GAT B Biology

Sample Paper – 1

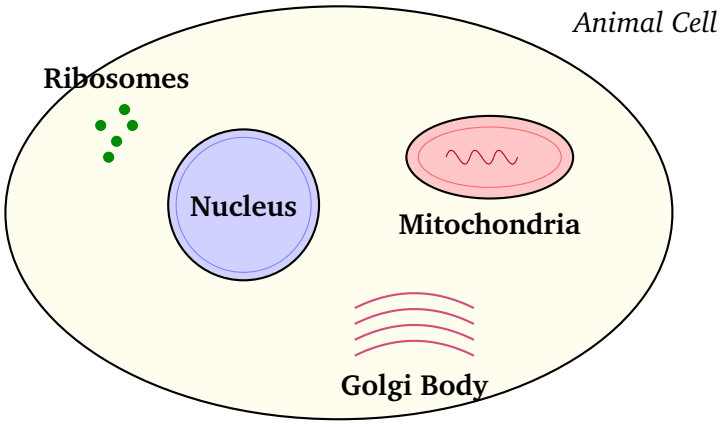
Duration: 23 Minutes **Maximum Marks: 15**

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. The diagram below represents a simplified animal cell with key organelles labelled. Which organelle shown is the **primary site of aerobic respiration**?



(A) Nucleus

(B) Mitochondria

(C) Ribosome

(D) Golgi body

Q2. In a monohybrid cross between two heterozygous tall pea plants ($Tt \times Tt$), what is the expected **phenotypic** ratio of the offspring?

(A) 3 : 1

(B) 1 : 2 : 1

(C) 1 : 1

(D) 9 : 3 : 3 : 1

Q3. The bicuspid (mitral) valve of the human heart is located between which two chambers?

(A) Right atrium and right ventricle

(B) Right ventricle and pulmonary artery

(C) Left ventricle and aorta

(D) Left atrium and left ventricle

Q4. Which of the following molecules acts as the **primary electron donor** during the light reactions of photosynthesis?

(A) NADPH

(B) ATP

(C) Water (H_2O)

(D) CO_2

Q5. Which of the following is a **characteristic feature** of Kingdom Fungi?

(A) Autotrophic nutrition

(B) Presence of chitin in the cell wall

(C) Absence of cell wall

(D) Motile spores bearing two flagella

Q6. In enzyme kinetics, the Michaelis constant (K_m) of an enzyme is defined as the:

(A) Substrate concentration at which the reaction velocity equals $V_{\max}/2$

(B) Maximum reaction velocity achieved by the enzyme at substrate saturation

(C) Enzyme concentration required to saturate all available substrate

(D) Product inhibition constant of the catalysed reaction

Q7. Which enzyme is responsible for synthesising new DNA strands in the $5' \rightarrow 3'$ direction during DNA replication in *E. coli*?

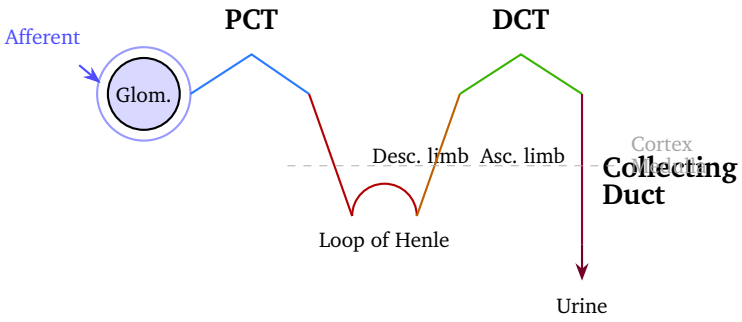
(A) DNA ligase

(B) Helicase

(C) Primase

(D) DNA polymerase III

Q8. The diagram below shows a simplified schematic of a nephron. In which tubular segment does reabsorption of **glucose** primarily occur?



(A) Loop of Henle

(B) Collecting duct

(C) Proximal convoluted tubule (PCT)

(D) Distal convoluted tubule (DCT)

Q9. In an ecosystem, energy transfer follows Lindeman's **10% law**. If the producers fix $10{,}000$ kJ of energy, how much energy (in kJ) is available to **secondary consumers**?

