NIOS Class 12 Biology Sample Paper-10

Duration: 180 Minutes **Maximum Marks: 80**

Instructions

- This paper contains **43** Questions. The paper is divided into two sections: **Section A – 40** marks, **Section B – 40** marks.
- **Section A** consists of
  - **Q.No. 1 to 16** – Multiple Choice type questions (MCQs) carrying 1 mark each. Select and write the most appropriate option out of the four options given in each of these questions. An internal choice has been provided in some of these questions. You have to attempt only one of the given choices in such questions.
  - **Q. No. 17 to 28**– Objective-type questions. Q. No. 17 to 28 carry 02 marks each (with 2 sub- parts of 1 mark each). Attempt these questions as per the instructions given for each of the questions 17 –28.
- **Section B** consists of
  - **Q.No. 29 to 37** – Very Short questions carrying 02 marks each to be answered in the range of 30 to 50 words.
  - **Q.No. 38 to 41** – Short Answer type questions carrying 03 marks each to be answered in the range of 50 to 80 words.
  - **Q.No. 42 and 43** – Long Answer type questions carrying 05 marks each to be answered in the range of 80 to 120 words.
- There is **No Negative marking**.
- Use of mobile phones, smartwatches, calculators, or any electronic gadgets is strictly prohibited.

Section: A

Q1. During non-cyclic photophosphorylation in chloroplasts of higher plants, the high-energy electrons excited from the P680 reaction centre of Photosystem II are first captured by which primary electron acceptor? **(1)**

(A) Plastocyanin

(B) Pheophytin

(C) Ferredoxin

(D) Plastoquinone

Q2. In a genetic cross involving *Mirabilis jalapa* (four o'clock plant), crossing a pure red-flowered plant (RR) with a pure white-flowered plant (rr) yields F1 hybrids bearing pink flowers (Rr). This phenotypic expression illustrates: **(1)**

(A) Co-dominance

(B) Incomplete dominance

(C) Multiple allelism

(D) Polygenic inheritance

Q3. Which major class of Kingdom Fungi produces endogenous sexual spores known as ascospores contained within specialized sac-like structures called asci? **(1)**

(A) Basidiomycetes

(B) Ascomycetes

(C) Zygomycetes

(D) Deuteromycetes

Q4. In an ecological food chain or trophic structure, the total rate of capture of solar energy or total synthesis of organic matter by green producers during photosynthesis prior to any respiratory loss is termed: **(1)**

(A) Net primary productivity (NPP)

(B) Gross primary productivity (GPP)

(C) Secondary productivity

(D) Ecological efficiency

Q5. Within the mitochondrial matrix during the Krebs citric acid cycle, the enzymatic conversion of alpha-ketoglutarate to succinyl-CoA is characterized by: **(1)**

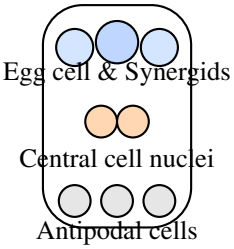
(A) Substrate-level phosphorylation yielding ATP alone

(B) Oxidative decarboxylation generating NADH and releasing CO_2

(C) Simple hydrolytic cleavage without redox changes

(D) Direct reduction of FAD to $FADH_2$

Q6. In angiosperms, the unique phenomenon of double fertilisation involves syngamy (fusion of one sperm cell with the egg cell) and triple fusion, where the second sperm cell fuses with the: **(1)**



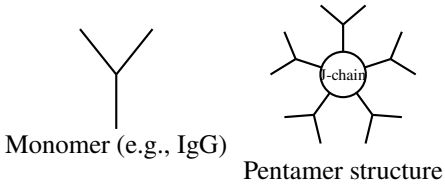
(A) Antipodal cells at the chalazal end

(B) Synergid cells flanking the egg apparatus

(C) Central cell containing two polar nuclei (or secondary nucleus)

(D) Nucellar tissue surrounding the embryo sac

Q7. Observe the schematic diagrams below representing antibody architectures. Which immunoglobulin class is structurally secreted as a pentamer stabilized by a J-chain and represents the primary circulating antibody produced during an initial humoral immune response? **(1)**



(A) IgG

(B) IgA

(C) IgM

(D) IgE

Q8. Which animal phylum is diagnostically distinguished by the presence of specialized stinging cells called cnidoblasts (or nematocysts) utilized for anchorage, prey capture, and defense? **(1)**

(A) Porifera

(B) Cnidaria (Coelenterata)

(C) Platyhelminthes

(D) Annelida

Q9. The enzyme nitrogenase, which catalyzes nitrogen fixation within leguminous root nodules, is rapidly inactivated by molecular oxygen (O_2). Which pink-coloured pigment present inside nodules acts as an oxygen scavenger to protect nitrogenase? **(1)**

(A) Anthocyanin

(B) Leghaemoglobin

(C) Chlorophyll b

(D) Xanthophyll

Q10. Prolonged dietary deficiency of iodine reduces the synthesis of triiodothyronine (T_3) and thyroxine (T_4), causing compensatory hypertrophy of the thyroid gland known clinically as: **(1)**

(A) Simple (endemic) goitre

(B) Exophthalmic goitre (Graves' disease)

(C) Acromegaly

(D) Addison's disease

Q11. During DNA replication, lagging strand synthesis produces discontinuous polynucleotide stretches called Okazaki fragments. Which enzyme catalyzes the formation of phosphodiester bonds to join these fragments into a continuous strand? **(1)**

(A) DNA helicase

(B) DNA topoisomerase

(C) DNA ligase

(D) RNA primase

Q12. In the human cardiac conduction system, which specialised nodal tissue spontaneously initiates action potentials at the highest frequency (≈ 70–75 beats/min) and functions as the primary pacemaker of the heart? **(1)**

(A) Atrioventricular (AV) node

(B) Sinoatrial (SA) node

(C) Bundle of His

(D) Purkinje network

Q13. Which mechanical plant tissue consists of living cells possessing uneven local thickenings of cellulose, hemicellulose, and pectin at their cell corners, providing flexible structural support to young growing petioles and stems? **(1)**

(A) Parenchyma

(B) Sclerenchyma fibres

(C) Collenchyma

(D) Xylem vessels

Q14. In the Polymerase Chain Reaction (PCR), the high-temperature denaturation step (94°C–96°C) requires a heat-stable DNA polymerase known as Taq polymerase, which is isolated from the thermophilic bacterium: **(1)**

(A) *Escherichia coli*

(B) *Bacillus thuringiensis*

(C) *Thermus aquaticus*

(D) *Agrobacterium tumefaciens*

Q15. Which permanent surgical contraceptive method in human males involves bilateral incision and ligation of a small segment of the ductus deferens to prevent sperm entry into the ejaculated semen? **(1)**

(A) Tubectomy

(B) Vasectomy

(C) Intrauterine device insertion

(D) Gonadectomy

Q16. Which mineralocorticoid steroid hormone secreted by the zona glomerulosa of the adrenal cortex stimulates the reabsorption of sodium (Na^+) and water from renal distal convoluted tubules while enhancing potassium (K^+) excretion? **(1)**

(A) Aldosterone

(B) Cortisol

(C) Epinephrine

(D) Thyroxine

Note: Q. No. 17 to 28 are objective-type questions carrying 2 marks each.

Q17. Read the passage given below and answer the following questions:

Cellular respiration involves step-wise oxidation of organic substrates within living cells. In eukaryotic organisms, glycolysis takes place in the cytosol and breaks down one glucose molecule into two molecules of pyruvate. Pyruvate then enters the mitochondrial matrix where it undergoes oxidative decarboxylation to form a key two-carbon acetyl coenzyme A compound, which links glycolysis to the Krebs citric acid cycle. **(2)**

1. Name the multi-enzyme complex responsible for catalyzing the oxidative decarboxylation of pyruvate to acetyl-CoA in the mitochondrial matrix.
2. How many carbon atoms are present in one molecule of acetyl-CoA?

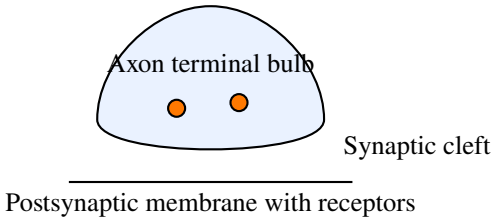
Q18. Complete the following sentences using the words given below:
(*stomata, lenticels, transpiration, guttation, hydathodes*) **(2)**

1. The loss of water in the form of water vapour from aerial parts of plants through microscopic epidermal pores called ..... is termed .....

