BITSAT Biology Sample Paper-6

Duration: 60 Minutes **Maximum Marks: 120**

Instructions

- This paper contains **40** Multiple Choice Questions (Single Correct).
- Each correct answer carries **+3 marks**. Each incorrect answer carries: **−1** marks. Unattempted questions carry **0** marks.
- Only one option is correct for each question.
- Use of mobile phones, smartwatches, calculators, or any electronic gadgets is strictly prohibited.

Q1. Which of the following statements correctly differentiates the regulatory mechanisms of the operon system during the metabolism of lactose in Escherichia coli?

(A) The lac repressor is inactivated by the binding of glucose, allowing RNA polymerase to initiate transcription.

(B) In the absence of lactose, the repressor protein binds tightly to the promoter region, blocking transcription.

(C) Allolactose acts as an inducer by binding to the repressor, changing its conformation so it can no longer bind to the operator.

(D) The structural genes z, y, and a are transcribed into three separate monocistronic mRNA molecules when the inducer is present.

Q2. An investigator isolates a mutant strain of yeast that fails to transport proteins from the endoplasmic reticulum to the Golgi apparatus. A molecular analysis reveals a defect in a specific coat protein complex. Which vesicle coat is most likely non-functional in this mutant

(A) Clathrin

(B) COP I

(C) COP II

(D) Caveolin

Q3. Consider the following sequence of events during the process of microsporogenesis and male gametophyte development in angiosperms:

1. Generative cell undergoes mitosis to form two male gametes.
2. Microspore mother cell undergoes meiosis to form a microspore tetrad.
3. Microspore undergoes asymmetric mitosis to form a large vegetative cell and a small generative cell.
4. Dehydration of the anther causes the microspores to dissociate from each other.

Which of the following options represents the correct chronological order of these events?

(A) $2 \rightarrow 4 \rightarrow 3 \rightarrow 1$

(B) $2 \rightarrow 3 \rightarrow 4 \rightarrow 1$

(C) $4 \rightarrow 2 \rightarrow 3 \rightarrow 1$

(D) $2 \rightarrow 4 \rightarrow 1 \rightarrow 3$

Q4. In a classical Mendelian dihybrid cross involving yellow round seeds ($YYRR$) and green wrinkled seeds ($yyrr$), the F_2 generation exhibits a phenotypic ratio of 9:3:3:1. If a researcher randomly selects an F_2 plant displaying the dominant phenotype for both traits (yellow and round), what is the probability that this specific plant is completely homozygous for both loci?

(A) 1/16

(B) 1/9

(C) 1/4

(D) 2/9

Q5. Which of the following is an example of a homologous structure?

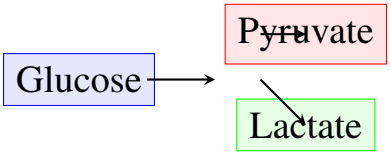
(A) Bat wing and insect wing

(B) Human arm and whale flipper

(C) Butterfly wing and bird wing

(D) Fish fin and insect wing

Q6. During anaerobic respiration, glucose is broken down into:



(A) Pyruvate and Lactate

(B) Acetyl-CoA and CO2

(C) Ethanol and CO2

(D) Glucose-6-phosphate and ATP

Q7. During a routine histological examination of human reproductive tissue, a medical student observes a specific developmental stage characterized by an outer layer of cells called the trophoblast and an inner cell mass.
Which of the following options correctly identifies this stage and its precise anatomical site of implantation within the female reproductive tract?

(A) Morula; Ampulla of the fallopian tube

(B) Blastocyst; Myometrium of the uterus

(C) Blastocyst; Endometrium of the uterus

(D) Gastrula; Fundus of the uterus

Q8. A molecular biologist design an experiment to amplify a target DNA sequence using Polymerase Chain Reaction (PCR). If the reaction mixture lacks heat-stable DNA polymerase (Taq polymerase) but contains standard human DNA polymerase instead, what will be the primary consequence after the first cycle of denaturation (94 degrees Celsius)?

(A) The primers will bind non-specifically to multiple unwanted regions of the template DNA.

(B) The human DNA polymerase will become permanently denatured and fail to extend the primers during the synthesis phase.

(C) The double-stranded template DNA will fail to separate into single strands.

(D) The phosphodiester backbone of the newly synthesized DNA strands will be hydrolyzed.

Q9. In an ecosystem experiencing primary ecological succession on a bare rock surface
which of the following sequences represents the correct order of seral stages leading to a stable climax community

(A) Lichens → Mosses → Herbs → Shrubs → Trees

(B) Mosses → Lichens → Shrubs → Herbs → Trees

(C) Lichens → Herbs → Mosses → Shrubs → Trees

(D) Mosses → Herbs → Lichens → Shrubs → Trees

Q10. Statement 1: The secondary immune response in humans is highly intensified (anamnestique) and occurs much faster than the primary immune response upon subsequent exposure to the same pathogen.
Statement 2: The rapid nature of the secondary immune response is primary driven by the presence of long-lived memory T and B cells that were generated during the initial encounter with the antigen.

(A) Both Statement 1 and Statement 2 are true, and Statement 2 is the correct explanation of Statement 1.

(B) Both Statement 1 and Statement 2 are true, but Statement 2 is not the correct explanation of Statement 1.

(C) Statement 1 is true, but Statement 2 is false.

(D) Statement 1 is false, but Statement 2 is true.

Q11. Which of the following represents the correct hierarchy of biological classification?

(A) Kingdom, Class, Phylum, Order, Family, Genus, Species

(B) Kingdom, Phylum, Class, Order, Family, Genus, Species

(C) Kingdom, Order, Class, Phylum, Family, Genus, Species

(D) Phylum, Kingdom, Class, Order, Family, Genus, Species

Q12. In the human nephron, the master regulation of water reabsorption in the collecting duct depends heavily on the action of Antidiuretic Hormone (ADH). A patient presents with a rare mutation that renders the ADH receptors in the kidney non-functional. What clinical presentation and physiological adjustments are expected?

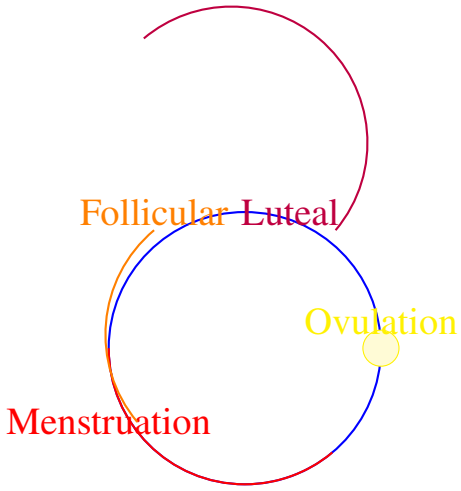
(A) Excretion of highly concentrated urine due to over-activation of aquaporins.

(B) Excretion of large volumes of dilute urine, accompanied by a decrease in blood pressure.

(C) Enhanced reabsorption of sodium ions in the proximal convoluted tubule to offset water loss.

(D) Increased secretion of aldosterone from the adrenal medulla to promote water retention.

Q13. Which stage of the menstrual cycle is the longest?



(A) Menstruation

(B) Follicular phase

(C) Ovulation

(D) Luteal phase

Q14. During an experiment on plant hormones, a researcher blocks the polar transport of auxin in a growing coleoptile. Which of the following physiological responses will be most directly inhibited as a result of this treatment?

(A) Rapid elongation of cells on the shaded side during phototropic bending.

(B) Promoted cell division in the lateral meristems leading to secondary growth.

(C) Abscission of mature leaves and fruits under environmental stress.

(D) Breaking of seed dormancy by stimulating amylase production in the aleurone layer.

Q15. The human menstrual cycle is tightly regulated by an intricate hormonal feedback loop involving the hypothalamus, anterior pituitary, and ovaries. Which of the following events acts as the immediate physiological trigger for the process of ovulation?

(A) A sudden drop in progesterone levels accompanied by degeneration of the corpus luteum.

(B) A sharp surge in Luteinizing Hormone (LH) levels induced by high positive feedback of estrogen.

