GUJCET Biology

Sample Paper – 5

Duration: 60 Minutes **Maximum Marks: 40**

Instructions

- This paper contains **40** Multiple Choice Questions (Single Correct Answer), modelled on the Biology portion of **GUJCET** (Gujarat Common Entrance Test).
- Each correct answer carries **+1 mark**. There is a negative marking of -0.25 **marks** for each incorrect answer. Unanswered questions carry no penalty.
- Only **one** option is correct per question. Mark responses on the OMR sheet carefully.
- Syllabus level: **GSEB Class 11–12 Biology (NCERT aligned) — Human Physiology, Plant Physiology, Reproduction, Genetics, Ecology, Biotechnology.**
- Use of mobile phones, calculators, or any electronic device is strictly prohibited.

Q1. Which enzyme secreted by the exocrine pancreas acts on polypeptide chains in the lumen of the small intestine, converting them into shorter peptides and amino acids?

A. Salivary amylase

B. Pancreatic lipase

C. Trypsin

D. Pepsin

Q2. In the small intestine, the finger-like projections that increase the surface area for absorption are called villi; each villus is further covered with microscopic projections called:

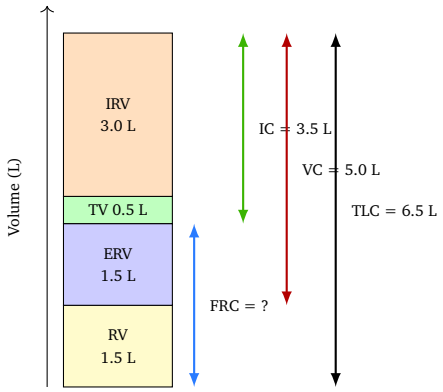
A. Microvilli (brush border)

B. Rugae

C. Haustra

D. Crypts of Lieberkühn

Q3. Study the diagram of lung volumes and capacities below and answer: Which combination of volumes constitutes the **Functional Residual Capacity (FRC)**?



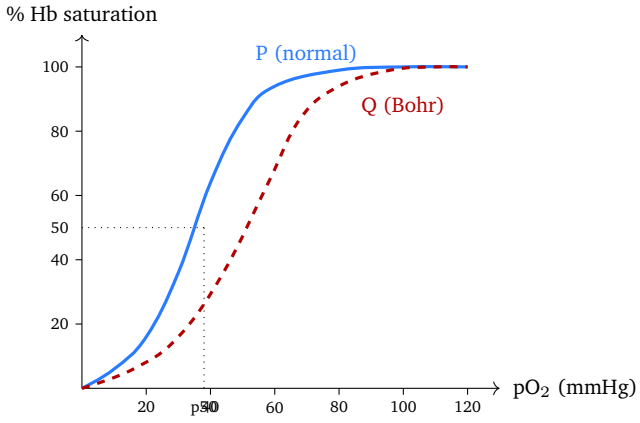
A. IRV + TV

B. ERV + RV

C. IRV + TV + ERV

D. TV + ERV + RV

Q4. The graph shows two oxygen–haemoglobin dissociation curves. Curve P is the normal curve; Curve Q is shifted to the right. Study the graph and identify the **correct** statement about the Bohr effect.



A. Curve Q represents decreased pCO_2 and increased blood pH

B. Curve Q represents decreased body temperature at normal pCO_2

C. Curve Q represents increased pO_2 with unchanged pCO_2

D. Curve Q represents increased pCO_2 and decreased blood pH (Bohr effect)

Q5. A person belonging to blood group 'O' has which of the following immunological profile?

A. No antigens on RBCs; both anti-A and anti-B antibodies in plasma

B. Antigen A on RBCs; anti-B antibody in plasma

C. Antigen B on RBCs; anti-A antibody in plasma

D. Both A and B antigens on RBCs; no antibodies in plasma

Q6. During the blood coagulation cascade, prothrombin activator converts prothrombin to thrombin, which then converts fibrinogen to fibrin. Which of the following substances is **correctly** matched with its role in haemostasis?

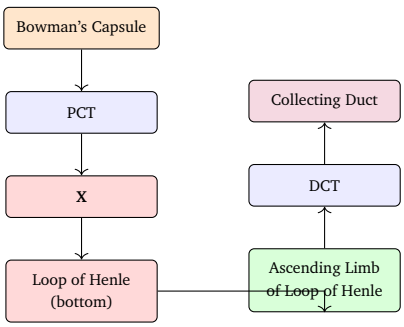
A. Fibrin — dissolves the clot after healing

B. Heparin — promotes clot formation by activating thrombin

C. Thromboplastin (tissue factor) — initiates the extrinsic pathway of coagulation

D. Fibrinogen — directly converts prothrombin to thrombin

Q7. The diagram below shows a simplified nephron with one segment labeled **X**. Identify segment X.



A. Proximal Convoluted Tubule (PCT)

B. Descending Limb of Loop of Henle

C. Distal Convoluted Tubule (DCT)

D. Collecting Duct

Q8. Which hormone, released by the posterior pituitary gland in response to high plasma osmolality, promotes water reabsorption from the collecting duct of the nephron, thus concentrating the urine?

A. Aldosterone

B. Renin

C. Atrial natriuretic peptide (ANP)

D. Antidiuretic hormone (ADH / vasopressin)

Q9. The kidney maintains a relatively constant glomerular filtration rate (GFR) despite fluctuations in systemic blood pressure. This intrinsic property of the kidney is called:

A. Autoregulation (myogenic and tubuloglomerular feedback)

B. Hormonal regulation by renin-angiotensin-aldosterone system

C. Neural regulation via sympathetic vasoconstriction

D. Paracrine regulation by prostaglandins only

Q10. At a chemical synapse, neurotransmitters are stored in and released from:

A. Dendrites of the postsynaptic neuron

B. Axon hillock of the presynaptic neuron

C. Synaptic vesicles in the presynaptic terminal knob

D. Myelin sheath of the presynaptic axon

Q11. When blood glucose level falls below the normal range (hypoglycaemia), which hormone is secreted by the **alpha cells** of the islets of Langerhans and what is its primary effect?

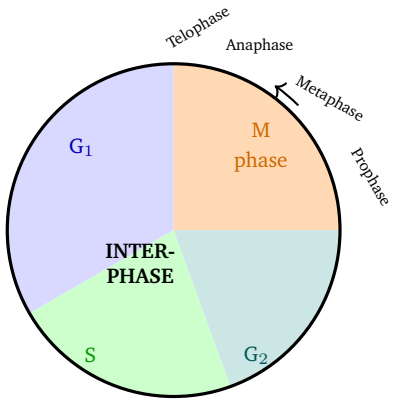
A. Insulin; promotes glycogen synthesis in liver

B. Glucagon; stimulates glycogenolysis and gluconeogenesis to raise blood glucose

C. Somatostatin; inhibits both insulin and glucagon secretion

D. Cortisol; suppresses immune response and raises blood glucose

Q12. The diagram below shows the eukaryotic cell cycle. The **spindle assembly checkpoint (SAC)** monitors the correct attachment of chromosomes to spindle fibres. In which phase of the cell cycle does this checkpoint operate?



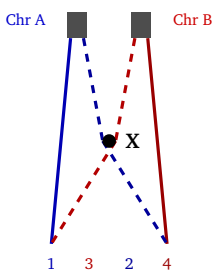
A. G_1 phase — before DNA replication begins

B. S phase — during DNA synthesis

C. G_2 phase — after DNA replication is complete

D. Metaphase — when chromosomes are aligned at the metaphase plate

Q13. The diagram below shows two homologous chromosomes undergoing crossing over during meiosis I. The four chromatids are labeled 1, 2, 3 and 4. The point of exchange marked **X** between non-sister chromatids 2 and 3 is called:



A. Chiasma

B. Centromere

C. Bivalent (tetrad)

D. Kinetochore

Q14. In Michaelis-Menten enzyme kinetics, the Michaelis constant (K_m) is defined as:

A. The maximum rate of an enzyme-catalyzed reaction at saturating substrate concentration

B. The minimum substrate concentration required for enzyme activity to begin

C. The substrate concentration at which the reaction velocity equals half of V_{max}

D. The total amount of enzyme present in the reaction mixture

Q15. In a monohybrid cross, two heterozygous tall plants (Tt) are crossed. What is the expected phenotypic ratio in the F_2 generation?