2. The exudation of liquid water droplets containing dissolved inorganic salts from uninjured leaf margins through specialized structures called is known as .....

Q19. Read the passage and answer the questions that follow it.

Synapses are functional junctions where neural communication occurs between a presynaptic neuron and a postsynaptic cell. When an action potential reaches the axonal terminal bulb, it opens voltage-gated calcium channels. The resulting influx of calcium ions triggers the exocytosis of synaptic vesicles filled with chemical neurotransmitter molecules into the synaptic cleft. **(2)**



1. Name the primary excitatory chemical neurotransmitter released at vertebrate skeletal neuromuscular junctions and cholinergic synapses.
2. Which specific mineral ion influx into the presynaptic terminal triggers the exocytosis of neurotransmitter vesicles?

Q20. Fill in the blanks: **(2)**

1. The fundamental functional and structural unit of heredity transferred from parents to offspring, corresponding to a specific segment of DNA located on a chromosome, is called a .....
2. A diploid organism possessing two identical alleles for a given genetic locus (such as TT or tt) is described as being ..... for that trait.

Q21. Match the endocrine structures in Column I with their corresponding secretions/functions in Column II: **(2)**

Column I	Column II
(a) Parathyroid gland	(i) Secretes insulin and glucagon regulating blood glucose
(b) Adrenal medulla	(ii) Secretes parathormone regulating extracellular blood calcium
(c) Anterior pituitary	(iii) Secretes epinephrine and norepinephrine during stress responses
(d) Islets of Langerhans	(iv) Secretes trophic hormones including TSH, ACTH, and GH

Q22. Fill in the blanks: **(2)**

1. An obligate positive species interaction where both interacting partners derive reciprocal nutritional or shelter benefits and neither can survive alone in nature is termed .....
2. The progressive accumulation and increase in concentration of persistent, non-biodegradable toxic substances (such as DDT or heavy metals) at successive trophic levels in a food chain is called biological .....

Q23. Write TRUE (T) for the correct statement and FALSE (F) for the incorrect statement: **(2)**

1. In the human female reproductive cycle, a rapid mid-cycle surge in Luteinizing Hormone (LH surge) triggers ovulation around the 14th day of a 28-day cycle.
2. The interstitial cells of Leydig located inside the seminiferous tubules undergo meiotic cell division directly to transform into haploid spermatozoa.

Q24. Match the plant vascular/anatomical terms in Column I with their correct roles in Column II: **(2)**

Column I	Column II
(a) Xylem vessels	(i) Regulate stomatal pore opening and closing via turgor changes
(b) Phloem sieve tubes	(ii) Responsible for secondary radial growth (girth expansion)
(c) Vascular cambium	(iii) Conduct water and dissolved inorganic minerals upward from roots
(d) Guard cells	(iv) Translocate photoassimilated organic food from sources to sinks

Q25. Fill in the blanks: **(2)**

1. In plant nitrogen assimilation, the synthesis of glutamate from alpha-ketoglutarate and ammonium ions catalyzed by glutamate dehydrogenase is called reductive .....
2. The enzymatic reduction of atmospheric dinitrogen gas (N_2) into ammonia (NH_3) carried out by specialized prokaryotic organisms is termed biological nitrogen .....

Q26. Match the biotechnology tools in Column I with their correct applications in Column II: **(2)**

Column I	Column II
(a) Plasmid vector (e.g., pBR322)	(i) Separates DNA fragments based on molecular size under electric current
(b) Gel electrophoresis	(ii) Distinguishes recombinant host cells from non-recombinants
(c) Bioreactor	(iii) Autonomously replicating circular DNA used to transfer foreign genes
(d) Selectable marker	(iv) Large stainless vessel for industrial cultivation of engineered cells

Q27. Write TRUE (T) for the correct statement and FALSE (F) for the incorrect statement: **(2)**

1. Vitamin B_{12} (cyanocobalamin) contains cobalt and is essential for normal erythropoiesis; its deficiency leads to pernicious anaemia.
2. Marasmus is a dietary disorder caused solely by excessive consumption of dietary saturated fats and refined carbohydrates in mature adults.

Q28. Match the molecular genetics terms in Column I with their precise definitions in Column II: **(2)**

Column I	**Column II**
(a) Promoter	(i) Triplet nucleotide sequence on mRNA coding for a specific amino acid
(b) Intron	(ii) Complementary triplet loop sequence on tRNA recognizing codons
(c) Codon	(iii) Upstream DNA sequence where RNA polymerase binds to initiate transcription
(d) Anticodon	(iv) Non-coding intervening nucleotide sequence spliced out from pre-mRNA

Section: B

Q29. Differentiate between parenchyma and collenchyma plant tissues based on cell wall thickening and intercellular spaces. State one principal function of each tissue. **(2)**

Q30. State any two significant advantages of plant tissue culture (micropropagation) in commercial crop improvement and horticulture. **(2)**

Q31. (i) Distinguish between primary air pollutants and secondary air pollutants, citing one chemical example for each category.

OR

(ii) Define ecological pyramid of biomass. Why does an aquatic ecosystem (such as a pond or open ocean) typically display an inverted pyramid of biomass? **(2)**

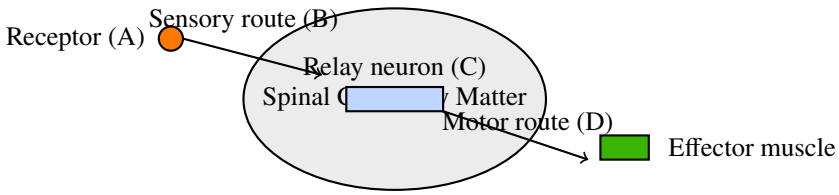
Q32. (i) State two diagnostic morphological characteristics of Kingdom Fungi that separate them from Kingdom Plantae.

OR

(ii) State two diagnostic features of Phylum Chordata that distinguish chordates from non-chordate invertebrate phyla. **(2)**

Q33. A double-stranded DNA molecule contains 1,200 base pairs (total 2,400 nucleotides). If 25% of the total nitrogenous bases are Adenine (A), calculate the exact number of Guanine (G), Cytosine (C), and Thymine (T) nucleotides present in this DNA molecule. Determine the total number of hydrogen bonds stabilizing the helix. **(2)**

Q34. Observe the diagrammatic representation of a spinal reflex arc shown below. Identify the anatomical structures labelled A, B, C, and D, and state the physiological role of component C. **(2)**



Q35. (i) Name the two peptide hormones released by the posterior lobe of the human pituitary gland (neurohypophysis) and specify their primary physiological target organs.

OR

(ii) Briefly explain how the sympathetic and parasympathetic autonomic neural divisions exert antagonistic regulation over human heart rate. **(2)**

Q36. Differentiate between active immunity and passive immunity based on the origin of protective antibodies and duration of immunological memory. Provide one clinical example for each type. **(2)**

Q37. Describe the structural features of human pulmonary alveoli that make them

highly adapted for rapid and efficient respiratory gas exchange. **(2)**

Q38. Define the following botanical terms and provide one biological example or practical context for each:

A. Plasmolysis

B. Apical dominance

C. Phototropism **(3)**

Q39. (i) Explain the mechanism of stomatal opening and closing during daytime and night according to Levitt's potassium ion (K^+) influx theory.

OR

(ii) Explain how Dixon and Joly's cohesion-tension transpiration pull theory accounts for the continuous ascent of sap in exceptionally tall vascular trees. **(3)**

Q40. Differentiate between innate immunity and acquired (adaptive) immunity across three fundamental aspects: antigen specificity, presence of immunological memory, and cellular/barrier components. **(3)**

Q41. (i) Describe the clinical etiology, primary physiological manifestations, and dietary preventive measures for infants suffering from Protein-Energy Malnutrition (PEM) manifested as Marasmus.

OR

(ii) Describe the underlying nutritional deficiency, diagnostic physiological symptoms, and effective preventive measures for rickets in developing children. **(3)**

Q42. (i) (a) Explain the structural architecture of Watson and Crick's double-stranded B-DNA double helix model.

