KIITEE Biology Sample Paper – 12

Duration: 50 Minutes **Maximum Marks: 160**

Instructions

- This paper contains **40** Multiple Choice Questions (Single Correct Answer), modelled on the Biology portion of **KIITEE** entrance.
- Each correct answer carries **+4 marks**. There is −1 **mark per wrong answer;** unattempted questions score **0**
- Only **one** option is correct. Choose carefully.
- Syllabus level: **Class 11 12 (10+2) Biology — Diversity of Life, Cell Biology, Plant Human Physiology, Reproduction, Genetics Evolution, Biotechnology and Ecology**
- The test is computer based. Personal calculators, log tables, mobile phones, and other electronic gadgets are strictly prohibited.

Q1. Which of the following organelles is present in plant cells but completely absent in typical animal cells?

(A) Mitochondrion

(B) Golgi apparatus

(C) Plastids (chloroplasts, chromoplasts, leucoplasts) and a large central vacuole

(D) Ribosome

Q2. During which specific sub-stage of prophase I in meiosis does the process of genetic recombination via crossing over initiate, mediated by the recombinase enzyme complex?

(A) Leptotene

(B) Zygotene

(C) Pachytene

(D) Diplotene

Q3. An enzyme-catalyzed reaction exhibits a specific Michaelis constant (K_m). If the concentration of the substrate is exactly equal to $2K_m$, what fraction of the maximum velocity (V_{max}) will the initial reaction velocity (v_0) achieve?

(A) $\frac{1}{2}V_{max}$

(B) $\frac{2}{3}V_{max}$

(C) $\frac{1}{3}V_{max}$

(D) $\frac{3}{4}V_{max}$

Q4. Which of the following structural descriptions accurately details a key difference between a nucleotide and a nucleoside found within a typical eukaryotic cell matrix?

(A) A nucleotide lacks a nitrogenous base.

(B) A nucleoside contains a phosphate group attached to the $C5'$ hydroxyl group of the pentose sugar.

(C) A nucleotide possesses a phosphate group esterified to the sugar molecule, whereas a nucleoside lacks this phosphate.

(D) A nucleoside contains an extra hydroxyl group at the $C2'$ position relative to a nucleotide.

Q5. A dihybrid cross is performed between two plants heterozygous for both seed shape (Round, R dominant to wrinkled, r) and seed color (Yellow, Y dominant to green, y). What is the exact expected phenotypic ratio of the offspring if these two genes exhibit complete independent assortment?

(A) 9 : 3 : 4

(B) 9 : 3 : 3 : 1

(C) 1 : 1 : 1 : 1

(D) 12 : 3 : 1

Q6. In a multi-generational pedigree analysis tracking an uncommon physiological trait, it is observed that affected fathers pass the trait to all of their daughters, but none of their sons. Affected mothers pass the trait to approximately half of their sons and half of their daughters. What is the mode of inheritance?

(A) Autosomal Recessive

(B) X-linked Recessive

(C) X-linked Dominant

(D) Y-linked (Holandric)

Q7. During DNA replication in prokaryotes, which specific enzyme is primarily responsible for removing RNA primers via its $5' \rightarrow 3'$ exonuclease activity and filling the resulting gaps with deoxyribonucleotides via its $5' \rightarrow 3'$ polymerase activity?

(A) DNA Polymerase III

(B) DNA Polymerase I

(C) DNA Helicase

(D) Topoisomerase (DNA Gyrase)

Q8. A population is in Hardy-Weinberg equilibrium for a specific gene with two alleles, A and a. If the frequency of the recessive phenotype (aa) in this population is determined to be 0.16, what is the percentage frequency of the heterozygous (Aa) individual genotype?

(A) 48%

(B) 36%

(C) 24%

(D) 64%

Q9. Which of the following represents a classic example of directional selection operating on a natural population over a observable evolutionary timescale?

(A) Human birth weight clustering around an optimal average of 3.5 kg.

(B) Industrial melanism in the peppered moth (*Biston betularia*) during the industrial revolution in England.

(C) Co-existence of small-billed and large-billed finches in environments lacking intermediate-sized seeds.

(D) Sickle-cell trait persistence in malaria-endemic regions due to heterozygote advantage.

Q10. The codon AUG codes uniquely for methionine and also functions as the universal translation initiation signal. Which structural feature of the genetic code is demonstrated when multiple distinct codons, such as UUU and UUC, both encode the single amino acid phenylalanine?

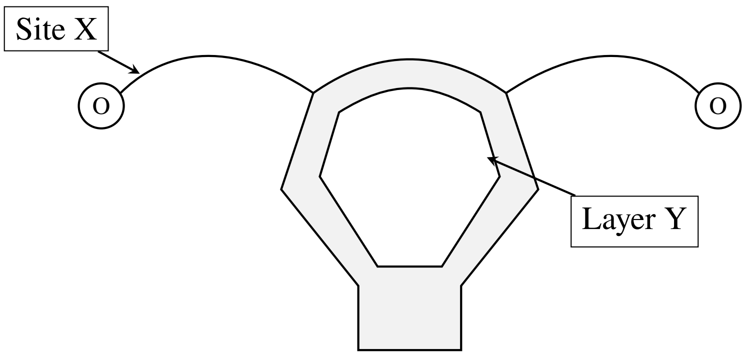
(A) Non-overlapping nature

(B) Universality

(C) Degeneracy (Redundancy)

(D) Unambiguous nature

Q11. Consider the provided anatomical schematic detailing the female human reproductive tract during early gestational development?



Identify the biological structures or processes that occur at Site X and the functional layer Y during a healthy pregnancy cycle:

(A) Site X is the ampullary-isthmic junction where fertilization occurs; Layer Y is the Myometrium which undergoes cyclic shedding.

(B) Site X is the infundibulum; Layer Y is the Perimetrium.

(C) Site X is the ampullary region where fertilization occurs; Layer Y is the Endometrium where blastocyst implantation takes place.

(D) Site X is the uterine fundus; Layer Y is the cervical canal.

Q12. Which of the following options correctly maps the structural components of a typical angiosperm ovule before fertilization to its corresponding post-fertilization seed structure?

(A) Integuments → Pericarp; Ovary wall → Seed coat

(B) Outer Integument → Testa; Inner Integument → Tegmen; Ovule → Seed

(C) Synergids → Endosperm; Central Cell → Embryo

(D) Nucellus → Fruit wall; Zygote → Suspensor

Q13. A human female experiences a normal 28-day menstrual cycle. On which range of days would a sharp surge in Luteinizing Hormone (LH) induce ovulation from the mature Graafian follicle?

(A) Days 1–5

(B) Days 6–10

(C) Days 13–15

(D) Days 20–25

Q14. What is the primary operational mechanism of the non-hormonal Intrauterine Device (IUD) such as Lippes Loop or CuT within the female reproductive tract?

(A) Complete suppression of ovulation via negative feedback on the hypothalamus.

(B) Thickening of cervical mucus to create a physical barrier impermeable to spermatozoa.

(C) Increasing phagocytosis of sperm within the uterus via localized inflammatory response, with copper ions suppressing sperm motility.

(D) Surgical block of the fallopian tubes to prevent gametic transport.

Q15. During aerobic respiration of one single molecule of glucose, how many net molecules of ATP are generated purely via substrate-level phosphorylation (SLP) throughout the combined pathways of Glycolysis and the Tricarboxylic Acid (TCA) cycle?

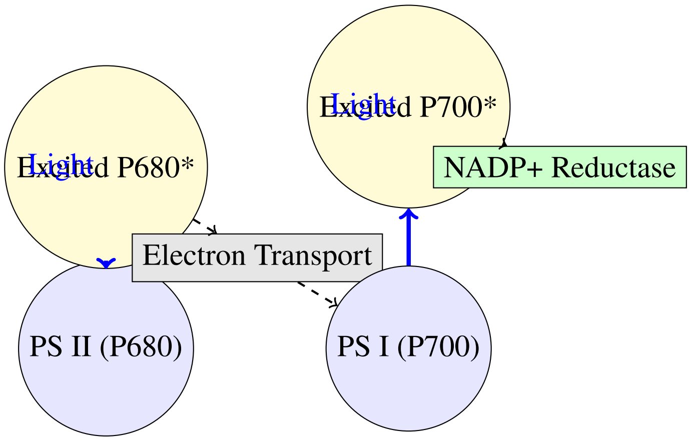
(A) 2 ATP

(B) 4 ATP

(C) 6 ATP

(D) 34 ATP

Q16. The diagram below shows the basic Z-scheme of light reactions in oxygenic photosynthesis?



