AIIMS Paramedical Biology Sample Paper – 12

Duration: 30 Minutes **Maximum Marks: 30**

Instructions

- This paper contains **30** Multiple Choice Questions (Single Correct Answer), modelled on the Biology portion of **AIIMS Paramedical** entrance.
- Each correct answer carries **+1 mark**. Each incorrect answer attracts **a penalty of $-\frac{1}{3}$ mark**. Unattempted questions carry **0 marks**.
- Only **one** option is correct. Choose carefully.
- Syllabus level: **Class 11 & 12 NCERT Biology**
- Use of mobile phones, calculators, or electronic gadgets is strictly prohibited.

Q1. An unlabelled tissue slide shows cells with uniform thickening at the corners due to the deposition of cellulose, hemicellulose, and pectin. The cells are living and provide mechanical support to the growing parts of the plant. Identify this tissue.

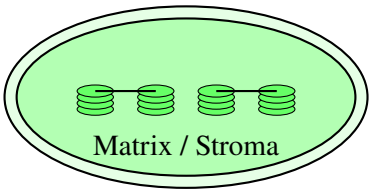
(A) Sclerenchyma

(B) Collenchyma

(C) Parenchyma

(D) Xylem vessels

Q2. Consider the following schematic representing a specific eukaryotic cell organelle structural component:



Which metabolic pathway possesses its major limiting enzymes localized directly within the stacked internal membranous structures shown inside this organelle?

(A) Tricarboxylic acid cycle

(B) Glycolysis

(C) Light-dependent reactions of photosynthesis

(D) Calvin-Benson Cycle

Q3. A patient presents with extreme fatigue and a clinical report indicating megaloblastic anemia. The physician suspects a complete lack of intrinsic factor secretion. Which specific cells of the gastric mucosa are malfunctioning?

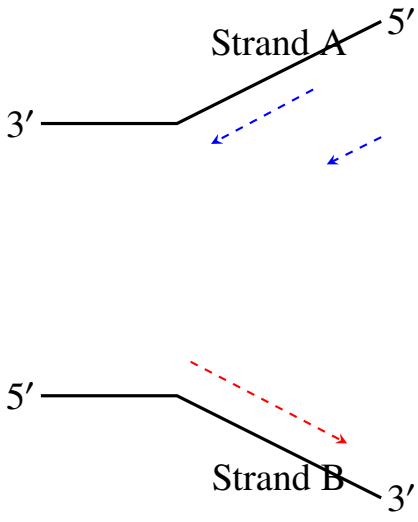
(A) Peptic or chief cells

(B) Mucus neck cells

(C) Oxyntic or parietal cells

(D) Argentaffin cells

Q4. The diagram below shows a classic representation of DNA replication fork dynamics:



Which of the following correctly describes the synthesis occurring specifically along Strand A?

(A) Continuous synthesis running in the $5' \rightarrow 3'$ direction towards the replication fork

(B) Discontinuous synthesis producing Okazaki fragments away from the replication fork

(C) Discontinuous synthesis running in the $3' \rightarrow 5'$ direction

(D) Continuous synthesis using RNA polymerase without requiring primers

Q5. During a field study of an open grassland ecosystem, an ecologist constructs a pyramid of biomass. Which of the following trends is expected, and how does it compare to a typical marine ecosystem?

(A) Grassland: Inverted; Marine: Upright

(B) Grassland: Upright; Marine: Upright

(C) Grassland: Inverted; Marine: Inverted

(D) Grassland: Upright; Marine: Inverted

Q6. A pure-breeding pea plant with yellow and round seeds ($YYRR$) is crossed with a pure-breeding pea plant with green and wrinkled seeds ($yyrr$). If the F_1 generation is self-pollinated, what is the theoretical probability of obtaining offspring that express a recombinant phenotype showing green and round seeds?

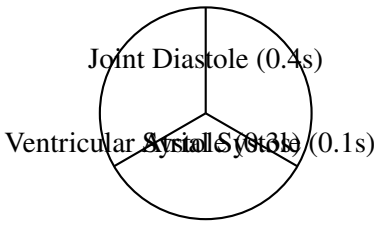
(A) $9/16$

(B) $3/16$

(C) $1/16$

(D) $6/16$

Q7. The schematic below represents the relative durations of the mechanical phases within a single human cardiac cycle:



During which specific segment of the timeline presented above do the atrioventricular valves remain tightly shut while the semilunar valves are forced open?

(A) Joint Diastole

(B) Atrial Systole

(C) Ventricular Systole

(D) Throughout the entire 0.8 seconds duration

Q8. An unlabelled slide shows a transverse section of an organism exhibiting a pseudocoelom flanked by ectoderm and an undifferentiated mesodermal layer that does not completely line the cavity. To which phylum does this organism belong?

(A) Annelida

(B) Aschelminthes

(C) Platyhelminthes

(D) Arthropoda

Q9. An analytical biochemistry procedure isolates a segment of double-stranded DNA. If the molar composition of Cytosine is determined to be 28%, calculate the expected percentage composition of Adenine in this specific sample?

(A) 22%

(B) 28%

(C) 44%

(D) 56%

Q10. Which of the following choices correctly matches an animal phylum with its unique anatomical trait?

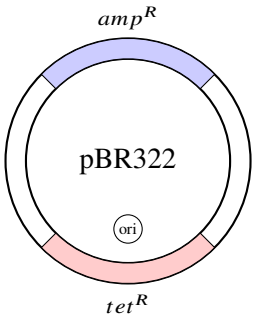
(A) Ctenophora → Radially symmetrical, pseudocoelomate with cnidocytes

(B) Porifera → Cellular level of organization with a water canal system lined by choanocytes

(C) Platyhelminthes → Coelomate, segmented bodies with flame cells

(D) Echinodermata → Bilaterally symmetrical adults with a chitinous exoskeleton

Q11. The cloning vector pBR322 is extensively used in recombinant DNA technology. The diagram below highlights its structural layout:



If a foreign gene of interest is ligated specifically at the unique *Bam*HI restriction endonuclease site located inside the tet^R gene, what transformation outcome is expected?

