UPCATET Biology Sample Paper-4

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 where the osmotic pressure of the external solution balances the osmotic pressure of the cytoplasm. What will be the state of this cell, and what is its turgor pressure (TP)?

(A) Plasmolyzed, $TP = 0$

(B) Flaccid, $TP = 0$

(C) Turgid, $TP =$ Osmotic Pressure

(D) Fully turgid, $TP >$ Osmotic Pressure

Q2. During the contraction of a mammalian skeletal muscle fiber, which of the following bands or zones shortens in length?

(A) A-band

(B) I-band only

(C) H-zone and I-band

(D) H-zone and A-band

Q3. In a dihybrid cross between two heterozygous individuals ($AaBb \times AaBb$), assuming independent assortment and complete dominance, what is the probability of obtaining an offspring that expresses the dominant phenotype for both traits?

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

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

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

(D) $\frac{1}{2}$

Q4. Which of the following cell organelles is bounded by a single membrane and is rich in hydrolytic enzymes that function optimally at an acidic pH?

(A) Peroxisome

(B) Lysosome

(C) Glyoxysome

(D) Golgi apparatus

Q5. In a terrestrial ecosystem, if the net primary productivity (NPP) is 2000 $g/m^2/year$ and the respiration loss (R) by plants is 1500 $g/m^2/year$, what is the gross primary productivity (GPP) of this ecosystem?

(A) 500 $g/m^2/year$

(B) 1500 $g/m^2/year$

(C) 2000 $g/m^2/year$

(D) 3500 $g/m^2/year$

Q6. A botanist observes a plant with actinomorphic flowers, bicarpellary syncarpous ovary, superior ovary with swollen placenta, and oblique septum. To which of the following families does this plant belong?

(A) Cruciferae

(B) Solanaceae

(C) Leguminosae

(D) Malvaceae

Q7. In a mature unfertilized polygonum-type embryo sac of an angiosperm, what is the exact distribution and ploidy of cells at the chalazal end?

(A) Three haploid antipodal cells

(B) Two haploid synergids

(C) One diploid central cell

(D) Three diploid antipodal cells

Q8. Which of the following enzymes is used to seal the nicks in the sugar-phosphate backbone of DNA during recombinant DNA technology by forming a phosphodiester bond?

(A) EcoRI

(B) DNA Helicase

(C) DNA Ligase

(D) Alkaline Phosphatase

Q9. During the light reaction of photosynthesis, when electrons flow through non-cyclic photophosphorylation, which of the following complexes is directly responsible for pumping protons from the stroma into the thylakoid lumen?

(A) Photosystem II

(B) Cytochrome b_6f complex

(C) Photosystem I

(D) Ferredoxin-$NADP^+$ reductase

Q10. A patient's blood report reveals a significant reduction in the count of platelets. Which of the following processes will be most severely impaired in this patient?

(A) Oxygen transport in tissues

(B) Humoral immunity

(C) Coagulation of blood

(D) Phagocytosis of pathogens

Q11. A standard piece of double-stranded DNA contains 30% adenine bases. What is the expected percentage of cytosine bases in this DNA molecule according to Chargaff's rule?

(A) 20%

(B) 30%

(C) 40%

(D) 70%

Q12. During which specific stage of prophase I of meiosis does the process of crossing over take place between non-sister chromatids of homologous chromosomes?

(A) Leptotene

(B) Zygotene

(C) Pachytene

(D) Diplotene

Q13. Which of the following interactions represents a relationship where one species is harmed or inhibited while the other species remains completely unaffected?

(A) Commensalism

(B) Amensalism

(C) Parasitism

(D) Mutualism

Q14. Organisms belonging to Phylum Aschelminthes (Nematodes) differ fundamentally from Platyhelminthes in possessing which of the following features?

(A) Bilateral symmetry

(B) Triploblastic germ layers

(C) Pseudocoelom

(D) Organ-system level of organization

Q15. What is the role of the tapetum layer in the wall of a microsporangium during microsporogenesis?

(A) It provides protection to the developing anther

(B) It helps in the dehiscence of the anther wall

(C) It provides nourishment to the developing pollen grains

(D) It differentiates into microspore mother cells

Q16. In the process of polymerase chain reaction (PCR), what is the correct sequential order of steps carried out in each cycle?

(A) Extension → Denaturation → Annealing

(B) Denaturation → Annealing → Extension

(C) Annealing → Denaturation → Extension

(D) Denaturation → Extension → Annealing

Q17. If the respiratory quotient (RQ) of a substrate oxidized during aerobic respiration is measured to be approximately 0.7, what is the nature of the respiratory substrate being utilized?

(A) Carbohydrate

(B) Protein

(C) Organic acid

(D) Fat

Q18. A change in the partial pressure of carbon dioxide (pCO_2) alters the affinity of hemoglobin for oxygen. What is this physiological phenomenon known as?

(A) Bohr effect

(B) Haldane effect

(C) Chloride shift

(D) Hamburger phenomenon

Q19. During replication of DNA, the lagging strand is synthesized discontinuously in short segments called Okazaki fragments. In which direction does this synthesis proceed?

(A) Always $3' \rightarrow 5'$

(B) Always $5' \rightarrow 3'$

(C) $5' \rightarrow 3'$ towards the replication fork

(D) $3' \rightarrow 5'$ away from the replication fork

Q20. Amino acids are linked together by peptide bonds to form polypeptide chains. Which functional group of one amino acid reacts with which functional group of the adjacent amino acid to form this bond?

(A) Amino group with another amino group

(B) Carboxyl group with another carboxyl group

(C) Amino group with a carboxyl group

(D) Side-chain R group with a carboxyl group

Q21. According to the concept of species-area relationships proposed by Alexander von Humboldt, what happens to the value of the regression coefficient (Z) when species-area relationships are analyzed across very large areas like an entire continent?

(A) It becomes much steeper, in the range of 0.6 to 1.2

(B) It becomes much flatter, in the range of 0.01 to 0.05

(C) It remains constant regardless of the area size, at 0.1 to 0.2

(D) It drops to zero because biodiversity plateaus completely

Q22. Choose the correct option that matches a specific plant family with its characteristic fruit type.

(A) Solanaceae – Siliqua

(B) Cruciferae – Berry or Capsule

(C) Cruciferae – Siliqua

(D) Solanaceae – Caryopsis

Q23. Which of the following embryonic membranes forms a fluid-filled sac around the developing mammalian embryo to protect it from mechanical shock and desiccation?

(A) Yolk sac

(B) Amnion

(C) Chorion

(D) Allantois

Q24. Bt-toxin proteins produced by *Bacillus thuriengiensis* do not kill the bacterium itself because the toxin exists in an inactive protoxin form. What triggers the activation of this protoxin into active toxin in the gut of target insects?

(A) Acidic pH of the insect midgut

(B) High temperature in the insect body

(C) Alkaline pH of the insect midgut

(D) Proteolytic enzymes present in the insect saliva

Q25. Abscisic acid (ABA) acts as a stress hormone in plants. Under severe drought conditions, which physiological response is directly regulated by a rapid increase in ABA concentration within the leaves?

(A) Rapid opening of stomata to increase transpiration

(B) Closure of stomata by inducing efflux of potassium ions from guard cells

(C) Accelerated elongation of shoot apex cells

(D) Conversion of starches into reducing sugars in the companion cells

Q26. Which anatomical zone of the human adrenal cortex is correctly matched with the major class of hormones it synthesizes and secretes?

(A) Zona glomerulosa – Glucocorticoids

(B) Zona fasciculata – Mineralocorticoids

(C) Zona reticularis – Androgens

(D) Zona fasciculata – Catecholamines

Q27. In an *E. coli* lac operon, if a mutation occurs in the regulatory gene (i-gene) such that its repressor protein product can no longer bind to the inducer (lactose), what will be the status of operon expression?

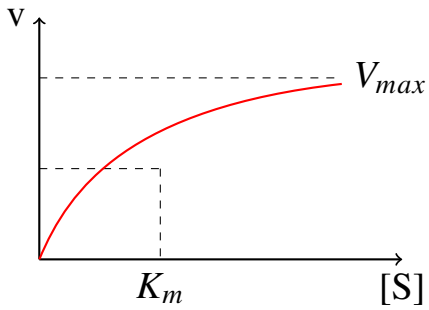
(A) Continuous constitutive expression of structural genes

(B) Normal inducible expression when lactose is added

(C) No expression of structural genes even in the presence of lactose

(D) Expression of only the z gene but not y or a genes

Q28. A student isolates an active enzyme from a thermophilic bacterium. During an experiment, the reaction velocity is measured at different substrate concentrations. Which of the following statements is true regarding the Michaelis constant (K_m) of this enzyme?



(A) A lower K_m value indicates a lower affinity of the enzyme for its substrate

(B) K_m is equal to the substrate concentration at which the reaction velocity reaches $\frac{1}{2}V_{max}$

(C) K_m is independent of the temperature and pH of the medium

(D) K_m increases significantly when a competitive inhibitor is removed

Q29. Which of the following chemical substances is a major component of photochemical smog and is formed by the reaction of nitrogen oxides and hydrocarbons in the presence of sunlight?

(A) Carbon monoxide

(B) Peroxyacetyl nitrate (PAN)

(C) Sulfur dioxide

(D) Chlorofluorocarbons (CFCs)

Q30. Organisms belonging to Phylum Cnidaria exhibit two basic body forms: polyps and medusae. Which of the following cnidarians exhibits alternation of generations (metagenesis) between these two forms?

(A) Hydra

(B) Aurelia

(C) Adamsia

(D) Obelia

Q31. Which of the following methods of contraception acts by preventing ovulation as well as altering the quality of cervical mucus to prevent the entry of sperms into the uterus?

(A) Barrier methods (Condoms)

(B) Copper-releasing IUDs

(C) Oral contraceptive pills

(D) Tubectomy

Q32. In a genetic engineering laboratory, a plasmid vector is cleaved using a specific restriction enzyme. To ensure that the vector does not undergo self-ligation before the foreign DNA insert can be integrated, which enzyme should be used to treat the linear plasmid?

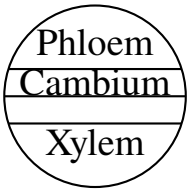
(A) Exonuclease III

(B) Alkaline phosphatase

(C) DNA polymerase I

(D) T4 polynucleotide kinase

Q33. Which type of vascular bundle arrangement is typically characterized by the presence of a strip of cambium between the xylem and phloem, and is commonly found in dicotyledonous stems?



(A) Conjoint, closed, collateral

(B) Conjoint, open, collateral

(C) Radial, open, exarch

(D) Bicollateral, closed

Q34. A sudden drop in blood pressure stimulates the juxtaglomerular apparatus (JGA) to release an enzyme into the bloodstream. What is this enzyme, and what is its immediate substrate?

(A) Renin, converts Angiotensinogen to Angiotensin I

(B) Erythropoietin, converts Angiotensin I to Angiotensin II

(C) Angiotensin-converting enzyme, converts Angiotensin I to II

(D) Renin, converts Angiotensin I to Angiotensin II

Q35. During transcription in prokaryotes, which subunit of the RNA polymerase holoenzyme is specifically required for the recognition of the promoter sequence and initiation of transcription?

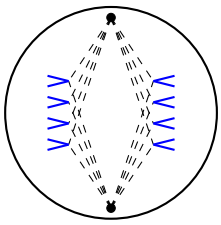
(A) Core enzyme ($\alpha_2\beta\beta'$)

(B) Sigma (σ) factor

(C) Rho (ρ) factor

(D) Omega (ω) subunit

Q36. During the stage of anaphase in mitosis, which of the following events takes place clearly under a light microscope?



(A) Chromosomes line up at the equatorial plate

(B) Nucleolus and nuclear membrane completely reappear

(C) Centromeres split and sister chromatids migrate to opposite poles

(D) Homologous chromosomes separate while sister chromatids remain attached

Q37. Which of the following specific protected areas is considered an example of *ex-situ* conservation of biodiversity?

(A) National Park

(B) Wildlife Sanctuary

(C) Biosphere Reserve

(D) Botanical Garden

Q38. In the plant family Brassicaceae (Cruciferae), what is the characteristic modification of the stamens observed in the flower?

(A) Monadelphous stamens

(B) Syngenesious stamens

(C) Tetradynamous stamens

(D) Didynamous stamens

Q39. What is the correct path of transport of sperms from the seminiferous tubules out of the human male reproductive system?

(A) Simple paths from tubules to Rete testis, Vasa efferentia, Epididymis, Vas deferens, and out via Urethra

(B) Seminiferous tubules → Epididymis → Rete testis → Vasa efferentia → Vas deferens → Urethra

(C) Seminiferous tubules → Vasa efferentia → Rete testis → Epididymis → Vas deferens → Urethra

(D) Seminiferous tubules → Rete testis → Vas deferens → Epididymis → Vasa efferentia → Urethra

Q40. Production of humulin (human insulin) by genetic engineering techniques involves inserting the gene sequences for which of the following chains directly into *E. coli* plasmids?

(A) Chains A, B, and C together as a proinsulin sequence

(B) Chains A and B separately in different host cells

(C) Chain C alone, followed by enzymatic cleavage

(D) Chains A and C combined, ignoring Chain B

Q41. A plant exhibits a unique mechanism of carbon fixation where the first stable product formed after atmospheric CO_2 fixation is oxaloacetic acid (OAA). Where does this initial fixation step take place within the leaf tissue?

(A) Mesophyll cells cytoplasm

(B) Bundle sheath cells chloroplast stroma

(C) Mesophyll cells chloroplast stroma

(D) Bundle sheath cells cytoplasm

Q42. In the human central nervous system, which specific part is primarily responsible for the regulation of body temperature, hunger, thirst, and expression of emotional behaviors?

(A) Cerebellum

(B) Medulla oblongata

(C) Hypothalamus

(D) Corpus callosum

Q43. A point mutation in the gene encoding the β-globin chain of hemoglobin results

in the substitution of glutamic acid by valine at the sixth position. What type of mutation is this, and what disease does it cause?

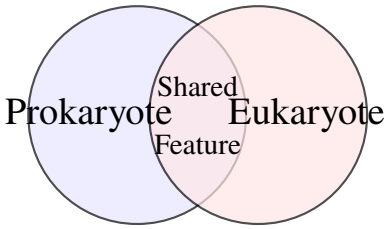
(A) Frame-shift mutation, Thalassemia

(B) Missense mutation, Sickle-cell anemia

(C) Nonsense mutation, Sickle-cell anemia

(D) Silent mutation, Phenylketonuria

Q44. Which of the following features is shared by both prokaryotic cells and eukaryotic cells?



