GAT B Biology

Sample Paper – 4

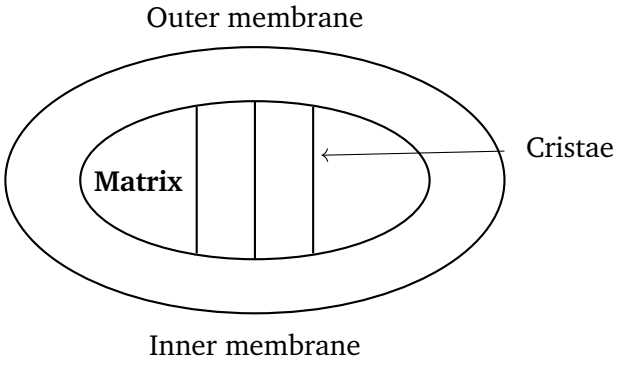
Duration: 23 Minutes **Maximum Marks: 15**

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 (Class 11 & 12 Level) [15 Questions × 1 Mark]

Q.1. The following diagram represents a mitochondrion in cross-section.



ATP synthesis in mitochondria occurs via:

(A) Oxidative phosphorylation at the inner mitochondrial membrane

(B) Substrate-level phosphorylation in the matrix only

(C) Photophosphorylation in the matrix

(D) Anaerobic glycolysis in the cytoplasm

Q.2. A woman who is a carrier for haemophilia (genotype X^HX^h) marries a normal man (genotype X^HY). The probability that their son will be affected by haemophilia is:

(A) 0%

(B) 25%

(C) 50%

(D) 100%

Q.3. The ornithine cycle (urea cycle), which converts toxic ammonia into the less toxic compound urea, occurs primarily in the:

(A) Kidneys

(B) Liver

(C) Spleen

(D) Pancreas

Q.4. Root pressure, which causes upward movement of water through the stem during night or early morning, is caused by:

(A) Transpiration pull from leaves

(B) Capillary action in xylem vessels

(C) Active transport of water molecules into root cells

(D) Active absorption of mineral salts creating an osmotic gradient

Q.5. Which pigment is primarily responsible for the characteristic red colour of red algae (Division Rhodophyta)?

(A) Phycoerythrin

(B) Fucoxanthin

(C) Chlorophyll b

(D) Xanthophyll

Q.6. Bile salts, which play a crucial role in the emulsification of dietary fats in the small intestine, are derived from:

(A) Phospholipids

(B) Triglycerides

(C) Cholesterol

(D) Sphingomyelin

Q.7. The start codon that initiates translation in the ribosome in most organisms is:

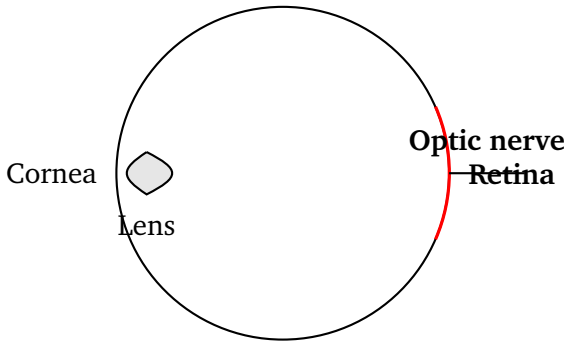
(A) UAA

(B) AUG

(C) UAG

(D) UGA

Q.8. The diagram below shows a simplified cross-section of the human eye.



The photoreceptor cells in the human eye that are responsible for colour vision are:

(A) Rod cells

(B) Bipolar cells

(C) Ganglion cells

(D) Cone cells

Q.9. Which process is primarily responsible for the return of carbon from the biotic (living) component back to the atmosphere as carbon dioxide (CO_2)?

(A) Decomposition and respiration

(B) Photosynthesis

(C) Nitrogen fixation

(D) Transpiration

Q.10. Cross-pollination mediated by insects is specifically termed:

(A) Anemophily

(B) Hydrophily

(C) Entomophily

(D) Ornithophily

Q.11. The geological era during which mammals diversified extensively and became the dominant land vertebrates is the:

(A) Paleozoic Era

(B) Cenozoic Era

(C) Mesozoic Era

(D) Proterozoic Era

Q.12. The first transgenic crop approved for commercial cultivation was:

(A) Golden Rice

(B) Bt brinjal

(C) Flavr Savr tomato developed by Monsanto

(D) Flavr Savr tomato developed by Calgene

Q.13. Leaf fall (abscission) in deciduous trees during autumn is promoted by which hormonal change?