A. 1 : 2 : 1 (tall : medium : dwarf)

B. 3 : 1 (tall : dwarf)

C. 1 : 1 (tall : dwarf)

D. 9 : 3 : 3 : 1

Q16. In a dihybrid cross between a plant homozygous dominant for both traits (RRYY; R = round seed, Y = yellow seed) and a plant homozygous recessive for both traits (rryy), the F_2 generation shows:

A. 3 : 1 ratio for each character independently

B. 1 : 1 : 1 : 1 (four equal phenotypic classes)

C. 1 : 2 : 1 ratio for each character

D. 9 : 3 : 3 : 1 (round yellow : round green : wrinkled yellow : wrinkled green)

Q17. T.H. Morgan performed classical genetics experiments that demonstrated linkage and crossing over. The model organism he used was:

A. *Drosophila melanogaster*

B. *Pisum sativum*

C. *Neurospora crassa*

D. *Escherichia coli*

Q18. In humans, the sex of an offspring is determined by:

A. The age of the mother at the time of fertilization

B. Environmental temperature during early embryonic development

C. The type of sperm (X-bearing or Y-bearing) that fertilizes the egg

D. The ratio of autosomes to X chromosomes

Q19. In *Antirrhinum majus* (snapdragon), when a red-flowered plant (RR) is crossed with a white-flowered plant (rr), all F_1 plants are pink (Rr). This phenomenon, where the heterozygote shows an intermediate phenotype, is called:

A. Codominance

B. Incomplete dominance

C. Epistasis

D. Pleiotropy

Q20. In a pedigree chart, two phenotypically normal (unaffected) parents have an affected child. Which mode of inheritance is **most consistent** with this observation?

A. Autosomal dominant (both parents affected or carrier needed)

B. X-linked dominant (mother must be affected)

C. X-linked recessive (mother must be a carrier; affected child would typically be male)

D. Autosomal recessive (both parents are carriers: Aa × Aa)

Q21. In the Meselson–Stahl experiment (1958), bacteria were grown in ^{15}N heavy medium and then transferred to ^{14}N light medium. After one round of replication, which density of DNA was observed by cesium chloride (CsCl) density-gradient centrifugation?

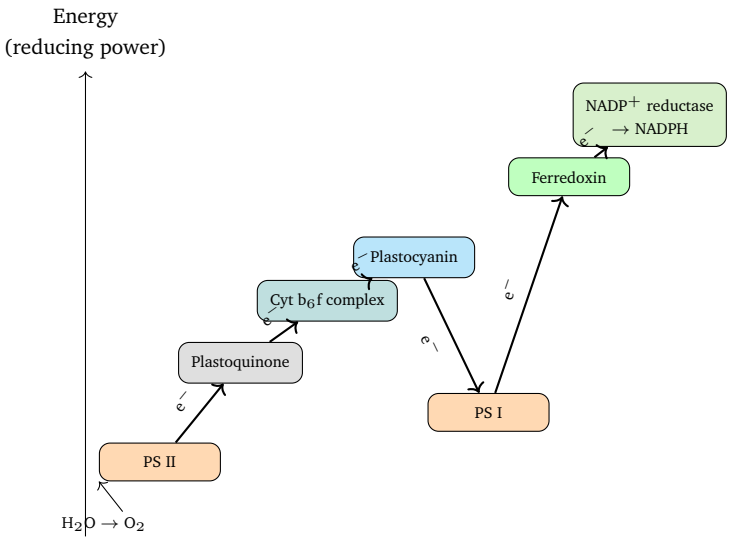
A. A single band of hybrid (intermediate) density DNA — confirming semi-conservative replication

B. Two bands: one heavy (^{15}N–^{15}N) and one light (^{14}N–^{14}N)

C. A single band of light (^{14}N–^{14}N) density DNA

D. Three bands: heavy, intermediate, and light

Q22. The diagram below shows the **Z-scheme** of photosynthesis (non-cyclic photophosphorylation). Identify the component that **directly receives electrons** from the Cytochrome b_6f complex and transfers them to Photosystem I (PS I).



A. Ferredoxin

B. $NADP^+$ reductase

C. Plastocyanin

D. Plastoquinone

Q23. In the Calvin cycle (C_3 pathway), the enzyme that catalyzes the carboxylation of ribulose-1,5-bisphosphate (RuBP) by fixing atmospheric CO_2 is:

A. PEP carboxylase (PEPC)

B. RuBisCO (ribulose-1,5-bisphosphate carboxylase/oxygenase)

C. Phosphoglycerate kinase

D. Fructose-1,6-bisphosphatase

Q24. Plants require various mineral nutrients in different quantities. Which of the following is classified as a **micronutrient** (trace element) in plants?

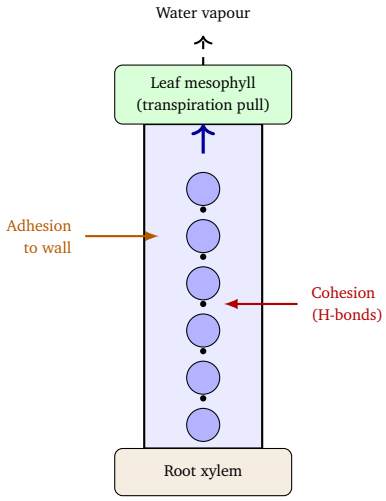
A. Nitrogen (N)

B. Phosphorus (P)

C. Calcium (Ca)

D. Manganese (Mn)

Q25. The diagram below shows water transport in xylem vessels according to the **cohesion-tension theory**. The primary driving force for the upward movement of water is:



A. Transpiration pull created by water evaporation from leaf mesophyll cells

B. Root pressure generated by osmotic uptake of water from soil

C. Capillary action in narrow xylem vessels

D. Active transport of water by xylem parenchyma cells

Q26. According to the **pressure flow (mass flow) hypothesis** proposed by Münch, the translocation of sucrose through phloem occurs from:

A. Sink to source due to lower osmotic pressure at sink

B. Xylem to phloem by active transport at the bundle sheath

C. Source (high sucrose, high turgor) to sink (low sucrose, low turgor) driven by pressure gradient

D. Leaves to roots only, driven by root sink demand

Q27. In one complete turn of the Krebs cycle (TCA cycle), how many molecules of **NADH** are produced from a single molecule of acetyl-CoA?

A. 2 NADH

B. 3 NADH

C. 4 NADH

D. 1 NADH

Q28. Which of the following organisms reproduces by **binary fission**, a type of asexual reproduction where the parent cell divides into two equal daughter cells?

A. *Hydra* (reproduces by budding)

B. *Planaria* (reproduces by fragmentation / regeneration)

C. *Spirogyra* (reproduces by fragmentation)

D. *Amoeba* (reproduces by binary fission)

Q29. A horizontal stem that runs along the surface of the soil and produces new plants at nodes (e.g., in strawberry) is called a:

A. Runner (stolon)

B. Rhizome

C. Tuber

D. Bulb

Q30. During oogenesis in human females, the secondary oocyte is arrested at which stage at the time of **ovulation**?

A. Prophase I of meiosis

B. Telophase I of meiosis

C. Metaphase II of meiosis

D. Completion of meiosis II (mature ovum)

Q31. When pollen grains from the anther of a flower are transferred to the stigma of a flower on a **different plant** of the same species, the process is termed:

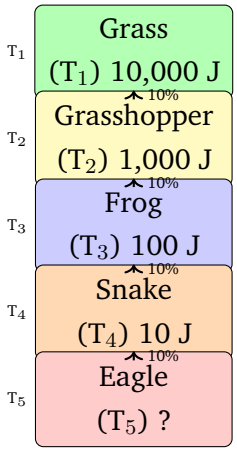
A. Autogamy (self-pollination within same flower)

B. Xenogamy (cross-pollination between different plants)

C. Geitonogamy (pollination between different flowers of same plant)

D. Cleistogamy (pollination within closed flowers)

Q32. The diagram below shows a food chain with five trophic levels. If **10,000 J** of energy is available at the producer level (T_1), how much energy (in joules) reaches the **quaternary consumer** (T_5), assuming 10% energy transfer efficiency at each level?