(A) Presence of membrane-bound organelles

(B) 80S ribosomes in the cytoplasm

(C) Presence of a well-defined nuclear envelope

(D) Presence of a plasma membrane composed of a lipid bilayer

Q45. The phenomenon where a heavy accumulation of plant nutrients, such as nitrates and phosphates, causes excessive algal growth and eventual oxygen depletion in a freshwater lake is called:

(A) Biomagnification

(B) Eutrophication

(C) Biofortification

(D) Thermal inversion

Q46. Organisms that are single-celled, eukaryotic, and primarily aquatic are classified under which of the following kingdoms in the Five-Kingdom classification system?

(A) Monera

(B) Protista

(C) Fungi

(D) Plantae

Q47. During human embryonic development, the blastocyst embeds itself into which specific layer of the uterine wall during implantation?

(A) Perimetrium

(B) Myometrium

(C) Endometrium

(D) Epimetrium

Q48. In the screening of recombinant colonies using blue-white selection, what causes the recombinant colonies to appear white in color on a medium containing X-gal?

(A) Synthesis of active β-galactosidase enzyme

(B) Insertional inactivation of the β-galactosidase gene ($lacZ$)

(C) Presence of ampicillin resistance gene

(D) Overproduction of alpha-amylase

Q49. Active transport of ions across a plant cell membrane against a concentration gradient requires energy. Which of the following transport proteins is directly involved in generating such primary active electrochemical gradients?

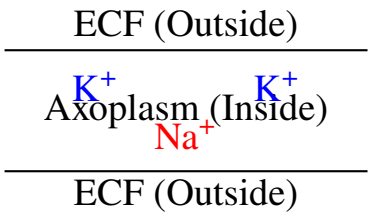
(A) Aquaporins

(B) Proton pumps (H^+-ATPases)

(C) Potassium leak channels

(D) Glucose symporters

Q50. Under resting conditions, the axoplasm inside the nerve fiber axon has a specific ion concentration relative to the fluid outside. Choose the correct description of this state.



(A) High concentration of Na^+ and low concentration of K^+

(B) High concentration of K^+ and high concentration of Na^+

(C) High concentration of K^+ and low concentration of Na^+

(D) Low concentration of K^+ and low concentration of Na^+

Q51. In a translation factory, which molecules act as the adapters that carry specific amino acids to the ribosome and recognize corresponding codons on the mRNA template?

(A) rRNA molecules

(B) tRNA molecules

(C) snRNA molecules

(D) hnRNA molecules

Q52. Which of the following options correctly aligns a biomolecule with its characteristic chemical linkage or bond?

(A) Polysaccharides – Phosphodiester bond

(B) Proteins – Glycosidic bond

(C) Nucleic acids – Peptide bond

(D) Lipids – Ester bond

Q53. According to the competitive exclusion principle proposed by G.F. Gause, what happens when two closely related species compete for the exact same limiting resources?

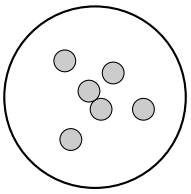
(A) Both species evolve to coexist harmoniously by resource partitioning

(B) The competitively inferior species will eventually be eliminated

(C) Both species will experience an increase in population size

(D) The species with higher mutation rate will change its niche completely

Q54. A plant specimen shows a stem with scattered vascular bundles, each surrounded by a sclerenchymatous bundle sheath. Phloem parenchyma is completely absent. This specimen is most likely a:



Scattered Bundles

(A) Dicotyledonous stem

(B) Monocotyledonous stem

(C) Dicotyledonous root

(D) Monocotyledonous root

Q55. What is the functional role of the acrosome present at the anterior tip of a mature human sperm head during fertilization?

(A) It produces ATP to drive flagellar movement

(B) It contains genetic material required for zygote formation

(C) It contains hydrolytic enzymes that digest the egg envelopes

(D) It initiates the first mitotic cleavage of the zygote

Q56. Transgenic "Golden Rice" has been genetically engineered to synthesize high amounts of which nutrient to combat nutritional deficiencies?

(A) Vitamin C

(B) Vitamin B12

(C) Essential fatty acids

(D) β-carotene (Pro-vitamin A)

Q57. A plant hormone is applied to a dwarf plant variety, which immediately induces extreme internodal elongation, making the plant grow to normal height. Which hormone is responsible for this effect?

(A) Auxin

(B) Cytokinin

(C) Gibberellin

(D) Ethylene

Q58. A routine clinical analysis of a patient's urine sample reveals the presence of significant amounts of glucose (Glycosuria) and ketone bodies (Ketonuria). This clinical correlation is a classic indicator of:

(A) Diabetes insipidus

(B) Diabetes mellitus

(C) Acute renal failure

(D) Addison's disease

Q59. In the human genome, what type of inheritance pattern is typically responsible for traits that show a continuous gradient of phenotypes, such as human skin color or height?

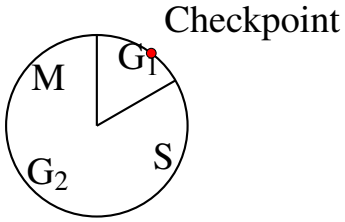
(A) Codominance

(B) Polygenic inheritance

(C) Multiple allelism

(D) Pleiotropy

Q60. During the cell cycle, which checkpoint is considered the primary restriction point where the cell commits irreversibly to DNA replication and subsequent division?



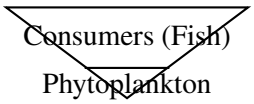
(A) G_2/M checkpoint

(B) G_1/S checkpoint

(C) Metaphase-to-Anaphase transition point

(D) G_0 exit checkpoint

Q61. In an ecological pyramid of biomass constructed for a deep marine ecosystem, what is the typical shape of the pyramid, and why?



(A) Upright, because primary producers have the largest biomass

(B) Inverted, because the small standing crop of phytoplankton supports a larger biomass of zooplankton and fish

(C) Spindle-shaped, because carnivores dominate the middle levels

(D) Completely flat, because biomass is evenly distributed at all trophic levels

Q62. Cell walls of true fungi differ fundamentally from those of green plants because the fungal cell wall is primarily composed of which polymer?

(A) Cellulose

(B) Chitin

(C) Peptidoglycan

(D) Hemicellulose

Q63. Which of the following conditions is a temporary structure formed in the mammalian ovary immediately following ovulation from the remnants of the ruptured Graafian follicle?

(A) Corpus albicans

(B) Corpus luteum

(C) Primary oocyte

(D) Corona radiata

Q64. In recombinant DNA technology, what is the role of a selectable marker gene integrated into a cloning vector?

(A) It provides a unique site for restriction enzymes to cleave

(B) It assists in identifying and selecting host cells that have taken up the vector

(C) It initiates the independent replication of the plasmid

(D) It codes for the production of the desired therapeutic protein

Q65. During cellular respiration, for every molecule of $FADH_2$ oxidized through the electron transport chain (ETC) starting at Complex II, how many molecules of ATP are generated via ATP synthase?

(A) 1

(B) 2

(C) 3

(D) 4

Q66. The human heart is myogenic. Which specialized cardiac tissue patch located in the right upper corner of the right atrium acts as the primary pacemaker by generating spontaneous action potentials?

(A) Atrioventricular node (AVN)

(B) Sinoatrial node (SAN)

(C) Bundle of His

(D) Purkinje fibers

Q67. A woman with blood group O (ii) marries a man who is heterozygous for blood group A (I^Ai). What are the possible blood groups expected among their biological children?

(A) Only blood group A

(B) Only blood group O

(C) Blood groups A and O in a 1 : 1 ratio

(D) Blood groups A, B, and O in equal proportions

Q68. Which of the following proteins forms the structural framework of microfilaments within the eukaryotic cytoskeleton and is involved in amoeboid movement and cytoplasmic streaming?

(A) Tubulin

(B) Keratin

(C) Actin

(D) Myosin

Q69. The international treaty signed in 1987 to control the emission of ozone-depleting substances into the atmosphere is known as the:

(A) Kyoto Protocol

(B) Montreal Protocol

(C) Nagoya Protocol

(D) Earth Summit

Q70. Plants belonging to the family Liliaceae exhibit which of the following combinations of vegetative and floral characteristics?

(A) Reticulate venation, pentamerous flowers, 5 stamens

(B) Parallel venation, trimerous flowers, epiphyllous stamens

(C) Parallel venation, tetramerous flowers, monadelphous stamens

(D) Reticulate venation, trimerous flowers, inferior ovary

Q71. What type of pollination mechanism is typical for flowers that produce large quantities of dry, non-sticky pollen grains, have large feathery stigmas, and lack bright colors or nectar rewards?

(A) Entomophily (Insect pollination)

(B) Anemophily (Wind pollination)

(C) Hydrophily (Water pollination)

(D) Ornithophily (Bird pollination)

Q72. Which of the following diagnostic tools utilizes the principle of antigen-antibody interactions to detect the presence of specific viral pathogens or antibodies in a patient's serum sample?

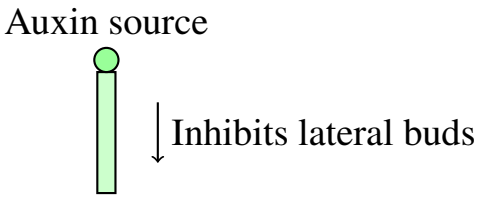
(A) Gel electrophoresis

(B) Polymerase Chain Reaction (PCR)

(C) Western blotting only

(D) Enzyme-Linked Immunosorbent Assay (ELISA)

Q73. A physiological experiment demonstrates that apical dominance in a plant can be overcome or counteracted by the exogenous application of which class of plant hormones?



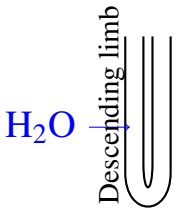
(A) Auxins

(B) Cytokinins

(C) Gibberellins

(D) Ethylene

Q74. In the human nephron, which segment is highly permeable to water but almost completely impermeable to electrolytes, leading to the concentration of filtrate as it moves downwards?



(A) Proximal Convoluted Tubule (PCT)

(B) Descending limb of Henle's loop

(C) Ascending limb of Henle's loop

(D) Distal Convoluted Tubule (DCT)

Q75. During transcription in eukaryotes, the primary transcript (hnRNA) must undergo processing before it becomes functional mRNA. Which processing step involves the precise removal of non-coding regions (introns) and joining of coding regions (exons)?

(A) Capping

(B) Tailing

(C) Splicing

(D) Polyadenylation

Q76. Which of the following cellular components is synthesized and assembled inside the nucleolus of a eukaryotic cell?

(A) Messenger RNA (mRNA)

(B) Transfer RNA (tRNA)

(C) Ribosomal RNA (rRNA)

(D) DNA Polymerase

Q77. The total number of links or individual pathways in a food web that contribute to its stability is determined by biodiversity. Which of the following statements about food webs is correct?

(A) An increase in biodiversity decreases the complexity of a food web

(B) Food webs are linear chains showing unidirectional energy flow without interlinking

(C) Interlinked food webs provide alternative pathways for energy flow, enhancing ecosystem stability

(D) Energy flow in a food web is cyclic, returning to primary producers

Q78. Organisms like *Methanogens* belong to which specific domain or group, and where are they commonly found?

(A) Eubacteria, in well-aerated soils

(B) Archaebacteria, in the gut of ruminant animals

(C) Cyanobacteria, in freshwater lakes

(D) Protista, in marine environments

Q79. What is the phenomenon called where a single gene product can influence multiple, completely unrelated phenotypic traits in an organism?

(A) Epistasis

(B) Pleiotropy

(C) Polygenic inheritance

(D) Codominance

Q80. In cyclic photophosphorylation occurring in the stroma lamellae membranes of chloroplasts, which photosystem is active, and what are the products of this reaction?

(A) Both PS I and PS II; ATP and NADPH

(B) Only PS II; ATP only

(C) Only PS I; ATP only

(D) Only PS I; NADPH only

Detailed Solutions

Q1.

Solution

Concept: The relationship between osmotic pressure (π), turgor pressure (TP), and water potential or diffusion pressure deficit (DPD) governs the movement of water across a plant cell membrane. When a cell is in dynamic equilibrium with its external surroundings, net water movement ceases.

Solution: Step 1: Understand the given parameters where the osmotic pressure of the external solution perfectly balances the osmotic pressure of the cytoplasm. This environment represents an isotonic solution.

Step 2: In an isotonic solution, the amount of water entering the cell is exactly equal to the amount of water exiting the cell. There is no net influx or efflux of water molecules across the plasma membrane.

Step 3: Because there is no net entry of water, the protoplast does not press against the rigid cell wall. Consequently, the wall pressure is zero, which means the turgor pressure (TP) drops to zero.

Step 4: A plant cell with a turgor pressure of zero that shows no structural expansion or shrinkage is defined as a flaccid cell.

Step 5: Therefore, the state of the cell is flaccid, and its corresponding turgor pressure equation is $TP = 0$.

Final Answer: Flaccid, $TP = 0$

Answer: (B)

Go Back to Question 1

Q2.

Solution

Concept: The sliding filament mechanism explains how muscle fibers contract. The sarcomere contains thick myosin filaments and thin actin filaments that slide past each other, altering the structural width of specific functional bands without changing the absolute lengths of the protein filaments themselves.

Solution: Step 1: Identify the components of a sarcomere. The A-band represents the entire span of thick myosin filaments. The I-band represents the region containing only thin actin filaments. The H-zone is the central portion of the A-band where actin does not overlap myosin under resting conditions.

Step 2: During contraction, myosin cross-bridges pull the thin actin filaments inward toward the center of the sarcomere (the M-line).

Step 3: As the actin filaments slide deep into the A-band, the central gap containing only myosin narrows down significantly. Thus, the H-zone shortens or may disappear completely.

Step 4: Concurrently, the distance between successive thick bands decreases, which causes the light I-band to shorten in total width.

Step 5: The dark A-band maintains a constant length because the length of the thick filaments remains completely unchanged during this biological process. Hence, both the H-zone and I-band shorten together.

Final Answer: H-zone and I-band

Answer: (C)

Go Back to Question 2

Q3.

Solution

Concept: Mendelian dihybrid crosses involving two independently assorting genes follow the law of independent assortment. The probability of inheriting individual independent traits can be calculated separately and multiplied together using the product rule of probability.

