GUJCET Biology

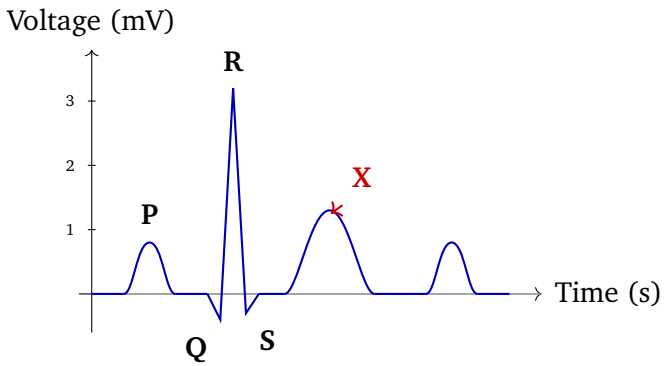
Sample Paper – 6

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. Study the ECG trace of one complete cardiac cycle shown below. The deflection labeled **X** represents which physiological event?



A. Atrial depolarization, producing the P wave

B. Ventricular repolarization, producing the T wave

C. Ventricular depolarization, producing the QRS complex

D. Atrial repolarization, hidden within the QRS complex

Q2. According to Starling's law of the heart, which statement best describes the relationship between venous return and stroke volume?

A. Increased end-diastolic volume causes greater myocardial stretch, leading to a stronger contraction and higher stroke volume

B. Stroke volume decreases proportionally as venous return increases, to prevent cardiac overload

C. Heart rate increases to compensate whenever stroke volume falls, keeping cardiac output constant

D. Cardiac output is independent of venous return and is regulated solely by the autonomic nervous system

Q3. Which sequence correctly describes activation of the renin-angiotensin-aldosterone system (RAAS) when blood pressure falls?

A. Renin $\rightarrow$ Angiotensin II $\rightarrow$ ACE $\rightarrow$ Angiotensin I $\rightarrow$ Aldosterone release

B. Renin $\rightarrow$ Aldosterone $\rightarrow$ ACE $\rightarrow$ Angiotensin I $\rightarrow$ Angiotensin II

C. Renin $\rightarrow$ Angiotensin I $\rightarrow$ ACE $\rightarrow$ Angiotensin II $\rightarrow$ Aldosterone release

D. Renin $\rightarrow$ Angiotensin II $\rightarrow$ Aldosterone $\rightarrow$ Na^+ retention $\rightarrow$ ACE inactivation

Q4. Which of the following statements about lymph and the lymphatic system is **INCORRECT**?

A. Lymph is a colourless fluid derived from interstitial (tissue) fluid that has entered lymphatic capillaries

B. Lymph contains lymphocytes and monocytes but does not contain erythrocytes (red blood cells)

C. Lymphatic capillaries are blind-ended and highly permeable, allowing large molecules to enter

D. Lymph has a higher protein concentration than blood plasma because plasma proteins are too large to enter capillaries

Q5. The countercurrent multiplier mechanism in the loop of Henle is essential for producing concentrated urine. What does this mechanism primarily achieve?

A. Active transport of water out of the descending limb into the interstitium

B. Establishment of an osmotic gradient in the medullary interstitium that drives water reabsorption from the collecting duct

C. Active reabsorption of glucose and amino acids in the ascending limb of the loop

D. Secretion of H^+ ions into the filtrate in the descending limb to acidify the urine

Q6. Under normal blood glucose levels, glucose is completely reabsorbed from the glomerular filtrate. Which transport mechanism is primarily responsible for glucose reabsorption in the proximal convoluted tubule (PCT)?

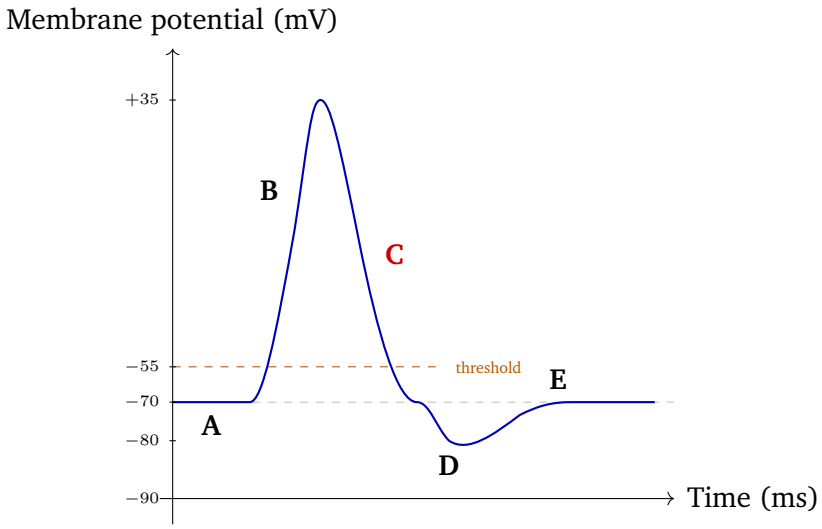
A. Secondary active transport via sodium-glucose linked transporters (SGLT), driven by the Na^+ gradient

B. Simple diffusion through aquaporin-2 water channels in the apical membrane

C. Primary active transport powered directly by ATP hydrolysis in the distal convoluted tubule

D. Facilitated diffusion through GLUT5 uniporters in the loop of Henle

Q7. Study the action potential graph below. The phase labeled **C** represents which event in the generation of the action potential?



A. The resting membrane potential maintained by the Na^+/K^+-ATPase pump

B. Rapid depolarization due to opening of voltage-gated Na^+ channels and Na^+ influx

C. Repolarization caused by closing of Na^+ channels and opening of voltage-gated K^+ channels

D. Hyperpolarization where membrane potential briefly falls below the resting level

Q8. Which type of neuron is most abundant in the human central nervous system, possesses a single axon together with numerous dendrites, and integrates information from many presynaptic inputs?

A. Unipolar neuron

B. Bipolar neuron

C. Pseudounipolar neuron

D. Multipolar neuron

Q9. Insufficient secretion of thyroid hormones (T_3 and T_4) during foetal development and early childhood leads to which condition?

A. Graves' disease, characterised by exophthalmos, goitre, and weight loss

B. Cretinism, characterised by stunted physical growth, intellectual disability, and delayed bone maturation

C. Addison's disease, characterised by hyperpigmentation and electrolyte imbalance

D. Cushing's syndrome, characterised by moon face, truncal obesity, and hypertension

Q10. Which hormone, secreted by the zona fasciculata of the adrenal cortex, primarily promotes gluconeogenesis in the liver and suppresses the immune response?

A. Cortisol

B. Aldosterone

C. Androstenedione

D. Epinephrine (adrenaline)

Q11. Antidiuretic hormone (ADH/vasopressin) is synthesised in the hypothalamus and released from the posterior pituitary. Its primary action on the kidney collecting duct is to:

A. Inhibit Na^+ reabsorption in the thick ascending limb of the loop of Henle

B. Stimulate aldosterone secretion from the adrenal cortex via the RAAS cascade

C. Insert aquaporin-2 (AQP2) water channels into the apical membrane, increasing water permeability and reabsorption

D. Decrease glomerular filtration rate by constricting the afferent arteriole

Q12. Which of the following events does **NOT** occur within the Golgi apparatus?

A. N-glycosylation: addition and processing of oligosaccharide chains on glycoproteins received from the ER

B. Sorting and packaging of proteins into vesicles destined for lysosomes, plasma membrane, or secretion

C. Formation of clathrin-coated vesicles for transport from the trans-Golgi network

D. De novo synthesis of membrane phospholipids via the Kennedy (CDP-choline) pathway

Q13. ATP synthesis by ATP synthase (Complex V) during oxidative phosphorylation occurs at which specific location within the mitochondrion?

A. The inner mitochondrial membrane (cristae), driven by the proton (H^+) electrochemical gradient

B. The outer mitochondrial membrane, facing the cytoplasm

C. The mitochondrial matrix, coupled to citric acid cycle reactions

D. The intermembrane space, where protons accumulate after pumping by Complexes I, III, and IV

Q14. According to the fluid mosaic model of the cell membrane proposed by Singer and Nicolson (1972), which statement is correct?