What is the immediate source of electrons that restores the oxidized reaction center chlorophyll ($P680^+$) of Photosystem II following its photo-excitation?

(A) Photolysis of water ($2H_2O \longrightarrow 4H^+ + 4e^- + O_2$)

(B) Reduced Plastoquinone (PQH_2)

(C) Direct cyclic return of electrons from Photosystem I

(D) Splitting of Carbon Dioxide (CO_2)

Q17. In C_4 plants, such as maize or sorghum, what is the specific primary CO_2 acceptor molecule, and in which cell type is it localized to optimize carbon fixation?

(A) RuBP (5-carbon) located in the Bundle Sheath cells

(B) PEP (3-carbon) located in the Mesophyll cells

(C) Oxaloacetate (4-carbon) located in the Mesophyll cells

(D) RuBP (5-carbon) located in the Mesophyll cells

Q18. Which plant growth regulator is synthesized primarily in root tips and is responsible for promoting lateral bud growth, delaying leaf senescence, and counteracting apical dominance?

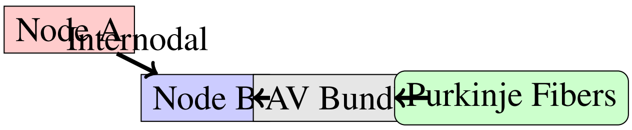
(A) Indole-3-acetic acid (IAA)

(B) Gibberellic Acid (GA_3)

(C) Cytokinin (Zeatin / Kinetin)

(D) Abscisic Acid (ABA)

Q19. Consider the schematic representing the human cardiac conduction pathway during a single cycle:



If Node A fails to generate an action potential spontaneously, what immediate effect will this have on Node B and the cardiac cycle profile?

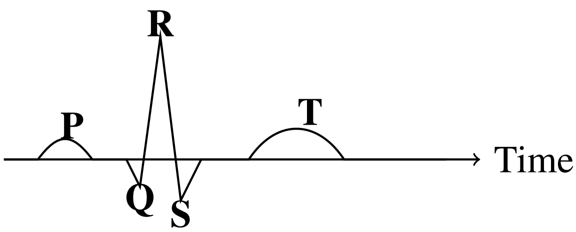
(A) Ventricular contraction stops completely.

(B) Node B (AV Node) assumes pacemaker activity, but fires at a lower intrinsic rate (40 – 60 bpm).

(C) The heart rate increases to compensate for the electrical block.

(D) Atria contract faster while ventricles slow down.

Q20. The physiological trace below depicts a typical human Electrocardiogram (ECG) sequence:



Which functional cardiodynamic phase is perfectly synchronized with the electrical events represented by the high-amplitude QRS complex?

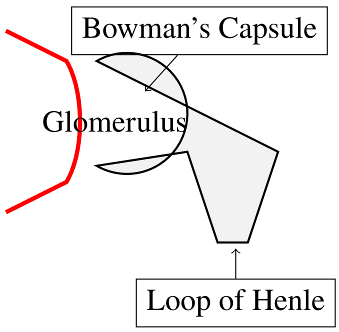
(A) Atrial depolarization leading to atrial contraction.

(B) Ventricular depolarization initiating ventricular systole.

(C) Ventricular repolarization marking the start of diastole.

(D) Complete joint diastole of all chambers.

Q21. The diagram below models a specialized structural functional unit within the human renal cortex and medulla:



Which physiological mechanism occurs across the descending limb versus the ascending limb of the Loop of Henle to establish the medullary osmotic gradient?

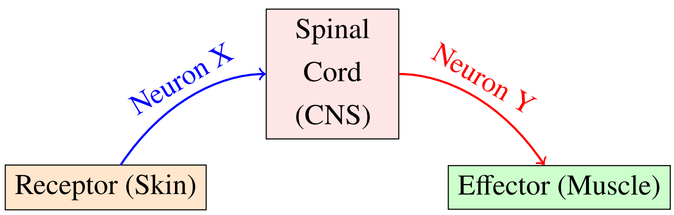
(A) The descending limb is permeable to electrolytes but completely impermeable to water.

(B) The descending limb is highly permeable to water but impermeable to electrolytes; the ascending limb is impermeable to water but actively/passively transports electrolytes.

(C) Both limbs actively pump urea out into the interstitial fluid.

(D) The ascending limb allows rapid osmotic movement of water back into the vasa recta.

Q22. The diagram below illustrates a classic neural pathways loop operating within the human somatic nervous system:



Identify the classifications of Neuron X and Neuron Y in this standard reflex arc network:

(A) Neuron X is a motor efferent; Neuron Y is a sensory afferent.

(B) Neuron X is an afferent sensory neuron; Neuron Y is an efferent motor neuron.

(C) Both neurons represent specialized autonomic sympathetic pathways.

(D) Neuron X belongs to the cranial system, whereas Neuron Y is spinal.

Q23. Which cell types in the gastric mucosal lining are responsible for secreting intrinsic factor (essential for Vitamin B_{12} absorption) and hydrochloric acid (HCl)?

(A) Peptic or Chief cells

(B) Oxyntic or Parietal cells

(C) Mucus neck cells

(D) Argentaffin cells

Q24. A person experiences a sudden acute drop in blood pressure and systemic blood volume. Which endocrine cascade is triggered inside the juxtaglomerular apparatus (JGA) to re-establish homeostatic equilibrium?

(A) Suppression of ADH release from the posterior pituitary gland.

(B) Release of Renin, converting angiotensinogen to angiotensin I, ultimately leading to aldosterone secretion.

(C) Secretion of Atrial Natriuretic Factor (ANF) to promote systemic vasodilation.

(D) Direct inhibition of active sodium reabsorption in proximal convoluted tubules.

Q25. During skeletal muscle contraction, which molecular step triggers the conformational change known as the "power stroke," pulling the actin filament toward the center of the sarcomere?

(A) Binding of a fresh ATP molecule to the myosin heavy chain head.

(B) Binding of calcium ions directly to the troponin C subunit.

(C) Release of the bound ADP and inorganic phosphate (P_i) from the myosin head.

(D) Hydrolysis of ATP into ADP and P_i by the structural myosin ATPase domain.

Q26. Which option details a correct statement regarding structural cell organelles and their internal metabolic functions?

(A) Lysosomes are double-membrane structures that synthesize lipid molecules.

(B) Nucleolus is a membrane-bound region inside the nucleus where translation takes place.

(C) Mitochondria are semi-autonomous organelles possessing circular DNA and 70S ribosomes.

(D) Rough Endoplasmic Reticulum is the major site for steroid hormone synthesis.

Q27. An experimental inhibitor blocks the enzyme phosphofructokinase during glycolysis. What immediate effect will this have on the net production of pyruvate and downstream ATP counts?

(A) Pyruvate yield doubles via alternate pathway activation.

(B) Glycolysis halts, stopping pyruvate synthesis and severely lowering anaerobic ATP generation.

(C) The cell shifts entirely to light-dependent photophosphorylation.

(D) Citric acid cycle functions normally without any alteration.

Q28. Which type of chromosomal structural mutation involves a segment breaking off, rotating 180°, and rejoining the exact same chromosome without changing gene counts?

(A) Duplication

(B) Translocation

(C) Inversion

(D) Deletion

Q29. In human genetics, a hemophilic male marries a homozygous normal female. What is the probability that their firstborn biological son will inherit hemophilia?

(A) 100%

(B) 50%

(C) 0%

(D) 25%

Q30. The biological process of translation termination requires which specific factor to recognize a stop codon (UAA, UAG, or UGA) arriving at the ribosomal A-site?

(A) Sigma Factor

(B) Rho Factor

(C) Release Factor (RF)

(D) Elongation Factor Tu

Q31. What occurs immediately during the depolarization phase of an action potential along an unmyelinated neuronal axon membrane?

(A) Voltage-gated potassium channels open rapidly, allowing efflux of K^+ ions.

(B) The sodium-potassium pump exchanges 3 Na^+ out for 2 K^+ in against gradient.

(C) Voltage-gated sodium channels open rapidly, allowing influx of Na^+ ions.

(D) Calcium channels open, forcing neurotransmitter vesicular fusion.

Q32. The fluid mosaic model of cell membrane structure states that the membrane consists of a fluid lipid bilayer with embedded proteins. Which property explains the lateral movement of proteins within the bilayer?