Solution: Step 1: Analyze the first genetic trait governed by alleles A and a. For a monohybrid cross of heterozygous parents ($Aa \times Aa$), the resulting phenotypic ratio of dominant to recessive is 3 : 1. The probability of a dominant phenotype ($A-$) is $\frac{3}{4}$.
Step 2: Analyze the second independent trait governed by alleles B and b. For the cross ($Bb \times Bb$), the phenotypic ratio is identical, meaning the probability of expressing the dominant phenotype ($B-$) is also $\frac{3}{4}$.
Step 3: Since the two gene pairs assort independently on separate chromosomes, apply the product rule to find the joint probability of both events occurring simultaneously.
Step 4: Multiply the individual probabilities together:

$$\text{Probability} = \frac{3}{4} \times \frac{3}{4} = \frac{9}{16}$$

Step 5: This aligns perfectly with the standard Mendelian dihybrid phenotypic ratio of 9 : 3 : 3 : 1, where 9 out of 16 offspring express both dominant characteristics.

Final Answer: $\boxed{\frac{9}{16}}$

Answer: (A)

Go Back to Question 3

Q4.

Solution

Concept: Endomembrane cell organelles specialized for intracellular digestion contain diverse acid hydrolases. These specialized enzymes require a low internal pH to break down biological polymers like proteins, lipids, carbohydrates, and nucleic acids.

Solution: Step 1: Evaluate the structural and biochemical features provided in the problem statement. The organelle is single-membraned and maintains an internally acidic microenvironment.
Step 2: Examine lysosomes, which are small membrane-bound vesicles originating from the trans-Golgi network. They contain active proton pumps (H^+-ATPases) embedded in their membrane that actively pump hydrogen ions inside to create an acidic pH.
Step 3: This low pH environment activates optimal hydrolytic enzymes such as proteases, nucleases, glycosidases, and lipases for macro-molecular degradation.
Step 4: Compare with other options: Peroxisomes and glyoxysomes contain oxidative enzymes like catalase, not acid hydrolases. The Golgi apparatus processes proteins but does not serve as a digestive hydrolytic reservoir.
Step 5: Therefore, the lysosome matches every described functional and morphological characteristic.
Final Answer: Lysosome

Answer: (B)

Go Back to Question 4

Q5.

Solution

Concept: Ecosystem productivity is divided into gross primary productivity (GPP) and net primary productivity (NPP). GPP represents the total rate of organic matter synthesized by photosynthetic autotrophs, while NPP is the remaining energy stored after accounting for autotrophic metabolic maintenance.

Solution: Step 1: State the fundamental thermodynamic ecological equation relating primary productivity values:

$$\text{NPP} = \text{GPP} - \text{R}$$

where R represents the respiration losses incurred by the plant community.

Step 2: Substitute the known values provided in the question text into this formula. The given NPP value is 2000 g/m^2/year and the given respiration value R is 1500 g/m^2/year.

Step 3: Rearrange the equation algebraically to isolate the unknown variable, gross primary productivity (GPP):

$$\text{GPP} = \text{NPP} + \text{R}$$

Step 4: Perform the final arithmetic summation using the aligned values:

$$\text{GPP} = 2000 + 1500 = 3500 \text{ g/m}^2\text{/year}$$

Step 5: Thus, the absolute total organic production generated by the autotrophs prior to metabolic expenditure is 3500 g/m^2/year.

Final Answer: 3500 g/m^2/year

Answer: (D)

Go Back to Question 5

Q6.

Solution

Concept: Angiosperm taxonomy involves identifying diagnostic floral features belonging to specific families. Characteristics such as regular symmetry, carpel number, fusion, and internal ovarian features serve as distinct structural identifiers for plant classification.

Solution: Step 1: Break down the anatomical clues provided. Actinomorphic flowers exhibit radial symmetry. Bicarpellary syncarpous indicates an ovary composed of two fused carpels.
Step 2: A superior ovary positions the floral whorls below its base. A swollen placenta with numerous ovules along with an obliquely oriented septum is a unique structural hallmark.
Step 3: Correlate these specific traits with economic plant families. The family Solanaceae, commonly known as the potato family, uniquely features an ovary oriented obliquely at an angle of roughly 45° relative to the median plane.
Step 4: It also displays a visibly swollen axile placenta crowded with functional ovules.
Step 5: Other families like Cruciferae have a parietal placenta with a false septum (replum), while Malvaceae has monadelphous stamens. Thus, the plant belongs to Solanaceae.
Final Answer: Solanaceae

Answer: (B)
Go Back to Question 6

Q7.

Solution

Concept: The development of a monosporic Polygonum-type embryo sac results in a mature, seven-celled, eight-nucleate female gametophyte structure. The cells are highly polarized and distributed specifically between the micropylar and chalazal poles.

Solution: Step 1: Visualize the internal layout of a mature megagametophyte. At the micropylar end, three cells form the egg apparatus, consisting of two haploid synergids and one haploid egg cell.
Step 2: In the massive central zone, a large central cell contains two haploid polar nuclei that may fuse to form a single diploid secondary nucleus.
Step 3: At the opposite chalazal pole, the remaining three nuclei are partitioned into distinct independent cells called antipodal cells.
Step 4: Each individual antipodal cell receives a single haploid (n) nucleus during cellularization. These cells often play a transient role in absorbing and transferring nutrients to the developing embryo sac.
Step 5: Therefore, the precise spatial arrangement at the chalazal end consists of exactly three individual haploid antipodal cells.
Final Answer: Three haploid antipodal cells

Answer: (A)
Go Back to Question 7

Q8.

Solution

Concept: Recombinant DNA technology requires precise enzymatic tools to manipulate DNA strands. While restriction endonucleases cut phosphodiester backbones at specific palindromic sequences, specific joining enzymes restore structural integrity to recombinant plasmids.

Solution: Step 1: Identify the biochemical requirement described. The goal is to join structural nicks by sealing adjacent nucleotide residues in a sugar-phosphate backbone.
Step 2: This process requires the catalyzed formation of a covalent phosphodiester bond between a 3′-hydroxyl group and an adjacent 5′-phosphate group.
Step 3: The enzyme responsible for driving this energy-dependent condensation reaction is DNA Ligase. It uses ATP or NAD^+ to seal structural breaks.
Step 4: Eliminate alternate options. EcoRI is a restriction enzyme that breaks bonds rather than forming them. Helicase unwinds helical regions. Alkaline phosphatase removes terminal phosphate groups to prevent self-ligation.
Step 5: Thus, DNA ligase is the correct genetic glue used to seal the fragments together.
Final Answer: DNA Ligase

Answer: (C)

Go Back to Question 8

Q9.

Solution

Concept: Non-cyclic photophosphorylation (Z-scheme) relies on a continuous chain of membrane protein complexes to transport electrons from water to $NADP^+$. This electron movement releases free energy, which is used to generate a proton gradient across the thylakoid membrane.

Solution: Step 1: Trace the path of electron flow. Excited electrons leave Photosystem II (PS II) and pass through plastoquinone to reach an intermediary multi-subunit integral complex.
Step 2: This intermediate complex is the Cytochrome b_6f complex. As it accepts and passes electrons to plastocyanin, it simultaneously acts as a proton pump.
Step 3: The complex translocates hydrogen ions (H^+) across the hydrophobic thylakoid membrane from the chloroplast stroma directly into the interior thylakoid lumen.
Step 4: This action contributes directly to building a concentrated electrochemical proton gradient that drives ATP synthesis via the CF_0-CF_1 complex.
Step 5: Neither PS II, PS I, nor Ferredoxin-$NADP^+$ reductase performs this direct physical translocation of protons into the lumen.
Final Answer: Cytochrome b_6f complex

Answer: (B)

Go Back to Question 9

Q10.

Solution

Concept: Formed elements of human blood include erythrocytes, leukocytes, and thrombocytes (platelets). Each cell lineage is specialized for distinct homeostatic, physiological, or immunological roles within the cardiovascular system.

Solution: Step 1: Note the specific hematological abnormality described: a sharp reduction in platelet count, a clinical condition termed thrombocytopenia.
Step 2: Determine the primary function of thrombocytes. When vascular injury occurs, platelets undergo adhesion, activation, and aggregation at the site of endothelial damage.
Step 3: They release clotting factors (such as thromboplastin) and provide a phospholipid surface that accelerates the blood coagulation cascade, converting fibrinogen to fibrin.
Step 4: If platelets are severely depleted, the formation of a physical platelet plug and the subsequent coagulation cascade are significantly delayed. This leads to prolonged bleeding times.
Step 5: Other processes like oxygen transport depend on red blood cells, while immunity relies on white blood cells, meaning coagulation is the primary process impaired.
Final Answer: Coagulation of blood

Answer: (C)

Go Back to Question 10

Q11.

Solution

Concept: Chargaff's rules state that in any double-stranded DNA molecule, base composition follows a strict stoichiometric relationship. The concentration of purines equals the concentration of pyrimidines, meaning Adenine pairs with Thymine and Guanine pairs with Cytosine.

Solution: Step 1: Write down the mathematical representations of Chargaff's rules for double-stranded DNA:

$$\%A = \%T \quad \text{and} \quad \%G = \%C$$

Step 2: Identify the given percentage value from the problem text, which is $\%A = 30\%$.
Step 3: Calculate the percentage of thymine based on the complementary pairing rule:

$$\%T = \%A = 30\%$$

Step 4: Find the combined total percentage of the Adenine-Thymine base pairs:

$$\%A + \%T = 30\% + 30\% = 60\%$$

Step 5: Subtract this value from 100% to determine the remaining percentage allocated for Guanine and Cytosine:

$$\%G + \%C = 100\% - 60\% = 40\%$$

Step 6: Since $\%G = \%C$, divide this remaining portion equally by 2 to isolate the percentage of cytosine:

$$\%C = \frac{40\%}{2} = 20\%$$

Final Answer: 20%

Answer: (A)

Go Back to Question 11

Q12.

Solution

Concept: Prophase I of meiosis is a prolonged, complex stage divided into five distinct sequential substages based on chromosomal behavior: leptotene, zygotene, pachytene, diplotene, and diakinesis. Genetic recombination is highly stage-specific.

Solution: Step 1: Review the main chromosomal events in order. During leptotene, chromatin condenses into visible threads. In zygotene, homologous chromosomes pair up via synapsis to form bivalents.
Step 2: Following synapsis, the homologous chromosomes form a synaptonemal complex, leading into the pachytene substage.
Step 3: During pachytene, the bivalent chromosomes appear clearly as tetrads. Non-sister chromatids of homologous pairs undergo physical breakage and reciprocal exchange of genetic segments.
Step 4: This physical exchange process is mediated by recombination nodules containing the enzyme recombinase and is known as crossing over.
Step 5: Subsequent stages like diplotene involve the dissolution of the synaptonemal complex, leaving X-shaped structures called chiasmata. Thus, crossing over occurs specifically during pachytene.
Final Answer: Pachytene

Answer: (C)

Go Back to Question 12

Q13.

Solution

Concept: Interspecific biological interactions are classified based on the positive (+), negative (−), or neutral (0) impact they exert on the interacting populations. These ecological designations help categorize natural community dynamics.

Solution: Step 1: Analyze the specific constraints set by the question. One biological species must experience a negative effect (harmed/inhibited), while the other companion species experiences a neutral effect (completely unaffected). This represents a $(-, 0)$ interaction pattern.
Step 2: Evaluate the provided options. Commensalism represents a $(+, 0)$ interaction where one benefits and the other is unaffected. Parasitism is a $(+, -)$ relationship. Mutualism is a $(+, +)$ relationship.
Step 3: Examine amensalism. This interaction is characterized as a $(-, 0)$ relationship. One organism exerts an inhibitory or toxic effect on another without gaining any direct benefit or suffering harm itself.
Step 4: An example is the mold *Penicillium* producing penicillin, which kills surrounding bacteria while the mold remains unaffected.
Step 5: Therefore, amensalism perfectly fits the description.
Final Answer: Amensalism

Answer: (B)

Go Back to Question 13

Q14.

Solution

Concept: Animal kingdom classification relies on fundamental body plans, including embryonic germ layers, structural symmetry, and the presence or absence of a true coelom derived from the embryonic mesoderm layer.

Solution: Step 1: Identify the structural characteristics of Phylum Platyhelminthes (flatworms). They are triploblastic, bilaterally symmetrical, exhibit an organ level of organization, and are completely acoelomate.
Step 2: Examine Phylum Aschelminthes (roundworms). They share triploblastic development, bilateral symmetry, and an organ-system level of organization with advanced phyla.
Step 3: However, Aschelminthes possess a unique anatomical feature: their body cavity is not lined by mesoderm. Instead, mesoderm exists as scattered pouches within the blastocoel.
Step 4: This specific architectural arrangement is defined as a pseudocoelom (false body cavity).
Step 5: Since flatworms completely lack any body cavity, the presence of a pseudocoelom is the primary evolutionary advancement that distinguishes roundworms from Platyhelminthes.
Final Answer: Pseudocoelom

Answer: (C)

Go Back to Question 14

Q15.

Solution

Concept: The microsporangial wall of an angiosperm anther typically consists of four distinct layers: epidermis, endothecium, middle layers, and tapetum. Each layer is structurally specialized to support pollen development.

Solution: Step 1: Analyze the spatial position of the tapetum. It forms the innermost cellular layer of the microsporangial wall, completely surrounding the sporogenous tissue.
Step 2: Characterize the cells of the tapetum. They possess dense cytoplasm and generally contain more than one nucleus due to endomitosis.
Step 3: Determine its functional role. As microspore mother cells undergo meiosis to form microspore tetrads, the tapetal cells synthesize and secrete essential nutrients, proteins, and sporopollenin precursors.
Step 4: This specialized secretion provides direct metabolic and structural nourishment to the developing pollen grains.
Step 5: Outer layers like the epidermis and endothecium provide protection and aid in anther dehiscence, leaving nourishment as the primary function of the tapetum.
Final Answer: It provides nourishment to the developing pollen grains

Answer: (C)

Go Back to Question 15

Q16.

Solution

Concept: The Polymerase Chain Reaction (PCR) is an *in-vitro* technique used to amplify specific DNA sequences. Each thermocycling loop depends on precise, temperature-dependent structural transitions of the DNA strands and primers.

