680} of PS II, accumulate in a highly reduced state. This stops the photolysis of water, reducing O_2 evolution rather than increasing it.

Step 3: Because electron flow through the cytochrome b_6f complex is halted, the active pumping of protons from the stroma into the thylakoid lumen ceases immediately. Consequently, the pH of the lumen increases rather than decreases.

Step 4: Without electron delivery from the cytochrome b_6f complex through plastocyanin to PS I, $NADP^+$ cannot be reduced to NADPH, which stops the linear electron transport completely. ATP synthesis will eventually stop as the existing proton gradient dissipates.

Step 5: The accumulation of fully reduced plastoquinone (PQH_2) and the inability to dissipate absorbed light energy safely via active electron transport leads to a significant increase in non-photochemical quenching (NPQ) mechanisms to protect the photosystem from photo-inhibition.

Final Answer: The non-photochemical quenching of chlorophyll fluorescence will increase due to the accumulation of reduced plastoquinone.

Answer: (D)

Go Back to Question 2

Q3.

Solution

Concept: Different cellular organelles house distinct sets of metabolic pathways and marker enzymes. Cellular respiration and electron transport involving cytochromes and ATP synthases are restricted to mitochondria. In contrast, the direct utilization of molecular oxygen (O_2) by oxidases to strip hydrogen from organic substrates, forming hydrogen peroxide (H_2O_2) as a byproduct, is the hallmark biochemical feature of peroxisomes.

Solution: Step 1: We evaluate the biochemical properties of Fraction X. The fraction consumes molecular oxygen (O_2) at a very high rate and simultaneously accumulates hydrogen peroxide (H_2O_2).

Step 2: Mitochondria consume oxygen during oxidative phosphorylation via the electron transport chain. However, this process relies strictly on cytochromes (such as cytochrome c and cytochrome c oxidase) and generates ATP using $F_0 - F_1$ ATPase complexes. Since Fraction X lacks cytochromes and $F_0 - F_1$ complexes, it cannot be of mitochondrial origin.

Step 3: Peroxisomes contain flavin-containing oxidases (such as uric acid oxidase and D-amino acid oxidase). These enzymes transfer electrons directly from their organic substrates to molecular oxygen, reducing it to H_2O_2:

$$\text{R-H}_2 + \text{O}_2 \rightarrow \text{R} + \text{H}_2\text{O}_2$$

Step 4: Peroxisomes do not possess an electron transport chain containing cytochromes, nor do they couple this oxidative process to ATP synthesis via ATPase complexes. Instead, they utilize the enzyme catalase to safely break down the accumulated H_2O_2 into water and oxygen.

Step 5: Thus, a subcellular fraction demonstrating oxygen consumption and H_2O_2 generation without cytochromes or ATP synthases matches the profile of peroxisomes.

Final Answer: Peroxisomes

Answer: (A)

Go Back to Question 3

Q4.

Solution

Concept: Trophic efficiency represents the percentage of energy or biomass that is transferred from one trophic level to the next higher level. The Lindeman's efficiency rule or ecological efficiency dictates that net productivity at a specific trophic level can be calculated by sequentially applying the transfer efficiencies of each intermediate step to the base Net Primary Productivity (NPP).

Solution: Step 1: Identify the given quantitative parameters from the ecosystem model:

$$\text{Net Primary Productivity (NPP of Primary Producers)} = 2000 \text{ g C m}^{-2} \text{ yr}^{-1}$$

$$\text{Efficiency from Primary Producers to Primary Consumers } (\eta_1) = 10\% = 0.10$$

$$\text{Efficiency from Primary Consumers to Secondary Consumers } (\eta_2) = 15\% = 0.15$$

Step 2: Calculate the net secondary productivity of the primary consumers ($\text{NSP}_{\text{primary}}$) by applying the first trophic efficiency to the primary productivity:

$$\text{NSP}_{\text{primary}} = \text{NPP} \times \eta_1$$

$$\text{NSP}_{\text{primary}} = 2000 \times 0.10 = 200 \text{ g C m}^{-2} \text{ yr}^{-1}$$

Step 3: Calculate the net secondary productivity of the secondary consumers ($\text{NSP}_{\text{secondary}}$) by applying the second trophic efficiency to the productivity of the primary consumers:

$$\text{NSP}_{\text{secondary}} = \text{NSP}_{\text{primary}} \times \eta_2$$

$$\text{NSP}_{\text{secondary}} = 200 \times 0.15 = 30 \text{ g C m}^{-2} \text{ yr}^{-1}$$

Step 4: Double-check the math to ensure accuracy:

$$2000 \times 0.10 \times 0.15 = 200 \times 0.15 = 30$$

The final value matches option B exactly.