A. 100 J

B. 10 J

C. 5 J

D. 1 J

Q33. The concept of 10% energy transfer efficiency between trophic levels in an ecosystem was proposed by:

A. Raymond Lindeman

B. Charles Elton

C. Ernst Haeckel

D. G.F. Gause

Q34. The process in the nitrogen cycle by which soil bacteria convert nitrates (NO_3^-) back into gaseous nitrogen (N_2), releasing it into the atmosphere, is called:

A. Nitrification (conversion of NH_3 to NO_2^-/NO_3^-)

B. Ammonification (decomposition of organic nitrogen to NH_3)

C. Denitrification (conversion of NO_3^- to N_2)

D. Nitrogen fixation (conversion of N_2 to NH_3)

Q35. In logistic population growth (S-shaped or sigmoid growth curve), the population growth rate (dN/dt) is **maximum** when the population size (N) is:

A. Equal to the carrying capacity (K)

B. Equal to half the carrying capacity (K/2)

C. Greater than the carrying capacity (K)

D. Very small (close to zero, like exponential growth)

Q36. In recombinant DNA technology, restriction endonucleases are used to cut DNA. Which of the following restriction enzymes cuts DNA to produce **blunt ends** (no overhangs)?

A. *Eco*RI — cuts to produce 5’ sticky ends

B. *Hin*dIII — cuts to produce 5’ sticky ends

C. *Bam*HI — cuts to produce 5’ sticky ends

D. *Sma*I — cuts within its palindromic recognition sequence to produce blunt ends

Q37. In Polymerase Chain Reaction (PCR), the thermostable DNA polymerase used to synthesize new DNA strands is called **Taq polymerase**. It is isolated from the thermophilic bacterium:

A. *Thermus aquaticus*

B. *Thermus thermophilus*

C. *Pyrococcus furiosus*

D. *Bacillus subtilis*

Q38. Which of the following correctly describes a component of **innate (non-specific) immunity**?

A. B lymphocytes that produce highly specific antibodies against antigens

B. T lymphocytes with long-lived immunological memory against specific pathogens

C. Natural killer (NK) cells and phagocytes (neutrophils and macrophages)

D. Plasma cells secreting specific immunoglobulins after clonal selection

Q39. In **passive immunization**, protection against a disease is achieved by:

A. Injecting killed or attenuated pathogens to stimulate the host’s own immune memory

B. Administering preformed antibodies (antiserum/immunoglobulins) directly to the patient

C. Stimulating T-cell mediated adaptive immunity through repeated antigen exposure

D. Enhancing innate immune response through cytokine administration

Q40. Which class of fungi is characterized by club-shaped reproductive structures called **basidia**, which bear the sexual spores (basidiospores) externally on their surface?

A. Ascomycetes (sac fungi; spores in asci)

B. Phycomycetes (algal fungi; mostly aquatic/terrestrial)

C. Deuteromycetes (imperfect fungi; asexual reproduction only)

D. Basidiomycetes (club fungi; basidia bear basidiospores)

Detailed Solutions

Q1.

Solution

Concept — Digestion: Pancreatic Enzymes in Small Intestine

The pancreas secretes several digestive enzymes into the duodenum. Trypsin (along with chymotrypsin) is a protease that acts on proteins and polypeptides in the small intestine, breaking them into smaller peptides and amino acids. It is secreted as the inactive zymogen trypsinogen, which is activated by enterokinase (enteropeptidase) in the intestinal lumen.

Step 1 — Identify the enzyme that acts on proteins in the small intestine:

Trypsin is a serine protease secreted by the exocrine pancreas; it specifically cleaves peptide bonds and converts polypeptides to shorter peptides. This matches Option C.

Why other options are wrong:

Option A: Salivary amylase acts on starch (carbohydrates) and its activity is largely halted in the acidic stomach environment.

Option B: Pancreatic lipase acts on fats (triglycerides) to release fatty acids and glycerol, not proteins.

Option D: Pepsin is a protease but it is secreted by the gastric glands in the stomach, not the pancreas or small intestine.

Answer: (C) ← Go back to Q1

Q2.

Solution

Concept — Absorption: Villi and Microvilli (Brush Border)

The inner lining of the small intestine is covered with villi (finger-like projections) that greatly increase the surface area. The apical surface of each villus epithelial cell (enterocyte) is further covered with thousands of microscopic projections called microvilli, collectively forming the brush border. Microvilli increase the absorptive area by approximately 600-fold.

Step 1 — Identify the correct term:

Microvilli (brush border) are the sub-microscopic projections on the surface of each villus cell. The question asks for what the villi are "further covered with" — the answer is microvilli, Option A.

Why other options are wrong:

Option B: Rugae are the large mucosal folds of the stomach, not projections in the small intestine.

Option C: Haustra are the pouches of the large intestine (colon).

Option D: Crypts of Lieberkühn are invaginations between villi that contain secretory cells (goblet cells, Paneth cells), not projections on villi.

Answer: (A) ← Go back to Q2

Q3.

Solution

Concept — Lung Volumes and Capacities

Key lung volumes: Tidal Volume (TV) = 0.5 L (normal breathing); Inspiratory Reserve Volume (IRV) = 3.0 L; Expiratory Reserve Volume (ERV) = 1.5 L; Residual Volume (RV) = 1.5 L. Capacities are sums of volumes: Functional Residual Capacity (FRC) = ERV + RV; Inspiratory Capacity (IC) = TV + IRV; Vital Capacity (VC) = IRV + TV + ERV; Total Lung Capacity (TLC) = VC + RV.

Step 1 — Calculate FRC:

FRC = ERV + RV = 1.5 + 1.5 = 3.0 L. It represents the volume remaining in the lungs after a normal (passive) expiration. From the bar diagram, FRC is the sum of the ERV bar and the RV bar. This is Option B.

Why other options are wrong:

Option A: IRV + TV = 3.0 + 0.5 = 3.5 L, which is the Inspiratory Capacity (IC), not FRC.

Option C: IRV + TV + ERV = 5.0 L, which is the Vital Capacity (VC).

Option D: TV + ERV + RV = 0.5 + 1.5 + 1.5 = 3.5 L, which does not correspond to any standard named capacity and is not FRC.

Answer: (B) ← Go back to Q3

Q4.

Solution

Concept — Bohr Effect and O_2–Hb Dissociation Curve

The oxygen–haemoglobin (O_2–Hb) dissociation curve is sigmoid. The Bohr effect describes the rightward shift of this curve in response to increased pCO_2 and/or decreased pH (increased H^+). A rightward shift means Hb has lower affinity for O_2 at any given pO_2, facilitating O_2 unloading to tissues. Increased temperature also shifts the curve right.

Step 1 — Identify the cause of the rightward shift (Curve Q):

Curve Q is shifted right compared to the normal Curve P. This indicates decreased O_2 affinity of Hb. The Bohr effect is caused by increased pCO_2 (CO_2 combines with water to form $H_2CO_3 \rightarrow H^+ + HCO_3^-$) and decreased pH (increased acidity). This is Option D.

Why other options are wrong:

Option A: Decreased pCO_2 and increased pH would shift the curve *left* (increased Hb affinity for O_2).
Option B: Decreased temperature shifts the curve left, not right; increased pH also shifts left.
Option C: Increased pO_2 increases saturation along the *same* curve; it does not shift the curve.

Answer: (D) ← Go back to Q4

Q5.

Solution

Concept — ABO Blood Grouping System
The ABO blood group system is based on the presence or absence of glycoprotein antigens (agglutinogens) on the surface of red blood cells (RBCs) and corresponding antibodies (agglutinins) in the plasma. Blood group O individuals have the H antigen (not A or B) on their RBCs and carry both anti-A and anti-B antibodies in their plasma.

Step 1 — Profile of blood group O:
Group O: No A or B antigens on RBCs; plasma contains anti-A AND anti-B antibodies. This is Option A. Group O individuals are universal donors (their RBCs are not agglutinated by anti-A or anti-B antibodies in recipient plasma).

Why other options are wrong:
Option B: Antigen A + anti-B antibody describes blood group A.
Option C: Antigen B + anti-A antibody describes blood group B.
Option D: Both A and B antigens with no antibodies describes blood group AB (universal recipient).

Answer: (A) ← Go back to Q5

Q6.

Solution

Concept — Blood Coagulation Cascade
Haemostasis involves a cascade of reactions. Tissue damage exposes tissue factor (thromboplastin), which initiates the *extrinsic pathway*. Thromboplastin (tissue factor + factor VII) activates factor X to form prothrombin activator. Prothrombin activator converts prothrombin (factor II) into thrombin. Thrombin then converts soluble fibrinogen into insoluble fibrin threads, forming the clot.

Step 1 — Identify the correct role:
Thromboplastin (tissue factor) initiates the extrinsic coagulation pathway. This is Option C.