(A) Transformants lose resistance to ampicillin but remain resistant to tetracycline

(B) Transformants retain resistance to tetracycline but lose viability completely

(C) Transformants become sensitive to tetracycline while remaining resistant to ampicillin

(D) Transformants gain resistance to both ampicillin and tetracycline simultaneously

Q12. In human female reproductive physiology, a sharp mid-cycle surge of which hormone acts as the immediate physiological trigger for ovulation?

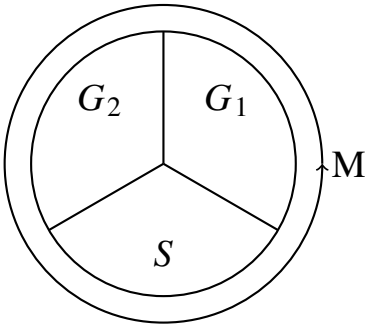
(A) Progesterone

(B) Estrogen

(C) Luteinizing Hormone (LH)

(D) Follicle Stimulating Hormone (FSH)

Q13. The basic blueprint of a regular eukaryotic cell cycle is illustrated below:



During which phase labeled above does the quantitative duplication of nuclear DNA occur without any change in the absolute chromosome number of the cell?

(A) G_1 phase

(B) S phase

(C) G_2 phase

(D) M phase

Q14. Which of the following taxonomical classifications correctly groups organisms under the single kingdom Fungi based on Whittaker's five-kingdom classification system?

(A) *Mucor*, *Penicillium*, *Agaricus*

(B) *Nostoc*, *Anabaena*, *Rhizopus*

(C) *Euglena*, *Amoeba*, *Spirogyra*

(D) *Albugo*, *Chlamydomonas*, *Chlorella*

Q15. A drop in systemic blood pressure and fluid volume triggers the renin-angiotensin-aldosterone system (RAAS). Which specific cellular structure detects this drop to release Renin into circulation?

(A) Podocytes of Bowman's capsule

(B) Macula densa and Juxtaglomerular (JG) cells of the afferent arteriole

(C) Cells of the Proximal Convoluted Tubule (PCT)

(D) Endothelial cells of Henle's loop

Q16. What primary evolutionary role do restriction endonucleases play in nature within the bacterial cells that naturally synthesize them?

(A) To assist in the alignment of lagging strand fragments during replication

(B) To degrade foreign viral (bacteriophage) DNA as a defense mechanism

(C) To accelerate transcription of structural operons

(D) To methylate host genomic DNA to prevent spontaneous mutations

Q17. An experimental setup exposes a sprig of *Hydrilla* to varying colors of light. Under which of the following monochromatic light spectrum illumination conditions will the rate of oxygen bubble evolution drop to its lowest point?

(A) Blue light

(B) Red light

(C) Green light

(D) White light

Q18. A geneticist analyses an individual showing mild intellectual disability, a tall stature with feminized physical characteristics such as gynecomastia, and sterile testes. Karyotypic analysis confirms a total of 47 chromosomes. What is the diagnosis?

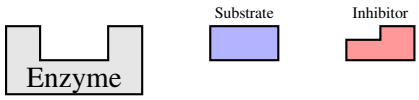
(A) Down's Syndrome

(B) Turner's Syndrome

(C) Klinefelter's Syndrome

(D) Edward's Syndrome

Q19. The following structural diagram presents the layout of a typical competitive enzyme-inhibitor interaction scenario:



How do the values of K_m (Michaelis constant) and V_{max} shift when a true competitive inhibitor is introduced into this biological assay?

(A) K_m increases; V_{max} remains unchanged

(B) K_m remains unchanged; V_{max} decreases

(C) Both K_m and V_{max} decrease proportionally

(D) K_m decreases; V_{max} increases

Q20. Which structural component of the human brain functions as the supreme regulatory center for controlling basic autonomic homeostasis, including thermoregulation, hunger, thirst, and circadian rhythms?

(A) Cerebellum

(B) Corpora quadrigemina

(C) Thalamus

(D) Hypothalamus

Q21. The embryonic structure that directly implants into the functional endometrial lining of the human uterine wall roughly 7 days after fertilization is the:

(A) Zygote

(B) Morula

(C) Blastocyst

(D) Gastrula

Q22. During aerobic cellular respiration, which specific metabolic transition step directly links the cytosolic pathway of glycolysis to the mitochondrial matrix reactions of the Krebs cycle?

(A) Oxidative decarboxylation of Pyruvate into Acetyl-CoA

(B) Reduction of Oxaloacetate into Malate

(C) Phosphorylation of Glucose into Glucose-6-Phosphate

(D) Cleavage of Fructose-1,6-bisphosphate

Q23. An environmental biological monitoring station records an algal bloom in a freshwater lake accompanied by massive fish mortality. What is the sequential mechanism responsible for this catastrophe?

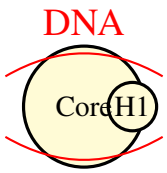
(A) Algal blooms directly block light → submerged plants fix excess toxic oxygen → fish die

(B) Algae die → aerobic decomposers multiply rapidly → Dissolved Oxygen (DO) plummets → asphyxiation of fish

(C) Algal blooms cause industrial biomagnification → heavy metals accumulate → acute poisoning of aquatic organisms

(D) Algae consume all organic wastes → Biochemical Oxygen Demand (BOD) falls to zero → nutrient starvation of fish

Q24. The structural configuration below represents an essential molecular configuration involved in genetic processing:



What basic amino acid residues are predominantly present within this structural core to facilitate its binding interaction with the surrounding polymer?

(A) Tryptophan and Phenylalanine

(B) Aspartate and Glutamate

(C) Lysine and Arginine

(D) Methionine and Cysteine

Q25. Which of the following choices lists a set of mechanical barriers used as contraceptive methods to block fertilization by preventing physical contact between sperm and ova?

(A) Lippes Loop, CuT, Cu7

(B) Saheli pills, Mala-D

(C) Condoms, Diaphragms, Cervical caps

(D) Vasectomy, Tubectomy

Q26. The dynamic transport of mineral ions into root cortical cells occurs via a mix of processes. Why does the primary influx of ions into root hair cells generally require active transport rather than simple passive diffusion?