Solution: Step 1: Analyze the initial step of a PCR cycle. The reaction mixture is heated to a high temperature (around 94°C – 96°C). This thermal energy breaks the hydrogen bonds holding the double-stranded target DNA together, separating it into single strands. This step is called denaturation.

Step 2: Analyze the second step. The temperature is lowered to a moderate range (around 50°C – 65°C). This allows synthetic oligonucleotide primers to bind to their complementary sequences on the single-stranded DNA templates. This step is called annealing.

Step 3: Analyze the final step. The temperature is raised to the optimal working range of a thermostable DNA polymerase (around 72°C), such as *Taq* polymerase. The enzyme adds deoxyribonucleoside triphosphates (dNTPs) to the 3′-hydroxyl ends of the primers to synthesize new complementary strands. This step is called extension.

Step 4: Order these phases sequentially: Denaturation → Annealing → Extension.

Final Answer: Denaturation → Annealing → Extension

Answer: (B)

Go Back to Question 16

Q17.

Solution

Concept: The Respiratory Quotient (RQ) is a dimensionless ratio calculated by dividing the volume of carbon dioxide eliminated by the volume of oxygen absorbed during cellular respiration over a given period. It varies based on the chemical structure of the nutrient substrate being oxidized.

Solution: Step 1: Write out the mathematical expression for the respiratory quotient:

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

Step 2: Understand how substrate composition affects this value. Carbohydrates have an RQ equal to 1.0 because their chemical formulas contain sufficient internal oxygen for complete oxidation.
Step 3: Organic acids contain relatively high amounts of internal oxygen, yielding an RQ value greater than 1.0 (e.g., malic acid has an RQ of 1.33).
Step 4: Fats and lipids are highly reduced molecules with low internal oxygen content. They require more external oxygen for complete oxidation, resulting in an RQ below 1.0. For instance, the oxidation of tripalmitin yields an RQ of exactly 0.7.
Step 5: Since the measured value in the question is approximately 0.7, the respiratory substrate is a fat.

Final Answer: Fat

Answer: (D)

Go Back to Question 17

Q18.

Solution

Concept: Gas transport in human blood depends on changes in hemoglobin's structural affinity for oxygen. These changes are driven by local chemical factors in the microenvironment, including the partial pressure of carbon dioxide (pCO_2) and hydrogen ion concentrations (H^+).

Solution: Step 1: Define the physiological event described. An increase in pCO_2 or a decrease in pH in metabolically active tissues reduces hemoglobin's affinity for oxygen.
Step 2: This shift alters the oxygen-hemoglobin dissociation curve down and to the right, promoting the release of oxygen to actively respiring cells.
Step 3: This specific physiological phenomenon is known as the Bohr effect. It ensures efficient oxygen delivery to peripheral tissues with high metabolic activity.
Step 4: Differentiate from other choices. The Haldane effect describes how oxygen binding promotes the displacement of carbon dioxide from hemoglobin in the lungs. The chloride shift (Hamburger phenomenon) involves the exchange of bicarbonate and chloride ions across erythrocyte membranes.
Step 5: Thus, the Bohr effect is the correct term for the described carbon dioxide-driven affinity change.
Final Answer: Bohr effect

Answer: (A)

Go Back to Question 18

Q19.

Solution

Concept: DNA polymerases possess a strict biochemical limitation: they can only catalyze the polymerization of deoxyribonucleotides in a single directional pathway. They add incoming nucleotides exclusively to the free 3′-hydroxyl group of a growing primer strand.

Solution: Step 1: State the fixed catalytic direction of DNA polymerase enzymes. Elongation of any new DNA strand always occurs in the $5' \rightarrow 3'$ direction.
Step 2: Analyze a replication fork. Because the two parental template strands run antiparallel, one strand ($3' \rightarrow 5'$) allows continuous synthesis toward the advancing fork.
Step 3: The opposite parental template strand runs in a $5' \rightarrow 3'$ direction away from the fork. To maintain the $5' \rightarrow 3'$ catalytic direction of synthesis, DNA polymerase must synthesize this strand discontinuously in short segments.
Step 4: These short segments are Okazaki fragments. Each fragment is individually synthesized in the $5' \rightarrow 3'$ direction, moving away from the replication fork.
Step 5: Therefore, while the collective growth of the lagging strand progresses toward the fork, individual Okazaki fragment synthesis always proceeds in the $5' \rightarrow 3'$ direction.
Final Answer: Always $5' \rightarrow 3'$

Answer: (B)

Go Back to Question 19

Q20.

Solution

Concept: Proteins are linear heteropolymers composed of individual amino acid subunits linked by covalent peptide bonds. The formation of this primary structural backbone occurs via a condensation reaction between specific functional groups on adjacent amino acids.

Solution: Step 1: Examine the basic molecular structure of an amino acid. Each molecule contains a central alpha-carbon attached to a hydrogen atom, a variable side-chain R group, a basic amino group ($-NH_2$), and an acidic carboxyl group ($-COOH$).
Step 2: During translation on a ribosome, the carboxyl group ($-COOH$) of the first amino acid is positioned adjacent to the amino group ($-NH_2$) of the incoming amino acid.
Step 3: A dehydration synthesis reaction occurs, releasing a molecule of water (H_2O) and forming a covalent $-CO\text{-}NH-$ linkage.
Step 4: This specific linkage is a peptide bond, connecting the carboxyl carbon of one amino acid to the amino nitrogen of the next.
Step 5: Thus, a peptide bond forms through the reaction of an amino group with a carboxyl group.
Final Answer: Amino group with a carboxyl group

Answer: (C)

Go Back to Question 20

Q21.

Solution

Concept: The species-area relationship describes how species richness scales with geographic area. This pattern is mathematically represented on a logarithmic scale as a straight line described by the equation $\log S = \log C + Z \log A$, where Z is the regression coefficient.

Solution: Step 1: Review the standard values of the regression coefficient (Z). When analyzing small localized regions (such as plants in a small county or birds in a local forest), the value of Z is relatively stable, falling within a predictable range of 0.1 to 0.2.
Step 2: Consider what happens when the geographic scale expands significantly to encompass an entire continent.
Step 3: At a continental scale, the rate of discovering new species across different habitat zones increases substantially. This causes the species-area curve to become significantly steeper.
Step 4: For very large areas, the regression coefficient (Z) shifts to a much steeper range, typically between 0.6 and 1.2.
Step 5: Therefore, expanding the scale to an entire continent results in a steeper slope, changing the value of Z to the 0.6 to 1.2 range.
Final Answer: It becomes much steeper, in the range of 0.6 to 1.2

Answer: (A)
Go Back to Question 21

Q22.

Solution

Concept: Gynoecium development and subsequent fertilization lead to the formation of distinct fruit types characteristic of specific angiosperm families. These fruit classifications serve as key identification features in plant taxonomy.

Solution: Step 1: Evaluate the fruit characteristics of family Cruciferae (Brassicaceae). They possess a bicarpellary syncarpous ovary with a false internal septum called a replum.
Step 2: This unique ovarian structure develops into a specialized dehiscent dry fruit known as a siliqua, which dehisces from the base upward along both sutures.
Step 3: Evaluate family Solanaceae. Its flowers develop into a fleshy berry (such as tomato or brinjal) or a dehiscent capsule (such as *Datura*). It does not produce a siliqua.
Step 4: Evaluate family Poaceae (Gramineae), which produces a caryopsis where the pericarp is completely fused with the seed coat.
Step 5: Comparing the options reveals that Cruciferae paired with Siliqua is the correct and accurate taxonomic match.
Final Answer: Cruciferae – Siliqua

Answer: (C)
Go Back to Question 22

Q23.

Solution

Concept: Amniote vertebrates, including mammals, develop four extra-embryonic membranes during gestation: the yolk sac, amnion, chorion, and allantois. These specialized membranes support and protect the developing embryo within the uterine environment.

Solution: Step 1: Define the specific functional requirement: creating a fluid-filled protective sac around the growing embryo to absorb mechanical shocks and prevent tissue desiccation.
Step 2: Examine the amnion layer. The amnion is an extra-embryonic membrane that grows around the embryo, forming a sealed cavity called the amniotic cavity.
Step 3: This cavity is filled with amniotic fluid, which suspends the embryo in a liquid environment. This fluid acts as an efficient hydraulic shock absorber and protects delicate embryonic tissues from drying out.
Step 4: Check other options. The chorion forms the outer boundary and contributes to placenta formation. The yolk sac handles early blood cell formation, and the allantois deals with structural waste or vascularization.
Step 5: Thus, the amnion is the specific membrane responsible for creating this fluid-filled protective sac.
Final Answer: Amnion

Answer: (B)

Go Back to Question 23

Q24.

Solution

Concept: The bacterium *Bacillus thuringiensis* synthesizes crystalline insecticidal proteins (Bt toxins). These proteins remain harmless inside the bacterial cell because they are synthesized as inactive protoxins that require specific biochemical conditions to become active.

Solution: Step 1: Note that the Bt toxin gene expressions accumulate as crystalline inclusions within the bacterial sporulation body. These crystals are stable and non-toxic in neutral or acidic conditions.
Step 2: When an insect ingests the plant tissue containing these protoxins, the crystalline inclusions enter its digestive tract.
Step 3: The insect midgut features a highly alkaline pH microenvironment. This alkaline environment dissolves the crystalline structures, releasing the protoxins.
Step 4: Midgut proteases then cleave the inactive protoxin, converting it into an active, toxic core. This active toxin binds to epithelial cells, creating pores that cause cell lysis and eventual death.
Step 5: Since this activation requires an alkaline environment, the high alkaline pH of the insect midgut is the specific trigger for toxin activation.
Final Answer: Alkaline pH of the insect midgut

Answer: (C)

Go Back to Question 24

Q25.

Solution

Concept: Abscisic acid (ABA) is a key plant hormone that coordinates physiological stress responses. Under drought conditions, plants must limit water loss through transpiration to maintain internal cell turgor.

Solution: Step 1: Identify the immediate physiological challenge during a drought: water deficit within the leaf tissues. This stress triggers a rapid synthesis and accumulation of ABA within the guard cells.
Step 2: Analyze the biochemical effect of ABA on guard cell membranes. ABA binds to specific receptors, triggering an influx of calcium ions into the cytoplasm.
Step 3: This calcium influx induces the rapid efflux of potassium ions (K^+) and chloride anions out of the guard cells, accompanied by a decrease in internal malate concentrations.
Step 4: The loss of these solutes raises the osmotic and water potential inside the guard cells, causing water to diffuse out into surrounding epidermal cells. The guard cells lose turgor pressure, leading to the closure of the stomatal pore.
Step 5: Therefore, ABA protects the plant by inducing stomatal closure via ion efflux, conserving internal water reserves.
Final Answer: Closure of stomata by inducing efflux of potassium ions from guard cells

Answer: (B)

Go Back to Question 25

Q26.

Solution

Concept: The human adrenal cortex is histologically organized into three distinct concentric cellular zones: the outer zona glomerulosa, the middle zona fasciculata, and the inner zona reticularis. Each zone synthesizes specific steroid hormones.

Solution: Step 1: Analyze the outer layer, the zona glomerulosa. It is responsible for secreting mineralocorticoids, primarily aldosterone, which regulate electrolyte and water balance.
Step 2: Analyze the middle layer, the zona fasciculata. It is the thickest cortical zone and synthesizes glucocorticoids, primarily cortisol, which regulate carbohydrate metabolism and stress responses.
Step 3: Analyze the innermost layer, the zona reticularis. It forms an interconnected network of cells that synthesizes and secretes gonadocorticoids, primarily adrenal androgens like dehydroepiandrosterone (DHEA).
Step 4: Evaluate the options based on these descriptions. Option C correctly matches the zona reticularis with the production of androgens.
Step 5: Other choices incorrectly mix up zones or include catecholamines, which are secreted by the adrenal medulla rather than the cortex.
Final Answer: Zona reticularis – Androgens

Answer: (C)

Go Back to Question 26

Q27.

Solution

Concept: The *E. coli* lac operon regulates the transcription of genes involved in lactose metabolism. It is controlled by an allosteric repressor protein synthesized by the regulatory i-gene, which binds to the operator locus to block transcription unless an inducer is present.

Solution: Step 1: Understand the functional role of a normal repressor protein. In the absence of lactose, the repressor binds to the operator, blocking RNA polymerase from transcribing the structural genes (z, y, a).
Step 2: When lactose enters the cell, it is converted to allolactose, which acts as an inducer. The inducer binds to the repressor, changing its shape so it can no longer bind to the operator. This allows transcription to proceed.
Step 3: Analyze the given mutation: the repressor protein is altered so that it can no longer bind to the inducer molecule (lactose/allolactose).
Step 4: Because it cannot bind the inducer, the mutant repressor remains permanently bound to the operator locus. It continually blocks RNA polymerase regardless of how much lactose accumulates in the medium.
Step 5: As a result, the operon cannot be turned on, leading to no expression of the structural genes even in the presence of lactose.

Final Answer: No expression of structural genes even in the presence of lactose

Answer: (C)

Go Back to Question 27

Q28.

Solution

Concept: The Michaelis constant (K_m) is a key parameter in enzyme kinetics derived from the Michaelis-Menten equation. It quantifies the affinity between an enzyme and its substrate under specific experimental conditions.

Solution: Step 1: Define K_m using the Michaelis-Menten kinetic model. The constant K_m represents the specific substrate concentration at which the initial catalytic reaction velocity (v) reaches exactly half of its maximum possible velocity (V_{max}).
Step 2: Evaluate the mathematical relationship: when $v = \frac{1}{2}V_{max}$, the equation simplifies such that $[S] = K_m$.
Step 3: Analyze how K_m values relate to substrate affinity. A lower K_m value indicates that the enzyme requires less substrate to reach half-maximal velocity, signifying a higher affinity for the substrate. Conversely, a higher K_m indicates lower affinity.
Step 4: Note that K_m is highly sensitive to changes in environmental factors like temperature and pH, which can alter enzyme structure.
Step 5: Based on these points, option B provides the correct biochemical definition of the Michaelis constant.

Final Answer: K_m is equal to the substrate concentration at which the reaction velocity reaches $\frac{1}{2}V_{max}$

Answer: (B)

Go Back to Question 28

Q29.

Solution

Concept: Photochemical smog is a type of air pollution common in warm, sunny urban environments. It is formed through secondary atmospheric reactions driven by solar radiation rather than being emitted directly from pollution sources.