(b) Describe the molecular mechanisms underlying initiation, elongation, and termination during semi-conservative DNA replication in prokaryotes.

OR

(ii) (a) Explain the concept of incomplete dominance with a schematic Punnett square cross involving flower colour inheritance in snapdragon (*Antirrhinum majus*).

(b) State Mendel's Law of Segregation and justify why it is universally recognized as the law of purity of gametes. **(5)**

Q43. (i) (a) Draw a well-labelled diagram of a typical human nephron illustrating its tubular segments and vascular supply.

(b) Explain the three physiological mechanisms governing urine formation: glomerular ultrafiltration, selective tubular reabsorption, and tubular secretion.

OR

(ii) (a) Describe the sequential physiological and uterine changes occurring during the four phases of the human menstrual cycle.

(b) Explain the hormonal regulation governing ovulation and the maintenance of secretory uterine endometrium by corpus luteum secretions. **(5)**

Detailed Solutions

Q1.

Solution

Concept: In light-dependent non-cyclic photophosphorylation (Z-scheme of photosynthesis), excitation of light-harvesting complex II (Photosystem II) at 680 nm ejects high-energy electrons from the chlorophyll molecule P680. These excited electrons pass onto a primary electron acceptor located inside the thylakoid membrane before traversing the plastoquinone-cytochrome b_6f transport chain.

Step 1: When PS II absorbs photons of wavelength $\leq$ 680 nm, the reaction centre chlorophyll *a* (P680) becomes excited (P680*) and donates its energized electron.
Step 2: The primary electron acceptor of PS II is pheophytin, a modified chlorophyll *a* molecule that lacks the central magnesium (Mg^{2+}) ion, having two hydrogen atoms in its place.
Step 3: Pheophytin transfers the electron to plastoquinone (PQ), while plastocyanin transfers electrons between cytochrome b_6f and PS I, and ferredoxin serves as the electron acceptor for Photosystem I.
Final Answer: Pheophytin is the primary electron acceptor of Photosystem II.

Answer: (B) Go Back to Question 1

Q2.

Solution

Concept: In standard Mendelian dominance, heterozygous individuals completely express the dominant phenotype. However, when neither allele is completely dominant over the other, the F1 heterozygote shows an intermediate phenotype blending the parental traits.

Step 1: In *Mirabilis jalapa*, homozygous red flowers carry genotype RR and homozygous white flowers carry genotype rr.
Step 2: Crossing RR $\times$ rr produces F1 offspring with genotype Rr. Because the red allele R cannot completely mask the white allele r, less red pigment (anthocyanin) is synthesized.
Step 3: As a result, heterozygous Rr plants develop pink flowers. Selfing F1 pink (Rr $\times$ Rr) yields an F2 phenotypic and genotypic ratio of 1 Red (RR) : 2 Pink (Rr) : 1 White (rr), which is the hallmark of incomplete dominance.
Final Answer: Incomplete dominance

Answer: (B) Go Back to Question 2

Q3.

Solution

Concept: Kingdom Fungi is subdivided into four major classes based on mycelial morphology and fungal reproductive structures: Phycomycetes (Zygomycetes), Ascomycetes, Basidiomycetes, and Deuteromycetes.

Step 1: Ascomycetes are commonly called 'sac fungi' because their karyogamy and meiosis occur inside sac-like cells called asci (singular: ascus).
Step 2: Inside each ascus, typically eight haploid endogenous sexual spores called ascospores are formed.
Step 3: Basidiomycetes (club fungi like mushrooms) produce exogenous basidiospores on club-shaped basidia, while Deuteromycetes (imperfect fungi) lack known sexual reproductive cycles.
Final Answer: Ascomycetes

Answer: (B) Go Back to Question 3

Q4.

Solution

Concept: Primary productivity in an ecosystem represents the rate at which radiant solar energy is captured and converted into organic biomass by autotrophic producers.

Step 1: Gross Primary Productivity (GPP) is defined as the total rate of photosynthesis or total biomass generated by primary producers per unit area per unit time.
Step 2: Plants utilize a significant fraction of this fixed energy for their own metabolic maintenance through cellular respiration (R).
Step 3: The remaining organic matter stored in plant tissues available for consumption by herbivores is Net Primary Productivity (NPP), mathematically formulated as NPP = GPP – R. Therefore, total capture before respiration is GPP.
Final Answer: Gross primary productivity (GPP)

Answer: (B) Go Back to Question 4

Q5.

Solution

Concept: The Krebs cycle involves a series of redox and decarboxylation reactions inside the mitochondrial matrix that oxidize acetyl-CoA to carbon dioxide and reduced coenzymes.

Step 1: Alpha-ketoglutarate is a 5-carbon dicarboxylic acid intermediate formed during the citric acid cycle.

Step 2: The enzyme complex alpha-ketoglutarate dehydrogenase catalyzes the oxidative decarboxylation of alpha-ketoglutarate (C_5).

Step 3: During this reaction, one molecule of carbon dioxide (CO_2) is released, and NAD^+ is reduced to NADH + H^+, while coenzyme A is attached to form the 4-carbon compound succinyl-CoA.

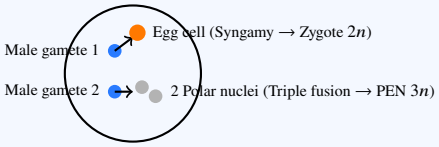
Final Answer: Oxidative decarboxylation generating NADH and releasing CO_2

Answer: (B) Go Back to Question 5

Q6.

Solution

Concept: Double fertilisation is a unique evolutionary characteristic of flowering plants (angiosperms). A mature pollen tube discharges two haploid male gametes into one of the synergids inside the embryo sac.



Step 1: The first haploid sperm cell (n) fuses with the haploid egg nucleus (n) in a process termed syngamy (or generative fertilisation), generating a diploid zygote ($2n$) that develops into the embryo.

Step 2: The second haploid sperm cell (n) migrates toward the central cell and fuses with the two polar nuclei ($n + n$) (or secondary nucleus $2n$) in a process called vegetative fertilisation or triple fusion.

Step 3: This triple fusion produces the triploid Primary Endosperm Nucleus (PEN, $3n$), which divides to form nutritive endosperm tissue.

Final Answer: Central cell containing two polar nuclei (or secondary nucleus)

Answer: (C) Go Back to Question 6

Q7.

Solution

Concept: Immunoglobulins (antibodies) are synthesized by activated plasma B-cells. They exist in five classes (IgG, IgA, IgM, IgE, IgD) differing in heavy chain structure, valency, and biological effector functions.

Step 1: IgM is structurally the largest immunoglobulin molecule, consisting of five basic Y-shaped monomer units (valency = 10) joined together by disulfide bonds and a polypeptide joining chain (J-chain).
Step 2: Due to its pentameric structure, IgM is a potent agglutinating and complement-activating antibody.
Step 3: It is the very first antibody isotype synthesized and secreted into the bloodstream by B-cells during the primary immune response against a newly encountered pathogen.
Final Answer: IgM

Answer: (C) Go Back to Question 7

Q8.

Solution

Concept: Phylum Cnidaria (formerly Coelenterata) comprises aquatic, radially symmetrical, diploblastic animals exhibiting tissue level of organization.

Step 1: Members of Cnidaria (such as *Hydra*, jellyfish, sea anemones, and corals) bear specialized stinging cells termed cnidoblasts or cnidocytes concentrated along their tentacles and body wall.
Step 2: Each cnidocyte houses a subcellular organelle called a nematocyst, containing a coiled stinging thread bathed in a neurotoxin called hypnotoxin.
Step 3: Upon mechanical or chemical stimulation, the nematocyst thread fires rapidly to pierce prey, paralyzing it and aiding in anchorage or defense.
Final Answer: Cnidaria (Coelenterata)

Answer: (B) Go Back to Question 8

Q9.

Solution

Concept: Symbiotic nitrogen fixation occurs inside nodules formed on legume roots by *Rhizobium* bacteria. The nitrogen-fixing enzyme nitrogenase is a molybdenum-iron (Mo-Fe) protein that requires strictly anaerobic conditions because O_2 irreversibly oxidizes its active site.