(A) Ions are non-charged particles that move easily through lipid bilayers

(B) The concentration of minerals in the soil is typically lower than the concentration inside the root cells

(C) Soil particles actively pump water molecules away from root borders

(D) Cortical cell walls are completely hydrophobic and block ion entry

Q27. A molecular biologist isolates an mRNA strand containing the following sequence: 5′-AUGGCCUUUUGAAAG-3′. If a point mutation causes a transition changing the third Uracil (U) of the third codon into an Adenine (A), what will be the effect on translation?

(A) A longer polypeptide chain will be translated due to read-through

(B) Translation will terminate prematurely, producing a truncated peptide

(C) The primary structure of the protein remains completely unaffected

(D) The ribosome will skip the mutated codon entirely without stopping

Q28. Which of the following cell junctions functions primarily to seal adjacent epithelial cells together to prevent the leakage of extracellular fluid across a tissue layer?

(A) Gap junctions

(B) Adhering junctions

(C) Tight junctions

(D) Synaptic junctions

Q29. Bt-cotton exhibits high resistance to specific pests like bollworms. What is the biochemical mechanism underlying this resistance?

(A) The plant contains pre-formed active toxins that dissolve pest cuticles upon contact

(B) Ingestion of the inactive protoxin leads to its conversion into active toxin due to the alkaline pH of the insect gut, causing pore formation and epithelial lysis

(C) The transgene induces systemic acquired resistance against all viral, bacterial, and insect pathogens

(D) The plant generates a sticky secondary metabolite that physically blocks the insect's spiracles

Q30. An isolated population has limited resources and exhibits a sigmoid population growth curve over time. This dynamic behavior can be modeled using the logistic growth equation: $\frac{dN}{dt} = rN\left(\frac{K-N}{K}\right)$. What ecological parameter does the variable K represent?

(A) Intrinsic rate of natural increase

(B) Population density at time zero

(C) Environmental carrying capacity

(D) Biotic potential index

Detailed Solutions

Q1.

Solution

Concept: Plant tissues are categorized into meristematic and permanent types based on their capacity for cellular division. Simple permanent tissues consist of structurally and functionally homogenous cells, comprising parenchyma, collenchyma, and sclerenchyma. Collenchyma tissue features localized primary cell wall deposition and specialized mechanical capacity.

Solution:

(a) Collenchyma consists of living, elongated cells characterized by unevenly thickened cell walls. This distinct mechanical structural reinforcement is due to the localized deposition of cellulose, hemicellulose, and pectin at the cell corners.

(b) Unlike sclerenchyma, which develops thick, lignified secondary cell walls and undergoes programmed cell death at maturity, collenchyma cells remain metabolic, flexible, and fully capable of elongation.

(c) Functionally, collenchyma provides vital tensile strength and mechanical support to young, expanding herbaceous organs, including petioles, leaf laminas, and growing green stems, allowing bending without fracturing.

(d) Parenchyma possesses thin, uniform primary cellulosic walls optimized for metabolic storage but lacks specialized reinforcement, while xylem vessels are dead, hollow, lignified elements designed for specialized water translocation.

(e) Therefore, the tissue profile matching living mechanical cells with uneven pectin-cellulose corner thickens corresponds directly to collenchyma.

Final Answer: Collenchyma.

Answer: (B)

Go Back to Question 1

Q2.

Solution

Concept: The eukaryotic chloroplast contains an outer membrane, an inner membrane, and an internal membrane network. This internal architecture is segregated into the fluid-filled stroma matrix and a distinct network of flat, disc-like membranous sacs called thylakoids, which stack together to form grana.

Solution:

(a) The provided schematic illustrates a eukaryotic chloroplast, where the stacked internal membranous structures represent thylakoids grouped into grana, embedded within the external fluid stroma.

(b) Photosynthesis is explicitly divided into the light-dependent reactions, which harvest radiant energy, and the light-independent Calvin-Benson cycle, which fixes gaseous carbon dioxide.

(c) The thylakoid membranes physically contain the light-harvesting chlorophyll complexes, electron transport chains, and ATP synthase complexes. Consequently, the light-dependent reactions of photosynthesis occur here.

(d) The rate-limiting enzymes and regulatory complexes driving photolysis and photophosphorylation are embedded directly within these thylakoid membranes to preserve the functional proton gradient.

(e) In contrast, the enzymes for the Calvin cycle are situated within the stroma, while glycolysis takes place in the cytosol and the tricarboxylic acid cycle operates inside the mitochondrial matrix.

Final Answer: Light-dependent reactions of photosynthesis.

Answer: (C)

Go Back to Question 2

Q3.

Solution

Concept: The human stomach lining contains deep gastric pits that branch into functional gastric glands. These specialized glands possess an assortment of distinct secretory epithelial cell types, including mucous neck cells, chief cells, and parietal cells, which coordinate chemical digestion and systemic absorption pathways.

Solution:

(a) Oxyntic cells, alternatively known as parietal cells, are primarily concentrated within the fundus and body regions of the functional gastric glands.

(b) These specialized cells are responsible for secreting concentrated hydrochloric acid (HCl), which creates an optimal acidic environment for protein denaturation and activation of zymogens, and intrinsic factor.

(c) Intrinsic factor is a crucial glycoprotein required for binding dietary vitamin B_{12} (cyanocobalamin) in the small intestine, facilitating its receptor-mediated endocytosis within the terminal ileum.

(d) A severe autoimmune or structural deficit in parietal cells causes a complete lack of intrinsic factor secretion, leading to an inability to absorb vitamin B_{12} and resulting in megaloblastic (pernicious) anemia.

(e) Peptic or chief cells secrete inactive pepsinogen, mucous neck cells produce protective mucus, and argentaffin cells release local paracrine hormones, none of which synthesize intrinsic factor.

Final Answer: Oxyntic or parietal cells.

Answer: (C)

Go Back to Question 3

Q4.

Solution

Concept: DNA replication is catalyzed by DNA-dependent DNA polymerase, an enzyme that exhibits strict directional constraints. It can only polymerize a new nucleotide strand in the $5' \rightarrow 3'$ direction, adding new nucleotides exclusively to the free $3'$-OH group of a pre-existing primer or extending strand.