Why other options are wrong:
Option A: Fibrin is the end product of coagulation (the clot itself); plasmin (not fibrin) dissolves the clot during fibrinolysis.
Option B: Heparin is an anticoagulant — it inhibits thrombin and factor Xa, thereby preventing clot formation.
Option D: Fibrinogen is the inactive precursor that thrombin converts to fibrin; fibrinogen does not convert prothrombin to thrombin.

Answer: (C) ← Go back to Q6

Q7.

Solution

Concept — Nephron Structure: Loop of Henle
The nephron is the structural and functional unit of the kidney. After filtration in the Bowman's capsule, the filtrate passes through: Proximal Convoluted Tubule (PCT) → Descending Limb of Loop of Henle → thin ascending limb → thick ascending limb → Distal Convoluted Tubule (DCT) → Collecting Duct. The descending limb is permeable to water but not solutes; the ascending limb is impermeable to water but actively transports NaCl.

Step 1 — Identify segment X from the diagram:
In the diagram, segment X is positioned immediately below the PCT and leads into the bottom of the loop (hairpin turn). This corresponds to the Descending Limb of the Loop of Henle, Option B. Its key function is water reabsorption by osmosis into the hypertonic medullary interstitium.

Why other options are wrong:
Option A: PCT is shown at the top of the diagram, just below Bowman's capsule, not at segment X.
Option C: DCT is on the ascending side of the loop, connecting to the collecting duct.
Option D: Collecting duct is the final segment that empties into the renal pelvis; it is shown at the top of the ascending pathway.

Answer: (B) ← Go back to Q7

Q8.

Solution

Concept — ADH (Vasopressin) in Osmoregulation
Antidiuretic hormone (ADH), also called vasopressin, is synthesized in the hypothalamus and released from the posterior pituitary. It acts on the principal cells of the collecting duct, inserting aquaporin-2 (water channels) into the apical membrane, allowing water reabsorption from the filtrate back into the bloodstream.

This reduces urine volume and conserves body water.

Step 1 — Identify the hormone and its site of action:
ADH acts on the collecting duct to increase water reabsorption when plasma osmolality is high (e.g., dehydration). This is Option D.

Why other options are wrong:
Option A: Aldosterone is secreted by the adrenal cortex and acts on the DCT and collecting duct to increase Na^+ reabsorption (not primarily water); water follows Na^+ secondarily.
Option B: Renin is an enzyme (not a hormone acting directly on the tubule) released by juxtaglomerular cells; it cleaves angiotensinogen.
Option C: ANP (atrial natriuretic peptide) opposes aldosterone and ADH; it promotes natriuresis and diuresis, reducing blood pressure and volume.

Answer: (D) ← Go back to Q8

Q9.

Solution

Concept — GFR Autoregulation
Glomerular filtration rate (GFR) is maintained relatively constant (approximately 125 mL/min) despite changes in systemic blood pressure, through an intrinsic property of the kidney called autoregulation. Two main mechanisms: (1) Myogenic response — the afferent arteriole smooth muscle contracts when stretched by high pressure, reducing blood flow; (2) Tubuloglomerular feedback — the macula densa detects increased NaCl delivery and signals constriction of the afferent arteriole.

Step 1 — Identify the correct mechanism:
The afferent arteriole constricts in response to elevated blood pressure, maintaining constant glomerular capillary pressure and thus constant GFR. This is Option A — autoregulation.

Why other options are wrong:
Option B: The RAAS (renin-angiotensin-aldosterone system) is a hormonal mechanism that responds to prolonged hypotension; it is not purely intrinsic autoregulation.
Option C: Neural regulation by sympathetic vasoconstriction overrides autoregulation during extreme stress ("fight or flight") and reduces GFR.
Option D: Prostaglandins modulate renal haemodynamics but are not the primary autoregulatory mechanism; autoregulation includes both myogenic and tubuloglomerular feedback components.

Answer: (A) ← Go back to Q9

Q10.

Solution

Concept — Chemical Synapse: Neurotransmitter Release

At a chemical synapse, the presynaptic terminal knob contains numerous membrane-bound synaptic vesicles packed with neurotransmitter molecules (e.g., acetylcholine, dopamine, serotonin). When an action potential arrives at the presynaptic terminal, Ca^{2+} influx through voltage-gated channels triggers exocytosis of vesicles, releasing neurotransmitters into the synaptic cleft. Neurotransmitters then diffuse across and bind to receptors on the postsynaptic membrane.

Step 1 — Identify the site of neurotransmitter storage and release:

Synaptic vesicles in the presynaptic terminal store and release neurotransmitters. This is Option C.

Why other options are wrong:

Option A: Dendrites of the postsynaptic neuron receive signals; they do not store or release neurotransmitters.

Option B: The axon hillock integrates signals and generates action potentials; neurotransmitters are released from the terminal knob (synaptic bouton), not the hillock.

Option D: The myelin sheath is an insulating layer (of Schwann cells/oligodendrocytes) around the axon; it has no role in neurotransmitter storage or release.

Answer: (C) ← Go back to Q10

Q11.

Solution

Concept — Glucagon and Blood Glucose Regulation

The islets of Langerhans in the pancreas contain alpha (α) cells and beta (β) cells. Alpha cells secrete glucagon in response to hypoglycaemia (low blood glucose). Glucagon promotes glycogenolysis (glycogen breakdown in the liver) and gluconeogenesis (synthesis of glucose from non-carbohydrate precursors), thereby raising blood glucose back to normal. Beta cells secrete insulin in response to hyperglycaemia.

Step 1 — Identify the hormone and its effect:

Glucagon is secreted by alpha cells when blood glucose is low. It raises blood glucose by stimulating glycogenolysis and gluconeogenesis. This is Option B.

Why other options are wrong:

Option A: Insulin is secreted by beta cells (not alpha cells) in response to high blood glucose; it lowers blood glucose by promoting glucose uptake and glycogen synthesis.

Option C: Somatostatin (from delta cells) inhibits secretion of both insulin and glucagon but does not directly raise blood glucose.
Option D: Cortisol is a glucocorticoid from the adrenal cortex; while it can raise blood glucose, it is not secreted by alpha cells of the islets of Langerhans.

Answer: (B) ← Go back to Q11

Q12.

Solution

Concept — Mitosis: Spindle Assembly Checkpoint (SAC)
The cell cycle has multiple checkpoints to ensure fidelity. The spindle assembly checkpoint (SAC), also called the M-phase checkpoint, monitors whether all chromosomes are correctly attached (bioriented) to spindle microtubules at their kinetochores. It operates during metaphase of mitosis. If any kinetochore is unattached or incorrectly attached, the SAC halts progression to anaphase by inhibiting the anaphase-promoting complex/cyclosome (APC/C).

Step 1 — Identify the phase from the diagram:
The circular cell cycle diagram shows M phase (orange sector) subdivided into prophase, metaphase, anaphase, and telophase. The SAC operates at metaphase, when chromosomes are aligned at the metaphase plate and their kinetochores must be attached to spindle fibres from opposite poles. This is Option D.

Why other options are wrong:
Option A: G_1 phase is monitored by the restriction point (R point), which checks cell size, nutrient availability, and growth factor signals before committing to S phase.
Option B: S phase is monitored by the intra-S checkpoint for DNA damage and replication fidelity.
Option C: G_2 phase has the G_2/M checkpoint that ensures DNA replication is complete and checks for DNA damage before entry into mitosis.

Answer: (D) ← Go back to Q12

Q13.

Solution

Concept — Meiosis I: Crossing Over and Chiasma
During prophase I of meiosis, homologous chromosomes pair up (synapsis) to form bivalents (tetrads). Non-sister chromatids of homologous chromosomes exchange segments at points called chiasmata (singular: chiasma). This physical exchange of chromatid segments is crossing over (recombination). Chiasmata are visible cytologically as X-shaped structures holding homologues together until anaphase I.

Step 1 — Identify the structure labeled X:
In the diagram, point X is where chromatids 2 and 3 (non-sister chromatids of homologous chromosomes A and B) physically cross and exchange segments. This point of exchange is a chiasma. This is Option A.

Why other options are wrong:
Option B: The centromere is the constricted region of the chromosome where the kinetochore assembles and spindle fibres attach; it is at the top of each chromosome pair, not at the crossing point.
Option C: A bivalent (tetrad) refers to the entire paired structure of two homologous chromosomes (4 chromatids total), not the specific crossing point.
Option D: A kinetochore is the protein complex on the centromere that attaches to spindle microtubules; it is not the crossing-over point.