Step 1: To ensure an anaerobic microenvironment within nodule cells while maintaining sufficient cellular respiration for ATP synthesis, legume nodules synthesize a specialized hemoprotein.
Step 2: This hemoprotein is leghaemoglobin (legume haemoglobin), which gives healthy root nodules their characteristic pink or reddish interior coloration.
Step 3: Leghaemoglobin binds oxygen with high affinity, functioning as an efficient oxygen scavenger that maintains free dissolved O_2 at extremely low levels harmless to nitrogenase.
Final Answer: Leghaemoglobin

Answer: (B) Go Back to Question 9

Q10.

Solution

Concept: Iodine is an essential trace element required by follicular cells of the thyroid gland to iodinate tyrosine residues for synthesizing thyroxine (T_4) and triiodothyronine (T_3).

Step 1: When dietary iodine intake is chronically deficient, blood levels of circulating thyroid hormones drop below normal (hypothyroidism).
Step 2: Reduced T_3/T_4 removes negative feedback inhibition on the anterior pituitary gland, leading to excessive hypersecretion of Thyroid Stimulating Hormone (TSH).
Step 3: Sustained high TSH stimulation causes hyperplasia and hypertrophy of thyroid follicular cells, resulting in prominent swelling of the neck known as simple or endemic goitre.
Final Answer: Simple (endemic) goitre

Answer: (A) Go Back to Question 10

Q11.

Solution

Concept: DNA polymerases can synthesize new polynucleotide strands only in the $5' \rightarrow 3'$ direction. Consequently, at replication forks, the leading strand is synthesized continuously while the lagging strand is synthesized discontinuously as short Okazaki fragments.

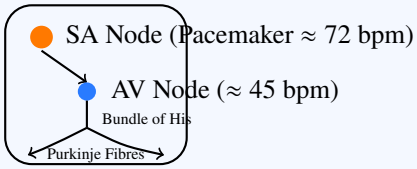
Step 1: RNA primers synthesized by primase initiate each Okazaki fragment on the lagging strand template.
Step 2: Once DNA polymerase I removes RNA primers and fills gaps with deoxyribonucleotides, nicks remain in the sugar-phosphate backbone between adjacent DNA fragments.
Step 3: The enzyme DNA ligase catalyzes the formation of phosphodiester bonds between the $3'$-OH terminus of one fragment and the $5'$-phosphate group of the next, sealing the strand.
Final Answer: DNA ligase

Answer: (C) Go Back to Question 11

Q12.

Solution

Concept: The human heart is myogenic, meaning rhythmic cardiac contractions originate within specialized autoexcitatory nodal cardiac muscle tissue without external nervous stimuli.



Step 1: The Sinoatrial (SA) node is embedded in the upper right dorsal wall of the right atrium near the superior vena cava entry.
Step 2: Although all nodal tissues (SA node, AV node, Bundle of His, Purkinje fibres) possess autoexcitatory rhythmicity, the SA node exhibits the highest intrinsic rate of depolarization (70–75 impulses/min).
Step 3: Because it initiates the electrical wave that spreads through both atria and dictates overall heart rate, the SA node serves as the natural anatomical pacemaker.
Final Answer: Sinoatrial (SA) node

Answer: (B) Go Back to Question 12

Q13.

Solution

Concept: Simple permanent plant tissues comprise three categories based on cell wall composition and mechanical support: parenchyma, collenchyma, and sclerenchyma.

Step 1: Collenchyma consists of living, elongated cells containing functional protoplasts and nuclei, typically situated just beneath the epidermis in dicot stems and leaf petioles.
Step 2: Unlike thin-walled parenchyma, collenchyma cell walls exhibit uneven localized thickenings at corners or tangential walls due to heavy deposition of cellulose, hemicellulose, and hydrophilic pectin.
Step 3: This structure grants high tensile strength and flexibility, allowing young stems and petioles to bend under wind stress without breaking.
Final Answer: Collenchyma

Answer: (C) Go Back to Question 13

Q14.

Solution

Concept: Polymerase Chain Reaction (PCR) is an *in vitro* enzymatic gene amplification technique that cyclically repeats thermal denaturation (94°C), primer annealing (55°C), and extension (72°C).

Step 1: Standard mesophilic enzymes like *E. coli* DNA polymerase denature and lose catalytic function when heated above 90°C during strand denaturation.
Step 2: To automate PCR without adding fresh enzyme at every cycle, scientists isolated a thermostable DNA polymerase called Taq polymerase from the extremophilic eubacterium *Thermus aquaticus*, discovered in hot springs.
Step 3: Taq polymerase remains fully active at optimal extension temperatures (72°C) and withstands repeated denaturation cycles at 95°C.
Final Answer: *Thermus aquaticus*

Answer: (C) Go Back to Question 14

Q15.

Solution

Concept: Surgical sterilization procedures provide permanent contraception by blocking gamete transport ducts without affecting endocrine hormone production or sexual desire.

Step 1: In human males, sperm produced in the testes mature in the epididymis and ascend through bilateral ducts called the vas deferens (ductus deferens) toward the urethra.
Step 2: In vasectomy, a surgeon makes small scrotal incisions to excise and surgically ligate a short segment of each vas deferens.
Step 3: While testicular androgen secretion and seminal plasma production continue normally, ejaculation releases semen devoid of spermatozoa (azoospermia), preventing fertilization.
Final Answer: Vasectomy

Answer: (B) Go Back to Question 15

Q16.

Solution

Concept: The adrenal cortex comprises three concentric histological zones: zona glomerulosa (outer), zona fasciculata (middle), and zona reticularis (inner), synthesizing mineralocorticoids, glucocorticoids, and sex corticoids respectively.

Step 1: Aldosterone is the principal mineralocorticoid secreted by cells of the zona glomerulosa in response to low systemic blood pressure or high extracellular potassium via the Renin-Angiotensin-Aldosterone System (RAAS).
Step 2: Aldosterone acts directly on principal cells of the renal distal convoluted tubule (DCT) and cortical collecting duct.
Step 3: It stimulates active reabsorption of sodium (Na^+) and osmotic reabsorption of water back into blood, while promoting tubular secretion and elimination of potassium (K^+) and protons (H^+).
Final Answer: Aldosterone

Answer: (A) Go Back to Question 16

Q17.

Solution

Concept: The link reaction (oxidative decarboxylation) connects cytosolic glycolysis with the mitochondrial Krebs cycle. Pyruvate (C_3) formed in the cytosol enters the mitochondrial matrix via specific transport proteins.

Step 1: Inside the matrix, pyruvate undergoes oxidative decarboxylation catalyzed by the multi-enzyme pyruvate dehydrogenase complex requiring five cofactors (CoA, NAD^+, FAD, TPP, lipoic acid).
Step 2: Pyruvate (C_3) loses one carbon atom as CO_2 and transfers electrons to NAD^+, forming a 2-carbon acetyl fragment covalently bound to coenzyme A (Acetyl-CoA).
Step 3: Thus, the enzyme complex is Pyruvate Dehydrogenase, and acetyl-CoA contains exactly 2 carbon atoms.
Final Answer: 1. Pyruvate dehydrogenase complex 2. Two (2) carbon atoms

Answer: (See above) Go Back to Question 17

Q18.

Solution

Concept: Plants lose excess water to the atmosphere through two distinct physiological mechanisms: gaseous transpiration and liquid guttation.

Step 1: Nearly 90%–95% of plant water loss occurs as vapor diffusing out through microscopic epidermal pores called stomata located primarily on leaf blades; this process is transpiration.
Step 2: Under conditions of high root pressure and low relative humidity or cool nights, liquid water containing dissolved minerals is forced out of specialized pore structures called hydathodes at leaf vein tips; this phenomenon is guttation.
Final Answer: 1. stomata; transpiration 2. hydathodes; guttation

Answer: (See above) Go Back to Question 18

Q19.

Solution

Concept: Synaptic transmission across chemical synapses relies on depolarization-induced calcium entry and subsequent neurotransmitter exocytosis across the synaptic cleft.

