UPCATET Biology Sample Paper-1

Duration: 80 Minutes **Maximum Marks: 320**

Instructions

- This paper contains **80** 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. A plant cell is placed in a solution, and its turgor pressure becomes equal to its osmotic pressure. If this cell is now transferred to a solution of identical osmotic strength but containing a non-penetrating solute, what will be the immediate net movement of water?

(A) Water will move out of the cell rapidly causing plasmolysis.

(B) Water will enter the cell until it bursts due to high pressure.

(C) There will be no net movement of water across the membrane.

(D) Solutes will move out of the cell to balance the dynamic equilibrium.

Q2. During human cardiac cycles, a sudden blockage in the bundle of His would directly disrupt which of the following physiological events?

(A) The generation of action potentials by the sinoatrial node.

(B) The transmission of contractile impulses to the ventricular myocardium.

(C) The backflow prevention mechanism of the bicuspid and tricuspid valves.

(D) The delay of the cardiac impulse at the atrioventricular node.

Q3. A researcher extracts a double-stranded DNA sample and determines that it contains 34% cytosine. What is the expected percentage of adenine in this specific genomic sample?

(A) 34%

(B) 16%

(C) 68%

(D) 32%

Q4. If a metabolic poison selectively inhibits the functioning of the nucleolus within an active eukaryotic cell, which cellular process will be most directly and immediately compromised?

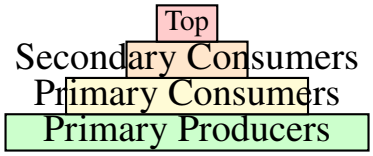
(A) Synthesis of ribosomal RNA and assembly of ribosome subunits.

(B) Translation of messenger RNA into polypeptide chains in the cytoplasm.

(C) Post-translational modification of secretory proteins in the cisternae.

(D) Transcription of structural genes into primary mRNA transcripts.

Q5. In a highly stable terrestrial ecosystem, which of the following statements best explains why the pyramid of energy can never be inverted?



(A) Decomposers rapidly recycle energy back into the primary trophic level.

(B) Herbivores consume a higher biomass percentage than top carnivores.

(C) Energy is systematically lost as metabolic heat at each trophic transfer.

(D) Net primary productivity increases exponentially with higher trophic ranks.

Q6. A botanist observes a plant with actinomorphic flowers, bicarpellary syncarpous ovary with oblique septa, and swollen placenta bearing many ovules. To which family does this plant belong?

(A) Cruciferae

(B) Fabaceae

(C) Solanaceae

(D) Liliaceae

Q7. In a flowering plant, a microspore mother cell undergoes meiotic and subsequent mitotic divisions to form a mature male gametophyte. What is the total number of nuclei present in a fully mature, shed pollen grain of a typical angiosperm before fertilization?

(A) One

(B) Two or Three

(C) Four

(D) Eight

Q8. Which of the following components is absolutely required in a standard Polymerase Chain Reaction (PCR) mixture to allow the thermostable DNA polymerase to initiate synthesis?

(A) Ribonucleoside triphosphates

(B) Single-stranded RNA primers

(C) Chemically synthesized DNA primers

(D) Dideoxynucleotide triphosphates

Q9. During cyclic photophosphorylation in chloroplasts, what is the primary destination of the electron after it is excited from the reaction center of Photosystem I?

(A) $NADP^+$ Reductase

(B) Oxygen Evolving Complex

(C) Primary Electron Acceptor (Fe-S center)

(D) Photosystem II core

Q10. A patient reports persistent fatigue, polyuria, polydipsia, and significant weight loss. Laboratory assays reveal high blood glucose levels but normal to high circulating insulin levels. Which condition is most consistent with these findings?

(A) Diabetes insipidus

(B) Type 1 Diabetes mellitus

(C) Type 2 Diabetes mellitus

(D) Diabetes due to hyposecretion of glucagon

Q11. A true-breeding pea plant with round seeds and yellow cotyledons is crossed with a true-breeding plant having wrinkled seeds and green cotyledons. If the F_1 generation is selfed, what proportion of the F_2 generation is expected to display a completely recombinant phenotype?

(A) 9/16

(B) 3/16

(C) 6/16

(D) 1/16

Q12. Which of the following biomolecules contains non-hydrolyzable ester linkages and represents a major structural constituent of biological membranes?

(A) Triacylglycerols

(B) Phosphoglycerides

(C) Glycogen

(D) Globular proteins

Q13. In a deep-sea hydrothermal vent ecosystem, which group of organisms acts as the primary producers by utilizing inorganic chemical energy to fix carbon?

(A) Photoautotrophic cyanobacteria

(B) Chemoautotrophic bacteria

(C) Benthic saprophytic fungi

(D) Heterotrophic zooplankton

Q14. An organism is found to be multicellular, eukaryotic, heterotrophic, lacking a cell wall, and exhibiting holozoic nutrition. According to Whittaker's five-kingdom classification, this organism must be placed in:

(A) Monera

(B) Protista

(C) Fungi

(D) Animalia

Q15. During human embryonic development, the blastocyst secretes a specific hormone to maintain the corpus luteum in the maternal ovary. Name this hormone.

(A) Luteinizing Hormone (LH)

(B) Progesterone

(C) Human Chorionic Gonadotropin (hCG)

(D) Estrogen

Q16. What is the main purpose of adding selectable markers, such as antibiotic resistance genes, into a cloning vector during recombinant DNA procedures?

(A) To initiate the replication of foreign DNA within host cells.

(B) To permit the target gene to integrate into the host chromosome.

(C) To differentiate between transformants and non-transformants.

(D) To increase the copy number of the recombinant plasmid.

Q17. Under conditions of acute water stress, which endogenous plant hormone increases rapidly in leaves to trigger the closure of stomata?

(A) Indole-3-acetic acid

(B) Gibberellic acid

(C) Abscisic acid

(D) Zeatin

Q18. A major portion of carbon dioxide is transported from the body tissues to the lungs through the blood in which of the following forms?

(A) Dissolved gas molecules in blood plasma

(B) Carbaminohemoglobin complexes inside red blood cells

(C) Bicarbonate ions in plasma and red blood cells

(D) Carbonic acid bound to plasma proteins

Q19. During the process of transcription in prokaryotes, which specific subunit of RNA polymerase is required to recognize and bind to the promoter sequence to initiate synthesis?

(A) Alpha subunit

(B) Beta subunit

(C) Rho factor

(D) Sigma factor (σ)

Q20. During which specific stage of cell division do homologous chromosomes separate from one another while sister chromatids remain attached at their centromeres?

(A) Anaphase of mitosis

(B) Anaphase I of meiosis

(C) Anaphase II of meiosis

(D) Metaphase I of meiosis

Q21. Which conservation strategy involves protecting an endangered species within its natural habitat by declaring the area a national park or biosphere reserve?

(A) Ex-situ conservation

(B) In-situ conservation

(C) Cryopreservation

(D) Botanical garden preservation

Q22. Plants belonging to the family Cruciferae (Brassicaceae) are easily identified by which distinctive modification or feature of their androecium?

(A) Monadelphous stamens

(B) Diadelphous stamens

(C) Tetradynamous stamens

(D) Syngenesious stamens

Q23. What is the functional role of the acrosome reaction during the process of human fertilization?

(A) To trigger the second meiotic division of the sperm cell.

(B) To facilitate the penetration of the sperm through the corona radiata and zona pellucida.

(C) To prevent more than one sperm from entering the perivitelline space.

(D) To stimulate the movement of the sperm flagellum inside the uterus.

Q24. In the creation of Bt cotton, the Cry endotoxins produced by Bacillus thuringiensis are lethal to certain insect pests. Why does this toxin not harm the bacterium itself?

(A) The bacterium lacks the specific intracellular receptors for the toxin.

(B) The toxin exists as an inactive protoxin within the bacterium.

(C) The bacterial cell wall is completely impermeable to proteins.

(D) The toxin is instantly degraded by bacterial lysosomal enzymes.

Q25. Which enzyme catalyzes the initial fixation of atmospheric carbon dioxide in the mesophyll cells of C_4 plants?

(A) Ribulose-1,5-bisphosphate carboxylase-oxygenase

(B) Phosphoenolpyruvate carboxylase

(C) Pyruvate phosphate dikinase

(D) Malate dehydrogenase

Q26. Which anatomical structure in the human brain contains vital reflex centers that regulate cardiovascular functions, respiration, and gastric secretions?

(A) Cerebellum

(B) Cerebrum

(C) Medulla oblongata

(D) Hypothalamus

Q27. A point mutation occurs in a gene where a purine base is replaced by another purine base. This type of nucleotide substitution is classified as a:

(A) Transition

(B) Transversion

(C) Frameshift mutation

(D) Nonsense mutation

Q28. A student observes a slide of a dividing plant tissue and notes the formation of a cell plate across the equatorial plane during cytokinesis. Which organelle is primarily responsible for generating the vesicles that fuse to form this cell plate?

(A) Mitochondria

(B) Lysosomes

(C) Golgi apparatus

(D) Centrioles

Q29. The excessive enrichment of water bodies with nutrients like nitrates and phosphates leads to algal blooms and subsequent oxygen depletion. This ecological phenomenon is known as:

(A) Biomagnification

(B) Eutrophication

(C) Biofortification

(D) Thermal pollution

Q30. Which of the following plants possesses a modified underground stem known as a corm, which serves as an organ of perennation and vegetative propagation?

(A) Solanum tuberosum

(B) Allium cepa

(C) Amorphophallus

(D) Zingiber officinale

Q31. Which of the following conditions is an example of an auto-immune disorder where the body's immune system attacks neuromuscular junctions, leading to progressive skeletal muscle weakness?

(A) Muscular dystrophy

(B) Myasthenia gravis

(C) Osteoarthritis

(D) Gouty arthritis

Q32. In a segment of mature mRNA, the region that is situated between the start codon and the stop codon is composed of:

(A) Introns only

(B) Exons only

(C) Both introns and exons alternately

(D) Non-coding regulatory elements

Q33. Which of the following cell organelles is bounded by a single unit membrane and contains high concentrations of hydrolytic enzymes active at an acidic pH?

(A) Mitochondrion

(B) Chloroplast

(C) Lysosome

(D) Ribosome

Q34. The population interaction where one species benefits significantly while the other associated species is neither helped nor harmed is termed:

(A) Parasitism

(B) Mutualism

(C) Amensalism

(D) Commensalism

Q35. Plants with naked seeds that lack an enclosing ovary wall, and possess specialized structures called cones, belong to which group?

(A) Bryophytes

(B) Pteridophytes

(C) Gymnosperms

(D) Angiosperms

Q36. What is the primary function of the Leydig cells located in the interstitial spaces of the human testes?

(A) To provide structural support to developing spermatids.

(B) To secrete androgens, principally testosterone.

(C) To nourish mature spermatozoa before ejaculation.

(D) To undergo meiotic divisions to form spermatogonia.

Q37. Which technique is widely employed to introduce foreign DNA directly into a plant host cell by bombarding it with high-velocity microparticles coated with DNA?

(A) Microinjection

(B) Electroporation

(C) Biolistics (Gene gun)

(D) Heat-shock treatment

Q38. During aerobic respiration, what is the net yield of ATP molecules produced solely through substrate-level phosphorylation when one molecule of glucose is completely oxidized to carbon dioxide and water?

(A) 2 ATP

(B) 4 ATP

(C) 32 ATP

(D) 36 ATP

Q39. What prevents the backflow of fecal matter from the large intestine back into the small intestine of humans?

(A) Pyloric sphincter

(B) Sphincter of Oddi

(C) Ileocaecal valve

(D) Gastroesophageal sphincter

Q40. An individual with Klinefelter syndrome possesses which of the following sex chromosomal constitutions?

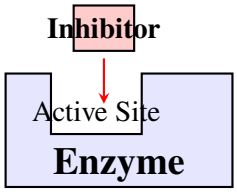
(A) 45, XO

(B) 47, XXY

(C) 47, XYY

(D) 47, XXX

Q41. Which of the following statements regarding competitive enzyme inhibition is correct?



(A) The inhibitor binds irreversibly to an allosteric site on the enzyme.

(B) The inhibitor increases the apparent K_m of the enzyme for its substrate.

(C) The inhibitor decreases the maximum velocity (V_{max}) of the reaction.

(D) The inhibitor alters the primary amino acid conformation of the active site.

Q42. According to the competitive exclusion principle proposed by G.F. Gause, what occurs when two closely related species compete for identical, limiting resources?

(A) Both species evolve to share the resource equally through cooperation.

(B) Competitively inferior species is eventually eliminated.

(C) Both species experience a mutual increase in population density.

(D) One species changes its niche to become a primary producer.

Q43. Velamen tissue, which is responsible for absorbing moisture directly from the atmosphere, is characteristically found in the roots of:

(A) Hydrophytic submerged plants

(B) Epiphytic orchids

(C) Halophytic mangroves

(D) Xerophytic cacti

Q44. In human females, the cessation of the menstrual cycle and the decline of ovarian hormone production that normally occurs between 45 to 50 years of age is defined as:

(A) Menarche

(B) Menopause

(C) Amenorrhea

(D) Ovulation

Q45. Which property of Thermus aquaticus makes its DNA polymerase ideal for use in the automated amplification of DNA?

(A) It replicates DNA at an exceptionally rapid rate.

(B) It does not require a primer to initiate synthesis.

(C) It retains structural stability and catalytic activity at high temperatures.

(D) It corrects all replication errors via proofreading.

Q46. The final electron acceptor in the mitochondrial electron transport chain during oxidative phosphorylation is:

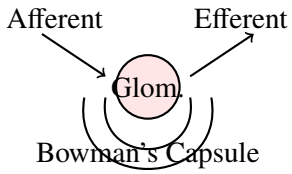
(A) NAD^+

(B) FAD

(C) Cytochrome c

(D) Molecular oxygen

Q47. If the dynamic filtration pressure in the glomerulus drops to zero due to a decrease in systemic blood pressure, what will be the immediate impact on renal function?



(A) Ultrafiltration will stop completely.

(B) Tubular reabsorption of glucose will double.

(C) Secretion of urea will increase dramatically.

(D) Large quantities of protein will enter Bowman's capsule.

