GAT B Biology

Sample Paper – 3

Duration: 23 Minutes **Maximum Marks: 15**

Instructions

- This paper contains **15** Multiple Choice Questions (Single Correct Answer), modelled on the Biology portion of **GAT B** entrance (Section A).
- Each correct answer carries **+1 mark**. There is **a deduction of 0.5 marks for each incorrect answer**.
- Only **one** option is correct. Choose carefully.
- Syllabus level: **NCERT Class 11 & 12 Biology — Cell Biology, Genetics, Plant & Human Physiology, Ecology, Evolution, and Biotechnology.**
- Use of mobile phones, calculators, or electronic gadgets is strictly prohibited.

SECTION A — Biology (15 Questions)

Q1. In prokaryotes, the large subunit of the ribosome has a sedimentation coefficient of:

(A) 40S
(B) 30S
(C) 70S in total
(D) 50S

Q2. Two genes A and B are 20 map units apart on the same chromosome. If 1000 offspring are produced from a testcross, the expected number of recombinant offspring is:

(A) 100
(B) 200

(C) 400
(D) 500

Q3. Which of the following is the CORRECT statement about blood?

(A) Neutrophils are the rarest white blood cells
(B) RBCs have a nucleus and mitochondria
(C) Platelets are cell fragments derived from megakaryocytes
(D) Plasma constitutes 40–45% of blood volume

Q4. Indole-3-acetic acid (IAA) is primarily synthesized in:

(A) Shoot apical meristem and young leaves
(B) Root tips only
(C) Mature leaves
(D) Bark of stem

Q5. Bryophytes are called “amphibians of the plant kingdom” because:

(A) They lack vascular tissue and seeds
(B) They can survive in water and on land
(C) They have alternation of generations
(D) They require water for fertilization but live on land

Q6. Glycogen, the storage polysaccharide of animals, is structurally similar to:

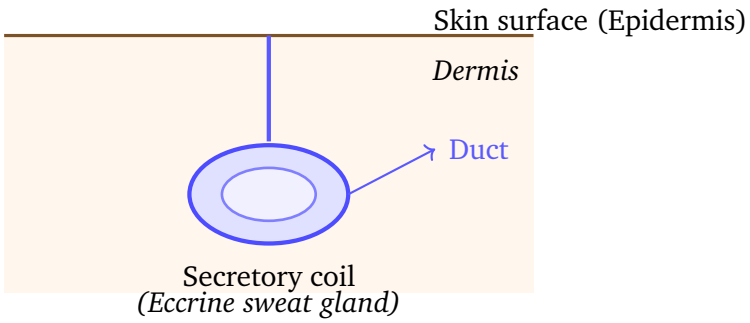
(A) Cellulose
(B) Amylopectin
(C) Amylose
(D) Chitin

Q7. A transition mutation involves:

(A) Deletion of a nucleotide
(B) Insertion of an extra nucleotide
(C) Replacement of a purine by another purine or pyrimidine by pyrimidine

(D) Inversion of a DNA segment

Q8. Study the diagram of a sweat gland in the dermis below and answer the question.



Eccrine sweat glands help in thermoregulation by:

(A) Evaporative cooling through sweat secretion
(B) Secreting sebum to lubricate skin
(C) Producing cerumen in the ear canal
(D) Secreting pheromones for communication

Q9. Which biome is characterised by permafrost, very low temperatures, and is dominated by lichens, mosses, and dwarf shrubs?

(A) Taiga
(B) Temperate grassland
(C) Desert
(D) Tundra

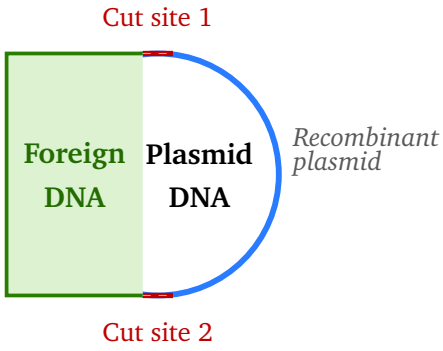
Q10. The site of fertilization in the human female reproductive system is the:

(A) Uterus
(B) Fallopian tube (ampullary-isthmic junction)
(C) Ovary
(D) Cervix

Q11. The phenomenon in which a single ancestral species gives rise to many different species adapted to different environments is called:

(A) Convergent evolution
(B) Co-evolution
(C) Adaptive radiation
(D) Allopatric speciation only

Q12. Study the diagram below showing insertion of foreign DNA into a plasmid at restriction sites and answer the question.