Solution:

(a) The replication fork is asymmetric due to the antiparallel nature of parental DNA. The two template strands run in opposite directions relative to the advancing replication fork.

(b) Strand A serves as a template strand running in the $5' \rightarrow 3'$ direction toward the fork, which means its complementary new strand must be synthesized in the $3' \rightarrow 5'$ direction relative to the fork movement.

(c) Because DNA polymerase cannot synthesize a strand in the $3' \rightarrow 5'$ direction, replication along Strand A must occur in short, fragmented segments moving away from the fork in the required $5' \rightarrow 3'$ direction.

(d) These isolated segments are known as Okazaki fragments, and this pattern of replication is called discontinuous synthesis. The fragments are later covalently joined together by DNA ligase.

(e) Strand B undergoes continuous synthesis toward the fork as the leading strand, making the description of discontinuous synthesis of Okazaki fragments away from the fork unique to Strand A.

Final Answer: Discontinuous synthesis producing Okazaki fragments away from the replication fork.

Answer: (B)

Go Back to Question 4

Q5.

Solution

Concept: Ecological pyramids graphically represent trophic structures, quantifying parameters like numerical abundance, energy flow, or total biomass. Biomass measures the dry weight of organic matter across trophic levels at a given time, varying based on the reproductive dynamics of the primary producers.

Solution:

(a) In a typical terrestrial open grassland ecosystem, the primary producers consist of grasses and herbs that possess a massive total dry weight and a relatively low turnover rate.

(b) This substantial foundational mass easily supports a lower total biomass of primary consumers, which in turn supports an even smaller biomass of secondary consumers, creating a standard upright pyramid.

(c) Conversely, a typical marine ecosystem exhibits a highly dynamic, inverted pyramid of biomass due to its primary producers, which consist of microscopic phytoplankton.

(d) Phytoplankton possess a very small standing crop biomass at any single moment, but they maintain exceptionally high rates of reproduction and turnover to sustain a larger biomass of zooplankton and fish.

(e) Thus, the biomass distribution trend shifts from a stable upright structure in the grassland ecosystem to an inverted profile within the open marine environment.

Final Answer: Grassland: Upright; Marine: Inverted.

Answer: (D)

Go Back to Question 5

Q6.

Solution

Concept: Mendelian genetics dictates that a dihybrid cross tracking two unlinked genes follows the Principle of Independent Assortment. During gametogenesis, alleles for different traits segregate independently, producing predictable phenotypic frequencies among the resulting offspring.

Solution:

(a) Crossing homozygous yellow-round ($YYRR$) and green-wrinkled ($yyrr$) pea plants produces a uniform F_1 generation with a heterozygous dihybrid genotype ($YyRr$), displaying the dominant yellow-round phenotype.

(b) Self-pollinating this F_1 generation ($YyRr \times YyRr$) yields a classic Mendelian F_2 phenotypic ratio of $9:3:3:1$ across sixteen theoretical combinations.

(c) This total population splits into two parental phenotypes and two recombinant phenotypes. The parental groups comprise yellow-round ($9/16$) and green-wrinkled ($1/16$) individuals.

(d) The remaining combinations represent novel recombinant phenotypes: yellow-wrinkled ($3/16$) and green-round ($3/16$). These combinations arise from the independent assortment of alleles.

(e) The question isolates the probability of obtaining the specific recombinant phenotype of green and round seeds. According to the ratio, this specific outcome corresponds to a mathematical probability of exactly $3/16$.

Final Answer: $3/16$.

Answer: (B)

Go Back to Question 6

Q7.

Solution

Concept: The human cardiac cycle consists of coordinated mechanical and electrical events that regulate blood flow through the heart. This cycle includes atrial systole, ventricular systole, and joint diastole, which are governed by pressure changes that operate the valves.

Solution:

(a) During the ventricular systole phase, which lasts approximately 0.3 seconds, the ventricles contract, causing a rapid rise in intraventricular pressure.

(b) This sudden pressure increase forces the atrioventricular valves (tricuspid and bicuspid) to snap shut, preventing blood from flowing back into the atria and producing the first heart sound, "lub."

(c) As ventricular contraction continues, intraventricular pressure exceeds the pressure within the major arterial trunks (the pulmonary artery and aorta).

(d) This pressure differential forces the pocket-like semilunar valves open, allowing blood to be ejected from the ventricles into systemic and pulmonary circulation.

(e) During atrial systole, the atrioventricular valves are open. During joint diastole, the semilunar valves are closed. Therefore, the state where the atrioventricular valves are closed and semilunar valves are open occurs exclusively during ventricular systole.

Final Answer: Ventricular Systole.

Answer: (C)

Go Back to Question 7

Q8.

Solution

Concept: Animal classification relies on structural features like body symmetry, tissue organization, and coelom architecture. The coelom is an internal fluid-filled body cavity situated between the digestive tract and the outer body wall, developing differently across phyla.

Solution:

(a) A true coelom is completely lined by mesoderm-derived epithelium. Animals lacking a body cavity are acoelomate, while those with a cavity not fully lined by mesoderm are pseudocoelomate.

(b) In pseudocoelomate organisms, the blastocoel persists as the adult body cavity. The mesoderm forms isolated cellular pouches rather than a continuous lining along the endoderm.

(c) This specific structural plan, featuring a pseudocoelom bounded by ectoderm and unlined mesoderm, is the defining anatomical characteristic of the phylum Aschelminthes (Nematoda).

(d) Phyla like Annelida and Arthropoda exhibit a true coelom lined by mesoderm, whereas Platyhelminthes represents an acoelomate group filled with solid parenchyma tissue.

(e) Consequently, any organism that displays a distinct pseudocoelomate cavity lacking a complete mesodermal lining is classified under the phylum Aschelminthes.

Final Answer: Aschelminthes.

Answer: (B)

Go Back to Question 8

Q9.

Solution

Concept: Biochemist Erwin Chargaff formulated rules regarding the composition of double-stranded DNA. These rules state that a structural equivalence exists between purine and pyrimidine bases, establishing specific stoichiometric partnerships within the double helix.