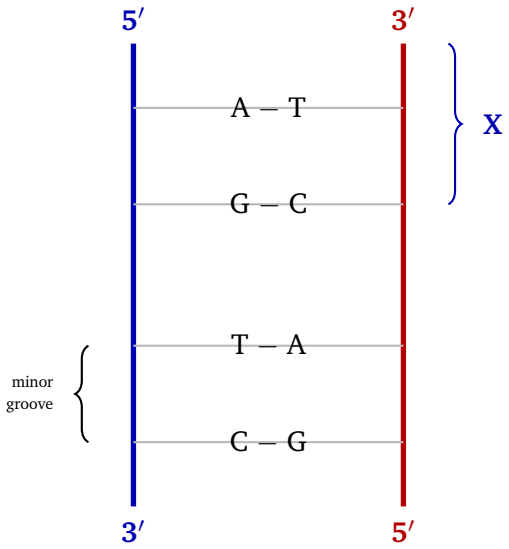
A. The lipid bilayer is a rigid, static scaffold that holds membrane proteins in permanently fixed positions

B. Both integral and peripheral proteins float in a fluid phospholipid bilayer and can undergo lateral movement within the membrane plane

C. All integral proteins are restricted to the outer leaflet, while peripheral proteins are confined to the inner leaflet

D. Cholesterol is absent from plasma membranes and is found exclusively in myelin sheaths of nerve fibres

Q15. Study the schematic diagram of the DNA double helix. The region labeled **X** (indicated by the bracket) represents which structural feature?



A. A hydrogen bond between complementary nitrogenous bases

B. A covalent phosphodiester bond linking adjacent nucleotides in the backbone

C. The major groove of the DNA double helix

D. The 5′ to 3′ directionality of the right-hand strand

Q16. Which modification occurs to eukaryotic pre-mRNA transcripts but is **absent** in prokaryotic transcription?

A. Binding of RNA polymerase to a promoter sequence upstream of the gene

B. Synthesis of the RNA strand in the 5′ to 3′ direction

C. Reading the template strand in the 3′ to 5′ direction during transcription

D. Addition of a 7-methylguanosine cap at the 5′ end and a poly-A tail at the 3′ end

Q17. During eukaryotic translation initiation, which sequence of events is correct?

A. The 43S pre-initiation complex (40S + Met-tRNA$_i$) binds the 5′ cap, scans for the AUG start codon, then the 60S subunit joins to form the 80S ribosome

B. The 60S ribosomal subunit first binds the 3′ poly-A tail, then recruits the 40S subunit with Met-tRNA

C. Both the 40S and 60S subunits simultaneously assemble at an IRES in the 5′ UTR of all eukaryotic mRNAs

D. A stop codon must first be recognised at the A site to signal assembly of the ribosome at the AUG codon

Q18. In *E. coli*, when lactose is present and glucose is absent, the *lac* operon is transcribed. This occurs because:

A. The lac repressor is phosphorylated, causing it to dissociate from the operator irreversibly

B. Allolactose (the true inducer) binds to the lac repressor, causing a conformational change that releases it from the operator, allowing RNA polymerase to transcribe the structural genes

C. The cAMP-CAP complex degrades the repressor protein to eliminate transcriptional inhibition

D. RNA polymerase bypasses the operator region without requiring repressor removal under high lactose conditions

Q19. A single nucleotide insertion within the open reading frame (coding sequence) of a gene will most likely result in:

A. A missense mutation that changes only the single codon containing the insertion

B. A nonsense mutation that introduces a premature stop codon at the insertion site

C. A frameshift mutation that alters the reading frame for all codons downstream of the insertion

D. A silent mutation with no effect on the amino acid sequence of the protein

Q20. Turner syndrome (45,X) arises from monosomy of the sex chromosome. Which combination of features is characteristic of Turner syndrome?

A. Trisomy 21, intellectual disability, flat nasal bridge, and single palmar crease

B. 47,XXY karyotype, tall stature, hypogonadism, and gynecomastia

C. Trisomy 18, clenched fist with overlapping fingers, and heart defects

D. Short stature, webbed neck (pterygium colli), widely spaced nipples, and primary amenorrhoea

Q21. The genetic code is described as **degenerate** (redundant). This property specifically means that:

A. Multiple different codons can specify the same amino acid (e.g., six codons each for leucine and serine)

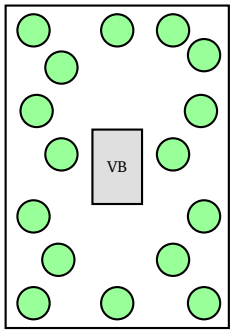
B. A single codon can code for two or more different amino acids depending on cellular conditions

C. Adjacent codons overlap by sharing one nucleotide, so a mutation affects two amino acids simultaneously

D. The genetic code has changed over evolutionary time, differing significantly among ancient organisms

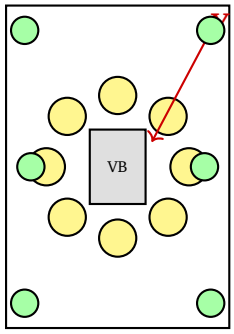
Q22. Study the two leaf cross-section diagrams below. In the C4 plant (Diagram II), the cells labeled **Y** are arranged in a distinctive wreath-like pattern. What are these cells, and where does the Calvin cycle primarily occur in C4 plants?

Diagram I: C3 Plant



Uniform mesophyll

Diagram II: C4 Plant



Kranz anatomy

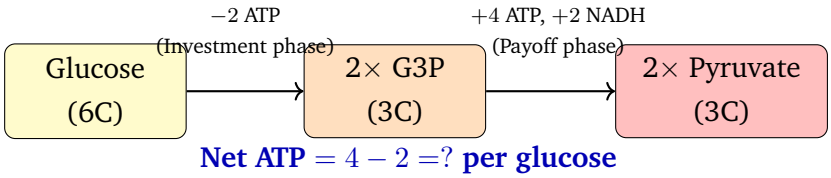
A. Palisade mesophyll cells with high chloroplast density, arranged perpendicular to the leaf surface

B. Bundle sheath cells forming a wreath around the vascular bundle; the Calvin cycle (C3) occurs here in C4 plants

C. Spongy mesophyll cells with large intercellular air spaces for CO_2 diffusion

D. Guard cells surrounding the stomatal pore, regulating gas exchange and water loss

Q23. Study the glycolysis flowchart below. What is the **net** gain of ATP molecules per glucose molecule through glycolysis (substrate-level phosphorylation only)?



A. 4 ATP (total ATP produced in the payoff phase, without subtracting the investment)

B. 8 ATP (incorrectly including NADH contributions as direct ATP within glycolysis)

C. 2 ATP (4 ATP produced minus 2 ATP invested in the preparatory phase)

D. 6 ATP (incorrectly assuming 3 ATP per NADH are generated within glycolysis itself)

Q24. The primary metabolic role of alcoholic fermentation in yeast under anaerobic conditions is to:

A. Generate additional ATP through substrate-level phosphorylation beyond what glycolysis produces

B. Produce CO_2 as the main carbon source for biosynthetic reactions under anaerobic conditions

C. Convert acetaldehyde back to pyruvate to fuel the citric acid cycle anaerobically

D. Regenerate NAD^+ from NADH so that glycolysis can continue to produce ATP in the absence of oxygen

Q25. Apical dominance in plants, where the growing shoot apex suppresses the outgrowth of axillary (lateral) buds, is primarily regulated by:

A. High auxin (IAA) concentration exported from the apical bud that inhibits lateral bud activation

B. Gibberellin secreted by young apical leaves that redirects nutrients away from lateral buds

C. Ethylene synthesised in the shoot apex that causes abscission of lateral branch primordia

D. Abscisic acid transported from root tips through the xylem to suppress axillary bud growth

Q26. Gibberellins promote seed germination in cereal grains such as barley. The mechanism involves:

A. Directly stimulating cell division within the embryonic axis to push the radicle through the seed coat

B. Signalling the aleurone layer cells to synthesise and secrete α-amylase, which hydrolyses starch reserves in the endosperm

C. Degrading the hard seed coat by activating cellulase and pectinase enzymes within the testa

D. Activating the pentose phosphate pathway in the endosperm to supply pentoses for nucleic acid synthesis

Q27. In plant tissue culture, the ratio of plant hormones determines organogenesis. A high cytokinin-to-auxin ratio in the culture medium promotes:

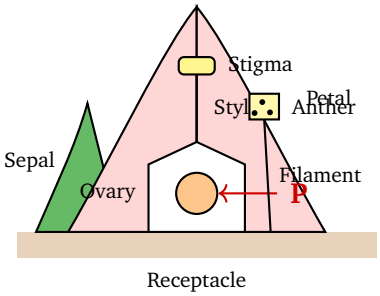
A. Root organogenesis and suppression of shoot formation in callus tissue

B. Undifferentiated callus proliferation without commitment to any organ type

C. Shoot organogenesis and development of multiple axillary buds from callus

D. Somatic embryogenesis and formation of embryoids in suspension culture

Q28. Study the half-section of the dicot flower shown below. The structure labeled **P** represents which floral part?



A. The stigma, which receives pollen grains and provides a surface for pollen germination

B. The style, through which the pollen tube grows toward the ovary

C. The anther, where meiosis produces haploid microspores (pollen grains)

D. The ovule, which contains the embryo sac and develops into a seed after fertilisation

Q29. In angiosperms, double fertilisation is a unique feature. Which statement correctly describes both fusion events that occur?

