JCECE Biology Sample Paper-12

Duration: 60 Minutes **Maximum Marks: 50**

Instructions

- his paper contains **50** Multiple Choice Questions (Single Correct Answer), modelled on the Biology portion of JCECE entrance.
- Each correct answer carries **+1** mark. Incorrect answer: **−0.25** marks.unattempted questions get 0.
- Only one option is correct. Choose carefully.
- Syllabus level: **Class 11 and Class 12 NCERT Physics (Jharkhand JAC / CBSE aligned)**
- Use of mobile phones, calculators, or electronic gadgets is strictly prohibited.

Q1. Which of the following taxonomic categories holds the highest number of common characteristics among the organisms included within it?

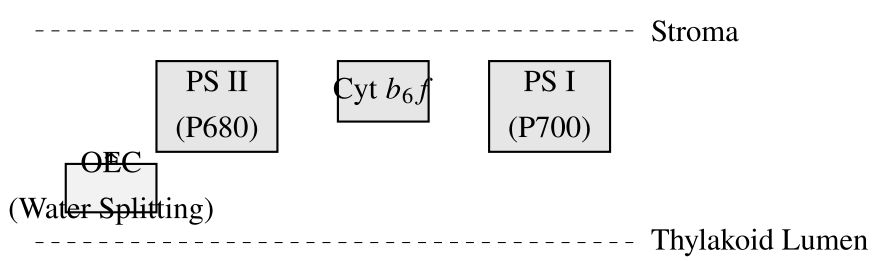
(A) Order

(B) Family

(C) Genus

(D) Species

Q2. During standard non-cyclic photophosphorylation, which complex is directly responsible for the photolysis of water molecules on the inner side of the thylakoid membrane?



(A) Cytochrome b_6f complex

(B) Oxygen-evolving complex associated with PS II

(C) NADP reductase complex

(D) Reaction center of PS I

Q3. A cross is made between a true-breeding tall plant with round seeds (TTRR) and a true-breeding dwarf plant with wrinkled seeds (ttrr). If the F_1 progeny is selfed, what proportion of the F_2 generation is expected to display a phenotype that is completely different from both original parental strains?

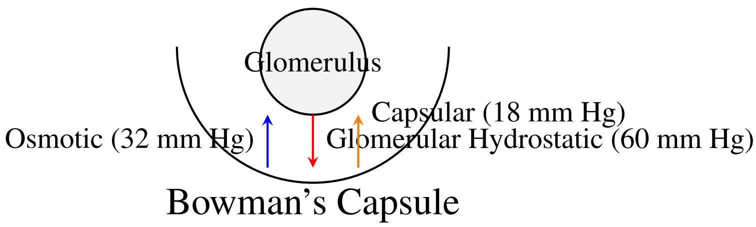
(A) $\frac{9}{16}$

(B) $\frac{6}{16}$

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

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

Q4. In a human nephron, if the hydrostatic pressure in the glomerular capillaries is 60 mm Hg, the osmotic pressure of plasma proteins is 32 mm Hg, and the hydrostatic pressure of the fluid in Bowman's capsule is 18 mm Hg, what is the net filtration pressure (NFP)?



(A) 10 mm Hg

(B) 14 mm Hg

(C) 46 mm Hg

(D) 74 mm Hg

Q5. Which of the following options correctly describes the structural feature and functional status of the human mature erythrocyte?

(A) Biconcave, nucleated, and performs aerobic respiration

(B) Spherical, enucleated, and lacks mitochondria

(C) Biconcave, enucleated, and exhibits anaerobic metabolism

(D) Discoid, nucleated, and possesses high density of ribosomes

Q6. Identify the incorrect statement regarding the secondary structure of DNA as proposed by Watson and Crick.

(A) The two strands run antiparallel to each other in a $5' \rightarrow 3'$ and $3' \rightarrow 5'$ direction.

(B) Adenine pairs with Thymine via three weak hydrogen bonds.

(C) The pitch of the helix is 3.4 nm with roughly 10 base pairs per turn.

(D) The backbone is formed by alternating sugar-phosphate-sugar units.

Q7. In the human female reproductive cycle, what triggers the sudden surge of Luteinizing Hormone (LH) that induces ovulation?

(A) High sustained levels of progesterone acting via positive feedback

(B) High levels of estrogen reaching a critical peak threshold near the mid-cycle

(C) Sudden withdrawal of Gonadotropin-Releasing Hormone (GnRH)

(D) A sharp drop in the secretion of Inhibin by granulosa cells

Q8. Which specific region of the human brain contains vital reflex centers responsible for controlling gastric secretions, cardiovascular reflexes, and respiration?

(A) Cerebellum

(B) Medulla oblongata

(C) Hypothalamus

(D) Corpus callosum

Q9. In an ecosystem, if the Net Primary Productivity (NPP) is calculated to be $12,000\ \text{kcal/m}^2/\text{yr}$ and the respiration losses (R) by the autotrophs amount to $8,000\ \text{kcal/m}^2/\text{yr}$, what is the Gross Primary Productivity (GPP) of this ecosystem?

(A) $4,000\ \text{kcal/m}^2/\text{yr}$

(B) $16,000$ kcal/m^2/yr

(C) $20,000$ kcal/m^2/yr

(D) $9,600$ kcal/m^2/yr

Q10. During the process of isolation of genetic material for recombinant DNA technology, which enzyme is specifically used to degrade the cell wall of fungal cells?

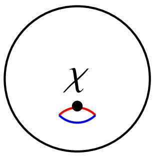
(A) Lysozyme

(B) Cellulase

(C) Chitinase

(D) Ribonuclease

Q11. Which stage of prophase I during meiosis is characterized by the clear visual appearance of recombinant nodules and the initiation of crossing over between non-sister chromatids?



Chiasma/Nodule formation

(A) Leptotene

(B) Zygotene

(C) Pachytene

(D) Diplotene

Q12. In restriction endonuclease nomenclature, such as in EcoRI, what does the letter 'R' signify?

(A) The genus of the source organism

(B) The specific species identifier

(C) The strain from which the enzyme was isolated

(D) The order of discovery of the enzyme

Q13. In a population at Hardy-Weinberg equilibrium, the frequency of a recessive allele causing a specific metabolic disorder is 0.3. What is the frequency of healthy heterozygous individuals in this population?

(A) 0.09

(B) 0.42

(C) 0.49

(D) 0.21

Q14. Which plant hormone is derived from carotenoids and acts as a general plant growth inhibitor, stimulating the closure of stomata during severe water stress?

(A) Indole-3-acetic acid

(B) Abscisic acid

(C) Gibberellic acid

(D) Zeatin

Q15. In a double-stranded DNA molecule, if Cytosine constitutes 28% of the total nitrogenous bases, what will be the percentage of Adenine present?

(A) 22%

(B) 28%

(C) 44%

(D) 56%

Q16. Which of the following cells in the human gastric glands are responsible for secreting intrinsic factor, which is absolutely essential for the absorption of vitamin B_{12}?

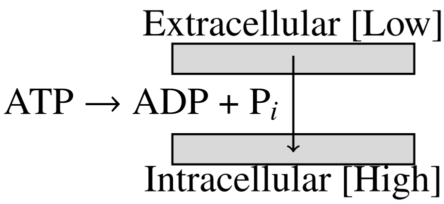
(A) Peptic cells

(B) Mucus neck cells

(C) Oxyntic cells

(D) Chief cells

Q17. The mechanism of active transport across a biological membrane is fundamentally distinguished from facilitated diffusion because active transport:



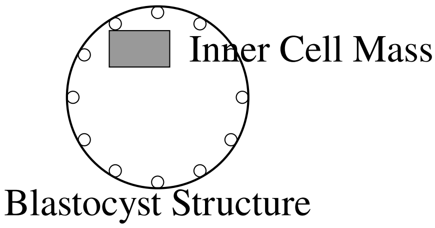
(A) Requires specific transmembrane carrier proteins

(B) Moves substances against their electrochemical gradient utilizing ATP

(C) Exhibits saturation kinetics when all transporters are occupied

(D) Operates independent of the structural conformation of lipids

Q18. Which structural part of the human blastocyst differentiates directly to form the primary germ layers of the embryo during gastrulation?



(A) Trophoblast

(B) Inner cell mass

(C) Blastocoel roof

(D) Zona pellucida residual layer

Q19. Which ecological interaction is correctly exemplified by the relationship between a cuckoo laying its eggs in a crow's nest and the crow incubating them?

(A) Mutualism

(B) Commensalism

(C) Brood parasitism

(D) Amensalism

Q20. What is the precise function of the enzyme aminoacyl-tRNA synthetase during the translation process?