Solution:

(a) Chargaff's rules state that Adenine (A) pairs exclusively with Thymine (T) via two hydrogen bonds, and Guanine (G) pairs with Cytosine (C) via three hydrogen bonds.

(b) This specific base-pairing mechanism means that the molar concentration of Adenine equals Thymine ($A = T$), and Cytosine equals Guanine ($C = G$) within a double-stranded molecule.

(c) Given that the Cytosine composition is 28%, the Guanine composition must also be exactly 28%. Together, the $G + C$ pyrimidine-purine content accounts for 56% (28% + 28%).

(d) The remaining percentage of the DNA molecule consists of Adenine and Thymine bases ($A + T$), which equals 44% (100% − 56%).

(e) Because Adenine and Thymine are present in equal amounts ($A = T$), this remaining value is divided equally, yielding an Adenine composition of exactly 22% (44%/2).

Final Answer: 22%.

Answer: (A)

Go Back to Question 9

Q10.

Solution

Concept: The kingdom Animalia is divided into distinct phyla based on fundamental anatomical structures. Each phylum possesses unique diagnostic traits, evolutionary milestones, and specialized cellular configurations that distinguish it from other groups.

Solution:

(a) The phylum Porifera (sponges) is characterized by a cellular level of organization, lacking true tissues. They possess a central water transport system where water enters through ostia and exits via the osculum.

(b) This unique canal system is lined by flagellated choanocytes (collar cells) that generate water currents and capture food particles, making this a true match.

(c) Organisms in the phylum Ctenophora are radially symmetrical and acoelomate. They use specialized sticky cells called colloblasts for prey capture, whereas cnidocytes are unique to Cnidaria.

(d) Platyhelminthes are unsegmented, acoelomate flatworms, and Echinodermata adults display radial symmetry with a calcareous endoskeleton, rather than a bilateral plan with a chitinous exoskeleton.

(e) Therefore, the selection describing Porifera with its cellular organization and choanocyte-lined water canal system represents the only correct anatomical pairing.

Final Answer: Porifera → Cellular level of organization with a water canal system lined by choanocytes.

Answer: (B)

Go Back to Question 10

Q11.

Solution

Concept: Recombinant DNA technology employs cloning vectors like pBR322 to transfer foreign genetic material into host cells. These plasmids contain antibiotic resistance genes that serve as selectable markers to differentiate transformed cells from non-transformed cells, as well as recombinants from non-recombinants, through insertional inactivation.

Solution:

(a) The plasmid vector pBR322 carries two distinct antibiotic selectable markers: an ampicillin resistance gene (amp^R) and a tetracycline resistance gene (tet^R).

(b) The unique recognition site for the restriction endonuclease *Bam*HI is located directly within the coding sequence of the tetracycline resistance gene (tet^R).

(c) When a foreign gene of interest is ligated specifically into the *Bam*HI site, it disrupts the open reading frame of the tet^R gene, leading to insertional inactivation.

(d) As a direct consequence of this disruption, recombinant transformants completely lose their ability to survive in environments containing tetracycline.

(e) Because the ampicillin resistance gene (amp^R) remains fully intact and unaffected by this ligation, these host cells retain their resistance to ampicillin, enabling selective identification on replica plates.

Final Answer: Transformants become sensitive to tetracycline while remaining resistant to ampicillin.

Answer: (C)

Go Back to Question 11

Q12.

Solution

Concept: The human menstrual cycle is regulated by complex neuroendocrine feedback loops involving the hypothalamus, anterior pituitary gland, and ovaries. Gonadotropins and ovarian steroid hormones fluctuate systematically to coordinate follicle maturation, ovulation, and luteinization.

Solution:

(a) During the follicular phase, developing ovarian follicles secrete increasing amounts of estrogen, which exerts positive feedback on the anterior pituitary once it crosses a threshold concentration.

(b) This positive feedback loop triggers a rapid and intense increase in the secretion of gonadotropins around the midpoint of a typical twenty-eight-day cycle.

(c) This sharp spike is known as the LH surge, where Luteinizing Hormone levels reach their peak roughly twenty-four to thirty-six hours before the mechanical event.

(d) The high concentration of Luteinizing Hormone induces the rupture of the mature Graafian follicle and stimulates the subsequent release of the secondary oocyte into the fallopian tube.

(e) While follicle-stimulating hormone also exhibits a mid-cycle rise, and progesterone increases during the luteal phase, Luteinizing Hormone is the immediate physiological signal that drives ovulation.

Final Answer: Luteinizing Hormone (LH).

Answer: (C)

Go Back to Question 12

Q13.

Solution

Concept: The eukaryotic cell cycle is divided into interphase and the mitotic phase. Interphase represents a period of intense metabolic preparation and growth, which is further subdivided into the G_1, S, and G_2 phases to ensure precise genomic duplication and distribution.

Solution:

(a) Quantitative replication of nuclear DNA takes place exclusively during the Synthesis or S phase of the cell cycle.

(b) During this interval, the absolute content of DNA within the nucleus is exactly doubled, changing from an initial amount of 2C to a final value of 4C.

(c) However, this active replication occurs without any alteration to the absolute chromosome number, meaning a diploid cell starting with 2N chromosomes finishes with 2N chromosomes.

(d) This occurs because each chromosome replicates to form two identical, tightly linked sister chromatids that remain joined together at a single shared centromere.

(e) The preceding G_1 phase focuses on metabolic growth, the succeeding G_2 phase synthesizes proteins required for division, and the M phase physically segregates these duplicated elements.

Final Answer: S phase.

Answer: (B)

Go Back to Question 13

Q14.

Solution

Concept: Whittaker's five-kingdom classification system segregates organisms based on structural cell type, thallus organization, nutritional modes, and phylogenetic relationships. The kingdom Fungi accommodates eukaryotic, heterotrophic, non-photosynthetic organisms that possess cell walls composed primarily of chitin.

Solution:

(a) The genus *Mucor* belongs to the class Phycomycetes, *Penicillium* is classified under Ascomycetes, and *Agaricus* is a mushroom belonging to Basidiomycetes, making them all true fungi.

(b) Organisms such as *Nostoc* and *Anabaena* are photosynthetic prokaryotes classified under the kingdom Monera as cyanobacteria, which excludes them from the fungal group.

