

UPCATET Biology Sample Paper-10

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. In the electron transport chain of mitochondria, the proton gradient established across the inner membrane is primarily utilized to synthesize ATP through which mechanism?

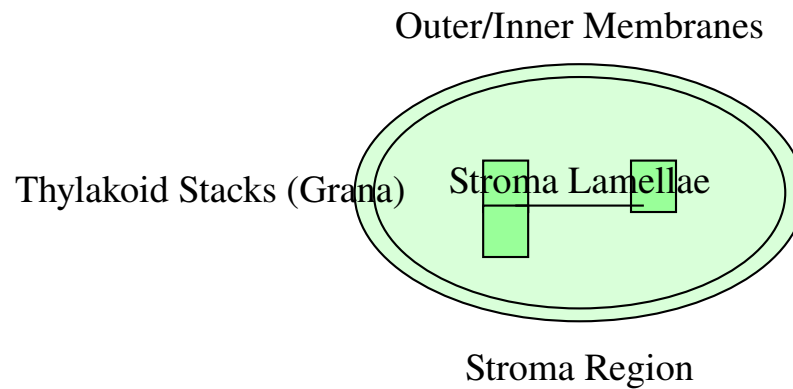
- (A) Substrate-level phosphorylation coupled to NADH oxidation
- (B) Chemiosmotic coupling via ATP synthase rotating mechanism
- (C) Direct electron transfer to ADP molecules
- (D) Phosphate group migration along the membrane

Q2. A cross-section of a monocot stem reveals scattered vascular bundles with closed arrangement, lacking any intrafascicular cambium tissue. Which of the following family characteristics does this represent?

- (A) Dicotyledonous plants with eustele vascular pattern
- (B) Monocotyledonous plants with atactostele vascular pattern
- (C) Gymnosperm plants with plectostele arrangement
- (D) Pteridophytes with protostele configuration

Q3. Refer to the diagram below representing a specialized plant cell organelle involved in photosynthetic light reactions:





Where specifically do the light-independent Calvin cycle reactions proceed in this structure?

- (A) Within the thylakoid lumen accumulating protons
 - (B) In the stroma fluid-filled matrix space
 - (C) Embedded within the inner membrane bilayer
 - (D) Localized to the grana stacking regions only
- Q4.** During the human neural transmission process, after an action potential depolarizes a presynaptic neuron terminal, which specific ion flux drives the exocytosis of neurotransmitter-containing synaptic vesicles?
- (A) Rapid efflux of sodium ions along the synapse
 - (B) Influx of potassium ions opening voltage-gated channels
 - (C) Massive inward movement of calcium ions through channels
 - (D) Outflow of chloride ions establishing electrical gradients
- Q5.** The photosynthetic C₄ pathway represents an evolutionary adaptation reducing photorespiratory losses in hot, arid climates. The initial carboxylation enzyme capturing atmospheric CO₂ in mesophyll cells is:
- (A) RuBisCO (Ribulose-1,5-bisphosphate carboxylase)
 - (B) PEP Carboxylase (Phosphoenolpyruvate carboxylase)
 - (C) Pyruvate dehydrogenase complex
 - (D) Malic dehydrogenase enzyme



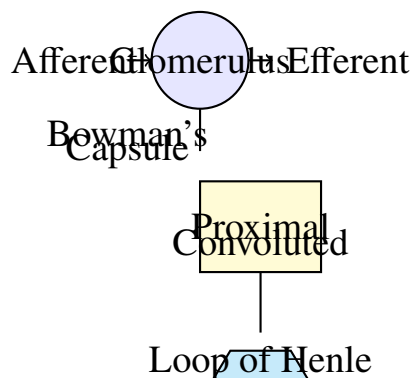
- Q6.** In human reproduction, the hormone responsible for initiating the final maturation division of the secondary oocyte and triggering ovulation from the Graafian follicle is:
- (A) Follicle-stimulating hormone from anterior pituitary
 - (B) Luteinizing hormone surge from anterior pituitary
 - (C) Estrogen peak from growing follicle cells
 - (D) Progesterone release from corpus luteum
- Q7.** Which of the following best defines ecological carrying capacity of an environment?
- (A) Maximum population size sustainable indefinitely without resource depletion
 - (B) Minimum population required for successful reproduction
 - (C) Initial exponential growth phase before limiting factors emerge
 - (D) Rate of energy transfer between trophic levels
- Q8.** A mutation in a gene coding for a mitochondrial membrane protein prevents proper coupling between the electron transport chain and ATP synthase. The primary consequence would be:
- (A) Excessive ATP production with no energy loss
 - (B) Dissipation of the proton gradient as heat without ATP synthesis
 - (C) Complete cessation of all cellular respiration
 - (D) Accumulation of electrons in the cristae membranes
- Q9.** During meiosis I, the physical connections between non-sister chromatids of homologous chromosomes that enable genetic exchange are called:
- (A) Tetrads aligned on the metaphase plate
 - (B) Chiasmata formed at crossing over points
 - (C) Spindle fibers organizing the division
 - (D) Kinetochore complexes binding centromeres



Q10. The structural differentiation between Type I and Type II alveolar cells reflects specialization for different respiratory functions. Type II pneumocytes are primarily responsible for:

- (A) Direct gas exchange with pulmonary capillaries
- (B) Synthesis and secretion of pulmonary surfactant
- (C) Immune defense against inhaled pathogens
- (D) Mechanical filtration of inspired air

Q11. Refer to the diagram illustrating the structural organization of a human nephron functional unit:



The selective reabsorption of glucose, amino acids, and ions from the glomerular filtrate occurs primarily in which nephron segment?

- (A) Bowman's capsule chamber
- (B) Proximal convoluted tubule cells
- (C) Loop of Henle descending limb
- (D) Collecting duct final segment

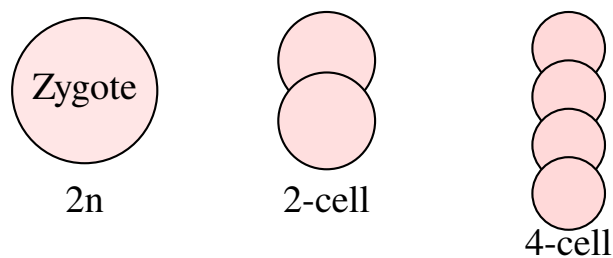
Q12. In plant cell walls, the cross-linking between parallel cellulose microfibrils is strengthened by hydrogen bonds to which hemicelluloses component?

- (A) Pectin polymers in the middle lamella
- (B) Lignin compounds providing structural rigidity
- (C) Xyloglucan branched polysaccharides
- (D) Chitin-like N-acetyl derivatives



- Q13.** A diploid organism ($2n=8$) undergoes abnormal meiosis where both homologous pairs fail to separate during Meiosis I. The resulting gamete would contain which chromosome number?
- (A) 4 chromosomes (normal haploid)
 - (B) 8 chromosomes (unreduced diploid)
 - (C) 2 chromosomes (nullisomic)
 - (D) 6 chromosomes (aneuploid variant)
- Q14.** The process by which a virus injects its genetic material into a host cell while leaving its protective coat outside is termed:
- (A) Latency during lysogenic integration
 - (B) Penetration through the cell membrane
 - (C) Uncoating the nucleic acid core
 - (D) Budding with envelope acquisition
- Q15.** In the immune system, which T-lymphocyte subtype directly kills infected or abnormal cells by releasing cytotoxic granules?
- (A) Helper T cells (CD4+) coordinating immune responses
 - (B) Regulatory T cells (Treg) suppressing inflammation
 - (C) Cytotoxic T lymphocytes (CD8+) eliminating threats
 - (D) Memory T cells sustaining long-term immunity
- Q16.** During the process of bacterial DNA replication, the enzyme synthesizing the leading strand continuously in the 5' to 3' direction is:
- (A) DNA Polymerase III synthesizing continuously
 - (B) Primase laying initial RNA primer sequences
 - (C) DNA Polymerase I removing RNA primers
 - (D) DNA Ligase joining Okazaki fragments
- Q17.** Refer to the diagram representing the stages of embryonic cell cleavage:





During early embryonic cleavage divisions, which property distinguishes these mitotic events from typical somatic cell divisions?

- (A) Reduction in chromosome number with each division
- (B) Lack of growth phase (G1/G2) between divisions
- (C) Production of non-identical daughter cells
- (D) Cytokinesis failure resulting in multinucleate cells

Q18. In photosynthesis, the quantum yield refers to the number of CO₂ molecules fixed per light photon absorbed. The theoretical maximum quantum yield value for oxygenic photosynthesis is approximately:

- (A) 1 CO₂ per 4 photons absorbed
- (B) 1 CO₂ per 8 photons absorbed
- (C) 1 CO₂ per 2 photons absorbed
- (D) 1 CO₂ per 16 photons absorbed

Q19. Which plant family is characterized by the presence of tetradynamous stamens (four long and two short), a cruciform corolla, and siliqua or silicula fruit types?

- (A) Brassicaceae (Cruciferae family)
- (B) Rosaceae with spiral arrangement
- (C) Fabaceae with papilionaceous structure
- (D) Apiaceae with umbel inflorescence

Q20. The enzyme complex in prokaryotic cells that unwinds the double-stranded DNA helix during replication, breaking hydrogen bonds between bases, is:

- (A) RNA Polymerase initiating transcription



- (B) Helicase unwinding the double helix
- (C) Topoisomerase relieving supercoiling tension
- (D) Single-stranded binding proteins stabilizing strands

Q21. In terrestrial ecosystems, the nutrient cycling process returning phosphorus from animal waste and dead organisms to soil is mediated primarily by:

- (A) Atmospheric deposition and rainfall
- (B) Decomposer organisms breaking down organic matter
- (C) Photosynthetic uptake by plant roots
- (D) Denitrifying bacteria in anaerobic zones

Q22. A genetic cross between two heterozygous tall pea plants ($Aa \times Aa$) yields offspring in a 3:1 phenotypic ratio, demonstrating which fundamental Mendelian principle?

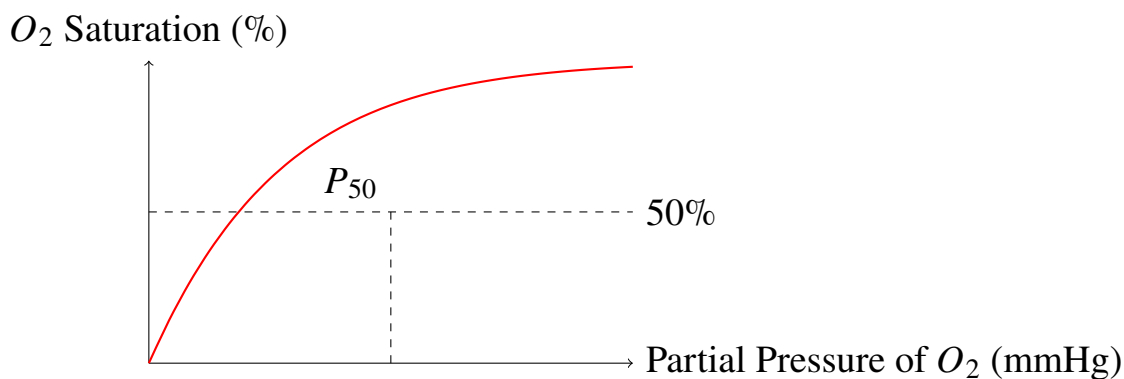
- (A) Law of segregation during gamete formation
- (B) Law of independent assortment of alleles
- (C) Principle of genetic linkage on same chromosome
- (D) Epistatic interaction masking dominant traits

Q23. The structural organization of chromatin into nucleosomes around histone octamers serves primarily to:

- (A) Increase the total length of DNA packable in nucleus
- (B) Regulate gene expression through epigenetic modifications
- (C) Provide scaffolding for spindle fiber attachment
- (D) Enable direct transcription of DNA sequences

Q24. Refer to the TikZ diagram illustrating oxygen dissociation from hemoglobin:





The S-shaped sigmoid curve illustrated represents cooperative binding of oxygen to hemoglobin. This phenomenon occurs because:

- (A) Each oxygen binding induces allosteric structural changes in the protein
- (B) Competitive inhibition prevents additional oxygen binding
- (C) Denaturation of hemoglobin increases oxygen affinity
- (D) Formation of hydrogen bonds reduces oxygen solubility

Q25. In the lac operon of bacteria, the repressor protein binds to the operator region primarily to:

- (A) Promote RNA polymerase transcription initiation
- (B) Block physical access of RNA polymerase to structural genes
- (C) Stabilize mRNA transcripts for translation
- (D) Facilitate ribosomal binding to mRNA