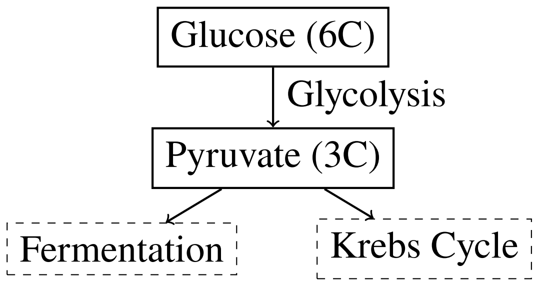
(A) Cleavage of peptide bonds at the termination site

(B) Transcription of tRNA genes in the nucleolus

(C) Covalent alignment of an amino acid to its cognate tRNA molecule

(D) Unwinding the mRNA secondary structures near the ribosome

Q21. During cellular respiration, which specific step is common to both aerobic breakdown of glucose and anaerobic fermentation pathways?



(A) Oxidative decarboxylation of pyruvate

(B) Conversion of glucose to pyruvic acid

(C) Citric acid cycle running in the mitochondrial matrix

(D) Electron transport chain coupled with ATP synthase

Q22. Select the pair of structures that represent homologous organs, pointing toward divergent evolution.

(A) Wings of a butterfly and wings of a sparrow

(B) Flippers of a penguin and flippers of a dolphin

(C) Tendrils of Cucurbita and thorns of Bougainvillea

(D) Eye of an octopus and eye of a cat

Q23. In an illuminated green leaf, which cell type acts as the primary site for the C_4 pathway's initial carbon fixation mediated by PEP carboxylase?

(A) Bundle sheath cells

(B) Mesophyll cells

(C) Epidermal cells

(D) Trichome cells

Q24. Which of the following secondary metabolites is a toxin classified under natural plant defense chemicals?

(A) Vinblastine

(B) Ricin

(C) Codeine

(D) Curcumin

Q25. Which hormone is released by the juxtaglomerular cells of the kidney in response to a drop in glomerular blood pressure or volume, initiating the activation of angiotensinogen?

(A) Aldosterone

(B) Atrial Natriuretic Peptide

(C) Renin

(D) Vasopressin

Q26. What type of modification or structure prevents self-pollination in bisexual flowers by ensuring that pollen release and stigma receptivity are not synchronized?

(A) Cleistogamy

(B) Dichogamy

(C) Herkogamy

(D) Self-incompatibility

Q27. According to the fluid mosaic model of biological membranes, the quasi-fluid nature of lipids enables lateral movement of proteins. This ability to move within the membrane is measured as its:

(A) Elasticity

(B) Permeability

(C) Fluidity

(D) Compressibility

Q28. In which of the following plant groups is the dominant, independent phase represented by a free-living, photosynthetic gametophyte, while the sporophyte is completely dependent on it?

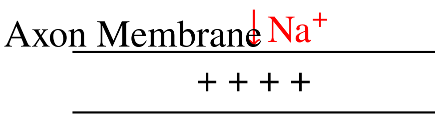
(A) Pteridophytes

(B) Bryophytes

(C) Gymnosperms

(D) Angiosperms

Q29. During the depolarization phase of an action potential along a human nerve axon, what constitutes the primary movement of ions?



(A) Rapid influx of Na^+ ions into the intracellular fluid

(B) Active efflux of K^+ ions via the sodium-potassium pump

(C) Influx of Cl^- ions balancing the resting potential

(D) Efflux of Na^+ ions through voltage-gated channels

Q30. Which of the following is an example of an autosomal dominant genetic disorder in humans?

(A) Phenylketonuria

(B) Sickle-cell anemia

(C) Myotonic dystrophy

(D) Cystic fibrosis

Q31. The functional reservoir of calcium ions inside a skeletal muscle fiber, which releases them into the sarcoplasm upon receiving a neural impulse, is the:

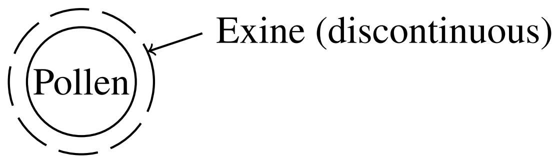
(A) T-tubule network

(B) Sarcolemma

(C) Sarcoplasmic reticulum

(D) Golgi apparatus

Q32. Which of the following components forms the hard, highly resistant outer layer of a pollen grain called exine, allowing it to be well-preserved as fossils?



(A) Cellulose

(B) Pectocellulose

(C) Sporopollenin

(D) Lignin

Q33. If a double-stranded DNA segment contains 400 nucleotides in total and 60 of them are Thymine, how many cytosine bases are present in this segment?

(A) 60

(B) 140

(C) 200

(D) 280

Q34. Which vector is most widely and successfully used to introduce functional human genes into mammalian target tissue during ex vivo gene therapy procedures?

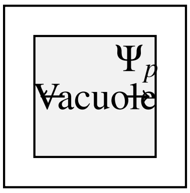
(A) pBR322

(B) Ti plasmid of Agrobacterium

(C) Retrovirus

(D) Lambda bacteriophage

Q35. In an actively growing plant cell, what primary factor drives the expansion of the central vacuole, pushing the cytoplasm against the cell wall?



Plant Cell

(A) High turgor pressure created by osmotic water entry

(B) Active exocytosis of cellular proteins into the wall space

(C) Synthesis of additional lipid bilayers by the smooth ER

(D) Microfilament shortening within the cytoskeleton

Q36. Which specific type of permanent tissue forms the major ground tissue of plants, possesses thin cellulosic walls, and retains the ability to divide under wound-healing conditions?

(A) Sclerenchyma

(B) Collenchyma

(C) Parenchyma

(D) Xylem vessels

Q37. During the cardiac cycle, the second heart sound ("dub") is produced when:

(A) Mitral and tricuspid valves close sharply at the onset of ventricular systole.

(B) Semilunar valves close at the beginning of ventricular diastole.

(C) AV nodes send an electrical signal to the Bundle of His.

(D) Blood rushes rapidly from the atria into the relaxed ventricles.

Q38. Which type of antibody molecule is the most abundant in human colostrum, providing crucial passive immunity to a newborn infant?

(A) IgG

(B) IgM

(C) IgA

(D) IgE

Q39. In a lac operon system, when an inducer molecule binds to the repressor protein, what is the immediate biochemical consequence?

(A) The repressor becomes active and binds tightly to the promoter.

(B) The repressor undergoes a conformational change and releases from the operator.

(C) RNA polymerase is degraded by cellular proteases.

(D) Structural genes are transcribed at a permanently reduced basal rate.

Q40. The process of conversion of atmospheric nitrogen gas (N_2) into ammonia (NH_3) by free-living or symbiotic microbes is catalyzed by which highly oxygen-sensitive enzyme?

(A) Nitrate reductase

(B) Nitrite reductase

(C) Nitrogenase

(D) Transaminase

Q41. Which of the industrial products is synthesized by the yeast strain Saccharomyces cerevisiae via anaerobic fermentation of sugars?

(A) Citric acid

(B) Cyclosporin A

(C) Ethanol

(D) Statins

Q42. Which primary cell wall polymer provides tensile strength and prevents plant cells from bursting due to high internal osmotic pressure?

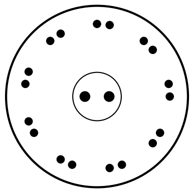
(A) Suberin

(B) Cellulose

(C) Callose

(D) Pectin

Q43. What is the structural arrangement of microtubules in the core of a eukaryotic flagellum (axoneme)?



9 + 2 Microtubule Array

(A) 9 + 0 triplet pattern

(B) 9 + 2 doublet pattern

(C) 7 + 2 singlet pattern

(D) Parallel non-ordered bundles

Q44. In the human male reproductive system, which specific cells provide structural and metabolic support to developing germ cells throughout spermatogenesis?

(A) Leydig cells

(B) Sertoli cells

(C) Interstitial macrophages

(D) Spermatogonia

Q45. Which of the following basic amino acids possesses a net positive charge at physiological pH due to its unique side-chain properties?

(A) Valine

(B) Glutamic acid

(C) Lysine

(D) Alanine

Q46. According to the Central Pollution Control Board (CPCB) of India, particulate matter of which aerodynamic diameter size (in micrometers) is responsible for causing the greatest harm to human respiratory health?

(A) 10.0 or less

(B) 5.0 or less

(C) 2.5 or less

(D) 1.5 or less

Q47. Which classification system category includes organisms that are multicellular, heterotrophic, lack a cell wall, and exhibit holozoic nutrition?

(A) Monera

(B) Fungi

(C) Plantae

(D) Animalia

Q48. What unique morphological feature distinguishes the phylum Aschelminthes (Roundworms) from the phylum Platyhelminthes (Flatworms)?

(A) Presence of bilateral symmetry

(B) Triploblastic germ layer organization

(C) Presence of a pseudocoelom

(D) Complete absence of a digestive tract

Q49. Which of the following methods of biological conservation involves preserving threatened plant or animal species outside their natural habitats, such as in a botanical garden or cryopreservation facility?