(A) Rigid hydrophobic core

(B) Quasi-fluid nature of lipids

(C) Continuous hydrophilic outer coat

(D) High concentration of peripheral carbohydrates

Q33. Which specific enzyme catalyzes the synthesis of a peptide bond during the translation elongation step in eukaryotic ribosomes?

(A) Aminoacyl-tRNA synthetase

(B) Peptidyl transferase (ribozyme)

(C) RNA Polymerase II

(D) Protease complex

Q34. Which of the following hormones works as a direct functional antagonist to Insulin, raising blood glucose levels by accelerating glycogenolysis in hepatocytes?

(A) Cortisol

(B) Thyroxine

(C) Glucagon

(D) Growth Hormone

Q35. A patient presents with a high basal metabolic rate, significant weight loss despite increased appetite, exophthalmos (protruding eyeballs), and tremors. Which endocrine condition is most likely responsible?

(A) Hypothyroidism (Myxedema)

(B) Hyperthyroidism (Grave's Disease)

(C) Hyperparathyroidism

(D) Hypoadrenalism (Addison's Disease)

Q36. During the light reactions of photosynthesis, what provides the direct thermodynamic driving force for ATP synthesis via the $CF_0 - CF_1$ particle complex?

(A) Oxidation of NADPH to NADP+

(B) Proton motive force generated by a transmembrane electrochemical proton gradient (ΔpH) across the thylakoid membrane

(C) Direct absorption of green wavelengths by accessory pigments

(D) Active transport of potassium ions out into the stroma

Q37. Which of the following features represents a defining characteristic of non-cyclic photophosphorylation that distinguishes it from cyclic photophosphorylation?

(A) Synthesis of ATP only

(B) Involvement of Photosystem I only

(C) Generation of both ATP and NADPH along with evolution of oxygen (O_2)

(D) Utilization of stroma lamellae instead of grana lamellae

Q38. A plant cell with an initial osmotic potential ($\psi_s = -0.8$ MPa) and pressure potential ($\psi_p = 0.2$ MPa) is placed in a beaker containing a sucrose solution with a total water potential ($\psi_w = -0.9$ MPa). What is the net direction of water movement?

(A) Net movement of water into the cell until turgor pressure doubles.

(B) No net movement because the systems are already at equilibrium.

(C) Net movement of water out of the cell into the solution, causing plasmolysis.

(D) Active influx of sucrose molecules into the vacuole.

Q39. Which molecular structure constitutes the true physical linker holding adjacent nucleosome core particles together in eukaryotic chromatin fiber layouts?

(A) Non-histone chromosomal proteins

(B) H1 linker histone protein along with linker DNA

(C) RNA primer fragments

(D) Centromeric repetitive satellite DNA

Q40. In double-stranded DNA, if a biochemical assay shows that Cytosine accounts for exactly 32% of the total nitrogenous bases present, what is the expected percentage of Thymine in this sample?

(A) 32%

(B) 18%

(C) 36%

(D) 64%

Detailed Solutions

Q1.

Solution

Concept: Plant and animal cells share several core eukaryotic organelles, including mitochondria, ribosomes, and the Golgi apparatus. However, they exhibit unique structural differences evolved to suit their distinct metabolic lifestyles. Plants require specialized plastids for synthesis/storage and a massive central vacuole to maintain turgor pressure.

Solution:

(a) Mitochondria, ribosomes, and the Golgi apparatus are basic, universal cellular machinery essential for cellular respiration, protein translation, and protein processing in both typical plant and animal systems.

(b) Plastids are a diverse group of double-membrane organelles specific to plant cells and algae. They include chloroplasts (for driving photosynthesis), chromoplasts (for pigment storage), and leucoplasts (for starch and oil storage).

(c) A large central vacuole often occupies up to 90

(d) Typical animal cells lack plastids entirely because they are heterotrophic organisms that do not manufacture their own food. Furthermore, they may possess multiple small, transient vacuoles, but never a single large central vacuole.

(e) Therefore, the definitive structural presence of plastids paired with a large central vacuole establishes a clear cytological distinction separating plant biology from typical animal architecture.

Final Answer: Plastids (chloroplasts, chromoplasts, leucoplasts) and a large central vacuole

Answer: (C)

Go Back to Question 1

Q2.

Solution

Concept: Meiotic prophase I is a highly regulated, extended phase subdivided into five structurally distinct sub-stages: leptotene, zygotene, pachytene, diplotene, and diakinesis. Genetic diversity relies heavily on recombination, which involves the physical breakage and swapping of non-sister chromatid segments mediated by complex enzymatic machinery.

Solution:

(a) During leptotene, chromatin fibers condense into visible chromosomes. In the subsequent zygotene stage, homologous chromosomes begin pairing up side-by-side in a configuration called synapsis, stabilized by the synaptonemal complex.

(b) The pachytene sub-stage initiates once synapsis is fully completed. Homologous pairs are visible as tetrads or bivalents consisting of four distinct chromatids.

(c) Genetic recombination via crossing over actively initiates during pachytene. Large protein assemblies called recombination nodules appear at intervals along the synaptonemal complex, holding the active enzymatic machinery.

(d) The key enzyme driving this molecular recombination process is the recombinase enzyme complex, which facilitates precise strands breaking and reciprocal exchanging between non-sister chromatids.

(e) Diplotene follows pachytene, characterized by the dissolution of the synaptonemal complex and the structural visibility of X-shaped cross-connection sites known as chiasmata, where crossing over has successfully concluded.

Final Answer: Pachytene

Answer: (C)

Go Back to Question 2

Q3.

Solution

Concept: The relationship modeling initial reaction velocity (v_0) as a function of substrate concentration ($[S]$) in single-substrate enzyme kinetics is mathematically defined by the standard Michaelis-Menten formulation: $v_0 = \frac{V_{\max}[S]}{K_m+[S]}$. Here, K_m is the substrate concentration at which the velocity hits half-maximum.

Solution:

(a) The problem establishes a specific condition where the operating substrate concentration is exactly double the value of the Michaelis constant, yielding the algebraic equality $[S] = 2K_m$.

(b) Substituting $2K_m$ directly in place of $[S]$ within the Michaelis-Menten expression yields the corresponding relation: $v_0 = \frac{V_{\max}(2K_m)}{K_m+2K_m}$.

(c) Simplifying the denominator term by combining the constants results in an updated expression: $v_0 = \frac{2V_{\max}K_m}{3K_m}$.

(d) Factoring out the mutual K_m variable from both the numerator and the denominator isolates the fractional coefficient, simplifying the entire equation cleanly down to: $v_0 = \frac{2}{3}V_{\max}$.

(e) This mathematical outcome demonstrates that when substrate levels reach twice the K_m threshold, the catalytic system operates at precisely two-thirds of its maximum theoretical velocity ($V_{\max}$).

Final Answer: $\frac{2}{3}V_{\max}$

Answer: (B)

Go Back to Question 3

Q4.

Solution

Concept: Nucleic acids are built from monomeric subunits whose structures are systematically assembled from three distinct molecular components: a nitrogenous base (purine or pyrimidine), a pentose sugar (ribose or deoxyribose), and a charged inorganic phosphate group.

Solution:

(a) A nucleoside represents a specific two-component structural unit consisting of a nitrogenous base covalently linked via an N-glycosidic bond to the $C1'$ position of a pentose sugar molecule.

(b) A nucleotide is formed when a nucleoside undergoes a chemical esterification reaction, attaching a phosphate group to the free hydroxyl group located at the $C5'$ position of the pentose sugar.

(c) Therefore, the core chemical difference distinguishing these two compounds relies entirely on the presence or absence of the highly charged phosphate group entity.

(d) Options suggesting that nucleotides lack a base, or that nucleosides carry the phosphate group, invert established biochemical terminology. Ribose versus deoxyribose designations reflect RNA/DNA differences, not nucleoside/nucleotide statuses.

(e) Consequently, a nucleotide is accurately defined as a complete phosphate ester of a nucleoside, possessing the essential phosphate component that its nucleoside precursor completely lacks.

Final Answer: A nucleotide possesses a phosphate group esterified to the sugar molecule, whereas a nucleoside lacks this phosphate.

Answer: (C)

Go Back to Question 4

Q5.

Solution

Concept: Mendel's Law of Independent Assortment asserts that alleles of distinct genes segregate into gametes independently of one another during meiosis, provided the genetic loci reside on different chromosomes or are situated far apart on the same chromosome.

Solution:

(a) The parental generation in this dihybrid cross involves two individuals that are completely heterozygous at both independent genetic loci, represented by the uniform double-heterozygous genotype $RrYy$.