Q26. The polymerase chain reaction (PCR) technique amplifies specific DNA sequences through repeated cycles of denaturation, primer annealing, and extension. The heat-stable polymerase commonly used is isolated from:

- (A) *Bacillus subtilis* thermophilic bacteria
- (B) *Thermus aquaticus* hot spring thermophile
- (C) *Escherichia coli* standard laboratory strain
- (D) *Streptomyces* soil actinomycete

Q27. During primary succession on barren volcanic rock, pioneer lichens establish through a mutualistic relationship between fungi and:

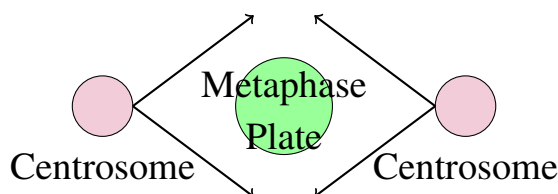


- (A) Photosynthetic algae or cyanobacteria partners
- (B) Heterotrophic decomposer bacteria
- (C) Mycorrhizal fungal networks
- (D) Root-nodule nitrogen-fixing rhizobia

Q28. In human skeletal muscle contraction, the binding of myosin heads to actin filaments is directly powered by energy from:

- (A) Hydrolysis of ATP molecules providing energy
- (B) Oxidation of glucose in mitochondria
- (C) Phosphorylation of actin protein chains
- (D) Direct transfer of electrons along the muscle fiber

Q29. Refer to the diagram illustrating mitotic spindle organization during metaphase:



The spindle checkpoint mechanism ensures proper chromosome segregation by detecting the presence of:

- (A) Unattached kinetochores on chromosomes
- (B) Excessive ATP depletion in the cell
- (C) Damaged telomere sequences on DNA
- (D) Accumulation of checkpoint proteins in nucleus

Q30. The secondary structure of proteins, including alpha-helices and beta-sheets, is stabilized primarily by:

- (A) Hydrogen bonds between carbonyl oxygen and amide hydrogen
- (B) Disulfide bridges between cysteine residues
- (C) Ionic interactions between charged amino acids



(D) Hydrophobic interactions with nonpolar side chains

Q31. In the human digestive system, which organ produces a hormone regulating blood glucose levels while also secreting digestive enzymes into the small intestine?

- (A) Stomach with gastric glands
- (B) Liver with hepatic portal vein
- (C) Pancreas with endocrine and exocrine functions
- (D) Gallbladder storing concentrated bile

Q32. The phenomenon of apoptosis represents programmed cell death triggering the activation of proteolytic caspase enzymes. This process is important for:

- (A) Tissue remodeling and elimination of damaged cells
- (B) Rapid protein synthesis during development
- (C) Increasing ATP production in mitochondria
- (D) Prevention of all cell division cycles

Q33. In plant hormones, abscisic acid (ABA) acts as a stress hormone primarily by:

- (A) Promoting cell elongation and internodal growth
- (B) Triggering stomatal closure during water stress
- (C) Inducing flowering and reproductive development
- (D) Accelerating fruit ripening and senescence

Q34. The Bohr effect describes how carbon dioxide and hydrogen ions influence hemoglobin's oxygen-binding affinity by:

- (A) Competing directly for iron coordination sites
- (B) Inducing conformational changes in subunit interactions
- (C) Dissolving in plasma and reducing oxygen availability
- (D) Forming stable carbaminohemoglobin complexes

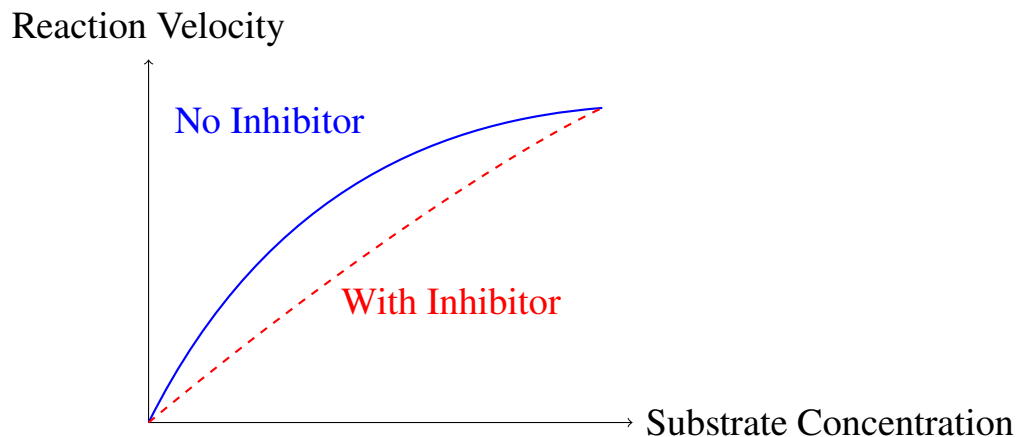


- Q35.** A severe mutation in the BRCA1 gene significantly increases susceptibility to which cancer types due to impaired DNA repair mechanisms?
- (A) Lung and liver cancers from environmental toxins
 - (B) Breast and ovarian cancers from unrepaired DNA damage
 - (C) Skin cancers from ultraviolet radiation exposure
 - (D) Leukemia from bone marrow mutations
- Q36.** During prophase I of meiosis, homologous chromosomes pair and form a protein-based structure called the:
- (A) Kinetochore attached to spindle fibers
 - (B) Synaptonemal complex mediating chromosome pairing
 - (C) Centrosome organizing microtubules
 - (D) Cleavage furrow dividing cytoplasm
- Q37.** The endoplasmic reticulum synthesizing proteins destined for secretion is termed rough ER because of the presence of:
- (A) Attached ribosome complexes engaged in translation
 - (B) Smooth surface allowing protein movement
 - (C) Crystallized protein aggregates
 - (D) Invaginations forming cisternal networks
- Q38.** In bacterial conjugation, genetic material is transferred from donor to recipient cells through a specialized hollow structure called the:
- (A) Flagellum for motility and attachment
 - (B) Pilus or sex pilus for DNA transfer
 - (C) Capsule providing protective coating
 - (D) Fimbria for surface adhesion
- Q39.** Which of the following represents an example of convergent evolution producing analogous structures in unrelated organisms?



- (A) Forelimbs of mammals and birds sharing common ancestor
- (B) Wings of insects and wings of birds with similar function
- (C) Spinal columns of vertebrates showing homology
- (D) Eyes of cephalopods and vertebrates both detecting light

Q40. Refer to the graph depicting enzyme kinetics without and with a competitive inhibitor:



In competitive inhibition, the Michaelis-Menten constant (K_m) changes because:

- (A) Maximum velocity decreases proportionally with inhibitor
 - (B) Higher substrate concentration is needed to achieve half-maximal velocity
 - (C) The inhibitor permanently denatures the enzyme
 - (D) Substrate concentration becomes independent of enzyme binding
- Q41.** In human blood composition, which formed element is anucleate and functions primarily in hemostasis through aggregation and clot formation?
- (A) Red blood cells (erythrocytes)
 - (B) White blood cells (leukocytes)
 - (C) Platelets (thrombocytes)
 - (D) Lymph fluid components
- Q42.** The phenomenon where different alleles of a gene show similar expression levels in heterozygotes, with no clear dominance, is termed:



- (A) Complete dominance with heterozygous phenotype
- (B) Codominance expressing both allelic phenotypes
- (C) Incomplete dominance showing intermediate phenotype
- (D) Epistasis masking one allele completely

Q43. During neural development, the primitive ectoderm undergoes neurulation to form the neural tube, which subsequently differentiates into:

- (A) Central nervous system (brain and spinal cord)
- (B) Peripheral nervous system (nerves and ganglia)
- (C) Skeletal muscles and bone tissues
- (D) Cardiovascular and respiratory systems

Q44. The Krebs cycle intermediate that replenishes cycle capacity when amino acids are catabolized is called an:

- (A) Allosteric enzyme regulating glucose metabolism
- (B) Anaplerotic reaction regenerating oxaloacetate
- (C) Anaerobic process in mitochondrial matrix
- (D) Allozyme variant of citric acid synthase

Q45. In mammalian female reproduction, the corpus luteum persists and continues secreting hormones when:

- (A) Menstruation begins due to progesterone withdrawal
- (B) Human chorionic gonadotropin from trophoblast maintains it
- (C) Follicle-stimulating hormone initiates follicle development
- (D) Ovulation has just occurred releasing the oocyte

Q46. The biogeographic realm concept divides Earth into major regions with distinctive evolutionary history and endemic species. Continental drift has separated which two ancient landmasses?

- (A) Gondwana separating Africa, South America, Australia



- (B) Laurasia uniting North America and Eurasia
- (C) Pangaea combining all continents
- (D) Tethys ocean between Africa and Europe

Q47. Which specific part of the renal corpuscle acts as the actual selective barrier for ultrafiltration, consisting of fenestrated endothelium and basement membrane?

- (A) Bowman's capsule parietal layer
- (B) Glomerular filtration barrier (endothelium, BM, podocytes)
- (C) Afferent arteriole smooth muscle layer
- (D) Proximal tubule brush border epithelium

Q48. In photosynthesis, non-cyclic photophosphorylation produces which two essential high-energy molecules?

- (A) ATP and NADPH from light reactions
- (B) Glucose and oxygen from dark reactions
- (C) Chlorophyll and carotenoid pigments
- (D) Water and carbon dioxide substrates

Q49. The modification of proteins by addition of bulky carbohydrate groups in the Golgi apparatus results in the formation of:

- (A) Lipoproteins with embedded lipid bilayers
- (B) Glycoproteins with covalently attached sugars
- (C) Phosphoproteins with phosphate modifications
- (D) Lipidated proteins with membrane anchors

Q50. A mutation causing a premature stop codon within a protein-coding gene results in:

- (A) Silent mutation with no phenotypic change
- (B) Missense mutation altering amino acid sequence



- (C) Frameshift mutation disrupting reading frame
- (D) Nonsense mutation producing truncated protein

- Q51.** In ecological succession, secondary succession on abandoned farmland proceeds more rapidly than primary succession on barren rock because:
- (A) Soil microorganisms and nutrients are already present
 - (B) Climate conditions are more favorable year-round
 - (C) Vegetation height increases more quickly
 - (D) Water retention capacity is minimized
- Q52.** The structural integrity of the DNA double helix is maintained by hydrogen bonding between complementary base pairs and:
- (A) Hydrophobic interactions between nonpolar bases
 - (B) Base stacking interactions between adjacent bases
 - (C) Ionic bonds between phosphate groups
 - (D) Disulfide bridges between sugar molecules
- Q53.** In the human endocrine system, the hypothalamus synthesizes hormones that travel via the hypothalamic-hypophyseal portal blood system to the:
- (A) Anterior pituitary controlling hormone secretion
 - (B) Thyroid gland regulating metabolism
 - (C) Adrenal medulla releasing catecholamines
 - (D) Parathyroid glands managing calcium
- Q54.** The process of tumor metastasis involves cancer cells acquiring the ability to:
- (A) Undergo apoptosis when exposed to immune cells
 - (B) Detach from original tissue and invade distant sites
 - (C) Decrease mutation accumulation in daughter cells
 - (D) Remain responsive to normal growth inhibition signals



- Q55.** In the carbon cycle, decomposer organisms return carbon dioxide to the atmosphere through:
- (A) Photosynthesis converting CO₂ into organic matter
 - (B) Cellular respiration oxidizing organic compounds
 - (C) Combustion of fossil fuels from petroleum deposits
 - (D) Volcanic eruptions releasing geothermal carbon
- Q56.** The symbiotic relationship between flowering plants and their pollinating insects demonstrates which ecological interaction type?
- (A) Parasitism with plant as parasite
 - (B) Mutualism with mutual benefit
 - (C) Commensalism with insect benefiting only
 - (D) Amensalism with plant inhibiting insect
- Q57.** During translation, the initiator tRNA carrying formyl-methionine recognizes which codon on the mRNA template?
- (A) UUA leucine codon on 5' end
 - (B) AUG methionine start codon
 - (C) AUA isoleucine alternative codon
 - (D) AAA lysine stop codon sequence
- Q58.** The enzyme RuBisCO catalyzes the initial carbon fixation step in the Calvin cycle by carboxylating:
- (A) Phosphoenolpyruvate into oxaloacetate
 - (B) Ribulose-1,5-bisphosphate into 3-phosphoglycerate
 - (C) Glyceraldehyde-3-phosphate into glucose
 - (D) Acetyl-CoA into citric acid
- Q59.** In the human immune system, B lymphocytes differentiate into plasma cells that directly synthesize:



