KIITEE Biology Sample Paper – 11

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

Instructions

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

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

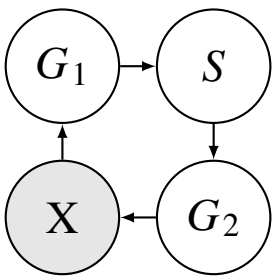
(A) Mitochondrion

(B) Golgi apparatus

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

(D) Ribosome

Q2. Consider the following simplified schematic representing the phases of the eukaryotic cell cycle:



Which important biological event occurs during the phase labeled as **X**?

(A) Separation of sister chromatids or chromosomes

(B) Semi-conservative replication of nuclear DNA

(C) Rapid synthesis of proteins and organelle duplication

(D) Metabolic resting phase or quiescence

Q3. During which specific sub-stage of prophase I in meiosis does the process of genetic recombination or crossing over occur, mediated by the enzyme recombinase?

(A) Leptotene

(B) Zygotene

(C) Pachytene

(D) Diplotene

Q4. An enzyme catalyzes a chemical reaction by altering which of the following thermodynamic parameters?

(A) Increasing the free energy change (ΔG) of the reaction

(B) Decreasing the activation energy (E_a) required for the transition state

(C) Altering the absolute equilibrium constant (K_{eq})

(D) Increasing the total enthalpy change (ΔH) of the system

Q5. In C_4 plants, the primary carbon dioxide (CO_2) fixation occurs in the mesophyll cells, while the Calvin cycle takes place in the bundle sheath cells. Which enzyme is responsible for the initial fixation of CO_2 in the mesophyll?

(A) RuBisCO

(B) Phosphoenolpyruvate (PEP) carboxylase

(C) Pyruvate dehydrogenase

(D) Malate dehydrogenase

Q6. During aerobic respiration, what is the net theoretical yield of ATP molecules produced purely from the complete oxidation of one molecule of glucose via the malate-aspartate shuttle system?

(A) 2 ATP

(B) 30 to 32 ATP

(C) 36 to 38 ATP

(D) 24 ATP

Q7. According to the mass flow hypothesis, the translocational movement of organic solutes through the phloem sieve tubes is driven by which type of gradient?

(A) Hydrostatic pressure gradient

(B) Electrical potential gradient

(C) Active proton (H^+) pump gradient

(D) Absolute chemical concentration gradient of dry sucrose

Q8. Which of the following plant growth regulators (hormones) is primarily responsible for inducing triple response in seedlings, promoting fruit ripening, and overcoming seed dormancy in some plants?

(A) Abscisic acid

(B) Gibberellic acid

(C) Ethylene

(D) Cytokinin

Q9. A typical mature angiosperm embryo sac at the time of fertilization exhibits which cellular and nuclear organizational arrangement?

(A) 8-celled and 7-nucleate

(B) 7-celled and 8-nucleate

(C) 8-celled and 8-nucleate

(D) 7-celled and 7-nucleate

Q10. During human oogenesis, the primary oocyte initiates its first meiotic division during embryonic development but remains suspended at which stage until puberty?

(A) Metaphase I

(B) Prophase I (Diplotene stage)

(C) Anaphase II

(D) Telophase I

Q11. Which of the following hormones triggers the critical surge from the anterior pituitary gland that induces the rupture of the mature Graafian follicle and subsequent ovulation?

(A) Progesterone

(B) Follicle-Stimulating Hormone (FSH)

(C) Luteinizing Hormone (LH)

(D) Human Chorionic Gonadotropin (hCG)

Q12. Which of the following barrier methods of contraception also functions effectively in preventing the transmission of sexually transmitted infections (STIs)?

(A) Intrauterine Devices (IUDs)

(B) Condoms

(C) Oral Contraceptive Pills

(D) Copper-T

Q13. In the human digestive system, the parietal (oxyntic) cells of the gastric mucosa are responsible for secreting which essential substances?

(A) Pepsinogen and Mucus

(B) Hydrochloric acid (HCl) and Intrinsic factor

(C) Trypsinogen and Chymotrypsinogen

(D) Gastrin and Somatostatin

Q14. Under normal physiological conditions, what is the primary chemical form in which the majority of carbon dioxide (CO_2, approximately 70%) is transported from the peripheral tissues back to the lungs through the blood?

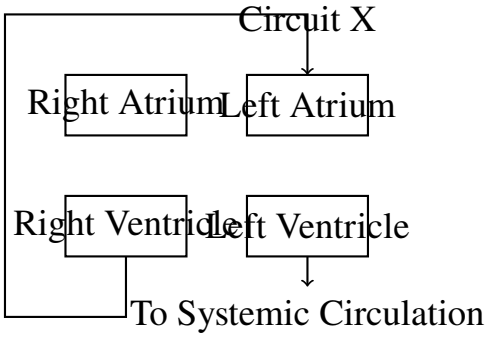
(A) Dissolved as gas molecules in blood plasma

(B) Bound to hemoglobin as carbaminohemoglobin

(C) As bicarbonate ions (HCO_3^-) in plasma

(D) As carbonic acid (H_2CO_3) inside leukocytes

Q15. Below is a simplified functional diagram representing a component of the human cardiovascular circuit:



Which organ system acts as the primary destination for the deoxygenated blood traveling via **Circuit X** before returning to the heart?

(A) Kidneys

(B) Lungs

(C) Liver

(D) Brain

Q16. The functional unit of the human kidney is the nephron. Examine the basic flow layout below:

Glom ← ~~DCT~~ → of Henle

Which specific process is primarily carried out by the mucosal layer lining **Segment Y**?

(A) Obligatory reabsorption of nearly 70-80% of electrolytes and water

(B) Conditional or optional reabsorption of sodium ions under aldosterone control

(C) Maintenance of high medullary osmotic gradient via counter-current multiplication

(D) Pure filtration driven solely by ultra-high hydrostatic pressure

Q17. During the generation and propagation of an action potential along a myelinated neuron, the rapid phase of depolarization is driven by which ion flux?