Q48. In the operon model of gene regulation in prokaryotes, what happens when an inducer molecule binds to the repressor protein?

(A) The repressor binds tightly to the operator gene.

(B) The repressor becomes inactive and dissociates from the operator.

(C) Transcription of structural genes is completely blocked.

(D) The repressor promotes the degradation of messenger RNA.

Q49. Which of the following stages of prophase I of meiosis is characterized by the visual appearance of chiasmata as homologous chromosomes begin to separate?

(A) Leptotene

(B) Zygotene

(C) Pachytene

(D) Diplotene

Q50. The accumulation of non-biodegradable synthetic pesticides through successive trophic levels in a food chain at higher concentrations is called:

(A) Bioremediation

(B) Biomagnification

(C) Eutrophication

(D) Biofortification

Q51. Hydroponics is a specialized technique used by plant physiologists to grow plants in:

(A) Enriched organic soils under greenhouse conditions

(B) Defined nutrient solutions in the complete absence of soil

(C) Arid sand cultures supplemented with minimal water

(D) Peat moss containing high moisture and trace minerals

Q52. The dark bands present in skeletal muscle fibers, which contain the protein filaments myosin along with overlapping actin filaments, are designated as:

(A) I-bands

(B) A-bands

(C) H-zones

(D) Z-lines

Q53. A geneticist performs a test cross of an F_1 dihybrid individual. If the genes are linked on the same chromosome and do not assort independently, what phenotypic ratio is expected in the offspring?

(A) 9 : 3 : 3 : 1

(B) 1 : 1 : 1 : 1

(C) A high frequency of parental types and low frequency of recombinant types

(D) A high frequency of recombinant types and low frequency of parental types

Q54. Which cellular junction acts as a mechanical barrier to completely prevent the leaking of substances across a layer of epithelial tissue?

(A) Gap junction

(B) Tight junction

(C) Adhering junction

(D) Plasmodesmata

Q55. Which of the following acts as a primary pollutant in urban environments and participates in the formation of photochemical smog?

(A) Carbon dioxide

(B) Nitrogen oxides

(C) Ozone

(D) PAN (Peroxyacetyl nitrate)

Q56. The highly specialized asymmetric cell division that gives rise to a small polar body and a large ootid during human oogenesis occurs during which phase?

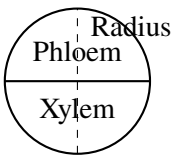
(A) Multiplication phase in embryonic life

(B) First and second meiotic divisions

(C) Mitotic maturation in the Graafian follicle

(D) Fertilization within the uterus

Q57. In a vascular bundle, when xylem and phloem are arranged along the same radius with phloem located towards the outer side of the xylem, the bundle is described as:



(A) Radial and open

(B) Conjoint and collateral

(C) Conjoint and bicollateral

(D) Concentric and amphivasal

Q58. Which of the following cells present in the gastric glands of the stomach mucosa is responsible for secreting intrinsic factor, which is essential for the absorption of vitamin B_{12}?

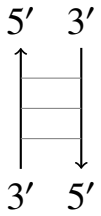
(A) Peptic cells

(B) Mucus neck cells

(C) Oxyntic (parietal) cells

(D) G-cells

Q59. The structural model of DNA proposed by Watson and Crick describes a double helix where the two strands run in opposite directions. This arrangement is termed:



(A) Parallel orientation

(B) Antiparallel orientation

(C) Symmetrical replication

(D) Complementary transcription

Q60. Which of the following is an accurate structural difference between a typical plant cell and an animal cell?

(A) Plant cells have centrioles, whereas animal cells lack them.

(B) Plant cells possess a rigid cellulose cell wall, whereas animal cells lack a cell wall.

(C) Plant cells store carbohydrates as glycogen, whereas animal cells store them as starch.

(D) Plant cells possess small, numerous vacuoles, whereas animal cells have a single large central vacuole.

Q61. Which structural component of an ecosystem includes all the living organisms interacting with each other within a specified geographic area?

(A) Abiotic component

(B) Biotic component

(C) Edaphic component

(D) Climatic component

Q62. The standard floral formula $\oplus \subsetneq K_{(5)}C_{(5)}A_5\underline{G}_{(2)}$ belongs to which economically important family of angiosperms?

(A) Fabaceae

(B) Solanaceae

(C) Liliaceae

(D) Cruciferae

Q63. Which part of the human fallopian tube is wide, funnel-shaped, closest to the ovary, and possesses finger-like projections called fimbriae?

(A) Isthmus

(B) Ampulla

(C) Infundibulum

(D) Uterine part

Q64. During the process of biological nitrogen fixation in legume root nodules, which specialized enzyme converts atmospheric dinitrogen into ammonia?

(A) Nitrate reductase

(B) Nitrite reductase

(C) Nitrogenase

(D) Glutamate dehydrogenase

Q65. The mineralocorticoid hormone aldosterone, which regulates the reabsorption of sodium ions and water in the distal nephron, is synthesized and secreted by which specific zone of the adrenal cortex?

(A) Zona glomerulosa

(B) Zona fasciculata

(C) Zona reticularis

(D) Adrenal medulla

Q66. An X-linked recessive genetic disorder will express its phenotype most frequently in which group of individuals within a human population?

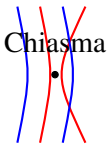
(A) Heterozygous females

(B) Homozygous females

(C) Hemizygous males

(D) Both males and females with equal frequency

Q67. During which specific sub-stage of prophase I of meiosis does the biochemical process of genetic recombination (crossing over) take place between non-sister chromatids?



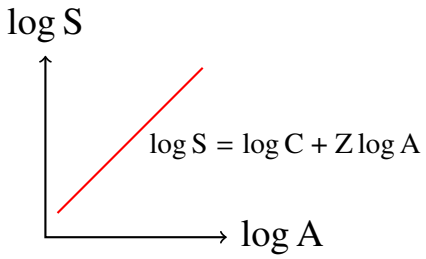
(A) Zygotene

(B) Pachytene

(C) Diplotene

(D) Diakinesis

Q68. According to the species-area relationship described by Alexander von Humboldt, within a region, species richness increases with increasing explored area up to a certain limit. On a logarithmic scale, this relationship is represented as a:



(A) Parabolic curve

(B) Rectangular hyperbola

(C) Straight line

(D) Sigmoid curve

Q69. In which plant family do we observe a characteristic inflorescence known as a spadix, which is often enclosed by a large, brightly colored bract called a spathe?

(A) Gramineae

(B) Araceae

(C) Malvaceae

(D) Brassicaceae

Q70. What is the physiological mechanism of action of oral contraceptive pills containing synthetic progestogen-estrogen combinations in preventing pregnancy?

(A) They act as spermicides and physically destroy the sperm in the vagina.

(B) They completely block the fallopian tubes to prevent fertilization.

(C) They inhibit ovulation and implantation by altering the feedback loop of gonadotropins.

(D) They cause immediate regression of a fertilized zygote.

Q71. The respiratory quotient (RQ) value obtained during the complete aerobic oxidation of a pure fat or lipid substrate, such as tripalmitin, is approximately:

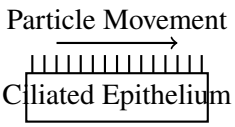
(A) 1.0

(B) 0.7

(C) 0.9

(D) More than 1.0

Q72. What is the primary function of the ciliated epithelial cells that line the inner surface of the human fallopian tubes and bronchioles?



(A) To secrete specialized mucus to engulf dust particles.

(B) To maximize surface area for efficient nutrient absorption.

(C) To move particles or mucus in a specific direction over the epithelial surface.

(D) To provide mechanical protection against abrasion and physical stress.

Q73. The experiment conducted by Hershey and Chase utilizing radioactive sulfur (^{35}S) and radioactive phosphorus (^{32}P) in bacteriophages provided unequivocal proof that:

(A) Proteins are the basic structural component of genes.

(B) RNA acts as the primary genetic material in viruses.

(C) DNA is the genetic material injected into host bacteria.

(D) Replication of DNA proceeds via a semi-conservative pattern.

Q74. Which of the following lipid derivatives is an essential component of eukaryotic plasma membranes and acts as a precursor for the synthesis of steroid hormones?

(A) Phosphatidylcholine

(B) Cholesterol

(C) Sphingomyelin

(D) Palmitic acid

Q75. The interaction where an orchid plant grows harmlessly as an epiphyte on the branch of a large mango tree is classified as:

(A) Mutualism

(B) Parasitism

(C) Commensalism

(D) Amensalism

Q76. A root system that develops from any part of the plant body other than the radicle of the embryo is classified as:

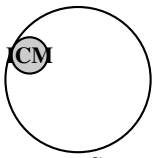
(A) Tap root system

(B) Fibrous root system

(C) Adventitious root system

(D) Prop root system

Q77. What is the structural destination of the inner cell mass of the human blastocyst after implantation is complete?



Blastocyst Structure

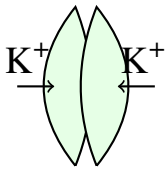
(A) It differentiates to form the fetal portion of the placenta.

(B) It gives rise to the protective amnion layer only.

(C) It differentiates as the embryo proper.

(D) It transforms into the trophoblast layer to absorb nutrients.

Q78. In the mechanism of opening and closing of stomata, which intracellular change occurs within the guard cells to induce their turgidity and opening?



(A) Efflux of potassium ions (K^+) into adjacent subsidiary cells.

(B) Influx of potassium ions (K^+) leading to a decrease in water potential.

(C) Rapid conversion of soluble sugars into insoluble starch grains.

(D) Active pumping of protons (H^+) into the guard cells from epidermal cells.

Q79. Which specialized structure of the human inner ear is directly responsible for converting mechanical sound vibrations into nerve impulses to allow hearing?

(A) Macula

(B) Crista ampullaris

(C) Organ of Corti

(D) Eustachian tube

Q80. In recombinant DNA technology, which specific enzyme is used to break the phosphodiester bonds within a double-stranded DNA molecule at specific recognition sequences?

(A) DNA Ligase

(B) Restriction Endonuclease

(C) Alkaline Phosphatase

(D) Exonuclease

Detailed Solutions

Q1.

Solution

Concept: The movement of water across a plant cell membrane is governed by water potential (Ψ_w), which is determined by the balance between osmotic pressure (π or solute potential Ψ_s) and turgor pressure (P or pressure potential Ψ_p).

Solution: Step 1: Understand the initial state of the plant cell. When a cell is placed in a solution and its turgor pressure becomes equal to its osmotic pressure ($P = \pi$), the net water potential of the cell becomes zero ($\Psi_w = \Psi_p + \Psi_s = 0$). This state represents a fully turgid cell where no net movement occurs initially.

Step 2: Analyze the second solution. The cell is transferred to a solution with identical osmotic strength. This means the external environment has the exact same solute concentration and osmotic pressure as the initial setup.

Step 3: Evaluate the property of the solute. The external solution contains a non-penetrating solute, meaning these solute particles cannot pass through the semi-permeable cell membrane to alter the internal concentrations.

Step 4: Formulate the net water potential gradient. Since the external solution has the same osmotic strength as the original environment, the chemical potential of water outside remains balanced with the internal system. The turgor pressure pushing outward is perfectly counterbalanced by the osmotic forces.

Step 5: Determine the final direction of flow. Because there is no difference in water potential ($\Delta\Psi_w = 0$) between the interior of the fully turgid cell and the external solution of identical osmotic strength, there will be no net movement of water across the membrane.

Final Answer: There will be no net movement of water across the membrane.

Answer: (C)

Go Back to Question 1

Q2.

Solution

Concept: The human cardiac conduction system coordinates the heartbeat through specialized muscle tissues. Electrical impulses travel sequentially from the sinoatrial node to the atrioventricular node, down the bundle of His, and into the Purkinje fibers.

Solution: Step 1: Identify the components of the cardiac conduction pathway. The sinoatrial (SA) node generates the action potential, which spreads across the atria and reaches the atrioventricular (AV) node.

Step 2: Trace the path after the AV node. The electrical impulse experiences a brief delay at the AV node to allow the atria to empty completely. From the AV node, the impulse enters the bundle of His, which divides into right and left bundle branches.

Step 3: Analyze the effect of a blockage in the bundle of His. The bundle of His is the unique electrical bridge connecting the atria to the ventricles. If a sudden blockage occurs at this critical point, the action potentials cannot pass down to the ventricles.

Step 4: Assess the downstream consequences. Without impulses traveling through the bundle branches and Purkinje fibers, the ventricular myocardium will not receive the signals required for coordinated contraction, leading to a disruption of ventricular systole.

Step 5: Verify the options against independent nodes. A blockage in the bundle of His does not stop the SA node from firing, nor does it affect the structure of the valves or the intrinsic delay inside the AV node itself. Thus, it directly halts transmission to the ventricular walls.

Final Answer: The transmission of contractile impulses to the ventricular myocardium.

Answer: (B)

Go Back to Question 2

Q3.

Solution

Concept: According to Chargaff's rules for double-stranded DNA, the total number of purines always equals the total number of pyrimidines. Specifically, the amount of adenine (A) equals thymine (T), and the amount of guanine (G) equals cytosine (C).

Solution: Step 1: Extract the given value from the problem statement. The double-stranded DNA sample contains 34% cytosine (C = 34%).

Step 2: Apply Chargaff's rule for the specific base-pairing partner. Since cytosine pairs exclusively with guanine in a double-stranded helix, the percentage of guanine must be equal to the percentage of cytosine (G = C = 34%).

Step 3: Calculate the combined percentage of the guanine-cytosine base pairs. Summing these two percentages yields G + C = 34% + 34% = 68%.

Step 4: Determine the remaining portion of the genome allocated to adenine-thymine pairs. Subtract the combined G + C percentage from the total genomic composition of 100%, which gives A + T = 100% − 68% = 32%.

Step 5: Isolate the individual percentage for adenine. Because adenine and thymine are present in equal amounts (A = T), divide the remaining pool by 2. This gives A = 32%/2 = 16%. Therefore, the expected percentage of adenine is 16%.

Final Answer: 16%

Answer: (B)

Go Back to Question 3

Q4.

Solution

Concept: The nucleolus is a dense, non-membrane-bound sub-compartment located inside the nucleus of eukaryotic cells. It serves as the dedicated site for the transcription of ribosomal RNA (rRNA) and the subsequent assembly of large and small ribosomal subunits.