(A) In situ conservation

(B) Ex situ conservation

(C) Biosphere reserve zoning

(D) National park preservation

Q50. During the processing of pro-insulin into mature insulin in human cells, which structural segment is proteolytically removed to make the hormone functional?

(A) A-peptide

(B) B-peptide

(C) C-peptide

(D) Disulfide bridges

Detailed Solutions

Q1.

Solution

Concept:
Taxonomic hierarchy represents the systematic arrangement of various taxonomic categories in a descending order. As we move from species to kingdom, the number of common characteristics decreases. Conversely, descending from kingdom down to species results in an increase in shared, unique biological traits among the organisms.

Solution:
Step 1: Understand the taxonomic categories provided in the options, which include Order, Family, Genus, and Species. This follows the standard hierarchical structure.
Step 2: Apply the fundamental taxonomic principle stating that lower taxonomic categories contain organisms with a greater degree of similarity and more common traits.
Step 3: Analyze the positions of the given categories: Species is the lowest unit, followed upwardly by Genus, Family, and Order.
Step 4: Since Species is the most specific unit of classification, the individuals belonging to a particular species share the maximum number of structural, functional, and evolutionary traits.
Step 5: Comparing all options, Species represents the highest taxonomic specificity among the choices, making it the category with the most common characteristics.
Final Answer: $\boxed{\text{Species}}$

$\boxed{\textbf{Answer: (D)}}$

Go Back to Question 1

Q2.

Solution

Concept:

Light-dependent reactions in photosynthesis utilize specialized multi-protein complexes embedded in the thylakoid membrane. Photolysis, or the catalytic splitting of water molecules into protons, electrons, and molecular oxygen, is specifically performed to replenish electrons lost by the reaction center chlorophyll.

Solution:

Step 1: Recall the process of non-cyclic photophosphorylation where electrons flow from water to Photosystem II, then to Photosystem I, and finally to $NADP^+$.

Step 2: Identify that Photosystem II (P_{680}) becomes highly oxidized upon absorbing photons and requires an immediate source of replacement electrons to maintain the continuous flow.

Step 3: Pinpoint the location of the water-splitting site, which is structurally coupled to the inner lumen side of the thylakoid membrane to ensure protons accumulate inside the lumen.

Step 4: This physiological process is mediated by a specialized manganese-containing catalytic cluster known explicitly as the Oxygen-Evolving Complex (OEC).

Step 5: The Oxygen-Evolving Complex is physically associated with Photosystem II, making option B the correct mechanism.

Final Answer: $\boxed{\text{Oxygen-evolving complex associated with PS II}}$

Answer: (B)

Go Back to Question 2

Q3.

Solution

Concept:

A Mendelian dihybrid cross tracks the inheritance of two independent traits governed by two separate gene pairs. When the F_1 generation is self-pollinated, the resulting F_2 generation produces a classic phenotypic distribution ratio reflecting independent assortment.

Solution:

Step 1: Identify the parental phenotypes and genotypes: Tall, Round (TTRR) and Dwarf, Wrinkled (ttrr). The F_1 hybrid genotype is completely heterozygous, represented as TtRr.

Step 2: Recall the standard Mendelian F_2 phenotypic ratio for a dihybrid cross upon selfing TtRr, which is $9:3:3:1$.

Step 3: Break down the total 16 combinations: 9 are Tall-Round (Parental type 1), 3 are Tall-Wrinkled (Recombinant), 3 are Dwarf-Round (Recombinant), and 1 is Dwarf-Wrinkled (Parental type 2).

Step 4: The question asks for the proportion of the progeny displaying a phenotype completely different from both original parental strains, which refers specifically to the recombinant configurations.

Step 5: Sum up the recombinant phenotypes: 3 (Tall-Wrinkled) + 3 (Dwarf-Round) = 6. Therefore, the expected proportion out of 16 is precisely $\frac{6}{16}$.

Final Answer: $\boxed{\frac{6}{16}}$

Answer: (B)

Go Back to Question 3

Q4.

Solution

Concept:

Net Filtration Pressure (NFP) determines the rate of ultrafiltration across the glomerular membrane into Bowman's capsule. It balances the main outward driving forces against the inward opposing pressures exerted by plasma proteins and fluid already inside the capsule space.

Solution:

Step 1: Identify and categorize the pressures given in the problem statement. Glomerular Hydrostatic Pressure (GHP) is 60 mm Hg, acting as a promotional filtration force.

Step 2: Identify the counteracting pressures: Blood Colloidal Osmotic Pressure (BCOP) is 32 mm Hg and Capsular Hydrostatic Pressure (CHP) is 18 mm Hg. Both oppose filtration.

Step 3: Set up the mathematical relationship for Net Filtration Pressure: NFP = GHP − (BCOP + CHP).

Step 4: Substitute the verified numerical values directly into the formulated physiological equation: NFP = 60 − (32 + 18).

Step 5: Perform the arithmetic operations sequentially: NFP = 60 − 50 = 10 mm Hg. Thus, the net dynamic driving force equals 10 mm Hg.

Final Answer: $\boxed{\text{10 mm Hg}}$

Answer: (A)

Go Back to Question 4

Q5.

Solution

Concept:

Human erythrocytes undergo extensive structural optimization during maturation to clear space for maximum hemoglobin capacity. This developmental specialization alters their core cell architecture, eliminating major organelles and defining their specialized respiratory metabolic pathways.

Solution:

Step 1: Evaluate the structural geometry of a mature human red blood cell, which possesses a distinct biconcave shape optimized to increase surface-area-to-volume ratio for gas diffusion.

Step 2: Check for the presence of a cell nucleus. Mature mammalian erythrocytes lose their nuclei during development to accommodate maximum hemoglobin molecules, making them enucleated.

Step 3: Assess the metabolic machinery. They systematically eject mitochondria along with other internal organelles during terminal cellular differentiation.

Step 4: Because they lack functional mitochondria, mature red blood cells cannot generate adenosine triphosphate via aerobic pathways. Instead, they rely exclusively on anaerobic glycolysis.

Step 5: Combine these structural and metabolic evaluations to deduce that the mature erythrocyte is biconcave, enucleated, and relies entirely on anaerobic metabolism.

Final Answer: $\boxed{\text{Biconcave, enucleated, and exhibits anaerobic metabolism}}$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 5

Q6.

Solution

Concept:

The Watson and Crick double-helical structure of deoxyribonucleic acid is stabilized by specific structural rules, spatial arrangements, and thermodynamic structural interactions, including strict base-pairing rules established between purines and pyrimidines.

Solution:

Step 1: Review statement A: The two strands display an antiparallel orientation running from $5' \rightarrow 3'$ and $3' \rightarrow 5'$, which is a correct foundational feature.

Step 2: Review statement B: It claims Adenine pairs with Thymine via three weak hydrogen bonds. Let us cross-check the biochemical structural data.

Step 3: Recall the established Chargaff-compatible base-pairing parameters: Adenine binds with Thymine via exactly two hydrogen bonds ($A = T$), while Guanine pairs with Cytosine via three hydrogen bonds ($G \equiv C$).

Step 4: Therefore, statement B contains a precise numerical factual error regarding the number of hydrogen bonds stabilizing the adenine-thymine base pairs.

Step 5: Statements C and D are completely accurate regarding the helix pitch metrics (3.4 nm) and the alternating sugar-phosphate architectural polymer backbone.

Final Answer: $\boxed{\text{Adenine pairs with Thymine via three weak hydrogen bonds.}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 6

Q7.

Solution

Concept:
The female menstrual cycle relies on complex neuroendocrine feedback mechanisms between the ovaries and the anterior pituitary gland. While estrogen typically exerts a negative feedback influence on gonadotropins, a sharp reversal occurs at a critical hormonal threshold near mid-cycle.

Solution:
Step 1: Trace estrogen level fluctuations during the follicular phase of the ovarian cycle. As follicles grow, they secrete steadily increasing amounts of estrogen.
Step 2: Evaluate the physiological shift at mid-cycle. When blood concentrations of estrogen rise sharply to a high, sustained threshold for roughly 36 to 48 hours, it triggers positive feedback.
Step 3: Observe the pituitary response to this positive feedback. The anterior pituitary becomes highly sensitive to GnRH, resulting in an abrupt, massive release of Luteinizing Hormone.
Step 4: This rapid endocrine event is called the LH surge, and it is directly responsible for triggering follicular rupture and ovulation within 24 to 36 hours.
Step 5: Conclude that high levels of estrogen reaching a critical peak threshold near the mid-cycle is the precise upstream trigger for this hormonal surge.

Final Answer: $\boxed{\text{High levels of estrogen reaching a critical peak threshold near the mid-cycle}}$

Answer: (B)

Go Back to Question 7

Q8.