Answer: (A) ← Go back to Q13

Q14.

Solution

Concept — Michaelis-Menten Enzyme Kinetics
The Michaelis-Menten equation describes the relationship between substrate concentration [S] and reaction velocity (v): $v = V_{max}[S]/(K_m + [S])$. V_{max} is the maximum velocity at saturating [S]. K_m (Michaelis constant) equals the substrate concentration at which $v = V_{max}/2$. A low K_m indicates high affinity of enzyme for substrate; a high K_m indicates low affinity.

Step 1 — Define K_m:
K_m is the [S] at which the reaction rate equals $V_{max}/2$. It is a measure of the affinity of the enzyme for its substrate. This is Option C.

Why other options are wrong:
Option A: V_{max} (not K_m) is the maximum rate of the enzyme-catalyzed reaction at saturating substrate concentration.
Option B: K_m is not the minimum substrate concentration for activity to begin; some activity occurs at any non-zero [S], and K_m is a specific kinetic constant.
Option D: Total enzyme concentration $[E_T]$ is a separate parameter; $V_{max} = k_{cat} \times [E_T]$, but K_m is defined from the reaction kinetics, not from total enzyme amount.

Answer: (C) ← Go back to Q14

Q15.

Solution

Concept — Monohybrid Cross and Law of Segregation
In a monohybrid cross between two heterozygotes (Tt × Tt), the F_2 genotypic

ratio is 1 TT : 2 Tt : 1 tt (= 1:2:1). Since T (tall) is dominant over t (dwarf), both TT and Tt show the tall phenotype, and only tt shows the dwarf phenotype. The phenotypic ratio in F_2 is therefore 3 tall : 1 dwarf, or 3:1.

Step 1 — Punnett square for Tt × Tt:
Gametes T and t from each parent: TT, Tt, Tt, tt → phenotypic ratio = 3 tall (TT+Tt+Tt) : 1 dwarf (tt). This is Option B.

Why other options are wrong:
Option A: 1:2:1 is the *genotypic* ratio (TT:Tt:tt), not the phenotypic ratio; it would be the phenotypic ratio if dominance were incomplete.
Option C: 1:1 is the phenotypic ratio in a *testcross* (Tt × tt), not a heterozygous × heterozygous cross.
Option D: 9:3:3:1 is the phenotypic ratio in a *dihybrid* cross (AaBb × AaBb), involving two independently assorting gene pairs.

Answer: (B) ← Go back to Q15

Q16.

Solution

Concept — Dihybrid Cross and Independent Assortment
In a dihybrid cross where both genes assort independently (Mendel's Law of Independent Assortment), crossing F_1 dihybrid plants (RrYy × RrYy) yields F_2 with phenotypic ratio 9:3:3:1. This represents: 9 R_Y_ (round yellow) : 3 R_yy (round green) : 3 rrY_ (wrinkled yellow) : 1 rryy (wrinkled green).

Step 1 — Cross RRYY × rryy:
F_1 = RrYy (all round yellow). F_1 × F_1 (RrYy × RrYy) → F_2 phenotypic ratio = 9:3:3:1. This is Option D.

Why other options are wrong:
Option A: 3:1 is the phenotypic ratio for a *monohybrid* cross; each character individually shows 3:1, but the *combined* dihybrid ratio is 9:3:3:1.
Option B: 1:1:1:1 is the ratio from a dihybrid *testcross* (AaBb × aabb), not from crossing two dihybrids.
Option C: 1:2:1 is the genotypic ratio for a monohybrid cross; it is not a dihybrid phenotypic ratio.

Answer: (D) ← Go back to Q16

Q17.

Solution

Concept — Morgan's Linkage Experiments
Thomas Hunt Morgan (1866–1945) conducted pioneering experiments on hered-

ity using the fruit fly *Drosophila melanogaster*. He chose *Drosophila* because it has a short generation time (2 weeks), produces large numbers of offspring, is easy to maintain, and has only 4 pairs of chromosomes. Morgan demonstrated that genes located on the same chromosome are linked and do not independently assort, and he mapped genes to chromosomes — work for which he received the Nobel Prize in 1933.

Step 1 — Identify the model organism:
Morgan used *Drosophila melanogaster* (common fruit fly) for linkage and crossing-over experiments. This is Option A.

Why other options are wrong:
Option B: *Pisum sativum* (garden pea) was used by Gregor Mendel for his foundational inheritance experiments, not Morgan's linkage studies.
Option C: *Neurospora crassa* (bread mould) was used by Beadle and Tatum for the one gene-one enzyme hypothesis.
Option D: *Escherichia coli* was used for studies on DNA replication (Meselson-Stahl) and molecular genetics, not Morgan's linkage mapping.

Answer: (A) ← Go back to Q17

Q18.

Solution

Concept — Sex Determination: XY Mechanism in Humans
In humans, sex is genetically determined by the sex chromosomes. Females are XX; males are XY. During meiosis, females produce only X-bearing eggs, while males produce both X-bearing and Y-bearing sperm in equal proportions. The sex of the offspring is determined at fertilization by the type of sperm that fuses with the egg. A Y-bearing sperm produces a male (XY); an X-bearing sperm produces a female (XX). The SRY (sex-determining region Y) gene on the Y chromosome triggers male development.

Step 1 — Identify the determining factor:
The type of sperm (X or Y) that fertilizes the egg determines the sex of the offspring. This is Option C.

Why other options are wrong:
Option A: The mother's age does not determine the sex of the offspring; eggs always carry an X chromosome.
Option B: Environmental temperature determines sex in reptiles (e.g., crocodiles, some turtles) but NOT in humans or other mammals.
Option D: The ratio of autosomes to sex chromosomes (X:A ratio) is the sex determination mechanism in *Drosophila*, not in humans.

Answer: (C) ← Go back to Q18

Q19.

Solution

Concept — Incomplete Dominance

Incomplete dominance is a form of non-Mendelian inheritance in which neither allele is completely dominant over the other. The heterozygous (F_1) phenotype is intermediate between the two homozygous phenotypes. In snapdragon (*Antirrhinum majus*): RR (red) $\times$ rr (white) $\rightarrow$ Rr (pink). Self-fertilization of Rr gives F_2 ratio: 1 RR (red) : 2 Rr (pink) : 1 rr (white) — a 1:2:1 phenotypic ratio.

Step 1 — Identify the inheritance pattern:

The pink F_1 (Rr) is intermediate between red and white parents — this is incomplete dominance. This is Option B.

Why other options are wrong:

Option A: Codominance is when both alleles are *fully* expressed simultaneously in heterozygotes (e.g., ABO blood group AB shows both A and B antigens), not an intermediate blended phenotype.

Option C: Epistasis involves interaction between two different genes where one gene masks the expression of the other; this involves only one gene with two alleles.

Option D: Pleiotropy is when a single gene affects multiple phenotypic traits; here a single trait (flower colour) is determined by one gene with incomplete dominance.

Answer: (B) ← Go back to Q19

Q20.

Solution

Concept — Pedigree Analysis: Autosomal Recessive Inheritance

When two unaffected (normal-phenotype) parents produce an affected offspring, it indicates that both parents carry one copy of the recessive allele (they are carriers: Aa $\times$ Aa). The trait must be recessive (affected individuals are aa), and since both parents are unaffected, it cannot be dominant. The trait is autosomal recessive if it affects both sexes equally with no sex-linked pattern.

Step 1 — Determine mode of inheritance:

Both parents unaffected + affected child $\rightarrow$ both parents must be carriers (Aa $\times$ Aa $\rightarrow$ 25% aa affected). This fits autosomal recessive inheritance. This is Option D.

Why other options are wrong:

Option A: Autosomal dominant requires that at least one parent be affected (since the trait requires only one copy of the dominant allele); two unaffected par-

ents cannot have an autosomal dominant affected child (except by new mutation, which is rare).
Option B: X-linked dominant also requires an affected parent to pass on the allele; two unaffected parents would not have an X-linked dominant affected child.
Option C: X-linked recessive is possible (carrier mother $\times$ normal father $\rightarrow$ affected son), but the question states "affected child" (not sex-specified). Autosomal recessive is the most general and most consistent explanation.

Answer: (D) ← Go back to Q20

Q21.