(A) Efflux of potassium ions (K^+)

(B) Influx of sodium ions (Na^+)

(C) Influx of calcium ions (Ca^{2+})

(D) Efflux of chloride ions (Cl^-)

Q18. According to the sliding filament mechanism of muscle contraction, the active binding site on actin is unmasked when calcium ions bind to which specific regulatory protein complex?

(A) Tropomyosin

(B) Troponin

(C) Myosin light chain

(D) Meromyosin

Q19. Hypersecretion of growth hormone (GH) in adults leads to severe disfigurement, particularly of the face and extremities, without an increase in height. This clinical condition is known as:

(A) Gigantism

(B) Acromegaly

(C) Dwarfism

(D) Cretinism

Q20. Consider the following cross represented by a simple Punnett square mapping a single gene locus for seed shape:

	R	**r**
R	RR	Rr
r	Rr	rr

If a heterozygous round-seeded pea plant (Rr) is self-pollinated as shown, what is the phenotypic ratio of round seeds to wrinkled seeds expected in the F_2 generation?

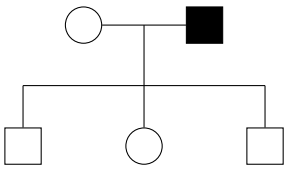
(A) 1 : 2 : 1

(B) 3 : 1

(C) 9 : 3 : 3 : 1

(D) 1 : 1

Q21. Examine the partial human pedigree chart below where shaded symbols indicate individuals expressing a rare genetic trait:



Given that an affected father (I-2) passes the trait exclusively to none of his sons but all children in generation II are unaffected carriers, which mode of inheritance is most consistent with this pattern?

(A) Autosomal dominant

(B) Autosomal recessive

(C) Y-linked dominant

(D) Cytoplasmic/Maternal inheritance

Q22. During DNA replication in prokaryotes, which specific enzyme is responsible for removing RNA primers and replacing them with complementary deoxyribonucleotides?

(A) DNA Polymerase III

(B) DNA Polymerase I

(C) DNA Helicase

(D) RNA Primase

Q23. The genetic code is described as "degenerate" because of which of the following biological properties?

(A) One codon can code for multiple different amino acids.

(B) Multiple different codons can code for the same single amino acid.

(C) The code is read continuously without any punctuation marks.

(D) The same codon specifies the same amino acid across all living species.

Q24. Which of the following evolutionary scenarios provides an unambiguous classic example of homologous structures, reflecting divergent evolution from a common ancestral form?

(A) Flippers of penguins and flippers of dolphins

(B) Wings of a butterfly and wings of a bird

(C) Forelimbs of a whale, a bat, and a human

(D) Eyes of an octopus and eyes of a mammal

Q25. In a population under Hardy-Weinberg equilibrium, the frequency of a recessive allele (a) is determined to be 0.4. What is the expected frequency of heterozygous individuals (Aa) within this population?

(A) 0.16

(B) 0.36

(C) 0.48

(D) 0.24

Q26. According to the five-kingdom classification system proposed by R.H. Whittaker, unicellular eukaryotic organisms are grouped under which taxonomic kingdom?

(A) Monera

(B) Protista

(C) Fungi

(D) Plantae

Q27. Which of the following structural animal tissues is characterized by cells tightly packed together with minimal intercellular matrix, forming a continuous protective barrier over internal organs and body surfaces?

(A) Epithelial tissue

(B) Connective tissue

(C) Muscular tissue

(D) Nervous tissue

Q28. The malignant malaria condition characterized by severe, life-threatening complications and high fever cycles is caused by which protozoan parasite?

(A) *Plasmodium vivax*

(B) *Plasmodium malariae*

(C) *Plasmodium falciparum*

(D) *Plasmodium ovale*

Q29. Which of the following microscopic organisms is commercially cultivated and utilized to produce the cholesterol-lowering bioactive molecules known as statins?

(A) *Saccharomyces cerevisiae*

(B) *Monascus purpureus*

(C) *Trichoderma polysporum*

(D) *Aspergillus niger*

Q30. In recombinant DNA technology, restriction endonucleases are specialized enzymes that cleave double-stranded DNA by recognizing which specific types of nucleotide sequences?

(A) Long poly-A tail sequences

(B) Random AT-rich regions

(C) Palindromic nucleotide sequences

(D) Telomeric repeating sequences

Q31. The technique known as Polymerase Chain Reaction (PCR) relies on a thermostable DNA polymerase called *Taq* polymerase. From which extremophilic microorganism is this enzyme isolated?

(A) *Thermus aquaticus*

(B) *Bacillus thuringiensis*

(C) *Escherichia coli*

(D) *Methanococcus jannaschii*

Q32. According to the competitive exclusion principle proposed by G.F. Gause, what is the ultimate evolutionary outcome when two closely related species compete intensely for identical, limiting resources?

(A) Both species evolve mutualistic adaptations to share resources.

(B) The inferior competitor will eventually be eliminated from the niche.

(C) Both species increase their reproductive rates to outcompete each other.

(D) They alter their niche requirements to survive together with equal abundance.

Q33. The fundamental unit of classification in the biological taxonomic hierarchy is the:

(A) Genus

(B) Family

(C) Species

(D) Order

Q34. Which type of cell junctions are specifically designed to stop substances from leaking across a tissue layer?

(A) Tight junctions

(B) Adhering junctions

(C) Gap junctions

(D) Synaptic junctions

Q35. Wuchereria bancrofti, a filarial worm transmitted through the bite of female Culex mosquitoes, causes chronic inflammation and swelling primarily in which human body system?

(A) Respiratory system

(B) Lymphatic vessels of the lower limbs

(C) Digestive tract lumen

(D) Central nervous system

Q36. The process of sewage treatment involves a primary phase and a secondary phase. Secondary treatment is fundamentally a:

(A) Purely physical screening process

(B) Chemical precipitation technique

(C) Biological process utilizing aerobic microbes

(D) Thermal sterilization step

Q37. During the separation of DNA fragments using agarose gel electrophoresis, the fragments migrate toward which electrode due to their intrinsic net charge?