- (A) Cytokines and interleukins activating other cells
- (B) Antibodies (immunoglobulins) specific for antigens
- (C) Complement proteins lysing pathogens
- (D) Histamine molecules triggering allergic responses

Q60. The condition where a person possesses an abnormal number of sex chromosomes (XXY) results in:

- (A) Turner's syndrome from X0 genotype
- (B) Klinefelter's syndrome with male phenotype
- (C) Triple-X syndrome from XXX genotype
- (D) Down's syndrome from trisomy 21

Q61. In plant tissue culture, the ratio of auxin to cytokinin hormones determines whether explants develop:

- (A) Only roots when cytokinin exceeds auxin
- (B) Only shoots when auxin exceeds cytokinin
- (C) Undifferentiated callus tissue at intermediate ratios
- (D) Flowers when both hormone levels are equal

Q62. The enzyme phosphofructokinase-1 (PFK-1) is the primary control point of glycolysis because it catalyzes:

- (A) Glucose phosphorylation to glucose-6-phosphate
- (B) The first committed step unique to glycolysis
- (C) NAD⁺ reduction generating NADH
- (D) Pyruvate oxidation entering the Krebs cycle

Q63. In vertebrate development, the three primary germ layers (ectoderm, mesoderm, endoderm) are established during:

- (A) Blastula stage with simple cell aggregation



- (B) Gastrulation involving massive cell movements
- (C) Organogenesis forming specialized organs
- (D) Neurulation initiating nervous system development

Q64. The phenomenon of genetic imprinting involves epigenetic silencing of one allele based on:

- (A) Random X-chromosome inactivation in females
- (B) Parental origin determining allele expression
- (C) Environmental factors during development
- (D) Codon usage preference in DNA sequence

Q65. In the human respiratory system, the vital capacity represents the maximum volume of air that can be:

- (A) Normally exchanged during quiet breathing
- (B) Forcefully expelled after maximum inspiration
- (C) Always retained in the lungs (residual volume)
- (D) Rapidly inhaled during intense exercise

Q66. The blood group system determined by A and B alleles and a recessive i allele demonstrates:

- (A) Simple Mendelian dominance with two phenotypes
- (B) Codominance of A and B with four phenotypes
- (C) Incomplete dominance producing intermediate types
- (D) Epistasis where one gene masks another

Q67. During mitochondrial oxidative phosphorylation, the energy coupling between electron transport and ATP synthesis is mediated by:

- (A) Direct phosphorylation of ADP by electron carriers
- (B) Chemiosmotic mechanism with proton gradient



- (C) Substrate-level phosphorylation in the matrix
- (D) Direct transfer of high-energy electrons to ATP

- Q68.** The process where tumor cells evade the immune system by expressing reduced levels of major histocompatibility complex (MHC) molecules is called:
- (A) Immune tolerance through self-antigen recognition
 - (B) Immune evasion reducing detection by T cells
 - (C) Immune memory from previous exposure
 - (D) Immune amplification through cytokine cascades
- Q69.** In plant reproduction, the male gametophyte (pollen grain) consists of a generative cell and a:
- (A) Synergid cell supporting ovule development
 - (B) Vegetative cell (tube cell) directing pollen tube growth
 - (C) Polar nucleus in the central cell
 - (D) Megaspore mother cell initiating meiosis
- Q70.** The Haber-Bosch process industrially fixes atmospheric nitrogen into ammonia using high pressure, temperature, and a:
- (A) Iron catalyst enhancing nitrogen fixation
 - (B) Enzymatic nitrogenase complex from bacteria
 - (C) Ultraviolet light breaking N₂ triple bond
 - (D) Organic solvent facilitating ammonia synthesis
- Q71.** In population genetics, the Hardy-Weinberg equilibrium predicts constant allele frequencies when populations are:
- (A) Large with random mating and no mutations
 - (B) Small with genetic drift operating strongly
 - (C) Undergoing directional natural selection



(D) Experiencing intense environmental pressure

Q72. The phenomenon where an allele reduces fitness in heterozygotes but increases fitness in homozygotes is called:

- (A) Overdominance favoring heterozygotes
- (B) Underdominance against heterozygotes
- (C) Incomplete dominance showing intermediate phenotype
- (D) Epistasis with one gene masking another

Q73. In the synaptic transmission process, the reuptake of neurotransmitter molecules from the synaptic cleft is mediated by:

- (A) Vesicular monoamine transporters recycling molecules
- (B) Enzymatic degradation by monoamine oxidase
- (C) Diffusion into surrounding cerebrospinal fluid
- (D) Binding to postsynaptic receptor proteins

Q74. The phototropic response of plants bending toward light involves unequal distribution of auxin causing:

- (A) Rapid elongation on the light-exposed side
- (B) Greater elongation on the shaded side
- (C) Uniform growth across all sides equally
- (D) Reduction in cell turgor pressure throughout

Q75. In cellular respiration, the P/O ratio refers to:

- (A) Moles of ATP produced per mole oxygen consumed
- (B) Probability of electron transport occurring
- (C) Proportion of energy captured as ATP
- (D) Partial pressure of oxygen in mitochondria



- Q76.** The enzyme telomerase lengthens telomeres by synthesizing repetitive sequences using:
- (A) DNA template from telomere sequences
 - (B) RNA template within its protein structure
 - (C) Free nucleotides without template direction
 - (D) Reverse transcriptase enzyme activity
- Q77.** In viral replication, the lytic cycle results in:
- (A) Viral DNA integration into host chromosome
 - (B) Host cell rupture releasing new viral particles
 - (C) Latent infection remaining dormant indefinitely
 - (D) Chronic persistent infection of tissue
- Q78.** The mycorrhizal association between fungal hyphae and plant roots facilitates:
- (A) Decomposition of dead organic matter
 - (B) Nutrient absorption especially phosphorus uptake
 - (C) Nitrogen fixation in root nodules
 - (D) Symbiotic nitrogen reduction
- Q79.** In signal transduction pathways, protein kinases phosphorylate target proteins to:
- (A) Reduce their enzymatic activity and function
 - (B) Alter conformations enabling signal amplification
 - (C) Prevent their interaction with other proteins
 - (D) Facilitate their degradation and turnover
- Q80.** The phenomenon of character displacement occurs when competing species in sympatry exhibit:
- (A) Increased similarity of traits reducing competition



- (B) Divergent character evolution avoiding competition
- (C) Similar ecological niche utilization patterns
- (D) Geographic isolation preventing gene flow



Detailed Solutions**Q1.****Solution**

Concept: The electron transport chain functions as the central energy conversion system in eukaryotic cells. As electrons move through a series of protein complexes, their energy is captured to pump protons across the inner mitochondrial membrane, creating an electrochemical gradient essential for ATP synthesis.

Solution:

- (a) In the electron transport chain, electrons move through Complexes I, III, and IV, with their energy used to pump H⁺ ions across the inner membrane.
- (b) This proton pumping establishes a concentration gradient across the membrane, making the matrix region more alkaline than the intermembrane space.
- (c) Rather than directly transferring energy to ADP, this gradient creates a chemiosmotic potential that drives ATP synthase.
- (d) ATP synthase is a rotary enzyme where the proton gradient pushes protons through the enzyme, causing it to rotate and catalyze the phosphorylation of ADP to ATP.
- (e) This elegant mechanism is called chemiosmotic coupling, coupling the electron transport chain to ATP production through the proton gradient rather than direct chemical transfer.

Final Answer: Chemiosmotic coupling via ATP synthase rotating mechanism

Answer: (B)

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Q2.

Solution

Concept: Plant tissue organization reflects the fundamental differences between monocot and dicot structure. The arrangement and connectivity of vascular bundles, combined with the presence or absence of cambium tissue, provides a reliable diagnostic feature for plant classification.

Solution:

- (a) Monocot stems display scattered vascular bundles distributed throughout the stem cross-section in a pattern called atactostele.
- (b) These bundles are closed, meaning they lack an intrafascicular cambium between the xylem and phloem tissues.
- (c) The absence of cambium prevents secondary growth, explaining why monocots typically maintain their original stem diameter throughout life.
- (d) In contrast, dicot stems have a ring-like arrangement of bundles (eustele) with open bundles containing cambium, allowing secondary thickening.
- (e) The monocot structure described in the question is therefore characteristic of the monocotyledonous plants with atactostele vascular patterns.

Final Answer: Monocotyledonous plants with atactostele vascular pattern

Answer: (B)

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Q3.

Solution

Concept: Chloroplast structure partitions photosynthesis into two distinct spatial regions. The light-dependent reactions occur on thylakoid membranes, while the light-independent fixation and reduction reactions occur in the surrounding aqueous matrix, allowing regulatory separation of these metabolic phases.

Solution:

- (a) The chloroplast stroma is the fluid-filled region surrounding the thylakoid stacks, containing soluble enzymes and substrates.
- (b) The Calvin cycle (dark reactions) requires no light energy directly but depends on ATP and NADPH produced by the light reactions.
- (c) The initial carboxylation step catalyzed by RuBisCO, the reduction phase generating G3P, and the regeneration of RuBP all occur in the stroma.
- (d) The thylakoid lumen functions to accumulate protons during water photolysis, not to house Calvin cycle enzymes.
- (e) Therefore, the stroma matrix is the exclusive location where the light-independent fixation of carbon dioxide occurs.

Final Answer: In the stroma fluid-filled matrix space

Answer: (B)

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Q4.

Solution

Concept: Synaptic transmission requires calcium ions as the critical second messenger triggering vesicle fusion. The depolarization wave arriving at the presynaptic terminal opens voltage-gated calcium channels, allowing a massive influx that cascades through the cell to mobilize neurotransmitters.

Solution:

- (a) When an action potential reaches the presynaptic terminal, the depolarization opens voltage-gated calcium channels in the plasma membrane.
- (b) Calcium concentration is much higher in the extracellular space than inside the neuron, creating a strong gradient that drives Ca^{2+} influx.
- (c) Entering calcium binds to protein complexes associated with synaptic vesicles, triggering conformational changes that promote membrane fusion.
- (d) This process, called SNARE-mediated exocytosis, requires calcium as the direct trigger for vesicle exocytosis.
- (e) Without calcium influx, neurotransmitter release cannot occur, preventing synaptic transmission regardless of depolarization status.

Final Answer: Massive inward movement of calcium ions through channels

Answer: (C)

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Q5.

Solution

Concept: The C₄ photosynthetic pathway evolved as an adaptation to high-temperature, high-light environments where photorespiration causes significant carbon loss. The pathway utilizes a specialized enzyme and anatomical organization to concentrate CO₂ and suppress wasteful oxygen reactions.

Solution:

- (a) In C₄ plants, the first step of carbon fixation in mesophyll cells uses the enzyme phosphoenolpyruvate carboxylase (PEP carboxylase).
- (b) This enzyme carboxylates phosphoenolpyruvate (PEP), a three-carbon molecule, to form oxaloacetate (a four-carbon compound).
- (c) This initial reaction is different from RuBisCO's Calvin cycle reaction, allowing C₄ plants to capture CO₂ even when RuBP carboxylase cannot.
- (d) The oxaloacetate is rapidly converted to malate and transported to bundle sheath cells, where CO₂ is released and fed into the normal Calvin cycle.
- (e) This anatomical and biochemical separation allows C₄ plants to maintain high internal CO₂ concentrations near RuBisCO, reducing photorespiration losses.

Final Answer: PEP Carboxylase (Phosphoenolpyruvate carboxylase)

Answer: (B)

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Q6.

Solution

Concept: Female meiosis is precisely regulated by hormonal signals from the pituitary gland. A surge in luteinizing hormone (LH) provides the stimulus that triggers the final maturation division and release of the secondary oocyte from the ovary.

Solution:

- (a) During the menstrual cycle, follicle-stimulating hormone (FSH) initially stimulates follicle growth and estrogen production.
- (b) Rising estrogen levels eventually trigger a positive feedback surge of luteinizing hormone from the anterior pituitary.
- (c) This LH surge directly stimulates the final maturation meiotic division of the primary oocyte, converting it to a secondary oocyte.
- (d) Simultaneously, the LH surge weakens the follicle wall, allowing the mature oocyte to be expelled from the ovary in the process of ovulation.
- (e) Without the LH surge, ovulation cannot occur, demonstrating this hormone's essential role in completing meiosis I and releasing the mature gamete.