(A) Increased ethylene and decreased auxin levels

(B) Increased cytokinin levels

(C) Increased gibberellin levels

(D) Decreased ethylene and increased abscisic acid levels

Q.14. Which vitamin is essential for the synthesis of clotting factors II (prothrombin), VII, IX, and X in the liver, and its deficiency leads to impaired blood coagulation?

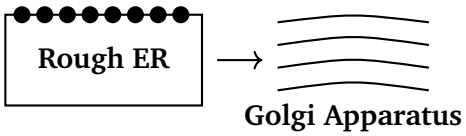
(A) Vitamin C

(B) Vitamin D

(C) Vitamin K

(D) Vitamin B_{12}

Q.15. The diagram below shows the rough endoplasmic reticulum (rough ER) connected to the Golgi apparatus.



The Golgi apparatus is primarily responsible for:

(A) Protein synthesis

(B) Processing, packaging, and secretion of proteins

(C) Lipid synthesis in the smooth ER

(D) DNA replication

Solutions

Sol.1.

Solution

Concept — ATP Synthesis in Mitochondria: Mitochondria are the primary sites of aerobic ATP production in eukaryotic cells. The inner mitochondrial membrane houses the electron transport chain (ETC) and ATP synthase (Complex V), which together drive oxidative phosphorylation.

Step 1 — Mechanism of oxidative phosphorylation: Electrons from NADH and $FADH_2$ pass through Complexes I–IV of the ETC, releasing energy that pumps protons (H^+) from the matrix into the intermembrane space. The resulting proton gradient (chemiosmotic gradient) drives protons back through ATP synthase, powering the phosphorylation of ADP to ATP. This process occurs specifically at the *inner mitochondrial membrane* and accounts for the bulk ($\sim$32–34 molecules) of ATP produced per glucose.

Why other options are wrong:

- Option B: Substrate-level phosphorylation does occur in the matrix (Krebs cycle produces 2 ATP per glucose), but it is a minor contribution, not the primary mechanism.
- Option C: Photophosphorylation is driven by light and occurs in chloroplasts; mitochondria do not perform photosynthesis.
- Option D: Anaerobic glycolysis occurs in the cytoplasm and is not a mitochondrial process; it produces only 2 ATP per glucose.

Final Answer: ATP is synthesised primarily by oxidative phosphorylation at the inner mitochondrial membrane $\Rightarrow$ A

Answer: (A) Go Back to Q 1

Sol.2.

Solution

Concept — X-linked Recessive Inheritance: Haemophilia A is an X-linked recessive disorder caused by deficiency of clotting factor VIII. Sons inherit their single X chromosome from the mother; daughters inherit one X from each parent.

Step 1 — Punnett square analysis:

	X^H (father)	Y (father)
X^H (mother)	X^HX^H (normal daughter)	X^HY (normal son)
X^h (mother)	X^HX^h (carrier daughter)	X^hY (affected son)

Sons: 50% are X^HY (unaffected) and 50% are X^hY (haemophiliac). Therefore, the probability that a son is affected is **50%**.

Why other options are wrong:

- Option A (0%): Incorrect; the carrier mother can transmit X^h to half her sons.
- Option B (25%): This would be the proportion of *all children* (sons + daughters) who are affected, not specifically sons.
- Option D (100%): All sons would be affected only if the mother were herself affected (X^hX^h), which is not the case here.

Final Answer: 50% of sons will have haemophilia $\Rightarrow$ C

Answer: (C) Go Back to Q 2

Sol.3.

Solution

Concept — Ornithine (Urea) Cycle: Amino acid catabolism generates toxic ammonia (NH_3). The liver detoxifies it by converting it into the less toxic, water-soluble compound urea via the ornithine cycle (Krebs–Henseleit cycle), first described in 1932.

Step 1 — Localisation of the cycle: The enzymes of the ornithine cycle are expressed almost exclusively in hepatocytes (liver parenchymal cells). Two steps occur in the mitochondrial matrix (formation of carbamoyl phosphate and citrulline) and the remaining steps occur in the cytoplasm. Urea produced is then transported to the kidneys for excretion in urine.