A. One sperm fuses with the egg cell (syngamy $\rightarrow$ diploid zygote) and the other sperm fuses with the two polar nuclei (triple fusion $\rightarrow$ triploid primary endosperm nucleus, 3n)

B. Both sperm cells fuse simultaneously with the egg cell to produce a tetraploid (4n) zygote

C. One sperm fertilises the central cell and the second sperm fertilises a synergid cell adjacent to the egg

D. Double fertilisation occurs in gymnosperms but not in angiosperms, which undergo only syngamy

Q30. Nuclear-type endosperm development, as seen in coconut (*Cocos nucifera*), is characterised by:

A. Immediate cell wall formation after each division of the primary endosperm nucleus, producing a cellular endosperm from the start

B. Repeated free nuclear divisions of the primary endosperm nucleus without cell wall formation, producing a multinucleate syncytium that later cellularises

C. An early asymmetric division producing a large chalazal haustorium and a small micropylar chamber

D. Suppression of endosperm development, with cotyledons directly absorbing nutrients from the nucellus

Q31. Which of the following correctly describes the mechanism of coat-imposed seed dormancy in seeds with physically hard seed coats?

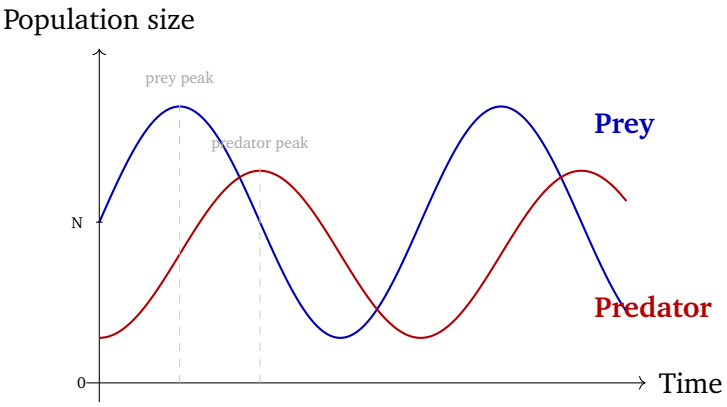
A. High gibberellin content within the seed coat actively inhibits embryo elongation by blocking aquaporin channels

B. Ethylene accumulates inside the seed and prevents radicle emergence by maintaining ABA sensitivity

C. The mechanically hard seed coat resists embryo expansion and may also contain germination inhibitors within the testa

D. Elevated cytokinin levels in the embryo itself overpower any hormonal promotion of germination from outside

Q32. Study the Lotka-Volterra predator-prey oscillation graph below. Which statement best describes the population dynamics shown?



A. Predator and prey populations oscillate perfectly in phase, with both peaks occurring simultaneously

B. When prey numbers decline, the predator population immediately rises due to stress-induced reproduction

C. The predator population consistently leads the prey, with predator numbers peaking before prey numbers

D. The prey population peaks before the predator population, with a time lag between the two oscillations

Q33. Which of the following is the best example of obligate mutualism in which both partner species derive a measurable benefit?

A. Mycorrhizal fungi associating with plant roots: the fungus receives photosynthates and the plant gains enhanced mineral absorption (especially phosphorus)

B. Barnacles attaching to whale skin: barnacles gain transport and access to plankton-rich water while the whale is unaffected

C. Cattle egrets feeding on insects disturbed by grazing cattle: the egret benefits while the cattle are unaffected

D. Remora fish attached to sharks: the remora obtains food scraps and transport while the shark is largely unaffected

Q34. Which combination of features correctly characterises a tropical rainforest biome?

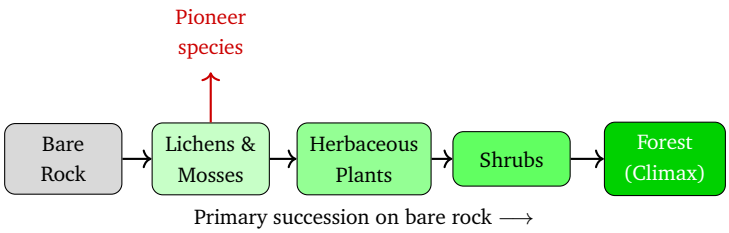
A. High seasonal variation in rainfall (50–100 cm/year), deciduous trees, and relatively low biodiversity

B. Annual rainfall exceeding 200 cm, year-round warmth, extremely high biodiversity, and a multi-layered canopy including emergent, canopy, understory, and shrub layers

C. Permafrost layer, low-growing shrubs and sedges, and prolonged winter darkness with minimal plant diversity

D. Grassland with scattered flat-topped trees, a marked wet-dry seasonality, and large migratory herbivores

Q35. Study the primary succession diagram below. The organisms that first colonise bare rock (pioneer species) are indicated. Which organisms fill this role, and why?



A. Herbaceous plants with shallow fibrous root systems that stabilise loose rock particles

B. Shrubs and woody plants whose root exudates dissolve mineral compounds from bare rock

C. Lichens and mosses, which can grow on bare rock, weather it chemically and physically, and accumulate organic matter to form a primitive soil

D. Fast-growing climax trees that shade the rock surface and accelerate temperature-driven weathering

Q36. In recombinant DNA technology, host bacterial cells must be made **competent** before a recombinant plasmid can enter. Chemical competence is induced by treating cells with:

A. Lysozyme to partially digest the peptidoglycan cell wall, creating spheroplasts for DNA uptake

B. DNase I to degrade endogenous DNA that would compete with the introduced recombinant plasmid

C. Sodium dodecyl sulfate (SDS) to solubilise the outer membrane and allow plasmid entry

D. Calcium chloride ($CaCl_2$) solution at low temperature, followed by a brief heat shock (42°C), which transiently increases membrane permeability for plasmid DNA uptake

Q37. In agarose gel electrophoresis of DNA fragments, which statement is correct regarding the migration of DNA fragments?

A. Smaller fragments migrate faster toward the positive electrode because they experience less molecular sieving resistance as they move through the gel matrix

B. Larger fragments migrate faster because they carry more negative charge from additional phosphate groups

C. DNA fragments are separated based on their GC versus AT base composition, not on molecular size

D. Ethidium bromide is added to the gel after electrophoresis, but it stains proteins rather than nucleic acids

Q38. Which species of *Plasmodium* is responsible for the most severe form of malaria, known as **malignant tertian malaria**, and can cause life-threatening complications including cerebral malaria?

A. *Plasmodium vivax* (causes benign tertian malaria with a 48-hour cycle)

B. *Plasmodium falciparum*

C. *Plasmodium malariae* (causes quartan malaria with a 72-hour erythrocytic cycle)

D. *Plasmodium ovale* (causes mild tertian malaria, mainly in West Africa)

Q39. Proto-oncogenes are normal cellular genes that regulate cell growth. They become oncogenes (cancer-causing genes) through which mechanism?

A. Loss-of-function mutations that inactivate the gene product, similar to how tumour suppressors are inactivated in cancer

B. Methylation of CpG islands in their promoters, permanently silencing their transcription

C. Gain-of-function mutations, chromosomal translocations, or gene amplification that causes constitutive (unregulated) activation of the encoded growth-promoting protein

D. Interaction with the p53 tumour suppressor, which paradoxically activates proto-oncogene expression during DNA damage

Q40. Brown algae (Phaeophyta) are distinguished from green algae (Chlorophyta) and red algae (Rhodophyta) by the presence of which characteristic photosynthetic pigment?

A. Phycoerythrin, a phycobiliprotein that gives red algae their characteristic colour

B. Phycocyanin and allophycocyanin, phycobiliproteins found in cyanobacteria and Rhodophyta

C. Chlorophyll a and b as the sole photosynthetic pigments, with no accessory xanthophylls

D. Fucoxanthin, a brown carotenoid (xanthophyll), combined with chlorophylls a and c

Detailed Solutions

Q1.

Solution

Concept — ECG and Cardiac Cycle:
An ECG records the electrical activity of the heart. The P wave represents atrial depolarisation (SAN impulse spreading across atria), the QRS complex represents ventricular depolarisation (bundle of His → Purkinje fibres), and the T wave represents ventricular repolarisation (recovery of ventricular muscle).

Step 1 — Identify X:
In the diagram, X is labelled on the smooth dome-shaped deflection following the QRS complex — this is the T wave, which corresponds to ventricular repolarisation (K^+ efflux restoring the resting potential in ventricular muscle cells).

Why other options are wrong:
Option A: Atrial depolarisation produces the P wave (the smaller deflection before the QRS), not the T wave.
Option C: Ventricular depolarisation produces the QRS complex, not the structure labelled X.
Option D: Atrial repolarisation does occur but is hidden within (masked by) the larger QRS complex; it does not produce a separate visible deflection.

Answer: (B) ← Go back to Q1

Q2.