Final Answer: Luteinizing hormone surge from anterior pituitary

Answer: (B)

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Q7.

Solution

Concept: Ecological carrying capacity represents the maximum population size that an environment can sustain indefinitely with its available resources. This concept is fundamental to understanding population dynamics, resource limitations, and sustainable use of ecosystems.

Solution:

- (a) Carrying capacity (K) is reached when birth rates equal death rates, resulting in a stable, non-growing population.
- (b) At this equilibrium point, available resources (food, water, space) are fully utilized but not exceeded, preventing population crash.
- (c) If population exceeds carrying capacity, resource depletion leads to increased death rate and population decline back toward K.
- (d) If population falls below K, abundant resources allow faster reproduction, increasing population until it returns to K.
- (e) This dynamic stability defines carrying capacity as the maximum sustainable population size for an environment.

Final Answer: Maximum population size sustainable indefinitely without resource depletion

Answer: (A)

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Q8.

Solution

Concept: The electron transport chain generates energy by transferring electrons through a series of protein complexes while simultaneously pumping protons across the inner mitochondrial membrane. This energy is normally captured efficiently by ATP synthase.

Solution:

- (a) In normal conditions, the proton gradient generated by electron transport drives ATP synthase, allowing efficient ATP synthesis.
- (b) However, if the coupling between electron transport and proton pumping is disrupted, electrons continue to flow through the chain.
- (c) Without ATP synthase to convert the proton gradient into ATP, the accumulated potential energy is released as heat in the membrane.
- (d) This energy dissipation as heat, without ATP synthesis, is called uncoupling of oxidative phosphorylation.
- (e) The result is continued electron transport and oxygen consumption, but minimal ATP production and maximal heat generation.

Final Answer: Dissipation of the proton gradient as heat without ATP synthesis

Answer: (B)

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Q9.

Solution

Concept: Homologous chromosome pairing during meiosis I enables the physical exchange of genetic material through crossing over. The visible structures where this exchange occurs are the junction points between non-sister chromatids.

Solution:

- (a) During prophase I, homologous chromosomes pair to form bivalents through a process called synapsis.
- (b) Each chromosome consists of two sister chromatids, so a bivalent contains four chromatids total.
- (c) Non-sister chromatids from the two homologous chromosomes can physically cross over and exchange genetic segments.
- (d) The physical attachment points where crossing over occurs are visible under microscopy as X-shaped structures called chiasmata.
- (e) These chiasmata represent the sites of recombination and serve as the physical evidence of genetic exchange between homologs.

Final Answer: Chiasmata formed at crossing over points

Answer: (B)

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Q10.

Solution

Concept: The alveolar epithelium consists of two functionally distinct cell types. While Type I cells handle gas exchange, Type II cells perform a specialized secretory function essential for maintaining lung mechanics.

Solution:

- (a) Type I pneumocytes cover approximately 95% of the alveolar surface and have extremely thin cytoplasm optimized for gas diffusion.
- (b) Type II pneumocytes, though covering only 5% of the surface, are large cuboidal cells packed with mitochondria for active secretion.
- (c) Type II cells synthesize and secrete pulmonary surfactant, a mixture of lipids and proteins essential for reducing surface tension.
- (d) Without surfactant, the high surface tension would cause alveolar collapse during expiration, making lung re-expansion extremely difficult.
- (e) Type II cells continuously produce and release surfactant to maintain optimal lung compliance and prevent atelectasis.

Final Answer:

Answer: (B)

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Q11.

Solution

Concept: The nephron demonstrates a functional division of labor where different segments specialize in specific aspects of urine formation. The proximal tubule, immediately following Bowman's capsule, performs extensive selective reabsorption of valuable substances.

Solution:

- (a) Bowman's capsule produces the initial filtrate containing all small molecular weight substances, both useful and waste.
- (b) The proximal convoluted tubule epithelium is lined with numerous mitochondria and a brush border, features indicating high metabolic activity.
- (c) This segment actively transports glucose, amino acids, ions, and other useful substances back into the blood through the peritubular capillaries.
- (d) The loop of Henle focuses on water and salt balance but lacks glucose transporters, indicating reabsorption already occurred upstream.
- (e) The collecting duct is the final site of water reabsorption, controlled by ADH, but doesn't reabsorb glucose or amino acids.

Final Answer: Proximal convoluted tubule cells

Answer: (B)

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Q12.

Solution

Concept: Plant cell wall architecture involves multiple polysaccharide components working synergistically. While cellulose forms the primary structural framework, other polymers cross-link and reinforce the cellulose network.

Solution:

- (a) Cellulose forms rigid crystalline microfibrils that constitute the primary load-bearing structure of plant cell walls.
- (b) These microfibrils are strengthened by cross-linking with other polysaccharides, particularly hemicelluloses.
- (c) Xyloglucan is a major hemicellulose in dicot and non-graminaceous plant cell walls, forming hydrogen bonds with cellulose.
- (d) These bonds cross-link adjacent cellulose microfibrils, creating an integrated network that increases wall strength and rigidity.
- (e) Pectin provides elasticity and is concentrated in the middle lamella, while lignin adds additional rigidity in woody tissues.

Final Answer: Xyloglucan branched polysaccharides

Answer: (B)

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Q13.

Solution

Concept: Meiotic nondisjunction represents a catastrophic error in chromosome segregation where homologous pairs fail to separate. The consequences are dramatic changes in chromosome number in resulting gametes.

Solution:

- (a) Normal meiosis I separates homologous chromosome pairs, so each gamete receives one chromosome from each pair.
- (b) With $2n=8$, normal gametes contain $n=4$ chromosomes (unreduced haploid).
- (c) If nondisjunction occurs in Meiosis I and both homologous pairs fail to separate, both go to one daughter cell.
- (d) That daughter cell receives all 8 chromosomes ($2n$), while the other receives 0.
- (e) The gamete produced from the cell receiving 8 chromosomes is therefore unreduced ($2n=8$), carrying a diploid set.

Final Answer: 8 chromosomes (unreduced diploid)

Answer: (B)

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Q14.

Solution

Concept: Viral replication depends on successful entry into host cells. The penetration phase involves the virus breaking through or merging with the host cell membrane to inject its genetic material.

Solution:

- (a) After an enveloped virus binds to host cell surface receptors through its glycoproteins, the viral envelope fuses with the host membrane.
- (b) For non-enveloped viruses, the protein capsule creates a pore or initiates endocytosis to allow entry.
- (c) The penetration phase refers specifically to the process of breaking through or fusing with the cellular membranes.
- (d) This is distinct from entry (attachment plus penetration) and subsequent uncoating (removal of the protective coat).
- (e) Successful penetration deposits the viral genome inside the host cell cytoplasm or nucleus, ready for replication.

Final Answer: Penetration through the cell membrane

Answer: (B)

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Q15.

Solution

Concept: The adaptive immune system contains specialized cell types with distinct effector functions. T lymphocytes differentiate into various subtypes, each with specific roles in immune defense.

Solution:

- (a) Helper T cells (CD4+) coordinate immune responses through cytokine production, activating both T cells and B cells.
- (b) Regulatory T cells suppress inflammatory responses to prevent autoimmunity and excessive tissue damage.
- (c) Cytotoxic T lymphocytes (CTLs, CD8+) recognize infected cells presenting viral peptides on MHC class I molecules.
- (d) CTLs kill compromised cells through release of cytotoxic granules containing perforin and granzymes that induce target cell apoptosis.
- (e) This cytotoxic function is essential for eliminating viral infections and tumor cells from the body.

Final Answer: Cytotoxic T lymphocytes (CD8+) eliminating threats

Answer: (C)

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Q16.

Solution

Concept: DNA replication requires multiple specialized enzymes with distinct functions. The DNA polymerases are classified by their specific roles in synthesizing the leading and lagging strands during replication.

Solution:

- (a) The leading strand template is read 3' to 5', allowing continuous 5' to 3' synthesis in the direction of fork movement.
- (b) DNA Polymerase III performs the bulk of leading strand synthesis, synthesizing continuously without interruption.
- (c) On the lagging strand, the same polymerase works discontinuously, synthesizing short Okazaki fragments.
- (d) Primase periodically synthesizes RNA primers required to initiate each Okazaki fragment synthesis.
- (e) DNA Polymerase I removes RNA primers and fills the gaps between fragments.
- (f) DNA Ligase joins the Okazaki fragments, creating the continuous lagging strand.

Final Answer: DNA Polymerase III synthesizing continuously

Answer: (A)

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Q17.

Solution

Concept: Embryonic cell division immediately following fertilization differs profoundly from normal somatic cell mitosis. These rapid divisions prioritize chromosome distribution over cell growth, creating unique temporal characteristics.

Solution:

- (a) Normal cell divisions include interphase periods (G1, S, G2) where cells grow and accumulate resources between mitotic events.
- (b) In contrast, early embryonic cleavage divisions compress or eliminate these growth phases, consisting almost entirely of mitotic phases.
- (c) Cleavage divisions occur rapidly in succession without intervening growth periods, allowing the zygote to divide repeatedly without increasing total volume.
- (d) This rapid successive division without growth initially produces increasingly smaller cells (blastomeres) from the original zygote.
- (e) The absence of significant growth phases distinguishes cleavage divisions from typical somatic divisions.

Final Answer: Lack of growth phase (G1/G2) between divisions

Answer: (B)

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Q18.

Solution

Concept: Photosynthetic efficiency is constrained by the number of photons required to generate the energy carriers needed for carbon fixation. The quantum yield quantifies this photon requirement.

Solution:

- (a) During the light reactions, photosystem II absorbs photons and uses their energy to oxidize water, releasing electrons, protons, and oxygen.
- (b) These electrons flow through the electron transport chain while their energy pumps protons across the thylakoid membrane.
- (c) The proton gradient drives ATP synthase, but only a portion of the energy forms ATP; much is lost as heat.
- (d) Photosystem I also absorbs photons to reduce NADP^+ to NADPH, consuming additional energy.
- (e) The theoretical minimum to fix one molecule of CO_2 requires 4 photons absorbed in Photosystem II and 4 in Photosystem I.
- (f) Therefore, the maximum theoretical quantum yield is 1 CO_2 fixed per 8 photons absorbed.

Final Answer: 1 CO_2 per 8 photons absorbed

Answer: (B)

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Q19.

Solution

Concept: Plant family classification relies on diagnostic floral characteristics that are conserved across species. The Brassicaceae family possesses a distinctive combination of stamen and fruit features.

Solution:

- (a) The Brassicaceae (formerly Cruciferae) family is easily identified by its characteristic tetradynamous androecium.
- (b) This means six stamens arranged as four long stamens and two short stamens, a unique arrangement.
- (c) The corolla is cruciform (cross-shaped), with four petals arranged opposite each other in a cross pattern.
- (d) The fruit is either a siliqua (long, narrow pod) or silicula (short, wide pod), depending on the length-to-width ratio.
- (e) All Brassicaceae members, including cabbage, mustard, and radish, share this combination of features.

Final Answer: Brassicaceae (Cruciferae family)

Answer: (A)

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Q20.

Solution

Concept: DNA replication requires breaking the hydrogen bonds holding the double helix together. Specialized enzymes evolved to catalyze this energy-requiring process while maintaining genomic integrity.

Solution:

- (a) The DNA double helix is stabilized by base pairing hydrogen bonds that must be disrupted to allow replication fork movement.
- (b) RNA Polymerase is specific to transcription and does not participate in replication processes.
- (c) Helicase is the specialized enzyme that catalyzes the unwinding of the double helix by breaking hydrogen bonds between complementary bases.
- (d) As helicase moves along the DNA, it creates the replication fork where single-stranded templates become accessible to polymerases.
- (e) Topoisomerase relieves supercoiling tension created by helicase unwinding, while SSB proteins stabilize unwound strands.

Final Answer: Helicase unwinding the double helix

Answer: (B)

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Q21.

Solution

Concept: Nutrient cycling involves both biological and chemical processes that return essential elements from organisms back to the soil. Decomposition represents the critical step where nutrients locked in organic matter are released for reuse.

Solution:

- (a) Phosphorus is an essential nutrient found in nucleic acids, ATP, and phospholipids throughout living organisms.
- (b) Unlike nitrogen, which cycles through the atmosphere, phosphorus remains largely in the lithosphere and biota.
- (c) Dead organisms, waste products, and decaying organic matter contain phosphorus locked in organic compounds.
- (d) Decomposer organisms (bacteria, fungi) break down this organic matter, releasing phosphorus as phosphate ions.
- (e) These phosphate ions are absorbed by plant roots and enter the food chain again.
- (f) While some phosphorus may be leached into aquatic systems, the primary return pathway is through decomposition.