Solution: Step 1: Define the primary function of the nucleolus. The nucleolus forms around specific chromosomal regions known as nucleolar organizer regions. It contains the molecular machinery needed to transcribe precursor rRNA genes.

Step 2: Analyze the impact of a selective metabolic poison. If a toxic agent specifically targets and shuts down the nucleolus, the synthesis of ribosomal RNA molecules will instantly stop.

Step 3: Connect rRNA synthesis to subunit assembly. Ribosomal subunits are constructed by combining newly synthesized rRNA strands with ribosomal proteins imported from the cytoplasm. Disruption of the nucleolus halts this complex assembly line.

Step 4: Trace the immediate cellular consequence. Without the functional assembly of these subunits in the nucleolus, the cell cannot export new ribosomes to the cytoplasm. This directly compromises the protein manufacturing infrastructure of the cell.

Step 5: Differentiate from other genomic processes. Transcription of typical structural genes into messenger RNA occurs in the loose euchromatin regions of the nucleoplasm via RNA polymerase II, which operates independently of the nucleolus. Thus, ribosome manufacturing is the primary target.

Final Answer: Synthesis of ribosomal RNA and assembly of ribosome subunits.

Answer: (A)

Go Back to Question 4

Q5.

Solution

Concept: The flow of energy through successive trophic levels in an ecosystem is governed by the laws of thermodynamics. According to Lindeman's 10% law, only a small fraction of energy is transferred from one level to the next higher level.

Solution: Step 1: Examine the foundational rules of ecological pyramids. Pyramids of biomass or numbers can occasionally be inverted under unique conditions, such as marine systems or parasitic chains. However, the pyramid of energy reflects the true rate of energy flux.

Step 2: Apply the second law of thermodynamics. Every time energy is converted from the chemical bonds of a prey organism into the tissues of a consumer, a significant portion of that energy is dissipated.

Step 3: Identify the major sinks of energy at each level. Organisms utilize the majority of their assimilated energy for cellular respiration, physical movement, maintenance, and metabolic processes, releasing this energy into the environment as unrecoverable heat.

Step 4: Calculate the efficiency of transfer. Approximately 90% of the available energy is lost at each step, leaving only about 10% to be integrated into the biomass of the next trophic tier.

Step 5: Conclude on the geometric shape of the energy pyramid. Because the total available energy content systematically decreases as you ascend from primary producers to top carnivores, the base must always remain wide and the apex narrow, making an inverted energy pyramid physically impossible.

Final Answer: Energy is systematically lost as metabolic heat at each trophic transfer.

Answer: (C)

Go Back to Question 5

Q6.

Solution

Concept: Angiosperm taxonomy relies on specific morphological and anatomical characteristics of flowers and reproductive organs to differentiate between plant families. The family Solanaceae exhibits a unique set of diagnostic reproductive features.

Solution: Step 1: Analyze the symmetry of the flower. The term actinomorphic implies that the flower possesses radial symmetry, meaning it can be divided into identical halves along multiple vertical planes passing through the center.

Step 2: Evaluate the gynoecium description. A bicarpellary, syncarpous ovary signifies that the female reproductive organ is composed of two carpels that are completely fused together.

Step 3: Focus on the orientation of the septum. A key distinguishing hallmark of the family Solanaceae is that the separating wall, or septum, inside the ovary is placed obliquely rather than along the standard median or transverse plane.

Step 4: Examine the placental architecture. The placenta in these plants is highly swollen and protrudes into the locules, bearing a large number of ovules arranged on an axile placentation system.

Step 5: Match the traits to the correct family. While Cruciferae features a replum and siliqua, and Liliaceae is trimerous, the combination of actinomorphic symmetry, an oblique septum, and a swollen placenta pointing toward an axile layout is exclusive to the family Solanaceae.

Final Answer: Solanaceae

Answer: (C)

Go Back to Question 6

Q7.

Solution

Concept: Microsporogenesis and microgametogenesis describe the formation of the male gametophyte in angiosperms. A diploid microspore mother cell undergoes meiosis to yield haploid microspores, which subsequently mature into pollen grains.

Solution: Step 1: Follow the initial meiotic division. The diploid microspore mother cell produces a tetrad of four haploid microspores through standard meiosis. Each microspore represents the start of the male gametophyte generation.

Step 2: Trace the first mitotic division within an individual microspore. The haploid nucleus undergoes an asymmetric mitotic division, splitting into two distinct cells: a larger vegetative cell and a smaller generative cell. At this stage, the pollen grain contains two nuclei.

Step 3: Analyze the behavior in different plant species. In over 60% of angiosperms, the pollen grain is shed at this specific two-celled (and thus two-nucleated) stage, consisting of one vegetative nucleus and one generative nucleus.

Step 4: Account for the remaining plant groups. In the remaining 40% of flowering plants, the generative cell undergoes a second mitotic division before shedding, splitting into two male gametes. This results in a three-celled, three-nucleated pollen grain.

Final Answer: Two or Three

Answer: (B)

Go Back to Question 7

Q8.

Solution

Concept: The Polymerase Chain Reaction (PCR) is an in vitro technique used to amplify specific segments of DNA. The process relies on a thermostable DNA polymerase, such as Taq polymerase, which requires pre-existing free 3′-OH ends to initiate nucleotide polymerization.

Solution: Step 1: Understand the limitations of DNA polymerase. Unlike RNA polymerases, DNA polymerases cannot synthesize a polynucleotide strand completely from scratch. They absolutely require a short stretch of double-stranded nucleic acid to begin adding nucleotides.

Step 2: Define the role of primers in PCR. Small, single-stranded sequences of nucleic acids must hybridize to the denatured target DNA strands during the annealing phase to act as starting blocks for elongation.

Step 3: Differentiate between the chemical types of primers. In living systems, cells use RNA primers generated by primase. However, in an artificial PCR setup, scientists utilize stable, chemically synthesized DNA primers.

Step 4: Verify compatibility with the enzyme. These synthetic oligodeoxynucleotide primers pair perfectly with the flanking regions of the target sequence, providing the necessary stable anchoring point for Taq polymerase.

Final Answer: Chemically synthesized DNA primers

Answer: (C)

Go Back to Question 8

Q9.

Solution

Concept: Photophosphorylation in the thylakoid membranes of chloroplasts can follow either a non-cyclic or a cyclic pathway. Cyclic photophosphorylation occurs exclusively when only Photosystem I (PSI) is active, leading to the production of ATP without generating NADPH or oxygen.

Solution: Step 1: Analyze the excitation phase of Photosystem I. When photons strike the light-harvesting complex of PSI, the reaction center chlorophyll molecule (P700) absorbs the energy and boosts an electron to a high-energy state.

Step 2: Identify the initial electron capture. This energized electron is instantly ejected from P700 and captured by the primary electron acceptor located within the core of PSI, which is an iron-sulfur (Fe-S) center.

Step 3: Map the pathway of the electron in the cyclic loop. From the primary acceptor (Fe-S), the electron is transferred to Ferredoxin (Fd). Instead of being passed to $NADP^+$ Reductase, the electron is rerouted.

Step 4: Follow the return path to the reaction center. The electron moves from Ferredoxin to the Cytochrome b_6f complex, then to Plastocyanin (PC), and finally returns to the electron-deficient P700 reaction center.

Step 5: Confirm the immediate destination. The prompt asks for the immediate primary destination right after excitation from the reaction center, which corresponds to the primary electron acceptor (Fe-S center) before moving down the rest of the loop.

Final Answer: Primary Electron Acceptor (Fe-S center)

Answer: (C)

Go Back to Question 9

Q10.

Solution

Concept: Diabetes mellitus is a metabolic disease characterized by chronic high blood sugar levels (hyperglycemia). It is broadly classified into Type 1, which results from an absolute lack of insulin, and Type 2, which involves cellular resistance to insulin.

Solution: Step 1: Evaluate the primary symptoms presented. The patient exhibits classic indicators of diabetes: extreme fatigue, frequent urination (polyuria), excessive thirst (polydipsia), and unexpected weight loss.

Step 2: Review the diagnostic blood panels. The clinical report indicates highly elevated blood glucose levels alongside normal or even elevated levels of circulating insulin in the bloodstream.

Step 3: Rule out Type 1 Diabetes. Type 1 diabetes is an autoimmune disease where the beta cells of the pancreas are destroyed, leading to a complete lack of insulin. The presence of normal-to-high insulin renders this option incorrect.

Step 4: Characterize Type 2 Diabetes. In Type 2 diabetes, the pancreas successfully produces insulin, but the target peripheral tissues (like liver, muscle, and adipose cells) display insulin resistance due to receptor or post-receptor defects.

Step 5: Conclude based on the biochemical marker. Because insulin levels are sufficient but glucose remains high in the blood, the cells are failing to respond to the hormone. This pattern is the hallmark of Type 2 Diabetes mellitus.

Final Answer: Type 2 Diabetes mellitus

Answer: (C)

Go Back to Question 10

Q11.

Solution

Concept: Mendelian dihybrid crosses track the inheritance patterns of two unlinked genetic traits simultaneously. A standard cross involving homozygous dominant and homozygous recessive parents produces an all-heterozygous F_1 generation.

Solution: Step 1: Identify the parental genotypes. Let Round seeds be R (dominant) and wrinkled be r (recessive); let Yellow cotyledons be Y (dominant) and green be y (recessive). The parents are RRYY and rryy.

Step 2: Determine the F_1 generation configuration. Crossing these parents yields a uniform F_1 generation with the double heterozygous genotype RrYy, displaying the dominant traits (Round, Yellow).

Step 3: Set up the F_2 phenotypic distribution. When the F_1 plants (RrYy $\times$ RrYy) are selfed, they generate a classic Mendelian ratio of $9 : 3 : 3 : 1$ among the sixteen possible combinations.

Step 4: Separate parental phenotypes from recombinant phenotypes. The parental combinations are Round-Yellow $(9/16)$ and Wrinkled-Green $(1/16)$. The completely new, non-parental arrangements are the recombinants.

Step 5: Sum the recombinant fractions. The two recombinant phenotypes are Wrinkled-Yellow $(3/16)$ and Round-Green $(3/16)$. Adding these together gives $3/16 + 3/16 = 6/16$.

Final Answer: $6/16$

Answer: (C)

Go Back to Question 11

Q12.

Solution

Concept: Biological membranes are thin, fluid structures primarily composed of an amphipathic lipid bilayer. The core structural molecules must contain hydrophobic fatty acid tails and hydrophilic polar head groups linked together stably.

Solution: Step 1: Analyze the chemical composition of phosphoglycerides. Phosphoglycerides are the primary class of phospholipids found in cellular membranes. They consist of a glycerol backbone attached to two fatty acid chains and a modified phosphate group.

Step 2: Examine the nature of chemical bonds within lipids. The fatty acids are coupled to the glycerol hydroxyl groups via ester bonds. These specific linkages are stable under normal physiological cell conditions but can be broken down by specialized esterase enzymes.

Step 3: Address the structural requirement. These molecules form the structural matrix of the plasma membrane, organizing spontaneously into a bilayer with hydrophobic tails pointing inward and hydrophilic heads facing outward.

Step 4: Eliminate alternative options. Triacylglycerols function primarily as energy storage molecules in fat tissue rather than structural units in membranes. Glycogen is a carbohydrate polymer, and globular proteins form functional units rather than structural lipid matrices.

Final Answer: Phosphoglycerides

Answer: (B)

Go Back to Question 12

Q13.

Solution

Concept: Ecosystems rely on a foundational trophic level composed of primary producers capable of capturing external energy to convert inorganic carbon into organic molecules. In extreme environments lacking sunlight, alternative energy pathways are utilized.

Solution: Step 1: Examine the conditions of a deep-sea hydrothermal vent. These unique ecological communities are located thousands of meters below the ocean surface, where solar radiation cannot penetrate, making standard photosynthesis impossible.

Step 2: Identify the alternative energy source. Hydrothermal vents discharge large quantities of reduced inorganic chemicals, such as hydrogen sulfide (H_2S), methane, and ferrous iron.

Step 3: Characterize the specialized metabolic adaptation. Certain specialized prokaryotes possess the enzymatic machinery to oxidize these inorganic chemical complexes. They capture the energy released from these chemical reactions to drive the fixation of carbon dioxide.

Step 4: Define the trophic classification. Because these organisms create organic biomass using chemical energy instead of light, they are classified as chemoautotrophic bacteria. They form the foundational base of the deep-sea food web.

Final Answer: Chemoautotrophic bacteria

Answer: (B)

Go Back to Question 13

Q14.

Solution

Concept: Robert H. Whittaker's five-kingdom classification system organizes life based on structural complexity, cellular organization, and modes of nutrition. The five designated kingdoms are Monera, Protista, Fungi, Plantae, and Animalia.

Solution: Step 1: Evaluate the cellular criteria provided. The organism is described as eukaryotic, which immediately eliminates the kingdom Monera since all monerans are prokaryotic.

Step 2: Check the structural complexity. It is a multicellular organism, which rules out the kingdom Protista, as protists are predominantly unicellular eukaryotic life forms.

Step 3: Assess the protective outer structures. The complete absence of a structural cell wall rules out both the kingdom Plantae (cellulose walls) and the kingdom Fungi (chitinous walls).

Step 4: Analyze the nutritional strategy. The organism exhibits heterotrophic, holozoic nutrition, meaning it actively ingests solid organic matter and processes it inside an internal digestive cavity.

Step 5: Synthesize the findings. The unique combination of a multicellular eukaryotic body, absence of cell walls, and holozoic ingestion is the definitive diagnostic signature of the kingdom Animalia.

Final Answer: Animalia

Answer: (D)

Go Back to Question 14

Q15.

Solution

Concept: Following successful fertilization, the developing human embryo must signal its presence to the maternal reproductive system to prevent the degradation of the uterine lining and ensure a successful pregnancy.

Solution: Step 1: Identify the developmental stage. The early embryo develops into a hollow ball of cells known as a blastocyst, which consists of an inner cell mass and an outer cellular layer called the trophoblast.

Step 2: Note the immediate hormonal requirement. To maintain the vascularized endometrium of the uterus, high levels of progesterone are continuously required. Normally, the corpus luteum in the ovary would degenerate at the end of the cycle, causing progesterone levels to drop.