(b) Each parent produces four distinct classes of gametes (RY, Ry, rY, and ry) in exactly equal proportions (25

(c) Combining these parental gametes in a comprehensive 16-square Punnett grid generates nine unique genotypic combinations among the resulting offspring.

(d) Grouping these genotypes according to their dominant and recessive expressions yields four distinct visible phenotypes: round-yellow, round-green, wrinkled-yellow, and wrinkled-green.

(e) Counting the individual occurrences across the grid reveals the classical Mendelian phenotypic distribution ratio of 9:3:3:1, confirming the operation of complete independent assortment without genetic linkage.

Final Answer: 9 : 3 : 3 : 1

Answer: (B)

Go Back to Question 5

Q6.

Solution

Concept: Pedigree analysis evaluates inheritance patterns across human generations. Sex-linked traits demonstrate distinct transmission profiles because males possess an XY sex chromosome pairing and are hemizygous for X-linked genes, whereas females possess a homomorphic XX pairing.

Solution:

(a) An affected father carries the mutant allele on his lone X chromosome (X^AY). He passes his Y chromosome to all of his sons, rendering them completely free of the trait.

(b) Conversely, an affected father must pass his single, mutant X chromosome to 100

(c) An affected heterozygous mother (X^AX^a) possesses a 50

(d) This matches the pedigree observation perfectly, where approximately half of her daughters and half of her sons inherit the phenotype from an affected maternal source.

(e) These asymmetric generational transmission phenotypes rule out autosomal mechanisms or recessive modes, explicitly confirming an X-linked dominant mode of genetic inheritance.

Final Answer: X-linked Dominant

Answer: (C)

Go Back to Question 6

Q7.

Solution

Concept: Prokaryotic DNA replication requires a specialized suite of DNA polymerases working in tandem to synthesize leading and lagging strands. Because DNA polymerases can only elongate existing strands, replication depends on temporary RNA primers synthesized by primase.

Solution:

(a) DNA Polymerase III functions as the main replicative enzyme complex, executing rapid, highly processive elongation of both strands, but it lacks the capacity to remove downstream RNA primers.

(b) As lagging-strand synthesis progresses, Okazaki fragments accumulate, separated by these short, embedded segments of temporary RNA primer sequences.

(c) DNA Polymerase I is a specialized enzyme possessing a crucial 5' to 3' exonuclease catalytic domain, allowing it to systematically degrade RNA primers lying ahead of it.

(d) Simultaneously, its 5' to 3' polymerase domain fills the structural gaps by adding complementary deoxyribonucleotides, utilizing the upstream Okazaki fragment as a primer.

(e) This dual primer excision and gap-filling property makes DNA Polymerase I unique, preparing the DNA nick for permanent structural sealing by DNA ligase.

Final Answer: DNA Polymerase I

Answer: (B)

Go Back to Question 7

Q8.

Solution

Concept: The Hardy-Weinberg equilibrium establishes a mathematical model relating allele frequencies to genotypic frequencies via the binomial expansion formula: $p^2 + 2pq + q^2 = 1$, where p is the dominant allele frequency (A) and q is the recessive allele frequency (a).

Solution:

(a) The question provides the absolute frequency of the homozygous recessive phenotype (aa), which corresponds directly to the algebraic term q^2, giving the value $q^2 = 0.16$.

(b) Taking the square root of this value yields the individual allele frequency for the recessive allele: $q = \sqrt{0.16} = 0.4$.

(c) Since the population contains only two alleles for this gene locus, the allele frequencies must sum to one ($p + q = 1$), isolating the dominant allele frequency: $p = 1 - 0.4 = 0.6$.

(d) The heterozygous genotype (Aa) frequency is represented by the middle term $2pq$. Substituting the computed values yields: $2pq = 2 \times 0.6 \times 0.4 = 0.48$.

(e) Converting this decimal value into a standard percentage format yields exactly 48

Final Answer: 48%

Answer: (A)

Go Back to Question 8

Q9.

Solution

Concept: Natural selection acts on phenotypic variations in populations through distinct profiles: stabilizing selection favors intermediate phenotypes, disruptive selection favors both phenotypic extremes, and directional selection systematically shifts the population mean toward one extreme over time.

Solution:

(a) Human birth weight is a classic example of stabilizing selection, where average-sized infants exhibit optimal survival rates compared to low or high birth-weight extremes.

(b) Industrial melanism in the peppered moth (*Biston betularia*) provides a well-documented textbook example of directional selection occurring over a rapid, human-observable timescale.

(c) Prior to the industrial revolution, light-colored moths matched light, lichen-covered tree trunks, enjoying a strong survival advantage against predatory birds.

(d) As coal soot blackened the woodlands, light moths became vulnerable while dark-colored (melanic) mutants gained camouflage, causing a rapid directional shift in allele frequencies toward the dark phenotype.

(e) Heterozygote advantage in sickle-cell anemia represents balancing selection, maintaining both alleles within malaria-endemic areas rather than directionally favoring a single phenotypic extreme.

Final Answer: Industrial melanism in the peppered moth (*Biston betularia*) during the industrial revolution in England.

Answer: (B)

Go Back to Question 9

Q10.

Solution

Concept: The genetic code utilizes a triplet nucleotide system to direct the incorporation of 20 amino acids during translation. This complex code exhibits distinct evolutionary characteristics, including being non-overlapping, universal, unambiguous, and degenerate.

Solution:

(a) The term unambiguous describes the feature where one specific codon sequence codes exclusively for a single amino acid, ensuring precise translation fidelity.

(b) The term degeneracy, or redundancy, refers to the property where a single amino acid can be specified by multiple distinct triplet codons.

(c) Because there are 64 possible triplet combinations but only 20 standard amino acids, many amino acids are specified by multiple codons that usually differ only at the third position.

(d) For example, both UUU and UUC code for phenylalanine, demonstrating how the genetic code accommodates nucleotide variations without altering the final polypeptide structure.

(e) This triplet redundancy allows the cell to tolerate certain point mutations, particularly wobble-position transitions, without suffering catastrophic alterations in essential protein functions.

Final Answer: Degeneracy (Redundancy)

Answer: (C)

Go Back to Question 10

Q11.

Solution

Concept:
The human female reproductive system is anatomically designed to facilitate gamete transport, fertilization, embryonic development, and gestation. Each sub-region of the fallopian tube and the multi-layered uterine wall possesses distinct structural attributes optimized to support these sequential physiological checkpoints during a successful pregnancy cycle.

Solution:

(a) The anatomical schematic highlights two critical regions of the reproductive tract. Site X points to the expanded lumen of the oviduct, specifically designated as the ampullary region, which provides the optimal microenvironment for gametic interaction.

(b) Fertilization between the secondary oocyte and a viable spermatozoon normally takes place within this ampullary domain, forming a diploid zygote that begins mitotic cleavage as it travels toward the womb.

(c) Layer Y denotes the highly vascularized, innermost mucosal lining of the uterine cavity, scientifically termed the endometrium, which undergoes significant cyclical proliferation under the direct influence of ovarian steroid hormones.

(d) During a healthy gestational cycle, the proliferating endometrium prepares for the reception of the blastocyst, providing a glandular and nutrient-rich cellular matrix where secure implantation can successfully occur.

(e) Other layers like the thick smooth-muscle myometrium drive powerful labor contractions rather than implantation, while the outermost perimetrium serves a purely protective structural role, making the identification of the ampulla and endometrium correct.

Final Answer: Site X is the ampullary region where fertilization occurs; Layer Y is the Endometrium where blastocyst implantation takes place.

Answer: (C)

Go Back to Question 11

Q12.

Solution

Concept:

Following double fertilization in angiosperms, the ovule undergoes complex morphogenetic transformations to develop into a mature seed. Each maternal tissue layer and embryonic precursor component inside the unfertilized ovule is pre-programmed to differentiate into a specific protective or nutritive post-fertilization structure.

Solution:

(a) The protective coverings of the unfertilized ovule, known as the integuments, undergo a hardening process to form the protective seed coat, ensuring the survival of the enclosed embryo.

(b) Specifically, the outer integument differentiates structurally to form the tough, waterproof outer layer of the seed coat called the testa, which shields internal tissues from mechanical damage and desiccation.

(c) The inner integument simultaneously develops into the thin, membranous inner layer of the seed coat known as the tegmen, providing an additional internal protective barrier.

(d) The entire megasporangium structure, or the ovule itself, matures into the complete seed, while the surrounding ovary wall transforms into the pericarp or fruit wall to assist in future dispersal.