Final Answer: Decomposer organisms breaking down organic matter

Answer: (B)

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Q22.

Solution

Concept: Mendelian genetics revealed that traits segregate during gamete formation in predictable ratios. When heterozygotes are crossed, the alleles segregate equally, producing characteristic phenotypic distributions.

Solution:

- (a) In a monohybrid cross $Aa \times Aa$, gamete types are A and a from each parent.
- (b) During meiosis, the alleles segregate so that half of gametes carry A and half carry a, a principle called segregation.
- (c) Fertilization produces offspring: $1/4 AA$, $1/2 Aa$, $1/4 aa$.
- (d) With A being dominant to a, the phenotypic ratio becomes 3 dominant (AA and Aa) : 1 recessive (aa).
- (e) This 3:1 ratio directly demonstrates that alleles segregate during gamete formation and assort randomly during fertilization.

Final Answer: Law of segregation during gamete formation

Answer: (A)

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Q23.

Solution

Concept: Chromatin organization into nucleosomes provides a solution to a fundamental packing problem. The enormous length of DNA molecules must fit into a nucleus much smaller than the linear distance DNA would span.

Solution:

- (a) If human DNA were stretched linearly, it would extend over 2 meters from each cell, far exceeding the nucleus dimensions.
- (b) Histone octamers (8 histone proteins) act as spools around which DNA wraps approximately 1.65 times per nucleosome.
- (c) This nucleosome structure compresses DNA length by a factor of approximately 7, fitting more DNA into the nucleus.
- (d) Higher-order chromatin structure with histone H1 creates 30-nm fiber structures that provide additional compression.
- (e) Beyond simply compacting DNA, nucleosomes also regulate gene expression by controlling access to DNA regulatory regions.

Final Answer: Increase the total length of DNA packable in nucleus

Answer: (A)

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Q24.

Solution

Concept: Hemoglobin exhibits cooperative binding, where oxygen binding to one subunit enhances oxygen affinity of neighboring subunits. This allosteric effect produces the characteristic S-shaped binding curve.

Solution:

- (a) Hemoglobin is a quaternary protein with four subunits that communicate with each other through conformational changes.
- (b) When oxygen binds to one subunit, it induces structural rearrangement that increases oxygen affinity in the other subunits.
- (c) This positive cooperativity causes hemoglobin's binding curve to be sigmoid (S-shaped) rather than hyperbolic.
- (d) At low oxygen pressures, the first oxygen binds weakly, but subsequent oxygens bind progressively more tightly.
- (e) At high oxygen pressures, hemoglobin becomes nearly saturated, ready to release oxygen efficiently at tissue oxygen levels.
- (f) This cooperative mechanism allows hemoglobin to load oxygen efficiently at the lungs while unloading it effectively at tissues.

Final Answer: Each oxygen binding induces allosteric structural changes in the protein

Answer: (A)

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Q25.

Solution

Concept: Gene regulation in prokaryotes allows rapid responses to environmental changes. The lac operon demonstrates negative control where a repressor protein blocks transcription when lactose is unavailable.

Solution:

- (a) The lac repressor protein is synthesized continuously from the regulatory gene and diffuses to bind the operator.
- (b) The operator is the DNA sequence immediately downstream of the promoter where RNA polymerase must bind.
- (c) When the repressor protein binds to the operator, it creates a physical barrier preventing RNA polymerase from accessing the promoter region.
- (d) This blockage prevents transcription of the lac genes (lacZ, lacY, lacA), conserving cellular resources when lactose is not present.
- (e) In the absence of lactose, the repressor remains bound indefinitely, keeping the operon off through steric hindrance.

Final Answer: Block physical access of RNA polymerase to structural genes

Answer: (B)

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Q26.

Solution

Concept: PCR revolutionized molecular biology by enabling rapid in vitro DNA amplification. The success of this technique depends critically on using a polymerase that survives repeated heating cycles.

Solution:

- (a) PCR requires 25-35 cycles of heating to 95°C to denature DNA, cooling to 50-65°C for primer annealing, and heating to 72°C for synthesis.
- (b) Standard DNA polymerases like E. coli Pol I denature irreversibly at these high temperatures, becoming inactive.
- (c) Taq polymerase was isolated from *Thermus aquaticus*, a thermophilic bacterium living in hot springs at temperatures up to 70°C.
- (d) This enzyme evolved to function at high temperatures, remaining stable through repeated PCR heating cycles.
- (e) Other thermophilic sources like Pfu and Tli polymerases also have high thermostability, but Taq remains the most commonly used.

Final Answer: *Thermus aquaticus* hot spring thermophile

Answer: (B)

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Q27.



Solution

Concept: Pioneer organisms in primary succession must tolerate extreme environmental conditions while gradually modifying the habitat. Lichens represent the earliest colonizers of barren rock through a unique partnership.

Solution:

- (a) Lichens are composite organisms consisting of a fungal partner and a photosynthetic partner (algae or cyanobacteria).
- (b) The fungus provides physical structure and absorbs water and minerals, while the photosynthetic partner provides organic carbon.
- (c) This mutualistic relationship allows colonization of bare rock where neither partner could survive independently.
- (d) The photosynthetic component (usually Trebouxia algae or Nostoc cyanobacteria) captures solar energy and fixes carbon.
- (e) As lichens grow, they secrete organic acids that chemically weather the rock, creating the foundation for soil formation.

Final Answer: Photosynthetic algae or cyanobacteria partners

Answer: (A)

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Q28.

Solution

Concept: Muscle contraction is powered by the hydrolysis of ATP molecules. The energy from ATP hydrolysis provides the force for myosin cross-bridge movement along actin filaments.

Solution:

- (a) Myosin heads bind to actin filaments forming cross-bridges that can pull the thin filaments toward the sarcomere center.
- (b) This pulling action requires energy from ATP hydrolysis, which is catalyzed by the myosin ATPase domain.
- (c) Each myosin head binds ATP and releases the actin, allowing the head to recock into a high-energy position.
- (d) ATP hydrolysis provides the energy for the power stroke that pulls the actin filament, generating the force of contraction.
- (e) Without ATP, myosin heads remain rigidly bound to actin (as seen in rigor mortis), and contraction cannot occur.

Final Answer: Hydrolysis of ATP molecules providing energy

Answer: (A)

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Q29.

Solution

Concept: Cell cycle checkpoints ensure proper progression through mitosis by verifying that preceding events completed successfully. The spindle checkpoint specifically monitors chromosome alignment before segregation.

Solution:

- (a) The spindle checkpoint (also called the mitotic checkpoint) monitors whether all chromosomes are properly attached to the mitotic spindle.
- (b) This checkpoint occurs during metaphase, before the anaphase separation of sister chromatids.
- (c) If any chromosome remains unattached to spindle fibers or not aligned at the metaphase plate, the checkpoint is activated.
- (d) Unattached kinetochores trigger the release of checkpoint inhibitor proteins, preventing the activation of anaphase-promoting complex.
- (e) Only when all kinetochores are properly attached to spindle fibers and chromosomes are aligned does the checkpoint release, allowing anaphase progression.

Final Answer: Unattached kinetochores on chromosomes

Answer: (A)

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Q30.

Solution

Concept: Protein structure is hierarchically organized, with secondary structures formed through regular, repeating interactions between backbone atoms. These structures are stabilized by hydrogen bonding.

Solution:

- (a) Alpha-helices are stabilized by hydrogen bonds between the carbonyl oxygen of one amino acid and the amide hydrogen of the amino acid four residues ahead.
- (b) Beta-sheets involve hydrogen bonds between adjacent polypeptide strands, with the carbonyl oxygen of one residue bonding to the amide hydrogen of another.
- (c) In both cases, the hydrogen bonds form specifically between the backbone atoms (carbonyl and amide groups) rather than side chains.
- (d) Disulfide bridges occur only in cysteine residues and are covalent bonds, not hydrogen bonds.
- (e) Ionic and hydrophobic interactions contribute to tertiary structure, not secondary structure formation.

Final Answer: Hydrogen bonds between carbonyl oxygen and amide hydrogen

Answer: (A)

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Q31.

Solution

Concept: The pancreas is unique in possessing both endocrine and exocrine functions. This organ is essential for both blood glucose regulation and nutrient digestion.

Solution:

- (a) The pancreas contains islets of Langerhans (endocrine tissue) producing insulin and glucagon that regulate blood glucose.
- (b) The same pancreas also contains acinar cells (exocrine tissue) that synthesize and secrete digestive enzymes.
- (c) These pancreatic enzymes (amylase, lipase, proteases) are released via a duct directly into the small intestine.
- (d) No other listed organ combines both endocrine hormone production and digestive enzyme secretion.
- (e) The stomach secretes gastric juices but not hormones, the liver stores bile but doesn't produce digestive enzymes in the same sense, and the gallbladder only stores bile.

Final Answer: Pancreas with endocrine and exocrine functions

Answer: (C)

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Q32.

Solution

Concept: Apoptosis represents programmed cell death that serves essential physiological functions. Rather than causing inflammation through necrotic rupture, apoptosis disposes of cells cleanly and efficiently.

Solution:

- (a) Apoptosis involves activation of caspase enzymes that cleave specific protein substrates within the cell.
- (b) These proteases systematically dismantle the cell structure, condensing chromatin, fragmenting DNA, and forming apoptotic bodies.
- (c) Apoptotic bodies are easily engulfed by neighboring cells without triggering inflammatory responses.
- (d) This programmed cell death is essential for tissue remodeling during development, eliminating dangerous cells like those infected by viruses.
- (e) Apoptosis also removes cells that have accumulated excessive DNA damage that might lead to cancer.

Final Answer: Tissue remodeling and elimination of damaged cells

Answer: (A)

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Q33.

Solution

Concept: Plant hormones are chemical messengers that coordinate responses to environmental stresses. Different hormones mediate different stress responses, with one hormone being particularly associated with drought.

Solution:

- (a) Abscisic acid (ABA) accumulates in plant tissues when water becomes limiting, acting as the primary stress hormone.
- (b) When roots sense water stress (water potential drop), ABA synthesis increases dramatically in root tissue.
- (c) ABA travels through the xylem to leaves where it triggers stomatal closure by promoting potassium efflux from guard cells.
- (d) Stomatal closure prevents water loss through transpiration, conserving available water during drought conditions.
- (e) ABA also induces seed dormancy and growth inhibition under stress, preventing development under unfavorable conditions.

Final Answer: Triggering stomatal closure during water stress

Answer: (B)

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Q34.

Solution

Concept: Oxygen and carbon dioxide both influence hemoglobin's oxygen-binding affinity, but through different mechanisms. The Bohr effect describes how CO₂ and pH alter hemoglobin conformation.

Solution:

- (a) Carbon dioxide is produced by metabolically active tissues and diffuses into red blood cells where it combines with water.
- (b) Carbonic acid formed from CO₂ dissociates to produce protons and bicarbonate ions.
- (c) These protons lower blood pH, and the decreased pH reduces hemoglobin's affinity for oxygen.
- (d) This is an allosteric effect: protons and CO₂ don't compete for the oxygen binding site but instead bind to other sites.
- (e) When hemoglobin carries oxygen to tissues producing CO₂, the presence of CO₂ facilitates oxygen release at precisely where it's needed.

Final Answer: Inducing conformational changes in subunit interactions

Answer: (B)

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Q35.

Solution

Concept: DNA repair mechanisms are essential for genomic stability. Mutations in genes encoding DNA repair proteins dramatically increase cancer risk through accumulation of additional mutations.

Solution:

- (a) BRCA1 encodes a protein involved in homologous recombination repair, fixing double-strand DNA breaks.
- (b) When BRCA1 is mutated, cells cannot efficiently repair DNA damage from endogenous sources and environmental exposures.
- (c) Accumulated mutations in breast and ovarian tissues lead to much higher cancer risk in BRCA1 carriers.
- (d) In contrast, lung cancer primarily results from carcinogen exposure, skin cancer from UV exposure, and leukemia from bone marrow mutations.
- (e) BRCA1 mutations specifically predispose to hormone-responsive tissues (breast, ovary), explaining the tissue specificity.

Final Answer: Breast and ovarian cancers from unrepaired DNA damage

Answer: (B)

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Q36.

Solution

Concept: Homologous chromosome pairing during meiosis I requires precise alignment and physical contact. A specialized protein framework organizes this pairing.