The role of a plasmid in gene cloning is to serve as:

(A) A cloning vector to carry foreign DNA into host cells
(B) A restriction enzyme to cut DNA
(C) A DNA polymerase for replication
(D) An expression promoter only

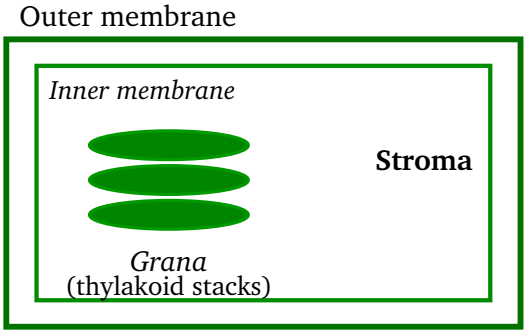
Q13. Short-day plants (SDPs) flower when:

(A) The day length exceeds a critical period
(B) They are exposed to continuous light
(C) Temperature drops below 10°C
(D) The night length exceeds a critical dark period

Q14. Synovial joints are characterised by the presence of:

(A) Fibrocartilage only between bones
(B) A fluid-filled joint cavity (synovial fluid)
(C) Complete fusion of two bones
(D) Ligaments only, no cartilage

Q15. Study the diagram of a chloroplast below and answer the question.



The light-dependent reactions of photosynthesis occur in:

(A) Stroma of chloroplast
(B) Cytoplasm
(C) Thylakoid membranes
(D) Outer membrane of chloroplast

Solutions

Sol. 1.

Solution

Concept — Ribosome subunit structure in prokaryotes: Prokaryotic ribosomes are 70S in total, composed of a large 50S subunit and a small 30S subunit. Svedberg (S) values are not additive because they depend on shape and density, not just mass.

Step 1 — Identifying the large subunit: The large subunit of the prokaryotic (70S) ribosome sediments at **50S**. It contains 23S rRNA, 5S rRNA, and approximately 34 ribosomal proteins. It provides the peptidyl transferase activity for peptide bond formation. The small 30S subunit contains 16S rRNA and about 21 proteins.

Why other options are wrong:

- Option A (40S): The 40S subunit is the *small* subunit of *eukaryotic* (80S) ribosomes, not prokaryotic.
- Option B (30S): This is the *small* subunit of prokaryotic ribosomes, not the large one.
- Option C (70S in total): The total prokaryotic ribosome is indeed 70S, but the question asks about the large subunit specifically, not the complete ribosome.

Final Answer: The large subunit of the prokaryotic ribosome has a sedimentation coefficient of 50S. $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q 1

Sol. 2.

Solution

Concept — Chromosome mapping and recombination frequency: One map unit (centimorgan, cM) corresponds to a 1% recombination frequency between two linked genes. In a testcross, the recombinant progeny directly reflect the recombination frequency.

Step 1 — Calculating recombinant offspring: A distance of 20 map units implies 20% recombination frequency.

$$\text{Recombinants} = 20\% \times 1000 = 0.20 \times 1000 = \mathbf{200}$$

These 200 recombinants consist of two reciprocal recombinant classes (approximately 100 each), while the remaining 800 are parental types.

Why other options are wrong:

- Option A (100): Corresponds to 10% recombination, i.e., genes only 10 map units apart.
- Option C (400): Would imply 40 map units between the two genes.
- Option D (500): Would imply 50% recombination — genes behaving as if independently assorting (unlinked).

Final Answer: Expected recombinant offspring $= 200$. $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 2

Sol. 3.

Solution

Concept — Composition and properties of blood cells: Blood is a connective tissue consisting of plasma ($\sim$55% of volume) and formed elements (erythrocytes, leukocytes, thrombocytes). Each component has characteristic structural and functional features.

Step 1 — Evaluating the correct statement: Platelets (thrombocytes) are **not cells** but anucleate cytoplasmic fragments pinched off from large polyploid bone marrow cells called **megakaryocytes**. A single megakaryocyte can produce 1,000–3,000 platelets. Platelets are essential for haemostasis (blood clotting).