Why other options are wrong:

- Option A (Kidneys): The kidneys filter and excrete urea from the blood but do not synthesise it; they lack the complete set of ornithine cycle enzymes.
- Option C (Spleen): The spleen is responsible for filtering blood, destroying old erythrocytes, and immune surveillance; it plays no role in urea synthesis.
- Option D (Pancreas): The pancreas secretes digestive enzymes (amylase, lipase, proteases) and hormones (insulin, glucagon); it does not harbour

the urea cycle.

Final Answer: The ornithine cycle occurs primarily in the liver $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q 3

Sol.4.

Solution

Concept — Root Pressure and Water Absorption: Water moves into roots by two mechanisms: passive absorption (driven by transpiration) and active absorption (which generates root pressure). Root pressure is most evident at night or in humid conditions when transpiration is minimal.

Step 1 — Mechanism of root pressure: Root cells *actively transport* inorganic mineral ions (K^+, NO_3^-, etc.) from the soil solution into the root xylem using ATP-driven membrane pumps. This increases solute concentration in the xylem, lowering its water potential relative to the soil. Water then moves *passively* into the root by osmosis, building up a positive hydrostatic pressure (root pressure) that pushes water upward through the stem.

Why other options are wrong:

- Option A: Transpiration pull is a tension-cohesion mechanism that pulls water from above; it is not the cause of root pressure.
- Option B: Capillary action (adhesion/cohesion) contributes to water rise in narrow xylem vessels but does not generate root pressure.
- Option C: Water molecules are not actively transported across cell membranes; only solutes (ions) are actively pumped. Water movement is always passive (osmosis).

Final Answer: Root pressure results from active absorption of mineral salts creating an osmotic gradient $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q 4

Sol.5.

Solution

Concept — Algal Pigments and Rhodophyta: Each algal division is characterised by a specific combination of photosynthetic pigments. The accessory pigments mask or supplement the colour of chlorophyll, giving different algal groups their distinctive colours.

Step 1 — Pigments of red algae: Red algae (Rhodophyta) contain phycobiliproteins — specifically **phycoerythrin** (a red pigment absorbing blue-green light, 490–570 nm) and phycocyanin (a blue pigment). Phycoerythrin is the dominant pigment and reflects red wavelengths, giving red algae their characteristic colour. This pigment allows red algae to photosynthesize at greater ocean depths where only blue-green light penetrates.

Why other options are wrong:

- Option B (Fucoxanthin): A brown accessory pigment (carotenoid) characteristic of brown algae (Phaeophyta) and diatoms — gives them a brownish colour.
- Option C (Chlorophyll b): Found in green algae (Chlorophyta) and land plants; not a characteristic pigment of Rhodophyta.
- Option D (Xanthophyll): A yellow carotenoid present in many algae and higher plants, but not the defining pigment of red algae.

Final Answer: Phycoerythrin gives red algae their characteristic colour $\Rightarrow \boxed{\text{A}}$

Answer: (A) Go Back to Q 5

Sol.6.

Solution

Concept — Biochemistry of Bile Salts: Bile is a digestive secretion produced by the liver, stored in the gallbladder, and released into the duodenum. Bile salts are the primary organic components of bile and are essential for fat digestion and absorption.

Step 1 — Biosynthesis of bile salts: The liver synthesises primary bile acids — **cholic acid** and **chenodeoxycholic acid** — directly from **cholesterol** through a multi-step enzymatic pathway (the classical or Wieland–Sato pathway). These bile acids are then conjugated with the amino acids glycine or taurine to form bile salts (e.g., sodium glycocholate, sodium taurocholate). This pathway is the major route of cholesterol catabolism in the human body, accounting for approximately

50% of daily cholesterol turnover.

Why other options are wrong:

- Option A (Phospholipids): Phosphatidylcholine (lecithin) is secreted alongside bile salts in bile to prevent gallstone formation, but it is not their precursor.
- Option B (Triglycerides): Triglycerides are dietary fats that bile salts emulsify; they are substrates for lipases, not precursors of bile salts.
- Option D (Sphingomyelin): A sphingolipid found in cell membranes; it has no role as a bile salt precursor.

Final Answer: Bile salts are derived from cholesterol $\Rightarrow$ C

Answer: (C) Go Back to Q 6

Sol.7.