Solution:

- (a) During prophase I, homologous chromosomes locate and align with each other, a process called synapsis.
- (b) This pairing is mediated by the synaptonemal complex, a protein scaffold that forms between the homologous chromosomes.
- (c) The synaptonemal complex maintains precise alignment and facilitates crossing over between non-sister chromatids.
- (d) At the end of prophase I, the synaptonemal complex dissolves, but chiasmata remain visible where crossing over occurred.
- (e) The kinetochore is the attachment site for spindle fibers and is present at both Meiosis I and II.

Final Answer: Synaptonemal complex mediating chromosome pairing

Answer: (B)

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Q37.

Solution

Concept: The endoplasmic reticulum is visually heterogeneous under electron microscopy due to its different functions. Areas engaged in protein synthesis appear structurally distinct.

Solution:

- (a) Ribosomes are macromolecular complexes composed of rRNA and proteins that catalyze protein synthesis.
- (b) When ribosomes actively translate mRNA, they remain physically attached to the endoplasmic reticulum membrane.
- (c) These attached ribosomes create a rough, beaded appearance when viewed under electron microscopy, hence "rough ER."
- (d) Proteins synthesized on rough ER are destined for secretion, membrane insertion, or encapsulation in vesicles.
- (e) In contrast, smooth ER lacks ribosomes and appears smooth under the electron microscope, specializing in lipid synthesis and metabolism.

Final Answer: Attached ribosome complexes engaged in translation

Answer: (A)

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Q38.

Solution

Concept: Bacterial conjugation involves direct transfer of genetic material between cells through a specialized structure. This horizontal gene transfer can spread beneficial genes rapidly through populations.

Solution:

- (a) Bacterial conjugation requires direct physical contact between donor and recipient cells.
- (b) The F (fertility) factor plasmid in donor cells encodes genes for pilus synthesis and DNA transfer functions.
- (c) The pilus (plural: pili) is a hollow, tube-like protein structure that extends from the donor cell toward the recipient.
- (d) Through the pilus, a single strand of the plasmid DNA is transferred to the recipient cell, which then replicates both strands.
- (e) Unlike fimbriae which mediate surface adhesion or flagella which provide motility, the pilus specifically functions in DNA transfer.

Final Answer: Pilus or sex pilus for DNA transfer

Answer: (B)

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Q39.

Solution

Concept: Convergent evolution demonstrates that similar selection pressures can produce similar solutions in unrelated organisms. These analogous structures are functionally similar but structurally and evolutionarily distinct.

Solution:

- (a) Homologous structures share common evolutionary origin, indicating shared ancestry (e.g., forelimbs of mammals and birds).
- (b) Analogous structures perform similar functions but evolved independently in unrelated organisms.
- (c) The wings of insects and the wings of birds are classic examples of convergent evolution.
- (d) Insect wings evolved from extensions of exoskeleton that develop separately from flight muscles.
- (e) Bird wings represent modified forelimbs with feathers and specific skeletal organization.
- (f) Despite functional similarity for flight, their structural origins are completely different, demonstrating convergent evolution.

Final Answer: Wings of insects and wings of birds with similar function

Answer: (B)

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Q40.

Solution

Concept: Competitive inhibition occurs when an inhibitor molecule structurally resembles the substrate and competes for the enzyme active site. This competition can be overcome by increasing substrate concentration.

Solution:

- (a) In competitive inhibition, the inhibitor and substrate compete for the same enzyme active site.
- (b) The inhibitor reduces the concentration of free enzyme available to bind substrate, decreasing the apparent enzyme affinity.
- (c) This is reflected in an increased K_m value, requiring higher substrate concentration to achieve half-maximal velocity.
- (d) However, if enough substrate is provided, it can outcompete all inhibitor molecules for the enzyme.
- (e) Therefore, V_{max} remains unchanged because enzyme molecules can still achieve maximum velocity rate when saturated with substrate.
- (f) The graph shows the inhibited reaction (red dashed) reaching the same V_{max} plateau but at higher substrate concentrations.

Final Answer: Higher substrate concentration is needed to achieve half-maximal velocity

Answer: (B)

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Q41.

Solution

Concept: Blood cell types have specialized structures matching their physiological functions. Some cells contain nuclei and organelles, while others lose these structures as part of their development.

Solution:

- (a) Red blood cells (erythrocytes) contain hemoglobin for oxygen transport but are nucleate in mammals.
- (b) Platelets (thrombocytes) are fragments of megakaryocyte cytoplasm lacking both nucleus and most organelles.
- (c) Despite their small size and lack of nuclei, platelets are critical for hemostasis (blood clotting).
- (d) Platelets circulate as disc-shaped fragments and respond to vessel injury by aggregating and forming clots.
- (e) The absence of nucleus allows platelets to be synthesized rapidly to replace those consumed during clotting.
- (f) White blood cells retain nuclei and organelles essential for their immune functions.

Final Answer: Platelets (thrombocytes)

Answer: (C)

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Q42.

Solution

Concept: Gene expression shows various patterns of dominance depending on how allelic products interact. When two alleles produce gene products with similar influence on phenotype, neither clearly dominates.

Solution:

- (a) Complete dominance occurs when one allele completely masks the recessive allele in heterozygotes.
- (b) Incomplete dominance produces a phenotype between the homozygous types, but each parental phenotype is distinguishable.
- (c) Codominance occurs when both alleles are fully expressed in heterozygotes, with both phenotypes visible simultaneously.
- (d) Classic codominance example: AB blood type where both A and B antigens are expressed equally on red blood cells.
- (e) Neither A nor B dominates the other; instead, both are fully expressed, demonstrating codominance.

Final Answer: Codominance expressing both allelic phenotypes

Answer: (B)

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Q43.

Solution

Concept: Embryonic development begins with the formation of basic body plans. Neurulation represents a critical early stage where future nervous system tissue is specified.

Solution:

- (a) During early development, the ectoderm (outer germ layer) is induced to form neural tissue through signaling from underlying mesoderm.
- (b) The neural plate ectoderm thickens and forms the neural groove, which closes to create the neural tube.
- (c) This neural tube subsequently undergoes regionalization and differentiation to form the central nervous system.
- (d) The anterior portion develops into the brain with major divisions: forebrain, midbrain, and hindbrain.
- (e) The posterior portion develops into the spinal cord, which transmits signals between the brain and body.
- (f) Peripheral nervous system components (nerves and ganglia) arise from neural crest, not from the neural tube directly.

Final Answer: Central nervous system (brain and spinal cord)

Answer: (A)

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Q44.

Solution

Concept: The Krebs cycle must operate as a complete cycle to function optimally. However, when amino acids are metabolized and their carbon skeletons enter the cycle, they sometimes consume cycle intermediates.

Solution:

- (a) The Krebs cycle converts acetyl-CoA into CO₂, capturing energy as NADH, FADH₂, and GTP.
- (b) When glucogenic amino acids are metabolized, their carbon skeletons enter as various Krebs cycle intermediates.
- (c) If more intermediates are withdrawn for biosynthesis (gluconeogenesis, amino acid synthesis) than are provided by acetyl-CoA oxidation, the cycle slows.
- (d) Anaplerotic reactions replenish these depleted intermediates, restoring cycle capacity.
- (e) The primary anaplerotic reaction is catalyzed by pyruvate carboxylase, which directly carboxylates pyruvate to form oxaloacetate.
- (f) This reaction is called anaplerotic (filling up) because it replenishes the cycle intermediates.

Final Answer: Anaplerotic reaction regenerating oxaloacetate

Answer: (B)

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Q45.

Solution

Concept: The corpus luteum is a transient endocrine gland formed after ovulation. Its hormonal function is maintained if pregnancy occurs but regresses if pregnancy does not occur.

Solution:

- (a) After ovulation, the remaining follicle cells differentiate into the corpus luteum, secreting progesterone.
- (b) Progesterone prepares the uterus for potential implantation by thickening and vascularizing the endometrium.
- (c) If fertilization does not occur, the corpus luteum degenerates after approximately 14 days, progesterone levels fall, and menstruation occurs.
- (d) However, if a zygote implants, the trophoblastic tissue surrounding the embryo begins secreting human chorionic gonadotropin (hCG).
- (e) hCG maintains the corpus luteum in early pregnancy, preventing its degeneration and ensuring continued progesterone secretion.
- (f) This hormonal support is necessary until the placenta develops sufficiently to produce its own progesterone.

Final Answer: Human chorionic gonadotropin from trophoblast maintains it

Answer: (B)

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Q46.

Solution

Concept: Continental drift theory explains the current distribution of fauna and flora across Earth's surface. Ancient supercontinents fragmented into modern landmasses, isolating populations and driving independent evolution.

Solution:

- (a) Approximately 200 million years ago, the supercontinent Pangaea existed, uniting all landmasses.
- (b) Pangaea broke apart, forming Laurasia (North America and Eurasia) in the north.
- (c) The southern continents formed Gondwana, which subsequently separated into Africa, South America, Antarctica, Australia, and India.
- (d) This Gondwanan separation explains why similar marsupial faunas are found in South America and Australia.
- (e) The Tethys Sea separated Africa from Europe/Asia but was not itself a separated continent.
- (f) Understanding these ancient separations helps explain modern biogeographic distributions and endemic species patterns.

Final Answer: Gondwana separating Africa, South America, Australia

Answer: (A)

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Q47.

Solution

Concept: The glomerular filtration barrier selectively separates small molecules from proteins, allowing filtrate formation while retaining blood cells and plasma proteins. Multiple components contribute to this selective permeability.

Solution:

- (a) The glomerular filtration barrier consists of three layers: the fenestrated endothelium, the basement membrane, and the filtration slit membrane.
- (b) Fenestrated endothelial cells have small pores (70-100 nm) that allow passage of water and small solutes while blocking blood cells.
- (c) The basement membrane provides the primary size selectivity, restricting molecules larger than approximately 10 nm.
- (d) Podocytes form the outer layer with foot processes creating filtration slits between themselves, providing an additional charge-selective barrier.
- (e) Together, these three layers form the glomerular filtration barrier that determines what enters Bowman's capsule.
- (f) Bowman's capsule itself is merely a collecting chamber, not part of the actual filtration mechanism.

Final Answer: Glomerular filtration barrier (endothelium, BM, podocytes)

Answer: (B)

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Q48.

Solution

Concept: Photosynthesis divides into light-dependent and light-independent reactions, each producing distinct essential molecules. The light reactions specifically generate energy carriers used by the Calvin cycle.

Solution:

- (a) Non-cyclic photophosphorylation involves electrons flowing from water through Photosystem II, the electron transport chain, and Photosystem I.
- (b) At Photosystem II, water is oxidized to produce oxygen gas, releasing electrons and protons.
- (c) These electrons flow through the cytochrome b6f complex, pumping additional protons to establish a gradient.
- (d) At Photosystem I, these electrons are re-energized and transferred to ferredoxin.
- (e) Ferredoxin reduces NADP⁺ to NADPH, capturing reducing power for the Calvin cycle.
- (f) Simultaneously, the proton gradient drives ATP synthase, producing ATP from ADP.
- (g) Both ATP and NADPH are essential for dark reaction carbon fixation and reduction phases.

Final Answer: ATP and NADPH from light reactions

Answer: (A)

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Q49.

Solution

Concept: Protein modification through carbohydrate addition is a critical post-translational event. This glycosylation occurs in the secretory pathway at specific organelles.

Solution:

- (a) Glycoproteins contain covalently attached carbohydrate chains linked through glycosidic bonds.
- (b) N-linked glycosylation occurs when sugars attach to asparagine residues in the rough ER.
- (c) O-linked glycosylation occurs when sugars attach to serine or threonine residues.
- (d) Both types of glycosylation are initiated in the rough ER and further modified in the Golgi apparatus.
- (e) The Golgi apparatus removes some initial sugars and adds additional glycan structures through enzyme action.
- (f) Glycoproteins are sorted and packaged into vesicles after completing modifications in the trans-Golgi network.

Final Answer: Glycoproteins with covalently attached sugars

Answer: (B)

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Q50.

Solution

Concept: Mutations are classified by their impact on the DNA sequence and resulting protein product. Premature termination of translation has particularly severe consequences.

Solution:

- (a) Silent mutations change a codon but don't alter the amino acid due to codon redundancy.
- (b) Missense mutations change one codon to another, altering the amino acid without stopping translation.
- (c) Frameshift mutations insert or delete nucleotides, shifting the reading frame and producing entirely different downstream amino acids.
- (d) Nonsense mutations create a stop codon (UAA, UAG, or UGA) within the protein-coding sequence.
- (e) When a nonsense mutation occurs, the ribosome terminates translation prematurely, releasing an incomplete polypeptide.
- (f) This truncated protein typically lacks critical functional domains and is non-functional.