(A) 1000 kJ

(B) 10 kJ

(C) 100 kJ

(D) 1 kJ

Q10. Spermatogenesis, the process that produces spermatozoa in human males, occurs in the:

(A) Seminiferous tubules

(B) Epididymis

(C) Vas deferens

(D) Seminal vesicle

Q11. Darwin's theory of natural selection is most accurately summarised as:

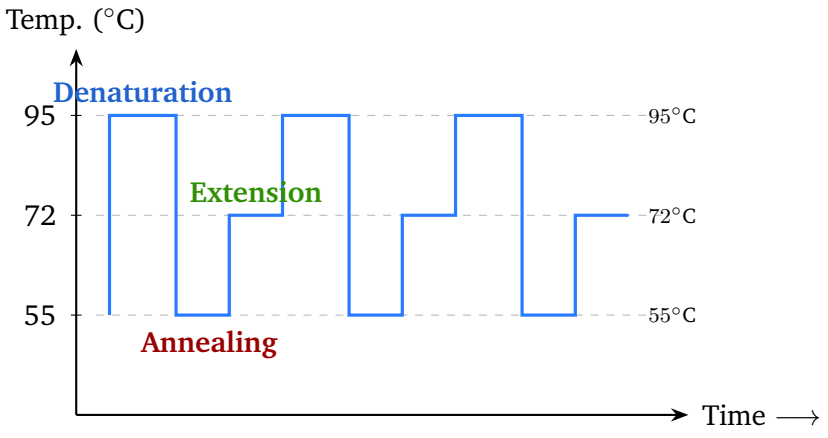
(A) Inheritance of characters acquired during an organism's lifetime

(B) Organs become more developed through use and degenerate through disuse

(C) Living organisms arise spontaneously from non-living matter

(D) Survival of the fittest individuals in a changing environment, leading to heritable change in populations over generations

Q12. The graph below illustrates the temperature profile of a single PCR thermal cycle. Which enzyme catalyses the **extension step** at approximately 72 °C?



Three thermal cycles shown

(A) Restriction endonuclease

(B) DNA ligase

(C) Taq polymerase

(D) RNA polymerase

Q13. Guard cells regulate the opening and closing of stomata. Under which condition do guard cells cause stomata to **open**?

(A) Potassium ions (K^+) move *out* of guard cells

(B) Potassium ions (K^+) accumulate *inside* guard cells

(C) Carbon dioxide concentration in the sub-stomatal cavity increases

(D) Turgor pressure in guard cells decreases

Q14. Which enzyme, secreted by the intestinal mucosa, converts inactive **trypsinogen** into active **trypsin** in the small intestine?

(A) Enterokinase (enteropeptidase)

(B) Pepsin

(C) Salivary amylase

(D) Lipase

Q15. Which of the following correctly represents the **sequence of phases** in the mitotic cell cycle?

(A) $G_1 \rightarrow M \rightarrow S \rightarrow G_2$

(B) $S \rightarrow G_1 \rightarrow G_2 \rightarrow M$

(C) $G_1 \rightarrow G_2 \rightarrow S \rightarrow M$

(D) $G_1 \rightarrow S \rightarrow G_2 \rightarrow M$

Detailed Solutions

Sol. 1.

Solution

Concept — Cell Organelles and Aerobic Respiration: The mitochondrion is a double-membraned organelle found in all aerobic eukaryotic cells. Its inner membrane, folded into cristae, houses the electron transport chain (ETC), while the matrix contains enzymes for the Krebs (citric acid) cycle. Together, these compartments make the mitochondrion the exclusive site of aerobic ATP production.

Step 1 — Trace the pathway of aerobic respiration: Glucose is first broken down by glycolysis in the cytoplasm, yielding pyruvate. Pyruvate is imported into the mitochondrial matrix, where it is oxidised via the pyruvate dehydrogenase complex and the Krebs cycle, generating NADH and $FADH_2$. These electron carriers donate electrons to the ETC embedded in the inner mitochondrial membrane, driving proton pumping and ultimately ATP synthesis via ATP synthase (oxidative phosphorylation). All steps after glycolysis occur within the mitochondria.

Why other options are wrong:

- Option A (Nucleus): Houses the genetic material (DNA) and is the site of transcription; it produces no ATP.
- Option C (Ribosome): Site of protein synthesis (translation); has no role in ATP generation.
- Option D (Golgi body): Sorts, modifies, and packages proteins and lipids for secretion or intracellular delivery; is not involved in respiration.

Final Answer: Mitochondria is the primary site of aerobic respiration $\Rightarrow$ $\boxed{\text{B}}$

Answer: (B) Go Back to Q 1

Sol. 2.