Solution

Concept:

The human brain stem acts as a vital bridge regulating autonomic homeostatic physiological reflexes. Highly specialized clusters of neurons localized within specific brainstem regions receive continuous sensory inputs to coordinate basic survival reflexes without conscious cortical involvement.

Solution:

Step 1: Analyze the specific functions assigned to the brain sub-regions listed in the options. Cerebellum coordinates muscle tone and balance, while Corpus callosum links hemispheres.

Step 2: Examine the Hypothalamus, which controls body temperature, circadian rhythms, and basic neuroendocrine pathways, but does not house core respiratory reflex centers.

Step 3: Evaluate the Medulla oblongata. It contains highly specialized autonomic nuclei, including the cardiovascular center and the medullary rhythmicity area for breathing.

Step 4: The Medulla oblongata also coordinates autonomic motor reflexes for vomiting, swallowing, coughing, sneezing, and regulating gastric secretions.

Step 5: Thus, the specific brain region containing centers that control gastric secretions, cardiovascular reflexes, and respiration is definitively the Medulla oblongata.

Final Answer: $\boxed{\text{Medulla oblongata}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 8

Q9.

Solution

Concept:
Primary productivity calculations determine energy transformations across primary trophic levels. Gross Primary Productivity (GPP) is the total organic matter fixed via photosynthesis, while Net Primary Productivity (NFP) represents what remains after meeting metabolic demands.

Solution:
Step 1: State the primary ecological formula linking primary productivity components: NPP = GPP − R, where R represents cellular respiration losses.
Step 2: Extract the numerical quantities provided in the problem context: Net Primary Productivity (NPP) equals $12,000$ kcal/m^2/yr.
Step 3: Extract the respiration value: Autotrophic respiration loss (R) equals $8,000$ kcal/m^2/yr.
Step 4: Rearrange the algebraic expression to solve directly for Gross Primary Productivity: GPP = NPP + R.
Step 5: Substitute the values and compute the total sum: $\text{GPP} = 12,000 + 8,000 = 20,000$ kcal/m^2/yr. This represents the total solar energy fixed.
Final Answer: $\boxed{20,000 \text{ kcal/m}^2\text{/yr}}$

Answer: (C)

Go Back to Question 9

Q10.

Solution

Concept:
Isolating high-purity genomic DNA requires the methodical degradation of outer protective cellular boundaries. Because different taxonomic groups possess distinct chemical compositions forming their cell walls, specific enzymes must be selected to target these structural polymers.

Solution:
Step 1: Analyze the chemical composition of the cell walls found in fungal organisms. Fungal cell walls are composed predominantly of chitin, a long-chain polymer of N-acetylglucosamine.
Step 2: Assess the catalytic specificity of the enzyme options. Lysozyme cleaves peptidoglycan linkages in bacterial walls; Cellulase breaks down plant cellulosic walls.
Step 3: Ribonuclease targets and degrades RNA molecules within the cytoplasm, leaving cell wall components entirely unaffected.
Step 4: Chitinase is a specialized hydrolytic enzyme that breaks the glycosidic bonds in chitin polymers, systematically liquefying the fungal cell wall.
Step 5: Therefore, Chitinase is the correct choice for isolating genetic material from fungal cells.
Final Answer: $\boxed{\text{Chitinase}}$

Answer: (C)

Go Back to Question 10

Q11.

Solution

Concept:

Meiotic prophase I is a highly complex, regulated phase divided into distinct stages based on chromosome morphology and behavior. The physical exchange of genetic segments between non-sister chromatids occurs at a precise structural step during this extended prophase.

Solution:

Step 1: Review the chronological stages of prophase I: Leptotene (condensation), Zygotene (synapsis), Pachytene (crossing over), Diplotene (desynapsis), and Diakinesis (terminalization).

Step 2: Identify the stage where homologous chromosomes complete synapsis to form bivalents or tetrads, which occurs during Zygotene.

Step 3: Analyze the subsequent stage, Pachytene. During this stage, the bivalent chromosomes appear clearly as tetrads, and distinctive recombination nodules become highly visible.

Step 4: These recombination nodules contain the enzymatic machinery required to mediate crossing over, leading to genetic recombination between non-sister chromatids.

Step 5: Thus, Pachytene is the precise substage characterized by both recombination nodules and active crossing over.

Final Answer: $\boxed{\text{Pachytene}}$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 11

Q12.

Solution

Concept:

The naming system for restriction endonucleases follows strict international microbiological nomenclature rules. Each letter and number in an enzyme designation provides specific information about the origin and isolation history of the biological catalyst.

Solution:

Step 1: Breakdown the specific components of the restriction enzyme nomenclature using the example EcoRI.

Step 2: Identify the first letter 'E'. It stands for the genus of the source bacterium, which is Escherichia.

Step 3: Identify the next two letters 'co'. They represent the specific species designation, which is coli.

Step 4: Examine the fourth letter 'R'. This letter indicates the specific strain of the bacterium from which the enzyme was extracted, which is the RY 13 strain.

Step 5: The final Roman numeral 'I' indicates the chronological order in which the enzyme was isolated from that bacterial strain. Thus, 'R' represents the strain.

Final Answer: $\boxed{\text{The strain from which the enzyme was isolated}}$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 12

Q13.

Solution

Concept:

The Hardy-Weinberg law mathematically models allele and genotype frequencies in an ideal, non-evolving population. For a gene locus with two alleles, the total algebraic distribution is represented by the expansion of a binomial equation.

Solution:

Step 1: State the basic Hardy-Weinberg equilibrium formulas: $p + q = 1$ and $p^2 + 2pq + q^2 = 1$. Let q represent the frequency of the recessive allele.
Step 2: Substitute the given value for the recessive allele frequency: $q = 0.3$.
Step 3: Calculate the dominant allele frequency (p) using the relation $p = 1 - q$:

$$p = 1 - 0.3 = 0.7$$

Step 4: Express the formula for the frequency of heterozygous individuals within the population, which is given by the term $2pq$.
Step 5: Substitute the calculated values into the term: $2 \times 0.7 \times 0.3 = 0.42$. Thus, the frequency of healthy heterozygous individuals is 0.42.
Final Answer: $\boxed{0.42}$

Answer: (B)

Go Back to Question 13

Q14.

Solution

Concept:

Plant growth substances regulate development and stress responses. Stress hormones accumulate rapidly during adverse environmental conditions like drought, driving physiological adaptations to prevent excessive moisture loss.

Solution:

Step 1: Analyze the chemical origins and main functions of the listed hormones. Indole-3-acetic acid is an auxin that promotes growth. Gibberellic acid and Zeatin drive elongation and division.

Step 2: Examine Abscisic Acid (ABA). It is synthesized via the carotenoid biosynthetic pathway, making it structurally derived from carotenoid precursors.

Step 3: Evaluate its physiological roles. ABA primarily acts as an inhibitor of plant growth, growth metabolism, and seed germination.

Step 4: Consider stress responses. Under severe desiccation or water stress, ABA concentrations rise rapidly, inducing the closing of stomata to reduce transpiration.

Step 5: Because of these characteristics, Abscisic acid is classified as the classic plant stress hormone.

Final Answer: $\boxed{\text{Abscisic acid}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 14

Q15.

Solution

Concept:
Chargaff's rules outline quantitative relationships for nitrogenous bases within double-stranded DNA molecules. The rules state that purines and pyrimidines occur in stoichiometric parity because of strict base-pairing requirements.

Solution:
Step 1: Recall Chargaff's rules for double-stranded DNA: Total Purines equal Total Pyrimidines ($A + G = T + C$). Specifically, $A = T$ and $G = C$.
Step 2: Utilize the given data: Cytosine (C) is 28%. According to base pairing, Guanine (G) must also equal 28%.
Step 3: Combine the percentages of Cytosine and Guanine:

$$G + C = 28\% + 28\% = 56\%$$

Step 4: Deduce the remaining percentage allocated to Adenine (A) and Thymine (T) base pairs out of 100%:

$$A + T = 100\% - 56\% = 44\%$$

Step 5: Since $A = T$, divide the remaining percentage equally by 2 to determine the frequency of Adenine: $44\%/2 = 22\%$.
Final Answer: $\boxed{22\%}$

Answer: (A)

Go Back to Question 15

Q16.

Solution

Concept:

The mucosal lining of the stomach contains gastric glands lined with specialized secretory epithelial cells. Each cell type possesses distinct structural properties enabling it to secrete specific digestive components or physiological factor molecules.

Solution:

Step 1: Identify the cell types located in human gastric pits: Peptic (chief) cells, mucus neck cells, and oxyntic (parietal) cells.

Step 2: Recall the secretion products of chief cells, which produce the inactive proenzyme pepsinogen. Mucus neck cells produce alkaline mucus protective layers.

Step 3: Examine Oxyntic cells, which are also known as parietal cells. These cells actively pump hydrogen ions to secrete hydrochloric acid (HCl).