Step 1: Acetylcholine (ACh) is the classic excitatory neurotransmitter synthesized from choline and acetyl-CoA inside cholinergic axonal terminals and released at neuromuscular junctions.
Step 2: When depolarization reaches the presynaptic knob, voltage-gated calcium (Ca^{2+}) channels open, driving an extracellular influx of Ca^{2+} ions into the cytoplasm.
Step 3: Elevated cytosolic Ca^{2+} binds to synaptotagmin proteins, triggering exocytotic fusion of synaptic vesicles with the presynaptic membrane.
Final Answer: 1. Acetylcholine (ACh) 2. Calcium ion (Ca^{2+})

Answer: (See above) Go Back to Question 19

Q20.

Solution

Concept: Classical and molecular genetics define distinct terms to categorize genetic factors and zygosity states in diploid organisms.

Step 1: A gene is the fundamental physical and functional unit of heredity, consisting of a specific sequence of nucleotides located at a precise position (locus) on a chromosome.
Step 2: In diploid individuals carrying homologous chromosome pairs, if both alleles at a specific gene locus are identical (such as homozygous dominant TT or recessive tt), the organism is homozygous.
Final Answer: 1. gene 2. homozygous

Answer: (See above) Go Back to Question 20

Q21.

Solution

Concept: Endocrine glands synthesize regulatory chemical messengers secreted directly into systemic circulation to maintain physiological homeostasis.

Step 1: Parathyroid glands secrete peptide parathormone (PTH), which increases blood calcium levels by stimulating bone resorption and renal calcium reabsorption, matching (a)-(ii).
Step 2: The adrenal medulla secretes catecholamines epinephrine (adrenaline) and norepinephrine during acute physical or emotional stress ("fight-or-flight"), matching (b)-(iii).
Step 3: The anterior pituitary (adenohypophysis) secretes trophic peptide hormones such as TSH, ACTH, GH, LH, and FSH, matching (c)-(iv).
Step 4: Islets of Langerhans in the endocrine pancreas contain beta and alpha cells secreting insulin and glucagon respectively to regulate blood glucose, matching (d)-(i).
Final Answer: (a)-(ii), (b)-(iii), (c)-(iv), (d)-(i)

Answer: (See above) Go Back to Question 21

Q22.

Solution

Concept: Ecological interactions and pollutant dynamics shape community structure and ecosystem health.

Step 1: Mutualism is an obligate positive species interaction (+, +) where both symbionts derive reciprocal nutritional or survival benefits (e.g., lichens comprising algae and fungi).
Step 2: Lipid-soluble, non-biodegradable xenobiotics like DDT are not metabolized or excreted; instead, they become concentrated as they pass upward through trophic levels, a phenomenon termed biomagnification or biological magnification.
Final Answer: 1. mutualism 2. magnification (or biomagnification)

Answer: (See above) Go Back to Question 22

Q23.

Solution

Concept: Reproductive physiology relies on precise pituitary gonadotropin surges and testicular cellular compartmentalization.

Step 1: In a standard 28-day human menstrual cycle, rising follicular oestrogen induces a rapid pre-ovulatory surge of Luteinizing Hormone (LH surge) from the anterior pituitary around day 14, causing Graafian follicle rupture and ovulation (TRUE).
Step 2: Interstitial cells of Leydig lie outside seminiferous tubules in the inter-tubular connective tissue and secrete testosterone; spermatogenesis occurs within seminiferous tubules via male germ cells (spermatogonia), not Leydig cells (FALSE).
Final Answer: 1. True (T) 2. False (F)

Answer: (See above) Go Back to Question 23

Q24.

Solution

Concept: Vascular plants possess specialized conductive tissues and epidermal structures coordinating transport and secondary enlargement.

Step 1: Xylem vessels are non-living tubular elements that conduct water and inorganic minerals unidirectionally from roots to aerial leaves, matching (a)-(iii).
Step 2: Phloem sieve tube elements translocate soluble organic sucrose and photoassimilated nutrients bidirectionally from source leaves to storage sinks, matching (b)-(iv).
Step 3: Vascular cambium is a lateral meristem producing secondary xylem (wood) and phloem, driving increase in stem girth (secondary growth), matching (c)-(ii).
Step 4: Guard cells are specialized bean-shaped epidermal cells whose turgor fluctuations regulate stomatal aperture diameter, matching (d)-(i).
Final Answer: (a)-(iii), (b)-(iv), (c)-(ii), (d)-(i)

Answer: (See above) Go Back to Question 24

Q25.

Solution

Concept: Biological nitrogen metabolism converts inert atmospheric dinitrogen and soil inorganic nitrogen into amino acids.

Step 1: In reductive amination, ammonia (NH_4^+) reacts with alpha-ketoglutaric acid in the presence of NADPH and glutamate dehydrogenase to yield the amino acid glutamate (or glutamic acid).
Step 2: The conversion of atmospheric dinitrogen (N_2) into ammonia by diazotrophic bacteria (like *Rhizobium* or *Azotobacter*) possessing nitrogenase is biological nitrogen fixation.
Final Answer: 1. amination 2. fixation

Answer: (See above) Go Back to Question 25

Q26.

Solution

Concept: Recombinant DNA methodology integrates specific cloning vectors, analytical separation devices, and fermentation engineering.

Step 1: Plasmid cloning vectors like pBR322 are circular, double-stranded DNA molecules capable of autonomous replication used to carry foreign DNA fragments into host cells, matching (a)-(iii).
Step 2: Agarose gel electrophoresis separates negatively charged DNA restriction fragments based on molecular size under an electrical field, matching (b)-(i).
Step 3: A bioreactor is a large engineered vessel providing optimal pH, temperature, oxygen, and agitation for industrial cultivation of recombinant microorganisms, matching (c)-(iv).
Step 4: Selectable markers (like ampicillin or tetracycline resistance genes) allow elimination of non-transformants and selective growth of transformant host cells, matching (d)-(ii).
Final Answer: (a)-(iii), (b)-(i), (c)-(iv), (d)-(ii)

Answer: (See above) Go Back to Question 26

Q27.

Solution

Concept: Nutritional deficiency diseases correlate with specific lack of water-soluble vitamins or macronutrient imbalances.

Step 1: Vitamin B_{12} (cyanocobalamin) contains a central cobalt atom and is vital for RBC maturation; lack of gastric intrinsic factor or dietary B_{12} leads to megaloblastic pernicious anaemia (TRUE).
Step 2: Marasmus is an acute Protein-Energy Malnutrition (PEM) disease occurring in infants below 1 year of age due to simultaneous deficiency of dietary proteins and caloric calories, not carbohydrate excess in adults (FALSE).
Final Answer: 1. True (T) 2. False (F)

Answer: (See above) Go Back to Question 27

Q28.

Solution

Concept: Molecular gene expression relies on specific regulatory DNA sequences, mRNA coding triplets, and tRNA adaptor structures.

Step 1: A promoter is an upstream regulatory DNA sequence where RNA polymerase binds specifically to initiate transcription, matching (a)-(iii).
Step 2: An intron is a non-coding intervening nucleotide sequence in eukaryotic pre-mRNA that is excised during post-transcriptional splicing, matching (b)-(iv).
Step 3: A codon is a consecutive sequence of three nucleotides on mRNA specifying a particular amino acid or translation stop signal, matching (c)-(i).
Step 4: An anticodon is a three-nucleotide complementary sequence located on the anticodon loop of tRNA that base-pairs with mRNA codons during translation, matching (d)-(ii).
Final Answer: (a)-(iii), (b)-(iv), (c)-(i), (d)-(ii)

Answer: (See above) Go Back to Question 28

Q29.

Solution

Concept: Parenchyma and collenchyma are simple permanent ground tissues showing fundamental structural differences in cell wall thickening and intercellular spaces.

Step 1: Cell Wall Thickening: Parenchyma cells possess uniform, thin primary walls composed solely of cellulose. In contrast, collenchyma cells exhibit uneven, primary local thickenings at cell corners composed of cellulose, hemicellulose, and pectin.
Step 2: Intercellular Spaces: Parenchyma cells are generally loosely packed with conspicuous intercellular air spaces. Collenchyma cells are compactly arranged without significant intercellular spaces.
Step 3: Principal Functions: - **Parenchyma:** Serves primarily as food storage tissue (storing starch and oils) and carries out photosynthesis when chloroplasts are present (chlorenchyma). - **Collenchyma:** Provides mechanical tensile strength and flexible elasticity to growing aerial organs such as young stems and leaf petioles without resisting elongation.
Final Answer: Parenchyma has thin uniform cellulosic walls with intercellular spaces for food storage; collenchyma has uneven corner thickenings without intercellular spaces for flexible mechanical support.