Solution

Concept — Mendel's Law of Segregation: During gamete formation, the two alleles of a gene separate so that each gamete carries only one allele. In a heterozygous individual (*Tt*), half the gametes carry T and half carry t.

Step 1 — Construct the Punnett square for *Tt* × *Tt*:

	T	t
T	TT	Tt
t	Tt	tt

Genotypic ratio: TT : Tt : tt = 1 : 2 : 1.

Step 2 — Determine the phenotypic ratio: Since T (tall) is completely dominant over t (dwarf), genotypes TT and Tt both express the tall phenotype. Only tt is dwarf.

$$\text{Tall (TT + Tt)} : \text{Dwarf (tt)} = 3 : 1$$

Why other options are wrong:

- Option B (1 : 2 : 1): This is the *genotypic* ratio (TT : Tt : tt), not the phenotypic ratio.
- Option C (1 : 1): Arises from a test cross (*Tt* × *tt*), not *Tt* × *Tt*.
- Option D (9 : 3 : 3 : 1): Phenotypic ratio for a *dihybrid* cross (*AaBb* × *AaBb*).

Final Answer: Phenotypic ratio is 3 : 1 (Tall : Dwarf) ⇒ A

Answer: (A) Go Back to Q 2

Sol. 3.

Solution

Concept — Heart Valves and Cardiac Anatomy: The human heart contains four valves that enforce one-way blood flow. The two atrioventricular (AV) valves separate each atrium from its ventricle; the two semilunar valves guard the exits from the ventricles.

Step 1 — Identify each valve and its location:

- **Tricuspid valve** (right AV valve): between right atrium and right ventricle (3 cusps).
- **Bicuspid / Mitral valve** (left AV valve): between **left atrium and left ventricle** (2 cusps).
- **Pulmonary semilunar valve**: between right ventricle and pulmonary artery.
- **Aortic semilunar valve**: between left ventricle and aorta.

Why other options are wrong:

- Option A: Describes the tricuspid valve, not the bicuspid/mitral.
- Option B: Describes the pulmonary semilunar valve location.
- Option C: Describes the aortic semilunar valve location.

Final Answer: The bicuspid (mitral) valve lies between the left atrium and left ventricle $\Rightarrow$ D

Answer: (D) Go Back to Q 3

Sol. 4.

Solution

Concept — Light Reactions and Photolysis of Water: The light reactions of photosynthesis take place in the thylakoid membranes. At Photosystem II (PSII), water molecules are oxidised (split) by the oxygen-evolving complex (OEC), providing electrons to replace those lost from P680 after photoexcitation. Oxygen is released as a by-product. Water is therefore the **primary electron donor**.

Step 1 — Electron flow in the light reactions:

$$H_2O \xrightarrow{\text{OEC at PSII}} e^- \rightarrow P680^* \rightarrow \text{Pheophytin} \rightarrow PQ \rightarrow \text{Cyt } b_6f \rightarrow PC \rightarrow PSI \rightarrow Fd \rightarrow NADP^+ \text{ redu}$$

Water donates electrons at the start; NADPH is produced at the end.

Why other options are wrong:

- Option A (NADPH): NADPH is the *product* of the light reactions, not the electron donor.
- Option B (ATP): ATP is generated via photophosphorylation; it is an energy currency, not an electron donor.
- Option D (CO_2): CO_2 is fixed during the Calvin cycle (dark/light-independent reactions); it does not participate in the light reactions.

Final Answer: Water (H_2O) is the primary electron donor in the light reactions $\Rightarrow$ C

Answer: (C) Go Back to Q 4

Sol. 5.

Solution

Concept — Kingdom Fungi Characteristics: Fungi are eukaryotic, heterotrophic (absorptive) organisms. Their cell walls are composed of **chitin**, a β-1,4-linked polymer of N-acetylglucosamine. This distinguishes them from plants (cellulose walls), bacteria (peptidoglycan walls), and animals (no cell wall).

Step 1 — Confirm the defining feature: All members of Kingdom Fungi — from unicellular yeasts to multicellular moulds and macrofungi — possess chitin in their cell walls. They are saprotrophic, parasitic, or symbiotic, but never photosynthetic. Their spores are typically non-motile (dispersed by wind or water).

Why other options are wrong:

- Option A (Autotrophic nutrition): Fungi are strictly heterotrophic; they cannot perform photosynthesis.
- Option C (Absence of cell wall): Fungi have well-developed cell walls (chitin); absence of cell walls is characteristic of Mycoplasma (a bacterium) or animal cells.
- Option D (Motile spores with two flagella): Biflagellate motile spores (zoospores) are characteristic of Oomycetes (e.g., *Phytophthora*), which are now classified in Kingdom Chromista, not Fungi.