Step 4: Along with HCl, oxyntic cells synthesize and secrete Intrinsic Factor (Castle's intrinsic factor), a glycoprotein vital for absorbing vitamin B_{12} in the ileum.

Step 5: Conclude that Oxyntic cells are directly responsible for the secretion of intrinsic factor.

Final Answer: $\boxed{\text{Oxyntic cells}}$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 16

Q17.

Solution

Concept:

Substances cross biological plasma membranes via distinct passive or active mechanisms. While both facilitated diffusion and active transport use specialized integral membrane protein channels, their thermodynamic energy requirements differ fundamentally.

Solution:

Step 1: Analyze facilitated diffusion. It uses carrier proteins to move solutes down their concentration gradient without requiring metabolic energy.

Step 2: Analyze active transport systems. These systems use specialized transmembrane protein pumps to transport molecules against their thermodynamic gradients.

Step 3: Moving a chemical substance from a region of low concentration to a region of high concentration requires an input of metabolic energy.

Step 4: This energetic requirement is fulfilled by hydrolyzing Adenosine Triphosphate (ATP) directly or indirectly.

Step 5: Thus, active transport is uniquely distinguished from facilitated diffusion by moving substances against their electrochemical gradient utilizing ATP.

Final Answer: $\boxed{\text{Moves substances against their electrochemical gradient utilizing ATP}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 17

Q18.

Solution

Concept:
Early embryonic development organizes blastocyst structures into distinct cellular subsets. Cells are segregated based on whether they form outer extra-embryonic supporting systems or give rise to the actual body of the embryo.

Solution:
Step 1: Examine the structural anatomy of a human blastocyst. It consists of an outer single layer of cells called the trophoblast and an internal cluster of cells.
Step 2: Define the developmental fate of the trophoblast layer, which contributes to forming extra-embryonic membranes and the fetal portion of the placenta.
Step 3: Analyze the internal cluster of cells attached to one pole, known as the inner cell mass (embryoblast).
Step 4: The inner cell mass contains pluripotent stem cells that retain the developmental potential to differentiate into all three primary embryonic germ layers during gastrulation.
Step 5: These layers are the ectoderm, mesoderm, and endoderm. Thus, the inner cell mass directly forms the embryonic body.

Final Answer: $\boxed{\text{Inner cell mass}}$

Answer: (B)

Go Back to Question 18

Q19.

Solution

Concept:
Interspecific ecological interactions govern how co-existing species influence each other's survival and reproductive success. Certain behavioral adaptations allow parasitic organisms to exploit the parental care behaviors of host species.

Solution:
Step 1: Analyze the interaction described. The cuckoo bird lays its eggs in the nest of a crow, relying on the host to incubate and feed its young.
Step 2: Notice that the parasitic bird's eggs have evolved to mimic the host's eggs in size, color, and patterning to avoid detection and ejection.
Step 3: This behavior directly reduces the host's reproductive fitness while benefiting the parasite, indicating a parasitic relationship.
Step 4: Because this parasitic strategy specifically exploits host nesting behavior and brood care, it is termed brood parasitism.
Step 5: Evaluate the options to confirm that brood parasitism is the correct term for this specific avian interaction.
Final Answer: $\boxed{\text{Brood parasitism}}$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 19

Q20.

Solution

Concept:
Translation requires high-fidelity matching between an amino acid and its corresponding codon on the mRNA transcript. This accurate genetic decoding depends on an enzymatic pre-activation process that links amino acids to their appropriate transfer RNA vectors.

Solution:
Step 1: Identify the role of transfer RNA (tRNA) molecules as adapters in protein translation. Each must carry its correct corresponding amino acid.
Step 2: Examine the enzyme responsible for charging tRNA molecules, which is aminoacyl-tRNA synthetase.
Step 3: Analyze the reaction catalyzed by this enzyme. It couples a specific amino acid to adenosine triphosphate (ATP) to form an activated intermediate.
Step 4: The enzyme then transfers the activated amino acid to the $3'$ acceptance stem of its cognate tRNA molecule, forming a covalent ester bond.
Step 5: Therefore, the precise function of aminoacyl-tRNA synthetase is the covalent alignment of an amino acid to its cognate tRNA molecule.
Final Answer: $\boxed{\text{Covalent alignment of an amino acid to its cognate tRNA molecule}}$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 20

Q21.

Solution

Concept:
Cellular metabolic pathways break down carbohydrate fuels to harvest chemical energy. Both aerobic and anaerobic respiration split hexose sugars into simpler intermediate compounds within the aqueous cytosolic compartment.

Solution:
Step 1: Compare aerobic respiration and anaerobic fermentation pathways. Aerobic processes proceed through the Krebs cycle and electron transport within mitochondria.
Step 2: Anaerobic fermentation bypasses mitochondria entirely, converting pyruvate into lactate or ethanol in the cytoplasm.
Step 3: Identify the upstream metabolic pathway required by both modes of respiration, which is Glycolysis (the EMK pathway).
Step 4: Glycolysis occurs in the cytoplasm and breaks down one molecule of glucose (6C) into two molecules of pyruvic acid (3C) without requiring molecular oxygen.
Step 5: Thus, the conversion of glucose to pyruvic acid represents the precise step shared by both aerobic and anaerobic pathways.
Final Answer: Conversion of glucose to pyruvic acid

Answer: (B)

Go Back to Question 21

Q22.

Solution

Concept:
Comparative anatomy provides structural evidence for evolutionary patterns. Homologous organs share a common embryonic origin and basic structural framework but have diversified to perform different functions due to varying environmental pressures.

Solution:
Step 1: Analyze option A and B: Wings of insects/birds and flippers of penguins/dolphins share similar functions but have distinct embryonic origins, representing analogous structures.
Step 2: Analyze option D: The eyes of octopuses and cats share a common vision function but evolved through entirely different structural pathways, making them analogous.
Step 3: Examine option C: Tendrils of *Cucurbita* and thorns of *Bougainvillea*. Both structures develop from the axillary bud position of the plant stem.
Step 4: Despite their shared anatomical origin, they have modified functions: tendrils assist in climbing, while thorns provide physical defense.
Step 5: Because they share an anatomical origin but serve different functions, they are classic examples of homologous organs reflecting divergent evolution.
Final Answer: $\boxed{\text{Tendrils of Cucurbita and thorns of Bougainvillea}}$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 22

Q23.

Solution

Concept:
Plants utilizing C_4 photosynthesis exhibit a specialized internal leaf structure known as Kranz anatomy. This structural layout splits photosynthetic tasks between two distinct cell layers to minimize photorespiration.

Solution:
Step 1: Review the spatial separation of carbon fixation steps in a typical C_4 plant leaf, which features mesophyll cells and bundle sheath cells.
Step 2: Identify where atmospheric carbon dioxide (CO_2) enters the leaf interior. It passes into the cytoplasmic space of outer mesophyll cells.
Step 3: Name the primary carbon acceptor in these outer cells: phosphoenolpyruvate (PEP). The fixation reaction is catalyzed by the enzyme PEP carboxylase (PEPCase).
Step 4: This enzymatic step fixes CO_2 into a four-carbon organic acid, which is then transported inward to the bundle sheath cells for decarboxylation.
Step 5: Thus, the initial carbon fixation step mediated by PEP carboxylase occurs exclusively within the mesophyll cells.

Final Answer: $\boxed{\text{Mesophyll cells}}$

Answer: (B)

Go Back to Question 23

Q24.

Solution

Concept:
Secondary metabolites are specialized chemical compounds synthesized by plants that are not directly involved in basic growth or reproduction. Instead, they serve ecological roles, such as chemical defense against herbivores and pathogens.

Solution:
Step 1: Classify the biochemical categories of the secondary metabolites listed in the options. Vinblastine is an anticancer alkaloid, while Codeine is an analgesic narcotic alkaloid.
Step 2: Curcumin is a phenolic compound derived from turmeric roots that exhibits anti-inflammatory properties.
Step 3: Examine Ricin, which is extracted from the seeds of the castor oil plant (*Ricinus communis*).
Step 4: Biochemically, Ricin is classified as a ribosome-inactivating protein and acts as an extremely potent natural cellular toxin.
Step 5: Because of its severe toxic properties, Ricin is categorized as a toxin secondary metabolite used for defense.
Final Answer: $\boxed{\text{Ricin}}$

Answer: (B)

Go Back to Question 24

Q25.

Solution

Concept:
The Renin-Angiotensin-Aldosterone System (RAAS) helps regulate systemic blood pressure and blood volume. Specialized baroreceptor cells located within the afferent arterioles of the renal cortex monitor perfusion pressures to initiate this hormonal cascade.