(e) Pre-fertilization cells like the short-lived synergids degenerate rapidly after guiding the pollen tube, whereas the central cell gives rise to the triploid endosperm, validating the precise mapping of integuments to coat components.

Final Answer: Outer Integument → Testa; Inner Integument → Tegmen; Ovule → Seed

Answer: (B)

Go Back to Question 12

Q13.

Solution

Concept:
The human menstrual cycle is regulated by an intricate neuroendocrine feedback loop involving the hypothalamus, anterior pituitary gland, and ovaries. Ovulation represents the pivotal event of this monthly cycle, wherein a mature oocyte is released from the dominant Graafian follicle in response to shifting gonadotropin profiles.

Solution:

(a) In a standard 28-day human menstrual cycle, the early days are dominated by follicle-stimulating hormone, which promotes the growth and selection of a cohort of primary ovarian follicles.

(b) As the chosen Graafian follicle matures during the follicular phase, it secretes increasing amounts of estrogen, which eventually exerts a positive feedback effect on the anterior pituitary gland.

(c) This sustained estrogen peak triggers a sudden, dramatic release of luteinizing hormone, a physiological phenomenon widely referred to as the LH surge, which reaches its absolute maximum around the midpoint.

(d) The sharp spike in luteinizing hormone concentrations induces rapid follicular rupture and enzymatic breakdown of the ovarian wall, causing the release of the secondary oocyte during days 13 to 15.

(e) This critical window represents the highly fertile phase of the cycle, contrasting sharply with the early menstrual phase or the late luteal phase when progesterone dominates to support potential implantation.

Final Answer: Days 13–15

Answer: (C)

Go Back to Question 13

Q14.

Solution

Concept:
Intrauterine devices are highly effective medical implements inserted into the uterine cavity to prevent unwanted pregnancies. Non-hormonal variants rely on localized structural alterations and biochemical modifications of the uterine microenvironment rather than systemically disrupting the hypothalamic-pituitary-ovarian axis.

Solution:

(a) Non-hormonal intrauterine devices, which include options like the inert Lippes Loop or copper-releasing devices like CuT, operate primarily by eliciting a localized foreign-body reaction within the uterine lining.

(b) This localized physical presence stimulates a mild, non-bacterial inflammatory response, causing a significant influx of white blood cells and macrophages into the endometrial cavity.

(c) The elevated concentration of cellular scavengers dramatically increases the natural phagocytosis of spermatozoa traversing the uterine lumen, effectively neutralizing them before they can reach the fallopian tubes.

(d) Furthermore, copper-releasing variants continuously liberate ionized copper, which acts as a powerful local spermicide by altering the metabolic activity and flagellar beating patterns of individual sperm.

(e) By suppressing sperm motility and reducing their overall fertilizing capacity, these devices prevent gametic fusion entirely without inhibiting ovulation, altering systemic hormone levels, or requiring surgical ligation of the oviducts.

Final Answer: Increasing phagocytosis of sperm within the uterus via localized inflammatory response, with copper ions suppressing sperm motility.

Answer: (C)

Go Back to Question 14

Q15.

Solution

Concept:
Cellular respiration extracts biochemical energy from organic substrates through coordinated pathways. While oxidative phosphorylation yields the majority of cellular energy via an electron transport chain, substrate-level phosphorylation provides immediate energy through direct chemical transfer of a phosphate group to ADP.

Solution:

(a) Substrate-level phosphorylation occurs when a high-energy phosphate group is transferred directly from a phosphorylated metabolic intermediate to ADP or GDP, entirely independent of the chemiosmotic proton gradient.

(b) During the initial preparatory and payoff phases of glycolysis in the cytoplasm, the breakdown of one glucose molecule yields a total of four ATP molecules via substrate-level phosphorylation events.

(c) However, because two ATP molecules are consumed during the early hexokinase and phosphofructokinase priming reactions, the net yield of substrate-level phosphorylation during glycolysis is exactly two ATP.

(d) Inside the mitochondrial matrix, the tricarboxylic acid cycle processes two molecules of acetyl-CoA per glucose, generating two molecules of GTP, which are energetically equivalent to two molecules of ATP.

(e) Combining the net two ATP from glycolysis with the two ATP equivalents from the citric acid cycle results in a total of four net ATP produced purely by substrate-level phosphorylation.

Final Answer: 4 ATP

Answer: (B)

Go Back to Question 15

Q16.

Solution

Concept:
The light-dependent reactions of oxygenic photosynthesis rely on a coordinated series of electron transfers known as the Z-scheme. Photo-excitation of reaction center chlorophyll molecules results in electron expulsion, leaving behind a highly reactive, oxidized chlorophyll species that must be rapidly reduced to sustain continuous photosynthesis.

Solution:

(a) When light energy is absorbed by the antenna complex of Photosystem II, the excitation energy is funneled directly to the primary reaction center chlorophyll, specialized as P680.

(b) This energy boosts an electron to a high-energy state, prompting its ejection to a primary electron acceptor, which converts the neutral reaction center into a powerfully oxidizing P680+ radical.

(c) To restore its ground state and prepare for the next photon absorption event, P680+ must immediately acquire a replacement electron from an external donor source.

(d) This replacement electron is supplied by a unique manganese-containing oxygen-evolving complex that catalyzes the photolysis of water molecules within the inner thylakoid lumen.

(e) The water-splitting reaction breaks down water molecules into protons, molecular oxygen, and free electrons, thereby providing the continuous electronic flow required to sustain the linear transport chain.

Final Answer: Photolysis of water ($2H_2O \rightarrow 4H^+ + 4e^- + O_2$)

Answer: (A)

Go Back to Question 16

Q17.

Solution

Concept:
Plants utilizing the C4 photosynthetic pathway have evolved a specialized internal leaf arrangement, termed Kranz anatomy, to overcome the efficiency limitations of photorespiration. This mechanism segregates initial carbon capture and the final Calvin cycle into two distinct, specialized cell layers to maximize carbon fixation.

Solution:

(a) In C4 species like maize, sugarcane, and sorghum, the initial capture of atmospheric carbon dioxide does not involve the enzyme RuBisCO, which is highly prone to wasteful oxygenase side-reactions.

(b) Instead, gaseous carbon dioxide is converted into bicarbonate ions within the cytoplasm of outer mesophyll cells, where it encounters the specialized enzyme phosphoenolpyruvate carboxylase.

(c) The true primary carbon dioxide acceptor molecule in this spatial system is phosphoenolpyruvate, which is a highly reactive three-carbon organic compound native to the mesophyll layer.

(d) Phosphoenolpyruvate carboxylase fixes the carbon to create the four-carbon organic acid oxaloacetate, which is subsequently converted into malate or aspartate for transport.

(e) This fixed carbon is later transported into the deeper, thick-walled bundle sheath cells, where it is decarboxylated to concentrate carbon dioxide directly around RuBisCO, safely isolating it from atmospheric oxygen.

Final Answer: PEP (3-carbon) located in the Mesophyll cells

Answer: (B)

Go Back to Question 17

Q18.

Solution

Concept:
Plant growth and developmental patterns are strictly regulated by specific biochemical signaling entities termed phytohormones. These growth regulators act either synergistically or antagonistically to modulate cellular division, elongation, tissue differentiation, and responses to environmental stimuli.

Solution:

(a) The regulation of shoot architecture relies on a delicate, competitive balance between different classes of phytohormones traveling through vascular tissues.

(b) Endogenous auxins synthesized in the actively growing shoot apical meristem travel downward, establishing a strong physiological phenomenon known as apical dominance that directly represses axillary bud development.

(c) Cytokinins, which include naturally occurring variants like zeatin and kinetin, are synthesized predominantly within root apical meristems and travel upward through the xylem stream.

(d) Upon reaching the shoot system, cytokinins actively promote cellular division in axillary buds, effectively counteracting the inhibitory influence of auxin and stimulating lateral branch growth.

(e) Additionally, cytokinins delay the onset of leaf senescence by promoting nutrient mobilization, distinguishing them from abscisic acid, which triggers senescence, and gibberellins, which primarily drive internodal stem elongation.

Final Answer: Cytokinin (Zeatin / Kinetin)

Answer: (C)

Go Back to Question 18

Q19.

Solution

Concept:
The rhythmic contraction of the human heart is driven by a specialized cardiac conduction system composed of auto-rhythmic neuromuscular tissues. These structures exhibit varying intrinsic rates of spontaneous depolarization, establishing a hierarchical system of pacemaking dominance.