Solution

Concept — Meselson-Stahl Experiment (1958)
Matthew Meselson and Franklin Stahl designed an experiment to distinguish between three proposed models of DNA replication: conservative, semi-conservative, and dispersive. They grew *E. coli* in ^{15}N (heavy nitrogen) medium for several generations, then switched them to ^{14}N (light nitrogen) medium. After one round of replication, they used CsCl density-gradient centrifugation to separate DNA by density.

Step 1 — Predict outcome of semi-conservative replication after one round:
In semi-conservative replication, each new DNA molecule consists of one original (old) strand (^{15}N) and one newly synthesized strand (^{14}N). Both daughter molecules have intermediate ($^{15}N/^{14}N$) density. CsCl centrifugation shows a **single band at intermediate (hybrid) density**. This is Option A.

Why other options are wrong:
Option B: Two bands (heavy + light) would indicate conservative replication (original double helix intact + new all-light double helix), which was disproved.
Option C: A single light band would indicate that both strands are newly synthesized — this would only occur much later (after many generations in ^{14}N).
Option D: Three bands (heavy + intermediate + light) are observed after TWO rounds of replication in ^{14}N, not one round.

Answer: (A) ← Go back to Q21

Q22.

Solution

Concept — Z-Scheme: Electron Transport in Non-Cyclic Photophosphorylation
The Z-scheme describes the pathway of electrons during the light reactions (non-cyclic photophosphorylation): $H_2O \rightarrow$ PS II $\rightarrow$ Plastoquinone (PQ) $\rightarrow$ Cytochrome b_6f complex $\rightarrow$ Plastocyanin (PC) $\rightarrow$ PS I $\rightarrow$ Ferredoxin (Fd) $\rightarrow$ $NADP^+$ reduc-

tase → NADPH. Plastocyanin is a copper-containing protein that shuttles electrons from the Cyt b_6f complex to PS I.

Step 1 — Trace the electron path from Cyt b_6f complex:
After the Cyt b_6f complex, electrons are passed to Plastocyanin, which then reduces the oxidized PS I ($P700^+$). From the Z-scheme diagram, Plastocyanin is the component between Cyt b_6f and PS I. This is Option C.

Why other options are wrong:
Option A: Ferredoxin (Fd) receives electrons *after* PS I is re-energized; it is downstream of PS I, not between Cyt b_6f and PS I.
Option B: $NADP^+$ reductase (ferredoxin-$NADP^+$ reductase) is the terminal enzyme that transfers electrons from Fd to $NADP^+$; it is even further downstream.
Option D: Plastoquinone (PQ) accepts electrons *from* PS II and passes them *to* Cyt b_6f complex; it is upstream of Cyt b_6f, not downstream.

Answer: (C) ← Go back to Q22

Q23.

Solution

Concept — Calvin Cycle: CO_2 Fixation by RuBisCO
The Calvin cycle (C_3 pathway) occurs in the stroma of chloroplasts. In the carboxylation step, the enzyme RuBisCO (ribulose-1,5-bisphosphate carboxylase/oxygenase) catalyzes the addition of one CO_2 molecule to ribulose-1,5-bisphosphate (RuBP; a 5-carbon compound), forming an unstable 6-carbon compound that immediately splits into two molecules of 3-phosphoglycerate (3-PGA; a 3-carbon compound — hence "C_3 pathway").

Step 1 — Identify the CO_2-fixing enzyme:
RuBisCO is the enzyme responsible for carbon fixation in the Calvin cycle. It is the most abundant protein on Earth. This is Option B.

Why other options are wrong:
Option A: PEP carboxylase (PEPC) fixes CO_2 in C_4 plants (into oxaloacetate from phosphoenolpyruvate in mesophyll cells); it has higher CO_2 affinity and does not react with O_2, unlike RuBisCO.
Option C: Phosphoglycerate kinase is an enzyme of the Calvin cycle that converts 3-PGA to 1,3-bisphosphoglycerate using ATP, but it does not fix CO_2.
Option D: Fructose-1,6-bisphosphatase is involved in the regeneration of RuBP in the Calvin cycle; it does not carboxylate RuBP.

Answer: (B) ← Go back to Q23

Q24.

Solution

Concept — Macronutrients vs. Micronutrients in Plants

Plants require 17 essential mineral nutrients. Macronutrients (required in larger quantities): C, H, O, N, P, K, Ca, Mg, S. Micronutrients (trace elements, required in very small quantities): Fe, Mn, Zn, Cu, B, Mo, Cl, Ni. Deficiency of Mn causes interveinal chlorosis (similar to Fe deficiency) as Mn is essential for the water-splitting reaction in PS II and various enzymatic reactions.

Step 1 — Classify each option:

Nitrogen (N), Phosphorus (P), and Calcium (Ca) are all macronutrients. Manganese (Mn) is a micronutrient/trace element. This is Option D.

Why other options are wrong:

Option A: Nitrogen is a macronutrient — it is a major component of amino acids, proteins, nucleic acids, and chlorophyll; required in large amounts.

Option B: Phosphorus is a macronutrient — essential for ATP, nucleic acids, phospholipids; required in significant quantities.

Option C: Calcium is a macronutrient — essential for cell wall stability (calcium pectate), membrane integrity, and cell signaling; required in relatively large amounts.

Answer: (D) ← Go back to Q24

Q25.

Solution

Concept — Cohesion-Tension Theory (Ascent of Sap)

The cohesion-tension (transpiration-pull) theory, proposed by Dixon and Joly, explains the upward movement of water in xylem vessels. Key points: (1) Transpiration — evaporation of water from mesophyll cells of leaves creates a negative pressure (tension) that pulls water upward; (2) Cohesion — strong hydrogen bonds between water molecules maintain a continuous water column; (3) Adhesion — hydrogen bonds between water and cellulose of xylem walls prevent the water column from pulling away from the walls.

Step 1 — Identify the primary driving force from the diagram:

The diagram shows water molecules (blue circles) held by H-bonds (cohesion) inside the xylem vessel, with the leaf cell at the top showing transpiration. The primary driving force is the transpiration pull — negative pressure created by water evaporation from leaf cells. This is Option A.

Why other options are wrong:

Option B: Root pressure is a secondary, supplementary force generated by osmosis in roots; it can push water up short distances (especially at night when transpiration is low) but cannot alone account for water rising to the tops of tall trees (up

to 100+ m).
Option C: Capillary action (due to surface tension in narrow vessels) contributes minimally and can only raise water a few metres; it is insufficient for tall plants.
Option D: Xylem is non-living tissue (dead at maturity); active transport by xylem cells does not occur in mature xylem vessels.

Answer: (A) ← Go back to Q25

Q26.

Solution

Concept — Pressure Flow (Mass Flow) Hypothesis of Phloem Transport
The pressure flow hypothesis (Münch, 1930) proposes that phloem sap flows from source (areas of high sucrose production, e.g., photosynthesizing leaves) to sink (areas of sucrose utilization, e.g., roots, fruits, seeds). At the source, sucrose is actively loaded into sieve tube elements, increasing solute concentration and hence osmotic potential, causing water to enter from adjacent xylem by osmosis. This raises hydrostatic (turgor) pressure at the source end. At the sink, sucrose is unloaded, reducing turgor pressure. The pressure gradient drives bulk flow from source to sink.

Step 1 — Identify the correct description:
Phloem sap flows from source (high sucrose, high turgor) to sink (low sucrose, low turgor) due to a turgor pressure gradient. This is Option C.

Why other options are wrong:
Option A: Flow is from source *to* sink, not from sink to source; sucrose moves DOWN its concentration gradient from source to sink.
Option B: Xylem transports water and minerals upward (apoplast/symplast); phloem transport is distinct and bidirectional (upward and downward); active transport loads sucrose into phloem at the source, not from xylem to phloem along the entire length.
Option D: Phloem can transport sucrose both upward (to growing shoot tips) and downward (to roots); it is not exclusively downward, and root sink demand is just one example.

Answer: (C) ← Go back to Q26

Q27.

Solution

Concept — Krebs Cycle: NADH Production per Acetyl-CoA
The Krebs cycle (tricarboxylic acid cycle / citric acid cycle) processes one acetyl-CoA (2C) per turn, combining it with oxaloacetate (4C) to form citrate (6C). Key steps yielding NADH: (1) Isocitrate $\rightarrow$ α-ketoglutarate (1 NADH); (2) α-

ketoglutarate → succinyl-CoA (1 NADH); (3) Malate → oxaloacetate (1 NADH). Additionally: 1 $FADH_2$ (succinate → fumarate) and 1 GTP (succinyl-CoA → succinate). Total per acetyl-CoA: 3 NADH, 1 $FADH_2$, 1 GTP.