Why other options are wrong:

- Option A: Neutrophils are the *most abundant* leukocytes (60–70% of WBCs). *Basophils* are the rarest ($<$1%).
- Option B: Mature human RBCs are *anucleate* (no nucleus) and lack mitochondria; they depend entirely on anaerobic glycolysis for energy (ATP).
- Option D: Plasma constitutes $\approx$55% of blood volume. The 40–45% range refers to haematocrit (the packed cell volume, dominated by RBCs).

Final Answer: Platelets are cell fragments derived from megakaryocytes. $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 3

Sol. 4.

Solution

Concept — Auxin biosynthesis site: Indole-3-acetic acid (IAA), the principal naturally occurring auxin, is biosynthesised primarily from the amino acid tryptophan in regions of rapid cell division and expansion.

Step 1 — Identifying the primary site: IAA is produced mainly in the **shoot apical meristem** and young, actively expanding leaves. From these source tissues, IAA is transported polarly (basipetally) through the phloem and parenchyma toward elongation zones, roots, and lateral organs, directing differential growth responses such as phototropism and gravitropism.

Why other options are wrong:

- Option B: Root tips do synthesise small amounts of IAA, but they receive the bulk of their auxin supply from the shoot. Root tips are not the primary synthesis site.
- Option C: Mature leaves have ceased expanding and contain little tryptophan-to-IAA metabolic machinery; young (expanding) leaves are the active sites.
- Option D: The bark (cork) consists of dead cells incapable of biosynthesis. The vascular cambium shows minor activity but is not the primary site.

Final Answer: IAA is primarily synthesised in the shoot apical meristem and young leaves. $\Rightarrow$ A

Answer: (A) Go Back to Q 4

Sol. 5.

Solution

Concept — Bryophytes and their dependence on water for fertilization: Bryophytes (mosses, liverworts, hornworts) are non-vascular, predominantly terrestrial plants. However, their sexual reproduction is fundamentally aquatic in nature because the male gametes are motile and flagellated.

Step 1 — The "amphibian" analogy explained: The term "amphibians of the plant kingdom" refers specifically to the fact that bryophytes **live on land** (terrestrial body) but **require a film of liquid water for fertilization**. The biflagellate antherozoids (male gametes) must swim through water to reach the egg housed in the archegonium. This dual dependency on water (for reproduction) and land (for vegetative existence) mirrors the situation of amphibians.

Why other options are wrong:

- Option A: Lacking vascular tissue and seeds is a structural fact about bryophytes, but it is NOT the basis of the "amphibian" analogy.
- Option B: While bryophytes prefer moist habitats, the analogy is not about general survival in two media but specifically about water required for *fertilization*.
- Option C: Alternation of generations is a universal feature of all plants (including fully terrestrial angiosperms), so it cannot uniquely explain this analogy.

Final Answer: Bryophytes require water for fertilization but live on land. $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q 5

Sol. 6.

Solution

Concept — Structural similarity of glycogen and amylopectin: Both glycogen and amylopectin are **branched homopolysaccharides of α-D-glucose**, using α-1,4 glycosidic bonds in the linear backbone and α-1,6 glycosidic bonds at branch points. Their key structural difference is the *frequency* of branching.

Step 1 — Comparing branching patterns: Amylopectin (the branched fraction of starch) branches every 24–30 glucose residues, while glycogen (animal storage carbohydrate) is more extensively branched, every 8–12 residues. Despite this difference in degree of branching, both molecules share the same fundamental architecture (α-1,4 linear chains with α-1,6 branch linkages) making them structurally analogous.

Why other options are wrong:

- Option A (cellulose): Cellulose is an *unbranched* polymer of β-D-glucose with β-1,4 bonds, forming rigid fibres — structurally opposite to glycogen.
- Option C (amylose): Amylose is the *unbranched*, helical fraction of starch with only α-1,4 bonds; it lacks the branching that characterises glycogen.
- Option D (chitin): Chitin is a polymer of N-acetylglucosamine (a glucose derivative) with β-1,4 bonds, found in fungal cell walls and arthropod exoskeletons — chemically and structurally unlike glycogen.

Final Answer: Glycogen is structurally similar to amylopectin. $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q 6

Sol. 7.