(C) A gradual increase in Follicle Stimulating Hormone (FSH) during the luteal phase.

(D) High sustained levels of human Chorionic Gonadotropin (hCG) produced by the endometrium.

Q16. The Hardy-Weinberg principle states that allele frequencies in a population will remain constant from generation to generation in the absence of evolutionary influences. If a population is in Hardy-Weinberg equilibrium and the frequency of a recessive allele (a) is 0.4, what is the frequency of heterozygous individuals (Aa) in this population?

(A) 0.16

(B) 0.48

(C) 0.36

(D) 0.24

Q17. A bioprocess engineer scales up an industrial fermentation process to produce recombinant human insulin using a stirred-tank bioreactor. Which structural component of the bioreactor is specifically designed to ensure continuous availability of oxygen throughout the entire volume of the culture medium?

(A) The foam breaker system located at the top of the vessel.

(B) The pH control subsystem linked to an automated acid-base pump.

(C) The sparger combined with an agile impeller system.

(D) The sterile sampling port used for real-time monitoring.

Q18. In the human cardiac cycle, a precise sequence of electrical and mechanical events ensures efficient blood circulation. Which of the following options correctly describes the structural mechanism responsible for preventing the backflow of blood from the ventricles into the atria during ventricular systole?

(A) The closing of the semilunar valves caused by high arterial pressure.

(B) The tightening of the chordae tendineae attached to the AV valves as intraventricular pressure rises.

(C) The passive relaxation of the pectinate muscles within the right atrial wall.

(D) The active contraction of the sinoatrial node creating an electrical block.

Q19. Under conditions of high light intensity and low internal carbon dioxide concentration, C3 plants suffer a significant reduction in photosynthetic efficiency due to a metabolic process known as photorespiration. Which organelle sequence is involved in the metabolic pathway of photorespiration?

(A) Chloroplast → Mitochondria → Peroxisome

(B) Chloroplast → Peroxisome → Mitochondria

(C) Peroxisome → Chloroplast → Mitochondria

(D) Mitochondria → Peroxisome → Chloroplast

Q20. Statement 1: Plasmids are extensively used as cloning vectors in genetic engineering because they are extra-chromosomal, self-replicating, circular double-stranded DNA molecules found naturally in bacteria.
Statement 2: All eukaryotic vectors must contain a unique antibiotic resistance marker gene to allow active transcription within human host tissues.

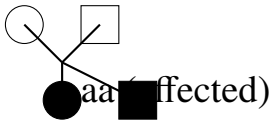
(A) Both Statement 1 and Statement 2 are true, and Statement 2 is the correct explanation of Statement 1.

(B) Both Statement 1 and Statement 2 are true, but Statement 2 is not the correct explanation of Statement 1.

(C) Statement 1 is true, but Statement 2 is false.

(D) Statement 1 is false, but Statement 2 is true.

Q21. Which of the following is an example of a recessive genetic disorder?



(A) Achondroplasia

(B) Cystic fibrosis

(C) Huntington disease

(D) Marfan syndrome

Q22. During replication of the lagging strand of DNA, synthesis occurs discontinuously in short segments called Okazaki fragments. Which of the following options accurately lists the enzymes required to complete synthesis of the lagging strand, in the correct operational sequence?

(A) DNA Ligase → DNA Polymerase I → Primase

(B) Primase → DNA Polymerase III → DNA Polymerase I → DNA Ligase

(C) DNA Polymerase III → Helicase → DNA Ligase → Topoisomerase

(D) Primase → DNA Ligase → DNA Polymerase III → Exonuclease

Q23. Muscle contraction is explained by the sliding filament mechanism. Which of the following biochemical events triggers the detachment of the myosin head from the actin binding site during the cross-bridge cycle?

(A) Hydrolysis of bound ATP into ADP and inorganic phosphate (P_i) by the myosin head.

(B) Binding of a new molecule of ATP to the myosin head.

(C) Active transport of calcium ions back into the sarcoplasmic reticulum.

(D) Conformational change in troponin caused by the release of magnesium ions.

Q24. A patient is diagnosed with a severe parasitic infection that induces an elevated allergic response. A differential white blood cell count reveals a dramatic increase in a specific type of granulocyte. Which leukocyte is primarily responsible for combating parasitic infections and mediating allergic reactions?

(A) Neutrophils

(B) Basophils

(C) Eosinophils

(D) Monocytes

Q25. In plant anatomy, the vascular cambium gives rise to secondary xylem and secondary phloem during secondary growth. If a mature dicot stem undergoes continuous secondary growth for five consecutive years, where would the oldest secondary xylem and the oldest secondary phloem be positioned relative to the vascular cambium ring?

(A) Oldest secondary xylem adjacent to the pith; oldest secondary phloem near the periphery.

(B) Oldest secondary xylem adjacent to the cambium; oldest secondary phloem near the cambium.

(C) Oldest secondary xylem near the periphery; oldest secondary phloem adjacent to the pith.

(D) Both oldest secondary xylem and phloem will be found intermingled within the cortex.

Q26. Which of the following features uniquely distinguishes members of the Phylum Chordata from all other animal phyla at some stage of their life cycle?

(A) Presence of a ventral nerve cord and a true coelom derived from the endoderm.

(B) A closed circulatory system and respiration through pharyngeal gill slits.

(C) Presence of a dorsal hollow nerve cord, a notochord, and pharyngeal gill slits.

(D) Bilateral symmetry, segmentations, and an open chitinous exoskeleton.

Q27. During cellular respiration, the generation of ATP via the electron transport chain involves the creation of a proton gradient across the inner mitochondrial membrane. If an uncoupling agent like 2,4-dinitrophenol (DNP) is introduced, making the inner mitochondrial membrane highly permeable to protons, what will be the immediate metabolic outcome?

(A) The electron transport chain will stop operating, halting oxygen consumption completely.

(B) Protons will bypass ATP synthase, decreasing ATP synthesis while releasing energy as heat.

(C) The citric acid cycle will accelerate rapidly to generate excess glucose via gluconeogenesis.

(D) The rate of NADH oxidation will drop to zero, shifting cells entirely to anaerobic lactic acid fermentation.

Q28. In the process of human oogenesis, the primary oocytes are formed during embryonic development. At which specific stage of cell division are these primary oocytes arrested until the individual reaches puberty?

(A) Metaphase of Meiosis I

(B) Prophase I (Diplotene stage) of Meiosis I

(C) Anaphase of Meiosis II

(D) Prophase II of Meiosis II

Q29. Biomolecules display unique structural properties. Which of the following statements correctly describes a structural characteristic of lipids?

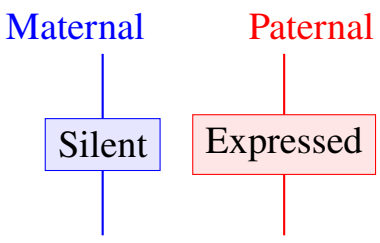
(A) Phospholipids are strictly hydrophobic molecules containing three long-chain saturated fatty acids linked to a nitrogenous base.

(B) Lecithin is a crucial components of the cell membrane characterized as a phosphorylated glycolipid.

(C) Triglycerides are formed via ester bonds connecting one molecule of glycerol with three molecules of fatty acids.

(D) Cholesterol is a polymer of amino acids arranged in a closed steroid ring structure.

Q30. The phenomenon where a gene is expressed only from the paternal chromosome is:



(A) Genomic imprinting

(B) X-inactivation

(C) Gene linkage

(D) Crossing over

Q31. Plant tissue culture relies on the concept of totipotency. A tissue culture specialist wants to induce rapid shoot differentiation from an undifferentiated mass of callus tissue. Which ratio of plant growth regulators should be added to the nutrient medium to achieve this?

(A) High concentration of abscisic acid paired with low gibberellins.

(B) Equal proportions of ethylene and auxins.

(C) High cytokinin concentration relative to auxin concentration.

(D) High auxin concentration relative to cytokinin concentration.

Q32. In the fluid mosaic model of the plasma membrane proposed by Singer and Nicolson, the membrane is described as a quasi-fluid structure. Which component of the membrane is primarily responsible for maintaining its fluidity at low temperatures, acting as a temperature buffer?