Step 3: Identify the embryonic signal. To prevent this hormonal drop, the outer trophoblast cells of the blastocyst begin secreting a specific gonadotropic signaling hormone into the maternal bloodstream.

Step 4: Name the specific chemical messenger. This hormone is Human Chorionic Gonadotropin (hCG). It targets the corpus luteum in the ovary, stimulating it to survive and continue secreting large amounts of progesterone.

Final Answer: Human Chorionic Gonadotropin (hCG)

Answer: (C)

Go Back to Question 15

Q16.

Solution

Concept: Cloning vectors used in recombinant DNA technology are artificial DNA molecules designed to carry foreign genetic material into a host cell. A standard functional vector requires an origin of replication, cloning sites, and selectable markers.

Solution: Step 1: Understand the objective of transformation experiments. When host bacterial cells are mixed with recombinant plasmids, the uptake efficiency is low. Only a small fraction of the total bacterial population successfully internalizes the plasmid.

Step 2: Define the role of a selectable marker. A selectable marker is a gene engineered into the vector backbone that imparts a new, easily identifiable trait to the host cell, such as resistance to a specific antibiotic (e.g., ampicillin or tetracycline).

Step 3: Analyze the screening process. When the treated bacterial culture is plated onto a growth medium containing that specific antibiotic, all the original, unmodified bacteria that failed to take up the plasmid will die.

Step 4: Determine the outcome. Only the cells that have been successfully transformed by the vector will express the resistance gene and survive to form visible colonies, allowing researchers to differentiate between transformants and non-transformants.

Final Answer: To differentiate between transformants and non-transformants.

Answer: (C)

Go Back to Question 16

Q17.

Solution

Concept: Plant growth regulators coordinate physiological adaptations to environmental stresses. Under drought or extreme water deficiency, plants must rapidly minimize water loss through transpiration by closing their stomatal pores.

Solution: Step 1: Identify the target physiological response. Stomatal closure is regulated by changes in the turgidity of the flanking guard cells, which is driven by coordinated ion and water fluxes across their membranes.

Step 2: Pinpoint the chemical trigger under stress. When a plant experiences acute water scarcity, the roots and leaves synthesize a major stress hormone that acts as an emergency signal.

Step 3: Name the specific hormone. This biochemical molecule is Abscisic acid (ABA). It acts rapidly on the plasma membrane receptors of the leaf guard cells.

Step 4: Detail the mechanism of action. Abscisic acid triggers a signaling cascade that induces a rapid efflux of potassium (K^+) and chloride ions from the guard cells, causing water to follow osmotically. The guard cells lose turgor and collapse, closing the pore.

Final Answer: Abscisic acid

Answer: (C)

Go Back to Question 17

Q18.

Solution

Concept: Carbon dioxide (CO_2) generated as a metabolic waste product by systemic tissues must be efficiently transported through the blood to the respiratory surfaces of the lungs to be exhaled. It is carried via three distinct mechanisms.

Solution: Step 1: Evaluate the first transportation mechanism. A small portion, roughly 7%, of the total carbon dioxide molecules simply dissolves directly into the aqueous matrix of the blood plasma.

Step 2: Evaluate the second transportation mechanism. Approximately 20% to 25% of the carbon dioxide entering the blood diffuses into red blood cells and binds directly to the amino groups of hemoglobin, forming carbaminohemoglobin.

Step 3: Evaluate the dominant transportation pathway. The largest portion, accounting for roughly 70% of all tissue-derived CO_2, undergoes a chemical conversion inside erythrocytes.

Step 4: Explain the biochemical conversion. The enzyme carbonic anhydrase rapidly combines CO_2 with water to form carbonic acid, which quickly dissociates into hydrogen ions and bicarbonate ions (HCO_3^-). These bicarbonate ions then diffuse out into the plasma.

Step 5: Conclude on the primary form. Because 70% of the gas travels in this chemical form, bicarbonate ions represent the primary mechanism for carbon dioxide transport in human blood.

Final Answer: Bicarbonate ions in plasma and red blood cells.

Answer: (C)

Go Back to Question 18

Q19.

Solution

Concept: Transcription in prokaryotic organisms is driven by a single multi-subunit RNA polymerase enzyme. The core enzyme consists of several subunits ($\alpha_2\beta\beta'\omega$) and is capable of elongation, but it requires an additional regulatory component to precisely locate and bind to gene promoters.

Solution: Step 1: Distribute roles between the core enzyme and the holoenzyme. The core enzyme complex possesses catalytic polymerization activity but cannot identify specific transcription start sites on a double-stranded DNA template.

Step 2: Identify the initiation factor. To achieve selective binding, the core enzyme must transiently associate with a specialized initiation protein subunit.

Step 3: Name the factor. This protein subunit is known as the Sigma factor (σ). Its presence converts the core enzyme into a functional transcription holoenzyme.

Step 4: Detail the interaction with the promoter. The sigma factor directly recognizes and binds to specific conserved nucleotide motifs (such as the -10 and -35 regions) within the promoter sequence up-stream of the gene.

Step 5: Outline the transition to elongation. Once the sigma factor anchors the enzyme and transcription initiates, it dissociates from the complex, allowing the core enzyme to move forward along the gene.

Final Answer: Sigma factor (σ)

Answer: (D)

Go Back to Question 19

Q20.

Solution

Concept: Meiosis consists of two successive nuclear divisions that reduce the chromosome number by half. The segregation of genetic material differs fundamentally between the anaphase stages of meiosis I and meiosis II.

Solution: Step 1: Analyze chromosome behavior in meiosis I. During prophase I, homologous chromosomes pair up to form bivalents, and crossing over occurs. At metaphase I, these pairs align along the equatorial plate.

Step 2: Examine the mechanics of Anaphase I. The spindle fibers pull the intact homologous chromosomes apart toward opposite poles of the dividing cell. Crucially, the centromeres do not split during this phase.

Step 3: Track the state of sister chromatids. Because the centromere remains intact, the individual sister chromatids stay joined together at their central hubs, moving as a single unified unit toward the cell poles.

Step 4: Differentiate from alternative phases. In mitosis and anaphase II of meiosis, the centromeres split, causing sister chromatids to separate and become individual chromosomes. Thus, the separation of intact homologous pairs with sister chromatids remaining attached occurs exclusively in Anaphase I.

Final Answer: Anaphase I of meiosis

Answer: (B)

Go Back to Question 20

Q21.

Solution

Concept: Biodiversity conservation strategies are broadly categorized into two approaches based on whether the target threatened species is protected inside or outside its natural environment: in-situ (on-site) and ex-situ (off-site) conservation.

Solution: Step 1: Define the core principle of in-situ conservation. In-situ conservation focuses on protecting and managing wild species within their natural habitats and ecosystems where they naturally occur and evolve.

Step 2: Identify the primary methods used. This strategy involves designating specific geographic regions as protected areas, restricting human exploitation, and maintaining the broader ecological framework.

Step 3: Evaluate the examples given in the prompt. National parks, biosphere reserves, and wildlife sanctuaries are human-demarcated geographic territories established to preserve natural wildlife populations.

Step 4: Contrast with ex-situ conservation. Ex-situ conservation removes individuals of an endangered species from their natural habitat and places them in managed environments like botanical gardens, zoos, or gene banks to ensure their survival. Since the prompt specifies protection within the natural habitat, it refers to in-situ conservation.

Final Answer: In-situ conservation

Answer: (B)

Go Back to Question 21

Q22.

Solution

Concept: The androecium represents the male reproductive organs of a flower, consisting of a collection of stamens. The spatial arrangement, numbers, and relative lengths of these stamens serve as important diagnostic features for plant families.

Solution: Step 1: Define the structural arrangement of the androecium in Cruciferae. Plants belonging to the family Cruciferae (also known as Brassicaceae) typically possess six total stamens in each flower.

Step 2: Analyze the length distribution of these stamens. The six stamens are arranged in two distinct whorls. The outer whorl consists of two shorter stamens, while the inner whorl contains four longer stamens.

Step 3: Apply the precise botanical terminology. This specific structural configuration—having four long inner stamens and two short outer stamens—is defined as a tetradynamous androecium.

Step 4: Eliminate alternative stamen layouts. Monadelphous configurations (all stamens fused into a single tube) are characteristic of Malvaceae, while diadelphous setups (stamens split into two groups) are typical of Fabaceae. Therefore, the tetradynamous condition uniquely identifies Cruciferae.

Final Answer: Tetradynamous stamens

Answer: (C)

Go Back to Question 22

Q23.

Solution

Concept: Human fertilization requires a single sperm cell to penetrate the protective outer cellular and extracellular layers surrounding the secondary oocyte to fuse its haploid nucleus with the egg.

Solution: Step 1: Identify the protective barriers around the egg. The ovulated secondary oocyte is protected by an outer layer of granulosa cells called the corona radiata, and an inner, thick extracellular glycoprotein matrix known as the zona pellucida.

Step 2: Locate the specialized organelle in the sperm. The anterior tip of the sperm head is covered by the acrosome, a modified lysosomal vesicle filled with hydrolytic enzymes like hyaluronidase and acrosin.

Step 3: Define the trigger for the acrosome reaction. When the sperm contacts the outer layers of the egg, specific binding interactions induce the acrosome membrane to fuse with the sperm plasma membrane, releasing its enzymatic contents via exocytosis.

Step 4: Trace the path of penetration. These released hydrolytic enzymes locally digest the protective matrix of the corona radiata and the zona pellucida, creating a clear pathway for the sperm to reach and fuse with the oocyte plasma membrane.

Final Answer: To facilitate the penetration of the sperm through the corona radiata and zona pellucida.

Answer: (B)

Go Back to Question 23

Q24.

Solution

Concept: Biopesticides utilize naturally occurring biological agents or molecules to target and control insect pests. The soil bacterium Bacillus thuringiensis synthesizes crystal (Cry) proteins that act as specific endotoxins.

Solution: Step 1: Identify the biochemical state of the toxin inside the bacterium. During sporulation, Bacillus thuringiensis produces the Cry protein in a crystalline, completely inactive form known as a protoxin.

Step 2: Understand why it is harmless to the host cell. Because it is synthesized as an inactive precursor, the protein cannot interact with membranes or exert toxic enzymatic effects inside the bacterial cytoplasm.

Step 3: Examine the activation requirements in target insects. For the protoxin to become active, it must be ingested by a susceptible insect larva and enter its digestive tract.

Step 4: Detail the role of midgut pH. The midgut of specific insect larvae exhibits a highly alkaline pH. This alkaline environment solubilizes the protein crystals, and midgut proteases then cleave the protoxin into its active toxic form.

Step 5: Conclude on safety. The active toxin binds to midgut epithelial receptors, creating pores that cause cell lysis and death. The bacterium remains safe because it lacks both the alkaline midgut environment and the specific target tissue receptors.

Final Answer: The toxin exists as an inactive protoxin within the bacterium.

Answer: (B)

Go Back to Question 24

Q25.

Solution

Concept: C_4 plants utilize a specialized anatomical structure (Kranz anatomy) and a spatial separation mechanism to minimize photorespiration and maximize carbon dioxide fixation efficiency in hot, dry environments.

Solution: Step 1: Locate the primary site of initial CO_2 entry. Atmospheric carbon dioxide enters the leaf through stomata and diffuses directly into the cytosolic space of the outer mesophyll cells.

Step 2: Identify the primary carbon acceptor molecule. Unlike C_3 plants which use a 5-carbon sugar, C_4 plants present a 3-carbon compound known as Phosphoenolpyruvate (PEP) as the initial acceptor in the mesophyll cytoplasm.

Step 3: Name the specific catalyzing enzyme. The reaction combining PEP with bicarbonate ions (HCO_3^-, derived from CO_2) is catalyzed by Phosphoenolpyruvate carboxylase (PEP carboxylase).

Step 4: Evaluate the properties of this enzyme. PEP carboxylase exhibits an exceptionally high affinity for inorganic carbon and is completely insensitive to molecular oxygen, preventing the wasteful oxygenation reactions that occur with RuBisCO.

Step 5: Trace the initial product. This step yields the 4-carbon organic acid oxaloacetate (OAA), establishing PEP carboxylase as the primary enzyme for initial carbon capture in the mesophyll layer of C_4 species.

Final Answer: Phosphoenolpyruvate carboxylase

Answer: (B)

Go Back to Question 25

Q26.

Solution

Concept: The human brain is divided into the forebrain, midbrain, and hindbrain, each containing specialized structures that regulate specific voluntary and involuntary physiological actions.

Solution: Step 1: Localize the brainstem components. The hindbrain contains three primary regions: the pons, the cerebellum, and the medulla oblongata. The medulla oblongata transitions directly into the spinal cord.

Step 2: Define the regulatory role of the medulla oblongata. The medulla contains specialized autonomic nuclei that act as crucial reflex centers for maintaining homeostasis and survival.

Step 3: Enumerate the specific centers within the medulla. It houses the cardiovascular center, which regulates heart rate and blood vessel diameter; the respiratory rhythm center, which coordinates basal breathing; and centers for swallowing, coughing, vomiting, and gastric secretions.

Step 4: Exclude alternative brain structures. The cerebellum coordinates voluntary motor movements and balance, the cerebrum handles higher-level cognitive functions, and the hypothalamus regulates body temperature and endocrine balance. Thus, autonomic control of respiration and gastric functions resides in the medulla.

Final Answer: Medulla oblongata

Answer: (C)

Go Back to Question 26

Q27.

Solution

Concept: Point mutations involve a change in a single nucleotide base pair within a DNA sequence. These substitutions are classified into transitions or transversions depending on the structural families of the bases involved.

Solution: Step 1: Categorize the nitrogenous bases into their chemical families. Adenine (A) and Guanine (G) are double-ringed structures classified as purines. Thymine (T) and Cytosine (C) are single-ringed structures classified as pyrimidines.

Step 2: Define a transition mutation. A transition occurs when a purine base is substituted by another purine base (A $\leftrightarrow$ G), or when a pyrimidine base is substituted by another pyrimidine base (C $\leftrightarrow$ T).