Solution

Concept — Classification of point mutations: Point mutations are changes affecting a single nucleotide pair. They are classified into two categories based on which bases are substituted: **transitions** (within the same class of base) and **transversions** (between different classes).

Step 1 — Defining transition mutations: A transition substitution preserves the *chemical class* of the nitrogenous base:

- Purine $\rightarrow$ Purine: Adenine (A) $\leftrightarrow$ Guanine (G)
- Pyrimidine $\rightarrow$ Pyrimidine: Cytosine (C) $\leftrightarrow$ Thymine (T) / Uracil (U)

Transitions are the most common type of spontaneous point mutation because the structural change is minimal.

Why other options are wrong:

- Option A (deletion): Loss of a nucleotide causes a *frameshift* mutation — all downstream codons are altered. This is not a transition.
- Option B (insertion): Addition of a nucleotide also causes a *frameshift* mutation, not a transition.
- Option D (inversion): Chromosome inversion is a large-scale *chromosomal rearrangement* where a segment is reversed in orientation — categorically different from a nucleotide-level transition.

Final Answer: A transition involves replacement of a purine by another purine, or a pyrimidine by another pyrimidine. $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C) Go Back to Q 7

Sol. 8.

Solution

Concept — Eccrine sweat glands and thermoregulation: Eccrine (merocrine) sweat glands are the most numerous and widespread cutaneous glands, distributed over almost the entire body surface. They are the principal effectors of heat dissipation by the integumentary system.

Step 1 — Mechanism of evaporative cooling: When core body temperature rises above the set-point ($\approx 37^{\circ}$C), the hypothalamus activates eccrine glands via sympathetic cholinergic fibres. The glands secrete a dilute, mostly aqueous sweat

(99% water + NaCl, urea, lactic acid) onto the skin surface. As sweat evaporates, it absorbs the latent heat of vaporisation (≈ 2.43 kJ/g) from the skin, lowering skin and core body temperature. This is **evaporative cooling**.

Why other options are wrong:

- Option B: Sebum (an oily secretion lubricating skin and hair) is produced by *sebaceous glands*, which are anatomically and functionally distinct from eccrine sweat glands.
- Option C: Cerumen (ear wax) is produced by *ceruminous glands* in the external auditory meatus — modified apocrine glands, unrelated to eccrine glands.
- Option D: Pheromone-associated secretions are linked to *apocrine sweat glands* located in axillary, genital, and areolar regions, not to eccrine glands.

Final Answer: Eccrine sweat glands facilitate thermoregulation via evaporative cooling through sweat secretion. $\Rightarrow$ A

Answer: (A) Go Back to Q 8

Sol. 9.

Solution

Concept — Biome identification by defining characteristics: A biome is a large-scale ecosystem defined by its climate, soil type, and dominant vegetation. Each biome has a unique set of abiotic factors that determine which organisms can survive there.

Step 1 — Identifying the tundra biome: The combination of (i) **permafrost** (a permanently frozen subsoil layer that prevents deep root penetration and drainage), (ii) extremely low temperatures (mean annual temperature below -5°C), very short growing seasons, and (iii) vegetation dominated by **lichens, mosses, sedges, and dwarf shrubs** (no trees) is the diagnostic signature of the **tundra** biome. Tundra exists in Arctic/Antarctic regions and high-altitude alpine zones.

Why other options are wrong:

- Option A (Taiga/Boreal forest): Cold but supports *coniferous tree* (spruce, fir, pine) dominated forest; lacks true permafrost over most of its extent.
- Option B (Temperate grassland): Characterised by moderate climate, rich deep soil, grass dominance (no permafrost); examples include steppes, prairies, and pampas.

- Option C (Desert): Defined by extremely low annual precipitation (<250 mm). Hot deserts have high temperatures; cold deserts can be cold but lack the permafrost and lichen–moss community typical of tundra.

Final Answer: The biome described is the Tundra. $\Rightarrow$ D

Answer: (D) Go Back to Q 9

Sol. 10.

Solution

Concept — Site of fertilization in the human female: After ovulation, the secondary oocyte is swept into the infundibulum of the fallopian tube (uterine tube). Spermatozoa that ascend from the vagina through the uterine cavity enter the fallopian tube and meet the oocyte.