Solution: Step 1: Identify the primary pollutants involved: nitrogen oxides (NO_x) and unburned volatile hydrocarbons emitted from internal combustion engines.
Step 2: When exposed to ultraviolet radiation in sunlight, these primary pollutants undergo complex photochemical reactions, producing highly reactive free radicals and ozone (O_3).
Step 3: These reactive intermediates interact with remaining hydrocarbons and atmospheric oxygen to produce secondary pollutants.
Step 4: A major secondary pollutant formed in this process is Peroxyacetyl nitrate (PAN). It is a powerful eye irritant and a key component of photochemical smog.
Step 5: Other gases listed, such as carbon monoxide and sulfur dioxide, are primary emissions or contribute to classical sulfurous smog rather than photochemical smog.
Final Answer: Peroxyacetyl nitrate (PAN)

Answer: (B)

Go Back to Question 29

Q30.

Solution

Concept: Phylum Cnidaria contains organisms that exhibit two distinct body plans: a sessile, cylindrical polyp form and a motile, umbrella-shaped medusa form. Certain advanced hydrozoan lineages alternate between these two stages during their life cycle.

Solution: Step 1: Define the biological term metagenesis. Metagenesis refers to the alternation of generations between an asexual polyp phase and a sexual medusa phase within the same species' life cycle.
Step 2: Trace this life cycle in a representative organism. Polyps reproduce asexually by budding to produce motile medusae. These medusae then reproduce sexually, shedding gametes that form a planula larva, which settles to grow into a new polyp.
Step 3: Evaluate the options. *Hydra* exists exclusively in the polyp form. *Aurelia* (jellyfish) is dominated by the medusa form. *Adamsia* (sea anemone) is a polyp.
Step 4: Examine *Obelia*, a colonial marine hydrozoan. It features well-developed polyp and medusa generations that alternate via metagenesis.
Step 5: Therefore, *Obelia* is the correct example of a cnidarian showing this pattern.
Final Answer: Obelia

Answer: (D)

Go Back to Question 30

Q31.

Solution

Concept: Hormonal contraceptive methods alter female endocrinology to prevent conception. They use synthetic combinations of progestogens or progestogen-estrogen blends to disrupt normal ovarian and uterine cycles.

Solution: Step 1: Identify the specific physiological actions described: inhibiting ovulation and altering cervical mucus quality to block sperm migration.
Step 2: Analyze the mechanism of oral contraceptive pills. These pills maintain steady systemic levels of synthetic hormones, which exert negative feedback on the hypothalamus and anterior pituitary gland.
Step 3: This negative feedback suppresses the secretion of Gonadotropin-Releasing Hormone (GnRH), Follicle-Stimulating Hormone (FSH), and Luteinizing Hormone (LH). Without an LH surge, follicular rupture and ovulation are blocked.
Step 4: Additionally, the progestin thickens and alters the chemical composition of cervical mucus. This forms a thick physical barrier at the cervix that impedes sperm entry into the upper reproductive tract.
Step 5: Barrier methods simply block sperm mechanically, while copper IUDs suppress sperm motility chemically. Thus, oral pills are the method responsible for both described actions.
Final Answer: Oral contraceptive pills

Answer: (C)

Go Back to Question 31

Q32.

Solution

Concept: Cloning vectors used in recombinant DNA technology are frequently cut with restriction endonucleases, creating linear molecules with exposed sticky or blunt ends. Preventing these ends from re-joining without an insert helps optimize cloning efficiency.

Solution: Step 1: Analyze why a linearized plasmid vector self-ligates. DNA ligase requires a free 5′-phosphate group on one strand and a free 3′-hydroxyl group on the adjacent strand to form a phosphodiester bond.
Step 2: If a restriction enzyme cuts a circular plasmid, the resulting linear molecule retains 5′-phosphate groups at both ends, allowing it to easily recircularize during ligation reactions.
Step 3: To prevent this self-ligation, the linearized plasmid can be treated with the enzyme Alkaline Phosphatase.
Step 4: Alkaline phosphatase catalyzes the removal of the terminal 5′-phosphate groups from both ends of the linear DNA molecule, leaving 5′-hydroxyl groups instead.
Step 5: Without these 5′-phosphate groups, DNA ligase cannot join the plasmid ends together unless an external foreign DNA fragment containing intact 5′-phosphate groups is introduced.
Final Answer: Alkaline phosphatase

Answer: (B)

Go Back to Question 32

Q33.

Solution

Concept: Plant anatomy classifies vascular bundles based on the spatial arrangement of xylem and phloem, along with the presence or absence of lateral meristematic tissue (cambium) between them.

Solution: Step 1: Define the structural terms used to describe vascular bundles. Conjoint means xylem and phloem are positioned together along the same radius. Collateral means phloem is located on the outer side and xylem on the inner side.
Step 2: Analyze the term open. A vascular bundle is classified as open if a strip of primary intrafascicular cambium is present between the xylem and phloem tissues.
Step 3: This cambium layer retains the capacity for secondary growth, dividing to produce secondary xylem internally and secondary phloem externally.
Step 4: This conjoint, collateral, open arrangement is a key anatomical feature of dicotyledonous stems, enabling them to undergo secondary thickening over time.
Step 5: Monocotyledonous stems, by contrast, lack cambium and are classified as closed bundles. Therefore, option B accurately describes the arrangement found in dicots.
Final Answer: Conjoint, open, collateral

Answer: (B)

Go Back to Question 33

Q34.

Solution

Concept: The Renin-Angiotensin-Aldosterone System (RAAS) helps regulate blood pressure, blood volume, and systemic sodium concentrations. This homeostatic cascade is triggered by specialized cells in the kidney in response to changes in perfusion pressure.

Solution: Step 1: Identify the physiological trigger: a drop in systemic blood pressure or a decrease in glomerular filtration rate (GFR). This change is detected by the juxtaglomerular (JG) cells of the afferent arteriole.
Step 2: In response, JG cells secrete the proteolytic enzyme Renin directly into the renal circulation.
Step 3: Identify the primary substrate of renin in the bloodstream. Renin acts specifically on Angiotensinogen, a large plasma glycoprotein synthesized and continuously released into the blood by the liver.
Step 4: Renin cleaves Angiotensinogen to produce the decapeptide Angiotensin I.
Step 5: Angiotensin I is then converted into the potent vasoconstrictor Angiotensin II by angiotensin-converting enzyme (ACE) in the lungs. Thus, the primary enzyme and its immediate substrate are renin and angiotensinogen.

Final Answer: Renin, converts Angiotensinogen to Angiotensin I

Answer: (A)

Go Back to Question 34

Q35.

Solution

Concept: Transcription in prokaryotes is carried out by a single multi-subunit RNA polymerase enzyme. The enzyme can exist as a core catalytic enzyme or as a complete holoenzyme complex associated with accessory initiation factors.

Solution: Step 1: Analyze the structural composition of prokaryotic RNA polymerase. The core enzyme consists of five polypeptide subunits ($\alpha_2\beta\beta'\omega$). While this core complex can elongate an RNA chain, it cannot initiate transcription at specific promoter sites on its own.
Step 2: To initiate transcription accurately, the core enzyme must bind an accessory initiation factor known as the Sigma (σ) factor, forming the complete RNA polymerase holoenzyme.
Step 3: The sigma factor recognizes specific conserved sequence elements within the gene promoter region, such as the -10 (Pribnow box) and -35 sequences.
Step 4: Once the sigma factor binds these sequences, it positions the catalytic core at the transcription start site. After transcription initiation occurs and a short RNA segment is synthesized, the sigma factor detaches.
Step 5: Therefore, the sigma factor is the specific subunit required to recognize the promoter and initiate transcription.
Final Answer: Sigma (σ) factor

Answer: (B)

Go Back to Question 35

Q36.

Solution

Concept: Mitosis preserves genetic consistency across somatic cells through a highly regulated series of structural changes. Each phase (prophase, metaphase, anaphase, and telophase) is characterized by distinct chromosomal movements and structural configurations.

Solution: Step 1: Review the cellular events of metaphase. Chromosomes align along the equatorial plane, held in place by mitotic spindle fibers attached to their kinetochores.
Step 2: Analyze the transition to anaphase. At the onset of anaphase, the cohesive proteins holding sister chromatids together are cleaved, causing the shared centromere of each chromosome to split.
Step 3: Once separated, the individual sister chromatids are considered independent daughter chromosomes.
Step 4: Spindle fibers shorten, pulling the newly separated centromeres toward opposite poles of the dividing cell. The arms of the chromosomes trail behind, creating characteristic V, L, J, or I shapes.
Step 5: Thus, the splitting of centromeres and migration of sister chromatids to opposite poles is the defining cellular event of anaphase.
Final Answer: Centromeres split and sister chromatids migrate to opposite poles

Answer: (C)

Go Back to Question 36

Q37.

Solution

Concept: Biodiversity conservation strategies are broadly categorized into two approaches based on where the target species are managed: *in-situ* (on-site) conservation and *ex-situ* (off-site) conservation.

Solution: Step 1: Define *in-situ* conservation. This approach protects endangered plant and animal species within their natural habitats by designating protected areas like National Parks, Wildlife Sanctuaries, and Biosphere Reserves.
Step 2: Define *ex-situ* conservation. This approach involves removing threatened or endangered species from their natural habitats and placing them in managed, artificial environments to ensure their survival and propagation.
Step 3: Evaluate the options. National Parks, Wildlife Sanctuaries, and Biosphere Reserves are all examples of *in-situ* conservation that preserve whole ecosystems.
Step 4: Examine Botanical Gardens. A botanical garden is a managed facility where rare or threatened plant species collected from various wild locations are grown and cultivated under controlled conditions. This is a classic example of *ex-situ* conservation.
Step 5: Therefore, Botanical Gardens represent an *ex-situ* conservation method.
Final Answer: Botanical Garden

Answer: (D)

Go Back to Question 37

Q38.

Solution

Concept: The family Brassicaceae (traditionally known as Cruciferae) exhibits a distinct floral structure. The morphology and arrangement of the androecium whorl serve as a key identification feature for this family.

Solution: Step 1: Examine the androecium configuration in a typical brassicaceous flower (such as mustard). The flower contains a total of six individual stamens.
Step 2: Analyze the structural arrangement of these six stamens. They are organized into two distinct concentric rings or whorls based on filament length.
Step 3: The outer whorl consists of two short stamens positioned laterally. The inner whorl contains four long stamens positioned medially.
Step 4: This specific configuration of four long internal stamens and two short external stamens is termed a tetradynamous arrangement.
Step 5: Other stamen arrangements, like the monadelphous condition (fused into a single bundle) found in Malvaceae, do not occur in this family, confirming tetradynamous as the correct feature.
Final Answer: Tetradynamous stamens

Answer: (C)

Go Back to Question 38

Q39.

Solution

Concept: The human male reproductive system contains an interconnected network of ducts that transport mature spermatozoa from their site of initial synthesis out through the external urogenital opening.

Solution: Step 1: Identify the site of sperm production: the seminiferous tubules located inside the testicular lobules.
Step 2: Trace the path of sperm movement out of the tubules. Spermatozoa leave the seminiferous tubules and enter a network of interconnected channels within the mediastinum testis called the rete testis.
Step 3: From the rete testis, the sperms travel through $15 - 20$ fine ciliated tubules known as the vasa efferentia, which pierce the tunica albuginea.
Step 4: The vasa efferentia empty into the epididymis, a highly coiled tubular structure running along the posterior border of each testis where sperms undergo functional maturation and storage.
Step 5: The epididymis leads into the vas deferens, a long muscular duct that ascends into the abdominal cavity, loops over the urinary bladder, joins the duct of the seminal vesicle to form the ejaculatory duct, and empties into the urethra.
Step 6: Therefore, the correct anatomical path is: Seminiferous tubules → Rete testis → Vasa efferentia → Epididymis → Vas deferens → Urethra.

Final Answer: Seminiferous tubules → Rete testis → Vasa efferentia → Epididymis → Vas deferens → Urethra

Answer: (A)

Go Back to Question 39

Q40.

Solution

Concept: The production of recombinant human insulin (humulin) requires bypassing mammalian post-translational processing mechanisms when expressing the protein in prokaryotic hosts like *E. coli*.

Solution: Step 1: Understand how insulin is naturally synthesized in human pancreatic beta cells. It is initially produced as an inactive precursor molecule called proinsulin, which consists of three peptide chains: A, B, and a connecting C peptide.
Step 2: During natural maturation, the C peptide is proteolytically cleaved and removed, leaving the active insulin molecule composed of chains A and B linked by disulfide bridges.
Step 3: Prokaryotic hosts like *E. coli* lack the specific enzymatic machinery required to excise the C peptide from a proinsulin precursor.
Step 4: To solve this problem in industrial biotechnology, Eli Lilly designed separate synthetic DNA sequences coding for chain A and chain B individually.
Step 5: These synthetic gene sequences were inserted into separate plasmid vectors and transformed into distinct *E. coli* host colonies. The independent chains were extracted, purified, and chemically linked *in-vitro* by forming disulfide bonds. Thus, chains A and B are synthesized separately.
Final Answer: Chains A and B separately in different host cells

Answer: (B)

Go Back to Question 40

Q41.

Solution

Concept: Plants possessing the C_4 photosynthetic pathway exhibit a specialized internal leaf layout known as Kranz anatomy. This structural modification splits carbon fixation across two distinct cellular compartments to minimize energy loss from photorespiration.

Solution: Step 1: Identify the metabolic pathway described in the problem. The formation of the four-carbon compound oxaloacetic acid (OAA) as the first stable product is a characteristic feature of C_4 plants.
Step 2: Trace the initial step of carbon capture. Atmospheric carbon dioxide (CO_2) enters the leaf through stomata and dissolves into the cytoplasm of outer mesophyll cells, converting into bicarbonate (HCO_3^-).
Step 3: The primary acceptor molecule, phosphoenolpyruvate (PEP), reacts with this bicarbonate. This initial carboxylation step is catalyzed by the enzyme PEP carboxylase (PEPCase).
Step 4: This enzymatic reaction takes place directly within the cytoplasm of the mesophyll cells, producing the stable four-carbon product OAA.
Step 5: The OAA is then converted into malic or aspartic acid and transported into the inner bundle sheath cells for decarboxylation and entry into the Calvin cycle (C_3 cycle). Thus, initial fixation occurs in the mesophyll cell cytoplasm.
Final Answer: Mesophyll cells cytoplasm

Answer: (A)

Go Back to Question 41

Q42.