Answer: (See above) Go Back to Question 29

Q30.

Solution

Concept: Plant tissue culture (micropropagation) utilizes cellular totipotency to regenerate complete plants from small explants cultured on nutrient media under aseptic conditions.

Step 1: Rapid Clonal Mass Propagation: Micropropagation enables rapid production of hundreds of thousands of genetically identical clones (somaclones) of a superior crop variety within a very short time frame and limited nursery space.

Step 2: Production of Disease-Free Plants: Systemic viral pathogens rarely infect apical meristems (shoot tips or axillary buds). By culturing excised shoot tip meristems *in vitro*, farmers and agronomists regenerate 100% virus-free healthy plant stock even from infected mother crops (widely used in banana, potato, and sugarcane).

Final Answer: 1. Rapid clonal mass multiplication in short time frames; 2. Recovery of virus-free healthy crops via meristem culture.

Answer: (See above) Go Back to Question 30

Q31.

Solution

Concept: Air pollutants differ in emission origin, while biomass pyramids reflect trophic standing crops across terrestrial and aquatic ecosystems.

Alternative (i): Primary vs Secondary Air Pollutants - Step 1 (Primary Pollutants): Harmful chemical agents emitted directly into the atmosphere from identifiable sources in their toxic form. *Example:* Carbon monoxide (CO), sulfur dioxide (SO_2), or nitric oxide (NO) emitted from vehicular exhausts and coal combustion. - **Step 2 (Secondary Pollutants):** Toxic chemicals synthesized within the atmosphere when primary pollutants undergo chemical or photochemical reactions driven by solar radiation. *Example:* Peroxyacetyl nitrate (PAN) or tropospheric ozone (O_3) generated in photochemical smog.

Alternative (ii): Inverted Pyramid of Biomass in Aquatic Ecosystems - Step 1 (Definition): An ecological pyramid of biomass illustrates the quantitative dry weight (standing crop biomass in g/m^2) of living organisms present at each trophic level at a specific time. - **Step 2 (Reason for Inversion):** In open water bodies (ponds or oceans), the producers are microscopic phytoplankton. They possess very small individual mass and rapid turnover (high reproductive rate combined with short lifespans). - **Step 3:** Herbivorous zooplankton and fish (primary and secondary consumers) live longer and accumulate far greater total biomass at any given instant. Consequently, the biomass of phytoplankton (≈ 4 g/m^2) is exceeded by zooplankton/fish (≈ 21 g/m^2), rendering the pyramid inverted.

Final Answer: (i) Primary pollutants are emitted directly (e.g., SO_2), secondary form via atmospheric reactions (e.g., PAN); (ii) Aquatic biomass pyramids are inverted because phytoplankton have low standing biomass but rapid turnover compared to larger consumer fish.

Answer: (See above) Go Back to Question 31

Q32.

Solution

Concept: Biological taxonomy distinguishes kingdoms and phyla through diagnostic cellular, structural, and developmental hallmarks.

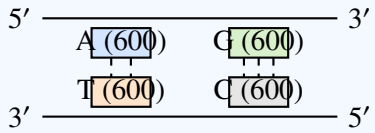
Alternative (i): Kingdom Fungi vs Kingdom Plantae - Step 1 (Cell Wall Composition): Fungal cell walls are composed primarily of fungal chitin (N-acetylglucosamine polymer) and non-cellulosic glucans, whereas plant cell walls are built from cellulose and hemicellulose. - **Step 2 (Nutritional Mode & Reserve Food):** Fungi are achlorophyllous heterotrophs exhibiting absorptive osmotrophic nutrition and storing surplus carbohydrate energy as glycogen and oil droplets. Plants are photosynthetic autotrophs storing surplus carbohydrates as starch granules.
Alternative (ii): Chordates vs Non-Chordates - Step 1 (Notochord): Chordates possess a solid, flexible skeletal rod called the notochord running along the dorsal longitudinal axis during at least some embryonic developmental stage; non-chordates completely lack a notochord. - **Step 2 (Central Nervous System):** Chordates possess a dorsal, hollow, single tubular central nerve cord located dorsal to the notochord; non-chordates (like annelids and arthropods) possess a ventral, solid, double ganglionated nerve cord.
Final Answer: (i) Fungi have chitinous cell walls and store glycogen/oils; plants have cellulosic walls and store starch. (ii) Chordates possess a dorsal notochord and hollow dorsal nerve cord; non-chordates lack notochords and have solid ventral nerve cords.

Answer: (See above) Go Back to Question 32

Q33.

Solution

Concept: According to Chargaff's rules for double-stranded DNA, purines equal pyrimidines: $\%A = \%T$ and $\%G = \%C$. Adenine pairs with Thymine via 2 hydrogen bonds (A = T), and Guanine pairs with Cytosine via 3 hydrogen bonds (G ≡ C).



Step 1 (Total Nucleotides): Total base pairs = $1,200$ bp. Thus, total nucleotide bases (N) = $1,200 \times 2 = 2,400$ nucleotides.

Step 2 (Base Frequencies): Given $\%A = 25\%$. - Number of Adenine (A) nucleotides = $0.25 \times 2,400 = 600$. - By Chargaff's rule, Number of Thymine (T) = A = 600. - Remaining percentage for G + C = $100\% - (25\% + 25\%) = 50\%$. - Therefore, $\%G = \%C = 25\%$. - Number of Guanine (G) = $0.25 \times 2,400 = 600$, and Cytosine (C) = 600.

Step 3 (Calculation of Hydrogen Bonds): - Each A – T base pair forms 2 hydrogen bonds. Total A – T bonds = $600 \times 2 = 1,200$. - Each G – C base pair forms 3 hydrogen bonds. Total G – C bonds = $600 \times 3 = 1,800$. - Total hydrogen bonds stabilizing the helix = $1,200 + 1,800 = 3,000$ hydrogen bonds.

Final Answer: A = 600, T = 600, G = 600, C = 600 nucleotides; Total hydrogen bonds = $3,000$.

Answer: (See above) Go Back to Question 33

Q34.

Solution

Concept: A reflex arc represents the shortest neural circuit mediating involuntary, protective rapid motor reflexes governed by spinal cord circuits without conscious cerebral processing.

Step 1: Anatomical Identification: - **A:** Sensory Receptor (detects painful thermal or mechanical stimuli in peripheral dermis). - **B:** Afferent / Sensory Neuron (conducts sensory action potentials through dorsal root ganglion into spinal cord grey matter). - **C:** Interneuron / Relay Neuron / Association Neuron (confined within central spinal grey matter). - **D:** Efferent / Motor Neuron (conducts motor command impulses out via ventral root to skeletal muscle).

Step 2: Physiological Function of Component C (Relay Neuron): The relay interneuron receives afferent sensory impulses from neuron B, integrates the synaptic input, and immediately routes an excitatory motor command directly to motor neuron D, enabling rapid withdrawal before pain sensation reaches cerebral sensory cortex.

Final Answer: A: Sensory Receptor, B: Afferent Sensory Neuron, C: Relay Interneuron, D: Efferent Motor Neuron; Component C rapidly routes sensory input to motor neurons inside spinal grey matter.

Answer: (See above) Go Back to Question 34

Q35.

Solution

Concept: Neuroendocrine axes and autonomic neural divisions regulate homeostasis through endocrine targets and antagonistic cardiac innervation.

Alternative (i): Posterior Pituitary Hormones - Step 1 (Synthesizing Source): Neurohypophyseal hormones are synthesized by hypothalamic supraoptic and paraventricular nuclei and transported down axons to the posterior pituitary for storage and release. - **Step 2 (Oxytocin):** Targets uterine smooth myometrium during parturition to stimulate rhythmic labor contractions, and targets myoepithelial cells surrounding mammary alveoli to trigger milk ejection (let-down reflex). - **Step 3 (Vasopressin / Antidiuretic Hormone - ADH):** Targets principal cells of renal distal convoluted tubules and collecting ducts to insert aquaporin channels, increasing water reabsorption and reducing urine volume.