(A) Peripheral proteins bound to the polar head groups.

(B) Cholesterol molecules interspersed within the hydrophobic core.

(C) Oligosaccharide chains attached to intrinsic glycoproteins.

(D) Saturated fatty acid tails closely packed within the bilayer.

Q33. A evolutionary biologist analyzes the forelimbs of a human, the wings of a bat, and the flippers of a whale. Although these structures perform vastly different functions, they share a remarkably similar skeletal anatomy. What type of evolution do these structures demonstrate?

(A) Convergent evolution reflecting analogous origins driven by identical environmental selective pressures.

(B) Divergent evolution reflecting homologous origins derived from a common ancestral form.

(C) Saltational evolution resulting from macromutations within isolated populations.

(D) Co-evolution where interacting species modify each other's phenotypic traits over generations.

Q34. During the process of transcription in eukaryotes, the primary transcript (hnRNA) must undergo post-transcriptional modifications before it can be exported to the cytoplasm for translation. Which option lists these processing steps in their correct functional sequence?

(A) Polyadenylation at 3' end → Splicing → 5' Methylguanosine capping

(B) Splicing → Polyadenylation → Intron insertion

(C) 5' Methylguanosine capping → Splicing of exons → Polyadenylation at 3' end

(D) Exon removal → 5' Capping → Polyadenylation

Q35. Certain pathogenic bacteria produce dangerous endotoxins. In contrast, many viral pathogens hijack host machinery to replicate. Which of the following human diseases is caused by a protozoan pathogen and is transmitted via the bite of an infected female Anopheles mosquito vector?

(A) Dengue fever

(B) Amoebiasis

(C) Filariasis

(D) Malaria

Q36. The structural organization of a skeletal muscle cell reveals a highly organized arrangement of proteins. Which structural zone of the sarcomere contains only thick myosin filaments and shortens or disappears entirely during maximum muscle contraction?

(A) The I-band

(B) The A-band

(C) The H-zone

(D) The Z-line

Q37. Algae are photosynthetic organisms classified into distinct classes based on pigment composition and storage products. Which of the following options correctly matches the algal class with its major photosynthetic pigment and storage carbohydrate?

(A) Chlorophyceae; Fucoxanthin; Laminarin

(B) Phaeophyceae; Chlorophyll a and b; Starch

(C) Rhodophyceae; Phycoerythrin; Floridean starch

(D) Phaeophyceae; Phycoerythrin; Mannitol

Q38. In a field experiment, ecologists apply the principle of competitive exclusion formulated by G.F. Gause. This principle states that two species competing for the exact same limiting resource cannot coexist indefinitely. What is the most common evolutionary outcome that allows similar species to avoid exclusion and coexist within the same habitat?

(A) Genetic drift

(B) Resource partitioning

(C) Mimicry

(D) Biomagnification

Q39. An agricultural scientist creates a pest-resistant variety of cotton (Bt Cotton) by introducing specific genes isolated from the bacterium Bacillus thuringiensis. How does the cry protein produced by this transgenic plant destroy target insect pests like the bollworm?

(A) It blocks the transmission of nerve impulses across the insect's neuromuscular junctions.

(B) It binds to the epithelial cells of the insect's midgut, creating pores that cause swelling and lysis.

(C) It inhibits the synthesis of chitin, preventing the insect from forming a functional exoskeleton.

(D) It degrades the insect's genomic DNA within its salivary glands upon ingestion.

Q40. The structural stability of DNA molecules depends on multiple non-covalent interactions. If a double-stranded DNA segment contains 30% Adenine bases, what will be the percentage of Cytosine bases present within this specific DNA molecule?

(A) 30

(B) 20

(C) 40

(D) 70

Detailed Solutions

Q1.

Solution

Concept:

The lac operon in Escherichia coli regulates lactose metabolism via transcriptional control. This operon operates dynamically based on chemical interactions between an enzyme-blocking repressor protein, an inducing molecule, and specific control segments located directly on the prokaryotic DNA molecule.

Solution:

(a) The regulatory i gene undergoes constitutive transcription to yield a repressor protein. In the absolute absence of a lactose substrate, this tetrameric repressor protein attaches specifically to the operator segment, physically hindering RNA polymerase from advancing.

(b) When lactose enters the bacterial system, a minute portion is converted into allolactose, which serves as the physiological inducer molecule. Allolactose binds directly to the active site of the repressor, triggering a significant conformational shift.

(c) This structural modification drastically reduces the affinity of the repressor protein for the operator sequence. The altered repressor detaches completely from the operator site, leaving the genetic pathway open for downstream transcription.

(d) With the operator unoccupied, RNA polymerase freely binds the adjacent promoter region and transcribes the polycistronic lac mRNA containing the linked z, y, and a structural genes.

(e) Glucose regulates the operon indirectly through cyclic AMP levels rather than direct repressor inactivation, and eukaryotic cells utilize monocistronic rather than polycistronic mRNA formatting.

Final Answer: Allolactose acts as an inducer by binding to the repressor, changing its conformation so it can no longer bind to the operator.

Answer: (C)

Go Back to Question 1

Q2.

Solution

Concept:

Eukaryotic intracellular protein transport depends on distinct membrane-bound transport vesicles. These specialized structures are enveloped by specific cytosolic coat proteins that regulate vesicle budding, cargo selection, and directional movement between internal membrane compartments.

Solution:

(a) Vesicles traveling along the secretory pathway utilize distinct protein coats to navigate between the rough endoplasmic reticulum and the components of the Golgi complex.

(b) COP II coated vesicles specifically mediate anterograde transport, carrying newly synthesized proteins and lipids forward from the rough endoplasmic reticulum toward the cis-Golgi network.

(c) COP I coated vesicles regulate retrograde transport, recycling essential membrane proteins and processing enzymes backward from the Golgi apparatus to the endoplasmic reticulum.

(d) Clathrin coats are responsible for executing endocytosis at the plasma membrane and directing transport from the trans-Golgi network to lysosomes or endosomes.

(e) Because the yeast mutant fails to initiate the forward transport of proteins from the endoplasmic reticulum to the Golgi complex, the underlying molecular lesion must reside within the budding mechanism governed by the COP II complex.

Final Answer: COP II

Answer: (C)

Go Back to Question 2

Q3.

Solution

Concept:

Microsporogenesis and male gametophyte development represent the processes by which specialized diploid cells within the anther undergo sequential cell divisions and cellular differentiation to give rise to mature, functional haploid male gametes.

Solution:

(a) The process begins inside the microsporangium, where diploid microspore mother cells undergo meiosis to generate a connected tetrad of four haploid microspores.

(b) As the anther matures and undergoes mechanical dehydration, the internal fluid pressures change, causing the individual microspores within the tetrad to dissociate completely from one another.

(c) Each isolated haploid microspore undergoes an asymmetric mitotic division, characterized by an eccentric spindle structure, yielding a large vegetative cell and a small generative cell.

(d) The generative cell is initially engulfed within the cytoplasm of the vegetative cell, forming a two-celled pollen grain which is common during pollination.

(e) Either before pollen dispersal or within the growing pollen tube, the generative cell undergoes a second mitotic division to produce two functional male gametes.

Final Answer: $2 \rightarrow 4 \rightarrow 3 \rightarrow 1$

Answer: (A)

Go Back to Question 3

Q4.

Solution

Concept:

Mendelian dihybrid crosses demonstrate the principle of independent assortment, where alleles at separate genetic loci distribute independently during gamete formation. Calculating specific genotypic probabilities among a restricted phenotypic group requires precise subset analysis.

Solution:

(a) A cross between homozygous parents ($YYRR \times yyrr$) generates uniform heterozygous F_1 offspring ($YyRr$). Selfing these individuals yields 16 combinations in the F_2 generation.

(b) The phenotypic distribution follows a standard 9:3:3:1 ratio. The individuals exhibiting both dominant traits (yellow and round seeds) constitute exactly 9 out of the 16 total combinations.

(c) This specific dominant phenotypic class includes multiple distinct genotypes: $YYRR$ (1), $YYRr$ (2), $YyRR$ (2), and $YyRr$ (4).