Solution

Concept — Start Codon and Initiation of Translation: Translation begins at a specific sequence on the mRNA called the start codon, which establishes the reading frame and recruits the initiator aminoacyl-tRNA to the ribosome.

Step 1 — The universal start codon: AUG is the start codon used by virtually all organisms (both prokaryotes and eukaryotes). It encodes the amino acid **methionine** (Met). In prokaryotes, the initiator tRNA carries *N*-formyl-methionine (fMet); in eukaryotes, it carries unmodified methionine. The ribosome assembles at AUG, and polypeptide chain elongation proceeds in the $5' \rightarrow 3'$ direction along the mRNA.

Why other options are wrong:

- Option A (UAA): A stop codon called "ochre"; it signals termination of translation and does not code for any amino acid.
- Option C (UAG): A stop codon called "amber"; it also signals termination of translation.
- Option D (UGA): A stop codon called "opal" or "umber"; it signals termination (and encodes selenocysteine in specialised contexts via a recoding mechanism).

Final Answer: AUG is the universal start codon that initiates translation $\Rightarrow$ B

Answer: (B) Go Back to Q 7

Sol.8.

Solution

Concept — Photoreceptors in the Human Retina: The neural retina contains two principal types of photoreceptor cells that convert light into electrochemical signals (phototransduction): **rods** (for dim-light, monochromatic vision) and **cones** (for bright-light, colour vision).

Step 1 — Function of cone cells: Cone cells are concentrated in the **fovea centralis**, the region of highest visual acuity. There are three types of cones, each expressing a different opsin photopigment: S-cones (short wavelength, blue, ≈420 nm), M-cones (medium wavelength, green, ≈530 nm), and L-cones (long wavelength, red, ≈560 nm). Differential stimulation of the three cone types enables colour discrimination (trichromacy). Cones function in photopic (bright-light) conditions.

Why other options are wrong:

- Option A (Rod cells): Rods contain a single photopigment (rhodopsin) and are responsible for scotopic (dim-light, night) vision; they cannot distinguish colours.
- Option B (Bipolar cells): Bipolar cells are interneurons in the inner nuclear layer of the retina; they relay signals from photoreceptors to ganglion cells but are not themselves photoreceptors.
- Option C (Ganglion cells): Ganglion cell axons form the optic nerve (CN II); they integrate and transmit signals to the brain but do not detect light directly.

Final Answer: Cone cells are responsible for colour vision in the human eye $\Rightarrow$ D

Answer: (D) Go Back to Q 8

Sol.9.

Solution

Concept — Carbon Cycle: Carbon is cycled between the abiotic environment (atmosphere, ocean, rocks) and the biotic community (living organisms) through photosynthesis, respiration, decomposition, and other processes.

Step 1 — Return of biotic carbon to the atmosphere: Two complementary processes return carbon from organisms to the atmosphere as CO_2:

- **Cellular respiration**: All living organisms (producers, consumers, decomposers) oxidise organic molecules (carbohydrates, fats, proteins) during respiration, releasing CO_2.
- **Decomposition**: Saprophytic microorganisms (bacteria, fungi) break down dead organic matter into simpler inorganic molecules, including CO_2 and H_2O, through the process of humification and mineralisation.

Together, these two processes constitute the primary return pathway of biotic carbon to the atmosphere.

Why other options are wrong:

- Option B (Photosynthesis): Photosynthesis *fixes* atmospheric CO_2 into organic molecules; it removes carbon from the atmosphere, not returns it.
- Option C (Nitrogen fixation): This is part of the nitrogen cycle, converting N_2 to NH_3; it has no direct role in carbon cycling.
- Option D (Transpiration): Transpiration releases water vapour (H_2O) from plant leaves; it is part of the water cycle, not the carbon cycle.

Final Answer: Decomposition and respiration return carbon to the atmosphere as $CO_2 \Rightarrow \boxed{A}$

Answer: (A) Go Back to Q 9

Sol.10.

Solution

Concept — Modes of Pollination: Pollination is the transfer of pollen from the anther (male organ) to the stigma (female organ). When this transfer requires a biotic or abiotic agent, it is named after that agent.