Final Answer: $30 \text{ g C m}^{-2} \text{ yr}^{-1}$

Answer: (B)

Go Back to Question 4

Q5.

Solution

Concept: The mammalian kidney concentrates urine via a countercurrent multiplier system, which depends entirely on the active transport of solutes out of the thick ascending limb of the loop of Henle. The ascending limb is impermeable to water but actively pumps Na^+, K^+, and Cl^- into the medullary interstitium. This active extrusion builds a hyperosmotic medullary gradient that draws water out of the descending limb and collecting duct.

Solution: Step 1: The experimental drug blocks the active transport of sodium ions (Na^+) out of the ascending limb of the loop of Henle.

Step 2: Because Na^+ and accompanying ions are no longer pumped into the interstitial space of the renal medulla, the concentration of solutes in the medullary interstitium falls rapidly.

Step 3: Without a high solute concentration in the medullary interstitium, the osmotic gradient between the nephron lumen and the surrounding tissue is completely abolished.

Step 4: In the absence of this osmotic gradient, water can no longer be drawn out passively from the water-permeable descending limb of the loop of Henle or the collecting ducts, regardless of whether Antidiuretic Hormone (ADH) is active.

Step 5: Consequently, the fluid remains dilute throughout its transit down the collecting duct, leading to the excretion of abnormally large volumes of highly dilute urine, a condition mimicking severe nephrogenic diabetes insipidus.

Final Answer: The medullary osmotic gradient will be abolished, resulting in the production of large volumes of dilute urine.

Answer: (A)

Go Back to Question 5

Q6.

Solution

Concept: The tapetum is the innermost nutritive layer of the microsporangial wall in anthers. It plays a critical role in microsporogenesis by providing nutrients, enzymes, and essential structural components like sporopollenin, pollenkit, and tryphine to the developing microspores. If the tapetum becomes non-functional, microspores are deprived of these vital materials during critical phases of maturation.

Solution: Step 1: Analyze the physiological role of the tapetum layer. It synthesizes and secretes nutrients, proteins, and the lipid-derived polymer sporopollenin, which forms the tough outer layer (exine) of pollen grains.

Step 2: During microsporogenesis, the microspore mother cells undergo meiosis to form microspore tetrads. The tapetum secretes the enzyme callase to dissolve the callose wall surrounding these tetrads, freeing individual microspores.

Step 3: If a genetic mutation renders the tapetum non-functional, the developing microspores fail to receive proper nourishment and cannot form a complete, functional exine coat due to the absence of sporopollenin.

Step 4: Lacking structural protection and nutritional support, the microspores arrest in development and completely degenerate before reaching maturity, leading to male sterility.

Step 5: This condition prevents the formation of any functional pollen grains, while leaving megasporogenesis and female reproductive tissues completely unaffected.

Final Answer: Microspores will degenerate before completing development due to lack of nourishment and sporopollenin precursors.

Answer: (C)

Go Back to Question 6

Q7.

Solution

Concept: Blue-white screening is a molecular technique used to identify recombinant bacteria. The plasmid vector pUC19 carries an ampicillin resistance gene (Amp^R) for selection and a lacZ' segment encoding the α-peptide of β-galactosidase. The Multiple Cloning Site (MCS) lies within the lacZ' gene sequence. Successful insertion of foreign DNA disrupts this gene, causing insertional inactivation.

Solution: Step 1: The host *E. coli* strains used in this technique carry a deletion mutation in their chromosomal lacZ gene but can synthesize the remaining portion of the enzyme.

Step 2: When non-recombinant pUC19 enters the host cell, the intact lacZ' gene produces the functional α-peptide. This peptide complements the host's defective enzyme via α-complementation, producing a fully functional β-galactosidase enzyme.