(d) Out of these 9 plants displaying both dominant phenotypes, only a single individual possesses the completely homozygous genotype ($YYRR$).

(e) To find the probability within this specific subset, the number of completely homozygous dominant individuals (1) is divided by the total size of the dominant phenotypic class (9), resulting in a value of 1/9.

Final Answer: 1/9

Answer: (B)

Go Back to Question 4

Q5.

Solution

Concept:

Evolutionary biology distinguishes between anatomical structures based on developmental origins and adaptive functions. Homology indicates a shared ancestral lineage, providing direct evidence of divergent evolution where organisms modify a core structural blueprint to adapt to unique ecological niches.

Solution:

(a) Homologous structures are organs or skeletal elements that share a fundamentally similar anatomical design and embryonic origin across different species, despite serving diverse functional roles.

(b) The human arm and the whale flipper contain an identical sequence of bones: the humerus, radius, ulna, carpals, metacarpals, and phalanges, which confirms a common mammalian ancestor.

(c) While the human arm is adapted for manipulation and grasping, the whale flipper has been structurally modified for aquatic propulsion.

(d) Analogous structures represent the opposite phenomenon, where unrelated organisms develop superficially similar structures, such as insect wings and bat wings, purely to perform the same function.

(e) Analogy arises through convergent evolution under similar environmental pressures, whereas the matching bone architecture of humans and whales confirms true homology.

Final Answer: Human arm and whale flipper

Answer: (B)

Go Back to Question 5

Q6.

Solution

Concept:

Cellular respiration under anaerobic conditions allows cells to regenerate essential biochemical cofactors in the absence of oxygen. This pathway relies on cytoplasmic enzyme networks to extract metabolic energy by breaking down hexose sugars into simpler organic compounds.

Solution:

(a) Anaerobic respiration initiates with glycolysis in the cytosol, where a single six-carbon glucose molecule is broken down through sequential enzymatic steps into two three-carbon pyruvate molecules.

(b) During glycolysis, net energy is captured as two ATP molecules, and two molecules of the coenzyme NAD+ are reduced to NADH.

(c) In the absence of an electron transport chain, the cell must oxidize NADH back to NAD+ to sustain glycolysis. In mammalian muscle tissue, lactate dehydrogenase reduces pyruvate directly into lactate.

(d) In anaerobic yeast cells, pyruvate undergoes decarboxylation and reduction to form ethanol and carbon dioxide.

(e) The provided metabolic diagram explicitly tracks the sequential breakdown of the initial glucose substrate into pyruvate, which is subsequently converted into lactate within the anaerobic pathway.

Final Answer: Pyruvate and Lactate

Answer: (A)

Go Back to Question 6

Q7.

Solution

Concept:

Early human embryogenesis involves a highly coordinated sequence of morula formation, blastogenesis, and subsequent implantation. Each developmental stage features unique morphological characteristics and precise spatial alignment within the maternal reproductive tract.

Solution:

(a) Following fertilization in the ampulla, the zygote undergoes cleavage divisions to form a solid ball of cells called the morula, which moves toward the uterine cavity.

(b) Continued fluid accumulation transforms the morula into a hollow sphere known as the blastocyst, which features an outer trophoblast layer and an asymmetric inner cell mass.

(c) The outer trophoblast layer is specialized to mediate attachment and enzymatic invasion, whereas the inner cell mass gives rise to the embryo proper.

(d) Implantation occurs specifically when the blastocyst attaches to and embeds within the nutrient-rich functional layer of the endometrium, which forms the inner mucosal lining of the uterus.

(e) The myometrium is the middle muscular layer of the uterus and is not the site of initial embryo implantation, while the gastrula represents a later stage of development.

Final Answer: Blastocyst; Endometrium of the uterus

Answer: (C)

Go Back to Question 7

Q8.

Solution

Concept:

The Polymerase Chain Reaction relies on distinct thermal phases to amplify target DNA sequences. The molecular stability of the replicating enzymes under high-temperature stress dictates whether the polymerization cycle can successfully proceed.

Solution:

(a) A typical PCR cycle consists of three temperature-dependent steps: denaturation at 94 degrees Celsius, primer annealing at roughly 50 to 60 degrees Celsius, and extension at 72 degrees Celsius.

(b) The initial denaturation phase utilizes extreme heat to disrupt the hydrogen bonds stabilizing the double-stranded DNA template, separating it into two single-stranded targets.

(c) Standard human DNA polymerases are evolutionarily adapted to operate at normal physiological body temperatures around 37 degrees Celsius.

(d) Exposing standard human DNA polymerase to the 94 degrees Celsius denaturation temperature disrupts its non-covalent interactions, causing the enzyme to unfold and permanently lose its functional tertiary structure.

(e) Because the human enzyme is completely denatured during the first heating phase, it becomes completely inactive and cannot extend the primers when the temperature is lowered.

Final Answer: The human DNA polymerase will become permanently denatured and fail to extend the primers during the synthesis phase.

Answer: (B)

Go Back to Question 8

Q9.

Solution

Concept:

Primary ecological succession describes the orderly process of community development on a previously barren substrate lacking pre-existing organic soil. Pioneer species gradually modify the local environment, enabling more complex ecological seral stages to establish over time.

Solution:

(a) Primary succession on a bare rock surface (xerarch succession) begins with pioneer organisms, typically lichens, which secrete organic acids that chemically weather the rock matrix.

(b) The accumulation of weathered rock particles and decomposing organic matter forms a primitive soil layer, allowing small, drought-resistant mosses to secure a foothold.

(c) As the mosses die and deepen the organic soil profile, the habitat becomes suitable for annual and perennial herbaceous plants, which outcompete the pioneer species for light and space.

(d) The growing root networks further break down the rocky substrate, building a deeper soil base that supports the colonization of larger woody shrubs.

(e) Eventually, when the soil is deep and nutrient-rich enough, arborescent tree species establish themselves, culminating in a stable, self-sustaining climax forest community aligned with the local climate.

Final Answer: Lichens → Mosses → Herbs → Shrubs → Trees

Answer: (A)

Go Back to Question 9

Q10.

Solution

Concept:

The adaptive immune system displays immunological memory, allowing the human body to mount distinct physiological defenses upon repeated exposures to a specific foreign antigen. This mechanism depends on specialized cell lines generated during the primary immune response.

Solution:

(a) When the human body encounters a novel pathogen for the first time, it initiates a primary immune response characterized by a prolonged lag phase as naive B and T cells undergo clonal selection.

(b) This initial contact leads to the differentiation of active effector cells alongside a pool of long-lived, highly specialized memory B and memory T lymphocytes.

(c) Upon subsequent reinfection by the identical pathogen, these pre-existing memory cells immediately recognize the antigen, skipping the prolonged activation phase required by naive cells.

(d) This rapid activation triggers an accelerated, high-affinity secondary immune response that neutralizes the pathogen before significant disease symptoms manifest.

(e) Thus, Statement 1 accurately describes the clinical features of the secondary immune response, and Statement 2 correctly identifies the cellular memory mechanism that directly drives this heightened physiological efficiency.

Final Answer: Both Statement 1 and Statement 2 are true, and Statement 2 is the correct explanation of Statement 1.

Answer: (A)

Go Back to Question 10

Q11.

Solution

Concept:

Enzyme kinetics describes how biological catalysts accelerate metabolic reactions. Reversible enzyme inhibition is classified based on where the inhibitor binds, which dynamically influences the affinity for the substrate and the overall catalytic capacity of the enzyme.

Solution:

(a) A competitive inhibitor possesses a three-dimensional structural conformation that closely mimics the true substrate molecule, allowing it to compete directly for binding at the active site of the free enzyme.

(b) Because the inhibitor and substrate compete for the same physical location, high concentrations of substrate can displace the inhibitor, meaning the maximum velocity (V_{max}) remains completely unchanged at saturating substrate levels.

(c) However, because the inhibitor reduces the proportion of free enzyme molecules available to bind the substrate at lower concentrations, a higher amount of substrate is required to reach half of V_{max}.

(d) The Michaelis constant (K_m) is defined as the substrate concentration at which the reaction velocity reaches exactly half of its maximum value, serving as an inverse measure of substrate affinity.