(A) Positive anode, because DNA is negatively charged

(B) Negative cathode, because DNA is positively charged

(C) Positive anode, because DNA is positively charged

(D) Negative cathode, because DNA is negatively charged

Q38. An interaction where one species is harmed or inhibited while the other species remains completely unaffected is classified as:

(A) Commensalism

(B) Amensalism

(C) Parasitism

(D) Mutualism

Q39. The historical international accord signed in 1987 to control and drastically reduce the emission of ozone-depleting substances (ODSs) into the atmosphere is known as the:

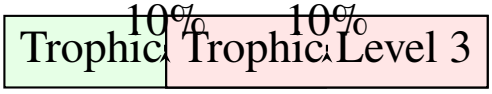
(A) Kyoto Protocol

(B) Montreal Protocol

(C) Paris Agreement

(D) Earth Summit

Q40. Look at the simplified schematic representation of the standard flow of energy through successive trophic levels in an ecosystem:



If the net primary productivity at Trophic Level 1 is measured to be $10,000$ kcal/m^2/yr, what is the net energy available to the organisms residing at Trophic Level 3 according to Lindeman's Efficiency Law?

(A) $1,000$ kcal/m^2/yr

(B) 100 kcal/m^2/yr

(C) 10 kcal/m^2/yr

(D) 1 kcal/m^2/yr

Detailed Solutions

Q1.

Solution

Concept: Plant and animal cells belong to the eukaryotic domain but differ significantly in their structural specializations. Plant cells possess unique structures dedicated to structural rigidity and autotrophic metabolic processing.

Solution:

(a) Typical plant cells are bounded by a rigid cellulose-based cell wall, which contains plastids like chloroplasts responsible for photosynthesis, chromoplasts containing non-photosynthetic pigments, and leucoplasts acting as nutrient storage houses.

(b) Plant cells feature a single, massive central vacuole that maintains cell turgor pressure, stores inorganic water and ions, and can occupy more than 90 percent of the absolute cellular volume.

(c) Animal cells lack plastids entirely because they utilize a heterotrophic mode of nutrition. They do not possess a large central vacuole, instead carrying small, temporary vacuoles scattered throughout the cytoplasm when needed.

(d) Mitochondria, Golgi apparatuses, and ribosomes are universal eukaryotic cellular machineries required by both plant and animal cell lines to maintain active respiration, protein trafficking, and peptide translation processes.

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

Answer: (C)

Go Back to Question 1

Q2.

Solution

Concept: The cell cycle consists of interphase (growth and replication stages) and the mitotic M phase (nuclear division), during which synthesized genetic materials are partitioned.

Solution:

(a) The given loop shows standard sequential phases: G1 (first gap phase), S (synthesis phase where DNA replication happens), G2 (second gap phase checking replication accuracy), and X, which denotes the karyokinetic M phase.

(b) The primary goal of phase X is the segregation of replicated genomes. Chromosomes condense, mitotic spindles attach to kinetochores, and sister chromatids separate toward poles.

(c) Synthesis of proteins and organelle replication occurs continuously during the interphase blocks (G1 and G2) rather than the active physical division stage.

(d) DNA replication is exclusive to the S phase, while quiescence describes cells exiting the active cycle to enter G0. Thus, X represents chromosome segregation.

Final Answer: Separation of sister chromatids or chromosomes.

Answer: (A)

Go Back to Question 2

Q3.

Solution

Concept: Meiosis introduces structural genetic diversity through homologous chromosome interactions during an elongated and complex prophase I stage.

Solution:

(a) Prophase I is divided into five distinct stages: leptotene, zygotene, pachytene, diplotene, and diakinesis, each representing unique molecular modifications.

(b) During leptotene, chromosomes condense. In zygotene, synapsis occurs as homologous chromosomes align and form synaptonemal complexes, yielding bivalent structures.

(c) Pachytene features the physical exchange of corresponding genetic segments between non-sister chromatids of homologous pairs, known as crossing over. This step relies on the multi-enzyme recombinase complex.

(d) Diplotene follows pachytene and is marked by the dissolution of the synaptonemal complex, revealing X-shaped cross-connection sites called chiasmata. Recombination is completed during pachytene.

Final Answer: Pachytene.

Answer: (C)

Go Back to Question 3

Q4.

Solution

Concept: Enzymes serve as biological catalysts that accelerate chemical reactions without altering final product thermodynamic stability or total chemical equilibrium states.

Solution:

(a) Chemical transformations require reactant molecules to gain a specific amount of energy to reach a transient, unstable transition state. This energy barrier is known as activation energy.

(b) Enzymes bind substrates at active sites, stabilizing the transition state via non-covalent interactions and lowering the activation energy needed for conversion.

(c) The absolute free energy change (ΔG) and total reaction enthalpy change (ΔH) depend solely on reactant and product characteristics, remaining unaltered by enzymes.

(d) Because the catalyst increases both forward and reverse reaction rates equally, the overall chemical equilibrium constant (K_{eq}) stays constant.

Final Answer: Decreasing the activation energy (E_a) required for the transition state.

Answer: (B)

Go Back to Question 4

Q5.

Solution

Concept: C4 plants use spatial separation to concentrate carbon dioxide around RuBisCO, minimizing energy-wasteful photorespiratory losses.

Solution:

(a) C4 leaf anatomy separates initial carbon capture and carbohydrate synthesis across two distinct cell types: mesophyll cells and bundle sheath cells.

(b) Atmosphere-derived carbon dioxide dissolves into mesophyll cytoplasm as bicarbonate ions. Here, phosphoenolpyruvate carboxylase links it to phosphoenolpyruvate, creating oxaloacetate.

(c) Phosphoenolpyruvate carboxylase lacks affinity for molecular oxygen, preventing the primary oxygenation reactions that trigger photorespiration under high heat.

(d) RuBisCO is sequestered in the bundle sheath layer, where C4 acids are decarboxylated to create a high-CO2 environment, optimizing Calvin cycle efficiency.

Final Answer: Phosphoenolpyruvate (PEP) carboxylase.

Answer: (B)

Go Back to Question 5

Q6.