(c) The genera *Euglena* and *Amoeba* are unicellular eukaryotes grouped within the kingdom Protista, whereas *Spirogyra*, *Chlamydomonas*, and *Chlorella* are green algae placed inside the kingdom Plantae.

(d) The parasitic genus *Albugo* is a fungus-like oomycete, but grouping it alongside true green algae violates the single-kingdom criteria established by Whittaker.

(e) Therefore, the only taxonomic cluster consisting entirely of heterotrophic, chitinous organisms classified within the true kingdom Fungi is *Mucor*, *Penicillium*, and *Agaricus*.

Final Answer: *Mucor*, *Penicillium*, *Agaricus*.

Answer: (A)

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Q15.

Solution

Concept: The human kidneys regulate systemic blood pressure and intravascular volume via the renin-angiotensin-aldosterone system. This homeostatic mechanism relies on the juxtaglomerular apparatus, a specialized structural modification located at the vascular pole of each nephron.

Solution:

(a) The juxtaglomerular apparatus is composed of modified smooth muscle cells called juxtaglomerular cells and specialized distal tubular epithelial cells known as the macula densa.

(b) Juxtaglomerular cells are located within the walls of the afferent arteriole and act as intrarenal baroreceptors that directly sense drops in systemic perfusion pressure.

(c) The adjacent macula densa cells monitor the composition of tubular fluid, detecting reductions in the delivery of sodium and chloride ions.

(d) When a drop in systemic blood pressure occurs, these two cell populations coordinate to trigger the exocytic release of the proteolytic enzyme renin into circulation.

(e) Podocytes form the filtration slits of Bowman's capsule, while proximal tubule and loop cells handle bulk reabsorption, making them incapable of synthesizing or releasing renin.

Final Answer: Macula densa and Juxtaglomerular (JG) cells of the afferent arteriole.

Answer: (B)

Go Back to Question 15

Q16.

Solution

Concept: Restriction endonucleases are specialized biochemical tools extensively utilized in molecular cloning. In evolutionary history, these enzymes evolved not as tools for biotechnology, but as a component of the primitive immune networks operating inside prokaryotes.

Solution:

(a) Bacterial cells are routinely exposed to lethal infections by virulent bacterial viruses, which are known as bacteriophages.

(b) To counter this threat, bacteria express restriction endonucleases that recognize specific, short palindromic nucleotide sequences present within foreign DNA molecules.

(c) Upon encountering invading bacteriophage genomes, these enzymes execute precise double-stranded phosphodiester cleavages, effectively fragments and degrading the viral nucleic acids.

(d) The host bacterium prevents self-destruction of its own genomic DNA by utilizing matching methyltransferase enzymes that add protective methyl groups to host restriction sites.

(e) This dual network is known as the restriction-modification system and serves strictly as an evolutionary defense mechanism against foreign genetic invasion.

Final Answer: To degrade foreign viral (bacteriophage) DNA as a defense mechanism.

Answer: (B)

Go Back to Question 16

Q17.

Solution

Concept: Photosynthesis is driven by photosynthetic pigments that absorb specific wavelengths of radiant energy. The action spectrum of photosynthesis quantifies the efficiency of different wavelengths, reflecting the absorption profiles of chlorophyll *a* and chlorophyll *b*.

Solution:

(a) The primary photosynthetic pigments absorb light energy predominantly within the blue and red regions of the visible spectrum.

(b) Wavelengths corresponding to green light are poorly absorbed by these pigments and are instead largely reflected or transmitted by green plant tissues.

(c) Because photosynthetic pigments cannot efficiently harvest green wavelengths, the light-dependent reactions slow down significantly under monochromatic green illumination.

(d) This causes a sharp reduction in the photolysis of water molecules at the oxygen-evolving complex of photosystem II, causing the rate of oxygen bubble evolution to drop to its lowest point.

(e) Blue, red, and polychromatic white light provide wavelengths that match the absorption peaks of chlorophyll, resulting in high rates of photosynthetic activity.

Final Answer: Green light.

Answer: (C)

Go Back to Question 17

Q18.

Solution

Concept: Human chromosomal disorders arise from errors in chromosome segregation during meiosis, leading to aneuploidy. Non-disjunction of sex chromosomes produces distinct syndromes characterized by alterations in phenotypic development, endocrine function, and fertility.

Solution:

(a) Klinefelter's syndrome is a genetic condition caused by the non-disjunction of sex chromosomes during gametogenesis, resulting in an extra X chromosome.

(b) Affected individuals possess a total karyotype of forty-seven chromosomes, expressed specifically as 47, XXY.

(c) Phenotypically, these individuals develop as males due to the presence of the Y chromosome, but the additional X chromosome introduces feminized traits.

(d) These clinical features include a tall stature, mild intellectual disability, gynecomastia (enlargement of breast tissue), diminished secondary sexual characteristics, and sterile testes due to hypergonadotropic hypogonadism.

(e) Down's syndrome involves trisomy twenty-one, Turner's syndrome presents a 45, X monosomy, and Edward's syndrome involves trisomy eighteen, none of which match the 47, XXY presentation.

Final Answer: Klinefelter's Syndrome.

Answer: (C)

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Q19.

Solution

Concept: Enzyme kinetics describe how biochemical reaction velocities change in response to substrate concentrations. Inhibitors alter these kinetics by disrupting substrate binding or the catalytic cycle, with changes quantified by shifts in the parameters V_{max} and K_m.

Solution:

(a) A competitive inhibitor structurally resembles the natural substrate and competes directly for binding at the active site of the free enzyme.

(b) Because the inhibitor binds reversibly to the active site, it decreases the apparent affinity between the enzyme and its substrate.

(c) This shifts the Michaelis constant (K_m) to a higher value, indicating that a greater concentration of substrate is required to reach half-maximal velocity.

(d) At high concentrations, the substrate outcompetes the inhibitor for active site binding, allowing the reaction to reach its original maximum velocity.

(e) Consequently, the maximum velocity (V_{max}) remains completely unchanged, distinguishing competitive inhibition from non-competitive profiles.