(e) In the presence of a competitive inhibitor, the apparent K_m increases because the overall binding affinity between the enzyme and the substrate is effectively lowered by the competing molecule.

Final Answer: K_m increases; V_{max} remains unchanged

Answer: (C)

Go Back to Question 11

Q12.

Solution

Concept:

The renal system maintains fluid volume through osmoregulation overseen by the endocrine system. The hormone vasopressin, or antidiuretic hormone, controls water permeability in the distal regions of the nephron by triggering specific intracellular signaling pathways.

Solution:

(a) When osmoreceptors detect high blood osmolarity, the posterior pituitary gland secretes antidiuretic hormone into the bloodstream to act upon the basolateral membrane of the collecting duct cells.

(b) Under normal conditions, the binding of this hormone to its specific G-protein coupled receptors stimulates the intracellular insertion of aquaporin-2 water channels into the apical membrane.

(c) These aquaporin channels create a pathway that allows water to move passively out of the dilute tubular fluid and into the highly concentrated renal medullary interstitium.

(d) A mutation that renders these receptors non-functional prevents the insertion of aquaporins, making the collecting duct entirely impermeable to water regardless of circulating hormone levels.

(e) Consequently, water cannot be reabsorbed, leading to the clinical excretion of massive volumes of highly dilute urine, a condition known as nephrogenic diabetes insipidus, which causes dehydration and low blood pressure.

Final Answer: Excretion of large volumes of dilute urine, accompanied by a decrease in blood pressure.

Answer: (B)

Go Back to Question 12

Q13.

Solution

Concept:

Biological classification organizes the vast diversity of living organisms into an interconnected hierarchical system. This framework consists of mandatory taxonomic ranks arranged in a precise sequence based on shared evolutionary histories and structural complexities.

Solution:

(a) Linnaean taxonomy arranges organisms into a nested hierarchy where each successive tier represents a more specific grouping characterized by a higher degree of shared anatomical and genetic traits.

(b) The highest and most comprehensive standard category is the Kingdom, which groups broad assemblages of life, such as Animalia or Plantae, based on fundamental cellular characteristics.

(c) Kingdoms are divided into Phyla for animals or Divisions for plants, which segregate organisms based on distinct structural body plans or major anatomical features.

(d) Each Phylum is subdivided into Classes, which further partition the organisms into groups like Mammalia or Aves based on shared physiological adaptions.

(e) Following Class, the remaining taxonomic ranks proceed downward through Order, Family, Genus, and ultimately Species, which represents the most specific fundamental unit of biological classification capable of interbreeding.

Final Answer: Kingdom, Phylum, Class, Order, Family, Genus, Species

Answer: (B)

Go Back to Question 13

Q14.

Solution

Concept:

Plant growth and development are coordinated by chemical messengers known as phytohormones. Auxin, or indole-3-acetic acid, regulates differential growth movements like phototropism through asymmetric distribution within elongated tissues.

Solution:

(a) Phototropism is the directional growth of plant organs in response to an asymmetrical light source, causing shoots to bend toward the light and roots to grow away from it.

(b) When a growing coleoptile is exposed to unilateral light, active photoreceptors trigger the lateral translocation of auxin from the illuminated side to the shaded side of the tip.

(c) Auxin is transported downward through the tissue via specialized PIN proteins in a process called polar auxin transport, establishing a concentration gradient along the stem.

(d) The higher concentration of auxin on the shaded side stimulates active proton secretion into the cell wall, activating expansin proteins that loosen the cellulose microfibrils.

(e) This cell wall loosening permits rapid turgor-driven cell elongation on the shaded side, causing the coleoptile to bend toward the light; blocking this transport completely halts the phototropic response.

Final Answer: Rapid elongation of cells on the shaded side during phototropic bending.

Answer: (A)

Go Back to Question 14

Q15.

Solution

Concept:

The female reproductive cycle is governed by hormonal interactions between the hypothalamus, anterior pituitary, and ovaries. Ovulation requires a shift from negative to positive feedback control within this neuroendocrine axis.

Solution:

(a) During the early follicular phase, developing ovarian follicles secrete low levels of estrogen, which exerts negative feedback on the secretion of gonadotropins from the pituitary gland.

(b) As the dominant Graafian follicle matures, its granulosa cells proliferate rapidly and secrete increasingly high concentrations of estrogen into the systemic circulation.

(c) When circulating estrogen levels surpass a specific threshold and remain elevated for roughly 48 hours, the feedback mechanism switches from negative to strongly positive.

(d) This high concentration of estrogen acts directly on the hypothalamus and anterior pituitary, triggering a massive, rapid release of stored Luteinizing Hormone, known as the LH surge.

(e) This surge of Luteinizing Hormone induces enzymatic rupture of the follicular wall and follicular swelling, which expels the secondary oocyte into the fallopian tube during ovulation.

Final Answer: A sharp surge in Luteinizing Hormone (LH) levels induced by high positive feedback of estrogen.

Answer: (B)

Go Back to Question 15

Q16.

Solution

Concept:

Population genetics uses mathematical models to track allele and genotype frequencies within evolving groups. The Hardy-Weinberg principle provides a baseline model for populations that are free from active evolutionary forces.

Solution:

(a) The Hardy-Weinberg principle utilizes a simple algebraic expansion, $p^2 + 2pq + q^2 = 1$, where the variables p and q represent the frequencies of the dominant and recessive alleles respectively.

(b) The prompt establishes that the frequency of the recessive allele, designated as q, is exactly 0.4 within this stable population.

(c) Because the sum of all allele frequencies at a single genetic locus must equal one ($p + q = 1$), the frequency of the dominant allele, p, is calculated as $1 - 0.4 = 0.6$.

(d) Within the Hardy-Weinberg equation, the individual terms describe distinct genotypic classes: p^2 represents homozygous dominant individuals, q^2 represents homozygous recessive individuals, and $2pq$ represents heterozygous individuals.

(e) To calculate the frequency of the heterozygous genotype (Aa), the values are substituted into the middle term: $2 \times 0.6 \times 0.4 = 0.48$, which translates to 48 percent of the population.

Final Answer: 0.48

Answer: (B)

Go Back to Question 16

Q17.

Solution

Concept:

Bioprocess engineering optimizes the growth conditions for genetically engineered microorganisms in large-scale industrial cultures. Maintaining high concentrations of dissolved oxygen is essential for sustaining aerobic cellular respiration in dense populations.

Solution:

(a) A stirred-tank bioreactor is an industrial growth vessel designed to provide continuous mixing, nutrient distribution, and temperature regulation for biological cultures.

(b) Aerobic microorganisms consuming nutrients at high metabolic rates rapidly deplete the dissolved oxygen within the liquid nutrient broth, which can limit population growth and product yield.

(c) To prevent oxygen depletion, sterile air is pumped under high pressure into the base of the bioreactor through a specialized ring of micro-apertures called a sparger.

(d) The sparger breaks the incoming air stream into millions of small gas bubbles, vastly increasing the total surface area available for gas exchange with the liquid.

(e) Motorized impellers stir the broth to break up large bubbles, maximize bubble residence time, and distribute oxygen uniformly, preventing anaerobic pockets.

Final Answer: The sparger combined with an agile impeller system.

Answer: (C)

Go Back to Question 17

Q18.

Solution

Concept:

The cardiac cycle coordinates pressure changes within the heart chambers to maintain unidirectional blood flow. Structural valves open and close passively in response to changing hydrostatic forces.

Solution:

(a) The cardiac cycle transitions from atrial contraction to ventricular systole as electrical impulses propagate through the bundle of His and Purkinje fibers.

(b) As the ventricles contract, intraventricular pressure rises rapidly above atrial pressure, forcing blood backward against the flaps of the atrioventricular valves.

(c) This backward pressure forces the tricuspid and bicuspid valves closed, preventing blood from flowing back into the atria and directing it toward the arteries.

(d) To prevent these flexible valve cusps from prolapsing into the lower pressure atria, specialized fibrous cords called chordae tendineae anchor the valve edges to the papillary muscles.

(e) As the ventricles contract, the papillary muscles contract simultaneously, tightening the chordae tendineae to hold the valve flaps firmly in place against the high systolic pressure.