Step 1 — Ampullary-isthmic junction as the fertilization site: Fertilization characteristically occurs in the **ampulla** of the fallopian tube, specifically at or near the **ampullary-isthmic junction** (AIJ). The ampulla is the widest, most tortuous portion of the tube. Here, the zona pellucida is penetrated by a sperm, triggering the completion of meiosis II in the oocyte, followed by formation of the zygote. The zygote then undergoes cleavage as it travels toward the uterus over 3–4 days.

Why other options are wrong:

- Option A (uterus): The uterus is the site of *implantation* (blastocyst embeds in endometrium), not fertilization. Implantation in the uterus occurs $\approx$7 days after fertilization.
- Option C (ovary): Ovulation releases the oocyte from the ovary into the peritoneal cavity; fertilization does not occur within the ovary itself.
- Option D (cervix): The cervix is the narrow lower opening of the uterus; sperm traverse it, but fertilization does not take place there.

Final Answer: Fertilization occurs in the fallopian tube (ampullary-isthmic junction). $\Rightarrow$ B

Answer: (B) Go Back to Q 10

Sol. 11.

Solution

Concept — Adaptive radiation: Adaptive radiation is the evolutionary process by which organisms diversify rapidly from an ancestral species into a multitude of new forms, each adapted to a particular ecological niche or environment. It is driven by ecological opportunity (vacant niches or release from competition).

Step 1 — Key features of adaptive radiation: (i) Originates from a **single common ancestor**; (ii) produces multiple descendant species in a relatively short geological time; (iii) each species is specialised for a different ecological role or habitat. Classic examples include Darwin's finches (Geospizinae) of the Galápagos, Hawaiian honeycreepers, Australian marsupials, and African cichlid fishes.

Why other options are wrong:

- Option A (convergent evolution): Different, *unrelated* lineages independently evolve similar traits under similar selective pressures (e.g., streamlined body in dolphins, ichthyosaurs, and sharks). Multiple ancestors converge, not one diverges.
- Option B (co-evolution): Reciprocal evolutionary change in two or more interacting species (e.g., flowers and their specific pollinators); it does not involve radiation from one ancestor into many niches.
- Option D (allopatric speciation only): Allopatric speciation (geographic isolation $\rightarrow$ divergence) is one *mechanism* by which species form, but adaptive radiation is a broader *pattern* that can occur via sympatric and allopatric means.

Final Answer: The phenomenon described is adaptive radiation. $\Rightarrow$ C

Answer: (C) Go Back to Q 11

Sol. 12.

Solution

Concept — Plasmid as a cloning vector in recombinant DNA technology: A cloning vector is a DNA molecule capable of autonomous replication inside a host cell that serves as a vehicle to carry and propagate a foreign gene of interest. Plasmids are the most widely used vectors in bacterial cloning systems.

Step 1 — Essential elements of a plasmid vector: A plasmid used in gene cloning must have: (i) an **origin of replication (ori)** to replicate independently in the host; (ii) a **multiple cloning site (MCS)** containing restriction enzyme

recognition sequences where the foreign DNA is inserted; (iii) one or more **selectable marker genes** (e.g., ampicillin resistance gene) to identify cells that have taken up the recombinant plasmid. The recombinant plasmid is introduced into host bacteria by **transformation**, and the foreign gene is expressed or propagated as required.

Why other options are wrong:

- Option B: *Restriction endonucleases* (e.g., EcoRI, BamHI) are protein enzymes that cut double-stranded DNA at specific sequences. The plasmid is the substrate, not the enzyme.
- Option C: *DNA polymerase* is the enzyme that synthesises new DNA strands. The plasmid carries an *ori* sequence that signals DNA polymerase to begin replication, but the plasmid itself is not a polymerase.
- Option D: Some expression vectors contain promoters (e.g., T7, lac, tac), but calling a plasmid "only an expression promoter" is incorrect and incomplete. The primary defining role is as a *vector* (carrier/vehicle).

Final Answer: A plasmid serves as a cloning vector to carry foreign DNA into host cells. $\Rightarrow$ $\boxed{\text{A}}$

Answer: (A) Go Back to Q 12

Sol. 13.

Solution

Concept — Photoperiodism and the critical night length: Photoperiodism is the physiological response of plants (and animals) to the relative duration of light and dark periods within a 24-hour cycle. Plants are classified as short-day plants (SDPs), long-day plants (LDPs), or day-neutral plants based on their critical photoperiod requirement for flowering.