Solution

Concept — Starling's Law of the Heart:
Starling's law (Frank-Starling mechanism) states that the force of cardiac contraction is proportional to the initial length of the myocardial fibres at the end of diastole. Greater venous return → greater end-diastolic volume → more myocardial stretch → stronger contraction → larger stroke volume.

Step 1 — Analysis:
When venous return increases, the heart fills more during diastole (increased end-diastolic volume). The stretched sarcomeres operate on a more favourable part of the length-tension curve, generating greater force. Stroke volume therefore increases without requiring a change in heart rate.

Why other options are wrong:
Option B: Stroke volume increases (not decreases) with greater venous return; this is the opposite of Starling's law.
Option C: Heart rate is not the mechanism described by Starling's law; the law specifically concerns stroke volume changes due to preload.

Option D: Cardiac output is not independent of venous return; Starling's law precisely describes how it responds to changes in preload.

Answer: (A) ← Go back to Q2

Q3.

Solution

Concept — RAAS and Blood Pressure Regulation:
Low blood pressure is detected by juxtaglomerular cells, which secrete renin. Renin cleaves angiotensinogen (liver) to Angiotensin I. Angiotensin-converting enzyme (ACE, mainly in lungs) converts Angiotensin I to Angiotensin II. Angiotensin II stimulates the adrenal cortex to release aldosterone, which promotes Na^+ and water retention, raising blood pressure.

Step 1 — Correct sequence:
Renin $\rightarrow$ Angiotensinogen $\rightarrow$ Angiotensin I $\xrightarrow{\text{ACE}}$ Angiotensin II $\rightarrow$ Aldosterone release. This matches option C.

Why other options are wrong:
Option A: Angiotensin II cannot be produced before ACE acts on Angiotensin I; the order is reversed.
Option B: Aldosterone is the end product, not an intermediate step before ACE action.
Option D: ACE is not inactivated by aldosterone; it continues functioning in the renin-angiotensin pathway.

Answer: (C) ← Go back to Q3

Q4.

Solution

Concept — Lymph Composition and the Lymphatic System:
Lymph is derived from interstitial fluid that enters blind-ended lymphatic capillaries. It is colourless and contains lymphocytes, monocytes, and other leucocytes but no erythrocytes. Lymph has a *lower* protein concentration than blood plasma because plasma proteins are largely too large to pass through capillary walls and are retained in the blood.

Step 1 — Identify the incorrect statement:
Option D states lymph has a *higher* protein concentration than blood plasma. This is incorrect: lymph has a lower protein concentration because plasma proteins remain in the bloodstream and only small amounts leak into interstitial fluid.

Why other options are wrong:
Option A: Correct — lymph is colourless and is formed from tissue fluid entering

lymphatic capillaries.
Option B: Correct — lymph contains WBCs (lymphocytes, monocytes) but no RBCs; erythrocytes are too large to enter lymphatic capillaries under normal conditions.
Option C: Correct — lymphatic capillaries are blind-ended (closed at one end) and lined by loosely joined endothelial cells that are highly permeable.

Answer: (D) ← Go back to Q4

Q5.

Solution

Concept — Countercurrent Mechanism in the Loop of Henle:
The descending limb is permeable to water but not NaCl; the ascending limb is impermeable to water but actively pumps NaCl into the interstitium. This countercurrent multiplier creates a progressively hyperosmotic medullary interstitium (up to ∼1200 mOsm at the tip of the loop). This gradient drives water reabsorption from the collecting duct (when ADH is present), concentrating the urine.

Step 1 — Key mechanism:
The primary function is to establish an osmotic gradient in the renal medulla that allows the collecting duct (under ADH influence) to reabsorb water, producing concentrated urine. This matches option B.

Why other options are wrong:
Option A: Water moves osmotically (passively) out of the descending limb, not by active transport; there are no water pumps.
Option C: Glucose and amino acid reabsorption occurs in the PCT, not in the loop of Henle.
Option D: NaCl is pumped *out* of the ascending limb (not into the lumen); and the descending limb is impermeable to solutes, not a site of H^+ secretion.

Answer: (B) ← Go back to Q5

Q6.

Solution

Concept — Tubular Reabsorption of Glucose in the PCT:
The glomerular filtrate contains glucose at the same concentration as plasma. All filtered glucose is normally reabsorbed in the PCT via SGLT1 and SGLT2 (sodium-glucose linked transporters) on the apical (luminal) membrane. These are secondary active transporters: Na^+ moves down its electrochemical gradient (maintained by Na^+/K^+-ATPase on the basolateral side), co-transporting glucose against its concentration gradient.

Step 1 — Identify the mechanism:
SGLT transporters use the Na^+ gradient (created by the basolateral Na^+/K^+-ATPase) to drive glucose reabsorption uphill. This is secondary active transport. Option A is correct.

Why other options are wrong:
Option B: Aquaporins transport water, not glucose; they are not involved in glucose reabsorption.
Option C: H^+/K^+-ATPase is found in the stomach and collecting duct; glucose is not reabsorbed in the DCT.
Option D: GLUT5 is a fructose transporter found in the intestine; the loop of Henle is not a glucose reabsorption site.

Answer: (A) ← Go back to Q6

Q7.

Solution

Concept — Action Potential Phases:
An action potential has five phases: A = resting potential (-70 mV, maintained by Na^+/K^+-ATPase); B = rapid depolarisation (voltage-gated Na^+ channels open, Na^+ influx drives membrane toward $+35$ mV); C = repolarisation (Na^+ channels inactivate, voltage-gated K^+ channels open, K^+ efflux restores negative potential); D = hyperpolarisation (K^+ channels slow to close, membrane overshoots below -70 mV); E = return to resting potential.

Step 1 — Identify phase C:
In the graph, phase C is the falling phase after the peak. This corresponds to K^+ channel opening and K^+ efflux, which repolarises the membrane. Option C is correct.

Why other options are wrong:
Option A: Phase A is the flat resting potential (-70 mV) before stimulation; it is maintained by the Na^+/K^+-ATPase.
Option B: Phase B is the rapid rising (depolarisation) phase due to Na^+ channel opening and Na^+ influx.
Option D: Phase D is the hyperpolarisation dip below -70 mV, not the repolarisation falling phase.

Answer: (C) ← Go back to Q7

Q8.

Solution

Concept — Classification of Neurons by Number of Processes:
Neurons are classified by morphology: unipolar (one process, rare in vertebrates), bipolar (two processes: one dendrite, one axon, e.g., retinal rods/cones), pseudounipolar (one process that divides into central and peripheral branches, e.g., dorsal root ganglion neurons), and multipolar (multiple dendrites + one axon). Multipolar neurons are by far the most abundant type in the brain and spinal cord.

Step 1 — Identify the neuron type:
Multiple dendrites and one axon = multipolar neuron. These are the predominant neurons in the CNS, including motor neurons and interneurons. Option D is correct.

Why other options are wrong:
Option A: Unipolar neurons have only one process and are not the dominant CNS type in vertebrates.
Option B: Bipolar neurons have exactly one dendrite and one axon; they are found in special sensory organs (retina, olfactory epithelium) but are not the most common CNS neuron.
Option C: Pseudounipolar neurons have a single process that bifurcates; they are found in sensory ganglia (dorsal root ganglia), not predominantly in the brain and spinal cord.

Answer: (D) ← Go back to Q8

Q9.

Solution

Concept — Thyroid Hormone Deficiency: Cretinism:
T_3 and T_4 are essential for normal growth and CNS development during foetal life and early childhood. Hyposecretion of thyroid hormones during this critical period causes cretinism: severely stunted growth (dwarfism), intellectual disability, delayed bone maturation, coarse facial features, and protruding tongue. In adults, hypothyroidism leads to myxoedema (not cretinism).

Step 1 — Match condition to cause:
Cretinism results from foetal/neonatal hypothyroidism. The hallmarks (stunted growth + intellectual disability) match option B.

Why other options are wrong:
Option A: Graves' disease is an autoimmune *hyperthyroid* condition (excess T_3/T_4) with exophthalmos, goitre, tachycardia, and weight loss — the opposite of hypothyroidism.
Option C: Addison's disease results from adrenocortical insufficiency (low cortisol and aldosterone), not thyroid dysfunction.

Option D: Cushing's syndrome is caused by excess cortisol (glucocorticoid), not thyroid hormone deficiency.

Answer: (B) ← Go back to Q9

Q10.

Solution

Concept — Adrenal Cortex Hormones:
The adrenal cortex has three zones: zona glomerulosa (aldosterone — mineralocorticoid, Na^+/water retention), zona fasciculata (cortisol — glucocorticoid, gluconeogenesis, immunosuppression, anti-inflammatory), and zona reticularis (sex corticoids — androgens such as DHEA). The adrenal medulla secretes epinephrine and norepinephrine (catecholamines).