Step 1 — Definition of entomophily: Entomophily (Greek: *entomon* = insect; *philos* = loving) is the pollination of flowers by insects such as bees, butterflies, moths, beetles, and wasps. Entomophilous flowers are typically characterised by: bright colours, sweet fragrance or nectar rewards, sticky or rough pollen grains, and structures that facilitate contact with the insect body. Entomophily is the most common mode of cross-pollination in flowering plants.

Why other options are wrong:

- Option A (Anemophily): Pollination by *wind*. Flowers are inconspicuous, lack nectar/fragrance, and produce enormous quantities of light, smooth pollen (e.g., grasses, maize, *Cannabis*).

- Option B (Hydrophily): Pollination by *water*. Pollen is carried by water currents on or below the water surface (e.g., *Vallisneria*, *Zostera*).
- Option D (Ornithophily): Pollination by *birds* (mainly hummingbirds in the Americas and sunbirds in Africa/Asia). Flowers are often red, tubular, and odourless.

Final Answer: Insect-mediated cross-pollination is called entomophily $\Rightarrow$ C

Answer: (C) Go Back to Q 10

Sol.11.

Solution

Concept — Geological Time Scale and Mammalian Diversification: Earth's history is divided into eons, eras, and periods. The diversification of major animal groups is correlated with specific geological eras based on fossil evidence.

Step 1 — The Cenozoic Era: The **Cenozoic Era** (approximately 66 million years ago to the present) is often called the "Age of Mammals." Following the Cretaceous–Paleogene (K–Pg) mass extinction event ($\sim$66 Ma), which eliminated non-avian dinosaurs and many other taxa, mammals underwent explosive adaptive radiation. Freed from competition with dinosaurs, they diversified into numerous ecological niches — producing the orders Primates, Rodentia, Carnivora, Cetacea, Perissodactyla, Artiodactyla, and others — becoming the dominant terrestrial vertebrates.

Why other options are wrong:

- Option A (Paleozoic Era, 541–252 Ma): Characterised by the diversification of fish, amphibians, and early amniotes; mammals had not yet evolved.
- Option C (Mesozoic Era, 252–66 Ma): The "Age of Reptiles/Dinosaurs"; early small, nocturnal mammals (e.g., *Morganucodon*) existed but remained minor components of the fauna.
- Option D (Proterozoic Era, 2500–541 Ma): A Precambrian era with only microbial mats, single-celled eukaryotes, and early multicellular life; no animals existed.

Final Answer: Mammals diversified during the Cenozoic Era $\Rightarrow$ B

Answer: (B) Go Back to Q 11

Sol.12.

Solution

Concept — History of Transgenic Crops: Transgenic (genetically modified, GM) crops carry genes from another organism introduced by recombinant DNA technology. The Flavr Savr tomato was a landmark achievement in agricultural biotechnology and the first GM food approved for human consumption.

Step 1 — The Flavr Savr tomato: The Flavr Savr tomato was developed by **Calgene Inc.** (Davis, California) and received approval from the US Food and Drug Administration (FDA) in 1994 — making it the *first transgenic food crop approved for commercial cultivation and sale*. It was engineered to express an antisense RNA complementary to the mRNA of polygalacturonase (PG), an enzyme that degrades pectin and causes fruit softening. Reduced PG activity extended shelf life and allowed the tomato to remain firm longer after harvest.

Why other options are wrong:

- Option A (Golden Rice): Developed by Ingo Potrykus and Peter Beyer; it is biofortified with β-carotene (provitamin A) and was developed much later; it is not the first transgenic crop approved commercially.
- Option B (Bt brinjal): A Bt toxin-expressing eggplant; it was approved in Bangladesh only in 2013.
- Option C (Flavr Savr by Monsanto): Monsanto later *acquired* Calgene in 1997 but was *not* the developer of the Flavr Savr tomato.

Final Answer: The Flavr Savr tomato was developed by Calgene $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q 12

Sol.13.

Solution

Concept — Plant Hormones and Leaf Abscission: Abscission is the controlled shedding of organs (leaves, fruits, flowers) by plants. It involves the formation of a specialised abscission zone at the base of the petiole, regulated by the balance of plant hormones.