Solution

Concept: Aerobic respiration extracts ATP from glucose oxidation via glycolysis, the citric acid cycle, and oxidative phosphorylation.

Solution:

(a) Glycolysis in the cytoplasm produces two molecules of NADH. Since the inner mitochondrial membrane is impermeable to NADH, shuttle mechanisms transport these reducing equivalents into the matrix.

(b) Heart, liver, and kidney tissues utilize the malate-aspartate shuttle. This pathway transfers electrons from cytoplasmic NADH to mitochondrial NAD+, yielding mitochondrial NADH.

(c) Each mitochondrial NADH drives the extrusion of protons to generate approximately 2.5 to 3 ATP molecules via the electron transport chain.

(d) Accounting for substrate-level phosphorylation and FADH2 inputs, the malate-aspartate shuttle yields a theoretical maximum of 36 to 38 ATP per glucose molecule.

Final Answer: 36 to 38 ATP.

Answer: (C)

Go Back to Question 6

Q7.

Solution

Concept: The Munch mass flow hypothesis explains how organic nutrients move through a plant's vascular network from source tissues to sink regions.

Solution:

(a) Photosynthetic source cells produce sucrose, which is actively loaded into phloem sieve tubes via companion cells using ATP-driven proton cotransport.

(b) This loading increases solute concentration in the phloem, lowering its water potential. Water then enters the sieve tubes from adjacent xylem vessels by osmosis.

(c) Influx of water generates high turgor or hydrostatic pressure at the source end. At the sink, sucrose is unloaded, raising water potential and driving water back into the xylem.

(d) This establishes a continuous hydrostatic pressure gradient between source and sink, moving bulk sap through the sieve tube network.

Final Answer: Hydrostatic pressure gradient.

Answer: (A)

Go Back to Question 7

Q8.

Solution

Concept: Plant hormones coordinate growth, development, and environmental responses through biochemical signaling pathways.

Solution:

(a) Ethylene is a gaseous plant hormone synthesized in tissues undergoing senescence or ripening, influencing a variety of growth responses.

(b) In seedlings, ethylene triggers a triple response: inhibition of elongation, swelling of the hypocotyl, and horizontal growth shifts to navigate soil barriers.

(c) Ethylene regulates fruit ripening by accelerating respiration rates, breaking down cell walls, and converting complex starches into simple sugars.

(d) Abscisic acid maintains seed dormancy, while gibberellins promote seed germination. Ethylene works alongside these pathways to help specific seeds break dormancy.

Final Answer: Ethylene.

Answer: (C)

Go Back to Question 8

Q9.

Solution

Concept: The female gametophyte of angiosperms develops through a structured pattern of nuclear divisions followed by asymmetrical cytokinesis.

Solution:

(a) A single functional megaspore undergoes three consecutive rounds of free-nuclear mitotic divisions, generating eight haploid nuclei within a shared cytoplasm.

(b) Cytokinesis then organizes these nuclei. Three migrate to the chalazal end to form antipodal cells, while three move to the micropylar end to form the egg apparatus.

(c) The egg apparatus contains a central egg cell flanked by two helper synergid cells, which assist in guiding the pollen tube.

(d) The remaining two polar nuclei stay in the large central cell. This produces a mature embryo sac with seven distinct cells containing eight total nuclei.

Final Answer: 7-celled and 8-nucleate.

Answer: (B)

Go Back to Question 9

Q10.

Solution

Concept: Human oogenesis is characterized by prolonged developmental pauses, delaying the completion of meiosis until fertilization occurs.

Solution:

(a) Fetal ovaries produce oogonia that transition into primary oocytes during embryonic development. These cells initiate meiosis I before birth.

(b) Chromosomes undergo synapsis and crossing over but arrest at the diplotene stage of prophase I, remaining dormant for years.

(c) This meiotic arrest is maintained by cyclic nucleotides until puberty, when monthly surges of luteinizing hormone prompt individual oocytes to resume division.

(d) The oocyte completes meiosis I to produce a secondary oocyte, which then arrests in metaphase II until a sperm triggers fertilization.

Final Answer: Prophase I (Diplotene stage).

Answer: (B)

Go Back to Question 10

Q11.

Solution

Concept: The menstrual cycle and ovulation are tightly regulated by complex feedback loops involving the hypothalamus, anterior pituitary gland, and ovarian hormones.

Solution:

(a) During the follicular phase, developing ovarian follicles secrete increasing amounts of estrogen into the bloodstream. This sustained high concentration of estrogen eventually triggers a switch from negative to positive feedback at the level of the hypothalamus and anterior pituitary.

(b) This positive feedback loop causes a sudden, massive release of gonadotropins, specifically resulting in a dramatic peak in Luteinizing Hormone levels, an event clinically termed the LH surge.

(c) The LH surge induces a cascade of physiological changes within the mature Graafian follicle. It stimulates the production of proteolytic enzymes and prostaglandins that weaken the follicular wall.

(d) Consequently, the mature follicle ruptures, releasing the secondary oocyte into the fallopian tube, a process known as ovulation. Folricle-Stimulating Hormone also rises but is not the primary inducer of rupture.

Final Answer: Luteinizing Hormone (LH).

Answer: (C)

Go Back to Question 11

Q12.

Solution

Concept: Contraceptive strategies vary widely in their mechanism of action, including hormonal prevention of ovulation, blocking implantation, or physically preventing the union of gametes.

Solution:

(a) Barrier methods function by creating a physical wall that prevents sperm from entering the female reproductive tract and reaching the ovum. Among these methods, condoms serve a critical dual purpose.

(b) Because they prevent direct skin-to-skin contact and the exchange of bodily fluids during intercourse, they are the only contraceptive devices highly effective at blocking pathogens.

(c) Other barrier options, like diaphragms or cervical caps, block sperm from entering the cervix but do not fully prevent fluid exchange or protect external mucosal layers.

(d) Hormonal methods, such as oral pills, and chemical methods, like Intrauterine Devices, alter systemic physiology or the uterine environment to stop pregnancy but offer no defense against infectious microorganisms.