Step 1 — Count NADH produced per turn:
3 NADH molecules are produced per acetyl-CoA per turn of the Krebs cycle. This is Option B.

Why other options are wrong:
Option A: 2 NADH is incorrect; there are three distinct NADH-yielding dehydrogenase reactions per cycle turn.
Option C: 4 NADH is incorrect; the 4th reducing equivalent from the cycle goes to FAD (producing $FADH_2$), not to NAD^+.
Option D: 1 NADH is incorrect; if only 1 NADH per turn, the cycle would be far less efficient.

Answer: (B) ← Go back to Q27

Q28.

Solution

Concept — Asexual Reproduction: Binary Fission
Binary fission is a form of asexual reproduction in which an organism divides into two equal daughter cells. It is the primary reproductive mode of prokaryotes and also occurs in some unicellular eukaryotes. *Amoeba* reproduces by binary fission — the nucleus divides by amitosis (or mitosis-like division) and the cytoplasm cleaves to produce two daughter amoebae.

Step 1 — Match organism to binary fission:
Amoeba reproduces by binary fission — Option D.

Why other options are wrong:
Option A: *Hydra* reproduces asexually by budding — a new individual forms as an outgrowth (bud) from the body wall of the parent and eventually detaches.
Option B: *Planaria* reproduces by fragmentation and subsequent regeneration; each fragment can regenerate into a complete individual.
Option C: *Spirogyra* (filamentous green alga) reproduces asexually by fragmentation, where the filament breaks into pieces and each piece grows into a new filament.

Answer: (D) ← Go back to Q28

Q29.

Solution

Concept — Vegetative Propagation: Runner (Stolon)

Vegetative propagation involves growth of new plants from vegetative parts (stems, roots, leaves). A runner (also called stolon) is a specialized horizontal stem that grows along the soil surface; at each node, adventitious roots and a new shoot develop, forming a new plant. Examples: strawberry (*Fragaria*), Bermuda grass (*Cynodon dactylon*), wood sorrel (*Oxalis*).

Step 1 — Identify the structure:

Horizontal stem running along the soil surface, producing new plants at nodes = runner (stolon). This is Option A.

Why other options are wrong:

Option B: A rhizome is a horizontal underground stem (e.g., ginger, turmeric, ferns); it grows below the soil surface, not along it.

Option C: A tuber is a swollen, fleshy underground stem (e.g., potato) that stores food; new plants grow from "eyes" (axillary buds) on the tuber surface.

Option D: A bulb is a compact underground structure with fleshy leaves (scale leaves) surrounding a short stem (e.g., onion, lily, garlic); new plants grow from the lateral bud of the bulb.

Answer: (A) ← Go back to Q29

Q30.

Solution

Concept — Oogenesis: Stage of Oocyte at Ovulation

Oogenesis begins before birth when oogonia differentiate into primary oocytes and are arrested at prophase I of meiosis. At puberty, one primary oocyte completes meiosis I each cycle to form a secondary oocyte + first polar body. The secondary oocyte then begins meiosis II but is arrested at **metaphase II**. This secondary oocyte (arrested at metaphase II) is what is released during ovulation. Meiosis II is only completed if fertilization occurs (forming the ovum + second polar body).

Step 1 — Identify the stage at ovulation:

At ovulation, the secondary oocyte is released while arrested at metaphase II of meiosis. This is Option C.

Why other options are wrong:

Option A: Prophase I is the stage at which the primary oocyte is arrested from birth until puberty — ovulation has not yet occurred at this stage.

Option B: Telophase I is the brief end of meiosis I when the secondary oocyte is forming; ovulation occurs after this, when the secondary oocyte is in metaphase II.

Option D: Completion of meiosis II (mature ovum) only occurs after sperm penetration/fertilization, not at the time of ovulation.

Answer: (C) ← Go back to Q30

Q31.

Solution

Concept — Types of Pollination: Xenogamy

Pollination types based on pollen source: (1) Autogamy — self-pollination within the same flower; (2) Geitonogamy — transfer of pollen from one flower to another flower on the *same plant* (genetically equivalent to self-pollination); (3) Xenogamy — transfer of pollen from a flower of one plant to a flower of a *different plant* of the same species (true cross-pollination; promotes genetic diversity).

Step 1 — Identify the type of pollination described:

Pollen from one plant to another plant = xenogamy (cross-pollination). This is Option B.

Why other options are wrong:

Option A: Autogamy is self-pollination within the *same flower* (pollen from the anther of a flower reaches the stigma of the same flower).

Option C: Geitonogamy involves pollen transfer between different flowers on the *same plant* — though cross-pollination mechanically, it is genetically self-pollination.

Option D: Cleistogamy refers to self-pollination within closed (non-opening) flowers, ensuring self-fertilization (e.g., *Commelina*, some violets); pollen never leaves the flower.

Answer: (B) ← Go back to Q31

Q32.

Solution

Concept — Energy Flow and 10% Law (Lindeman's Efficiency)

According to Lindeman's 10% law (1942), only about 10% of the energy available at each trophic level is transferred to the next trophic level; the remaining 90% is lost as heat through metabolic activities (respiration). So energy decreases by a factor of 10 at each successive trophic level.

Step 1 — Calculate energy at T_5 (quaternary consumer):

T_1 (Producer): 10,000 J

T_2 (Primary Consumer): 10% of 10,000 = 1,000 J

T_3 (Secondary Consumer): 10% of 1,000 = 100 J

T_4 (Tertiary Consumer): 10% of 100 = 10 J

T_5 (Quaternary Consumer / Eagle): 10% of 10 = **1 J**

This is Option D.

Why other options are wrong:

Option A: 100 J is the energy at T_3 (secondary consumer / frog), not T_5.

Option B: 10 J is the energy at T_4 (tertiary consumer / snake), not T_5.
Option C: 5 J is incorrect; the 10% law gives exactly 1 J at the 5th trophic level when starting with 10,000 J at T_1.

Answer: (D) ← Go back to Q32

Q33.

Solution

Concept — Energy Flow: Lindeman's 10% Law
Raymond Lindeman (1942) formulated the 10% law (also called Lindeman's efficiency or trophic efficiency) after studying Cedar Bog Lake ecosystem. He proposed that only about 10% of the energy available at one trophic level is transferred to and fixed at the next trophic level. This forms the basis for understanding energy pyramids and explains why food chains rarely have more than 4–5 trophic levels.

Step 1 — Identify the scientist:
Raymond Lindeman proposed the 10% energy transfer law. This is Option A.

Why other options are wrong:
Option B: Charles Elton pioneered the concept of ecological pyramids (pyramids of numbers, biomass, energy) — "Eltonian pyramids" — and the concept of food chains and food webs; he did not formulate the 10% law.
Option C: Ernst Haeckel coined the term "ecology" (1866) and proposed the concept of ecosystems; he did not formulate the energy transfer law.
Option D: G.F. Gause is famous for the competitive exclusion principle (Gause's law) based on *Paramecium* experiments; he did not propose the 10% energy transfer law.

Answer: (A) ← Go back to Q33

Q34.

Solution

Concept — Nitrogen Cycle: Denitrification
The nitrogen cycle includes several processes: (1) Nitrogen fixation: $N_2 \rightarrow NH_3$ (by *Rhizobium*, *Azotobacter*, blue-green algae); (2) Nitrification: $NH_3 \rightarrow NO_2^-$ (by *Nitrosomonas*) $\rightarrow NO_3^-$ (by *Nitrobacter*); (3) Ammonification: organic N (proteins, nucleic acids) $\rightarrow NH_3$ (by decomposers); (4) Denitrification: $NO_3^- \rightarrow N_2O \rightarrow N_2$ (by *Pseudomonas*, *Thiobacillus denitrificans*) under anaerobic conditions. Denitrification returns nitrogen to the atmosphere, completing the cycle.

Step 1 — Identify denitrification:
Conversion of $NO_3^- \rightarrow N_2$ (atmospheric nitrogen) by bacteria = denitrification.

This is Option C.