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

Answer: (A)

Go Back to Question 19

Q20.

Solution

Concept: The human brain is a highly compartmentalized organ divided into the forebrain, midbrain, and hindbrain. Each region contains specialized neural centers that process sensory inputs and coordinate homeostatic, motor, or cognitive responses.

Solution:

(a) The hypothalamus is a small structural component of the forebrain situated directly below the thalamus and connected to the pituitary gland.

(b) It serves as the primary integration center between the central nervous system and the endocrine system, regulating autonomic homeostasis.

(c) The hypothalamus contains specialized neural nuclei that continuously monitor blood temperature and osmolarity, acting as the body's thermostat and osmostat to regulate hunger, thirst, and satiety.

(d) It also regulates circadian rhythms via inputs from the retina and coordinates systemic visceral responses through autonomic pathways.

(e) The cerebellum coordinates motor movement, the corpora quadrigemina manage visual and auditory reflexes, and the thalamus acts as a sensory relay station.

Final Answer: Hypothalamus.

Answer: (D)

Go Back to Question 20

Q21.

Solution

Concept: Human embryonic development begins with fertilization in the ampulla of the fallopian tube, forming a single-celled zygote. This cell undergoes rapid mitotic divisions called cleavage, transitioning into a solid ball of cells and then into a hollow, differentiated structural mass that physically anchors into maternal tissue.

Solution:

(a) Following fertilization, the zygote travels along the oviduct toward the uterine cavity while dividing mitotically to form an eight-to-sixteen-celled solid sphere known as the morula.

(b) As cellular division continues, rearrangement occurs to form a hollow sphere called the blastocyst, which consists of an outer epithelial layer termed the trophoblast and an inner cell mass.

(c) The trophoblast layer is specialized to mediate interactions with maternal tissue, secreting proteolytic enzymes that enable it to penetrate the functional endometrial layer of the uterine wall.

(d) This mechanical process of attachment and embedding is known as implantation, and it occurs approximately seven days following the initial fertilization event.

(e) The blastocyst is the specific developmental stage that implants, whereas the zygote and morula are early free-floating structures, and the gastrula forms after implantation occurs.

Final Answer: Blastocyst.

Answer: (C)

Go Back to Question 21

Q22.

Solution

Concept: Aerobic cellular respiration breaks down glucose to harvest biochemical energy in the form of ATP. This multi-step process involves distinct localized pathways, starting with cytosolic glycolysis and ending with mitochondrial matrix reactions and inner membrane oxidative phosphorylation.

Solution:

(a) Glycolysis operates entirely within the cytosol, converting one six-carbon glucose molecule into two molecules of the three-carbon organic acid known as pyruvate.

(b) To enter the citric acid cycle, this pyruvate must be actively transported across the double mitochondrial membrane into the internal fluid matrix.

(c) Once inside the matrix, pyruvate undergoes an irreversible chemical transition catalyzed by the multi-enzyme complex known as the pyruvate dehydrogenase complex.

(d) This reaction is an oxidative decarboxylation, where a carboxyl group is removed as carbon dioxide (CO_2), electrons are transferred to reduce NAD^+ into NADH, and the remaining acetyl group is joined to Coenzyme A.

(e) This step generates acetyl-coenzyme A, which acts as the direct fuel molecule that enters the Krebs cycle by condensing with oxaloacetate, effectively bridging the two main metabolic pathways.

Final Answer: Oxidative decarboxylation of Pyruvate into Acetyl-CoA.

Answer: (A)

Go Back to Question 22

Q23.

Solution

Concept: Cultural or accelerated eutrophication occurs when excessive nutrient runoff, particularly nitrogen and phosphorus, enters an aquatic ecosystem. This sudden nutrient surplus disrupts homeostatic biological mechanisms, triggering a cascading ecological collapse that severely alters food webs and water chemistry.

Solution:

(a) The influx of limiting nutrients triggers rapid population growth among primary producers, resulting in a dense accumulation of surface biomass known as an algal bloom.

(b) This massive algal population eventually depletes the available nutrient supply, causing a widespread die-off of the algae.

(c) The resulting organic detritus falls to the bottom of the water body, leading to a massive increase in the population of heterotrophic, aerobic bacterial decomposers.

(d) These decomposers consume oxygen at extremely high rates to break down the dead organic matter, causing the biochemical oxygen demand of the system to skyrocket.

(e) As a direct result, the concentration of dissolved oxygen in the water plummets, causing severe hypoxia and widespread suffocation of fish and other aerobic aquatic organisms.

Final Answer: Algae die → aerobic decomposers multiply rapidly → Dissolved Oxygen (DO) plummets → asphyxiation of fish.

Answer: (B)

Go Back to Question 23

Q24.

Solution

Concept: Eukaryotic genomic DNA is organized into a dense structure called chromatin to fit within the boundaries of the cell nucleus. This architectural packaging relies on specialized protein complexes that interact with the repeating polymer backbone of the double helix.

Solution:

(a) The diagram depicts a nucleosome core, which represents the fundamental structural unit of chromatin packaging in eukaryotic cells.

(b) This configuration consists of a negatively charged DNA double helix wrapped around an octamer core composed of two copies each of the histones H2A, H2B, H3, and H4.

(c) The structural stability of this complex depends on electrostatic interactions between the negatively charged phosphate backbone of the DNA and the surface of the histone octamer.

(d) To facilitate this binding, histone proteins contain a high proportion of basic amino acid residues, specifically lysine and arginine.

(e) These basic amino acids possess positively charged side-chain groups at physiological pH, allowing them to form stable ionic bonds with the acidic phosphate groups of the DNA polymer.

Final Answer: Lysine and Arginine.

Answer: (C)

Go Back to Question 24

Q25.

Solution

Concept: Contraceptive strategies are designed to prevent unwanted pregnancies by disrupting various stages of reproduction. These approaches include chemical, hormonal, surgical, and mechanical methods, each operating through distinct physiological mechanisms.

Solution:

(a) Mechanical or barrier methods prevent pregnancy by placing a physical barrier between male and female gametes, blocking fertilization without altering endocrine pathways.

(b) This category includes condoms, diaphragms, cervical caps, and vaults, which physically contain or block semen to prevent sperm from entering the cervix.