Final Answer: The tightening of the chordae tendineae attached to the AV valves as intraventricular pressure rises.

Answer: (B)

Go Back to Question 18

Q19.

Solution

Concept:

Photorespiration is a wasteful metabolic pathway that occurs when the enzyme RuBisCO binds oxygen instead of carbon dioxide. Processing the resulting toxic byproduct requires coordinated enzymatic steps across three distinct organelles.

Solution:

(a) When internal carbon dioxide levels drop, the oxygenase activity of RuBisCO fixes oxygen to ribulose-1,5-bisphosphate, producing one molecule of 3-phosphoglycerate and one molecule of 2-phosphoglycolate.

(b) The 2-phosphoglycolate cannot be used in the Calvin cycle and is converted to glycolate inside the stroma of the chloroplast.

(c) Transporter proteins move this glycolate out of the chloroplast and into an adjacent peroxisome, where it is oxidized to glyoxylate and then aminated to form the amino acid glycine.

(d) Two molecules of glycine exit the peroxisome and enter the matrix of a mitochondrion, where they undergo decarboxylation and deamination to form a single molecule of serine.

(e) This serine is transported back into the peroxisome and then the chloroplast to regenerate 3-phosphoglycerate, making the sequential organelle pathway proceed from Chloroplast to Peroxisome to Mitochondria.

Final Answer: Chloroplast → Peroxisome → Mitochondria

Answer: (B)

Go Back to Question 19

Q20.

Solution

Concept:

Recombinant DNA technology relies on cloning vectors to introduce foreign genetic material into target host cells. These vectors require specific structural elements to replicate independently and allow for the selection of transformed cells.

Solution:

(a) Plasmids are small, circular, double-stranded DNA molecules that exist independently of the bacterial chromosome, making them effective tools for genetic engineering.

(b) Because plasmids possess a distinct origin of replication, they replicate autonomously within a host cell, producing multiple copies of the inserted target gene.

(c) To identify host cells that have successfully taken up the plasmid, vectors carry selectable markers, which are typically genes that confer resistance to specific antibiotics.

(d) While selectable markers are essential for filtering out non-transformed cells, Statement 2 is false because eukaryotic cloning vectors do not require antibiotic resistance genes to drive transcription.

(e) Transcription in eukaryotic systems is driven by specific promoter and enhancer elements that recruit host RNA polymerases, making selectable markers unnecessary for the transcription process itself.

Final Answer: Statement 1 is true, but Statement 2 is false.

Answer: (C)

Go Back to Question 20

Q21.

Solution

Concept:

Autosomal recessive genetic disorders manifest phenotypically only when an individual inherits two mutant or non-functional alleles of a specific gene, one from each parent. Heterozygous carriers possess a single copy of the mutated allele and typically show no clinical symptoms of the condition. In pedigree analysis, this transmission pattern frequently skips generations, with unaffected carrier parents giving birth to affected offspring.

Solution:

(a) Cystic fibrosis is caused by a loss of function mutation in the CFTR gene located on chromosome 7, which impairs chloride ion transport and leads to thick mucus accumulation in the lungs and digestive tract. It follows a classic autosomal recessive inheritance pattern.

(b) Huntington disease is a neurodegenerative disorder inherited in an autosomal dominant manner, resulting from the expansion of CAG trinucleotide repeats in the HTT gene.

(c) Achondroplasia is a common form of dwarfism caused by a specific mutation in the FGFR3 gene, and it is inherited as an autosomal dominant trait.

(d) Marfan syndrome is an autosomal dominant connective tissue disorder caused by mutations in the FBN1 gene, which encodes the glycoprotein fibrillin-1.

(e) The provided diagram demonstrates a classic recessive trait lineage where unaffected parents yield affected individuals, confirming cystic fibrosis as the matching disease profile.

Final Answer: The correct option is Cystic fibrosis.

Answer: (B)

Go Back to Question 21

Q22.

Solution

Concept:

DNA replication is an asymmetric, semi-discontinuous process dictated by the antiparallel structure of the double helix. Because DNA polymerases can only synthesize new strands in a 5' to 3' direction, the lagging strand must be assembled in fragments.

Solution:

(a) As the replication fork opens, the lagging strand template is exposed in a 5' to 3' direction, requiring a specialized team of enzymes to synthesize the new strand discontinuously.

(b) The process initiates when the enzyme primase synthesizes a short RNA primer complementary to the template strand, providing a free 3'-OH group.

(c) DNA Polymerase III then binds to this primer and extends it, synthesizing an Okazaki fragment until it reaches the primer of the preceding fragment.

(d) Once the fragment is complete, DNA Polymerase I removes the RNA primer using its 5' to 3' exonuclease activity and replaces the missing nucleotides with DNA.

(e) Finally, DNA ligase catalyzes the formation of phosphodiester bonds to seal the nicks between adjacent fragments, joining them into a continuous DNA strand.

Final Answer: Primase → DNA Polymerase III → DNA Polymerase I → DNA Ligase

Answer: (B)

Go Back to Question 22

Q23.

Solution

Concept:

Muscle contraction relies on structural alterations governed by the sliding filament mechanism. This biochemical pathway uses the energy stored in adenosine triphosphate to drive cyclic structural interactions between actin and myosin.

Solution:

(a) The cross-bridge cycle describes the cyclic binding and release of the myosin head on the actin filament, which generates the mechanical force needed for muscle contraction.

(b) In the active state, the myosin head splits its bound ATP into ADP and inorganic phosphate, storing the released energy to cock into a high-energy conformation.

(c) This energized myosin head binds to an exposed active site on the actin filament, releasing the phosphate to trigger the power stroke that slides the filament.

(d) After completing the power stroke, ADP dissociates from the myosin head, leaving the actin-myosin cross-bridge locked in a stable, low-energy rigour state.

(e) To break this cross-bridge and allow the cycle to continue, a new molecule of ATP must bind to the myosin head, inducing a conformational shift that detaches it from actin.

Final Answer: Binding of a new molecule of ATP to the myosin head.

Answer: (B)

Go Back to Question 23

Q24.

Solution

Concept:

The immune system categorizes circulating white blood cells based on their lineage and internal morphology. Granulocytes contain specialized cytoplasmic vesicles filled with chemical mediators that neutralize specific classes of pathogens.

Solution:

(a) Eosinophils are specialized granulocytes that play a central role in defending the body against multicellular parasite infections and coordinating allergic inflammatory responses.

(b) When a parasitic worm enters the body, eosinophils migrate to the infection site and release toxic proteins from their granules to damage the parasite's outer membrane.

(c) These granules contain specialized enzymes, such as major basic protein and eosinophil cationic protein, that are optimized to destroy targets too large for phagocytosis.

(d) Eosinophils also express low-affinity surface receptors for IgE antibodies, allowing them to bind to antibody-coated parasites and release their granule contents directly onto the target.

(e) In contrast, neutrophils target smaller bacterial cells, basophils release histamine to trigger acute inflammation, and monocytes mature into large phagocytic macrophages.

Final Answer: Eosinophils

Answer: (C)

Go Back to Question 24

Q25.

Solution

Concept:

Secondary growth in dicotyledonous stems increases the diameter of the plant through the activity of lateral meristems. The vascular cambium produces new vascular tissues bidirectionally, continuously displacing older cell layers over time.

Solution:

(a) The vascular cambium is a ring of actively dividing meristematic cells located between the primary xylem and primary phloem in mature plant stems.

(b) When cambial cells divide, they produce secondary xylem cells toward the inside of the stem and secondary phloem cells toward the outside of the stem.

(c) Because new secondary xylem cells are added directly to the outer edge of the xylem core, older layers are pushed inward toward the central pith.

(d) Conversely, because new secondary phloem cells are added to the inner edge of the phloem layer, older phloem layers are pushed outward toward the cortex and bark.

(e) Over years of secondary growth, the oldest secondary xylem remains located deep inside adjacent to the pith, while the oldest secondary phloem is pushed to the outer periphery.

Final Answer: Oldest secondary xylem adjacent to the pith; oldest secondary phloem near the periphery.

Answer: (A)

Go Back to Question 25

Q26.