Step 1 — The real determinant is night length: Research by Hamner and Bonner (1938) using cocklebur (*Xanthium*) demonstrated unequivocally that it is the **length of the uninterrupted dark period** (night), not the light period, that is the critical factor in photoperiodic flowering. SDPs flower when the **night length exceeds their critical dark period**. If the night is interrupted by even a brief red-light flash (night-break experiment), flowering in SDPs is completely suppressed — confirming that continuous darkness, not short days, is the trigger.

Why other options are wrong:

- Option A: Day length exceeding a critical period is the condition for *long-*

day plants (LDPs), not SDPs.

- Option B: Continuous light provides no uninterrupted dark period; this would suppress SDP flowering entirely.
- Option C: Temperature below 10°C triggers *vernalization* (cold-induced flowering competence in certain plants, e.g., wheat, carrot) — this is a separate phenomenon unrelated to photoperiodism.

Final Answer: Short-day plants flower when the night length exceeds a critical dark period. $\Rightarrow$ D

Answer: (D) Go Back to Q 13

Sol. 14.

Solution

Concept — Classification and characteristics of synovial joints: Joints (articulations) are classified by structure and function. Synovial joints are the most common and most freely movable joints in the human body, characterised by their unique structural features.

Step 1 — Defining feature of synovial joints: The hallmark of a synovial joint is the presence of a **joint (synovial) cavity** containing **synovial fluid** — a viscous, straw-coloured fluid secreted by the synovial membrane (inner lining of the fibrous joint capsule). Synovial fluid serves to: (i) lubricate articular surfaces (reducing friction), (ii) nourish the avascular articular cartilage (which is hyaline cartilage), and (iii) absorb shock. Examples of synovial joints include the knee (hinge), hip (ball-and-socket), elbow, shoulder, and wrist.

Why other options are wrong:

- Option A: Fibrocartilage pads are found in *fibrocartilaginous joints* (secondary cartilaginous joints or symphyses), such as the pubic symphysis and intervertebral discs. These are amphiarthroses (slightly movable), not the highly mobile synovial joints.
- Option C: Complete bony fusion describes *synostosis* (e.g., cranial sutures in adult skulls) — a type of fibrous joint that is completely immovable (synarthrosis).
- Option D: Ligaments are present in synovial joints but are also found in other joint types. The unique defining feature of a synovial joint is the fluid-filled cavity, not ligaments alone.

Final Answer: Synovial joints are characterised by a fluid-filled joint cavity containing synovial fluid. $\Rightarrow$ B

Answer: (B) Go Back to Q 14

Sol. 15.

Solution

Concept — Compartmentalisation of photosynthesis in the chloroplast: Photosynthesis in plants occurs in two spatially separated stages within the chloroplast: (i) **light-dependent reactions** (light reactions) and (ii) **light-independent reactions** (Calvin cycle / dark reactions). Each stage is confined to a distinct structural compartment.

Step 1 — Location of light-dependent reactions: The thylakoid membranes house all the molecular machinery for the light reactions: Photosystem II (PSII), the cytochrome b_6f complex (electron transport chain), Photosystem I (PSI), and ATP synthase (CF_0-CF_1). Light energy absorbed by chlorophyll drives: (a) photolysis of water ($2H_2O \rightarrow 4H^+ + 4e^- + O_2$), (b) synthesis of **NADPH** (via PSI), and (c) synthesis of **ATP** by photophosphorylation. The products (ATP + NADPH) pass into the stroma for carbon fixation in the Calvin cycle.

Why other options are wrong:

- Option A (stroma): The stroma is the fluid-filled matrix around the thylakoids where the *Calvin cycle* (light-independent reactions) takes place, fixing CO_2 into glucose using ATP and NADPH produced in the thylakoids.
- Option B (cytoplasm): Photosynthesis is entirely chloroplast-based; the cytoplasm (outside the chloroplast) plays no role in either the light reactions or the Calvin cycle.
- Option D (outer membrane): The outer membrane is freely permeable to small molecules and ions but contains no photosynthetic complexes; it serves a structural/selective barrier function.

Final Answer: Light-dependent reactions of photosynthesis occur in the thylakoid membranes. $\Rightarrow$ C

Answer: (C) Go Back to Q 15

Answer Key

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