Final Answer: Nonsense mutation producing truncated protein

Answer: (D)

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Q51.

Solution

Concept: Secondary succession occurs on sites that previously supported vegetation but have been disturbed. Recovery proceeds faster than primary succession because existing soil and residual nutrients remain.

Solution:

- (a) Primary succession on bare rock must establish soil from scratch through weathering and organic matter accumulation.
- (b) This process is extremely slow, requiring decades to centuries for complete soil development.
- (c) In secondary succession, soil already exists with established microbial communities and nutrient banks.
- (d) Previous vegetation left behind seeds and vegetative propagules that can quickly reestablish.
- (e) Existing mycorrhizal networks can support rapid plant establishment.
- (f) Most importantly, the pre-existing soil structure, microorganisms, and nutrients eliminate the longest bottleneck of primary succession.

Final Answer: Soil microorganisms and nutrients are already present

Answer: (A)

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Q52.

Solution

Concept: DNA structure depends on both hydrogen bonding and favorable interactions between adjacent bases. These complementary stabilizing forces work together to maintain the double helix.

Solution:

- (a) The DNA double helix consists of two complementary strands held together by hydrogen bonds between bases.
- (b) Adenine pairs with thymine through two hydrogen bonds, while guanine pairs with cytosine through three hydrogen bonds.
- (c) Beyond hydrogen bonding, the bases also interact through base stacking interactions with adjacent bases on the same strand.
- (d) These stacking interactions occur between the flat aromatic rings of nucleotide bases, providing hydrophobic interactions.
- (e) Base stacking contributes more energy to DNA stability than the hydrogen bonds between complementary bases.
- (f) Together, hydrogen bonding and base stacking create the stable, compact double helix structure.

Final Answer: Base stacking interactions between adjacent bases

Answer: (B)

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Q53.

Solution

Concept: The hypothalamic-pituitary axis represents the key communication link between the nervous and endocrine systems. Hypothalamic hormones directly control anterior pituitary hormone secretion.

Solution:

- (a) The hypothalamus synthesizes releasing hormones (RH) and inhibiting hormones (IH) in specialized neurons.
- (b) These hormones are transported through axons to the posterior pituitary, which releases them directly into the bloodstream.
- (c) For anterior pituitary control, the hypothalamic hormones travel through the hypothalamic-hypophyseal portal blood vessels.
- (d) This portal system delivers hypothalamic hormones directly to the anterior pituitary, bypassing systemic circulation.
- (e) Releasing hormones stimulate anterior pituitary cells to synthesize and secrete specific hormones (FSH, LH, ACTH, TSH, prolactin).
- (f) Inhibiting hormones suppress specific pituitary hormone secretion.

Final Answer: Anterior pituitary controlling hormone secretion

Answer: (A)

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Q54.

Solution

Concept: Cancer progression involves acquisition of multiple mutations enabling cell transformation. Metastasis requires specific adaptations allowing cells to escape their tissue of origin.

Solution:

- (a) Early tumors are localized within their tissue of origin, surrounded by basement membrane.
- (b) Malignant tumors acquire invasive capacity through loss of cell-cell adhesion molecules and upregulation of proteases.
- (c) These changes allow cells to degrade basement membrane components and invade surrounding tissues.
- (d) Intravasation describes entry of tumor cells into blood vessels, allowing systemic dissemination.
- (e) Circulating tumor cells extravasate into distant tissues where they proliferate and establish secondary tumors.
- (f) This metastatic spread requires loss of contact inhibition, gain of invasive enzymes, and resistance to anoikis.

Final Answer: Detach from original tissue and invade distant sites

Answer: (B)

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Q55.

Solution

Concept: The carbon cycle moves carbon between the atmosphere, biota, and geological reservoirs. One major pathway returns carbon to the atmosphere through metabolic processes.

Solution:

- (a) Carbon dioxide is fixed from the atmosphere by photosynthetic organisms, becoming incorporated into organic molecules.
- (b) This organic carbon flows through food chains as organisms consume other organisms.
- (c) Heterotrophic organisms (consumers and decomposers) oxidize organic compounds to generate ATP through cellular respiration.
- (d) This oxidation of glucose and other organic molecules produces CO₂ as a byproduct.
- (e) Decomposer organisms (bacteria, fungi) break down dead organic matter, releasing CO₂ through respiration.
- (f) The CO₂ returns to the atmosphere, completing the cycle.

Final Answer: Cellular respiration oxidizing organic compounds

Answer: (B)

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Q56.

Solution

Concept: Ecological interactions are classified by whether they benefit, harm, or have no effect on participants. Pollination relationships demonstrate a particularly important interaction type.

Solution:

- (a) Parasitism: one organism benefits (parasite) while harming the other (host).
- (b) Mutualism: both organisms benefit from the relationship.
- (c) Commensalism: one organism benefits while the other is unaffected.
- (d) Amensalism: one organism is harmed while the other is unaffected.
- (e) In pollination, insects gain nectar as food energy (benefit).
- (f) Flowering plants gain pollination services enabling reproduction (benefit).
- (g) Since both participants benefit, this is mutualism.

Final Answer: Mutualism with mutual benefit

Answer: (B)

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Q57.

Solution

Concept: Translation begins at a specific codon recognized by the initiator tRNA. This start codon establishes the reading frame and initiates protein synthesis.

Solution:

- (a) In prokaryotes, the initiator tRNA carries N-formylmethionine (fMet).
- (b) In eukaryotes, the initiator tRNA carries methionine without formylation.
- (c) Both recognize the AUG start codon, the only AUG codon that functions as a translation start.
- (d) The ribosome binds at the ribosomal binding site (Shine-Dalgarno sequence in prokaryotes, Kozak sequence in eukaryotes).
- (e) The initiator tRNA is placed in the P site (peptidyl site) of the ribosome.
- (f) Subsequent codons are read sequentially from this start point, establishing the reading frame.

Final Answer:

Answer: (B)

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Q58.

Solution

Concept: Carbon fixation, the first committed step of photosynthetic carbon assimilation, is catalyzed by a highly abundant enzyme. This enzyme is also a major source of photorespiratory loss.

Solution:

- (a) RuBisCO (ribulose-1,5-bisphosphate carboxylase/oxygenase) catalyzes the initial carboxylation reaction of the Calvin cycle.
- (b) The substrate is ribulose-1,5-bisphosphate (RuBP), a five-carbon compound.
- (c) RuBisCO adds CO₂ to RuBP, creating an unstable six-carbon intermediate.
- (d) This intermediate immediately splits into two molecules of 3-phosphoglycerate, a three-carbon compound.
- (e) RuBisCO is a bifunctional enzyme: it can also catalyze oxygenation of RuBP using O₂.
- (f) When O₂ rather than CO₂ is fixed, photorespiration occurs, wasting organic carbon.

Final Answer: Ribulose-1,5-bisphosphate into 3-phosphoglycerate

Answer: (B)

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Q59.

Solution

Concept: The humoral immune response depends on B lymphocytes producing specific proteins. These protein products are the molecular weapons of antibody-mediated immunity.

Solution:

- (a) B lymphocytes recognize antigens through surface-bound antibodies (B cell receptors).
- (b) Upon antigen recognition and T cell help, B cells differentiate into plasma cells.
- (c) Plasma cells are specialized for mass production of secreted antibodies.
- (d) Antibodies (immunoglobulins) are Y-shaped proteins with two identical antigen-binding sites.
- (e) Each plasma cell can synthesize thousands of copies of its specific antibody per second.
- (f) These antibodies circulate in blood and lymph, neutralizing pathogens and marking them for destruction.

Final Answer: Antibodies (immunoglobulins) specific for antigens

Answer: (B)

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Q60.

Solution

Concept: Chromosomal sex determines inheritance patterns in many organisms. Abnormalities in sex chromosome number produce distinctive phenotypes and clinical syndromes.

Solution:

- (a) Turner's syndrome results from complete or partial absence of one X chromosome, genotype X0 or mosaic XO/XX.
- (b) Klinefelter's syndrome results from an extra X chromosome, genotype XXY.
- (c) Triple-X syndrome results from three X chromosomes, genotype XXX.
- (d) Down's syndrome results from trisomy 21 (three copies of chromosome 21), not a sex chromosome abnormality.
- (e) The XXY individual has a male phenotype due to the Y chromosome, but with reduced fertility and some feminizing features.
- (f) This represents Klinefelter's syndrome, the most common sex chromosome abnormality in males.

Final Answer: Klinefelter's syndrome with male phenotype

Answer: (B)

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Q61.

Solution

Concept: Plant tissue culture allows in vitro cultivation and differentiation of plant cells. The balance between growth regulators determines the developmental pathway.

Solution:

- (a) Auxins promote cell elongation and cell division at moderate concentrations.
- (b) Cytokinins promote cell division and delay aging, also promoting shoot development.
- (c) When cytokinin exceeds auxin concentration, cells are stimulated to differentiate into shoot tissue.
- (d) When auxin exceeds cytokinin concentration, cells are stimulated to differentiate into root tissue.
- (e) When both hormones are at intermediate equal concentrations, cells form undifferentiated callus tissue.
- (f) When both hormones are absent or at very low levels, minimal growth occurs.

Final Answer: Undifferentiated callus tissue at intermediate ratios

Answer: (C)

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Q62.

Solution

Concept: Glycolysis is the fundamental pathway for glucose metabolism in all cells. Regulation at specific steps prevents wasteful cycling and responds to energy status.

Solution:

- (a) The first step (glucose to glucose-6-phosphate) is catalyzed by hexokinase but is not unique to glycolysis.
- (b) Glucose-6-phosphate can enter various pathways (glycogen synthesis, pentose phosphate pathway, glycolysis).
- (c) The third step, catalyzed by PFK-1, is the first committed step unique to glycolysis.
- (d) This step converts fructose-6-phosphate to fructose-1,6-bisphosphate, consuming ATP and initiating the splitting phase.
- (e) After this commitment, the glucose molecule is funneled irreversibly through glycolysis.
- (f) PFK-1 is highly regulated by ATP, AMP, and citrate, responding to cellular energy status.

Final Answer: The first committed step unique to glycolysis

Answer: (B)

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Q63.



Solution

Concept: Early embryonic development involves the formation of the primary germ layers. These tissue layers subsequently give rise to all major tissue types and organ systems.

Solution:

- (a) A blastula is a hollow sphere of cells formed through cleavage divisions but lacks internal tissue organization.
- (b) Gastrulation is a series of massive cell movements where the blastula reorganizes into a three-layered structure.
- (c) During gastrulation, the blastula invaginates and major tissue rearrangements form the ectoderm, mesoderm, and endoderm.
- (d) The ectoderm forms the nervous system and epidermis.
- (e) The mesoderm forms muscles, bones, blood, and connective tissues.
- (f) The endoderm forms the digestive and respiratory tract linings.

Final Answer:

Answer: (B)

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Q64.

Solution

Concept: Genetic imprinting represents an epigenetic mechanism where gene expression depends on which parent contributed the allele. DNA methylation patterns establish this parental marking.

Solution:

- (a) Random X-chromosome inactivation occurs in female mammals but affects all X-linked genes equally.
- (b) Genetic imprinting affects specific autosomal genes based on parental origin.
- (c) Environmental factors may influence expression but don't determine imprinting patterns established during gametogenesis.
- (d) Codon usage doesn't determine imprinting effects.
- (e) During gametogenesis, certain alleles are methylated in a parent-specific manner.
- (f) After fertilization, these methylation patterns are maintained through mitosis, silencing the imprinted alleles.
- (g) Some imprinted genes are expressed only from the maternal allele, others only from the paternal allele.

Final Answer: Parental origin determining allele expression

Answer: (B)

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Q65.

Solution

Concept: Pulmonary function is measured using standardized tests that quantify air volumes and flows. One key measurement integrates inspiratory and expiratory capacity.

Solution:

- (a) Tidal volume is the amount of air exchanged during quiet breathing.
- (b) Inspiratory reserve volume is the maximum air that can be inhaled after quiet inspiration.
- (c) Expiratory reserve volume is the maximum air that can be exhaled after quiet expiration.
- (d) Vital capacity is the total of these three: tidal + inspiratory reserve + expiratory reserve.
- (e) This represents the maximum air that can be forcefully expelled after maximum inspiration.
- (f) Residual volume is air remaining in lungs and cannot be expelled, always remaining in lungs.
- (g) Therefore, vital capacity is the maximum volume that can be forcefully expelled after maximum inspiration.