Step 3: Active β-galactosidase hydrolyzes the substrate X-gal in the medium in the presence of the inducer IPTG, producing an insoluble blue pigment. Thus, non-recombinant colonies turn blue.

Step 4: When a foreign DNA fragment is successfully ligated into the MCS, it breaks the open reading frame of the lacZ' gene. This insertional inactivation prevents the synthesis of the functional α-peptide.

Step 5: Without α-complementation, no functional β-galactosidase is assembled. Recombinant cells can still grow on ampicillin due to the intact Amp^R gene, but they cannot clear X-gal, meaning successful recombinant colonies remain white.

Final Answer: Colonies that grow and remain white because insertion disrupts the lacZ' open reading frame.

Answer: (B)

Go Back to Question 7

Q8.

Solution

Concept: A pulse-chase experiment tracks cellular processes over time by exposing cells to a labeled compound (pulse) followed by an excess of the unlabeled compound (chase). In secretory cells like pancreatic acinar cells, newly synthesized proteins travel through a highly organized pathway: Rough Endoplasmic Reticulum (RER) → Cis-Golgi network → Trans-Golgi network → Secretory vesicles → Plasma membrane.

Solution: Step 1: During the 3-minute pulse period, radioactive amino acids (^{3}H-Leucine) are incorporated into newly synthesizing polypeptide chains on the ribosomes of the Rough Endoplasmic Reticulum (RER). At the end of the pulse, the signal is concentrated entirely in the RER.

Step 2: During the subsequent chase with non-radioactive leucine, no more radioactive proteins are synthesized. The labeled proteins synthesized during the pulse move as a discrete wave through the secretory pathway.

Step 3: Around 10 to 20 minutes into the chase, these labeled proteins leave the RER via transport vesicles and migrate into the cis-Golgi network, where they undergo carbohydrate modification and sorting.

Step 4: By 40 minutes of chase time, the proteins have completed their sorting in the trans-Golgi network and are packaged into mature secretory vesicles (zymogen granules). These vesicles migrate toward the apical plasma membrane, preparing for exocytosis.

Step 5: Therefore, at a 40-minute time point, the bulk of the radioactive signal will be localized within secretory vesicles positioned near or fusing with the plasma membrane.

Final Answer: Secretory vesicles fused with or near the plasma membrane

Answer: (C)

Go Back to Question 8

Q9.

Solution

Concept: The human menstrual cycle consists of coordinated changes in the ovaries and endometrium. The mid-luteal phase (days 19–23 of a typical 28-day cycle) corresponds to the period of maximum activity of the corpus luteum in the ovary and the secretory phase in the uterus. This phase is optimized to create an ideal environment for the implantation of a blastocyst.

Solution: Step 1: Following ovulation around day 14, the remnants of the ovarian follicle transform into the corpus luteum under the influence of residual Luteinizing Hormone (LH).

Step 2: The corpus luteum secretes large amounts of progesterone along with moderate amounts of estrogen. During the mid-luteal phase, circulating blood levels of progesterone reach their absolute peak.

Step 3: Under the dominance of progesterone, the endometrium stops proliferating and transitions into the secretory phase. The endometrial glands become highly coiled, tortuous, and begin actively secreting glycogen-rich fluids.

Step 4: Simultaneously, vascularization of the tissue peaks as spiral arteries elongate and spin dramatically into the functional zone of the endometrium, maximizing blood supply and tissue thickness.

Step 5: This combination of peak progesterone levels, high glandular secretion, and maximal vascularization defines the mid-luteal uterine landscape.

Final Answer: Peak levels of progesterone, high secretory activity in endometrial glands, maximal vascularization.

Answer: (C)

Go Back to Question 9

Q10.

Solution

Concept: Linkage maps represent the relative distance between genes based on recombination frequencies. A standard testcross between a heterozygous dihybrid parent ($AaBb$) and a homozygous recessive parent ($aabb$) reveals the proportion of parental and recombinant gametes produced during meiosis. Recombination frequency (RF) is directly proportional to map distance in centimorgans (cM).