Step 1 — Match hormone to zone:
Zona fasciculata → cortisol. Cortisol stimulates gluconeogenesis (protein → glucose), reduces immune cell proliferation, and suppresses inflammatory mediators. Option A is correct.

Why other options are wrong:
Option B: Aldosterone (zona glomerulosa) regulates Na^+/K^+ balance and blood pressure, not gluconeogenesis or immunity.
Option C: Androstenedione/DHEA (zona reticularis) are weak androgens; they do not promote gluconeogenesis or immunosuppression.
Option D: Epinephrine is secreted by the adrenal *medulla* (chromaffin cells), not the adrenal cortex.

Answer: (A) ← Go back to Q10

Q11.

Solution

Concept — ADH and Aquaporin-2:
ADH (vasopressin), released when plasma osmolality rises or blood volume/pressure falls, binds to V2 receptors on the basolateral membrane of collecting duct principal cells. This activates adenylyl cyclase (via Gs protein), raising cAMP, which triggers PKA-mediated phosphorylation and insertion of aquaporin-2 (AQP2) vesicles into the apical membrane. The increased water permeability allows water to move from the tubular lumen into the hyperosmotic interstitium, concentrating the urine.

Step 1 — Key mechanism:
ADH → V2 receptor → cAMP → PKA → AQP2 insertion into apical membrane → water reabsorption. Option C is correct.

Why other options are wrong:
Option A: ADH acts on the collecting duct, not the thick ascending limb; Na^+ reabsorption in the ascending limb is regulated by different mechanisms.
Option B: ADH does not stimulate aldosterone release; that is the role of angiotensin II in the RAAS.
Option D: ADH does not constrict the afferent arteriole under physiological conditions (high doses can cause vasoconstriction via V1 receptors, but the primary renal action is AQP2-mediated water reabsorption).

Answer: (C) ← Go back to Q11

Q12.

Solution

Concept — Golgi Apparatus Functions:
The Golgi apparatus receives vesicles from the ER at its cis face, modifies glycoproteins (trimming and elaborating N-linked oligosaccharides; adding O-linked sugars), sulfates proteoglycans, and sorts proteins at the trans-Golgi network into vesicles destined for lysosomes, plasma membrane, or secretory pathway. De novo phospholipid synthesis (Kennedy pathway: CDP-choline + DAG → PC) occurs primarily in the *endoplasmic reticulum*, not the Golgi.

Step 1 — Identify what does NOT happen in Golgi:
Phospholipid synthesis via the Kennedy (CDP-choline) pathway is an ER function, not a Golgi function. Option D is the incorrect statement about the Golgi and is therefore the correct answer.

Why other options are wrong:
Option A: N-glycosylation (initiated in ER and extensively processed in Golgi) does occur in the Golgi.
Option B: Protein sorting and packaging into different vesicle types is a central Golgi (trans-Golgi network) function.
Option C: Clathrin-coated vesicles form at the trans-Golgi network to deliver cargo (e.g., lysosomal enzymes) to endosomes; this is a well-established Golgi activity.

Answer: (D) ← Go back to Q12

Q13.

Solution

Concept — Site of Oxidative Phosphorylation:
Oxidative phosphorylation (OXPHOS) occurs at the inner mitochondrial membrane (IMM), which is highly folded into cristae to maximise surface area. Complexes I, II, III, and IV pump H^+ from the matrix to the intermembrane space, creating a proton gradient (chemiosmotic potential). ATP synthase (Complex V),

embedded in the IMM, uses the H^+ flow back into the matrix to phosphorylate ADP to ATP (Mitchell's chemiosmotic hypothesis).

Step 1 — Locate ATP synthase:
ATP synthase is an integral protein of the inner mitochondrial membrane, with its catalytic F_1 head projecting into the matrix. Option A is correct.

Why other options are wrong:
Option B: The outer mitochondrial membrane is the site of VDAC channels and porin proteins; it is not where the ETC or ATP synthase resides.
Option C: The citric acid (Krebs) cycle reactions occur in the mitochondrial matrix (soluble enzymes), not at the membrane; they produce NADH/$FADH_2$ but not ATP via oxidative phosphorylation.
Option D: The intermembrane space is where protons accumulate (high H^+), but ATP synthesis occurs in the matrix side via the ATP synthase embedded in the IMM.

Answer: (A) ← Go back to Q13

Q14.

Solution

Concept — Fluid Mosaic Model (Singer and Nicolson, 1972):
The fluid mosaic model proposes that the plasma membrane is a fluid phospholipid bilayer in which proteins are embedded (integral/transmembrane proteins) or loosely associated on the surface (peripheral proteins). Both the lipid bilayer and the embedded proteins are mobile — they can undergo lateral diffusion (fluid state), though some proteins are anchored by the cytoskeleton. Cholesterol modulates fluidity. The model replaced the static "unit membrane" model.

Step 1 — Key principle:
The membrane is a 2D fluid: phospholipids and proteins can diffuse laterally. Both integral and peripheral proteins exist. Option B captures this correctly.

Why other options are wrong:
Option A: The lipid bilayer is *fluid*, not rigid or static; protein mobility is a key feature of the model.
Option C: Integral proteins span both leaflets (transmembrane domains); peripheral proteins are associated with either the inner or outer surface. There is no strict segregation between leaflets for these two protein types.
Option D: Cholesterol is abundantly present in eukaryotic plasma membranes (25–40% of membrane lipids) and modulates fluidity; it is not confined to myelin.

Answer: (B) ← Go back to Q14

Q15.

Solution

Concept — DNA Double Helix Structure:

The Watson-Crick DNA double helix has two antiparallel sugar-phosphate backbones wound around a central axis. The geometry creates two grooves of unequal size: the **major groove** (wider, ∼22 Å wide) and the minor groove (narrower, ∼12 Å wide). The major groove exposes more base-pair information and is the primary site for sequence-specific protein-DNA interactions (e.g., transcription factors, restriction enzymes).

Step 1 — Identify region X:

The bracket labelled X in the diagram spans the wider space between two consecutive base-pair rungs — this is the **major groove**. Option C is correct.

Why other options are wrong:

Option A: Hydrogen bonds are the horizontal connections between complementary bases in the interior of the helix; they are not grooves.

Option B: Phosphodiester bonds link adjacent nucleotides within each strand backbone; they are not a groove feature.

Option D: The 5′ to 3′ directionality is a property of the strand, not a structural groove between the two strands.

Answer: (C) ← Go back to Q15

Q16.

Solution

Concept — Eukaryotic vs Prokaryotic mRNA Processing:

Eukaryotic pre-mRNA undergoes three major modifications not seen in prokaryotes: (1) 5′ capping — addition of 7-methylguanosine (m^7G) cap co-transcriptionally; (2) 3′ polyadenylation — addition of 100–250 adenosine residues; (3) splicing of introns by spliceosomes. The 5′ cap protects mRNA from exonuclease degradation and is essential for ribosome recognition. The poly-A tail stabilises the mRNA and aids nuclear export.

Step 1 — Identify the eukaryote-specific modification:

The 5′ m^7G cap AND 3′ poly-A tail are both absent in prokaryotic mRNA. Option D is correct.

Why other options are wrong:

Option A: RNA polymerase binding to a promoter occurs in both prokaryotes (sigma factor-dependent) and eukaryotes; this is not eukaryote-specific.

Option B: RNA synthesis in the 5′ to 3′ direction is universal in all organisms.

Option C: Reading the template strand in the 3′ to 5′ direction is also universal; no organism reads a template in the opposite direction.

Answer: (D) ← Go back to Q16

Q17.

Solution

Concept — Eukaryotic Translation Initiation:
Translation initiation in eukaryotes involves: (1) Initiator Met-tRNA$_i$ charged with methionine binds to the 40S small subunit with initiation factors (eIF2·GTP) to form the 43S pre-initiation complex; (2) the 43S complex binds the 5′ m^{7}G cap via eIF4E/eIF4G and scans the 5′ UTR in the 5′ → 3′ direction; (3) AUG start codon is recognised by complementarity with the Met-tRNA anticodon (Kozak sequence context); (4) the 60S large subunit joins to form the 80S initiation complex.

Step 1 — Sequence:
43S complex binds 5′ cap → scans for AUG → 60S joins → 80S formed. Option A is correct.

Why other options are wrong:
Option B: The 60S subunit does not initiate by binding the 3′ poly-A tail; cap-dependent initiation starts at the 5′ end with the 40S subunit.
Option C: IRES-mediated initiation is an exception used by some viral mRNAs and stress-response mRNAs, not a universal mechanism for all eukaryotic mRNAs.
Option D: Stop codon recognition is a termination event (releasing factors); it plays no role in initiating ribosome assembly.

Answer: (A) ← Go back to Q17

Q18.