Final Answer: Chitin in the cell wall is a defining feature of Kingdom Fungi $\Rightarrow$ B

Answer: (B) Go Back to Q 5

Sol. 6.

Solution

Concept — Michaelis–Menten Kinetics: The Michaelis–Menten equation relates reaction rate v to substrate concentration $[S]$:

$$v = \frac{V_{\max}[S]}{K_m + [S]}$$

K_m is the Michaelis constant, a kinetic parameter with units of concentration.

Step 1 — Derive the physical meaning of K_m: Set $v = V_{\max}/2$:

$$\frac{V_{\max}}{2} = \frac{V_{\max}[S]}{K_m + [S]} \implies K_m + [S] = 2[S] \implies \boxed{K_m = [S]}$$

Thus K_m numerically equals the substrate concentration at which $v = V_{\max}/2$. A lower K_m means higher affinity of the enzyme for its substrate.

Why other options are wrong:

- Option B ($V_{\max}$): $V_{\max}$ is the maximum velocity; it is a separate parameter from K_m.
- Option C: K_m is an intrinsic property of the enzyme–substrate pair and is *independent* of enzyme concentration.
- Option D: Product inhibition is characterised by K_i (inhibition constant), not K_m.

Final Answer: K_m = substrate concentration at half-maximal reaction velocity $\Rightarrow$ A

Answer: (A) Go Back to Q 6

Sol. 7.

Solution

Concept — DNA Replication Enzymes in Prokaryotes: In *Escherichia coli*, DNA replication is carried out by a replisome complex. The main replicative polymerase is **DNA Polymerase III** (Pol III), a processive enzyme that synthesises new DNA only in the $5' \to 3'$ direction by extending a pre-existing primer.

Step 1 — Role of each enzyme at the replication fork:

- **Helicase (DnaB)**: Unwinds the double helix by breaking hydrogen bonds between base pairs.
- **Primase (DnaG)**: Synthesises short RNA primers that provide a 3'-OH for Pol III to extend.
- **DNA Pol III**: Reads the template $3' \to 5'$ and synthesises new DNA $5' \to 3'$; the main strand-synthesising enzyme.
- **DNA ligase**: Seals the nick between adjacent Okazaki fragments on the lagging strand (after Pol I removes RNA primers).

Why other options are wrong:

- Option A (DNA ligase): Joins fragments; has no polymerase/strand-synthesis activity.
- Option B (Helicase): Unwinds DNA; does not synthesise nucleotide chains.
- Option C (Primase): Synthesises short RNA primers only; does not synthesise the main DNA strand.

Final Answer: DNA Polymerase III synthesises new DNA in the $5' \rightarrow 3'$ direction $\Rightarrow$ D

Answer: (D) Go Back to Q 7

Sol. 8.

Solution

Concept — Nephron Tubular Reabsorption: The nephron is the structural and functional unit of the kidney. Glucose is a threshold substance — under normal blood glucose levels, *all* filtered glucose is reabsorbed before urine is excreted. This reabsorption is mediated by sodium-glucose co-transporters (SGLT1 and SGLT2) present exclusively in the **proximal convoluted tubule (PCT)** brush-border epithelium.

Step 1 — PCT reabsorption processes: The PCT reabsorbs approximately 70% of filtered water, 100% of glucose and amino acids, most Na^+, K^+, Cl^-, HCO_3^-, and urea. The dense brush-border microvilli greatly increase the absorptive surface area.

Step 2 — Function of other segments:

- **Loop of Henle**: Creates and maintains an osmotic gradient in the renal medulla (counter-current multiplier); no glucose transport.
- **DCT**: Fine-tunes ionic balance (Na^+, K^+, Ca^{2+}, H^+) and pH; glucose is absent by the time tubular fluid reaches DCT.
- **Collecting duct**: Regulates final water reabsorption (ADH-dependent) and urea recycling; no glucose transport.

Final Answer: Glucose reabsorption occurs entirely in the proximal convoluted tubule (PCT) $\Rightarrow$ C

Answer: (C) Go Back to Q 8

Sol. 9.

Solution

Concept — Lindeman's 10% Law of Energy Transfer: In a food chain, only approximately 10% of the energy available at one trophic level is transferred to the next, because the remaining ∼90% is lost as heat through cellular respiration, decomposition, and metabolic processes.