Solution:
Step 1: Identify the role of the juxtaglomerular (JG) cells in the kidney. They act as specialized sensors tracking blood pressure and sodium levels.
Step 2: When systemic blood pressure or glomerular filtration pressure drops, these juxtaglomerular cells detect the change and respond.
Step 3: In response, the JG cells secrete an enzymatic hormone called Renin directly into the bloodstream.
Step 4: Renin acts biochemically to cleave plasma angiotensinogen into angiotensin I, initiating the vasoconstrictive RAAS cascade.
Step 5: Review the options to verify that Renin is the specific molecule secreted by juxtaglomerular cells to trigger this pathway.
Final Answer: Renin

Answer: (C)

Go Back to Question 25

Q26.

Solution

Concept:
Bisexual flowers use outbreeding adaptations to prevent self-pollination and promote cross-pollination. These mechanisms include physical barriers, genetic incompatibility, or temporal separations during floral development.

Solution:
Step 1: Define the terminology in the options. Cleistogamy refers to flowers that never open, forcing self-pollination. Herkogamy involves physical structural barriers between anthers and stigmas.
Step 2: Self-incompatibility is a genetic mechanism that prevents pollen germination on the stigma of the same flower based on allelic patterns.
Step 3: Analyze Dichogamy, which describes a temporal separation where male and female reproductive structures mature at different times within the same flower.
Step 4: Dichogamy is divided into protandry (anthers mature first) and protogyny (stigma matures first), ensuring that pollen release and stigma receptivity are asynchronous.
Step 5: Thus, dichogamy is the specific adaptation that prevents self-pollination through asynchronous maturation.
Final Answer: $\boxed{\text{Dichogamy}}$

Answer: (B)

Go Back to Question 26

Q27.

Solution

Concept:
The fluid mosaic model describes plasma membranes as dynamic structures where lipids and proteins are arranged in a fluid bilayer. The physical properties of the hydrophobic lipid core determine the mobility of integrated macromolecules within the membrane plane.

Solution:
Step 1: Consider the structural description proposed by Singer and Nicolson. The membrane acts as a quasi-fluid matrix where components can move dynamically.
Step 2: The lateral movement of embedded integral and peripheral proteins within the lipid bilayer depends directly on this quasi-fluid characteristic.
Step 3: This specific physiological property, reflecting the freedom of movement within the lipid matrix, is termed fluidity.
Step 4: Fluidity is essential for cell growth, formation of intercellular junctions, endocytosis, and cell division.
Step 5: Therefore, the lateral movement of proteins within the membrane is a direct measure of its membrane fluidity.
Final Answer: $\boxed{\text{Fluidity}}$

Answer: (C)

Go Back to Question 27

Q28.

Solution

Concept:

Plant evolutionary lineages show a distinct shift in the dominance of life cycle phases. Over evolutionary time, the conspicuous phase shifts from a dominant haploid gametophyte to a dominant diploid sporophyte.

Solution:

Step 1: Analyze Pteridophytes, Gymnosperms, and Angiosperms. In these groups, the independent, dominant phase is the diploid sporophyte, while the gametophyte is reduced.

Step 2: Examine Bryophytes (mosses and liverworts). Their life cycle is characterized by an alternation of generations where the phases are structurally unequal.

Step 3: In Bryophytes, the dominant, long-lived, and photosynthetic phase is the haploid gametophyte, which forms the main plant body.

Step 4: The diploid sporophyte in Bryophytes is physically smaller, short-lived, and remains attached to and nutritionally dependent on the underlying gametophyte.

Step 5: Thus, Bryophytes are the plant group matching the description of a dominant gametophyte and a dependent sporophyte.

Final Answer: $\boxed{\text{Bryophytes}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 28

Q29.

Solution

Concept:
Nerve impulse propagation relies on rapid alterations in electrochemical potential across the axonal plasma membrane. These shifts are mediated by the opening and closing of gated ion channels in response to stimulation.

Solution:
Step 1: Consider the resting state of an axon membrane, which is polarized with a negative charge inside relative to the outside. This state is maintained by leaky channels and the Na^+/K^+ pump.
Step 2: When an adequate stimulus reaches the membrane, voltage-gated sodium channels open rapidly.
Step 3: Because sodium ions are in much higher concentration outside the cell, they rush into the intracellular fluid down their electrochemical gradient.
Step 4: This rapid influx of positively charged Na^+ ions neutralizes and reverses the internal electrical charge, making the interior positive. This phase is called depolarization.
Step 5: Conclude that the rapid influx of Na^+ ions into the intracellular fluid is the primary ionic movement driving depolarization.

Final Answer: $\boxed{\text{Rapid influx of Na}^+ \text{ ions into the intracellular fluid}}$

$\boxed{\textbf{Answer: (A)}}$

Go Back to Question 29

Q30.

Solution

Concept:
Human genetic disorders display distinct inheritance patterns depending on whether the mutant gene is located on an autosome or a sex chromosome, and whether the allele acts in a dominant or recessive manner.

Solution:
Step 1: Evaluate the inheritance mechanisms of the genetic disorders listed in the options. Phenylketonuria is an autosomal recessive metabolic disorder.
Step 2: Sickle-cell anemia and Cystic fibrosis are also well-characterized autosomal recessive conditions, requiring two copies of the mutant allele to manifest the disease phenotype.
Step 3: Examine Myotonic dystrophy. It is a muscular disorder characterized by progressive muscle wasting and weakness.
Step 4: Genetic analysis shows that Myotonic dystrophy is caused by a triplet repeat expansion mutation that acts in an autosomal dominant manner.
Step 5: This means inheriting a single copy of the mutant allele on an autosome is sufficient to express the disorder, identifying it as autosomal dominant.

Final Answer: $\boxed{\text{Myotonic dystrophy}}$

Answer: (C)

Go Back to Question 30

Q31.

Solution

Concept:
Skeletal muscle contraction requires excitation-contraction coupling to translate an electrical action potential into mechanical force. This process relies on internal cellular storage compartments that regulate calcium ion availability in the sarcoplasm.

Solution:
Step 1: Trace a neural impulse as it arrives at the neuromuscular junction, depolarizing the sarcolemma and propagating down into the muscle fiber via the T-tubules.
Step 2: Identify the intracellular organelle that physically interfaces with the T-tubules and acts as a specialized calcium storage reservoir.
Step 3: This modified smooth endoplasmic reticulum network in muscle cells is called the sarcoplasmic reticulum.
Step 4: The depolarization wave triggers the opening of voltage-gated calcium release channels in the sarcoplasmic reticulum membranes, allowing calcium ions (Ca^{2+}) to flood the sarcoplasm.
Step 5: These released calcium ions then bind to troponin to initiate cross-bridge cycling. Thus, the sarcoplasmic reticulum is the functional calcium reservoir.

Final Answer: Sarcoplasmic reticulum

Answer: (C)

Go Back to Question 31

Q32.

Solution

Concept:
Pollen grains possess a multi-layered cell wall (sporoderm) designed to protect male gametophytes during transport. The outer layer exhibits high chemical resistance, shielding the genetic material from harsh environmental conditions.

Solution:
Step 1: Analyze the structural components of the pollen wall, which consists of an inner layer called the intine and an outer layer called the exine.
Step 2: The intine is composed of cellulose and pectin, which does not provide exceptional resistance to chemical degradation.
Step 3: Examine the chemical composition of the exine layer. It is composed of a complex fatty acid derivative polymer known as Sporopollenin.
Step 4: Sporopollenin is one of the most chemically inert organic materials known, resisting high temperatures, strong acids, alkaline environments, and enzymatic breakdown.
Step 5: This extreme durability allows pollen grains to survive for long periods and remain well-preserved as fossils, identifying Sporopollenin as the correct component.
Final Answer: $\boxed{\text{Sporopollenin}}$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 32

Q33.

Solution

Concept:
Quantitative base ratios in double-stranded genomic segments follow stoichiometric relationships based on complementary hydrogen bonding rules between purines and pyrimidines.

Solution:
Step 1: Note the total number of nucleotides in the double-stranded DNA segment, which is 400.
Step 2: Apply Chargaff's base-pairing rules where Thymine (T) equals Adenine (A). Given that $T = 60$, it follows that $A = 60$.
Step 3: Calculate the total number of nucleotides accounted for by Adenine and Thymine base pairs:

$$A + T = 60 + 60 = 120 \text{ nucleotides}$$

Step 4: Subtract this value from the total nucleotide count to determine the remaining number of bases allocated to Guanine (G) and Cytosine (C):

$$G + C = 400 - 120 = 280 \text{ nucleotides}$$

Step 5: Since Cytosine pairs with Guanine in a 1:1 ratio ($G = C$), divide the remaining pool by 2: $280/2 = 140$. Thus, there are 140 cytosine bases.
Final Answer: $\boxed{140}$

Answer: (B)

Go Back to Question 33

Q34.

Solution

Concept:

Clinical gene therapy requires efficient molecular vehicles to deliver functional corrective genes into patient target cells. The vector must be optimized to infect mammalian host tissues and stably integrate therapeutic DNA without causing disease.