Solution

Concept — *lac* Operon Induction:
In the *lac* operon, the *lacI* gene encodes a repressor that normally binds the operator and blocks transcription. When lactose is present, it is metabolised to **allolactose** (the true inducer), which binds the repressor and causes a conformational change — the repressor loses affinity for the operator and dissociates. RNA polymerase can then transcribe the structural genes (*lacZ*, *lacY*, *lacA*). When glucose is also absent, cAMP levels are high; cAMP binds CAP protein, which binds the promoter and enhances transcription (catabolite activation).

Step 1 — Mechanism of induction:
Allolactose (inducer) → binds repressor → conformational change → repressor releases operator → transcription proceeds. Option B is correct.

Why other options are wrong:
Option A: The repressor is not phosphorylated; it is allosterically inactivated by allolactose binding.
Option C: cAMP-CAP is an activator (positive regulator), not a repressor degrader;

it enhances transcription but does not degrade the repressor.
Option D: RNA polymerase cannot simply bypass the operator without the repressor being physically removed; the repressor sterically blocks polymerase.

Answer: (B) ← Go back to Q18

Q19.

Solution

Concept — Frameshift Mutation from Insertion:
The genetic code is read in non-overlapping triplets (codons) from a fixed start point (AUG). A single nucleotide insertion shifts the reading frame by $+1$, causing all codons after the insertion site to be read in the wrong frame. This alters every amino acid from the insertion point onward and often introduces a premature stop codon, usually resulting in a truncated, non-functional protein.

Step 1 — Type of mutation:
A single nucleotide insertion $\rightarrow$ frameshift mutation affecting all downstream codons. Option C is correct.

Why other options are wrong:
Option A: A missense mutation changes *one* codon by base substitution; a single insertion does far more damage by shifting the reading frame.
Option B: A nonsense mutation (stop codon) may occur as a consequence of a frameshift, but the primary effect of the insertion is the frameshift itself, not a simple nonsense mutation.
Option D: A silent mutation results from a base substitution at a synonymous position; a frameshift cannot be silent because it alters all downstream codons.

Answer: (C) ← Go back to Q19

Q20.

Solution

Concept — Turner Syndrome (45,X):
Turner syndrome results from monosomy of the X chromosome (45,X), most commonly due to non-disjunction during meiosis I in the father or meiosis II in either parent. It presents exclusively in phenotypic females. Key features: short stature, webbed neck (pterygium colli), low posterior hairline, widely spaced nipples (shield chest), primary amenorrhoea (streak gonads, no functional ovaries), infertility, and sometimes coarctation of the aorta or horseshoe kidney.

Step 1 — Match features to syndrome:
Short stature + webbed neck + primary amenorrhoea = Turner syndrome (45,X).
Option D is correct.

Why other options are wrong:
Option A: These are features of Down syndrome (trisomy 21, 47,+21): intellectual disability, flat nasal bridge, epicanthal folds, single palmar crease.
Option B: Tall stature, small testes, gynecomastia, and mild cognitive impairment describe Klinefelter syndrome (47,XXY), not Turner syndrome.
Option C: Overlapping fingers and clenched fist with multiple organ defects describe Edwards syndrome (trisomy 18, 47,+18).

Answer: (D) ← Go back to Q20

Q21.

Solution

Concept — Degeneracy of the Genetic Code:
The genetic code has 64 codons (4^3) but only 20 amino acids plus 3 stop codons. Most amino acids are specified by more than one codon (synonymous codons). For example, leucine and serine each have 6 codons; arginine has 6; valine, alanine, glycine, and proline each have 4. This redundancy is called degeneracy or redundancy of the code. The wobble hypothesis (Crick) explains how one tRNA can recognise multiple synonymous codons.

Step 1 — Define degeneracy:
Multiple codons → same amino acid. Option A is the correct definition.

Why other options are wrong:
Option B: The code is *non-ambiguous* — each codon specifies only one amino acid (or stop). One codon cannot code for two different amino acids.
Option C: The code is *non-overlapping* — adjacent codons do not share nucleotides. A mutation in one codon affects only that codon's amino acid.
Option D: The genetic code is *universal* (with a few minor exceptions in mitochondria and some protists); it has not changed significantly across evolution.

Answer: (A) ← Go back to Q21

Q22.

Solution

Concept — C4 Photosynthesis and Kranz Anatomy:
C4 plants (e.g., maize, sugarcane) possess a specialised leaf anatomy called Kranz anatomy. Mesophyll cells fix CO_2 via PEP carboxylase into oxaloacetate (C4), which is converted to malate and transported to the **bundle sheath cells** surrounding the vascular bundle. In bundle sheath cells, CO_2 is released and refixed by RuBisCO via the Calvin cycle (C3). This concentrates CO_2 around RuBisCO, suppressing photorespiration, which is common in C3 plants at high temperatures.

Step 1 — Identify Y:
Y labels the ring of cells surrounding the vascular bundle in the C4 diagram — these are the bundle sheath cells where the Calvin cycle (C3 reactions) occur. Option B is correct.

Why other options are wrong:
Option A: Palisade mesophyll cells are found in C3 leaves and are involved in the initial fixation of CO_2, but they do not form a wreath around the vascular bundle.
Option C: Spongy mesophyll cells have large intercellular spaces for gas exchange; they are not the Kranz anatomy cells surrounding the vascular bundle.
Option D: Guard cells are specialised epidermal cells flanking stomata; they are unrelated to the vascular bundle-associated cells.

Answer: (B) ← Go back to Q22

Q23.

Solution

Concept — Net ATP Yield of Glycolysis:
Glycolysis converts one glucose (6C) into two pyruvate (3C). In the investment (preparatory) phase, 2 ATP are consumed (hexokinase and phosphofructokinase reactions). In the payoff (pay-off) phase, 4 ATP are produced by substrate-level phosphorylation (2× phosphoglycerate kinase + 2× pyruvate kinase), and 2 NADH are generated (2× glyceraldehyde-3-phosphate dehydrogenase). **Net ATP = 4 − 2 = 2 ATP** per glucose. The 2 NADH yield additional ATP only if fed into the ETC (oxidative phosphorylation), which is not part of glycolysis itself.

Step 1 — Calculate net ATP:
Gross ATP = 4; Investment ATP = 2; Net = 4 − 2 = **2 ATP**. Option C is correct.

Why other options are wrong:
Option A: 4 ATP is the *gross* yield in the payoff phase; subtracting the 2 ATP invested gives a net of 2 ATP.
Option B: 8 ATP incorrectly counts each NADH as directly yielding ATP within glycolysis; NADH is oxidised in the ETC to produce ATP, which is a separate process.
Option D: 6 ATP assumes 3 ATP per NADH generated within glycolysis; this confuses glycolysis with oxidative phosphorylation.

Answer: (C) ← Go back to Q23

Q24.

Solution

Concept — Alcoholic Fermentation and NAD^+ Regeneration:
Under anaerobic conditions, yeast performs alcoholic fermentation: pyruvate

$\xrightarrow{\text{pyruvate decarboxylase}}$ acetaldehyde + CO_2; acetaldehyde $\xrightarrow{\text{alcohol dehydrogenase}}$ ethanol. In the second step, NADH is oxidised to NAD^+. Without this regeneration, glycolysis would halt because NADH (produced by GAPDH) would accumulate, exhausting the available NAD^+ needed to oxidise glyceraldehyde-3-phosphate. Fermentation thus allows continued ATP production from glycolysis despite the absence of oxygen.

Step 1 — Primary metabolic role:
Fermentation regenerates NAD^+, sustaining glycolysis. Option D is correct.

Why other options are wrong:
Option A: Fermentation does not generate additional ATP beyond glycolysis; it only enables glycolysis to continue. No net ATP is made in the fermentation steps themselves.
Option B: CO_2 produced in fermentation is a waste product, not used as a carbon source for biosynthesis in yeast.
Option C: Acetaldehyde is the intermediate *before* ethanol formation; pyruvate is not reformed from acetaldehyde — the direction is pyruvate → acetaldehyde → ethanol.

Answer: (D) ← Go back to Q24

Q25.

Solution

Concept — Auxin and Apical Dominance:
Auxin (indole-3-acetic acid, IAA) is synthesised in young leaves and shoot tips and transported polarly downward. High auxin concentration from the apical bud maintains a local auxin concentration in axillary bud nodes that is above the threshold for bud outgrowth, keeping lateral buds dormant. Removal of the apical bud (decapitation) removes the auxin source, and lateral buds resume growth. Cytokinin from the roots promotes lateral bud outgrowth and opposes auxin's inhibitory effect.

Step 1 — Identify the primary regulator:
Auxin (IAA) from the shoot apex suppresses lateral bud activation. Option A is correct.

Why other options are wrong:
Option B: Gibberellins promote stem elongation and seed germination, not apical dominance; cytokinin (not gibberellin) from roots promotes lateral bud outgrowth.
Option C: Ethylene causes senescence, fruit ripening, and abscission; it does not mediate apical dominance over lateral buds.