Step 1 — Calculate energy at each trophic level:

$$\text{Producers (Trophic Level 1)} = 10{,}000 \text{ kJ}$$

$$\text{Primary Consumers (Trophic Level 2)} = 10\% \times 10{,}000 = 1{,}000 \text{ kJ}$$

$$\text{Secondary Consumers (Trophic Level 3)} = 10\% \times 1{,}000 = \mathbf{100} \text{ kJ}$$

Why other options are wrong:

- Option A (1000 kJ): Energy available to primary consumers (trophic level 2), not secondary.
- Option B (10 kJ): Energy available to tertiary consumers (trophic level 4), i.e., $10\% \times 100 = 10$ kJ.
- Option D (1 kJ): Energy available to quaternary consumers (trophic level 5), i.e., $10\% \times 10 = 1$ kJ.

Final Answer: Secondary consumers receive **100** kJ $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C) Go Back to Q 9

Sol. 10.

Solution

Concept — Male Reproductive System and Spermatogenesis: Spermatogenesis is the sequence of events by which diploid spermatogonia differentiate into haploid spermatozoa through mitosis, meiosis I, meiosis II, and spermiogenesis. This entire process occurs within the **seminiferous tubules** of the testes, supported by Sertoli cells that provide nourishment and a blood–testis barrier.

Step 1 — Sequence of events: Spermatogonia (2n) $\xrightarrow{\text{mitosis}}$ Primary spermatocytes (2n) $\xrightarrow{\text{meiosis I}}$ Secondary spermatocytes (n) $\xrightarrow{\text{meiosis II}}$ Spermatids (n) $\xrightarrow{\text{spermiogenesis}}$ Spermatozoa (n). All stages occur within the seminiferous tubular epithelium.

Why other options are wrong:

- Option B (Epididymis): Sperm are *stored* and undergo functional maturation here but are not produced here.
- Option C (Vas deferens): A muscular duct that transports mature sperm from the epididymis to the ejaculatory duct during ejaculation.
- Option D (Seminal vesicle): An accessory gland secreting a fructose-rich fluid that forms ∼60% of semen volume; does not produce sperm.

Final Answer: Spermatogenesis occurs within the seminiferous tubules ⇒ A

Answer: (A) Go Back to Q 10

Sol. 11.

Solution

Concept — Darwin's Theory of Natural Selection: Charles Darwin (1859, *On the Origin of Species*) proposed that evolution occurs through natural selection. The key premises are: (1) heritable variation exists within populations; (2) more offspring are produced than can survive (struggle for existence); (3) individuals with advantageous heritable traits survive and reproduce at higher rates; (4) over generations, favourable traits become more frequent — this is **evolution by natural selection**, or "survival of the fittest" (the phrase coined by Herbert Spencer).

Step 1 — Distinguish Darwinism from rival theories:

- Darwin's mechanism: heritable variation + differential reproductive success in an environment.
- Lamarck's mechanism: use/disuse of organs and inheritance of acquired characters (disproved).

Why other options are wrong:

- Option A: "Inheritance of acquired characters" is the central idea of **Lamarckism**, not Darwinism.
- Option B: "Use and disuse of organs" is Lamarck's first law, not related to natural selection.
- Option C: Spontaneous generation (abiogenesis from non-living matter) was refuted by Pasteur; it is unrelated to natural selection.

Final Answer: Natural selection = survival of the fittest in a changing environment ⇒ D

Answer: (D) Go Back to Q 11

Sol. 12.

Solution

Concept — Polymerase Chain Reaction (PCR): PCR is an in vitro technique for amplifying specific DNA sequences using repeated thermal cycles. Each cycle consists of three steps: (1) **Denaturation** ($\sim$95 °C) — strands separate; (2) **Annealing** ($\sim$55 °C) — primers hybridise; (3) **Extension** ($\sim$72 °C) — new strand synthesis by a thermostable DNA polymerase.

Step 1 — Why Taq polymerase? Taq polymerase is a heat-stable DNA polymerase isolated from the thermophilic bacterium *Thermus aquaticus* (found in hot springs). Its optimum activity is at $\sim$72 °C and it remains functional through the repeated 95 °C denaturation steps, making it ideal for PCR. It synthesises DNA in the $5' \to 3'$ direction.