Solution:

Step 1: Evaluate the host ranges of the vector options listed. The pBR322 plasmid and lambda bacteriophage are used as vectors within bacterial hosts like *E. coli*.

Step 2: The Ti plasmid isolated from *Agrobacterium tumefaciens* is a specialized gene transfer vector optimized for plant cells, not animal tissues.

Step 3: Analyze Retroviruses. These viruses naturally infect mammalian cells and possess a lifecycle that integrates their genetic material directly into the host genome.

Step 4: Disarmed retroviruses can be engineered to carry functional human genes, making them highly effective vectors for delivering therapeutic DNA into human cells during ex vivo procedures.

Step 5: Therefore, Retroviruses are the preferred choice for clinical mammalian gene delivery applications.

Final Answer: $\boxed{\text{Retrovirus}}$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 34

Q35.

Solution

Concept:

Plant cell expansion relies on mechanical forces driven by osmotic relationships. Solute accumulation within internal cellular compartments drops water potential, drawing moisture across semi-permeable membranes to generate outward physical forces.

Solution:

Step 1: Analyze how a growing plant cell increases in volume. It actively pumps ions and organic solutes into its large central vacuole.

Step 2: This accumulation of solutes significantly lowers the osmotic potential (Ψ_s) inside the vacuole relative to the surrounding cytoplasm.

Step 3: In response to this concentration gradient, water moves osmotically across the tonoplast membrane into the vacuole.

Step 4: This influx of water generates a high internal hydrostatic pressure, known as turgor pressure (Ψ_p), which pushes the cytoplasm outward against the cell wall.

Step 5: This turgor pressure provides the mechanical force needed to stretch the cell wall, identifying high turgor pressure as the primary driver of expansion.

Final Answer: $\boxed{\text{High turgor pressure created by osmotic water entry}}$

$\boxed{\textbf{Answer: (A)}}$

Go Back to Question 35

Q36.

Solution

Concept:
Plant ground tissue contains permanent cell types adapted for specific structural, metabolic, and storage functions. Certain cell types remain unspecialized and retain metabolic plasticity, allowing them to de-differentiate and resume cell division when triggered.

Solution:
Step 1: Review the permanent plant tissues listed. Sclerenchyma consists of dead cells with highly lignified secondary walls that provide rigid mechanical support.
Step 2: Collenchyma consists of living cells with localized pectin thickenings at their corners, serving as flexible support tissue in growing regions.
Step 3: Analyze Parenchyma tissue. It forms the major ground tissue component across various plant organs, including the cortex, pith, and mesophyll.
Step 4: Parenchyma cells are living, possess thin primary cell walls made of cellulose, and remain metabolically active with the potential to de-differentiate.
Step 5: This metabolic plasticity allows parenchyma cells to resume mitotic division during secondary growth or wound-healing processes, identifying them as the correct tissue type.

Final Answer: $\boxed{\text{Parenchyma}}$

Answer: (C)

Go Back to Question 36

Q37.

Solution

Concept:
The cardiac cycle produces distinct acoustic sounds created by structural valve movements within heart chambers. These sounds mark key physiological phases, preventing backflow as pressure gradients shift between the atria, ventricles, and major vessels.

Solution:
Step 1: Identify the two primary heart sounds, described phonetically as "lub" and "dub". Each corresponds to the closure of specific valve sets.
Step 2: Recall the first heart sound ("lub"). It is caused by the sudden closure of the atrioventricular (tricuspid and mitral) valves at the start of ventricular systole.
Step 3: Analyze the second heart sound ("dub"). This sound occurs at the beginning of ventricular diastole as ventricular pressures drop below arterial pressures.
Step 4: This pressure reversal causes blood to flow back toward the ventricles, catching and abruptly closing the pocket-like semilunar valves in the aorta and pulmonary trunk.
Step 5: Thus, the second heart sound is produced by the closure of the semilunar valves at the onset of ventricular diastole.

Final Answer: Semilunar valves close at the beginning of ventricular diastole.

Answer: (B)

Go Back to Question 37

Q38.

Solution

Concept:
Immunoglobulin distribution across body fluids depends on structural specializations that enable protection against pathogens. Maternal secretions provide critical passive immunity to protect newborns while their adaptive immune systems develop.

Solution:
Step 1: Analyze the functional roles of the antibody classes listed. IgG crosses the placenta, IgE mediates allergic reactions, and IgM is the primary early response antibody.
Step 2: Examine the composition of colostrum, the initial yellowish fluid secreted by mammary glands during the first few days after parturition.
Step 3: Colostrum contains high concentrations of secretory immunoglobulins designed to protect the infant's gastrointestinal tract.
Step 4: The predominant antibody class in colostrum is Immunoglobulin A (IgA), which exists as a dimer stabilized by a secretory component to resist enzymatic cleavage.
Step 5: This high concentration of IgA provides critical local mucosal immunity, identifying it as the most abundant antibody class in colostrum.

Final Answer: $\boxed{\text{IgA}}$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 38

Q39.

Solution

Concept:

The lac operon model illustrates transcriptional regulation in prokaryotes through allosteric control mechanisms. Regulatory proteins toggle transcription states by changing conformation when binding to specific chemical signals.

Solution:

Step 1: Identify the roles of the key components in the operon. The regulatory gene synthesizes a repressor protein that naturally binds tightly to the operator locus.

Step 2: When the repressor is bound to the operator, it physically blocks RNA polymerase from moving forward, preventing transcription of the structural genes.

Step 3: Analyze the entry of an inducer molecule, such as allolactose or lactose, into the intracellular environment.

Step 4: The inducer binds directly to an allosteric site on the repressor protein, causing a conformational change that reduces its affinity for DNA.

Step 5: This change causes the repressor to release from the operator locus, clearing the path for RNA polymerase to transcribe the operon.

Final Answer: The repressor undergoes a conformational change and releases from the operator.

Answer: (B)

Go Back to Question 39

Q40.

Solution

Concept:
Biological nitrogen fixation converts inert atmospheric dinitrogen gas into bioavailable forms. This process is driven by specialized metalloprotein complexes found in specific prokaryotic microbes, which require anaerobic conditions to function.

Solution:
Step 1: Review the biochemical conversion of atmospheric nitrogen gas (N_2) into ammonia (NH_3). This reaction involves breaking a highly stable covalent triple bond.
Step 2: Identify the enzyme complex that catalyzes this reduction reaction: Nitrogenase.
Step 3: Analyze the properties of the nitrogenase enzyme. It is a multi-subunit complex containing iron and molybdenum cofactors.
Step 4: Nitrogenase is highly sensitive to molecular oxygen, which irreversibly denatures its iron-protein components, requiring protected anaerobic environments to function.
Step 5: Thus, Nitrogenase is the specific oxygen-sensitive enzyme responsible for catalyzing biological nitrogen fixation.
Final Answer: $\boxed{\text{Nitrogenase}}$

$\boxed{\textbf{Answer: (C)}}$
Go Back to Question 40

Q41.

Solution

Concept:
Industrial biotechnology uses metabolic pathways in microbes to synthesize target commercial products. Industrial fermentation processes optimize these microbial pathways to convert organic substrates into high-yield products under controlled environmental conditions.

Solution:
Step 1: Evaluate the industrial products listed. Citric acid is produced via aerobic fermentation using the filamentous fungus *Aspergillus niger*.
Step 2: Cyclosporin A is an immunosuppressive agent synthesized by the fungus *Trichoderma polysporum*, and statins are produced by the yeast *Monascus purpureus*.
Step 3: Examine the metabolic properties of Brewer's yeast, *Saccharomyces cerevisiae*.
Step 4: Under anaerobic conditions, this yeast strain switches to ethanol fermentation, breaking down hexose sugars into ethyl alcohol (C_2H_5OH) and carbon dioxide (CO_2).
Step 5: This classic fermentation pathway is widely used across the beverage and biofuel industries, identifying ethanol as the correct product.
Final Answer: $\boxed{\text{Ethanol}}$

$\boxed{\textbf{Answer: (C)}}$
Go Back to Question 41

Q42.

Solution

Concept:

The primary plant cell wall is a complex extracellular matrix designed to provide structural support while accommodating cell growth. It must withstand high internal osmotic pressures, acting as a physical constraint against mechanical stress.

Solution:

Step 1: Analyze the chemical composition of the primary cell wall matrix, which includes cellulose microfibrils, hemicellulose, and pectin networks.

Step 2: Evaluate the properties of Suberin and Callose. Suberin is a waterproofing lipid polymer found in bark, and Callose acts as a specialized sealing carbohydrate.

Step 3: Examine Cellulose, a linear polymer of β-1,4-linked D-glucose units. These chains assemble via extensive hydrogen bonding into rigid structures called microfibrils.