Option D: ABA (abscisic acid) induces seed dormancy and stomatal closure; it is not the primary hormone responsible for axillary bud suppression.

Answer: (A) ← Go back to Q25

Q26.

Solution

Concept — Gibberellins in Cereal Seed Germination:
In cereal seeds (e.g., barley), the embryo secretes gibberellins (GAs) upon imbibition. GAs diffuse to the aleurone layer (outer layer of endosperm), where they activate the transcription of α-amylase genes. The newly synthesised α-amylase is secreted into the starchy endosperm, hydrolysing starch to sugars (maltose, glucose) that fuel embryo growth and germination. This is the classic GA-aleurone-α-amylase signalling pathway.

Step 1 — Mechanism:
GA from embryo $\rightarrow$ aleurone cells $\rightarrow$ α-amylase synthesis $\rightarrow$ starch digestion. Option B is correct.

Why other options are wrong:
Option A: GAs do not directly activate embryo cell division; their primary germination role is starch mobilisation via the aleurone.
Option C: Seed coat softening involves mechanical scarification and water uptake; GA-induced cellulase is not the primary mechanism for coat-imposed dormancy release.
Option D: The pentose phosphate pathway is not specifically activated by GAs; it operates independently for NADPH and ribose-5-phosphate production.

Answer: (B) ← Go back to Q26

Q27.

Solution

Concept — Cytokinin/Auxin Ratio in Tissue Culture:
Skoog and Miller (1957) demonstrated that the relative concentrations of cytokinin and auxin in plant tissue culture media determine organogenesis: a high cytokinin-to-auxin ratio promotes **shoot** organogenesis (shoot buds form); a low ratio (high auxin) promotes **root** organogenesis; an intermediate ratio maintains undifferentiated callus. Cytokinins promote cell division and release axillary buds from apical dominance.

Step 1 — High cytokinin:auxin ratio:
High CK/auxin $\rightarrow$ shoot organogenesis. Option C is correct.

Why other options are wrong:

Option A: Root organogenesis occurs with a *low* cytokinin-to-auxin ratio (high auxin), not a high one.
Option B: Undifferentiated callus proliferation occurs when cytokinin and auxin are present at a balanced intermediate ratio; a strongly biased ratio drives organogenesis.
Option D: Somatic embryogenesis (embryoid formation) requires specific conditions (often high auxin for callus, then auxin removal); it is not the direct outcome of a high cytokinin-to-auxin ratio in standard tissue culture.

Answer: (C) ← Go back to Q27

Q28.

Solution

Concept — Flower Structure: the Ovule:
In the dicot flower, the pistil (gynoecium) consists of stigma (pollen receptive surface), style (connects stigma to ovary), and ovary (encloses one or more ovules). Each ovule is a small structure inside the ovary, attached by a funiculus. The ovule contains the embryo sac (female gametophyte) with the egg cell and polar nuclei. After fertilisation, the ovule develops into a seed, and the ovary wall develops into the fruit.

Step 1 — Identify structure P:
In the diagram, P labels the rounded structure inside the ovary cavity. This is the ovule — the structure that becomes a seed after fertilisation. Option D is correct.

Why other options are wrong:
Option A: The stigma is the sticky surface at the top of the pistil (labelled at the top of the style in the diagram); it receives pollen.
Option B: The style is the elongated stalk connecting stigma to ovary (labelled in the diagram between stigma and ovary).
Option C: The anther is the pollen-producing part of the stamen (shown on the right side with small dots representing pollen).

Answer: (D) ← Go back to Q28

Q29.

Solution

Concept — Double Fertilisation in Angiosperms:
In angiosperms, the pollen tube delivers two sperm cells into the embryo sac. **Syngamy**: one sperm (n) + egg (n) → zygote (2n). **Triple fusion**: the second sperm (n) + two polar nuclei (n + n) → primary endosperm nucleus (3n, triploid). The zygote develops into the embryo; the primary endosperm nucleus develops into the nutritive endosperm. This unique double fertilisation is the defining feature of

angiosperms.

Step 1 — Verify both events:
Syngamy (egg + sperm → 2n zygote) + triple fusion (polar nuclei + sperm → 3n endosperm nucleus). Option A is correct.

Why other options are wrong:
Option B: Only one sperm fertilises the egg; two sperms never fuse with the egg simultaneously, which would produce an unusual tetraploid.
Option C: The synergid cells are accessory cells that guide the pollen tube; the second sperm fertilises the *central cell* (containing polar nuclei), not a synergid.
Option D: Double fertilisation is uniquely angiosperm-specific; gymnosperms have only one fertilisation event (syngamy).

Answer: (A) ← Go back to Q29

Q30.

Solution

Concept — Nuclear Endosperm Development:
Three types of endosperm development exist in angiosperms: (1) **Nuclear type**: the primary endosperm nucleus divides many times without forming cell walls, producing a free-nuclear (coenocytic) syncytium; later, cell walls form around the nuclei and the endosperm cellularises (e.g., coconut water = liquid endosperm; coconut meat = cellular endosperm). (2) **Cellular type**: each nuclear division is immediately followed by cell wall formation. (3) **Helobial type**: intermediate form seen in monocots.

Step 1 — Identify nuclear type:
Nuclear type → free nuclear divisions first → liquid syncytium → later cellularisation. Option B is correct.

Why other options are wrong:
Option A: Immediate cell wall formation after each division describes the *cellular* type (e.g., Adoxa), not the nuclear type.
Option C: Early asymmetric division into chalazal and micropylar chambers describes the *helobial* type.
Option D: Suppression of endosperm and direct nutrient absorption by cotyledons is seen in some non-endospermic seeds (e.g., pea, bean), not a type of nuclear endosperm development.

Answer: (B) ← Go back to Q30

Q31.

Solution

Concept — Coat-Imposed Seed Dormancy:

Coat-imposed dormancy occurs when the seed coat (testa) prevents germination independently of the embryo's readiness. Mechanisms include: (1) **mechanical resistance** — a hard, lignified seed coat physically prevents embryo expansion and radicle protrusion; (2) **inhibitor presence** — the testa may contain germination inhibitors (e.g., ABA, phenolics, coumarin) that must be leached before germination; (3) **impermeability to water or oxygen**. Scarification (mechanical abrasion or acid treatment) or leaching typically breaks coat-imposed dormancy.

Step 1 — Identify the mechanism:

Hard seed coat = mechanical barrier + possible inhibitors = coat-imposed dormancy. Option C is correct.

Why other options are wrong:

Option A: Gibberellins *break* dormancy; they do not inhibit embryo elongation or impose dormancy.

Option B: Ethylene does not accumulate to impose dormancy; it typically *promotes* seed germination at physiological concentrations.

Option D: ABA within the embryo itself causes *embryo dormancy*, not coat-imposed dormancy; these are distinct types of dormancy.

Answer: (C) ← Go back to Q31

Q32.

Solution

Concept — Lotka-Volterra Predator-Prey Dynamics:

The Lotka-Volterra equations describe cyclic oscillations in predator and prey populations. When prey are abundant, predators increase (more food). As predators increase, prey decline. Declining prey reduces predator food, so predator numbers fall. With fewer predators, prey recover, restarting the cycle. Crucially, there is a **time lag**: the prey population peaks first, then the predator population peaks after a quarter-period delay.

Step 1 — Identify the pattern:

In the graph, the prey (blue) peaks at $t \approx 1.25$ and the predator (red) peaks at $t \approx 2.5$. Prey peaks *before* predator, with a clear time lag. Option D is correct.

Why other options are wrong:

Option A: The peaks are clearly offset in the graph; they do not occur simultaneously (that would be in-phase oscillation).

Option B: Predator numbers do not rise immediately when prey decline; they lag behind prey changes because reproduction takes time.

Option C: The predator consistently lags *behind* (not ahead of) the prey; predator

peaks after prey, not before.

Answer: (D) ← Go back to Q32

Q33.

Solution

Concept — Mutualism vs Commensalism vs Parasitism:
Mutualism: both species benefit (+/+). Commensalism: one species benefits, the other is unaffected (+/0). Parasitism/predation: one benefits, one is harmed (+/−). Mycorrhizal associations are obligate or facultative mutualism: the fungal hyphae extend the plant's root surface area enormously, increasing uptake of phosphorus and other minerals; the plant provides photosynthetic sugars (sucrose) to the fungus. Both partners gain a measurable benefit.

Step 1 — Identify obligate mutualism:
Mycorrhizal fungi + plant roots: both benefit. Option A is correct.

Why other options are wrong:
Option B: Barnacles on whales is commensalism (+/0): the barnacle benefits from transport and access to nutrients; the whale is largely unaffected.
Option C: Cattle egrets and grazing cattle is commensalism (+/0): the egret gains food; the cattle are neither harmed nor benefited.
Option D: Remora and shark is commensalism (+/0): the remora benefits from transport and scavenged food; the shark is largely unaffected.