Why other options are wrong:

- Option A (Restriction endonuclease): Cleaves DNA at specific recognition sequences; does not synthesise DNA.
- Option B (DNA ligase): Joins DNA fragments by forming phosphodiester bonds; does not polymerise new strands.
- Option D (RNA polymerase): Synthesises RNA from a DNA template (transcription); it is not thermostable and does not synthesise DNA.

Final Answer: Taq polymerase catalyses the extension step at 72 °C in PCR $\Rightarrow$ $\boxed{\text{C}}$

Answer: (C) Go Back to Q 12

Sol. 13.

Solution

Concept — Stomatal Opening Mechanism (Potassium Ion Hypothesis): Stomatal aperture is regulated by changes in the turgidity of guard cells. When guard cells become turgid, the stomata open; when they lose turgor, the stomata close. The primary driver of stomatal opening is the active accumulation of potassium ions (K^+) into guard cells.

Step 1 — Mechanism of stomatal opening (in light):

1. Light activates H^+-ATPase pumps in guard cell plasma membrane.
2. Protons (H^+) are expelled from guard cells, hyperpolarising the membrane.
3. K^+ channels open; K^+ flows in down the electrochemical gradient (accumulates inside guard cells).

4. Malate^{2-} and Cl^- also accumulate, lowering the osmotic potential.
5. Water enters guard cells by osmosis $\rightarrow$ turgor pressure rises $\rightarrow$ stoma opens.

Why other options are wrong:

- Option A (K^+ leaves): Efflux of K^+ reduces osmotic pressure and causes stomatal *closure*.
- Option C (High CO_2): Elevated CO_2 triggers stomatal closure to reduce water loss.
- Option D (Turgor decreases): Stomatal closure accompanies decreased turgor; opening requires *increased* turgor.

Final Answer: Stomata open when K^+ accumulates inside guard cells, increasing turgor $\Rightarrow$ B

Answer: (B) Go Back to Q 13

Sol. 14.

Solution

Concept — Activation of Pancreatic Zymogens: The pancreas secretes several proteases as inactive precursors (zymogens) to prevent autodigestion. Trypsinogen is the inactive form of trypsin. In the duodenum, the intestinal brush-border enzyme **enterokinase** (enteropeptidase) cleaves the N-terminal hexapeptide from trypsinogen, producing active trypsin.

Step 1 — Cascade of zymogen activation:

$$\text{Trypsinogen} \xrightarrow{\text{enterokinase}} \text{Trypsin (active)} \xrightarrow{\text{autocatalysis}} \text{more Trypsin}$$

Active trypsin then activates chymotrypsinogen, proelastase, and procarboxypeptidase, establishing a proteolytic cascade in the small intestine.

Why other options are wrong:

- Option B (Pepsin): A gastric acid-active protease (pH optimum $\sim$2); it acts on proteins in the stomach but cannot activate trypsinogen in the alkaline duodenum.
- Option C (Salivary amylase): Hydrolyses starch (carbohydrate); has no proteolytic activity.
- Option D (Lipase): Cleaves ester bonds in triglycerides (fat digestion); does not activate zymogens.

Final Answer: Enterokinase (enteropeptidase) converts trypsinogen to active trypsin $\Rightarrow$ A

Answer: (A) Go Back to Q 14

Sol. 15.

Solution

Concept — Eukaryotic Cell Cycle Phases: The cell cycle comprises **interphase** (G_1, S, G_2) and the **mitotic phase** (M). Each sub-phase serves a distinct purpose: G_1 (first gap) — cell growth and preparation for DNA synthesis; S (synthesis) — DNA replication (chromosome number doubles); G_2 (second gap) — cell growth, synthesis of mitotic proteins; M — mitosis and cytokinesis.

Step 1 — Establish the correct sequence:

$$G_1 \xrightarrow{\text{cell growth}} S \xrightarrow{\text{DNA replication}} G_2 \xrightarrow{\text{mitotic prep.}} M \xrightarrow{\text{division}} \text{two daughter cells}$$

Why other options are wrong:

- Option A ($G_1 \to M \to S \to G_2$): Incorrect; M phase before S phase means division without prior DNA replication — this is lethal.
- Option B ($S \to G_1 \to G_2 \to M$): G_1 must precede S; this reverses their order.
- Option C ($G_1 \to G_2 \to S \to M$): Skips S phase between G_1 and G_2; DNA is replicated during S, which must occur before G_2.

Final Answer: Correct cell cycle sequence is $G_1 \to S \to G_2 \to M \Rightarrow$ D

Answer: (D) Go Back to Q 15

Answer Key

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