Solution:

(a) Under healthy physiological conditions, Node A, designated as the sinoatrial node, possesses the highest intrinsic frequency of spontaneous discharge, normally firing at seventy to eighty times per minute.

(b) Because the sinoatrial node depolarizes faster than any other downstream tissue, it drives the overall rhythm of the entire heart, acting as the primary pacemaker.

(c) Node B, known as the atrioventricular node, forms a critical electrical bridge between the upper atria and the lower ventricular chambers, possessing its own slower auto-rhythmic capabilities.

(d) If the sinoatrial node experiences a catastrophic failure or ceases to generate action potentials, the atrioventricular node automatically assumes control of the cardiac cycle as an emergency backup.

(e) Because its intrinsic pacemaking rate is naturally lower than the primary node, it commands a steady but reduced escape rhythm, typically firing between forty to sixty beats per minute.

Final Answer: Node B (AV Node) assumes pacemaker activity, but fires at a lower intrinsic rate (40 – 60 bpm).

Answer: (B)

Go Back to Question 19

Q20.

Solution

Concept:

An electrocardiogram traces the summation of electrical dipoles moving through cardiac muscle tissue over time. These electrical deflections are directly correlated with specific mechanical events within the cardiac cycle, allowing clinicians to precisely monitor cardiodynamic performance.

Solution:

(a) The standard electrocardiogram trace displays a sequence of distinct electrical waves, beginning with the low-amplitude P wave, which registers the spread of depolarization across the atria.

(b) The high-amplitude QRS complex represents a rapid, widespread wave of electrical depolarization sweeping through the thick muscular walls of the left and right ventricles.

(c) Because electrical activation serves as the immediate trigger for mechanical cross-bridge formation, this massive depolarization wave initiates ventricular systole.

(d) The onset of mechanical ventricular contraction begins immediately following the peak of the R wave, driving blood out into the pulmonary artery and systemic aorta.

(e) The subsequent T wave registers the slower process of ventricular repolarization, which marks the transition into ventricular diastole, meaning the QRS complex is perfectly synchronized with ventricular excitation.

Final Answer: Ventricular depolarization initiating ventricular systole.

Answer: (B)

Go Back to Question 20

Q21.

Solution

Concept:
The kidney maintains homeostatic fluid levels via a countercurrent multiplier mechanism running through specialized loops of Henle within the renal parenchyma. This intricate architectural framework selectively exploits passive and active transmembrane transport pathways across opposing parallel tubule segments to establish a steep osmotic concentration gradient stretching deep into the medullary tissue matrix.

Solution:

(a) The descending limb of the loop of Henle possesses thin epithelial walls featuring prominent aquaporin protein channels that render this segment highly permeable to water molecules.

(b) Because the surrounding medullary interstitium is hypertonic, water readily leaves the descending limb via passive osmosis, whereas the segment remains entirely impermeable to organic solutes and electrolytes.

(c) As a direct consequence of this selective fluid loss, the tubular fluid flowing within the descending segment becomes progressively concentrated as it approaches the hairpin turn.

(d) The ascending limb possesses a completely different structural profile, featuring a thick epithelial membrane that is entirely impermeable to water molecules under all baseline physiological conditions.

(e) Instead of moving fluid, the ascending segment utilizes specialized co-transporters to passively or actively transport sodium, potassium, and chloride ions outward into the interstitial fluid space.

Final Answer: The descending limb is highly permeable to water but impermeable to electrolytes; the ascending limb is impermeable to water but actively/passively transports electrolytes.

Answer: (B)

Go Back to Question 21

Q22.

Solution

Concept:
A basic reflex arc constitutes the fundamental structural and functional circuitry operating within the somatic nervous system to drive rapid, involuntary responses to external threats. This hardwired communication pathway relies on a specialized sequential sequence of neuronal cells to bridge peripheral receptors directly with central processing centers and muscle effectors.

Solution:

(a) When an environmental stimulus interacts with specialized sensory cutaneous receptors embedded in the skin matrix, it triggers a cascade of rapid action potentials.

(b) Neuron X functions as the primary afferent sensory pathway, collecting these localized peripheral impulses and propagating them along its axon toward the dorsal root of the spinal cord.

(c) Upon entering the gray matter of the central nervous system, this sensory cell communicates either directly or via an intermediate interneuron with the next pathway in the loop.

(d) Neuron Y emerges from the ventral horn of the spinal cord, classifying it as an efferent motor neuron that directs impulses away from the central integration center.

(e) This motor pathway terminates directly at the effector organ, such as a skeletal muscle bundle, stimulating rapid mechanical contraction to move the body part away from danger.

Final Answer: Neuron X is an afferent sensory neuron; Neuron Y is an efferent motor neuron.

Answer: (B)

Go Back to Question 22

Q23.

Solution

Concept:
The human gastric mucosa is lined with highly specialized epithelial pits containing distinct secretory cell populations. Each individual cell type is structurally adapted to synthesize and release specific biochemical agents that contribute uniquely to luminal digestion, microbial defense, or the systemic absorption of essential micronutrients.
Solution:

(a) Peptic or chief cells reside deep within the gastric glands and are responsible for synthesizing and releasing the inactive proteolytic proenzyme pepsinogen.

(b) Oxyntic or parietal cells constitute a distinct population of large, pyramidal secretory cells located predominantly along the mid-region of the gastric pits.

(c) These specialized oxyntic cells utilize hydrogen-potassium ATPase pumps to actively secrete concentrated hydrochloric acid directly into the stomach lumen, lowering the gastric pH.

(d) This acidic environment is critical for denaturing dietary proteins and cleaving inactive pepsinogen molecules into their active, catalytically functional pepsin forms.

(e) Simultaneously, parietal cells synthesize and secrete intrinsic factor, a specialized glycoprotein that binds dietary vitamin B12 to protect it and facilitate its receptor-mediated endocytosis within the terminal ileum.

Final Answer: Oxyntic or Parietal cells

Answer: (B)

Go Back to Question 23

Q24.

Solution

Concept:
The renin-angiotensin-aldosterone system acts as a primary neuroendocrine feedback mechanism for long-term blood pressure control and fluid volume regulation. Specialized baroreceptors and chemoreceptors within the juxtaglomerular apparatus track systemic perfusion levels and initiate a multi-organ biochemical cascade when internal fluid dynamics fall below baseline.
Solution:

(a) A sudden drop in systemic blood pressure or a reduction in total circulating blood volume decreases perfusion pressure within the afferent arteriole of the nephron.

(b) This physical deceleration stimulates specialized juxtaglomerular cells to synthesize and release the proteolytic enzyme renin directly into the systemic bloodstream.

(c) Renin acts catalytically upon circulating angiotensinogen, a plasma glycoprotein synthesized by the liver, converting it into the decapeptide intermediate known as angiotensin I.

(d) Angiotensin I is rapidly cleaved by endothelial converting enzymes, predominantly within the pulmonary vasculature, to produce the highly potent vasoconstrictor angiotensin II.

(e) Angiotensin II triggers widespread systemic arterial constriction while simultaneously stimulating the adrenal cortex to secrete aldosterone, driving sodium and water retention to restore homeostasis.

Final Answer: Release of Renin, converting angiotensinogen to angiotensin I, ultimately leading to aldosterone secretion.

Answer: (B)

Go Back to Question 24

Q25.

Solution

Concept:
Skeletal muscle contraction is driven at the molecular level by the sliding filament mechanism, described by the cross-bridge cycle. This continuous process involves a series of highly synchronized conformational shifts within the myosin heavy chain head as it interacts with adjacent actin polymers.

Solution:

(a) The cycle initiates when intracellular calcium binds to troponin C, inducing a conformational shift in tropomyosin that exposes the binding sites on the actin filament.

(b) The energized myosin head, bound to ADP and inorganic phosphate, binds to the exposed actin site to form a stable cross-bridge formation.

(c) The true power stroke represents the mechanical pivot of the myosin head that actively pulls the attached actin filament toward the central M-line.

(a) This specific mechanical pivoting action is directly triggered by the sequential release of the bound inorganic phosphate and ADP from the nucleotide-binding pocket.

(b) Following this power stroke, a fresh molecule of ATP must bind to the empty myosin head to induce cross-bridge dissociation, allowing the cycle to repeat.

Final Answer: Release of the bound ADP and inorganic phosphate (P_i) from the myosin head.

Answer: (C)

Go Back to Question 25

Q26.