Answer: (A) ← Go back to Q33

Q34.

Solution

Concept — Tropical Rainforest Biome Characteristics:
Tropical rainforests are characterised by: high annual rainfall (> 200 cm, often 200–400 cm), uniformly high temperatures (25–30°C year-round), extremely high biodiversity (contain $> 50\%$ of world's species on $< 7\%$ of land area), complex vertical stratification (emergent layer > 40 m; canopy ~20–35 m; understory; shrub layer; forest floor), abundant epiphytes, and rapid nutrient cycling in thin, laterised soils.

Step 1 — Match features to biome:
> 200 cm rainfall + year-round warmth + high biodiversity + multi-layered canopy = tropical rainforest. Option B is correct.

Why other options are wrong:
Option A: Seasonal rainfall (50–100 cm) and deciduous trees describe a tropical dry forest or tropical deciduous forest, not a rainforest.

Option C: Permafrost, low-growing sedges, and long winter darkness describe the *tundra* biome.
Option D: Grassland with scattered trees, pronounced wet-dry seasonality, and large migratory herbivores describe the *savanna* biome.

Answer: (B) ← Go back to Q34

Q35.

Solution

Concept — Primary Succession and Pioneer Species:
Primary succession begins on bare, lifeless substrate (rock, sand, lava) that has no soil. **Pioneer species** must tolerate extreme conditions (desiccation, temperature fluctuations, no soil nutrients). **Lichens** (fungi-algae/cyanobacteria symbiosis) and **mosses** are the classic pioneers: lichens secrete acids that dissolve minerals from rock (chemical weathering), accumulate organic matter when they die, and create a thin proto-soil. Mosses follow, adding more organic matter. Over time, conditions allow herbaceous plants, then shrubs, then forest (climax community) to establish.

Step 1 — Identify pioneer species:
Lichens and mosses are the initial colonisers of bare rock in primary succession. Option C is correct.

Why other options are wrong:
Option A: Herbaceous plants require a thin soil layer already formed by pioneer species; they cannot colonise truly bare rock.
Option B: Shrubs and woody plants require developed soil and some organic matter; they represent a mid-succession stage, not the pioneer stage.
Option D: Climax species (large trees) require fully developed soil, canopy, and complex community structure; they are the endpoint, not pioneers.

Answer: (C) ← Go back to Q35

Q36.

Solution

Concept — Bacterial Transformation and Competent Cells:
For a recombinant plasmid to enter an *E. coli* host, the bacterium must be made **competent** (capable of taking up naked DNA). Chemical competence is induced by: (1) suspending cells in ice-cold $CaCl_2$ solution — Ca^{2+} ions partially neutralise the negative charges of the phospholipid membrane and the DNA, reducing electrostatic repulsion; (2) mixing cells with the plasmid on ice; (3) applying a brief **heat shock** (42°C, 90 seconds), which creates transient pores/perturbations in the membrane, allowing plasmid entry. Alternatively, electroporation (electric pulse)

can create pores directly.

Step 1 — Chemical competence method:
$CaCl_2$ (low temp) + heat shock = chemical transformation. Option D is correct.

Why other options are wrong:
Option A: Lysozyme digests the peptidoglycan cell wall and is used to prepare spheroplasts or protoplasts, not to induce DNA uptake competence.
Option B: DNase I degrades DNA; it would destroy the plasmid being introduced, not facilitate its entry.
Option C: SDS is a detergent used in protein electrophoresis and cell lysis; it would kill bacteria and destroy membranes rather than facilitate transformation.

Answer: (D) ← Go back to Q36

Q37.

Solution

Concept — Agarose Gel Electrophoresis of DNA:
DNA is negatively charged (due to phosphate groups) and migrates toward the positive electrode (anode) when an electric field is applied. The agarose gel acts as a molecular sieve: **smaller fragments** navigate the pores more easily and migrate *faster* (travel further). Larger fragments are impeded by the gel matrix and move *slower* (travel less far). After electrophoresis, gels are stained with ethidium bromide (intercalates between base pairs) or SYBR Green, then visualised under UV light. A DNA ladder (size standards) is run in a parallel lane.

Step 1 — Migration direction and size relationship:
Smaller DNA = faster migration toward the anode. Option A is correct.

Why other options are wrong:
Option B: Larger fragments do *not* migrate faster; the charge-to-mass ratio of DNA is approximately constant regardless of size, so size-based sieving (not charge) determines mobility.
Option C: Fragments are separated by size (mass/length), not by base composition (GC vs AT); GC content does not significantly affect gel mobility.
Option D: Ethidium bromide stains *nucleic acids* (DNA and RNA) by intercalation, not proteins; and it can be added before or after electrophoresis (post-staining is safer as EtBr is a mutagen).

Answer: (A) ← Go back to Q37

Q38.

Solution

Concept — *Plasmodium* Species and Malaria Severity:

Four main *Plasmodium* species infect humans: *P. falciparum* (malignant tertian, 48-hour cycle), *P. vivax* (benign tertian, 48-hour, causes relapse via hypnozoites), *P. malariae* (quartan, 72-hour), and *P. ovale* (mild tertian). *P. falciparum* causes the most dangerous malaria because infected erythrocytes express PfEMP1 (adhesin), causing them to cytoadhere to endothelial cells ("rosetting"), leading to microvascular obstruction. Complications: cerebral malaria (seizures, coma), severe anaemia, respiratory distress, acute renal failure — high mortality if untreated.

Step 1 — Most severe species:

P. falciparum → malignant tertian malaria → cerebral malaria. Option B is correct.

Why other options are wrong:

Option A: *P. vivax* causes *benign* tertian malaria; it is rarely fatal and has a dormant liver stage (hypnozoites) causing relapses.

Option C: *P. malariae* causes quartan malaria (72-hour cycle); it is chronic but rarely causes severe acute complications.

Option D: *P. ovale* is limited mainly to West Africa; it causes mild tertian malaria similar to *P. vivax* and is not associated with cerebral malaria.

Answer: (B) ← Go back to Q**38**

Q39.

Solution

Concept — Proto-oncogenes Becoming Oncogenes:

Proto-oncogenes encode proteins involved in normal cell growth signalling (e.g., growth factor receptors like EGFR, signal transducers like RAS, transcription factors like MYC). They become oncogenes through **gain-of-function** alterations: (1) **point mutations** (e.g., *KRAS* G12V — constitutively active GTPase); (2) **chromosomal translocations** (e.g., BCR-ABL in CML, *c-MYC* translocation in Burkitt lymphoma); (3) **gene amplification** (e.g., HER2/neu in breast cancer). The result is constitutive (uncontrolled) pro-growth signalling.

Step 1 — Mechanism:

Proto-oncogene $\xrightarrow{\text{gain-of-function mutation/translocation/amplification}}$ oncogene → constitutive growth signalling. Option C is correct.

Why other options are wrong:

Option A: Loss-of-function mutations describe how *tumour suppressor genes* (e.g., TP53, RB1) are inactivated; proto-oncogenes become oncogenic through *gain* of function.

Option B: CpG methylation of promoters *silences* genes; silencing a proto-oncogene would reduce (not increase) growth signalling. Oncogenes are typically

over-activated, not silenced.
Option D: p53 is a tumour suppressor that normally triggers apoptosis or cell cycle arrest in response to DNA damage; it does not activate proto-oncogene expression.

Answer: (C) ← Go back to Q**39**

Q40.

Solution

Concept — Distinguishing Algal Divisions by Pigmentation:
The three major macroalgae divisions differ in characteristic pigments: **Chlorophyta** (green algae) — chlorophyll a & b, β-carotene; **Rhodophyta** (red algae) — chlorophyll a & d, phycoerythrin (red phycobiliprotein), phycocyanin; **Phaeophyta** (brown algae) — chlorophyll a & c, **fucoxanthin** (golden-brown xanthophyll carotenoid). Fucoxanthin absorbs blue-green light efficiently, allowing brown algae (kelp, Fucus, Sargassum) to photosynthesise in deeper coastal waters.

Step 1 — Identify Phaeophyta's signature pigment:
Brown algae (Phaeophyta) contain fucoxanthin + chlorophylls a and c. Option D is correct.

Why other options are wrong:
Option A: Phycoerythrin is characteristic of *Rhodophyta* (red algae); it gives red algae their red colour and is a phycobiliprotein, not a carotenoid.
Option B: Phycocyanin and allophycocyanin are phycobiliproteins found in cyanobacteria and Rhodophyta; they are not found in Phaeophyta.
Option C: Having only chlorophylls a and b with no accessory xanthophylls describes *Chlorophyta* (green algae); brown algae have chlorophyll c (not b) and the distinctive fucoxanthin.

Answer: (D) ← Go back to Q**40**

Answer Key

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