Step 3: Define a transversion mutation. A transversion occurs when a purine base is replaced by a pyrimidine base, or vice versa (e.g., A $\leftrightarrow$ C or G $\leftrightarrow$ T).

Step 4: Apply the definition to the problem scenario. The question specifies that a purine base is replaced by another purine base. This structural substitution within the same chemical family satisfies the definition of a transition mutation.

Final Answer: Transition

Answer: (A)

Go Back to Question 27

Q28.

Solution

Concept: Cytokinesis describes the physical division of the cytoplasm following nuclear division (karyokinesis). The mechanism of cytokinesis differs fundamentally between plant and animal cells due to the presence of a rigid plant cell wall.

Solution: Step 1: Contrast plant and animal cytokinesis. Animal cells divide via a contractile ring of microfilaments that pinches the plasma membrane inward, forming a cleavage furrow. Plant cells cannot form a furrow due to their rigid outer wall.

Step 2: Identify the plant-specific mechanism. Plant cells complete cytokinesis by building a completely new cell wall from the inside out, starting along the equatorial plane of the cell.

Step 3: Trace the assembly of the cell plate. During late anaphase and telophase, the phragmoplast structure forms, and an organelle begins sorting and shipping cell wall precursors.

Step 4: Name the responsible organelle. The Golgi apparatus produces secretory vesicles filled with pectin, hemicellulose, and other structural polysaccharides.

Step 5: Follow the vesicle fusion process. These Golgi-derived vesicles travel along microtubules to the center of the cell, where they fuse together to form the cell plate, which expands outward to meet the existing lateral walls.

Final Answer: Golgi apparatus

Answer: (C)

Go Back to Question 28

Q29.

Solution

Concept: Aquatic ecosystems are sensitive to alterations in nutrient balances. Human activities, such as agricultural runoff containing fertilizers or untreated sewage disposal, can introduce excess chemical compounds into water bodies.

Solution: Step 1: Identify the chemical drivers of the phenomenon. Runoff often contains high concentrations of essential plant nutrients, specifically nitrates and inorganic phosphates.

Step 2: Trace the initial biological response. This sudden enrichment triggers rapid, unconstrained growth among phytoplankton and surface algae populations, a phenomenon known as an algal bloom.

Step 3: Analyze the subsequent degradation phase. The dense mat of algae blocks sunlight from reaching deeper aquatic plants, causing them to die. Eventually, the short-lived surface algae exhaust the nutrients and die as well.

Step 4: Explain the oxygen depletion mechanism. Aerobic decomposers and heterotrophic bacteria multiply rapidly to break down this massive volume of dead organic matter, consuming the dissolved oxygen in the water.

Step 5: Define the ecological term. This entire process—from initial nutrient enrichment to severe dissolved oxygen depletion and subsequent aquatic mortality—is called eutrophication.

Final Answer: Eutrophication

Answer: (B)

Go Back to Question 29

Q30.

Solution

Concept: Stems can undergo various morphological modifications to function as specialized storage organs, structures for vegetative propagation, or survival units during unfavorable environmental periods (perennation).

Solution: Step 1: Define a corm modification. A corm is a short, vertically oriented, highly swollen underground stem segment surrounded by protective scale leaves, containing distinct nodes, internodes, and auxiliary buds.

Step 2: Evaluate Solanum tuberosum. The potato represents an underground stem modification known as a tuber, which stores starch within swollen terminal branch tips.

Step 3: Evaluate Allium cepa. The onion represents a highly reduced underground stem disc known as a bulb, surrounded by fleshy, water-storing scale leaves.

Step 4: Evaluate Zingiber officinale. Ginger represents a horizontally growing underground stem modification classified as a rhizome.

Step 5: Match the corm definition to the correct genus. Amorphophallus (commonly known as elephant foot yam) is a classic example of a large, vertically oriented underground corm that functions in storage and perennation.

Final Answer: Amorphophallus

Answer: (C)

Go Back to Question 30

Q31.

Solution

Concept: Autoimmune disorders occur when the body's adaptive immune system loses self-tolerance, producing autoantibodies that attack healthy cells, tissues, or physiological receptors.

Solution: Step 1: Define the specific site of pathology. The neuromuscular junction is the chemical synapse where an axon terminal of a motor neuron meets the motor endplate of a skeletal muscle fiber.

Step 2: Trace the physiological signaling pathway. Normally, the neurotransmitter acetylcholine (ACh) is released into the synaptic cleft and binds to nicotinic ACh receptors on the muscle membrane, triggering contraction.

Step 3: Detail the autoimmune defect. In patients with Myasthenia gravis, the immune system produces autoantibodies that bind to and block these nicotinic acetylcholine receptors.

Step 4: Analyze the downstream symptoms. This block induces receptor degradation, impairing signal transmission at the neuromuscular junction. The muscle fibers fail to contract reliably, leading to progressive muscle weakness and fatigue.

Step 5: Differentiate from muscular dystrophy. Muscular dystrophy is a genetic disorder caused by mutations in structural proteins like dystrophin, rather than an autoimmune attack on receptors. Thus, Myasthenia gravis matches the description.

Final Answer: Myasthenia gravis

Answer: (B)

Go Back to Question 31

Q32.

Solution

Concept: Gene expression in eukaryotes involves the transcription of DNA into a primary transcript (pre-mRNA), which must undergo post-transcriptional processing—including splicing—to remove non-coding segments before translation.

Solution: Step 1: Understand prokaryotic versus eukaryotic mRNA structure. In prokaryotes, mRNA is translated directly as transcribed. In eukaryotes, the initial transcript contains alternating coding and non-coding sequences.

Step 2: Define introns and exons. Introns are the non-coding intervening sequences that do not contain amino acid specifications, while exons are the coding segments that carry the genetic instructions for protein synthesis.

Step 3: Analyze the pre-mRNA splicing mechanism. Inside the nucleus, the spliceosome complex excises all the non-coding introns and splices the exons together back-to-tail.

Step 4: Examine the mature mRNA transcript exported to the cytoplasm. The resulting mature mRNA consists of a 5′ cap, a 5′ untranslated region, a continuous coding region bounded by the start (AUG) and stop codons, a 3′ untranslated region, and a poly-A tail.

Step 5: Conclude on the composition of the coding sequence. The structural region between the start and stop codons is composed exclusively of spliced, coding exons.

Final Answer: Exons only

Answer: (B)

Go Back to Question 32

Q33.

Solution

Concept: Eukaryotic cells contain membrane-bound compartments that isolate specific biochemical processes. Organelles can be non-membrane-bound, single-membrane-bound, or double-membrane-bound.

Solution: Step 1: Evaluate membrane structures across cell organelles. Mitochondria and chloroplasts are double-membrane-bound organelles containing their own genetic material. Ribosomes are non-membrane-bound complexes composed of protein and RNA.

Step 2: Characterize the lysosome membrane. The lysosome is a spherical vesicle bounded by a single phospholipid unit membrane.

Step 3: Analyze the internal environment of the lysosome. The interior of the lysosome is maintained at an acidic pH (around 4.5 to 5.0) by proton pumps embedded within its membrane.

Step 4: Identify the resident enzymes. The lysosome contains a variety of hydrolytic enzymes, such as acid hydrolases, proteases, lipases, and nucleases, which break down proteins, nucleic acids, and cellular debris.

Step 5: Match the criteria. The combination of a single unit membrane boundary and an acidic lumen containing active hydrolytic enzymes is characteristic of the lysosome.

Final Answer: Lysosome

Answer: (C)

Go Back to Question 33

Q34.

Solution

Concept: Biotic interactions describe the ecological relationships between different species living within a shared community. These interactions can have positive (+), negative (−), or neutral (0) effects on the fitness of the participating organisms.

Solution: Step 1: Define the effects on each species in the scenario. The prompt describes an interaction where one species derives a clear ecological benefit (+), while the other associated species is unaffected (0).

Step 2: Analyze Parasitism. In parasitism, one organism benefits (+) at the direct physiological cost and detriment of the host organism (−).

Step 3: Analyze Mutualism. In mutualism, both interacting species derive reciprocal benefits from the association (+/+).

Step 4: Analyze Amensalism. In amensalism, one species is inhibited or harmed (−) while the other remains completely unaffected (0).

Step 5: Define Commensalism. Commensalism describes an asymmetrical interaction where one species benefits (+) while the host species experiences no measurable positive or negative impact (0). This aligns with the conditions in the prompt.

Final Answer: Commensalism

Answer: (D)

Go Back to Question 34

Q35.

Solution

Concept: The plant kingdom is organized into major evolutionary groups based on structural complexity, vascular development, and reproductive adaptations: Bryophytes, Pteridophytes, Gymnosperms, and Angiosperms.

Solution: Step 1: Evaluate reproductive evolutionary markers. Bryophytes and Pteridophytes are non-seed-bearing tracheophytes that utilize spores for reproduction. Seed development evolved later in evolutionary history.

Step 2: Contrast the two seed-bearing plant groups. Gymnosperms and Angiosperms both produce seeds. However, they differ in the structural organization of their reproductive units and how those seeds are housed.

Step 3: Examine Angiosperm characteristics. Angiosperms produce flowers, and their ovules are enclosed within an ovary. Following fertilization, the ovary wall develops into a protective fruit surrounding the seeds.

Step 4: Examine Gymnosperm characteristics. The term gymnosperm translates directly to "naked seed." In these plants, the ovules are exposed on the surfaces of specialized scale leaves (sporophylls), which are typically arranged in compact structures called cones or strobili.

Step 5: Match the diagnostic features. Plants that produce seeds lacking an enclosing ovary wall, and possess specialized reproductive cones, belong to the Gymnosperms.

Final Answer: Gymnosperms

Answer: (C)

Go Back to Question 35

Q36.

Solution

Concept: The male human reproductive system includes specialized testicular tissues that coordinate the production of sperm cells (spermatogenesis) and the synthesis of male sex hormones.

Solution: Step 1: Map the internal anatomy of the testes. The testes contain tightly coiled seminiferous tubules separated by connective tissue gaps known as interstitial spaces.

Step 2: Differentiate internal tubule cells. Inside the seminiferous tubules, spermatogonia undergo meiosis to generate spermatozoa, while Sertoli cells provide structural support and nourishment to the developing germ cells.

Step 3: Identify cells within the interstitial spaces. The interstitial gaps contain specialized endocrine cells called Leydig cells (or interstitial cells of Leydig).

Step 4: Define the function of Leydig cells. In response to Luteinizing Hormone (LH) secreted by the anterior pituitary gland, Leydig cells synthesize and secrete male steroid hormones, primarily testosterone.

Final Answer: To secrete androgens, principally testosterone.

Answer: (B)

Go Back to Question 36

Q37.

Solution

Concept: Genetic engineering relies on gene transfer methods to introduce recombinant DNA vectors into host organisms. These methods are categorized into vector-mediated (e.g., Agrobacterium) or direct, vector-free delivery techniques.

Solution: Step 1: Understand the challenges of plant cell transformation. Plant cells possess a thick, rigid outer cellulose cell wall that acts as a physical barrier to the passive entry of large, negatively charged DNA molecules.

Step 2: Evaluate the physical transformation mechanism described. The prompt details a direct, vector-free delivery technique where exogenous DNA is introduced into target tissues using high-velocity microparticles.

Step 3: Identify the materials used. Small microparticles composed of dense, inert heavy metals—typically tungsten or gold—are coated with the target recombinant DNA constructs.

Step 4: Name the specific delivery apparatus. This mixture is loaded into a specialized device called a gene gun or biolistic particle delivery system. The gun uses a helium gas discharge to launch the coated microparticles at high speeds, penetrating the cell wall and delivering the DNA directly into the cell nucleus.

Final Answer: Biolistics (Gene gun)

Answer: (C)

Go Back to Question 37

Q38.

Solution

Concept: Cellular respiration extracts chemical energy from glucose through a sequence of metabolic pathways. ATP synthesis occurs via two mechanisms: oxidative phosphorylation driven by the electron transport chain, and substrate-level phosphorylation.

Solution: Step 1: Track substrate-level phosphorylation during Glycolysis. In the cytoplasm, the breakdown of one glucose molecule into two molecules of pyruvate yields a total of 4 ATP molecules, while consuming 2 ATP in the preparatory phase. This results in a net gain of 2 ATP at the substrate level.

Step 2: Track the Link Reaction. The conversion of pyruvate into acetyl-CoA within the mitochondrial matrix generates NADH but does not produce any ATP directly via substrate-level phosphorylation.

Step 3: Track substrate-level phosphorylation during the Krebs Cycle. Each turn of the citric acid cycle processes one acetyl-CoA molecule, generating one molecule of GTP (which is energetically equivalent to ATP) during the conversion of succinyl-CoA to succinate.

Step 4: Calculate the total yield for one glucose molecule. Since one glucose molecule yields two molecules of acetyl-CoA, the Krebs cycle operates twice per glucose molecule, contributing 2 ATP via substrate-level phosphorylation.

Step 5: Sum the totals. Adding the net 2 ATP from glycolysis to the 2 ATP from the Krebs cycle gives a total net yield of 4 ATP produced directly through substrate-level phosphorylation during aerobic glucose oxidation.

Final Answer: 4 ATP

Answer: (B)

Go Back to Question 38

Q39.

Solution

Concept: The human digestive system contains specialized muscular valves and anatomical junctions that regulate the one-way transit of food and waste material through the gastrointestinal tract, preventing backflow.

Solution: Step 1: Identify the structural segments of the lower digestive tract. The small intestine concludes at its terminal segment, the ileum. The large intestine begins at a blind pouch known as the caecum.

Step 2: Define the anatomical junction. The point where the terminal ileum meets the caecum forms a distinct physiological boundary.

Step 3: Name the regulatory valve. This structural boundary contains a muscular fold known as the ileocaecal valve.

Step 4: Explain its physiological function. The ileocaecal valve opens in response to pressure waves from the small intestine, allowing digested chyme to pass into the large intestine. Once the material enters the caecum, the valve closes tightly. This physical barrier prevents the reflux of fecal matter and associated bacteria back into the sterile small intestine.

Final Answer: Ileocaecal valve

Answer: (C)

Go Back to Question 39

Q40.

Solution

Concept: Chromosomal abnormalities can arise from nondisjunction events during meiosis, where homologous chromosomes or sister chromatids fail to separate properly, resulting in gametes with abnormal chromosome numbers.