Solution: Step 1: Group the offspring phenotypes into parental and recombinant classes. Parental classes reflect the genetic combinations present in the original gametes, which typically occur in higher numbers. Recombinant classes arise from crossing over and occur in lower numbers.

Step 2: Analyze the observed counts:

$$\text{Parental phenotypes: } AB = 415, \quad ab = 385$$

$$\text{Recombinant phenotypes: } Ab = 105, \quad aB = 95$$

Since the non-recombinant parental classes are AB and ab, the dominant alleles A and B must reside on one chromosome, while the recessive alleles a and b reside on the homologous chromosome. This arrangement represents a Cis configuration (AB/ab).

Step 3: Calculate the total number of offspring across all classes:

$$\text{Total} = 415 + 385 + 105 + 95 = 1000$$

Step 4: Calculate the total number of recombinant individuals:

$$\text{Recombinants} = 105 + 95 = 200$$

Step 5: Determine the recombination frequency (RF):

$$\text{RF} = \left(\frac{\text{Number of Recombinants}}{\text{Total Offspring}}\right) \times 100\%$$

$$\text{RF} = \left(\frac{200}{1000}\right) \times 100\% = 20\%$$

Since 1% recombination frequency equals 1 cM, the map distance between the two loci is 20 cM.

Final Answer: 20 cM; Cis configuration (AB/ab)

Answer: (A)

Go Back to Question 10

Q11.

Solution

Concept: Excitation-contraction coupling in skeletal muscle links electrical depolarization of the sarcolemma to mechanical force generation. An action potential travels down the T-tubules and activates voltage-gated dihydropyridine receptors (DHPR). These receptors physically interact with ryanodine receptors (RyR) on the sarcoplasmic reticulum, triggering calcium release into the sarcoplasm to initiate contraction.

Solution: Step 1: Electrical stimulation of the motor nerve generates an action potential that crosses the neuromuscular junction and propagates along the sarcolemma and down into the T-tubules. This phase of excitation remains fully intact.

Step 2: The depolarization of the T-tubules causes a conformational shift in the voltage-sensing DHPR complexes. Under normal conditions, this change opens the linked calcium-release channels (RyR) on the sarcoplasmic reticulum membrane.

Step 3: Because an experimental drug blocks the ryanodine receptors (RyR), calcium ions remain locked inside the sarcoplasmic reticulum lumen and cannot flow out down their concentration gradient into the cytoplasm.

Step 4: Without a spike in intracellular calcium (Ca^{2+}), calcium cannot bind to troponin C. Consequently, the conformational shift in tropomyosin does not occur, and myosin-binding sites on the actin filaments remain covered.

Step 5: As a result, cross-bridge cycling cannot begin. The muscle fiber shows normal electrical action potentials along its membranes, but fails to generate any mechanical contraction, uncoupling excitation from contraction.

Final Answer: Action potentials will propagate along the sarcolemma, but no contraction will occur.

Answer: (B)

Go Back to Question 11

Q12.

Solution

Concept: Character displacement is an evolutionary process where two closely related species diverge morphologically or behaviorally in regions where their ranges overlap (sympatry). This divergence minimizes ecological niche overlap and reduces interspecific competition for shared resources. In contrast, populations living in isolation (allopatry) face no such selection pressure and maintain similar traits.

Solution: Step 1: Analyze the traits of the finch species in isolation. In allopatry on separate islands, both Species X and Species Y have an identical average bill depth of 10 mm, indicating they exploit a similar ecological niche when competition is absent.

Step 2: When both species live together on the same island (sympatry), resource competition for seeds of intermediate sizes becomes intense.

Step 3: Natural selection favors individuals of Species X with larger bills (13 mm) that can crush larger, harder seeds, and individuals of Species Y with smaller bills (7 mm) that can manipulate smaller seeds efficiently.

Step 4: Over generations, directional selection shifts the beak size distributions in opposite directions within the shared environment, minimizing competition and allowing stable coexistence.

Step 5: This divergence in traits resulting from competition in sympatry is the definition of character displacement.

Final Answer: Character displacement driven by directional selection

Answer: (B)

Go Back to Question 12

Q13.