Final Answer: Condoms.

Answer: (B)

Go Back to Question 12

Q13.

Solution

Concept: The gastric mucosa contains specialized secretory cells arranged within gastric pits that produce the components of gastric juice necessary for chemical digestion.
Solution:

(a) Parietal cells, also known as oxyntic cells, are large, pyramid-shaped cells located primarily in the proximal regions of the gastric glands. They actively transport hydrogen and chloride ions to secrete hydrochloric acid.

(b) This hydrochloric acid creates a highly acidic environment in the stomach lumen, which is necessary to denature dietary proteins and convert inactive pepsinogen into active pepsin.

(c) Simultaneously, parietal cells secrete intrinsic factor, a glycoprotein indispensable for the binding and subsequent absorption of vitamin B12 in the terminal ileum.

(d) Chief cells secrete the zymogen pepsinogen, whereas mucous neck cells produce protective mucus. Gastrin and somatostatin are regulatory hormones secreted by specialized endocrine cells, not parietal cells.

Final Answer: Hydrochloric acid (HCl) and Intrinsic factor.

Answer: (B)

Go Back to Question 13

Q14.

Solution

Concept: Carbon dioxide generated by cellular respiration in peripheral tissues must be transported efficiently via the venous system to the lungs for elimination.
Solution:

(a) Carbon dioxide is transported in the blood through three primary pathways: dissolved in plasma, bound to hemoglobin molecules, or chemically converted into bicarbonate ions.

(b) Approximately 7 percent remains dissolved in plasma, while about 23 percent binds to the amino groups of hemoglobin to form carbaminohemoglobin.

(c) The vast majority, roughly 70 percent, diffuses into erythrocytes where the enzyme carbonic anhydrase rapidly catalyzes its hydration into carbonic acid, which dissociates into hydrogen and bicarbonate.

(d) Bicarbonate ions diffuse out into the plasma in exchange for chloride ions, a process known as the chloride shift. Thus, bicarbonate in plasma is the primary transport form.

Final Answer: As bicarbonate ions (HCO_3^-) in plasma.

Answer: (C)

Go Back to Question 14

Q15.

Solution

Concept: The human cardiovascular system is organized into a double circulatory loop where deoxygenated and oxygenated blood flows are completely segregated.

Solution:

(a) Deoxygenated blood returning from systemic tissues enters the right atrium and passes into the right ventricle. The right ventricle pumps this blood out through the pulmonary trunk.

(b) Circuit X represents the pulmonary circulation loop. It carries deoxygenated blood away from the right side of the heart directly to the respiratory exchange surfaces of the lungs.

(c) In the lungs, carbon dioxide diffuses out of the blood into the alveoli, while freshly inspired oxygen diffuses into the capillaries, binding to hemoglobin.

(d) This oxygenated blood then travels via the pulmonary veins into the left atrium, moving to the left ventricle to be driven into systemic circulation to supply organs like the kidneys, liver, and brain.

Final Answer: Lungs.

Answer: (B)

Go Back to Question 15

Q16.

Solution

Concept: The nephron processes blood through glomerular filtration, tubular reabsorption, and tubular secretion to maintain homeostatic fluid and electrolyte balances.

Solution:

(a) Segment Y in the flow layout is the Proximal Convoluted Tubule, located directly downstream from Bowman's capsule and the glomerulus.

(b) The simple cuboidal epithelium of the Proximal Convoluted Tubule features a dense brush border of microvilli that increases the surface area available for reabsorption.

(c) This segment reabsorbs nearly 70 to 80 percent of the filtered electrolytes and water along with virtually all essential organic nutrients like glucose and amino acids.

(d) The Loop of Henle is responsible for establishing the hyperosmotic medullary gradient, whereas the Distal Convoluted Tubule performs fine, hormone-regulated, conditional reabsorption under the control of aldosterone and antidiuretic hormone.

Final Answer: Obligatory reabsorption of nearly 70-80% of electrolytes and water.

Answer: (A)

Go Back to Question 16

Q17.

Solution

Concept: Excitable cells communicate via action potentials, which are rapid, transient changes in membrane potential driven by voltage-gated ion channels.

Solution:

(a) At rest, a neuron maintains a negative resting membrane potential, typically around -70 millivolts, maintained by leak channels and the sodium-potassium pump.

(b) When a stimulus depolarizes the membrane to a critical threshold level, voltage-gated sodium channels open rapidly, changing their structural conformation.

(c) Due to the steep concentration and electrical gradients, sodium ions rush into the intracellular space, causing a rapid shift toward a positive membrane potential, known as depolarization.

(d) Repolarization follows as sodium channels inactivate and voltage-gated potassium channels open, allowing an efflux of potassium ions to restore the negative resting potential.

Final Answer: Influx of sodium ions (Na^+).

Answer: (B)

Go Back to Question 17

Q18.

Solution

Concept: Skeletal muscle contraction is explained by the sliding filament theory, where structural changes are governed by intracellular calcium levels.

Solution:

(a) In a relaxed muscle fiber, myosin heads are energized but cannot bind to actin because the myosin-binding sites on the thin filament are physically blocked.

(b) The regulatory protein tropomyosin forms a continuous strand that covers these active sites along the actin filament during resting conditions.

(c) When an action potential triggers the release of calcium ions from the sarcoplasmic reticulum, these ions bind directly to the troponin complex.

(d) This binding causes a conformational shift in troponin that pulls tropomyosin away from the binding sites, exposing them and allowing myosin heads to bind and execute the power stroke.

Final Answer: Troponin.

Answer: (B)

Go Back to Question 18

Q19.

Solution

Concept: Endocrine disorders frequently arise from the hypersecretion or hyposecretion of specific hormones, with clinical presentations varying based on developmental age.

Solution:

(a) Growth hormone, secreted by the anterior pituitary gland, coordinates tissue growth, cellular proliferation, and metabolic processes throughout the human body.

(b) Hypersecretion during childhood, before the epiphyseal plates of long bones fuse, causes proportional overgrowth of the entire skeleton, a condition known as gigantism.