Solution: Step 1: Define Klinefelter syndrome. Klinefelter syndrome is a genetic condition that develops in males due to the presence of an extra X chromosome.

Step 2: Analyze the karyotype. Affected individuals possess the normal male complement of autosomes (44 autosomes) but have an abnormal sex chromosome constitution. Instead of the typical XY arrangement, they inherit an extra X chromosome, resulting in an XXY configuration.

Step 3: Calculate the total chromosome count. The presence of this additional sex chromosome increases the total count from the standard 46 to 47 chromosomes (44 autosomes + XXY).

Step 4: Contrast with alternative syndromes. An aneuploid condition with a single sex chromosome $(45, XO)$ causes Turner syndrome, which expresses as a female phenotype. An XXY sex chromosome constitution on a total count of 47 chromosomes is diagnostic of Klinefelter syndrome.

Final Answer: 47, XXY

Answer: (B)

Go Back to Question 40

Q41.

Solution

Concept: Enzyme inhibition occurs when a molecule binds to an enzyme and decreases its catalytic activity. In competitive inhibition, the inhibitor structurally resembles the substrate and competes directly for binding at the active site.

Solution: Step 1: Analyze the binding site of a competitive inhibitor. Because a competitive inhibitor features a chemical structure similar to the substrate, it binds reversibly to the active site of the enzyme, blocking substrate access.

Step 2: Evaluate the impact on maximum velocity (V_{max}). If the substrate concentration is increased to exceptionally high levels, the substrate will outcompete the inhibitor for the active sites. Therefore, the maximum velocity (V_{max}) of the reaction remains unchanged.

Step 3: Evaluate the impact on the Michaelis constant (K_m). K_m represents the substrate concentration at which the reaction velocity reaches half of V_{max}. Because the inhibitor interferes with substrate binding, a higher concentration of substrate is required to achieve the same rate.

Step 4: Conclude on the apparent parameter shift. This requirement for more substrate manifests mathematically as an increase in the apparent K_m value of the enzyme, while V_{max} remains unaffected.

Final Answer: The inhibitor increases the apparent K_m of the enzyme for its substrate.

Answer: (B)

Go Back to Question 41

Q42.

Solution

Concept: The competitive exclusion principle, formulated by ecologist G.F. Gause, governs the dynamics of resource limitation and niche overlap between coexisting species within an ecological community.

Solution: Step 1: Define the foundational premise of Gause's principle. The rule dictates that two distinct species cannot occupy the exact same ecological niche indefinitely if they are competing for identical, limited environmental resources.

Step 2: Analyze the impact of complete niche overlap. When two closely related species utilize the same resource pool, their fitness and growth rates are mutually constrained by competition.

Step 3: Factor in competitive asymmetry. In natural ecosystems, one species will inevitably possess a slight reproductive or foraging advantage, making it competitively superior to the other.

Step 4: Determine the long-term population outcome. The competitively superior species will exploit the resource pool more efficiently, causing the population of the inferior species to decline progressively until it is entirely eliminated from that habitat.

Final Answer: Competitively inferior species is eventually eliminated.

Answer: (B)

Go Back to Question 42

Q43.

Solution

Concept: Plants adapt anatomically to their environmental conditions. Velamen is a specialized, multi-layered dead hygroscopic epidermis that covers the roots of certain plants growing in unique habitats.

Solution: Step 1: Identify the function of velamen tissue. Velamen consists of sponge-like cells that absorb moisture, rain, and nutrients directly from the surrounding humid atmosphere.

Step 2: Evaluate hydrophytic plants. Submerged hydrophytes are surrounded by water and do not require specialized atmospheric absorption layers.

Step 3: Evaluate epiphytic configurations. Epiphytes are plants that grow non-parasitically on the surfaces of other trees. Because their roots hang freely in the air without reaching the soil, they must capture moisture from the air.

Step 4: Link the tissue to the plant group. Epiphytic orchids characteristically possess aerial roots wrapped in velamen tissue, allowing them to survive in the forest canopy away from ground-level water sources.

Final Answer: Epiphytic orchids

Answer: (B)

Go Back to Question 43

Q44.

Solution

Concept: The female reproductive lifespan is bounded by two major physiological milestones associated with changes in ovarian follicle pools and circulating gonadotropin levels.

Solution: Step 1: Define Menarche. Menarche refers to the initial onset of the menstrual cycle during puberty, marking the beginning of reproductive capability.

Step 2: Define the transition occurring in later years. As human females age, the population of primary oocytes in the ovaries becomes exhausted, and the remaining follicles become less responsive to follicle-stimulating hormone (FSH) and luteinizing hormone (LH).

Step 3: Analyze the hormonal shift. This lack of responsiveness leads to a steady decline in estrogen and progesterone production, causing the menstrual cycle to become irregular and eventually stop completely.

Step 4: Identify the correct physiological term. The permanent cessation of menstruation, typically occurring between 45 and 50 years of age, is defined as menopause.

Final Answer: Menopause

Answer: (B)

Go Back to Question 44

Q45.

Solution

Concept: The Polymerase Chain Reaction (PCR) utilizes high temperatures (typically 94°C to 95°C) during the denaturation step to separate double-stranded DNA templates. This requires an exceptionally resilient enzymatic catalyst.

Solution: Step 1: Analyze the environment inside a thermal cycler. Standard enzymatic proteins denature and lose their catalytic activity at high temperatures due to the disruption of their tertiary structure.

Step 2: Examine the source organism Thermus aquaticus. This organism is a hyperthermophilic bacterium that inhabits hot springs and hydrothermal environments.

Step 3: Evaluate its polymerase enzyme (Taq polymerase). The enzymes isolated from Thermus aquaticus have evolved to remain structurally stable and catalytically active at elevated temperatures.

Step 4: Connect this property to PCR utility. Because Taq polymerase can withstand the repeated heating cycles required for DNA denaturation without breaking down, it does not need to be replenished after every cycle, enabling automated amplification.

Final Answer: It retains structural stability and catalytic activity at high temperatures.

Answer: (C)

Go Back to Question 45

Q46.

Solution

Concept: Oxidative phosphorylation occurs within the inner mitochondrial membrane. Electrons derived from metabolic substrates are passed through a series of multi-protein complexes known as the electron transport chain (ETC).

Solution: Step 1: Trace the path of electrons. High-energy electrons from NADH and $FADH_2$ enter the ETC and are transferred sequentially through Complex I, II, III, and IV via mobile electron carriers like ubiquinone and cytochrome c.

Step 2: Identify the terminal complex. Complex IV (cytochrome c oxidase) receives the lower-energy electrons at the end of this transport pathway.

Step 3: Locate the terminal electron sink. To maintain the continuous flow of electrons and proton pumping across the membrane, these electrons must be transferred to a highly electronegative final acceptor molecule.

Step 4: Identify the final chemical step. Molecular oxygen (O_2) acts as this final electron acceptor. It binds electrons and combines with free protons from the matrix to form water molecules ($2H^+ + 2e^- + \frac{1}{2}O_2 \rightarrow H_2O$).

Final Answer: Molecular oxygen

Answer: (D)

Go Back to Question 46

Q47.

Solution

Concept: Renal ultrafiltration is driven by the net filtration pressure (NFP) within the glomerulus, which depends on the balance between hydrostatic pressure and opposing osmotic forces.

Solution: Step 1: State the equation for Net Filtration Pressure. The net movement of fluid across the glomerular membrane is determined by:

$$NFP = GHP - (BCOP + CHP)$$

where GHP is glomerular hydrostatic pressure, BCOP is blood colloid osmotic pressure, and CHP is capsular hydrostatic pressure.

Step 2: Analyze the effect of a systemic drop in blood pressure. A significant reduction in systemic arterial pressure lowers the glomerular hydrostatic pressure (GHP), decreasing the forward force driving fluid out of the capillaries.

Step 3: Evaluate the scenario where net filtration pressure drops to zero. If the opposing forces (BCOP + CHP) perfectly balance or exceed the forward hydrostatic pressure, the net filtration pressure becomes zero (NFP = 0).

Step 4: Determine the immediate consequence on urine formation. Without a positive pressure gradient to drive fluid across the filtration slits, the formation of glomerular filtrate ceases entirely, stopping the process of ultrafiltration.

Final Answer: Ultrafiltration will stop completely.

Answer: (A)

Go Back to Question 47

Q48.

Solution

Concept: The operon model, exemplified by the prokaryotic lac operon, describes a genetic mechanism where groups of structural genes are regulated by an operator site, a repressor protein, and an inducer molecule.

Solution: Step 1: Identify the baseline state of the operon in the absence of an inducer. The regulatory gene continuously synthesizes an active repressor protein that binds tightly to the operator DNA sequence, physically blocking RNA polymerase from transcribing the structural genes.

Step 2: Introduce the inducer molecule. When an inducer (such as allolactose) enters the cell, it acts as a chemical signal by binding directly to a specific allosteric site on the active repressor protein.

Step 3: Analyze the structural change in the repressor. Binding of the inducer alters the tertiary conformation of the repressor protein, reducing its affinity for the operator DNA sequence.

Step 4: Trace the downstream transcriptional outcome. The inactivated repressor dissociates from the operator site, leaving it unobstructed. This allows RNA polymerase to bind to the promoter and proceed with the transcription of the structural genes.

Final Answer: The repressor becomes inactive and dissociates from the operator.

Answer: (B)

Go Back to Question 48

Q49.

Solution

Concept: Prophase I of meiosis is a prolonged and complex stage divided into five distinct sub-stages based on chromosomal behavior: leptotene, zygotene, pachytene, diplotene, and diakinesis.

Solution: Step 1: Track chromosomal events through the sub-stages. In leptotene, chromatin condenses. In zygotene, homologous chromosomes pair up via the synaptonemal complex (synapsis).

Step 2: Analyze pachytene. During pachytene, crossing over occurs between non-sister chromatids of homologous chromosomes, mediated by recombination nodules.

Step 3: Analyze diplotene. Following genetic recombination, the synaptonemal complex dissolves, and the homologous chromosomes begin to separate from one another.

Step 4: Identify the visible structures in diplotene. Because the homologous chromosomes remain joined at the specific sites where crossing over occurred, these X-shaped intersection points, called chiasmata, become clearly visible under a microscope during the diplotene stage.

Final Answer: Diplotene

Answer: (D)

Go Back to Question 49

Q50.

Solution

Concept: Environmental toxicology tracks how synthetic chemical pollutants move through biological communities. Non-biodegradable substances cannot be metabolized or excreted efficiently by living organisms.

Solution: Step 1: Trace the entry of a persistent chemical. When a non-biodegradable pesticide like DDT is introduced into an ecosystem, it is absorbed by primary producers at low background concentrations.

Step 2: Analyze consumption across trophic levels. Consumers at higher trophic levels must ingest large quantities of biomass from the preceding level to fulfill their energy requirements.

Step 3: Explain the concentration mechanism. Because the pesticide is lipophilic and non-biodegradable, it remains stored within the fatty tissues of consumers rather than being excreted. As a result, the chemical concentration increases at each successive step up the food chain.

Step 4: Identify the correct ecological term. This progressive accumulation of a toxic substance at higher concentrations in top-level predators is defined as biomagnification.

Final Answer: Biomagnification

Answer: (B)

Go Back to Question 50

Q51.

Solution

Concept: Plant mineral nutrition research requires controlled experimental setups to identify which chemical elements are essential for plant growth, development, and metabolic function.

Solution: Step 1: Identify the historical context of the method. Hydroponics was pioneered and refined by botanists like Julius von Sachs as a technique to cultivate plants under fully defined chemical parameters.

Step 2: Define the growth medium. Hydroponics completely replaces natural soil matrices with an aqueous solution containing purified water and precisely measured mineral salts.

Step 3: Analyze the experimental utility. By systematically omitting specific minerals from this aqueous solution and monitoring the plant for structural or physiological deficiencies, researchers can determine whether a given element is essential.

Step 4: Select the definition that matches the method. Hydroponics is defined as the technique of growing plants in a complete water-nutrient solution in the absence of soil.

Final Answer: Defined nutrient solutions in the complete absence of soil.

Answer: (B)

Go Back to Question 51

Q52.

Solution

Concept: Skeletal muscle fibers possess a striated appearance due to the highly organized arrangement of alternating light and dark bands composed of overlapping contractile myofilaments.

Solution: Step 1: Identify the primary protein filaments. The myofibril is composed of thin filaments made of actin and thick filaments made of myosin.

Step 2: Characterize the light bands. The light bands contain only thin actin filaments and are isotropic to polarized light, which is why they are designated as I-bands.

Step 3: Characterize the dark bands. The dark bands contain the thick myosin filaments, along with the segments of thin actin filaments that overlap with them. These bands are anisotropic to polarized light and are designated as A-bands (Anisotropic bands).

Step 4: Confirm the structural classification. The dark zones that span the full length of the thick myosin filaments are defined as the A-bands.

Final Answer: A-bands

Answer: (B)

Go Back to Question 52

Q53.

Solution

Concept: Genetic linkage occurs when genes are located close to one another on the same chromosome, causing them to be inherited together during meiosis rather than assorting independently.

Solution: Step 1: Determine the baseline expectation for independent assortment. If two genes reside on different chromosomes, a test cross of a dihybrid (AaBb $\times$ aabb) yields a classic 1 : 1 : 1 : 1 phenotypic ratio due to independent assortment.

Step 2: Factor in complete or partial genetic linkage. When the two genes are physically linked on the same chromosome, they tend to remain in their parental configurations during gamete formation.

Step 3: Analyze the effect of crossing over. Recombinant gametes are only produced when a crossover event occurs between the two gene loci during prophase I of meiosis. Because the physical distance between linked genes is limited, crossing over is less frequent than independent assortment.

Step 4: Predict the phenotypic distribution in the offspring. Consequently, the test cross offspring will display a significantly higher frequency of parental phenotypes and a correspondingly low frequency of recombinant phenotypes.

Final Answer: A high frequency of parental types and low frequency of recombinant types

Answer: (C)

Go Back to Question 53

Q54.

Solution

Concept: Epithelial tissues line body cavities and organs, requiring specialized intercellular junctions to coordinate structural integrity, cell-to-cell communication, and barrier functions.