(c) Intrauterine devices like the Lippes Loop, CuT, and Cu7 are inserted into the uterine cavity, where they alter local chemical conditions and suppress sperm motility rather than acting as physical barriers.

(d) Oral contraceptive pills like Saheli or Mala-D rely on synthetic steroid hormones to suppress ovulation, while vasectomy and tubectomy are irreversible surgical sterilization procedures.

(e) Therefore, the selection containing condoms, diaphragms, and cervical caps represents the group that functions strictly as mechanical barriers to block gamete contact.

Final Answer: Condoms, Diaphragms, Cervical caps.

Answer: (C)

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Q26.

Solution

Concept: Plants absorb water and inorganic mineral nutrients from the surrounding soil via root hair cells. This uptake relies on specialized transport mechanisms across the plasma membrane, governed by relative concentration gradients and electrical potentials.

Solution:

(a) Mineral nutrients are dissolved in soil water as charged ions, which cannot pass through the hydrophobic lipid bilayer of root cell membranes via simple passive diffusion.

(b) The concentration of mineral ions in the soil solution is typically much lower than the concentration maintained inside the cytoplasm of root epidermal cells.

(c) Because of this unfavorable concentration gradient, plants must move these mineral ions inward against their natural chemical gradient.

(d) This directional movement requires active transport, utilizing specialized membrane-bound carrier proteins and pumps powered by the hydrolysis of adenosine triphosphate (ATP).

(e) Passive diffusion occurs only when moving down a concentration gradient, which does not apply to the active accumulation of soil minerals by root tissues.

Final Answer: The concentration of minerals in the soil is typically lower than the concentration inside the root cells.

Answer: (B)

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Q27.

Solution

Concept: The genetic code is translated into proteins through non-overlapping nucleotide triplets called codons. Point mutations within an open reading frame can alter these codons, changing the resulting amino acid sequence or prematurely halting translation.

Solution:

(a) The provided sequence is 5′-AUG GCC UUU UGA AAG-3′, which is read sequentially by ribosomes as five individual codons during protein synthesis.

(b) The third codon in this open reading frame is UUU, which specifies the insertion of the aromatic amino acid phenylalanine into the growing polypeptide chain.

(c) A transition mutation that changes the third uracil (U) of this triplet into an adenine (A) converts the original codon into the sequence UUA.

(d) According to the genetic code, the triplet UUA specifies the amino acid leucine instead of phenylalanine, representing a missense mutation.

(e) Because this single substitution replaces one amino acid with another without creating a premature stop codon (UAA, UAG, or UGA), the primary structure is modified but translation continues to the end.

Final Answer: The primary structure of the protein remains completely unaffected.

Answer: (C)

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Q28.

Solution

Concept: Epithelial tissues form continuous sheets of cells that line body cavities and cover internal and external surfaces. To maintain structural integrity and regulate transport, these cells utilize specialized intercellular junctions that coordinate adhesion and communication.

Solution:

(a) Epithelial cells are held together by three main types of intercellular junctions: tight junctions, adhering junctions, and gap junctions.

(b) Tight junctions (zonula occludens) are specialized protein structures that fuse the outer plasma membranes of adjacent epithelial cells together near their apical surfaces.

(c) This continuous seal encircles each cell, eliminating intercellular space and preventing the unregulated leakage of extracellular fluids across the tissue layer.

(d) Adhering junctions provide mechanical stability by anchoring the cytoskeletons of adjacent cells together, but they do not form a seal to block fluid transport.

(e) Gap junctions contain specialized channels that allow direct electrochemical communication between cells, while tight junctions function specifically to seal cellular barriers.

Final Answer: Tight junctions.

Answer: (C)

Go Back to Question 28

Q29.

Solution

Concept: Agricultural biotechnology utilizes transgenes to introduce beneficial traits into crop plants, such as pest resistance. A prominent example is Bt-cotton, which expresses crystal protein genes derived from the soil bacterium *Bacillus thuringiensis*.

Solution:

(a) The transgenic Bt-cotton plant synthesizes insecticidal crystal proteins, which are produced in an inactive form known as protoxins.

(b) Because these protoxins are inactive within plant tissues, they cause no physiological damage to the cotton crop itself.

(c) When a targeted insect pest, such as a bollworm, ingests the plant tissue, the inactive protoxins travel into its digestive tract.

(d) The highly alkaline environment of the insect's midgut solubilizes the protein crystals, and local proteases cleave them into active, functional toxins.

(e) These active toxins bind to specific receptors on the midgut epithelial cells, creating pores that disrupt osmotic balance and cause cell lysis, leading to the death of the pest.

Final Answer: Ingestion of the inactive protoxin leads to its conversion into active toxin due to the alkaline pH of the insect gut, causing pore formation and epithelial lysis.

Answer: (B)

Go Back to Question 29

Q30.

Solution

Concept: Population ecology utilizes mathematical models to track changes in population density over time. When resources are finite, population growth exhibits a sigmoidal pattern described by the Verhulst-Pearl logistic growth equation.

Solution:

(a) The logistic growth equation is formulated as $\frac{dN}{dt} = rN\left(\frac{K-N}{K}\right)$, where the variable N represents the population density at a given time t.

(b) The parameter r represents the intrinsic rate of natural increase, which defines the maximum reproductive potential of the species under ideal conditions.

(c) The variable K represents the environmental carrying capacity, which is the maximum population size that a specific habitat can sustainably support over time given its limited resources.

(d) The expression $\left(\frac{K-N}{K}\right)$ represents environmental resistance, which quantifies the proportional reduction in growth rate as the population density approaches the resource limit.

(e) When N equals K, this expression becomes zero, causing the net growth rate ($\frac{dN}{dt}$) to drop to zero and stabilizing the population at its carrying capacity.

Final Answer: Environmental carrying capacity.

Answer: (C)

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Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	B	2	C	3	C	4	B	5	D
6	B	7	C	8	B	9	A	10	B
11	C	12	C	13	B	14	A	15	B
16	B	17	C	18	C	19	A	20	D
21	C	22	A	23	B	24	C	25	C
26	B	27	C	28	C	29	B	30	C