Solution

Concept: The human brain is highly compartmentalized, with different structures handling specific cognitive, physiological, and behavioral functions. The diencephalon contains key control centers that regulate automated homeostatic processes.

Solution: Step 1: Analyze the functional requirements outlined in the prompt: regulating core body temperature, maintaining fluid and nutritional balance (hunger and thirst), and managing autonomic emotional responses.
Step 2: Evaluate the functional role of the hypothalamus. Located at the base of the diencephalon below the thalamus, the hypothalamus contains distinct clusters of neurosecretory cells.
Step 3: It acts as the master thermostat of the body, continuously monitoring blood temperature and coordinating physiological cooling or warming responses.
Step 4: It also contains specific feeding and satiety centers that regulate appetite, along with osmoreceptors that monitor blood concentration to trigger thirst and coordinate emotional responses with the limbic system.
Step 5: Other brain regions like the cerebellum handle motor coordination, while the medulla regulates cardiovascular and respiratory rhythms, making the hypothalamus the correct structure.
Final Answer: Hypothalamus

Answer: (C)

Go Back to Question 42

Q43.

Solution

Concept: Point mutations involve a change in a single nucleotide base pair within a gene sequence. Depending on how this change alters the triplet codon, it can cause the substitution of a single amino acid in the resulting polypeptide chain.

Solution: Step 1: Analyze the genetic alteration described. A single nucleotide substitution in the GAG codon alters it to GUG within the gene encoding the β-globin subunit of hemoglobin.
Step 2: This single base substitution alters the triplet code, causing the translation machinery to place valine instead of glutamic acid at the sixth position of the polypeptide chain.
Step 3: A point mutation that results in the substitution of one amino acid for another is termed a missense mutation.
Step 4: Identify the clinical condition caused by this structural change. The presence of valine creates hydrophobic patches that cause hemoglobin molecules to aggregate into long polymers under low oxygen conditions. This distorts red blood cells into a rigid sickle shape, a condition known as sickle-cell anemia.
Step 5: Thus, this point mutation is a missense mutation that leads directly to sickle-cell anemia.
Final Answer: Missense mutation, Sickle-cell anemia

Answer: (B)

Go Back to Question 43

Q44.

Solution

Concept: Despite clear differences in structural complexity, all cellular life forms share certain fundamental architectural features that maintain cellular integrity and control the transport of molecules.

Solution: Step 1: Evaluate the structural differences between prokaryotes and eukaryotes. Prokaryotes lack a nuclear envelope and internal membrane-bound organelles, meaning options A and C describe features unique to eukaryotic cells.
Step 2: Examine the translational machinery. Prokaryotic cells possess smaller 70S ribosomes suspended freely in their cytoplasm, whereas eukaryotic cells typically contain larger 80S ribosomes in their cytoplasm, eliminating option B.
Step 3: Examine the outermost boundary of the cytoplasm. Both prokaryotic and eukaryotic cells are enclosed by a functional plasma membrane.
Step 4: This plasma membrane shares a highly conserved molecular structure across both domains, consisting of a fluid phospholipid bilayer embedded with transport proteins and structural lipids.
Step 5: Therefore, the presence of a plasma membrane composed of a lipid bilayer is a fundamental feature shared by both cell types.
Final Answer: Presence of a plasma membrane composed of a lipid bilayer

Answer: (D)

Go Back to Question 44

Q45.

Solution

Concept: Human activities often disrupt aquatic ecosystems by releasing nutrient-rich wastewater into natural water bodies. This influx can trigger a rapid cascade of ecological changes that severely lowers water quality.

Solution: Step 1: Analyze the specific ecological sequence described: an accumulation of nitrogen and phosphorus nutrients in a freshwater body leads to an explosion of algal growth and severe oxygen depletion.
Step 2: Identify this biological process. This nutrient enrichment is called eutrophication. It can occur naturally over long periods but is vastly accelerated by agricultural runoff and sewage discharge (cultural eutrophication).
Step 3: The excess nutrients spark an explosive growth of phytoplankton and algae, creating a dense layer known as an algal bloom.
Step 4: This dense layer blocks sunlight from reaching submerged aquatic plants, causing them to die. As decomposers break down the dead plant and algal biomass, they consume large amounts of dissolved oxygen.
Step 5: This severe drop in dissolved oxygen levels causes widespread suffocation and death among fish and other aquatic animals, making eutrophication the correct term.
Final Answer: Eutrophication

Answer: (B)

Go Back to Question 45

Q46.

Solution

Concept: The Five-Kingdom classification system proposed by Robert H. Whittaker organizes organisms based on specific structural and metabolic criteria, including cell type, body organization, and nutritional mode.

Solution: Step 1: Break down the taxonomic criteria provided in the prompt: the organisms must be single-celled (unicellular), possess a true membrane-bound nucleus (eukaryotic), and live primarily in aquatic habitats.
Step 2: Evaluate Kingdom Monera. This kingdom contains all unicellular prokaryotic organisms, such as bacteria and cyanobacteria, which rules it out.
Step 3: Evaluate Kingdoms Fungi and Plantae. These groups consist primarily of multicellular eukaryotic organisms specialized for absorption or photosynthesis, which excludes them.
Step 4: Examine Kingdom Protista. Whittaker established this kingdom specifically to serve as a taxonomically clean group for all single-celled eukaryotic organisms.
Step 5: Protista includes diverse lineages such as photosynthetic chrysophytes and dinoflagellates, consumer slime molds, and heterotrophic protozoans. Thus, it perfectly matches the given criteria.
Final Answer: Protista

Answer: (B)

Go Back to Question 46

Q47.

Solution

Concept: Following successful fertilization in the fallopian tube, the zygote undergoes rapid mitotic divisions to form a blastocyst. This blastocyst travels down into the uterine cavity, where it must attach to and embed within the uterine wall to establish a pregnancy.

Solution: Step 1: Review the structural histology of the human uterine wall. The uterus is composed of three distinct tissue layers: the outer serous perimetrium, the middle muscular myometrium, and the inner glandular endometrium.
Step 2: Analyze the role of each layer. The myometrium consists of smooth muscle fibers that generate contractions during childbirth, while the perimetrium serves a protective role.
Step 3: The innermost layer, the endometrium, is a highly vascularized, glandular mucous membrane that undergoes cyclic thickness and structural changes during each menstrual cycle.
Step 4: During implantation, the outer trophoblast layer of the blastocyst attaches directly to the surface epithelial cells of this inner lining. The endometrial cells divide rapidly, growing around and completely enclosing the embryo.
Step 5: Therefore, implantation takes place specifically within the functional tissue layer of the endometrium.
Final Answer: Endometrium

Answer: (C)

Go Back to Question 47

Q48.

Solution

Concept: Screening recombinant colonies requires identifying host cells that contain a modified plasmid. Blue-white selection is a screening method that uses reporter genes to visually identify successful cloning events without destroying the host cells.

Solution: Step 1: Understand the genetic layout of the cloning vector. The plasmid contains a reporter gene called $lacZ$, which encodes the active enzyme β-galactosidase. This gene contains a multiple cloning site (MCS) inside its sequence.
Step 2: Analyze non-recombinant cells. If no foreign DNA is inserted, the $lacZ$ gene remains intact and expresses functional β-galactosidase. This enzyme cleaves the chromogenic substrate X-gal in the growth medium, causing the colonies to turn a distinct blue color.
Step 3: Analyze recombinant cells. When a foreign DNA fragment is successfully cloned into the restriction sites of the MCS, it breaks the continuous sequence of the $lacZ$ gene.
Step 4: This disruption prevents the gene from producing a functional enzyme, a phenomenon known as insertional inactivation.
Step 5: Lacking functional β-galactosidase, these recombinant colonies cannot cleave X-gal and remain their natural white color, allowing easy visual identification.
Final Answer: Insertional inactivation of the β-galactosidase gene ($lacZ$)

Answer: (B)

Go Back to Question 48

Q49.

Solution

Concept: Moving ions across biological membranes against a concentration gradient requires an input of metabolic energy. Primary active transport complexes use the chemical energy stored in ATP to actively pump specific ions across the hydrophobic lipid bilayer.

Solution: Step 1: Define primary active transport. This mechanism relies on specialized membrane-spanning enzymes that directly hydrolyze ATP molecules to drive ions against their natural electrochemical gradients.
Step 2: Examine the role of proton pumps (H^+-ATPases) in plant cells. These integral membrane proteins utilize energy from ATP hydrolysis to pump hydrogen ions (H^+) out of the cytoplasm into the extracellular space or vacuole.
Step 3: This continuous pumping creates a significant electrochemical proton gradient across the plasma membrane, establishing a membrane potential.
Step 4: This proton gradient provides the driving energy that powers secondary transport processes, such as the cotransport of sugars and amino acids.
Step 5: Other transport options like aquaporins or ion channels facilitate passive diffusion along a gradient rather than driving active transport, leaving proton pumps as the primary active mechanism.
Final Answer: Proton pumps (H^+-ATPases)

Answer: (B)

Go Back to Question 49

Q50.

Solution

Concept: The resting membrane potential of a neuron's axon is maintained by unequal concentrations of specific ions across the plasma membrane. This ionic imbalance is sustained by the selective permeability of the resting membrane and the continuous activity of ion pumps.

Solution: Step 1: Examine a neuron under resting conditions (when it is not conducting active nerve impulses). The axonal membrane is significantly more permeable to potassium ions (K^+) and nearly impermeable to sodium ions (Na^+).
Step 2: Analyze the active transport mechanisms at play. The Na^+/K^+ ATPase pump continually uses ATP to pump three sodium ions out of the cell for every two potassium ions it brings inside.
Step 3: This active pumping creates a specific concentration gradient across the membrane.
Step 4: As a result, the internal cytoplasm of the axon (the axoplasm) maintains a high concentration of potassium ions (K^+) and a low concentration of sodium ions (Na^+) relative to the extracellular fluid outside.
Step 5: This specific ionic distribution helps establish the resting potential, making option C the correct description.
Final Answer: High concentration of K^+ and low concentration of Na^+

Answer: (C)
Go Back to Question 50

Q51.

Solution

Concept: Translating genetic information from a nucleic acid sequence into a specific sequence of amino acids requires an adapter molecule. This adapter must physically interact with both the mRNA codons and the corresponding amino acids.

Solution: Step 1: Understand the molecular challenge of translation: amino acids cannot directly read or bind to triplet nucleotide codons on an mRNA strand.
Step 2: This process requires a specialized structural intermediary known as transfer RNA (tRNA), which acts as a physical molecular adapter.
Step 3: Analyze the functional domains of a tRNA molecule. At one end, it features a specific amino acid acceptor stem that binds to a particular amino acid in an energy-dependent reaction.
Step 4: At its opposite structural loop, it displays a unique sequence of three bases called an anticodon, which forms complementary base pairs with the corresponding codon on the mRNA strand.
Step 5: By linking a specific codon with its matching amino acid, tRNA molecules function as the essential adapters that drive accurate translation.
Final Answer: tRNA molecules

Answer: (B)
Go Back to Question 51

Q52.

Solution

Concept: Biological macromolecules are complex polymers constructed from smaller monomeric building blocks. These monomers are joined together by specific, highly conserved covalent bonds formed through dehydration synthesis reactions.

Solution: Step 1: Evaluate the chemical bonds in option A. Polysaccharides are carbohydrate polymers composed of monosaccharide units linked by glycosidic bonds, not phosphodiester bonds.
Step 2: Evaluate option B. Proteins are constructed from amino acid monomers linked together by covalent peptide bonds, not glycosidic bonds.
Step 3: Evaluate option C. Nucleic acids consist of nucleotide monomers joined along a sugar-phosphate backbone by strong phosphodiester linkages, not peptide bonds.
Step 4: Evaluate option D. Standard lipids, such as triglycerides, are formed by linking a glycerol molecule to three fatty acid chains through dehydration reactions that create covalent ester linkages.
Step 5: Comparing these matches shows that option D correctly and accurately pairs a biomolecule with its primary characteristic chemical linkage.
Final Answer: Lipids – Ester bond

Answer: (D)
Go Back to Question 52

Q53.

Solution

Concept: The niche concept states that no two species can occupy the exact same ecological niche within a community indefinitely if resources are limited. This limitation drives competitive interactions that shape population dynamics.

Solution: Step 1: State the core principle of Gause's competitive exclusion model. It states that two closely related species competing for identical, limiting resource pools cannot coexist in the same space indefinitely.
Step 2: Analyze the population outcome over time. Even a tiny competitive advantage in gathering resources will allow one species to outgrow and outcompete the other.
Step 3: The more efficient competitor will see its population expand, while the competitively inferior species will suffer a steady decline in numbers.
Step 4: If the ecological conditions remain constant and there is no spatial or resource partitioning, this process will eventually lead to the complete local extinction of the less efficient competitor.
Step 5: Therefore, Gause's principle dictates that the competitively inferior species will eventually be eliminated from that specific habitat.
Final Answer: The competitively inferior species will eventually be eliminated

Answer: (B)
Go Back to Question 53

Q54.

Solution

Concept: Angiosperm groups exhibit distinct tissue arrangements within their stems. Identifying specific micro-anatomical features, such as the distribution of vascular bundles and the presence of certain cell types, allows accurate plant classification.

Solution: Step 1: Analyze the anatomical characteristics provided in the problem statement. The specimen displays numerous vascular bundles scattered throughout the ground tissue rather than arranged in a neat ring.
Step 2: Note the secondary structural details: each vascular bundle is enclosed by a protective sheath of thick-walled sclerenchyma cells, and phloem parenchyma is completely absent from the tissue.
Step 3: Correlate these specific features with plant groups. A scattered distribution of vascular bundles accompanied by sclerenchymatous sheaths and a lack of phloem parenchyma are defining anatomical features of monocotyledonous stems.
Step 4: In contrast, dicotyledonous stems feature vascular bundles arranged in a distinct concentric ring, possess phloem parenchyma, and lack individual sclerenchymatous bundle sheaths.
Step 5: Therefore, the specimen is definitively identified as a monocotyledonous stem.
Final Answer: Monocotyledonous stem

Answer: (B)

Go Back to Question 54

Q55.

Solution

Concept: A mature human spermatozoon is a highly specialized, motile cell designed to deliver paternal genetic material to an egg cell. Its structure includes a distinct head, neck, middle piece, and tail, each serving a specific functional role.