Solution: Step 1: Evaluate Gap Junctions. Gap junctions contain protein channels (connexons) that facilitate direct chemical communication and ion transport between the cytoplasms of adjacent cells.

Step 2: Evaluate Adhering Junctions (Desmosomes). Adhering junctions structurally anchor adjacent cells together by linking their cytoskeletons, providing mechanical strength to the tissue layer.

Step 3: Evaluate Tight Junctions. Tight junctions are formed by localized webs of transmembrane proteins (like claudins and occludins) that fuse the outer plasma membranes of adjacent cells together.

Step 4: Connect the structure to the barrier function. This continuous seal obliterates the intercellular space, acting as a strict barrier that prevents the leakage of fluids, ions, or larger molecules across the epithelial sheet.

Final Answer: Tight junction

Answer: (B)

Go Back to Question 54

Q55.

Solution

Concept: Air pollutants are classified into primary pollutants, which are emitted directly from a source, and secondary pollutants, which form in the atmosphere through chemical reactions between primary precursors.

Solution: Step 1: Analyze the composition of photochemical smog. Photochemical smog is a brown haze that forms when sunlight drives chemical reactions between pollutants in urban air.

Step 2: Identify the primary emissions from vehicles and industrial plants. Combustion engines release volatile organic compounds (VOCs) and nitrogen oxides (NO_x, such as nitric oxide and nitrogen dioxide) directly into the atmosphere as primary pollutants.

Step 3: Trace the photochemical reaction pathway. When exposed to ultraviolet radiation from sunlight, nitrogen dioxide splits to release free oxygen atoms, which combine with molecular oxygen to form ozone (O_3).

Step 4: Differentiate from secondary products. Ozone and peroxyacetyl nitrate (PAN) are secondary pollutants that form during this chemical cascade. Nitrogen oxides serve as the primary pollutants that initiate the formation of photochemical smog.

Final Answer: Nitrogen oxides

Answer: (B)

Go Back to Question 55

Q56.

Solution

Concept: Oogenesis describes the developmental pathway that transforms a diploid female germ cell (oogonium) into a mature haploid ovum through coordinated mitotic and meiotic divisions.

Solution: Step 1: Trace early oogenesis. Oogonia undergo mitosis during embryonic development to form primary oocytes, which remain arrested in prophase I until puberty.

Step 2: Analyze the first meiotic division. Following puberty, a primary oocyte resumes and completes meiosis I within a maturing follicle, undergoing an asymmetric division of the cytoplasm.

Step 3: Identify the products of Meiosis I. This asymmetric division yields a large haploid secondary oocyte and a small, non-functional structure called the first polar body.

Step 4: Analyze the second meiotic division. The secondary oocyte arrests in metaphase II and is ovulated. It only completes meiosis II if it is penetrated by a sperm cell, undergoing a second asymmetric division that produces a large ootid and a second polar body. Therefore, polar bodies are formed during the first and second meiotic divisions.

Final Answer: First and second meiotic divisions

Answer: (B)

Go Back to Question 56

Q57.

Solution

Concept: Plant anatomy classifies complex vascular tissues based on the spatial arrangement and relative orientation of xylem and phloem strands within a vascular bundle.

Solution: Step 1: Analyze radial vascular bundles. In radial arrangements, xylem and phloem are grouped separately and alternate with one another along different radii, a pattern characteristic of plant roots.

Step 2: Analyze conjoint vascular bundles. In conjoint arrangements, xylem and phloem are positioned together within the same vascular bundle along a shared radius, a pattern characteristic of stems and leaves.

Step 3: Evaluate collateral configurations. A collateral conjoint bundle features xylem situated toward the inner side (adaxial) and phloem situated toward the outer side (abaxial) along that shared radius.

Step 4: Factor in the presence of cambium. If a vascular cambium layer is sandwiched between the xylem and phloem, the bundle is open; if cambium is absent, it is closed. The prompt describes a conjoint, collateral arrangement based on the shared radius and outer phloem placement.

Final Answer: Conjoint and collateral

Answer: (B)

Go Back to Question 57

Q58.

Solution

Concept: The stomach lining features deep folds containing specialized gastric glands, which house distinct secretory cell populations that contribute to chemical digestion and nutrient absorption.

Solution: Step 1: Identify the cell types within gastric pits. The primary secretory cells include mucous neck cells, chief (peptic) cells, and parietal (oxyntic) cells.

Step 2: Review the secretions of peptic cells. Peptic cells synthesize and release the inactive enzyme precursor pepsinogen into the stomach lumen.

Step 3: Analyze the functions of oxyntic (parietal) cells. Oxyntic cells possess specialized proton pumps that actively secrete hydrochloric acid (HCl) to lower the gastric pH and activate pepsinogen.

Step 4: Identify the co-secreted factor. Alongside HCl, oxyntic cells synthesize and secrete intrinsic factor, a glycoprotein that binds to dietary vitamin B_{12} in the stomach, protecting it from degradation and facilitating its absorption in the terminal ileum.

Final Answer: Oxyntic (parietal) cells

Answer: (C)

Go Back to Question 58

Q59.

Solution

Concept: The structural model of double-stranded DNA describes two polynucleotide chains wound around a central axis, stabilized by hydrogen bonding between complementary purine and pyrimidine bases.

Solution: Step 1: Examine the chemical orientation of a single DNA strand. A DNA strand is directional, bounded by a free phosphate group at the $5'$ end and a free hydroxyl group at the $3'$ end of the sugar-phosphate backbone.

Step 2: Analyze the spatial arrangement of the two strands in the helix. The Watson-Crick model shows that the two strands are aligned head-to-tail relative to each other.

Step 3: Trace the directional paths. One strand runs in the $5' \rightarrow 3'$ direction, while its complementary partner strand runs in the opposite $3' \rightarrow 5'$ direction.

Step 4: Apply the correct structural terminology. This symmetrical, reverse-parallel alignment of the complementary strands is defined as an antiparallel orientation.

Final Answer: Antiparallel orientation

Answer: (B)

Go Back to Question 59

Q60.

Solution

Concept: Eukaryotic organisms are classified into distinct kingdoms based on structural, cellular, and metabolic variations. Plant and animal cells share standard organelles but differ in several diagnostic structures.

Solution: Step 1: Evaluate the outer boundaries. Animal cells are enclosed solely by a flexible plasma membrane, whereas plant cells possess an additional, rigid outer cell wall composed primarily of cellulose.

Step 2: Evaluate vacuolar architecture. Mature plant cells typically contain a single, large central vacuole that maintains cell turgidity and occupies up to 90% of the volume. Animal cells may contain small, transient vacuoles.

Step 3: Evaluate carbohydrate storage forms. Plants store excess photosynthate as starch, while animal cells store glucose as glycogen.

Step 4: Evaluate centrioles. Centrioles, which organize the mitotic spindle, are present in animal cells but absent in most higher plant cells. Therefore, the presence of a rigid cellulose wall in plant cells is an accurate structural difference.

Final Answer: Plant cells possess a rigid cellulose cell wall, whereas animal cells lack a cell wall.

Answer: (B)

Go Back to Question 60

Q61.

Solution

Concept: An ecosystem is an ecological unit composed of interacting structural elements, which are broadly divided into living (biotic) and non-living (abiotic) components.

Solution: Step 1: Define the abiotic component. The abiotic component encompasses the non-living physical and chemical elements of an environment, such as sunlight, temperature, water, and soil minerals.

Step 2: Define the biotic component. The biotic component includes all the living organisms within that geographic area, such as primary producers (plants), consumers (animals), and decomposers (bacteria and fungi).

Step 3: Analyze the structural interaction. These living organisms form complex networks through trophic relationships and energy transfers within the shared ecosystem.

Step 4: Match the prompt's description. The living organisms interacting within a specified geographic area represent the biotic component of the ecosystem.

Final Answer: Biotic component

Answer: (B)

Go Back to Question 61

Q62.

Solution

Concept: A floral formula uses standardized symbols and numbers to represent the structural organization, symmetry, and arrangement of floral organs within a specific plant family.

Solution: Step 1: Decode the symbols in the given formula: $\oplus \subsetneq K_{(5)}C_{(5)}A_5\underline{G}_{(2)}$. The symbol $\oplus$ denotes actinomorphic (radial) symmetry, and $\subsetneq$ indicates a bisexual flower.

Step 2: Analyze the calyx and corolla. $K_{(5)}$ indicates five fused sepals (gamosepalous), and $C_{(5)}$ indicates five fused petals (gamopetalous).

Step 3: Analyze the androecium and gynoecium. A_5 indicates five stamens that are often epipetalous (fused to the petals). $\underline{G}_{(2)}$ indicates a bicarpellary, syncarpous, superior ovary.

Step 4: Match the structural formula to the correct family. This combination of actinomorphic symmetry, five fused petals, five epipetalous stamens, and a bicarpellary superior ovary is the diagnostic floral formula of the family Solanaceae (the potato and nightshade family).

Final Answer: Solanaceae

Answer: (B)

Go Back to Question 62

Q63.

Solution

Concept: The female reproductive tract includes the oviducts (fallopian tubes), which transport the ovulated secondary oocyte from the ovary to the uterus. The fallopian tube is divided into several anatomical regions.

Solution: Step 1: Map the segments of the fallopian tube from the ovary toward the uterus. The three primary regions are the infundibulum, the ampulla, and the isthmus.

Step 2: Characterize the segment closest to the ovary. The region adjacent to the ovary is a wide, funnel-shaped structure called the infundibulum.

Step 3: Identify the specialized modifications of the infundibulum. The margins of the infundibulum feature finger-like projections called fimbriae, which move to capture the egg as it is ovulated from the Graafian follicle.

Step 4: Differentiate from other segments. The ampulla is the wider, intermediate region where fertilization typically occurs, and the isthmus is the narrow, terminal segment that connects directly to the uterine cavity. Therefore, the funnel-shaped portion is the infundibulum.

Final Answer: Infundibulum

Answer: (C)

Go Back to Question 63

Q64.

Solution

Concept: Biological nitrogen fixation is the process by which specific prokaryotes reduce inert atmospheric dinitrogen gas (N_2) into bioavailable ammonia (NH_3).

Solution: Step 1: Identify the symbiotic relationship. Rhizobium bacteria form a mutualistic relationship with the roots of leguminous plants, inducing the formation of specialized structures called root nodules.

Step 2: Identify the enzyme responsible for catalysis. Within these root nodules, the reduction of atmospheric nitrogen is catalyzed by the nitrogenase enzyme complex.

Step 3: Analyze the chemical requirements of the reaction. The nitrogenase enzyme requires a significant input of metabolic energy (16 ATP per molecule of N_2 fixed) and a strong reducing agent.

Step 4: Note environmental sensitivities. Nitrogenase is sensitive to molecular oxygen, which can irreversibly denature its active site. Legumes utilize the oxygen-scavenging protein leghemoglobin to maintain an anaerobic environment within the nodule core, allowing nitrogenase to function efficiently.

Final Answer: Nitrogenase

Answer: (C)

Go Back to Question 64

Q65.

Solution

Concept: The adrenal gland is an endocrine organ structurally divided into an inner adrenal medulla and an outer adrenal cortex. The cortex is further organized into three concentric cellular zones.

Solution: Step 1: Map the layers of the adrenal cortex from the outside inward. The three concentric layers are the zona glomerulosa, the zona fasciculata, and the zona reticularis.

Step 2: Differentiate the endocrine secretions of each zone. The innermost layer, the zona reticularis, synthesizes weak androgens. The intermediate layer, the zona fasciculata, secretes glucocorticoids like cortisol.

Step 3: Identify the function of the outermost layer. The outermost layer, the zona glomerulosa, is responsible for synthesizing and secreting mineralocorticoids, primarily aldosterone.

Step 4: Relate to the prompt's description. Aldosterone regulates electrolyte and water balance by promoting sodium reabsorption in the distal tubules of the nephron. It is synthesized within the cells of the zona glomerulosa.

Final Answer: Zona glomerulosa

Answer: (A)

Go Back to Question 65

Q66.

Solution

Concept: Sex-linked inheritance describes the transmission of genetic traits located on the sex chromosomes (X or Y). X-linked recessive disorders exhibit distinct phenotypic ratios between males and females due to chromosomal differences.

Solution: Step 1: Analyze the sex chromosome configuration in human females. Females possess two X chromosomes (XX). For an X-linked recessive trait to manifest phenotypically, the individual must be homozygous, inheriting a mutant allele on both X chromosomes. Heterozygous females (X^AX^a) act as unaffected carriers.

Step 2: Analyze the sex chromosome configuration in human males. Males possess one X chromosome and one Y chromosome (XY).

Step 3: Define hemizygosity. Because males have only a single copy of the X chromosome, they are hemizygous for all X-linked genes. They do not possess a second X allele to mask a recessive mutation.

Step 4: Conclude on phenotypic expression frequency. If a male inherits a single mutant X chromosome from his mother, he will express the recessive phenotype. Consequently, X-linked recessive conditions manifest more frequently in hemizygous males than in females.

Final Answer: Hemizygous males

Answer: (C)

Go Back to Question 66

Q67.

Solution

Concept: Meiotic recombination generates genetic diversity through the physical exchange of chromosomal segments between non-sister chromatids of a homologous pair during prophase I.

Solution: Step 1: Track the progression of prophase I sub-stages. Homologous chromosomes align and form a synaptonemal complex during the zygotene stage.

Step 2: Identify the precise stage of recombination. Once synapsis is complete, the cell enters the pachytene stage. During pachytene, the paired chromosomes appear clearly as tetrads or bivalents.

Step 3: Explain the molecular event in pachytene. Recombination nodules form along the synaptonemal complex, containing the enzymatic machinery (including recombinase) required to break and rejoin the non-sister chromatids.

Step 4: Differentiate from later stages. The physical exchange of genetic material (crossing over) is completed during pachytene. The resulting chiasmata only become visible later, during diplotene, as the synaptonemal complex dissolves and the chromosomes begin to separate. Therefore, the crossing over process occurs during pachytene.

Final Answer: Pachytene

Answer: (B)

Go Back to Question 67

Q68.

Solution

Concept: The species-area relationship, described by Alexander von Humboldt, models how species richness (S) changes as a function of the explored geographic area (A).