(c) In contrast, hypersecretion during adulthood cannot increase stature because the epiphyseal plates are closed. Instead, it stimulates soft tissue and periosteal bone growth.

(d) This leads to acromegaly, a condition characterized by enlarged bones in the hands, feet, and face. Dwarfism and cretinism are caused by hormone deficiencies.

Final Answer: Acromegaly.

Answer: (B)

Go Back to Question 19

Q20.

Solution

Concept: Mendelian genetics uses mathematical models to predict the distribution of inherited traits across generations based on allele dominance hierarchies.

Solution:

(a) The cross examines a single gene locus regulating seed shape where the round allele (R) is completely dominant over the recessive wrinkled allele (r).

(b) When a heterozygous plant (Rr) is self-pollinated, the gametes carry either allele with equal probability, as illustrated by the headers of the Punnett square.

(c) Random fertilization yields three distinct genotypic combinations in a characteristic ratio: 1 RR, 2 Rr, and 1 rr.

(d) Because the dominant R allele masks the expression of r in heterozygotes, both RR and Rr individuals produce round seeds, resulting in an expected phenotypic ratio of 3 round to 1 wrinkled.

Final Answer: 3 : 1.

Answer: (B)

Go Back to Question 20

Q21.

Solution

Concept: Pedigree tracking evaluates how genetic phenotypes pass through families to establish whether traits reside on autosomes or sex chromosomes and whether they act as dominant or recessive alleles.

Solution:

(a) The pedigree shows an affected male parent in the first generation mating with an unaffected female. None of their immediate offspring in the second generation demonstrate the clinical trait.

(b) Because the trait disappears completely within the immediate second generation, the allele must be recessive, as dominant traits cannot skip generational lines without expressing the phenotype.

(c) If the trait were sex-linked or Y-linked dominant, all sons would display it. If it were X-linked recessive, the daughters would be carriers, which aligns with their unaffected clinical status.

(d) An autosomal recessive pattern works perfectly here because the children receive a dominant normal allele from their mother, making them unaffected heterozygous carriers who do not present the clinical phenotype.

Final Answer: Autosomal recessive.

Answer: (B)

Go Back to Question 21

Q22.

Solution

Concept: Prokaryotic replication requires coordinated enzyme steps to copy circular chromosomes precisely while removing temporary structural RNA components.

Solution:

(a) DNA polymerases can only elongate pre-existing nucleotide strands, meaning RNA primase must first build short RNA primers to provide the necessary free 3'-hydroxyl anchors.

(b) DNA Polymerase III is the primary replicative enzyme, binding to these anchors to synthesize the leading and lagging strands at high speeds.

(c) Once replication finishes, the temporary RNA primers must be removed. DNA Polymerase I uses its specialized 5' to 3' exonuclease activity to degrade the RNA.

(d) Simultaneously, DNA Polymerase I uses its polymerase activity to replace those spaces with accurate deoxyribonucleotides, leaving DNA ligase to seal the remaining nicks.

Final Answer: DNA Polymerase I.

Answer: (B)

Go Back to Question 22

Q23.

Solution

Concept: The genetic code uses mRNA nucleotide triplets to dictate peptide assignments, following specific patterns of redundancy and translation mechanics.

Solution:

(a) There are 64 possible combinations of three-letter codons built from the four RNA bases, but they translate into only 20 standard amino acids.

(b) Because codons outnumber amino acids, the code is degenerate, meaning several different codons can target and incorporate the exact same amino acid.

(c) For example, codons leucine, serine, and arginine are each specified by six different triplet combinations, often varying only at the third base position.

(d) This property is distinct from being unambiguous, which means one specific codon never codes for more than one amino acid, keeping translation precise.

Final Answer: Multiple different codons can code for the same single amino acid.

Answer: (B)

Go Back to Question 23

Q24.

Solution

Concept: Evolutionary morphology categorizes structural similarities as either homologous or analogous based on anatomical origins and environmental adaptation paths.

Solution:

(a) Homologous structures share a common anatomical framework derived from a shared ancestor, even if they have adapted to perform different tasks over time.

(b) The forelimbs of whales, bats, and humans share an identical skeletal layout of the humerus, radius, ulna, carpals, and phalanges, demonstrating divergent evolution.

(c) Whales adapted these limbs into flippers for swimming, bats turned them into wings for flight, and humans kept them versatile for manipulation and grasping.

(d) Structures like butterfly and bird wings are analogous, meaning they perform similar functions but evolved independently from completely different ancestral tissues.

Final Answer: Forelimbs of a whale, a bat, and a human.

Answer: (C)

Go Back to Question 24

Q25.

Solution

Concept: The Hardy-Weinberg principle provides a mathematical baseline to track allele and genotype frequencies within non-evolving populations.

Solution:

(a) The model uses the equation $p + q = 1$ for two alleles at a locus, where p is the dominant allele frequency and q is the recessive allele frequency.

(b) The prompt states the recessive allele frequency (a) is $q = 0.4$. Subtracting this from 1 gives the dominant allele frequency (A): $p = 1 - 0.4 = 0.6$.

(c) Genotype frequencies expand quadratically as $p^2 + 2pq + q^2 = 1$, where $2pq$ represents the frequency of heterozygous individuals (Aa).

(d) Multiplying these values yields the final heterozygous frequency: $2 \times 0.6 \times 0.4 = 0.48$. This indicates that 48 percent of the population carries both alleles.

Final Answer: 0.48.

Answer: (C)

Go Back to Question 25

Q26.

Solution

Concept: The five-kingdom system organizes living things by criteria like cellular architecture, body complexity, and primary nutritional modes.

Solution:

(a) Whittaker split single-celled organisms across two kingdoms based entirely on whether they lacked or possessed an organized nucleus.

(b) Unicellular prokaryotic organisms, such as bacteria and cyanobacteria, are grouped under Monera because they lack internal membrane-bound organelles.

(c) Unicellular eukaryotic organisms are assigned to the kingdom Protista, regardless of whether they act like autotrophic algae or heterotrophic protozoans.