Solution: Step 1: Identify the position of the acrosome. It forms a small, cap-like membrane-bound organelle covering the anterior half of the dense nucleus within the sperm head.
Step 2: Determine its cellular origin. The acrosome is derived from the Golgi apparatus during spermiogenesis and is filled with specialized lytic enzymes.
Step 3: Analyze what happens when a sperm contacts an egg. The sperm triggers an acrosome reaction, releasing powerful hydrolytic enzymes, including hyaluronidase and acrosin.
Step 4: These lytic enzymes chemically digest the outer protective envelopes of the ovum, breaking down the cellular corona radiata and the acellular zona pellucida layers.
Step 5: This enzymatic breakdown allows the sperm plasma membrane to fuse with the egg cell membrane, enabling successful fertilization. Thus, the acrosome contains enzymes that digest the egg envelopes.

Final Answer: It contains hydrolytic enzymes that digest the egg envelopes

Answer: (C)

Go Back to Question 55

Q56.

Solution

Concept: Agricultural biotechnology can improve the nutritional profile of crop plants through biofortification. This involves inserting specific metabolic genes into a plant's genome to enable it to synthesize essential vitamins or nutrients it normally lacks.

Solution: Step 1: Identify the target crop and its nutritional modification: "Golden Rice" (*Oryza sativa*), which was engineered to address nutritional deficiencies in regions dependent on rice as a staple food.
Step 2: Note that standard rice grains produce carotenoid precursors in their green tissues but lack the enzymes to synthesize them in the edible endosperm.
Step 3: Scientists inserted two specific genes—phytoene synthase from daffodil and carotene desaturase from a soil bacterium—into the rice genome under the control of an endosperm-specific promoter.
Step 4: This genetic modification allows the rice endosperm to produce high amounts of β-carotene, a pigment that gives the grains a distinct golden hue.
Step 5: When consumed, the human body converts β-carotene into Vitamin A, helping prevent childhood blindness and immune deficiencies associated with Vitamin A deficiency.
Final Answer: β-carotene (Pro-vitamin A)

Answer: (D)

Go Back to Question 56

Q57.

Solution

Concept: Plant hormones (phytohormones) regulate diverse growth and developmental processes. Many hormones were initially discovered by analyzing genetic mutants that show distinct dwarf phenotypes.

Solution: Step 1: Analyze the specific growth response described: an exogenous hormone application induces rapid internodal elongation in a genetically dwarf plant, restoring it to a normal phenotype.
Step 2: Evaluate the primary effects of different hormone classes. Auxins promote apical dominance and root initiation, while cytokinins drive active cell division.
Step 3: Examine gibberellins (GA). This class of hormones plays a central role in promoting stem elongation by stimulating both cell division and cell elongation within the internodes.
Step 4: Applying gibberellins to dwarf varieties of plants, such as pea or maize mutants, causes a rapid increase in internode length, completely reversing the dwarf phenotype.
Step 5: Therefore, gibberellin is the hormone responsible for driving this specific dramatic elongation response.
Final Answer: Gibberellin

Answer: (C)

Go Back to Question 57

Q58.

Solution

Concept: The endocrine activity of pancreatic islet cells is essential for regulating blood glucose levels. Disruptions in insulin production or tissue sensitivity can severely alter systemic metabolism, leading to detectable changes in renal excretion.

Solution: Step 1: Analyze the clinical findings provided in the prompt: significant amounts of glucose (glycosuria) and ketone bodies (ketonuria) detected in a urine sample.
Step 2: Understand the underlying cause of glycosuria. When blood glucose levels rise sharply and exceed the renal threshold (around 180 mg/dL), the proximal tubule transporters become saturated, and excess glucose spills into the urine.
Step 3: Understand the cause of ketonuria. In the absence of effective insulin action, cells cannot absorb glucose from the blood and must shift to burning fats for energy. This rapid fat breakdown produces excessive acetyl-CoA, which the liver converts into ketone bodies.
Step 4: The accumulation of these compounds in the blood leads to ketonemia, and the kidneys excrete the excess in the urine.
Step 5: This combination of glycosuria and ketonuria is a classic clinical indicator of poorly managed Diabetes mellitus, differentiating it from Diabetes insipidus (which involves vasopressin deficiency and dilute urine).
Final Answer: Diabetes mellitus

Answer: (B)

Go Back to Question 58

Q59.

Solution

Concept: Simple Mendelian traits show distinct, discrete phenotypic categories. However, many complex physical characteristics exhibit a continuous gradient of variation across a population, indicating a different genetic architecture.

Solution: Step 1: Analyze the nature of the traits described: human skin color and height. These characteristics do not fall into simple "either-or" categories; instead, they present as a continuous spectrum of variations.
Step 2: Identify the genetic mechanism behind continuous traits. They are governed by the additive effects of multiple independent genes located at different loci, a mechanism known as polygenic inheritance.
Step 3: For example, human skin color is regulated by at least three independent gene pairs (A, B, C). Each dominant allele contributes additively to melanin production.
Step 4: This additive action generates a wide range of intermediate phenotypes across a population, typically forming a bell-shaped curve.
Step 5: This pattern differs from pleiotropy (where one gene affects multiple traits) or codominance, making polygenic inheritance the correct mechanism.
Final Answer: Polygenic inheritance

Answer: (B)

Go Back to Question 59

Q60.

Solution

Concept: The eukaryotic cell cycle progresses through a tightly regulated sequence of phases (G_1, S, G_2, and M). Internal molecular checkpoints monitor each transition to ensure accurate replication and division.

Solution: Step 1: Understand the purpose of cell cycle checkpoints. They assess cell size, nutrient availability, DNA integrity, and environmental signals before allowing the cell to progress to the next phase.
Step 2: Identify the primary restriction point in mammalian cells. This critical checkpoint is located late in the G_1 phase, right before the cell transitions into the synthetic (S) phase.
Step 3: Analyze the significance of this checkpoint. Once a cell passes the G_1/S checkpoint, it commits irreversibly to replicating its nuclear DNA and completing the rest of the division cycle.
Step 4: If environmental conditions or growth factors are unfavorable before this point, the cell will halt progression and enter a quiescent, non-dividing state called G_0.
Step 5: Therefore, the G_1/S checkpoint represents the primary restriction point where the cell commits to subsequent division.
Final Answer: G_1/S checkpoint

Answer: (B)

Go Back to Question 60

Q61.

Solution

Concept: Ecological pyramids visually represent the structural features of different trophic levels, such as organism numbers, energy flow, or total biomass, within an ecosystem. The shape of a biomass pyramid depends heavily on the life cycles of its primary producers.

Solution: Step 1: Examine biomass distribution in terrestrial ecosystems. These ecosystems are dominated by large plants and trees, resulting in an upright pyramid where the producer biomass vastly exceeds consumer biomass.
Step 2: Examine biomass distribution in open aquatic ecosystems, such as deep marine environments. Here, the primary producers are tiny, single-celled phytoplankton.
Step 3: Phytoplankton have a very small standing crop biomass at any single point in time. However, they reproduce rapidly and exhibit high turnover rates.
Step 4: This small, fast-growing standing crop of producers supports a much larger, longer-lived biomass of zooplankton and predatory fish at higher trophic levels.
Step 5: As a result, when biomass is measured per unit area at any given moment, the pyramid appears completely inverted, with the base significantly narrower than the upper levels.

Final Answer: Inverted, because the small standing crop of phytoplankton supports a larger biomass of zooplankton and fish

Answer: (B)

Go Back to Question 61

Q62.

Solution

Concept: The structural composition of cell walls varies across kingdoms, providing specialized mechanical support and protection tailored to each group's evolutionary lineage and lifestyle.

Solution: Step 1: Review the composition of plant cell walls. Green plants possess a rigid cell wall composed primarily of the glucose polymer cellulose, along with hemicellulose and pectins.
Step 2: Examine the cell wall composition of true fungi (Kingdom Fungi). Their cell walls do not contain cellulose as a structural backbone.
Step 3: Instead, the primary structural component of fungal cell walls is chitin, a tough nitrogen-containing polysaccharide polymer made from repeating units of *N*-acetylglucosamine.
Step 4: Chitin provides exceptional structural strength and resistance to osmotic pressure, and it is chemically identical to the polymer found in the exoskeletons of arthropods.
Step 5: Compare with other choices: peptidoglycan is unique to bacterial cell walls. Thus, chitin is the defining component that distinguishes fungal cell walls from those of plants.

Final Answer: Chitin

Answer: (B)

Go Back to Question 62

Q63.

Solution

Concept: The mammalian ovarian cycle is regulated by periodic changes in gonadotropin levels. Following the mid-cycle surge of luteinizing hormone (LH), the mature follicle ruptures, triggering a structural transformation of the remaining follicular tissue.

Solution: Step 1: Trace the events of ovulation. Under the influence of the LH surge, a mature Graafian follicle ruptures, releasing the secondary oocyte into the peritoneal cavity toward the fallopian tube.
Step 2: Analyze what happens to the remaining follicular tissue left inside the ovary. The granulosa and theca interna cells undergo rapid structural changes, accumulating lipids and a yellow lutein pigment.
Step 3: This cellular transformation turns the ruptured follicle remnants into a temporary endocrine structure called the corpus luteum.
Step 4: The corpus luteum secretes high levels of progesterone, which helps prepare and maintain the uterine endometrium for potential embryo implantation.
Step 5: If fertilization does not occur, the corpus luteum eventually degrades into a white scar structure called the corpus albicans, making the corpus luteum the correct temporary structure.
Final Answer: Corpus luteum

Answer: (B)

Go Back to Question 63

Q64.

Solution

Concept: Cloning vectors used in recombinant DNA technology require specific genetic elements to facilitate gene cloning, including an origin of replication (ori), unique restriction enzyme sites, and selectable markers.

Solution: Step 1: Understand the challenge of genetic transformation: when host bacterial cells are treated with a plasmid mixture, only a small percentage successfully take up the vector.
Step 2: To isolate these successfully transformed cells, scientists integrate a selectable marker gene into the plasmid framework.
Step 3: Selectable markers typically consist of genes that confer resistance to specific antibiotics, such as ampicillin, tetracycline, or kanamycin, or encode metabolic enzymes like β-galactosidase.
Step 4: When the transformed cells are grown on a selection medium containing the corresponding antibiotic, only the host cells that successfully took up the plasmid can express the resistance gene and survive. Non-transformed cells are eliminated.
Step 5: Thus, a selectable marker serves specifically to assist in identifying and selecting host cells that have taken up the vector.

Final Answer: It assists in identifying and selecting host cells that have taken up the vector

Answer: (B)

Go Back to Question 64

Q65.

Solution

Concept: The oxidative phosphorylation cascade uses the free energy released by electron transport to drive ATP synthesis. The total number of ATP molecules generated per electron carrier depends on where that carrier enters the electron transport chain (ETC).

Solution: Step 1: Analyze electron entry via NADH. It transfers its electrons to Complex I (NADH dehydrogenase), passing them down the entire chain and pumping enough protons to generate approximately 3 molecules of ATP (or 2.5 using modern biochemical values).
Step 2: Analyze electron entry via $FADH_2$. This molecule transfers its electrons directly to Complex II (Succinate dehydrogenase), completely bypassing the proton-pumping Complex I.
Step 3: Because these electrons bypass the first complex, they pass through fewer proton-pumping steps (only Complexes III and IV) as they travel down the chain to oxygen.
Step 4: This shorter pathway pumps fewer hydrogen ions into the intermembrane space, generating a smaller proton-motive force. As a result, oxidizing one molecule of $FADH_2$ yields exactly 2 molecules of ATP via ATP synthase.
Step 5: Therefore, according to standard textbook stoichiometry, the net ATP yield from a single $FADH_2$ molecule is 2.
Final Answer: 2

Answer: (B)

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Q66.

Solution

Concept: The human heart features a myogenic conduction system composed of specialized auto-rhythmic cardiac muscle fibers. These specialized cells can spontaneously depolarize to generate and propagate action potentials without requiring external nervous system inputs.

Solution: Step 1: Identify the anatomical location specified in the prompt: the right upper corner of the wall of the right atrium.
Step 2: Identify the specialized patch of nodal tissue situated at this specific location: the Sinoatrial node (SAN).
Step 3: Analyze its physiological role. The SAN possesses the highest rate of spontaneous depolarization within the conduction system, generating regular electrical impulses at a rate of $70 - 75$ times per minute.
Step 4: These electrical impulses spread across the atrial walls, inducing atrial contraction, and travel down to the atrioventricular node (AVN) to coordinate the ventricular heartbeat.
Step 5: Because it sets the fundamental rhythmic pace of the heart, the SAN functions as the primary natural pacemaker, making it the correct structure.
Final Answer: Sinoatrial node (SAN)

Answer: (B)

Go Back to Question 66

Q67.

Solution

Concept: The inheritance of human ABO blood groups is governed by a single gene (I) that features three distinct alleles: I^A, I^B, and i. This genetic system exhibits both standard dominant-recessive relationships and codominance.

Solution: Step 1: Identify the genotypes of the parents from the information provided. The woman has blood group O, which is a recessive trait requiring a homozygous genotype (ii). The man has blood group A and is heterozygous, giving him the genotype I^Ai.
Step 2: Determine the types of gametes produced by each parent. The woman produces gametes that all carry the recessive i allele. The heterozygous man produces two types of sperm cells in equal proportions: 50% carrying the I^A allele and 50% carrying the i allele.
Step 3: Set up a Punnett square to determine the potential genetic combinations for their offspring:

	I^A	i
i	I^Ai (Group A)	ii (Group O)

Step 4: Analyze the resulting phenotypes from the Punnett square. Half (50%) of the offspring will inherit the I^Ai genotype, expressing blood group A. The other half (50%) will inherit the ii genotype, expressing blood group O.
Step 5: Therefore, the expected offspring will present blood groups A and O in an equal $1:1$ ratio.
Final Answer: Blood groups A and O in a $1:1$ ratio

Answer: (C)

Go Back to Question 67

Q68.

Solution

Concept: The eukaryotic cytoskeleton is an interconnected network of protein filaments suspended within the cytoplasm. It is composed of three primary structural components: microtubules, intermediate filaments, and microfilaments, each built from distinct protein subunits.