Alternative (ii): Autonomic Regulation of Heart Rate - Step 1 (Sympathetic Division): Cardioaccelerator sympathetic postganglionic fibers release norepinephrine, which stimulates beta-1 adrenergic receptors on SA nodal cells. This increases calcium influx, accelerates diastolic depolarization, and elevates heart rate (tachycardia). - **Step 2 (Parasympathetic Division):** Vagus nerve (CN X) cardioinhibitory fibers release acetylcholine (ACh), which stimulates muscarinic receptors on SA nodal cells. This opens potassium channels (hyperpolarization), slows depolarization, and reduces heart rate (bradycardia).

Final Answer: (i) Oxytocin targets uterine myometrium and mammary glands; Vasopressin (ADH) targets renal distal tubules and collecting ducts. (ii) Sympathetic norepinephrine accelerates SA node depolarization (raises heart rate); parasympathetic acetylcholine hyperpolarizes SA node (slows heart rate).

Answer: (See above) Go Back to Question 35

Q36.

Solution

Concept: Immunity is classified as active or passive depending on whether the host's endogenous immune system actively produces antibodies and memory cells or receives pre-formed exogenous antibodies.

Step 1: Origin of Antibodies: In active immunity, the host's own B and T lymphocytes actively synthesize antibodies and cellular defenses upon encounter with an antigen. In passive immunity, pre-formed antibodies synthesized by another immunized host or animal are injected directly into the recipient.

Step 2: Duration and Memory: Active immunity requires a latent phase (days to weeks) to generate antibody titers but establishes long-lived immunological memory via memory B and T cells providing lifelong protection. Passive immunity provides immediate protection but lasts only a few weeks to months because no memory cells are formed and exogenous immunoglobulins catabolize.

Step 3: Clinical Examples: - **Active Immunity Example:** Immunity developed after recovery from natural varicella (chickenpox) infection or administration of oral polio / hepatitis B vaccines. - **Passive Immunity Example:** Administration of anti-tetanus serum (ATS) containing pre-formed anti-tetanus immunoglobulins after a puncture wound, or maternal IgG crossing the placenta.

Final Answer: Active immunity involves endogenous antibody synthesis and immunological memory lasting years (e.g., vaccination); passive immunity provides immediate short-term protection via exogenous pre-formed antibodies without memory (e.g., anti-tetanus serum injection).

Answer: (See above) Go Back to Question 36

Q37.

Solution

Concept: Pulmonary alveoli represent the terminal respiratory sacs in mammalian lungs specialized for rapid passive diffusion of oxygen and carbon dioxide across the respiratory membrane.

Step 1: Immense Surface Area: Millions of microscopic alveoli ($\approx$ 300 million per human lung) create an expansive alveolar surface area ($\approx$ 70–100 m^2), maximizing surface contact for gaseous diffusion according to Fick's law.

Step 2: Extremely Thin Respiratory Membrane: The alveolar-capillary diffusion barrier is exceptionally thin ($\leq 0.5\ \mu m$), comprising only a single layer of squamous alveolar epithelial cells (Type I pneumocytes), a thin basement membrane, and capillary endothelial cells.

Step 3: Dense Capillary Perfusion & Surfactant: Each alveolus is embraced by an extensive network of pulmonary capillaries maintaining steep partial pressure gradients (pO_2 and pCO_2). Furthermore, Type II alveolar cells secrete phospholipid surfactant, lowering alveolar surface tension and preventing alveolar collapse during expiration.

Final Answer: Alveoli provide a massive surface area ($> 70\ m^2$), an ultra-thin diffusion barrier ($\leq 0.5\ \mu m$) made of squamous epithelium and capillary endothelium, and surfactant coating that prevents collapse during rapid diffusion.

Answer: (See above) Go Back to Question 37

Q38.

Solution

Concept: Plant cellular water relations, hormonal growth hierarchies, and directional tropic curvatures illustrate fundamental botanical adaptations.

Part A: Plasmolysis - **Definition:** The shrinkage and detachment of the living protoplast away from the rigid rigid cellulose cell wall when a plant cell is immersed in a hypertonic solution due to exosmosis of water from the central vacuole. - **Example:** When fresh *Rheo discolor* epidermal peels or spirogyra filaments are placed in 10% concentrated sodium chloride (NaCl) solution, cells become plasmolysed.

Part B: Apical Dominance - **Definition:** The physiological phenomenon where the growing terminal shoot apical bud exerts an inhibitory influence over the growth and sprouting of lateral (axillary) buds situated below it, mediated by basipetally transported auxin (IAA). - **Example:** In tea plantations and hedge pruning (decapitation), removal of shoot apexes eliminates auxin supply, allowing axillary buds to sprout and producing bushy growth.

Part C: Phototropism - **Definition:** The directional growth curvature of plant organs in response to unilateral light stimulation, caused by asymmetric redistribution of auxin toward the shaded side. - **Example:** Growing sunflower or coleoptile tips bend positively toward a window or unidirectional light source (positive phototropism).

Final Answer: Plasmolysis: Protoplast shrinkage in hypertonic medium (e.g., plant cells in 10% NaCl); Apical Dominance: Terminal bud inhibiting lateral buds via auxin (e.g., pruning tea bushes); Phototropism: Directional growth toward light (e.g., shoots bending toward sunlight).

Answer: (See above) Go Back to Question 38

Q39.

Solution

Concept: Stomatal movements depend on guard cell turgor regulated by active ion transport, while xylem sap ascent relies on tensile physical properties of water columns.

Alternative (i): Levitt's Potassium Ion (K^+) Influx Theory

Open Stoma (Day: K^+ influx → High Ψ_s) Closed Stoma (Night: K^+ efflux → Flaccid)

- **Daytime Opening:** Sunlight drives photosynthetic ATP synthesis in guard cell chloroplasts, activating plasmalemma H^+-ATPase pumps. Protons (H^+) are pumped out into subsidiary cells, driving active influx of potassium (K^+) ions alongside chloride (Cl^-) and malate synthesis. Elevated K^+ lowers solute potential (Ψ_s), causing endosmosis of water into guard cells. Increased turgor causes outer thin walls to stretch outward, pulling inner thickened walls apart to open the stomatal pore. - **Nighttime Closing:** In darkness, cessation of photosynthesis stops H^+ pumping. Abscisic acid (ABA) triggers K^+ efflux out of guard cells. Water leaves via exosmosis, guard cells become flaccid, and inner walls close the pore.

Alternative (ii): Cohesion-Tension Transpiration Pull Theory - Cohesion and Adhesion: Water molecules possess mutual attractive hydrogen bonding (cohesive strength up to 45–130 atm), forming an unbroken liquid column within xylem vessels. Adhesion forces attract water to lignocellulosic xylem walls. - **Transpiration Pull:** Evaporation of water from leaf mesophyll cell walls into intercellular spaces creates a strong negative hydrostatic tension (transpiration pull). This suction force is transmitted down continuous xylem water columns all the way to root tips, pulling sap upward even in trees exceeding 100 meters.

Final Answer: (i) Stomata open during day due to active K^+ influx causing endosmosis and turgor rise; close at night upon K^+ efflux. (ii) Ascent of sap is driven by negative transpiration pull transmitted through unbroken cohesive water columns inside xylem vessels.

Answer: (See above) Go Back to Question 39

Q40.

Solution

Concept: The mammalian immune system integrates non-specific inborn defenses with highly specific adaptive humoral and cellular responses.

Step 1: Antigen Specificity: Innate immunity is non-specific; it relies on germline-encoded Pattern Recognition Receptors (PRRs) that recognize conserved Pathogen-Associated Molecular Patterns (PAMPs) common to broad microbes. Acquired immunity is exquisitely specific; billions of unique B-cell and T-cell antigen receptors distinguish subtle molecular differences on specific pathogenic epitopes.

Step 2: Presence of Immunological Memory: Innate immunity develops zero immunological memory; repeated exposure to the exact same pathogen triggers identical baseline response kinetics. Acquired immunity establishes robust, long-lived immunological memory via memory B and T cells, ensuring rapid, high-affinity secondary immune responses upon re-infection.