Solution

Concept: Transpiration is driven by the water potential gradient between the interior of the leaf and the ambient atmosphere. A sudden drop in atmospheric relative humidity increases the vapor pressure deficit (VPD). This surge in the driving force accelerates water loss through open stomata, triggering rapid changes in leaf turgor and hormone signaling to prevent excessive dehydration.

Solution: Step 1: Dropping the ambient relative humidity from 80% to 20% decreases the water potential of the air, significantly increasing the water potential gradient between the leaf interior and the surrounding atmosphere.

Step 2: This sudden drop causes an immediate spike in the transpiration rate as water vapor diffuses rapidly out of the open stomata into the dry air.

Step 3: Because the initial rate of transpirational water loss outpaces the rate of water absorption by the root system, the hydrostatic pressure (turgor pressure) inside the leaf cells drops rapidly.

Step 4: This dehydration stress triggers the rapid synthesis and accumulation of abscisic acid (ABA) in the mesophyll and guard cells.

Step 5: ABA activates ion efflux channels in the guard cell membranes, causing a mass exit of potassium (K^+) and anions. Water follows passively out of the guard cells, reducing their turgor and forcing the stomata to close to conserve water.

Final Answer: Water potential gradient between leaf and air increases → Transpiration rate spikes transiently → Leaf turgor drops → ABA accumulation triggers stomatal closure.

Answer: (B)

Go Back to Question 13

Q14.

Solution

Concept: Modes of inheritance are identified by analyzing how a trait passes across generations between male and female relatives. An X-linked dominant trait has unique transmission patterns because males carry a single X chromosome (X^Y) which they pass to all of their daughters and none of their sons, while females pass one of their two X chromosomes to their offspring with equal probability.

Solution: Step 1: The trait affects both males and females, which eliminates Y-linked inheritance because Y-linked traits appear exclusively in males.

[Image of X-linked dominant inheritance pattern pedigree]

Step 2: An affected male passes the trait to all of his daughters. Because a father must pass his single X chromosome to every daughter, if that X chromosome carries a dominant mutation, 100% of his daughters will inherit the allele and display the phenotype.

Step 3: The affected male passes the trait to none of his sons. A father always contributes a Y chromosome to his sons, ensuring they never inherit his X-linked alleles. This rule confirms the pattern is X-linked rather than autosomal.

Step 4: Heterozygous affected females (X^DX^d) have a 50% chance of passing either the mutant allele (X^D) or the normal allele (X^d) to their offspring during meiosis. This leads to a 50% transmission rate among both sons and daughters.

Step 5: These rules match the transmission criteria for an X-linked dominant inheritance pattern.

Final Answer: X-linked dominant

Answer: (C)

Go Back to Question 14

Q15.

Solution

Concept: Organisms are classified into different domains and taxonomic groups based on cellular ultrastructure, biochemical composition of membranes, cell wall properties, and unique metabolic adaptations. Distinguishing these basic biochemical features allows the identification of specific microbial groups like Archaea, Cyanobacteria, and Mycoplasmas.

Solution: Step 1: Analyze Organism 1. It lacks a true cell wall but features a cell membrane composed of branched-chain hydrocarbons attached to glycerol by ether linkages rather than standard ester bonds. It fixes energy via methanogenesis under anaerobic conditions. These unique ether-linked lipids and methanogenic pathways are exclusive to the domain Archaea.

Step 2: Analyze Organism 2. It has a cell wall containing peptidoglycan, which places it firmly within the domain Bacteria. It carries out oxygenic photosynthesis using chlorophyll *a* and contains specialized, thick-walled cells called heterocysts dedicated to nitrogen fixation. These characteristics define the Cyanobacteria (blue-green algae).

Step 3: Analyze Organism 3. It lacks a cell wall entirely, allowing it to easily pass through ultra-fine 0.22 μm bacterial filters. It is known to cause pleuropneumonia-like diseases in animals. These properties define members of the genus *Mycoplasma* (originally known as PPLOs).

Step 4: Match the components sequentially: 1 corresponds to Archaea, 2 to Cyanobacteria, and 3 to Mycoplasma. This sequence corresponds to option A.

Final Answer: 1: Archaea; 2: Cyanobacteria; 3: Mycoplasma

Answer: (A)

Go Back to Question 15

Answer Key

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