Solution: Step 1: State the mathematical equation on a linear scale. The relationship is initially modeled as a power function:

$$S = CA^Z$$

where C is a constant and Z is the regression coefficient (slope). On a standard linear graph, this function produces a rectangular hyperbola.

Step 2: Convert the function to a logarithmic scale. To analyze the relationship linearly, apply log transformations to both sides of the equation:

$$\log S = \log C + Z \log A$$

Step 3: Analyze the transformed equation. The logarithmic version follows the standard algebraic equation for a straight line ($y = mx + c$), where $\log S$ is the dependent variable (y), $\log A$ is the independent variable (x), $\log C$ is the y-intercept, and Z is the slope (m).

Step 4: Conclude on the geometric shape. On a logarithmic scale, the species-area relationship plots as a straight line.

Final Answer: Straight line

Answer: (C)

Go Back to Question 68

Q69.

Solution

Concept: Inflorescence architecture describes how flowers are grouped and arranged on a shared floral axis (peduncle), serving as a key diagnostic trait in plant taxonomy.

Solution: Step 1: Define a spadix inflorescence. A spadix is a variant of a spike inflorescence characterized by a fleshy, elongated central axis covered in small, sessile, apetalous flowers.

Step 2: Identify the protective structures. The flowers are typically arranged with female flowers at the base and male flowers above. The entire fleshy spike is surrounded and protected by a large, leaf-like or brightly colored bract called a spathe.

Step 3: Evaluate the family Gramineae. Gramineae features a spikelet inflorescence typical of grasses.

Step 4: Evaluate the family Araceae. The combination of a fleshy spadix inflorescence enclosed by a prominent, protective spathe is a defining characteristic of the family Araceae (the arum family, which includes plants like peace lilies and taro).

Final Answer: Araceae

Answer: (B)

Go Back to Question 69

Q70.

Solution

Concept: Hormonal contraceptives utilize synthetic analogs of female sex hormones to temporarily alter reproductive endocrine feedback loops, preventing unintended pregnancies.

Solution: Step 1: Identify the composition of oral contraceptive pills. These pills typically contain combinations of synthetic estrogen and progestogen, or progestogen alone.

Step 2: Analyze the neuroendocrine feedback mechanism. High circulating levels of these synthetic steroids exert negative feedback on the hypothalamus and the anterior pituitary gland.

Step 3: Determine the impact on gonadotropins. This negative feedback suppresses the secretion of Gonadotropin-Releasing Hormone (GnRH), Follicle-Stimulating Hormone (FSH), and Luteinizing Hormone (LH).

Step 4: Relate to the ovarian cycle. Without the FSH surge, ovarian follicles fail to mature; without the LH surge, ovulation cannot occur. Additionally, these hormones alter the cervical mucus to impede sperm transit and modify the endometrium to prevent implantation, with the inhibition of ovulation serving as the primary mechanism.

Final Answer: They inhibit ovulation and implantation by altering the feedback loop of gonadotropins.

Answer: (C)

Go Back to Question 70

Q71.

Solution

Concept: The Respiratory Quotient (RQ) is a dimensionless ratio that reflects the chemical composition of the substrate being oxidized during aerobic cellular respiration.

Solution: Step 1: State the formula for the Respiratory Quotient. The value is calculated as:

$$\text{RQ} = \frac{\text{Volume of } CO_2 \text{ eliminated}}{\text{Volume of } O_2 \text{ consumed}}$$

Step 2: Write the balanced chemical equation for the oxidation of a typical fat, such as tripalmitin:

$$2C_{51}H_{98}O_6 + 145O_2 \rightarrow 102CO_2 + 98H_2O + \text{Energy}$$

Step 3: Extract the stoichiometric values from the equation. The oxidation of tripalmitin consumes 145 molecules of oxygen and eliminates 102 molecules of carbon dioxide.

Step 4: Calculate the ratio. Substituting these values into the formula yields:

$$\text{RQ} = \frac{102}{145} \approx 0.7$$

Because lipids are highly reduced molecules containing relatively less oxygen per carbon atom than carbohydrates (which have an RQ of 1.0), they require more oxygen for complete oxidation, resulting in an RQ value below 1.0, specifically 0.7.

Final Answer: 0.7

Answer: (B)

Go Back to Question 71

Q72.

Solution

Concept: Epithelial tissues are structurally modified to support specific physiological functions. Ciliated epithelium contains cells with hair-like cytoplasmic projections called cilia on their free apical surfaces.

Solution: Step 1: Analyze the structure of cilia. Cilia are microtubule-based extensions capable of coordinated, rhythmic beating.

Step 2: Examine the functional role in the respiratory tract. In the bronchioles, ciliated cells beat in a coordinated direction to move mucus, dust, and trapped foreign particles upward toward the pharynx, protecting the lungs from infection.

Step 3: Examine the functional role in the reproductive tract. In the fallopian tubes, the rhythmic beating of cilia helps propel the non-motile secondary oocyte or zygote toward the uterine cavity.

Step 4: Generalize the physiological function. Across these tissues, the primary function of ciliated epithelium is to move particles, fluids, or cells in a consistent, uniform direction over the tissue surface.

Final Answer: To move particles or mucus in a specific direction over the epithelial surface.

Answer: (C)

Go Back to Question 72

Q73.

Solution

Concept: Early molecular biology research focused on identifying the chemical nature of the hereditary material. Alfred Hershey and Martha Chase conducted experiments in 1952 utilizing T2 bacteriophages to distinguish between protein and DNA templates.

Solution: Step 1: Understand the composition of a bacteriophage. A T2 bacteriophage consists of an outer protein capsule enclosing an inner DNA core.

Step 2: Analyze the specific radioactive labeling strategies. Hershey and Chase grew phages in media containing either radioactive sulfur (^{35}S), which labels proteins via sulfur-containing amino acids, or radioactive phosphorus (^{32}P), which labels the phosphate backbone of DNA.

Step 3: Follow the experimental steps. Labeled phages were allowed to infect Escherichia coli cells. The cultures were then agitated in a blender to detach the empty viral capsids from the bacterial cells and centrifuged.

Step 4: Evaluate the distribution of radioactivity. Radioactivity from ^{32}P was recovered within the bacterial cell pellet, whereas ^{35}S remained in the supernatant fluid containing the empty viral coats. This demonstrated that DNA, not protein, enters the host cell and carries the genetic information for viral replication.

Final Answer: DNA is the genetic material injected into host bacteria.

Answer: (C)

Go Back to Question 73

Q74.

Solution

Concept: Eukaryotic plasma membranes are fluid lipid bilayers containing phospholipids, integral proteins, and specialized sterol derivatives that modulate membrane fluidity and structural integrity.

Solution: Step 1: Identify the role of lipids in membranes. Phospholipids form the structural bilayer matrix, while sterols interdigitate between the fatty acid tails to maintain appropriate membrane dynamics across varying temperatures.

Step 2: Identify the primary sterol in animal membranes. Cholesterol is the principal sterol embedded within the plasma membranes of animal cells.

Step 3: Analyze the biosynthetic role of cholesterol. Beyond its structural function in membranes, cholesterol serves as the metabolic precursor for the synthesis of vital lipid-soluble signaling molecules.

Step 4: List the downstream hormones. It is enzymatically converted into steroid hormones, including glucocorticoids (cortisol), mineralocorticoids (aldosterone), and sex steroids (estrogen, progesterone, and testosterone). Therefore, cholesterol satisfies both the structural and precursor criteria.

Final Answer: Cholesterol

Answer: (B)

Go Back to Question 74

Q75.

Solution

Concept: Interspecific interactions describe the ecological relationships between different species within a community, categorized by their positive (+), negative (−), or neutral (0) effects on the participating organisms.

Solution: Step 1: Analyze the specific interaction details. The prompt describes an epiphytic orchid growing on a structural branch of a large mango tree.

Step 2: Determine the impact on the orchid. The orchid derives an ecological advantage (+) by being elevated into the canopy, which improves its access to sunlight, air moisture, and rain.

Step 3: Determine the impact on the mango tree. Because the orchid is an epiphyte rather than a parasite, it does not penetrate the host vascular tissue or steal nutrients or water. The mango tree is neither harmed nor helped by the presence of the orchid (0).

Step 4: Identify the corresponding ecological interaction. An asymmetrical biological relationship characterized by a positive effect for one participant (+) and a neutral effect for the host (0) is defined as commensalism.

Final Answer: Commensalism

Answer: (C)

Go Back to Question 75

Q76.

Solution

Concept: Root systems are classified based on their embryonic origin and structural development into tap root systems, fibrous root systems, or adventitious root systems.

Solution: Step 1: Trace standard root development. In the majority of dicotyledonous plants, the radicle of the embryo elongates directly to form the primary tap root, which then branches into secondary and tertiary roots.

Step 2: Trace fibrous root development. In monocots, the primary root derived from the radicle is short-lived and is replaced by a cluster of thin roots that develop from the base of the stem.

Step 3: Define adventitious roots. Adventitious roots develop from any anatomical part of the plant body other than the embryonic radicle.

Step 4: Identify examples of adventitious structures. This includes roots arising from stem nodes (such as the prop roots of a banyan tree or stilt roots of maize) or from leaves, satisfying the definition of an adventitious root system.

Final Answer: Adventitious root system

Answer: (C)

Go Back to Question 76

Q77.

Solution

Concept: Following fertilization, the zygote undergoes a series of rapid mitotic divisions called cleavage, transforming into a morula and subsequently a hollow blastocyst before attaching to the uterine wall.

Solution: Step 1: Analyze the structural components of a blastocyst. A mature human blastocyst consists of an outer single layer of flattened cells called the trophoblast, and an internal cluster of cells localized at one pole, known as the inner cell mass (ICM).

Step 2: Define the role of the trophoblast layer. The trophoblast cells secrete enzymes to facilitate implantation into the endometrium and later differentiate into the embryonic portion of the placenta (chorion).

Step 3: Trace the developmental fate of the inner cell mass. The cells of the inner cell mass are pluripotent stem cells. Following successful implantation, they undergo gastrulation.

Step 4: Map the germ layer differentiation. During gastrulation, the inner cell mass reorganizes into three primary embryonic germ layers: the ectoderm, mesoderm, and endoderm. These layers give rise to all the organs and tissues of the embryo proper.

Final Answer: It differentiates as the embryo proper.

Answer: (C)

Go Back to Question 77

Q78.

Solution

Concept: Stomatal movements are regulated by changes in the turgor pressure of the flanking guard cells, which are driven by active ion transport and osmotic water movement across their plasma membranes.

Solution: Step 1: Identify the primary ion driving stomatal opening. The opening of stomata is initiated by the active transport of protons (H^+) out of the guard cells, which creates an electrochemical gradient.

Step 2: Trace the counter-ion movement. In response to this electrical gradient, guard cells actively import potassium ions (K^+) from adjacent subsidiary cells through voltage-gated channels, balancing the charge with malate and chloride anions.

Step 3: Analyze the change in intracellular osmotic parameters. This accumulation of potassium and other ions increases the solute concentration inside the guard cells, lowering their solute potential and overall water potential (Ψ_w).

Step 4: Describe the movement of water and resulting structural change. Because the water potential inside the guard cells is lower than that of surrounding epidermal cells, water moves into the guard cells via osmosis. The guard cells expand and become turgid, bowing outward to open the stomatal pore.

Final Answer: Influx of potassium ions (K^+) leading to a decrease in water potential.

Answer: (B)

Go Back to Question 78

Q79.

Solution

Concept: The human ear functions as both a vestibular organ for balance and an auditory organ for hearing, converting physical sound pressure waves into electrical action potentials.

Solution: Step 1: Map the transmission of sound vibrations. Sound waves travel through the external auditory canal, vibrate the tympanic membrane, move the middle ear ossicles (malleus, incus, stapes), and enter the fluid-filled cochlea of the inner ear via the oval window.

Step 2: Analyze the fluid dynamics within the cochlea. The resulting pressure waves ripple through the perilymph and endolymph, causing localized vibrations of the basilar membrane.

Step 3: Locate the sensory mechanoreceptors. The Organ of Corti is a specialized structure situated on the surface of the basilar membrane.

Step 4: Detail the signal transduction mechanism. The Organ of Corti contains auditory hair cells with stereocilia that project upward toward the tectorial membrane. When the basilar membrane vibrates, these hair cells shear against the tectorial membrane, opening mechanically gated ion channels that generate nerve impulses transmitted along the auditory nerve to the brain.

Final Answer: Organ of Corti

Answer: (C)

Go Back to Question 79

Q80.

Solution

Concept: Recombinant DNA technology relies on enzymatic tools to manipulate nucleic acids, including polymerases to synthesize DNA, ligases to seal backbones, and nucleases to cleave phosphodiester bonds.

Solution: Step 1: Define exonucleases. Exonucleases digest DNA molecules by sequentially removing nucleotides from the exposed free ends of a strand.

Step 2: Define restriction endonucleases. Restriction endonucleases (or restriction enzymes) cleave internal phosphodiester bonds within a double-stranded DNA molecule.

Step 3: Analyze the specificity of restriction endonucleases. These enzymes do not cut randomly; they recognize specific, often palindromic, nucleotide sequences known as restriction sites and cut the sugar-phosphate backbone at precise points within or near those sequences.

Step 4: Match to the prompt's description. The tool used to break internal phosphodiester bonds at specific recognition sequences is a restriction endonuclease, which enables precise genetic engineering.

Final Answer: Restriction Endonuclease

Answer: (B)

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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	C	7	B	8	C	9	C	10	C
11	C	12	B	13	B	14	D	15	C
16	C	17	C	18	C	19	D	20	B
21	B	22	C	23	B	24	B	25	B
26	C	27	A	28	C	29	B	30	C
31	B	32	B	33	C	34	D	35	C
36	B	37	C	38	B	39	C	40	B
41	B	42	B	43	B	44	B	45	C
46	D	47	A	48	B	49	D	50	B
51	B	52	B	53	C	54	B	55	B
56	B	57	B	58	C	59	B	60	B
61	B	62	B	63	C	64	C	65	A
66	C	67	B	68	C	69	B	70	C
71	B	72	C	73	C	74	B	75	C
76	C	77	C	78	B	79	C	80	B