(d) Multicellular eukaryotes are further split by nutrition: Fungi absorb nutrients, Plantae rely on photosynthesis, and Animalia use ingestion, making Protista the correct group here.

Final Answer: Protista.

Answer: (B)

Go Back to Question 26

Q27.

Solution

Concept: Animal tissues are divided into four primary groups—epithelial, connective, muscular, and nervous—based on their cellular shapes and functions.

Solution:

(a) Epithelial tissue consists of cells sheeted closely together with specialized cellular junctions and almost no extracellular matrix between them.

(b) This tissue lines internal body cavities, covers outer body surfaces, and forms protective barriers that control the transport of ions and fluids.

(c) In contrast, connective tissue features widely spaced cells embedded inside a large, self-secreted extracellular matrix that supports structural frameworks.

(d) Muscular tissue focuses entirely on contractile movement, while nervous tissue transmits electrochemical signals, leaving epithelial tissue as the body's primary protective shield.

Final Answer: Epithelial tissue.

Answer: (A)

Go Back to Question 27

Q28.

Solution

Concept: Malaria is caused by apicomplexan protozoans belonging to the genus Plasmodium, with species variations dictating the severity and timing of the disease.

Solution:

(a) While Plasmodium vivax, Plasmodium malariae, and Plasmodium ovale cause milder, recurring forms of malaria, Plasmodium falciparum causes the most severe infections.

(b) Plasmodium falciparum triggers malignant tertian malaria, characterized by massive red blood cell destruction and microvascular blockages.

(c) These blockages reduce blood flow to vital organs, potentially causing cerebral malaria, kidney failure, or acute respiratory distress.

(d) The synchronized rupture of red blood cells releases metabolic byproducts that cause intense, life-threatening fever spikes every 48 hours.

Final Answer: *Plasmodium falciparum*.

Answer: (C)

Go Back to Question 28

Q29.

Solution

Concept: Industrial microbiology harnesses fungal and bacterial metabolic pathways to mass-produce complex commercial drugs, enzymes, and organic acids.

Solution:

(a) Statins are important industrial compounds that lower blood cholesterol by competitively inhibiting HMG-CoA reductase, the rate-limiting enzyme in cholesterol synthesis.

(b) The filamentous red yeast strain Monascus purpureus is fermented commercially to produce lovastatin and related bioactive statins.

(c) Saccharomyces cerevisiae is used primarily for ethanol fermentation and baking, while Aspergillus niger is cultured to yield citric acid.

(d) Trichoderma polysporum produces cyclosporin A, an important immunosuppressant drug given to prevent organ transplant rejection.

Final Answer: *Monascus purpureus*.

Answer: (B)

Go Back to Question 29

Q30.

Solution

Concept: Genetic engineering relies on bacterial defense enzymes to isolate, cut, and manipulate specific double-stranded DNA target segments.

Solution:

(a) Restriction endonucleases are molecular scissors that scan DNA strands to find specific target configurations called restriction sites.

(b) These enzymes look for palindromic sequences, where the 5' to 3' nucleotide sequence reads identically on both complementary strands.

(c) For example, the restriction enzyme EcoRI recognizes the palindrome 5'-GAATTC-3' and cuts the sugar-phosphate backbone between G and A.

(d) This symmetric cutting produces single-stranded overhangs called sticky ends, which can readily base-pair with matching segments to form recombinant molecules.

Final Answer: Palindromic nucleotide sequences.

Answer: (C)

Go Back to Question 30

Q31.

Solution

Concept: The Polymerase Chain Reaction requires specialized enzymes capable of surviving repeated exposure to near-boiling temperatures during the denaturation phase of replication.

Solution:

(a) Normal DNA polymerases denature and lose structural functionality when exposed to temperatures exceeding 90 degrees Celsius. Therefore, early PCR iterations required manually adding fresh enzyme after each thermal cycle.

(b) The discovery of extremophilic bacteria revolutionized genetic technology. Thermus aquaticus is a thermophilic bacterium that thrives in high-temperature environments, such as hydrothermal vents and hot springs.

(c) The DNA polymerase isolated from this organism, known as Taq polymerase, exhibits high enzymatic activity and structural stability at temperatures around 72 to 80 degrees Celsius.

(d) More importantly, it remains functionally stable even after enduring the high-temperature denaturation phase near 95 degrees Celsius. This thermotolerance enables modern automated thermal cyclers to complete multiple amplification rounds efficiently without manual intervention.

Final Answer: *Thermus aquaticus*.

Answer: (A)

Go Back to Question 31

Q32.

Solution

Concept: Community ecology models analyze the long-term competitive dynamics and survival outcomes when sympatric populations vie for overlapping, non-infinite environmental assets.

Solution:

(a) The competitive exclusion principle states that two distinct species cannot occupy identical ecological niches indefinitely if they rely on the exact same limiting environmental resources.

(b) When resources are scarce and two species compete directly, minor physiological or behavioral advantages will allow one species to capture and utilize those resources more efficiently.

(c) This slight advantage translates into a higher reproductive rate and greater population growth for the superior competitor over successive generations.

(d) Concurrently, the less adapted, inferior competitor suffers a steady decline in population density due to resource deprivation. Deprived of a distinct fallback niche, the inferior species faces localized extinction or exclusion.

Final Answer: The inferior competitor will eventually be eliminated from the niche.

Answer: (B)

Go Back to Question 32

Q33.

Solution

Concept: Taxonomic classification organizes organic life using a standardized, nested structural ranking system that transitions from broad domains down to specific operational units.
Solution:

(a) Linnaean taxonomy groups organisms into a definitive series of hierarchical steps: Kingdom, Phylum, Class, Order, Family, Genus, and Species.

(b) As one ascends from species toward the kingdom level, the members of a group share fewer common traits and show greater genetic variation.

(c) A species represents the fundamental and base operational unit of this taxonomic hierarchy. It describes a discrete group of natural populations that share matching morphological, biochemical, and genetic features.

(d) Most importantly, individuals within a biological species are capable of interbreeding to produce fertile, viable offspring while remaining reproductively isolated from members of other distinct groups.

Final Answer: Species.