Solution: Step 1: Identify the structural component described: microfilaments, which form the thinnest filament network within the cytoskeleton.
Step 2: Determine the protein subunit that builds these structures. Microfilaments are constructed from globular protein subunits called G-actin, which polymerize into long, helical double-stranded filaments known as F-actin.
Step 3: Analyze the functional roles of actin microfilaments. Working alongside motor proteins like myosin, they provide the mechanical forces that drive structural cell shape changes, cellular motility, and cytokinesis.
Step 4: They are also directly responsible for internal movements, such as amoeboid pseudopodia extension and cytoplasmic streaming (cyclosis).
Step 5: Other structural proteins, like tubulin (which forms microtubules) or keratin (which forms intermediate filaments), do not construct microfilaments, leaving actin as the correct answer.
Final Answer: Actin

Answer: (C)

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Q69.

Solution

Concept: Human industrial activity has released synthetic chemicals that degrade the stratospheric ozone layer, which shields Earth from harmful ultraviolet radiation. International environmental agreements help coordinate global efforts to mitigate these ecological threats.

Solution: Step 1: Identify the environmental goal specified: controlling the emission of ozone-depleting substances (ODSs), such as chlorofluorocarbons (CFCs), to protect the stratospheric ozone layer.
Step 2: Evaluate the international agreement signed in 1987 to address this issue. This treaty was opened for signature in September 1987 in Montreal, Canada, and is known as the Montreal Protocol.
Step 3: The Montreal Protocol established legally binding limits and phase-out schedules for the production and consumption of chemicals that degrade stratospheric ozone.
Step 4: Compare with other choices. The Kyoto Protocol (1997) targets greenhouse gas emissions to address climate change. The Nagoya Protocol manages genetic resource sharing, and the Earth Summit was a broad environmental conference.
Step 5: Thus, the Montreal Protocol is the specific treaty dedicated to controlling ozone-depleting substances.
Final Answer: Montreal Protocol

Answer: (B)

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Q70.

Solution

Concept: The family Liliaceae, commonly known as the lily family, is a characteristic group of monocotyledonous plants. They display a distinct set of vegetative and floral traits that reflect their monocot lineage.

Solution: Step 1: Analyze the vegetative features of monocotyledonous plants like Liliaceae. Their leaves feature parallel venation rather than the reticulate venation typical of dicots, ruling out options A and D.
Step 2: Examine the floral symmetry and whorls. The flowers are trimerous, meaning their structural parts occur in groups of three or multiples of three.
Step 3: Analyze the perianth structure. The calyx and corolla are fused into a single undifferentiated whorl of tepals, forming a perianth.
Step 4: Examine the androecium. The flower features six stamens arranged in two whorls. The filaments of these stamens are often fused directly to the tepals, a condition described as epiphyllous.
Step 5: Combining these taxonomic features reveals that parallel venation, trimerous flowers, and epiphyllous stamens form the correct suite of characteristics for Liliaceae.
Final Answer: Parallel venation, trimerous flowers, epiphyllous stamens

Answer: (B)

Go Back to Question 70

Q71.

Solution

Concept: Angiosperm plants use various biotic and abiotic pollination vectors to transfer pollen grains from the anther to the receptive stigma surface. Flowers exhibit specific structural adaptations tailored to their primary pollination vector.

Solution: Step 1: Analyze the structural features described: production of immense quantities of lightweight, dry, non-sticky pollen grains along with large, feathery stigmas. The flowers also lack bright colors, fragrances, and nectar rewards.
Step 2: Evaluate biotic pollination modes like entomophily or ornithophily. Animal-pollinated flowers typically invest metabolic energy into producing vivid petals, strong scents, and sweet nectar to attract animal vectors. Their pollen grains are also sticky or textured to adhere to animal bodies.
Step 3: Evaluate wind pollination, known as anemophily. Wind is an abiotic, non-directional vector, meaning the vast majority of released pollen grains fail to reach a receptive flower.
Step 4: To overcome these low odds, wind-pollinated plants produce massive amounts of lightweight, dry pollen that can easily float on air currents. Their stigmas are large and feathery to efficiently catch drifting pollen grains from the air.
Step 5: Therefore, these specific structural adaptations point directly to an anemophilous (wind-pollinated) mechanism.
Final Answer: Anemophily (Wind pollination)

Answer: (B)

Go Back to Question 71

Q72.

Solution

Concept: Modern diagnostic medicine relies on highly sensitive molecular techniques to detect pathogens or specific proteins in patient samples. These assays use highly specific biochemical interactions to confirm the presence of a target molecule.

Solution: Step 1: Identify the core biochemical principle specified in the prompt: an assay that relies on highly specific antigen-antibody binding interactions.
Step 2: Evaluate the options. Gel electrophoresis separates molecules based on size and charge, while PCR amplifies nucleic acid sequences using thermal cycling, meaning neither relies on antibodies.
Step 3: Examine the Enzyme-Linked Immunosorbent Assay (ELISA). This diagnostic tool is designed around the specific binding between an antigen and its matching antibody.
Step 4: In a standard assay, a patient's serum sample is added to wells coated with a specific antigen or antibody. If the target pathogen or antibody is present, it binds tightly to the well. An enzyme-linked secondary antibody is then added, which reacts with a substrate to produce a visible color change.
Step 5: This color change confirms a positive test, making ELISA the correct technique based on the described principle.
Final Answer: Enzyme-Linked Immunosorbent Assay (ELISA)

Answer: (D)

Go Back to Question 72

Q73.

Solution

Concept: Apical dominance is a developmental pattern where the active terminal bud suppresses the growth of lower lateral buds. This coordination is controlled by the balance and interaction of different counteracting plant hormones.

Solution: Step 1: Understand the hormonal cause of apical dominance. Auxins are synthesized in high amounts at the shoot apex and move downward through polar transport. This high auxin concentration inhibits the development of lateral axillary buds, promoting vertical growth.
Step 2: Identify the hormone that counteracts this effect. To overcome apical dominance and promote lateral branching, the plant requires a hormone that actively stimulates cell division and axillary bud growth.
Step 3: Cytokinins, which are synthesized primarily in root tips and transported upward through the xylem, fulfill this role.
Step 4: Applying cytokinins directly to lateral buds antagonizes the inhibitory effect of downward-moving auxins, triggering cell division and causing the lateral buds to grow into branches even if the apex remains intact.
Step 5: Thus, cytokinins are the class of plant hormones that directly counteract apical dominance.
Final Answer: Cytokinins

Answer: (B)

Go Back to Question 73

Q74.

Solution

Concept: The loop of Henle acts as a countercurrent multiplier that establishes a concentration gradient in the renal medulla. The two limbs of the loop possess opposing membrane permeabilities, which allows the nephron to regulate water and electrolyte conservation.

Solution: Step 1: Review the anatomical layout of the loop of Henle, which consists of a thin descending limb that extends into the medulla and an ascending limb that loops back up toward the cortex.
Step 2: Analyze the membrane permeability of the descending limb. The epithelial cells lining this segment express high levels of aquaporin-1 water channels, making the membrane highly permeable to water. However, it lacks active transporters for ions and is nearly impermeable to NaCl and urea.
Step 3: As the renal filtrate flows down into the hypertonic environment of the medulla, water moves out of the tubule via osmosis and is reabsorbed by the vasa recta, concentrating the remaining filtrate.
Step 4: Analyze the ascending limb. This segment is completely impermeable to water but actively transports sodium and chloride ions out into the interstitial space.
Step 5: Therefore, the descending limb of Henle's loop is the specific segment that is highly permeable to water and impermeable to electrolytes.
Final Answer: Descending limb of Henle's loop

Answer: (B)

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Q75.

Solution

Concept: In eukaryotic cells, transcription yields an unstable primary RNA transcript (hnRNA) that contains alternating coding and non-coding sequences. This molecule must undergo a series of chemical modifications in the nucleus before it can be safely exported for translation.

Solution: Step 1: Identify the structural components of hnRNA. Exons represent the coding regions that contain the sequence for protein synthesis, while introns are non-coding intervening sequences that disrupt this message.
Step 2: Analyze the different processing steps. Capping adds a modified guanosine nucleotide to the 5′ end, and tailing appends a poly-A tail to the 3′ end to protect the transcript from degradation.
Step 3: Examine the splicing mechanism. Splicing is carried out by a large molecular complex called the spliceosome.
Step 4: The spliceosome precisely cleaves out the non-coding introns and covalently joins the coding exons together into a continuous sequence.
Step 5: This precise cutting and joining creates a mature, functional mRNA molecule ready for translation, confirming splicing as the correct process.
Final Answer: Splicing

Answer: (C)

Go Back to Question 75

Q76.

Solution

Concept: The nucleus contains specialized sub-compartments that coordinate different genetic tasks. The nucleolus is a prominent, non-membrane-bound structure that functions as a highly active site for synthesizing and assembling specific molecular complexes.

Solution: Step 1: Identify the structural nature of the nucleolus. It is a dense region of chromatin located within the nucleus, organized around the nucleolar organizer regions (NORs) of specific chromosomes.
Step 2: Determine its primary biosynthetic function. The nucleolus houses the genes that code for ribosomal RNA (rRNA). RNA polymerase I binds here to transcribe these genes into large rRNA precursor molecules.
Step 3: These primary transcripts are processed into smaller, mature rRNA molecules (18S, 5.8S, and 28S).
Step 4: Ribosomal proteins synthesized in the cytoplasm are imported into the nucleus and enter the nucleolus, where they combine with the mature rRNA strands to assemble the large and small ribosomal subunits.
Step 5: These completed subunits are then exported back to the cytoplasm, confirming the nucleolus as the primary site for rRNA synthesis and ribosomal assembly.
Final Answer: Ribosomal RNA (rRNA)

Answer: (C)

Go Back to Question 76

Q77.

Solution

Concept: Ecosystem dynamics rely on feeding relationships to transfer energy and nutrients across trophic levels. While simple food chains show a single linear path, natural communities form more complex networks.

Solution: Step 1: Differentiate between a food chain and a food web. A food chain is a simple, linear sequence of organisms, whereas a food web is an interconnected network of multiple overlapping food chains.
Step 2: Analyze how food webs affect ecosystem stability. In a complex web, most consumers feed on more than one type of organism.
Step 3: If a disease or environmental change causes one prey population to drop sharply, its predators do not starve; they can easily switch to alternative prey species within the web.
Step 4: This network of alternative energy pathways prevents population crashes and helps buffer the entire ecosystem against environmental shocks.
Step 5: Therefore, complex, interlinked food webs provide alternative energy pathways that enhance the overall stability of the biological community.

Final Answer: Interlinked food webs provide alternative pathways for energy flow, enhancing ecosystem stability

Answer: (C)

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Q78.

Solution

Concept: Prokaryotic life is split into two distinct evolutionary domains: Archaebacteria and Eubacteria. Archaebacteria possess unique cell wall structures and membrane lipids that allow them to thrive in highly specialized or extreme environments.

Solution: Step 1: Identify the group of organisms described: methanogens, which are specialized obligate anaerobes that produce methane gas (CH_4) as a metabolic byproduct of cellular respiration.
Step 2: Classify methanogens taxonomically. Because they possess unique cell walls that lack peptidoglycan and feature ether-linked lipids in their plasma membranes, they belong to the ancient group Archaebacteria.
Step 3: Identify their typical ecological habitats. Methanogens thrive in strictly anaerobic environments, such as sewage treatment plants, deep marsh sediments, and the digestive tracts of ruminant animals like cows and buffaloes.
Step 4: In the rumen, these microbes break down cellulose, producing methane gas that the animal eliminates.
Step 5: Therefore, methanogens are classified as Archaebacteria and are commonly found in the gut of ruminant animals.
Final Answer: Archaebacteria, in the gut of ruminant animals

Answer: (B)

Go Back to Question 78

Q79.

Solution

Concept: Classical genetics often focuses on simple traits where a single gene regulates a single physical characteristic. However, many individual genes code for proteins that serve widespread regulatory or metabolic roles across different tissue systems.

Solution: Step 1: Define the specific genetic scenario described: a single gene mutation or product simultaneously influences multiple, completely unrelated physical characteristics.
Step 2: Identify this genetic phenomenon. It is known as pleiotropy.
Step 3: Analyze a classic example of a pleiotropic gene: the human metabolic disorder phenylketonuria (PKU). This condition is caused by a mutation in a single gene that encodes the liver enzyme phenylalanine hydroxylase.
Step 4: Lacking this single enzyme, phenylalanine accumulates to toxic levels, causing a wide range of unrelated clinical symptoms, including severe mental retardation, reduced hair growth, and skin depigmentation.
Step 5: This wide range of impacts from a single genetic locus perfectly illustrates the concept of pleiotropy, distinguishing it from polygenic inheritance (where multiple genes influence one trait).
Final Answer: Pleiotropy

Answer: (B)

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Q80.

Solution

Concept: The light-dependent reactions of photosynthesis can follow either non-cyclic or cyclic electron pathways. The choice of pathway depends on which photosystems are active and the metabolic needs of the plant cell.

Solution: Step 1: Analyze the location specified in the prompt: the stroma lamellae membranes of the chloroplast. These membranes lack both Photosystem II (PS II) and the $NADP^+$ reductase enzyme.
Step 2: Determine the active photosystem under these conditions. Because PS II is absent, only Photosystem I (PS I) can be excited by incoming light.
Step 3: Trace the flow of electrons. Excited electrons leave the reaction center (P_{700}) of PS I and travel through a chain of electron carriers, but they cannot be passed to $NADP^+$ due to the missing reductase enzyme.
Step 4: Instead, the electrons loop back through the cytochrome b_6f complex to the oxidized reaction center of PS I. This cyclic flow drives protons across the membrane, generating a gradient that powers ATP synthase to produce ATP.
Step 5: Because the electrons recycle rather than reducing electron carriers, this cyclic pathway produces only ATP, with no synthesis of NADPH or release of O_2.
Final Answer: Only PS I; ATP only

Answer: (C)

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Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	B	2	C	3	A	4	B	5	D
6	B	7	A	8	C	9	B	10	C
11	A	12	C	13	B	14	C	15	C
16	B	17	D	18	A	19	B	20	C
21	A	22	C	23	B	24	C	25	B
26	C	27	C	28	B	29	B	30	D
31	C	32	B	33	B	34	A	35	B
36	C	37	D	38	C	39	A	40	B
41	A	42	C	43	B	44	D	45	B
46	B	47	C	48	B	49	B	50	C
51	B	52	D	53	B	54	B	55	C
56	D	57	C	58	B	59	B	60	B
61	B	62	B	63	B	64	B	65	B
66	B	67	C	68	C	69	B	70	B
71	B	72	D	73	B	74	B	75	C
76	C	77	C	78	B	79	B	80	C