Step 4: These crystalline microfibrils possess high tensile strength, forming the primary structural framework that prevents the cell from bursting under high turgor pressure.

Step 5: Thus, Cellulose is the primary cell wall component responsible for providing this structural resistance.

Final Answer: $\boxed{\text{Cellulose}}$

Answer: (B)

Go Back to Question 42

Q43.

Solution

Concept:

Eukaryotic cilia and flagella share a conserved internal structural core known as the axoneme. This motile structure is built from a precise geometric arrangement of microtubule polymers, driven by dynein motor proteins to generate movement.

Solution:

Step 1: Examine the cross-sectional ultrastructure of a eukaryotic motile flagellum under an electron microscope.

Step 2: Observe the outer ring of the axoneme, which consists of nine distinct pairs of fused microtubules arranged symmetrically around the periphery. These are called peripheral doublets.

Step 3: Observe the center of the axoneme core, which contains a single pair of unfused microtubules, referred to as the central singlets.

Step 4: This structural arrangement of microtubules is described as the classic 9 + 2 doublet pattern.

Step 5: Contrast this with the non-motile basal body or centriole core, which exhibits a 9 + 0 triplet pattern. Thus, the eukaryotic flagellum axoneme uses the 9 + 2 arrangement.

Final Answer: $\boxed{\text{9 + 2 doublet pattern}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 43

Q44.

Solution

Concept:
The epithelial lining of human seminiferous tubules contains germinal cells interspaced with somatic supporting structures. These supporting cells regulate the local biochemical environment, guiding germ cells through spermatogenesis.

Solution:
Step 1: Differentiate between the functions of the cell types located inside the male testes. Leydig cells reside in the interstitial spaces and secrete androgenic hormones like testosterone.
Step 2: Spermatogonia act as stem cells that undergo mitotic and meiotic divisions to produce haploid spermatid cells.
Step 3: Examine Sertoli cells, which are elongated somatic cells that span the width of the seminiferous tubule epithelium.
Step 4: Developing spermatids embed their heads into Sertoli cells, which provide mechanical support, protection, and essential nutrients throughout development.
Step 5: Because of these supporting functions, Sertoli cells are known as nurse cells, making option B the correct answer.

Final Answer: $\boxed{\text{Sertoli cells}}$

$\boxed{\textbf{Answer: (B)}}$

Go Back to Question 44

Q45.

Solution

Concept:

Amino acids are classified based on the chemical properties of their variable side chains (R-groups). At physiological pH (around 7.4), the ionization states of these side chains determine the overall charge of the amino acid molecule.

Solution:

Step 1: Analyze the side-chain structures of the given options. Alanine and Valine possess hydrophobic, non-polar aliphatic hydrocarbon side chains that carry no net charge.

Step 2: Glutamic acid possesses a carboxylic acid functional group in its side chain, which deprotonates at physiological pH to carry a net negative charge, making it acidic.

Step 3: Examine Lysine. Its variable side chain terminates in an amino group ($-NH_2$).

Step 4: At physiological pH, this amino side-chain group accepts a proton to form an ammonium ion ($-NH_3^+$), giving the molecule a net positive charge.

Step 5: Therefore, Lysine is classified as a basic amino acid that carries a net positive charge under physiological conditions.

Final Answer: $\boxed{\text{Lysine}}$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 45

Q46.

Solution

Concept:

Airborne particulate matter (PM) presents serious risks to environmental and human health. The physiological hazard of these suspended particles depends on their size, which determines how deeply they can penetrate human respiratory passages.

Solution:

Step 1: Consider the guidelines established by environmental protection agencies like the Central Pollution Control Board (CPCB) regarding air quality metrics.

Step 2: Large particulate matter is trapped by mucus and cilia in the nasal cavity and upper respiratory tract, limiting deep systemic exposure.

Step 3: Analyze fine particulate matter, specifically particles with an aerodynamic diameter of 2.5 micrometers or less ($PM_{2.5}$).

Step 4: Because of their small size, these particles bypass upper respiratory defenses and travel deep into the lungs, reaching the alveolar spaces.

Step 5: Once in the alveoli, $PM_{2.5}$ particles can cause inflammation, tissue damage, or enter the bloodstream, making 2.5 micrometers or less the most dangerous size class.

Final Answer: $\boxed{\text{2.5 or less}}$

Answer: (C)

Go Back to Question 46

Q47.

Solution

Concept:

The five-kingdom classification system organizes organisms based on criteria such as cellular complexity, structural organization, and primary modes of nutrition. Each kingdom is defined by a unique combination of these biological traits.

Solution:

Step 1: Evaluate the defining characteristics of the kingdoms. Monera consists of unicellular prokaryotic organisms, while Fungi features heterotrophic organisms with chitinous cell walls.

Step 2: Kingdom Plantae includes multicellular, autotrophic organisms with cellulosic cell walls optimized for photoautotrophic nutrition.

Step 3: Analyze Kingdom Animalia. Organisms in this group are multicellular eukaryotes that lack structural cell walls around their cells.

Step 4: Animals exhibit a heterotrophic mode of nutrition, specifically holozoic nutrition, meaning they ingest organic matter and digest it internally.

Step 5: This combination of traits—multicellularity, heterotrophy, absence of a cell wall, and holozoic ingestion—definitively defines Kingdom Animalia.

Final Answer: $\boxed{\text{Animalia}}$

$\boxed{\textbf{Answer: (D)}}$

Go Back to Question 47

Q48.

Solution

Concept:
Animal phyla are differentiated based on fundamental body plans, tissue layering, and the nature of internal body cavities. Structural developments in these body cavity types mark key evolutionary milestones between worm-like phyla.

Solution:
Step 1: Compare the morphological traits of Platyhelminthes and Aschelminthes. Both phyla exhibit bilateral symmetry and triploblastic germ layer organization.
Step 2: Platyhelminthes (flatworms) are acoelomate, meaning they lack any internal body cavity, and their mesodermal layer forms a solid tissue mass.
Step 3: Examine Aschelminthes (roundworms). They possess an internal fluid-filled body cavity situated between the gut and the outer body wall.
Step 4: This cavity is not completely lined by mesoderm; instead, the mesoderm is scattered as isolated pouches within the blastocoel space, defining a pseudocoelom.
Step 5: The presence of this pseudocoelom is the primary morphological feature distinguishing roundworms from flatworms.

Final Answer: $\boxed{\text{Presence of a pseudocoelom}}$

$\boxed{\textbf{Answer: (C)}}$

Go Back to Question 48

Q49.

Solution

Concept:
Biodiversity conservation strategies are classified based on whether threatened organisms are protected within their native environments or moved to managed facilities. Both approaches are essential for preventing species extinction.

Solution:
Step 1: Analyze *in situ* conservation methods. These strategies protect threatened species within their natural habitats by managing ecosystems, as seen in national parks, wildlife sanctuaries, and biosphere reserves.
Step 2: Analyze alternative strategies where human intervention moves endangered populations away from natural threats.
Step 3: This approach involves transferring threatened plants or animals to artificial, human-managed environments.
Step 4: Examples include botanical gardens, zoological parks, wildlife safari sanctuaries, gene banks, and cryopreservation repositories.
Step 5: This mode of preservation outside the natural habitat is formally defined as *ex situ* conservation.
Final Answer: Ex situ conservation

Answer: (B)

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Q50.

Solution

Concept:

Peptide hormones are often synthesized as larger, inactive prohormones that undergo post-translational modifications. Proteolytic cleavage removes structural segments from the precursor chain, folding the remaining peptides into a functional hormone configuration.

Solution:

Step 1: Examine the structure of human pro-insulin synthesized by pancreatic beta cells. It consists of a single polypeptide chain containing three distinct domains: the A-chain, the B-chain, and the C-peptide.

Step 2: In the prohormone state, the C-peptide acts as a structural link connecting the A and B domains to ensure correct folding and alignment.

Step 3: Analyze the subsequent maturation process inside secretory vesicles. Specialized endopeptidases recognize and cleave the precursor molecule.

Step 4: These enzymes excise the intermediate C-peptide chain entirely, leaving the A and B chains linked together by functional disulfide bridges.

Step 5: The excised C-peptide is co-secreted with mature insulin but plays no role in hormone activity, confirming that the C-peptide is the segment removed during processing.

Final Answer: $\boxed{\text{C-peptide}}$

Answer: (C)

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Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	D	2	B	3	B	4	A	5	C
6	B	7	B	8	B	9	C	10	C
11	C	12	C	13	B	14	B	15	A
16	C	17	B	18	B	19	C	20	C
21	B	22	C	23	B	24	B	25	C
26	B	27	C	28	B	29	A	30	C
31	C	32	C	33	B	34	C	35	A
36	C	37	B	38	C	39	B	40	C
41	C	42	B	43	B	44	B	45	C
46	C	47	D	48	C	49	B	50	C