Answer: (C)
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Q34.

Solution

Concept: Histological formations utilize specialized cellular membrane attachments to coordinate cell-to-cell communication, structural anchoring, and tissue barrier permeability.
Solution:

(a) Epithelial cell sheets form continuous barriers that line body cavities and internal organs, requiring precise control over the movement of extracellular materials.

(b) Tight junctions are specialized intercellular connections formed by transmembrane sealing proteins, such as occludins and claudins, which encircle the apical regions of cells.

(c) These proteins stitch adjacent cell membranes tightly together, effectively obliterating the intercellular space and blocking the paracellular diffusion of solutes and fluid.

(d) Adhering junctions mechanically anchor adjacent cytoskeletons together, gap junctions facilitate direct metabolic and electrical communication, and synaptic junctions mediate chemical neurotransmission, leaving tight junctions as the key leak-preventing seals.

Final Answer: Tight junctions.

Answer: (A)
Go Back to Question 34

Q35.

Solution

Concept: Parasitic helminths show precise tissue tropism, navigating to specific organ networks inside a definitive host to mature, reproduce, and trigger localized inflammation.

Solution:

(a) Wuchereria bancrofti is a filarial nematode worm transmitted to humans through the bite of an infected female Culex mosquito vector.

(b) Once inside the human body, the microscopic microfilariae migrate to the lymphatic vessels, establishing residency primarily in the lower limbs and inguinal regions.

(c) Over many years, the presence of maturing and dead adult worms triggers chronic inflammatory responses, endothelial proliferation, and progressive fibrosis.

(d) This damage obstructs normal lymph drainage, leading to severe lymphedema, fluid retention, and dramatic swelling of the limbs and external genitalia, a clinical pathology termed elephantiasis.

Final Answer: Lymphatic vessels of the lower limbs.

Answer: (B)

Go Back to Question 35

Q36.

Solution

Concept: Wastewater management relies on a sequence of physical, chemical, and biological steps to lower pollutant loads before discharging effluent back into natural waterways.

Solution:

(a) Primary sewage treatment is a mechanical process focused on the physical separation of large floating debris and suspended solid particles through sequential filtration and sedimentation.

(b) The remaining liquid effluent, which contains high concentrations of dissolved organic pollutants, is then moved to secondary treatment tanks.

(c) Secondary treatment is fundamentally a biological process that passes the effluent into large aeration tanks containing active cultures of aerobic microorganisms.

[Image of sewage treatment plant process]

(d) These aerobic microbes form dense structural clusters called flocs, which metabolize and consume organic matter, lowering the Biochemical Oxygen Demand of the wastewater.

Final Answer: Biological process utilizing aerobic microbes.

Answer: (C)

Go Back to Question 36

Q37.

Solution

Concept: Electrophoretic separation techniques leverage the unique charge properties of macromolecules to guide their migration through a matrix under an electrical current.

Solution:

(a) Every nucleotide within a DNA molecule contains a hydrophilic phosphate group that carries a negative electrical charge at physiological pH levels.

(b) Because these negative charges are evenly distributed along the sugar-phosphate backbone, DNA possesses a uniform charge-to-mass ratio regardless of its total length.

(c) When an electric current is applied across an agarose gel matrix, the negatively charged DNA fragments migrate away from the negative cathode.

(d) The fragments move toward the positive electrode, known as the anode. The porous gel matrix acts as a molecular sieve, allowing smaller fragments to travel faster and farther than larger ones.

Final Answer: Positive anode, because DNA is negatively charged.

Answer: (A)

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Q38.

Solution

Concept: Interspecific interactions describe the varied symbiotic, predatory, or competitive dynamics that occur between different species living within a shared ecosystem.

Solution:

(a) Ecological interactions are categorized based on their positive, negative, or neutral impacts on the participating species.

(b) Commensalism occurs when one species benefits while the other is unaffected, whereas mutualism describes a cooperative dynamic where both species benefit.

(c) Parasitism involves one organism extracting fitness benefits at the direct physiological cost of a host organism.

(d) Amensalism describes an asymmetric interaction where one species is harmed, suppressed, or destroyed while the second species experiences no measurable cost or benefit. An example is Penicillium mold producing penicillin, which kills surrounding bacteria without impacting the mold.

Final Answer: Amensalism.

Answer: (B)

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Q39.

Solution

Concept: Global environmental agreements establish legally binding limits to control anthropogenic emissions that degrade the Earth's atmosphere and biosphere.

Solution:

(a) The release of synthetic chlorofluorocarbons and other halogenated compounds causes catalytic breakdown of ozone molecules within the stratosphere, thinning the protective ozone layer.

(b) In response to this ecological threat, nations drafted the Montreal Protocol on Substances that Deplete the Ozone Layer, which was opened for signatures in 1987.

(c) This international treaty established strict, legally binding schedules to phase out the production and consumption of ozone-depleting chemicals worldwide.

(d) The Kyoto Protocol and Paris Agreement target greenhouse gases to mitigate global climate change, while the Earth Summit produced broad sustainability frameworks, making Montreal the correct accord.

Final Answer: Montreal Protocol.

Answer: (B)

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Q40.

Solution

Concept: Trophic dynamics model the unidirectional transfer of energy across successive feeding levels within an ecosystem, accounting for metabolic losses.

Solution:

(a) Lindeman's Ten Percent Law states that during the transfer of organic energy from one trophic level to the next, only about 10 percent of the energy is stored as biomass.

(b) The remaining 90 percent is lost as metabolic heat during respiration, used for cellular maintenance, or lost to decomposers as undigested material.

(c) Trophic Level 1, representing primary producers, possesses a baseline energy yield of $10,000$ kcal/m^2/yr.

(d) Transferring this energy to Trophic Level 2 yields 10 percent: $10,000 \times 0.10 = 1,000$ kcal/m^2/yr. Applying the 10 percent rule again for Trophic Level 3 yields $1,000 \times 0.10 = 100$ kcal/m^2/yr.

Final Answer: 100 kcal/m^2/yr.

Answer: (B)

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Answer Key

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