Solution

Concept:

Animal taxonomy categorizes organisms based on shared developmental patterns and structural features. The phylum Chordata is defined by a distinct suite of anatomical characteristics that must appear during at least one stage of development.

Solution:

(a) Members of the phylum Chordata are characterized by four unique structural traits: a notochord, a dorsal hollow nerve cord, pharyngeal gill slits, and a post-anal tail.

(b) The notochord is a flexible, rod-like structure that runs along the dorsal side of the embryo, providing structural support and serving as the framework for the vertebral column in vertebrates.

(c) The dorsal hollow nerve cord develops from ectoderm and forms the central nervous system, distinguishing chordates from non-chordates, which possess a solid, ventral nerve cord instead.

(d) Pharyngeal gill slits are perforations in the wall of the pharynx that function in filter-feeding or respiration in lower chordates, though they match embryonic arches in terrestrial vertebrates.

(e) Non-chordate phyla lack this combination of structures, often possessing open circulatory systems, solid ventral nerve cords, or external exoskeletons instead of an internal axial support skeleton.

Final Answer: Presence of a dorsal hollow nerve cord, a notochord, and pharyngeal gill slits.

Answer: (C)

Go Back to Question 26

Q27.

Solution

Concept:

Oxidative phosphorylation pairs the breakdown of nutrients with the synthesis of ATP by generating an electrochemical proton gradient across the inner mitochondrial membrane to drive ATP synthase.

Solution:

(a) During aerobic respiration, high-energy electrons from NADH and FADH2 travel through the electron transport chain, releasing energy that pumps protons into the intermembrane space.

(b) This active transport establishes an electrochemical proton gradient across the inner mitochondrial membrane, creating a proton-motive force that drives ATP synthesis.

(c) Uncoupling agents like 2,4-dinitrophenol act as lipid-soluble proton carriers that transport protons passively across the inner mitochondrial membrane, bypassing the ATP synthase channel.

(d) Dissipating the proton gradient uncouples electron transport from ATP synthesis, preventing the cell from producing ATP via oxidative phosphorylation.

(e) Because the energy stored in the gradient cannot be captured as ATP, it is lost as metabolic heat, while electron transport continues to consume oxygen.

Final Answer: Protons will bypass ATP synthase, decreasing ATP synthesis while releasing energy as heat.

Answer: (B)

Go Back to Question 27

Q28.

Solution

Concept:

Human oogenesis is a discontinuous developmental process that begins during embryonic growth. Meiotic division proceeds through specific stages before pausing at distinct points, regulated by chemical signals within the ovary.

Solution:

(a) Oogenesis initiates during fetal development when primordial germ cells differentiate into diploid oogonia, which multiply by mitosis before entering meiosis.

(b) These cells transform into primary oocytes and begin Meiosis I, but they are arrested early in the division process before birth occurs.

(c) This initial meiotic arrest occurs during the diplotene stage of Prophase I, where the homologous chromosomes remain paired but inactive for years.

(d) The primary oocytes remain dormant within protective primordial follicles until puberty, when monthly surges of gonadotropic hormones stimulate a small group to resume division.

(e) Upon resuming division, the primary oocyte completes Meiosis I to form a secondary oocyte and a polar body, which then arrests in Metaphase II until fertilization occurs.

Final Answer: Prophase I (Diplotene stage) of Meiosis I

Answer: (B)

Go Back to Question 28

Q29.

Solution

Concept:

Lipids are a diverse group of hydrophobic organic molecules composed primarily of hydrocarbons. They serve vital biological functions, including long-term energy storage, cellular signaling, and forming structural components of cell membranes.

Solution:

(a) Triglycerides, or neutral fats, are the primary energy-storage lipids in animals, formed by linking one glycerol molecule to three fatty acid chains via covalent ester bonds.

(b) Phospholipids are amphipathic molecules composed of a glycerol backbone linked to two hydrophobic fatty acid tails and a hydrophilic, charged phosphate head group.

(c) Lecithin is a specific type of phospholipid containing a choline group attached to the phosphate head, serving as a critical structural component of cell membranes.

(d) Cholesterol is a lipid characterized by a core structure of four fused carbon rings rather than amino acids, serving to modulate membrane fluidity.

(e) The options describe these structural features, confirming that triglycerides are assembled through ester linkages connecting a single glycerol molecule with three fatty acid chains.

Final Answer: Triglycerides are formed via ester bonds connecting one molecule of glycerol with three molecules of fatty acids.

Answer: (C)

Go Back to Question 29

Q30.

Solution

Concept:

Non-Mendelian inheritance includes epigenetic phenomena that alter gene expression without changing the underlying DNA sequence. These structural modifications result in parent-of-origin specific gene expression.

Solution:

(a) Genomic imprinting is an epigenetic process where specific genes are chemically marked with methyl groups during gametogenesis, silencing expression from one parent's chromosome.

(b) This allele-specific methylation pattern is maintained during mitosis in the offspring, ensuring that only the allele inherited from the non-imprinted parent is transcribed.

(c) As shown in the provided diagram, the maternal allele is methylated and remains transcriptionally silent, while the paternal allele remains unmethylated and is actively expressed.

(d) X-inactivation represents a different epigenetic mechanism where an entire X chromosome is randomly silenced in female mammals to achieve dosage compensation.

(e) This selective expression of a single gene based entirely on whether it was inherited from the father or the mother is defined as genomic imprinting.

Final Answer: Genomic imprinting

Answer: (A)

Go Back to Question 30

Q31.

Solution

Concept:

Plant tissue culture exploits the physiological property of totipotency, where isolated somatic cells regenerate into complete plants. Organogenesis is regulated by adding exogenous phytohormones to the nutrient medium in precise balancing concentrations.

Solution:

(a) An isolated plant tissue explant initially undergoes unorganized cell proliferation to form an undifferentiated, parenchymatous cell mass known as a callus.

(b) The subsequent structural differentiation of this callus into specific plant organs, such as roots or shoots, depends on the ratio of auxins to cytokinins.

(c) Cytokinins are adenine-derived plant growth regulators that stimulate cell division, chloroplast differentiation, and the structural development of axillary and adventitious shoots.

(d) High concentrations of cytokinins relative to auxins act as a molecular switch that suppresses root initiation while promoting rapid shoot differentiation from callus tissue.

(e) Conversely, a high auxin-to-cytokinin ratio promotes root differentiation, whereas balanced proportions of both hormones maintain the callus in an undifferentiated state.

Final Answer: High cytokinin concentration relative to auxin concentration.

Answer: (C)

Go Back to Question 31

Q32.

Solution

Concept:

The fluid mosaic model describes the plasma membrane as a dynamic, semi-fluid bilayer composed of amphipathic lipids interspersed with mobile proteins. Cellular survival requires homeostatic mechanisms to stabilize membrane fluidity against environmental temperature fluctuations.

Solution:

(a) The structural core of the plasma membrane consists of a phospholipid bilayer whose physical state changes from a flexible fluid to a rigid gel as temperatures drop.

(b) Steroid molecules known as cholesterol are embedded within the hydrophobic core of the membrane, positioned between the fatty acid tails of adjacent phospholipids.

(c) Cholesterol serves as a membrane fluidity buffer because its rigid ring structure prevents tight packing of saturated fatty acid chains at low temperatures.

(d) By disrupting this crystalline packing, cholesterol lowers the freezing point of the lipid bilayer, preventing the membrane from becoming overly rigid and brittle.

(e) At high temperatures, cholesterol restricts excessive phospholipid movement, ensuring the plasma membrane maintains its structural integrity across varying environmental conditions.

Final Answer: Cholesterol molecules interspersed within the hydrophobic core.

Answer: (B)

Go Back to Question 32

Q33.

Solution

Concept:

Comparative anatomy provides structural evidence of evolutionary lineages by analyzing phenotypic traits across different species. Divergent evolution occurs when a single ancestral structure adapts to distinct ecological roles.

Solution:

(a) The forelimbs of humans, bats, and whales represent classic examples of homologous structures because they share a fundamentally identical skeletal blueprint and embryonic development.