Step 3: Structural and Cellular Components: - **Innate Components:** Physical anatomical barriers (intact skin, mucous membranes), physiological barriers (gastric acid pH 1.5, lysozyme in tears), phagocytic leukocytes (neutrophils, macrophages), and complement proteins. - **Acquired Components:** Humoral immunity mediated by circulating antibodies secreted by B-lymphocyte plasma cells, and cell-mediated immunity executed by cytotoxic $CD8^+$ and helper $CD4^+$ T-lymphocytes.

Final Answer: Innate immunity is non-specific, lacks memory, and utilizes anatomical/phagocytic barriers; acquired immunity is highly antigen-specific, exhibits immunological memory, and relies on B-lymphocytes (antibodies) and T-lymphocytes.

Answer: (See above) Go Back to Question 40

Q41.

Solution

Concept: Nutritional pediatric disorders Marasmus and Rickets result from severe macronutrient starvation and impaired bone mineralization, respectively.

Alternative (i): Marasmus in Infants - **Etiology:** Acute Protein-Energy Malnutrition (PEM) occurring in infants below 1 year of age due to premature weaning from breast milk to dilute, low-calorie, and low-protein cereal diets. - **Clinical Symptoms:** Extreme emaciation and muscle wasting ("skin and bones" appearance), loss of subcutaneous fat, shrivelled old-man facial appearance, prominent rib cage, severe growth retardation, and chronic diarrhea without subcutaneous oedema. - **Prevention:** Promotion of exclusive breastfeeding for the first 6 months, timely introduction of nutrient-dense weaning mashed foods (pulses, milk, eggs), and maternal nutrition education.

Alternative (ii): Rickets in Children - **Etiology:** Dietary deficiency of Vitamin D (calciferol), calcium, or phosphorus, or lack of sunlight exposure (UV-B) needed to convert skin 7-dehydrocholesterol into active Vitamin D (calcitriol). - **Clinical Symptoms:** Defective bone calcification leading to soft, pliable bones, bow-legs (genu varum) or knock-knees, pigeon chest deformity (projecting sternum), rachitic rosary (bead-like swellings at costochondral rib junctions), and delayed teething. - **Prevention:** Daily exposure of children to morning sunlight, consumption of Vitamin D-fortified milk, dairy products, egg yolks, and fish liver oils, or pediatric calciferol drops.

Final Answer: (i) Marasmus results from severe protein-calorie deficit in infants under 1 year causing muscle wasting and emaciation without oedema; prevented by breastfeeding and protein-dense weaning foods. (ii) Rickets results from Vitamin D/calcium deficiency causing bow-legs and soft bones; prevented by sunlight exposure and dietary dairy/calciferol intake.

Answer: (See above) Go Back to Question 41

Q42.

Solution

Concept: DNA structure and enzymatic replication mechanics elucidate genetic stability, while classical crosses define transmission rules.

Alternative (i): DNA Double Helix Structure & Prokaryotic Replication - Part (a) Watson-Crick B-DNA Model: Consists of two right-handed antiparallel polynucleotide chains ($5' \rightarrow 3'$ and $3' \rightarrow 5'$) spiraling around a central axis. Sugar-phosphate backbones form exterior rails, while complementary purine-pyrimidine base pairs project inward (A = T with 2 H-bonds; G ≡ C with 3 H-bonds). One complete helical turn spans 3.4 nm (34 Å) enclosing exactly 10 base pairs, with adjacent base rise of 0.34 nm (3.4 Å) and helix diameter of 2.0 nm (20 Å). - **Part (b) Replication Steps:** 1. *Initiation:* Initiator proteins bind origin of replication (oriC). DNA helicase unwinds parental strands, forming replication forks stabilized by single-strand binding proteins (SSB) and DNA gyrase (topoisomerase II). Primase synthesizes short RNA primers. 2. *Elongation:* DNA polymerase III adds dNTPs in $5' \rightarrow 3'$ direction. Leading strand synthesizes continuously toward fork; lagging strand synthesizes discontinuously away from fork as Okazaki fragments. 3. *Termination:* DNA polymerase I excises RNA primers and fills gaps with DNA. DNA ligase seals backbone nicks, yielding two identical daughter duplexes.

Alternative (ii): Incomplete Dominance & Law of Segregation - Part (a) Incomplete Dominance in Snapdragon: When homozygous red-flowered *Antirrhinum majus* (RR) is crossed with homozygous white-flowered (rr), F1 hybrids (Rr) display pink flowers. Selfing F1 ($Rr \times Rr$) produces an F2 phenotypic and genotypic ratio of 1 Red (RR) : 2 Pink (Rr) : 1 White (rr). - **Part (b) Mendel's Law of Segregation:** States that during gametogenesis in a diploid heterozygote, the paired allelic factors separate (segregate) randomly such that each gamete receives only one allele with equal probability (50%). Because gametes contain only a single uncontaminated allele for any trait, this principle is universally termed the Law of Purity of Gametes.

Final Answer: (i) B-DNA has antiparallel strands with 3.4 nm pitch (10 bp/turn); replication proceeds via unwinding at oriC, continuous leading/discontinuous lagging synthesis by DNA pol III, and ligase sealing. (ii) Snapdragon cross yields 1 Red : 2 Pink : 1 White F2 ratio; Law of Segregation ensures pure haploid gametes carrying single alleles.

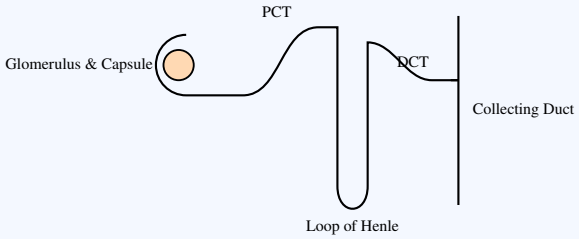
Answer: (See above) Go Back to Question 42

Q43.

Solution

Concept: Nephron filtration and tubular modification form urine, while pituitary-ovarian hormones drive the endometrial menstrual cycle.

Alternative (i): Human Nephron Structure & Urine Formation



- **Part (a) Nephron Structure:** Consists of Malpighian corpuscle (glomerulus + Bowman's capsule), Proximal Convoluted Tubule (PCT), Henle's loop (descending/ascending limbs), Distal Convoluted Tubule (DCT), and Collecting Duct. - **Part (b) Urine Formation:** 1. *Ultrafiltration:* High hydrostatic blood pressure forces fluid across glomerular capillaries into Bowman's capsule (GFR $\approx$ 125 mL/min). 2. *Reabsorption:* Over 99% of filtrate is recovered. PCT actively reabsorbs all glucose, amino acids, and 70% of water/electrolytes. Henle's loop reabsorbs water (descending) and NaCl (ascending). 3. *Secretion:* Active transport of H^+, K^+, and ammonia into tubular lumen (primarily at PCT/DCT) regulates body pH and ionic balance.

Alternative (ii): Menstrual Cycle Phases & Hormonal Control - Part (a) Cycle Phases (28 Days): 1. *Menstrual (Days 1–5):* Withdrawal of progesterone/oestrogen triggers breakdown and shedding of the uterine endometrium wall. 2. *Follicular / Proliferative (Days 6–13):* Pituitary FSH drives ovarian follicle development; growing follicles produce oestrogen, proliferating the endometrium. 3. *Ovulatory (Day 14):* Peak oestrogen triggers an LH surge, causing the Graafian follicle to rupture and release a secondary oocyte. 4. *Luteal / Secretory (Days 15–28):* LH transforms empty follicle into corpus luteum, which secretes high progesterone to prepare endometrium for implantation. - **Part (b) Hormonal Regulation:** Mid-cycle LH surge induces ovulation. Progesterone maintains endometrial thickening and quietens uterine contractions. If fertilization fails, corpus luteum degenerates into corpus albicans, hormone levels drop sharply, and menstruation recurs.

Final Answer: (i) Nephron filters blood at glomerulus, reabsorbs nutrients/water at PCT and Henle's loop, and secretes ions at DCT. (ii) Menstrual cycle comprises menstrual, proliferative (oestrogen), ovulatory (LH surge), and secretory (progesterone) phases.

Answer: (See above) Go Back to Question 43

Answer Key

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	B	2	B	3	B	4	B	5	B
6	C	7	C	8	B	9	B	10	A
11	C	12	B	13	C	14	C	15	B
16	A								