Solution

Concept:
Eukaryotic cells are compartmentalized into distinct membrane-bound organelles that maintain unique internal microenvironments optimized for specific metabolic activities. Understanding cellular biology requires mapping these specialized structural components to their exact, universally conserved biochemical pathways and synthesis operations.

Solution:

(a) Lysosomes are single-membrane vesicles containing acid hydrolases that break down polymers; they do not possess double membranes nor do they synthesize lipids.

(b) The nucleolus is a highly dense, non-membrane-bound sub-region inside the nucleus dedicated to ribosomal RNA transcription and ribosomal subunit assembly, not translation.

(c) Mitochondria are classic semi-autonomous organelles enclosed by a double membrane system, containing their own circular DNA molecules and specialized 70S prokaryotic-like ribosomes.

(d) The rough endoplasmic reticulum is structurally studded with ribosomes dedicated to protein synthesis, whereas the smooth endoplasmic reticulum serves as the site for steroid hormone synthesis.

(e) Therefore, the statement detailing the semi-autonomous nature and prokaryotic ribosome profile of mitochondria represents the only factually accurate cytological description provided.

Final Answer: Mitochondria are semi-autonomous organelles possessing circular DNA and 70S ribosomes.

Answer: (C)

Go Back to Question 26

Q27.

Solution

Concept:
Glycolysis is a highly regulated, ten-step anaerobic metabolic pathway that converts glucose into pyruvate while generating immediate cellular energy. Key enzymes act as flux-generating checkpoints that dictate the overall pace of downstream carbohydrate catabolism based on current cellular energetic requirements.

Solution:

(a) Phosphofructokinase functions as a primary rate-limiting regulatory enzyme in glycolysis, catalyzing the irreversible phosphorylation of fructose-6-phosphate into fructose-1,6-bisphosphate using one ATP molecule.

(b) Introducing a targeted biochemical inhibitor blocks this enzyme, completely halting the forward flow of intermediates through the remainder of the glycolytic pathway.

(c) Because the pathway is disrupted midway, the cell can no longer generate downstream three-carbon intermediates like glyceraldehyde-3-phosphate or phosphoenolpyruvate.

(d) Consequently, the net synthesis of pyruvate drops to zero, terminating the substrate-level phosphorylation reactions that generate anaerobic ATP during the payoff phase.

(e) This disruption starves the downstream mitochondrial citric acid cycle of its primary acetyl-CoA precursor, severely compromising the cell's baseline aerobic and anaerobic energy production.

Final Answer: Glycolysis halts, stopping pyruvate synthesis and severely lowering anaerobic ATP generation.

Answer: (B)

Go Back to Question 27

Q28.

Solution

Concept:
Chromosomal aberrations represent structural rearrangements that alter the linear sequence or total concentration of genes along a DNA molecule. These structural mutations are categorized by their physical mechanics into deletions, duplications, translocations, or balanced orientations.

Solution:

(a) A deletion mutation results in the permanent loss of a chromosomal segment, whereas a duplication duplicates a region, both causing direct changes in gene dosage.

(b) A translocation involves an exchange of genetic material between entirely non-homologous chromosomes, shifting segments away from their original chromosomal locus.

(c) An inversion occurs when a single chromosome experiences two distinct internal structural breaks at separate loci along its longitudinal axis.

(d) The detached intervening segment rotates physically by exactly 180 degrees before being enzymatically reinserted and sealed back into the same location.

(e) Because no genetic material is gained or lost, this rearrangement preserves the original gene count while completely reversing the linear orientation of the alleles.

Final Answer: Inversion

Answer: (C)

Go Back to Question 28

Q29.

Solution

Concept:
Hemophilia is a classic sex-linked recessive disorder caused by genetic deficiencies in key blood coagulation factor genes located on the X chromosome. Tracing the inheritance probability of sex-linked conditions requires modeling how maternal and paternal sex chromosomes segregate into male and female offspring.

Solution:

(a) A hemophilic male possesses a single mutant allele on his lone X chromosome, which is represented mathematically by the hemizygous genotype X^hY.

(b) A homozygous normal female possesses two unaffected wild-type alleles on her sex chromosomes, establishing a uniform normal maternal genotype of X^HX^H.

(c) During meiosis and gametogenesis, the father contributes his mutant X^h chromosome to all of his daughters, rendering them obligate carriers of the trait.

(d) To produce a biological male offspring, the father must contribute his unaffected Y chromosome to the fertilization event rather than his X chromosome.

(e) The normal mother can only contribute an unaffected X^H chromosome to her sons, resulting in a completely normal male genotype (X^HY) with zero probability of disease.

Final Answer: 0%

Answer: (C)

Go Back to Question 29

Q30.

Solution

Concept:
The termination of protein translation represents a highly precise molecular checkpoint that halts polypeptide elongation once the ribosome encounters a stop codon sequence along an mRNA transcript. This pathway relies on specialized protein factors that mimic the structure of transfer RNA to access the catalytic center.

Solution:

(a) The triplet codon sequences UAA, UAG, and UGA do not correspond to any complementary anticodon sequences on normal, aminoacylated transfer RNA molecules.

(b) When one of these stop signals shifts into the ribosomal A-site, the absence of corresponding tRNAs causes a transient pause in translation elongation.

(c) This vacant codon is specifically recognized and bound by a class of specialized non-ribosomal proteins called release factors (RF).

(d) The bound release factor fits into the ribosomal active site and activates the peptidyl transferase center to execute a hydrolytic reaction.

(a) This hydrolysis cleaves the ester bond holding the completed polypeptide chain to the terminal transfer RNA molecule inside the adjacent P-site.

(b) This reaction frees the newly synthesized protein and prompts the complete structural dissociation of the ribosomal subunits from the mRNA template.

Final Answer: Release Factor (RF)

Answer: (C)

Go Back to Question 30

Q31.

Solution

Concept:
An action potential is an all-or-nothing electrochemical signal that propagates along a neuronal axon membrane. The generation of this nerve impulse depends on a series of rapid modifications in the electrical permeability of the axonal lipid bilayer, driven specifically by the opening and closing of voltage-sensitive transmembrane ion channels.
Solution:

(a) Under resting conditions, the neuronal membrane maintains a stable negative potential of approximately -70 mV, with a higher relative concentration of potassium inside and sodium outside.

(b) When an incoming stimulus depolarizes the local membrane past a specific threshold value, it triggers a sudden structural shift in nearby voltage-gated sodium channels.

(c) These selective channels open rapidly, allowing a massive influx of sodium ions down both their chemical concentration and electrical charge gradients into the intracellular fluid.

(d) This sudden inward movement of positive charges rapidly reverses the membrane polarity, shifting it from a negative state to a transiently positive value of about $+30$ mV.

(e) The slower voltage-gated potassium channels only begin to open as depolarization peaks, facilitating potassium efflux to reset the potential during the subsequent repolarization phase.

Final Answer: Voltage-gated sodium channels open rapidly, allowing influx of Na^+ ions.

Answer: (C)

Go Back to Question 31

Q32.

Solution

Concept:

The architectural framework of biological membranes is best explained by the universally accepted fluid mosaic model. This dynamic structural paradigm describes the cell membrane as a non-rigid, continuous matrix where individual molecular components are held together by non-covalent interactions, permitting independent kinetic movement within the plane of the bilayer.

Solution:

(a) The biological membrane is composed primarily of an amphipathic phospholipid bilayer, which forms a stable hydrophobic interior core and exposes hydrophilic head groups to aqueous surroundings.

(b) Rather than existing as a rigid or static crystalline barrier, the lipid molecules exhibit a highly dynamic, quasi-fluid nature at physiological body temperatures.

(c) This unique quasi-fluidity allows individual lipid molecules to undergo rapid lateral diffusion, exchanging positions with neighboring lipids thousands of times per second.

(d) Integral and peripheral membrane proteins are embedded like a mosaic tile layout within this shifting fluid lipid matrix rather than being chemically fixed.

(e) Because of this fluid environment, embedded proteins can migrate horizontally across the membrane surface, enabling essential interactions like receptor clustering and signal transduction.

Final Answer: Quasi-fluid nature of lipids

Answer: (B)

Go Back to Question 32

Q33.

Solution

Concept:
Translation elongation requires the sequential joining of amino acids via strong covalent bonds to build a growing polypeptide chain. This highly specific biosynthetic process takes place at the ribosomal ribosomal RNA catalytic center, which acts directly as an organic biological catalyst to facilitate rapid protein polymerization.