Final Answer: Forcefully expelled after maximum inspiration

Answer: (B)

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Q66.

Solution

Concept: Human blood groups are determined by alleles that produce distinct cell surface antigens. Multiple alleles contribute to blood group diversity.

Solution:

- (a) The ABO blood group system involves three alleles: I^A , I^B , and i .
- (b) I^A codes for A antigen, I^B codes for B antigen, and i codes for no antigen.
- (c) I^A and I^B are codominant to each other, while both are dominant to i .
- (d) Genotype $I^A I^A$ produces blood type A.
- (e) Genotype $I^B I^b$ produces blood type B.
- (f) Genotype $I^A I^B$ produces blood type AB with both A and B antigens expressed equally (codominance).
- (g) Genotype ii produces blood type O.
- (h) Four distinct blood types exist, and A and B traits are equally expressed in AB blood.

Final Answer: Codominance of A and B with four phenotypes

Answer: (B)

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Q67.

Solution

Concept: Oxidative phosphorylation couples electron transport to ATP synthesis through a proton gradient. This chemiosmotic mechanism represents one of the most important energy-capture processes in cells.

Solution:

- (a) As electrons move through the electron transport chain, their energy pumps protons across the inner mitochondrial membrane.
- (b) This creates a proton concentration gradient across the membrane, with more protons in the intermembrane space.
- (c) This gradient represents stored potential energy, similar to water behind a dam.
- (d) ATP synthase is a rotary enzyme positioned in the inner membrane spanning both compartments.
- (e) Protons flow down their concentration gradient through ATP synthase, rotating the enzyme.
- (f) This rotation powers the phosphorylation of ADP to ATP, capturing the energy chemically.
- (g) This chemiosmotic mechanism is distinct from substrate-level phosphorylation, which directly transfers phosphate groups.

Final Answer: Chemiosmotic mechanism with proton gradient

Answer: (B)

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Q68.

Solution

Concept: Cancer cells employ multiple strategies to evade immune detection and elimination. One key mechanism involves reducing visibility to immune surveillance.

Solution:

- (a) Cytotoxic T lymphocytes recognize tumor cells through presentation of abnormal peptides on MHC class I molecules.
- (b) If tumor cells reduce MHC class I expression, CTLs cannot recognize them and cannot kill them.
- (c) Some tumors develop mutations reducing MHC production or altering MHC expression patterns.
- (d) Other tumors produce immunosuppressive cytokines creating an immunosuppressive microenvironment.
- (e) Immune tolerance represents the normal acceptance of self-antigens, not relevant to tumor immunity.
- (f) Immune evasion specifically refers to tumor strategies to avoid immune detection and elimination.

Final Answer: Immune evasion reducing detection by T cells

Answer: (B)

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Q69.

Solution

Concept: The pollen grain represents the male gametophyte of flowering plants. Its development from microspores creates a multicellular structure adapted for pollen tube growth.

Solution:

- (a) Pollen grains develop from microspore mother cells through meiosis, producing haploid microspores.
- (b) Each microspore undergoes mitosis to produce a two-celled pollen grain consisting of a vegetative cell and a generative cell.
- (c) The vegetative cell has a large nucleus and will form the pollen tube that grows through the pistil.
- (d) The generative cell will undergo mitosis to produce two sperm cells during pollen maturation or after pollination.
- (e) A synergid is part of the female gametophyte, not the male pollen grain.
- (f) The vegetative cell's nucleus controls pollen tube growth through the female reproductive tract.

Final Answer: Vegetative cell (tube cell) directing pollen tube growth

Answer: (B)

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Q70.

Solution

Concept: Industrial nitrogen fixation requires extreme conditions to break the strong triple bond of atmospheric nitrogen. This process demands metal catalysts and high energy inputs.

Solution:

- (a) The NN triple bond is extremely strong, requiring enormous energy to break for nitrogen fixation.
- (b) The Haber-Bosch process operates at high temperatures (400-500°C) and pressures (150-300 atm).
- (c) These conditions favor the forward reaction converting N₂ and H₂ to ammonia (NH₃).
- (d) An iron catalyst enhances the reaction rate, reducing activation energy without being consumed.
- (e) Iron clusters facilitate N₂ adsorption and activation on the catalyst surface.
- (f) This industrial process produces ammonia for fertilizers, explosives, and various chemicals.
- (g) Enzymatic nitrogenase cannot operate at such extreme conditions, making industrial catalysis necessary for bulk production.

Final Answer: Iron catalyst enhancing nitrogen fixation

Answer: (A)

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Q71.

Solution

Concept: Population genetics predicts that allele frequencies remain constant under specific conditions. The Hardy-Weinberg equilibrium provides a null hypothesis for evolutionary stability.

Solution:

- (a) The Hardy-Weinberg equilibrium predicts constant allele frequencies when specific conditions exist.
- (b) Large population size prevents random sampling errors (genetic drift).
- (c) Random mating ensures gamete frequencies follow allele frequencies.
- (d) Absence of mutations prevents new allele introduction.
- (e) No gene flow prevents alleles from entering or leaving the population.
- (f) Absence of natural selection prevents differential reproductive success.
- (g) When any of these conditions are violated, allele frequencies change over time.
- (h) Actual populations constantly violate these assumptions, resulting in evolution.

Final Answer:

Answer: (A)

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Q72.

Solution

Concept: Natural selection can favor different genetic variants depending on genotypic context. Some alleles show advantage in heterozygotes compared to both homozygotes.

Solution:

- (a) Overdominance (heterozygote advantage) occurs when heterozygotes have higher fitness than either homozygote.
- (b) Classic example: sickle-cell trait in malaria-endemic regions, where AS (heterozygous) has advantage over SS and AA.
- (c) Underdominance (heterozygote disadvantage) occurs when heterozygotes have lower fitness than both homozygotes.
- (d) In underdominance, heterozygotes are selected against, causing populations to diverge toward homozygotes.
- (e) This can create unstable polymorphisms or lead to fixation of whichever allele is more common initially.
- (f) Incomplete dominance describes phenotypic blending, not fitness relationships.

Final Answer: Underdominance against heterozygotes

Answer: (B)

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Q73.

Solution

Concept: Synaptic transmission involves not only release of neurotransmitters but also their clearance from the synaptic cleft. Reuptake is a major removal mechanism preventing receptor overstimulation.

Solution:

- (a) After neurotransmitter molecules activate postsynaptic receptors, they must be removed from the synaptic cleft.
- (b) Enzymatic degradation by monoamine oxidase is one removal mechanism.
- (c) Reuptake involves active transport of neurotransmitter molecules back into the presynaptic terminal or nearby glia.
- (d) Vesicular monoamine transporters (VMAT2) pump cytoplasmic neurotransmitters into synaptic vesicles for reuse.
- (e) This recycling mechanism conserves neurotransmitters and prevents depletion.
- (f) Selective reuptake inhibitors (SSRIs) block this reuptake, increasing synaptic neurotransmitter concentration for therapeutic benefit.

Final Answer: Vesicular monoamine transporters recycling molecules

Answer: (A)

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Q74.

Solution

Concept: Phototropism allows plants to detect light direction and grow toward it. This directional growth response depends on differential hormone distribution.

Solution:

- (a) When a plant perceives unidirectional light, phototropins (photoreceptors) sense the light direction.
- (b) This triggers relocation of auxin toward the shaded side of the stem or coleoptile.
- (c) Accumulation of auxin on the shaded side stimulates greater cell elongation on that side.
- (d) The light-exposed side experiences less elongation due to lower auxin concentration.
- (e) Differential elongation causes the stem to bend toward the light source.
- (f) This adaptive response orients plant growth toward the primary light source.

Final Answer: Greater elongation on the shaded side

Answer: (B)

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Q75.

Solution

Concept: Aerobic respiration produces energy by coupling electron transfer to ATP synthesis. The P/O ratio quantifies this energy capture efficiency.

Solution:

- (a) The P/O ratio (phosphate-to-oxygen ratio) measures moles of ATP synthesized per mole of oxygen consumed.
- (b) When NADH donates electrons through Complex I, the P/O ratio is approximately 2.5 ATP per O₂.
- (c) When FADH₂ donates electrons through Complex II, the P/O ratio is approximately 1.5 ATP per O₂.
- (d) This efficiency varies because FADH₂ enters at a lower potential, producing fewer protons pumped.
- (e) The partial pressure of oxygen describes oxygen availability, not ATP synthesis efficiency.
- (f) The P/O ratio is a direct measure of oxidative phosphorylation efficiency.

Final Answer: Moles of ATP produced per mole oxygen consumed

Answer: (A)

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Q76.

Solution

Concept: Telomeres shorten with each cell division due to end-replication problems. Telomerase extends telomeres using an internal RNA template.

Solution:

- (a) Telomeres are repetitive DNA sequences protecting chromosome ends from degradation.
- (b) During DNA replication, the 3' end of lagging strands cannot be fully replicated, causing shortening.
- (c) Telomerase is a ribonucleoprotein enzyme containing both protein and RNA components.
- (d) The RNA component serves as a template for adding repetitive telomeric sequences to chromosome ends.
- (e) Telomerase doesn't use a DNA template; instead, it uses its internal RNA template.
- (f) This mechanism allows unlimited cell divisions in germ cells and some somatic cells (immune cells).

Final Answer: RNA template within its protein structure

Answer: (B)

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Q77.

Solution

Concept: Viral replication follows distinct pathways depending on the virus and circumstances. The lytic cycle prioritizes rapid viral reproduction at the expense of host cell survival.

Solution:

- (a) The lytic cycle represents one mode of viral replication where the virus completely takes over host machinery.
- (b) Viral enzymes replicate the viral genome using host nucleotides and energy.
- (c) Viral proteins are synthesized using host ribosomes, tRNAs, and amino acids.
- (d) Late in infection, capsid proteins self-assemble around viral genomes forming mature virions.
- (e) The host cell membrane ruptures (lyses), releasing progeny viruses to infect neighboring cells.
- (f) Host cell death is inevitable in lytic infection, distinguishing it from lysogenic (latent) infection.

Final Answer: Host cell rupture releasing new viral particles

Answer: (B)

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Q78.

Solution

Concept: Mycorrhizal associations represent a critical symbiosis expanding plant nutrient absorption. Fungal partners extend the root system's reach for nutrient acquisition.

Solution:

- (a) Mycorrhizal fungi form associations with plant roots, extending into the soil with fungal hyphae.
- (b) The fungal partner receives carbohydrates from photosynthesis of the plant host.
- (c) In exchange, fungal hyphae greatly increase the absorptive surface area for nutrient uptake.
- (d) Phosphorus is particularly acquired through mycorrhizal associations because fungal enzymes access bound forms plants cannot utilize.
- (e) Nitrogen is fixed by rhizobial bacteria in root nodules, a different symbiotic association.
- (f) Mycorrhizal associations don't directly fix nitrogen but facilitate phosphorus and other nutrient absorption.

Final Answer: Nutrient absorption especially phosphorus uptake

Answer: (B)

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Q79.

Solution

Concept: Cellular signal transduction relies on protein phosphorylation as a rapid switch for altering protein function. Kinases add phosphate groups while phosphatases remove them.

Solution:

- (a) Protein kinases catalyze the transfer of phosphate groups from ATP to specific residues on target proteins.
- (b) Phosphorylation adds negative charge, causing conformational changes in the target protein structure.
- (c) These conformational changes can activate or inactivate enzyme activity depending on the specific protein.
- (d) Phosphorylation can create new binding sites for interaction with other proteins.
- (e) This enables signal amplification, where one activated kinase phosphorylates multiple substrates.
- (f) Reversibility comes from phosphatase enzymes that remove phosphate groups, allowing signal termination.

Final Answer: Alter conformations enabling signal amplification

Answer: (B)

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Q80.

Solution

Concept: Ecological competition drives evolutionary divergence when species occupy overlapping niches. Character displacement represents a specific evolutionary response to reduce competition.

Solution:

- (a) Character displacement occurs when competing species evolve greater differences in areas of sympatry.
- (b) This divergence reduces resource competition and allows coexistence.
- (c) For example, Darwin's finches in sympatry have larger beak differences than isolated populations.
- (d) In allopatry (geographic isolation), species face no competition, so displacement doesn't occur.
- (e) Selection for divergence in sympatry prevents extinction through competitive exclusion.
- (f) This demonstrates how ecological competition drives evolutionary change.

Final Answer: Divergent character evolution avoiding competition

Answer: (B)

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Answer Key

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