(b) This anatomical framework consists of a proximal humerus, intermediate radius and ulna, a cluster of carpals, and distal digits composed of metacarpals and phalanges.

(c) Despite their shared structural foundation, these limbs have been heavily modified by natural selection to perform vastly different mechanical functions like grasping, flying, or swimming.

(d) This pattern of anatomical variation provides direct evidence of divergent evolution, where lineages derived from a common ancestor accumulate structural differences over time.

(e) In contrast, convergent evolution produces analogous structures that share superficial functional similarities but lack a common ancestral origin, such as the wings of birds and insects.

Final Answer: Divergent evolution reflecting homologous origins derived from a common ancestral form.

Answer: (B)

Go Back to Question 33

Q34.

Solution

Concept:

Eukaryotic gene expression requires post-transcriptional modifications to convert the primary transcript into mature messenger RNA. This processing protects the transcript from enzymatic degradation and ensures accurate translation.

Solution:

(a) Transcription by RNA Polymerase II yields a primary transcript known as heterogeneous nuclear RNA, which contains alternating coding exons and non-coding introns.

(b) Co-transcriptional modification begins immediately during elongation, where a protective 7-methylguanosine cap is added to the 5' end via an unusual 5'-to-5' triphosphate linkage.

(c) Following transcription termination, an endonuclease cleaves the 3' end of the pre-mRNA, and polyadenylate polymerase adds a sequence of adenine residues to form a poly-A tail.

(d) The raw transcript then undergoes splicing, where large macromolecular complexes called spliceosomes precisely excise the non-coding introns and ligate the coding exons together.

(e) This orderly sequence of capping, tailing, and splicing converts raw hnRNA into functional mRNA, which is then exported from the nucleus to the cytoplasm for translation.

Final Answer: 5' Methylguanosine capping → Splicing of exons → Polyadenylation at 3' end

Answer: (C)

Go Back to Question 34

Q35.

Solution

Concept:

Infectious medical pathology classifies human diseases based on the structural characteristics of the underlying pathogen and its specific transmission vector. Vector-borne diseases require a biological agent to complete their life cycle.

Solution:

(a) Infectious diseases are caused by a variety of biological agents, including viruses, bacteria, fungi, helminths, and microscopic single-celled protozoans.

(b) Malaria is a parasitic disease caused by protozoan organisms belonging to the genus Plasmodium, with Plasmodium falciparum and Plasmodium vivax being the primary human pathogens.

(c) This protozoan parasite is transmitted to human hosts through the bite of an infected female Anopheles mosquito, which introduces sporozoites during a blood meal.

(d) Dengue fever is caused by a flavivirus transmitted by Aedes mosquitoes, amoebiasis is caused by an intestinal protozoan without an insect vector, and filariasis is caused by nematodes.

(e) Because Malaria is caused by a unicellular protozoan and relies on the Anopheles vector to complete its sexual reproductive phase, it matches the criteria specified in the prompt.

Final Answer: Malaria

Answer: (D)

Go Back to Question 35

Q36.

Solution

Concept:

The sarcomere is the functional contractile unit of myofibrils within skeletal muscle cells. Contraction is driven by the ATP-dependent sliding of thin actin filaments past stationary thick myosin filaments.

Solution:

(a) A sarcomere is structurally bounded by two dark vertical lines called Z-discs, which anchor the thin actin filaments extending inward toward the center.

(b) The structural arrangement of these overlapping filaments creates distinct bands: the light I-band contains only thin actin filaments, while the dark A-band spans the entire length of the thick myosin filaments.

(c) In the center of the relaxed A-band lies a paler region known as the H-zone, which contains only thick myosin filaments with no actin overlap.

(d) During muscle contraction, the myosin heads pull the thin actin filaments inward toward the M-line, increasing the region of filament overlap.

(e) As the actin filaments slide toward the center, the width of the H-zone decreases, causing it to disappear entirely during maximum muscle contraction.

Final Answer: The H-zone

Answer: (C)

Go Back to Question 36

Q37.

Solution

Concept:

Phycology categorizes photosynthetic algae into three major classes based on their primary light-harvesting accessory pigments, cellular wall composition, and biochemical storage products.

Solution:

(a) Members of the class Chlorophyceae, or green algae, possess chlorophyll a and b pigments and store excess photosynthetic energy as starch within specialized pyrenoids.

(b) The class Phaeophyceae, or brown algae, is characterized by the carotenoid pigment fucoxanthin, which masks chlorophylls a and c and produces mannitol and laminarin carbohydrates for storage.

(c) The class Rhodophyceae, or red algae, contains high concentrations of the accessory phycobiliprotein pigment alpha-phycoerythrin, which absorbs blue light at great ocean depths.

(d) Red algae store their fixed carbon as Floridean starch, a branched glucose polymer structurally similar to amylopectin and glycogen found in land plants and animals.

(e) The options list these diagnostic biochemical characteristics, confirming that Rhodophyceae uniquely pairs the phycoerythrin pigment with Floridean starch storage.

Final Answer: Rhodophyceae; Phycoerythrin; Floridean starch

Answer: (C)

Go Back to Question 37

Q38.

Solution

Concept:

Community ecology analyzes the competitive interactions that shape species distribution within an ecosystem. Gause's principle dictates that species with identical ecological niches face competitive exclusion if resources are strictly limiting.

Solution:

(a) The competitive exclusion principle states that two distinct species competing for the exact same limiting resource cannot stably coexist if all other ecological factors remain constant.

(b) To avoid competitive exclusion and extinction, coexisting species undergo natural selection that drives differentiation of their realized niches over evolutionary time.

(c) This evolutionary adaptation is known as resource partitioning, where species modify their behavior, feeding times, or structural traits to share resources.

(d) For example, similar bird species might forage in different parts of the same tree canopy or shift their activity patterns to hunt at different times of day.

(e) Resource partitioning reduces direct interspecific competition, allowing ecologically similar species to successfully coexist within the same biological community.

Final Answer: Resource partitioning

Answer: (B)

Go Back to Question 38

Q39.

Solution

Concept:

Agricultural biotechnology uses recombinant DNA methods to engineer pest-resistant crops. Transgenic Bt cotton expresses insecticidal crystal proteins derived from the soil bacterium Bacillus thuringiensis.

Solution:

(a) The genome of Bacillus thuringiensis contains cry genes that encode inactive crystalline protoxins during the sporulation phase of the bacterium.

(b) Genetic engineers isolate these cry genes and integrate them into the cotton genome, causing the transgenic plant tissues to continuously express the insecticidal protein.

(c) When a target lepidopteran insect pest eats the Bt cotton plant, it ingests the inactive protoxin along with the plant tissue.

(d) The highly alkaline environment of the insect midgut solubilizes the crystal matrix and triggers enzymatic cleavage, converting the protoxin into an active toxin.

(e) This active toxin binds specifically to receptors on the midgut epithelial cells, inserting into the membrane to form pores that disrupt osmotic balance, causing cell lysis and death.

Final Answer: It binds to the epithelial cells of the insect's midgut, creating pores that cause swelling and lysis.

Answer: (B)

Go Back to Question 39

Q40.

Solution

Concept:

The structural architecture of double-stranded DNA follows strict base-pairing constraints discovered by Erwin Chargaff. These rules dictate that the total quantity of purine bases always equals the total quantity of pyrimidine bases.

Solution:

(a) Chargaff's rules establish that within any double-stranded DNA molecule, adenine bases pair exclusively with thymine bases, while guanine bases pair exclusively with cytosine bases.

(b) Because of this complementary base pairing, the percentage of adenine must equal the percentage of thymine ($A = T$), and the percentage of guanine must equal the percentage of cytosine ($G = C$).

(c) The prompt states that the double-stranded DNA segment contains exactly 30 percent adenine, which means the thymine content must also be 30 percent ($A + T = 30\% + 30\% = 60\%$).

(d) The remaining portion of the DNA molecule consists of guanine and cytosine bases, which is calculated as $100\% - 60\% = 40\%$.

(e) Since guanine and cytosine are present in equal amounts ($G = C$), this remaining 40 percent is divided equally, resulting in exactly 20 percent cytosine bases.

Final Answer: 20

Answer: (B)

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Answer Key

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