Solution:

(a) During translation elongation, an aminoacyl-tRNA molecule enters the empty A-site of the ribosome, matching its anticodon sequence precisely with the corresponding mRNA codon.

(b) The adjacent P-site holds the peptidyl-tRNA molecule, which is currently attached to the carboxyl terminus of the growing ancestral polypeptide chain.

(c) The formation of a new peptide bond requires a condensation reaction between the amino group of the incoming amino acid and the carboxyl group of the preceding one.

(d) This crucial reaction is driven by peptidyl transferase, which is an intrinsic catalytic activity located within the large ribosomal subunit structure.

(e) Remarkably, this catalytic activity is driven by a highly conserved catalytic ribosomal RNA molecule rather than a protein, classifying it structurally as a ribozyme.

Final Answer: Peptidyl transferase (ribozyme)

Answer: (B)

Go Back to Question 33

Q34.

Solution

Concept:
Systemic glucose homeostasis is carefully regulated through the balanced actions of counter-regulatory pancreatic endocrine hormones. While certain signaling molecules lower circulating carbohydrate levels, specialized antagonist hormones are secreted to elevate glucose concentrations when baseline values fall below homeostatic levels.

Solution:

(a) Insulin is secreted by the beta cells of the pancreatic islets of Langerhans to promote glucose uptake into peripheral tissues and reduce circulating blood sugar levels.

(b) Glucagon is synthesized and secreted by the alpha cells of the same pancreatic islets, acting as a direct primary physiological antagonist to insulin.

(c) When blood glucose levels decline between meals, glucagon is released into the portal circulation and targets hepatocytes in the liver.

(d) Upon binding to its specific G-protein coupled receptors, glucagon activates an intracellular signaling cascade that accelerates the metabolic pathway of glycogenolysis.

(e) This pathway catalyzes the systematic breakdown of stored glycogen polymers into free glucose molecules, which are then exported into the bloodstream to maintain equilibrium.

Final Answer: Glucagon

Answer: (C)

Go Back to Question 34

Q35.

Solution

Concept:
The thyroid gland secretes iodinated amine hormones that function as primary determinants of baseline cellular metabolic rate throughout the body. An overproduction of these active hormones accelerates mitochondrial respiration and cellular turnover, leading to a distinct cluster of neuromuscular and physiological symptoms.

Solution:

(a) The clinical presentation of a high basal metabolic rate combined with paradoxical weight loss despite an increased appetite indicates an overactivation of metabolic pathways.

(b) Tremors and heat intolerance are standard systemic signs of hyperthyroidism, which results from the unregulated hypersecretion of thyroxine and triiodothyronine.

(c) Graves' disease is an autoimmune endocrine disorder where abnormal autoantibodies bind to and stimulate the thyroid-stimulating hormone receptors on the thyroid gland.

(d) This uninhibited stimulation causes marked glandular hyperplasia and excessive hormone output, along with exophthalmos, which is caused by retro-orbital tissue inflammation.

(e) This condition contrasts sharply with hypothyroidism, which causes weight gain and lethargy, or Addison's disease, which stems from an adrenal cortex hormone deficiency.

Final Answer: Hyperthyroidism (Grave's Disease)

Answer: (B)

Go Back to Question 35

Q36.

Solution

Concept:
The light-dependent reactions of photosynthesis convert radiant solar energy into stable biochemical energy storage molecules. This energy transduction relies on a chemiosmotic mechanism where the physical movement of electrons through transport chains drives the creation of a powerful transmembrane electrochemical potential.

Solution:

(a) As electrons flow through the photosynthetic electron transport chain, protons are actively translocated from the stromal matrix into the internal thylakoid lumen.

(b) Simultaneously, the photolysis of water molecules inside the lumen releases additional protons, generating a steep transmembrane electrochemical proton gradient (ΔpH).

(c) This unequal distribution of protons across the thylakoid membrane establishes a powerful proton motive force that stores significant potential energy.

(d) The hydrophobic CF_0 base piece embedded in the membrane provides a channel that allows accumulated protons to flow back down their gradient toward the stroma.

(e) This passive proton movement drives conformational changes within the catalytic CF_1 headpiece, providing the thermodynamic energy needed to phosphorylate ADP into ATP.

Final Answer: Proton motive force generated by a transmembrane electrochemical proton gradient (ΔpH) across the thylakoid membrane

Answer: (B)

Go Back to Question 36

Q37.

Solution

Concept:
Light reactions in oxygenic photosynthesis can proceed via two distinct biophysical pathways depending on cellular energy demands and environmental conditions. Non-cyclic photophosphorylation operates as a continuous, linear electron transport system that requires the coordinated cooperation of two separate light-harvesting complexes.

Solution:

(a) Cyclic photophosphorylation is a restricted pathway that utilizes only Photosystem I and circulates electrons back through the cytochrome complex to generate ATP exclusively.

(b) Non-cyclic photophosphorylation involves the sequential operation of both Photosystem II and Photosystem I arranged in a linear electron transport chain.

(c) This linear flow begins with the photo-excitation of Photosystem II, which extracts replacement electrons by splitting water molecules, releasing oxygen gas as a byproduct.

(d) As these electrons move through the intermediary transport chain to Photosystem I, a proton gradient is established to drive ATP synthesis.

(e) The electrons are ultimately transferred to the terminal electron acceptor, reducing NADP+ to NADPH, thereby generating both energy and reducing equivalents.

Final Answer: Generation of both ATP and NADPH along with evolution of oxygen (O_2)

Answer: (C)

Go Back to Question 37

Q38.

Solution

Concept:
Water relations in plant cells are governed by the laws of thermodynamics, where the net movement of water is determined by the total water potential gradient. Water always migrates passively from an area of higher water potential to an area of lower water potential across a semi-permeable membrane.

Solution:

(a) The total water potential of a plant cell (ψ_w) is calculated as the sum of its internal osmotic potential (ψ_s) and pressure potential (ψ_p).

(b) Given the cell values, $\psi_w = \psi_s + \psi_p = -0.8$ MPa + 0.2 MPa = -0.6 MPa.

(c) The cell is then placed into an external sucrose solution that has a significantly lower total water potential, measured at $\psi_w = -0.9$ MPa.

(d) Comparing these values shows that the internal water potential of the plant cell (-0.6 MPa) is higher than that of the surrounding solution (-0.9 MPa).

(e) Consequently, water moves out of the cell into the hypertonic solution, reducing turgor pressure and leading to plasmolysis.

Final Answer: Net movement of water out of the cell into the solution, causing plasmolysis.

Answer: (C)

Go Back to Question 38

Q39.

Solution

Concept:
Eukaryotic genomic DNA is packed into a highly organized, condensed structure called chromatin to fit within the confined space of the nucleus. The basic structural unit of this architecture is the nucleosome, which relies on specific histone proteins to wrap and secure the double-helix structure.

Solution:

(a) A nucleosome core particle consists of an octamer of core histone proteins wrapped around by approximately 146 base pairs of double-stranded DNA.

(b) These individual nucleosome cores appear as beads on a string, connected sequentially by sections of intervening DNA known as linker DNA.

(c) The H1 histone protein binds to the site where DNA enters and exits the core particle, acting as a physical seal to stabilize the structure.

(d) Together, the H1 protein and the linker DNA form the physical bridge that links adjacent nucleosome core units together in the fiber.

(e) This linker assembly is critical for organizing individual beads into more condensed structures, such as the thirty-nanometer chromatin fiber layout.

Final Answer: H1 linker histone protein along with linker DNA

Answer: (B)

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Q40.

Solution

Concept:
The structural organization of double-stranded DNA is governed by strict base-pairing rules known as Chargaff's rules. These rules state that within a regular double-stranded DNA molecule, total purines equal total pyrimidines due to specific complementary hydrogen bonding requirements.
Solution:

(a) Chargaff's rules establish that adenine pairs exclusively with thymine, while guanine pairs exclusively with cytosine along the double-stranded polymer.

(b) Because of this fixed complementary base-pairing, the percentage of cytosine must equal the percentage of guanine present in the sample ($C = G = 32\%$).

(c) Summing these two values shows that cytosine and guanine together account for 64% of the total nitrogenous bases ($32\% + 32\% = 64\%$).

(d) The remaining portion of the genome must consist entirely of adenine and thymine base pairs, which is calculated as $100\% - 64\% = 36\%$.

(e) Since adenine and thymine are present in equal amounts, this remaining value is divided by two, yielding a thymine frequency of exactly 18%.

Final Answer: 18%

Answer: (B)

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Answer Key

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