Step 1 — Hormonal regulation of abscission: In young, actively growing leaves, **auxin** (IAA) is produced in abundance and diffuses basipetally through the abscission zone, *inhibiting* abscission. As leaves age and senesce, auxin production decreases, removing this inhibition. Simultaneously, **ethylene** production in aging leaves *increases*. Ethylene stimulates the activity of hydrolytic enzymes

(cellulase, pectinase) in the abscission zone, which degrade the middle lamella and cell walls, leading to leaf separation. Thus, the combination of *increased ethylene* and *decreased auxin* promotes abscission.

Why other options are wrong:

- Option B (Increased cytokinin): Cytokinins *delay* senescence and abscission by maintaining chlorophyll and protein levels; they would *prevent*, not promote, leaf fall.
- Option C (Increased gibberellin): Gibberellins promote stem elongation, germination, and flowering; they are not primary promoters of abscission.
- Option D (Decreased ethylene, increased ABA): Abscisic acid (ABA) promotes dormancy, stomatal closure, and seed dormancy; it does not directly promote abscission, and decreased ethylene would *reduce*, not increase, abscission.

Final Answer: Increased ethylene and decreased auxin promote leaf abscission $\Rightarrow$ A

Answer: (A) Go Back to Q 13

Sol.14.

Solution

Concept — Vitamins and Blood Coagulation: The coagulation cascade involves a series of clotting factors (proteins) that act in sequence to form a fibrin clot. Several of these factors require specific post-translational modifications for their activation.

Step 1 — Role of Vitamin K: Vitamin K (a fat-soluble vitamin found in leafy vegetables and synthesised by gut microbiota) is an essential cofactor for the enzyme γ-glutamyl carboxylase. This enzyme catalyses the *carboxylation* of specific glutamate residues in clotting factors **II (prothrombin), VII, IX,** and **X**, as well as anticoagulant proteins C and S. The resulting γ-carboxyglutamate (Gla) residues bind Ca^{2+} ions, anchoring these factors to phospholipid surfaces during clot formation. Vitamin K deficiency (or treatment with warfarin, a Vitamin K antagonist) leads to impaired coagulation and prolonged bleeding.

Why other options are wrong:

- Option A (Vitamin C): Essential for collagen synthesis via prolyl hydroxylase; deficiency causes scurvy (fragile capillaries) but does not directly impair clotting factor synthesis.

- Option B (Vitamin D): Regulates calcium and phosphate metabolism; important for bone health; its deficiency causes rickets/osteomalacia, not coagulopathy.
- Option D (Vitamin B_{12}): Cobalamin is essential for DNA synthesis (via methylmalonyl-CoA mutase and methionine synthase); deficiency causes megaloblastic anaemia and neurological damage, not clotting defects.

Final Answer: Vitamin K is essential for the synthesis of clotting factors II, VII, IX, and X $\Rightarrow$ C

Answer: (C) Go Back to Q 14

Sol.15.

Solution

Concept — Golgi Apparatus Function: The Golgi apparatus (Golgi complex, discovered by Camillo Golgi in 1898) is a membrane-bound organelle composed of a stack of flattened cisternae. It acts as the cell's central "sorting and dispatch" station for proteins and lipids.

Step 1 — Processing, packaging, and secretion: Proteins synthesised on ribosomes of the rough ER enter the *cis* face of the Golgi via transport vesicles. As they traverse from *cis* to *medial* to *trans* cisternae, they undergo post-translational modifications: glycosylation (addition/trimming of sugar chains), phosphorylation, sulfation, and proteolytic cleavage. At the *trans* Golgi network (TGN), proteins are sorted by specific signal sequences and packaged into vesicles destined for: (1) secretion (exocytosis), (2) lysosomes, or (3) the plasma membrane. This makes processing, packaging, and secretion the primary function of the Golgi.

Why other options are wrong:

- Option A (Protein synthesis): Protein synthesis occurs on ribosomes (free in the cytoplasm or attached to the rough ER); the Golgi has no ribosomes and does not synthesise proteins.
- Option C (Lipid synthesis in smooth ER): Lipid synthesis (phospholipids, cholesterol) occurs in the smooth ER, not the Golgi; the Golgi modifies and sorts lipids but does not synthesise them.
- Option D (DNA replication): DNA replication occurs in the nucleus during the S phase of the cell cycle; the Golgi plays absolutely no role in this process.

Final Answer: The Golgi apparatus processes, packages, and secretes proteins $\Rightarrow$ B

Answer: (B) Go Back to Q 15

Answer Key

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