Why other options are wrong:
Option A: Nitrification is the conversion of ammonium/ammonia (NH_4^+/NH_3) to nitrite (NO_2^-) and then to nitrate (NO_3^-) by Nitrosomonas and Nitrobacter respectively — the opposite direction to denitrification.
Option B: Ammonification is the decomposition of dead organic matter (proteins, amino acids, urea) by decomposer bacteria and fungi, releasing ammonia (NH_3)/ammonium (NH_4^+).
Option D: Nitrogen fixation is the conversion of atmospheric N_2 into ammonia (NH_3) by nitrogen-fixing bacteria (e.g., *Rhizobium*) or by lightning; this is the entry point of nitrogen into biological systems.

Answer: (C) ← Go back to Q34

Q35.

Solution

Concept — Logistic Growth and Maximum Growth Rate
Logistic (S-shaped / sigmoid) population growth is described by the equation: $dN/dt = rN(K-N)/K$, where r = intrinsic rate of natural increase, N = population size, K = carrying capacity. The growth rate dN/dt is zero when $N = 0$ or $N = K$. The maximum growth rate occurs when the term $N(K-N)$ is maximized, which by differentiation or AM-GM inequality occurs at $N = K/2$.

Step 1 — Find N for maximum growth rate:
Differentiating $N(K-N) = KN - N^2$ with respect to N and setting to zero: $K - 2N = 0 \Rightarrow N = K/2$. Population growth rate is maximum at $N = K/2$. This is Option B.

Why other options are wrong:
Option A: At $N = K$, the growth rate $dN/dt = rN(K-K)/K = 0$ — the population has reached carrying capacity and growth ceases (zero growth rate).
Option C: At $N > K$, the term $(K-N)$ is negative, so $dN/dt < 0$ — the population actually declines (negative growth) because it exceeds carrying capacity.
Option D: At very small N (near zero), $dN/dt \approx rN \approx 0$ (nearly zero because N is tiny) — this resembles the initial phase of exponential growth but is not the maximum in logistic growth.

Answer: (B) ← Go back to Q35

Q36.

Solution

Concept — Restriction Endonucleases: Blunt Ends vs. Sticky Ends

Restriction endonucleases (Type II) cut DNA at specific palindromic recognition sequences. They may produce: (1) 5' overhangs (5' sticky/cohesive ends) — e.g., EcoRI, HindIII, BamHI; (2) 3' overhangs (3' sticky/cohesive ends) — e.g., PstI, KpnI; (3) Blunt ends (no overhangs) — e.g., SmaI (cuts at CCC↓GGG), EcoRV, HaeIII.

Step 1 — Identify the enzyme that produces blunt ends:

SmaI recognizes the sequence 5'-CCCGGG-3' and cuts in the middle (CCC↓GGG), producing blunt ends with no single-stranded overhangs. This is Option D.

Why other options are wrong:

Option A: EcoRI recognizes 5'-G↓AATTC-3' and cuts between G and A on both strands, leaving 5' overhangs (5'-AATT-3' sticky ends).

Option B: HindIII recognizes 5'-A↓AGCTT-3' and cuts to leave 5'-AGCT-3' overhangs (5' sticky ends).

Option C: BamHI recognizes 5'-G↓GATCC-3' and cuts to leave 5'-GATC-3' overhangs (5' sticky ends).

Answer: (D) ← Go back to Q36

Q37.

Solution

Concept — PCR: Taq Polymerase and Its Source

Polymerase Chain Reaction (PCR), developed by Kary Mullis (1983), amplifies specific DNA sequences in vitro through repeated cycles of: (1) Denaturation (∼95°C): strands separate; (2) Annealing (∼50–65°C): primers bind to complementary template; (3) Extension (∼72°C): new DNA strand synthesized from primer. Taq polymerase is a thermostable DNA polymerase isolated from the thermophilic bacterium *Thermus aquaticus*, which lives in hot springs (optimal temperature ∼72°C). Its thermostability means it is not denatured during the high-temperature denaturation step.

Step 1 — Identify the source organism of Taq polymerase:

Taq polymerase is from *Thermus aquaticus* (discovered by Thomas Brock in Yellowstone hot springs). This is Option A.

Why other options are wrong:

Option B: *Thermus thermophilus* is another thermophilic bacterium that has its own DNA polymerase (Tth polymerase), which also has reverse transcriptase activity; Taq specifically comes from *T. aquaticus*.

Option C: *Pyrococcus furiosus* is a hyperthermophilic archaeon that is the source of Pfu polymerase, which has proofreading (3' → 5' exonuclease) activity unlike

Taq; Pfu is more accurate but is not Taq.
Option D: *Bacillus subtilis* is a gram-positive soil bacterium used as a model organism; it does not produce a thermostable DNA polymerase suitable for PCR.

Answer: (A) ← Go back to Q37

Q38.

Solution

Concept — Innate (Non-Specific) Immunity
The immune system has two arms: (1) Innate immunity (non-specific, present from birth): physical barriers (skin, mucus), chemical barriers (lysozyme, complement), cellular components (phagocytes — neutrophils, macrophages; natural killer cells; dendritic cells); (2) Acquired (adaptive) immunity (specific, develops during lifetime): lymphocytes — B cells (humoral, antibody-mediated) and T cells (cell-mediated); features specificity and immunological memory.

Step 1 — Identify the innate immunity component:
Natural killer (NK) cells and phagocytes (neutrophils, macrophages) are cellular components of innate immunity. They respond rapidly and non-specifically to pathogens. This is Option C.

Why other options are wrong:
Option A: B lymphocytes that produce specific antibodies are part of *acquired (humoral) immunity*; antibody specificity is a hallmark of the adaptive immune response.
Option B: T lymphocytes with immunological memory are part of *acquired (cell-mediated) immunity*; long-lived memory T cells are generated after adaptive immune responses.
Option D: Plasma cells are differentiated B cells that secrete large quantities of specific immunoglobulins; they are part of acquired humoral immunity, not innate immunity.

Answer: (C) ← Go back to Q38

Q39.

Solution

Concept — Active vs. Passive Immunization
Immunization types: (1) Active immunization — the immune system is stimulated to produce its own antibodies and memory cells by exposure to antigens (vaccines with live attenuated, killed, or toxoid antigens); protection is long-lasting but takes time to develop. (2) Passive immunization — preformed antibodies (antiserum, immunoglobulins) are transferred directly to the recipient; provides immediate but short-lived protection (no memory cells formed). Examples: anti-

snake venom, anti-rabies immunoglobulin, maternal antibodies (IgG) crossing the placenta.

Step 1 — Identify passive immunization:
Passive immunization uses preformed antibodies (antiserum/immunoglobulins) administered directly. This is Option B.

Why other options are wrong:
Option A: Injecting killed or attenuated pathogens describes *active* immunization (vaccination); the host's immune system generates its own antibodies and memory cells.
Option C: Stimulating T-cell mediated adaptive immunity through antigen exposure is also part of *active* immunization; no memory T cells form during passive immunization.
Option D: Enhancing innate immune response through cytokines is neither active nor passive immunization in the traditional sense; it does not involve antigen-antibody interaction or memory formation.

Answer: (B) ← Go back to Q39

Q40.

Solution

Concept — Kingdom Fungi: Classification of Basidiomycetes
Fungi are classified into major classes based on their reproductive structures and life cycles: (1) Phycomycetes (algal fungi): coenocytic hyphae, mostly aquatic or on decaying organic matter (e.g., *Mucor*, *Rhizopus*); (2) Ascomycetes (sac fungi): septate hyphae, sexual spores (ascospores) produced inside sac-like asci (e.g., *Saccharomyces*, *Penicillium*, *Aspergillus*); (3) Basidiomycetes (club fungi): septate hyphae, sexual spores (basidiospores) borne externally on club-shaped basidia (e.g., mushrooms, puffballs, bracket fungi, *Agaricus*, *Ustilago*); (4) Deuteromycetes (imperfect fungi): no known sexual stage, reproduce only asexually (e.g., *Alternaria*, *Trichoderma*).

Step 1 — Identify the class with basidia:
Club-shaped basidia bearing basidiospores externally = Basidiomycetes. This is Option D.

Why other options are wrong:
Option A: Ascomycetes (sac fungi) produce sexual spores (ascospores) *inside* sac-like structures called asci (singular: ascus), not on club-shaped basidia.
Option B: Phycomycetes (algal fungi) are characterized by coenocytic (non-septate) hyphae and produce sporangiospores (asexual) or zygospores (sexual); they do not have basidia.
Option C: Deuteromycetes (imperfect fungi) have no known sexual stage; only

asexual conidia are produced; they do not have basidia or asci.

Answer: (D) ← Go back to Q**40**

Answer Key

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