GAT B Biology

Sample Paper – 2

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 fluid mosaic model of plasma membrane was proposed by:

(A) Robert Hooke

(B) Schleiden and Schwann

(C) Singer and Nicolson

(D) Watson and Crick

Q2. In a cross between red-flowered (*RR*) and white-flowered (*rr*) snapdragons showing incomplete dominance, the F_2 generation shows:

(A) All red flowers

(B) 1 red : 2 pink : 1 white

(C) 3 red : 1 white

(D) All pink flowers

Q3. The partial pressure of O_2 in alveolar air is approximately:

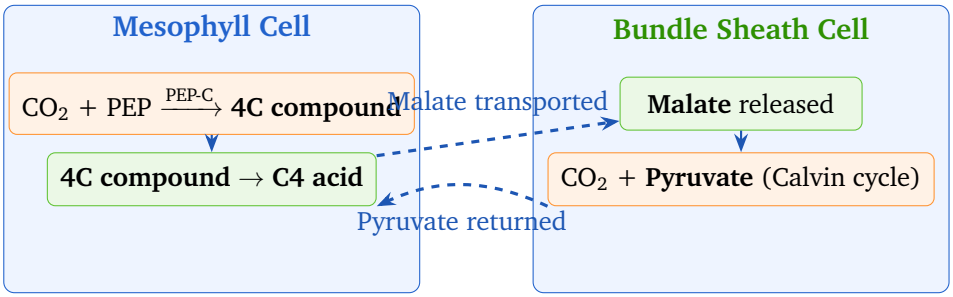
(A) 104 mmHg

(B) 40 mmHg

(C) 45 mmHg

(D) 760 mmHg

Q4. In C4 plants, the first stable product of CO_2 fixation is:



(A) 3-phosphoglycerate (3-PGA)

(B) Ribulose bisphosphate (RuBP)

(C) Glucose

(D) Oxaloacetate (OAA)

Q5. Which of the following statements about viruses is CORRECT?

(A) Viruses have their own ribosomes

(B) Viruses can grow on nutrient agar

(C) Viruses contain either DNA or RNA, never both

(D) All viruses have a lipid envelope

Q6. The alpha-helix and beta-pleated sheet are examples of:

(A) Secondary structure of proteins

(B) Primary structure of proteins

(C) Tertiary structure of proteins

(D) Quaternary structure of proteins

Q7. Which of the following RNA polymerases transcribes mRNA in eukaryotes?

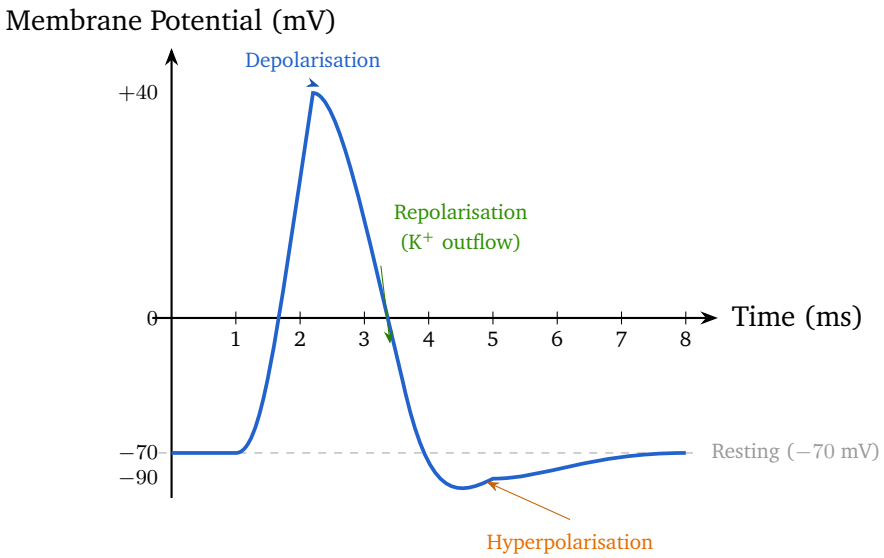
(A) RNA polymerase I

(B) RNA polymerase II

(C) RNA polymerase III

(D) Reverse transcriptase

Q8. During an action potential, the rapid depolarization phase is caused by:



(A) Outflow of K^+ ions

(B) Inflow of Ca^{2+} ions

(C) Outflow of Na^+ ions

(D) Inflow of Na^+ ions

Q9. The process by which a bare rock surface gradually develops into a climax community is called:

(A) Secondary succession

(B) Retrogressive succession

(C) Primary succession

(D) Biotic succession

Q10. The endosperm of a flowering plant is:

(A) Triploid

(B) Diploid

(C) Haploid

(D) Tetraploid

Q11. If the frequency of the recessive allele (q) in a population is 0.3 and the population is in Hardy-Weinberg equilibrium, the frequency of heterozygotes ($2pq$) is:

(A) 0.09

(B) 0.42

(C) 0.49

(D) 0.30

Q12. Restriction endonucleases cut DNA at specific sequences called:

(A) Promoters

(B) Enhancers

(C) Telomeres

(D) Palindromic sequences

Q13. Which of the following is a macronutrient required by plants?

(A) Iron

(B) Manganese

(C) Magnesium

(D) Zinc

Q14. Insulin is secreted by which cells of the pancreas?

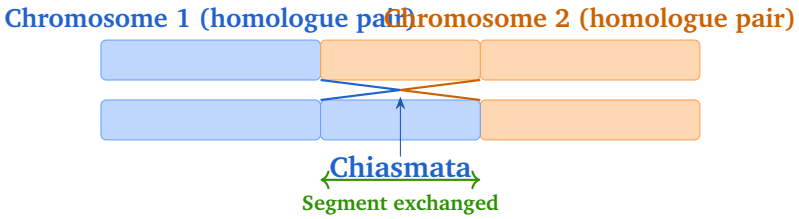
(A) Beta cells of islets of Langerhans

(B) Alpha cells of islets of Langerhans

(C) Delta cells

(D) Acinar cells

Q15. The exchange of genetic material between non-sister chromatids during meiosis I is called:



(A) Synapsis

(B) Crossing over

(C) Disjunction

(D) Translocation

Detailed Solutions

Sol 1.

Solution

Concept — Fluid Mosaic Model of Plasma Membrane: The structure of the cell membrane was described by Singer and Nicolson in 1972. Their model describes the membrane as a fluid phospholipid bilayer in which proteins are embedded and free to move laterally, giving a mosaic appearance.

Step 1 — Identifying the proposers: S. J. Singer and G. L. Nicolson proposed the fluid mosaic model based on thermodynamic principles, electron microscopy, and protein mobility experiments, replacing the earlier Davson-Danielli sandwich model.

Why other options are wrong:

- Option A: Robert Hooke discovered the cell (1665) using cork, not the membrane model.
- Option B: Schleiden and Schwann formulated the cell theory (1838–1839).
- Option D: Watson and Crick proposed the double-helix structure of DNA (1953).

Final Answer: Singer and Nicolson proposed the fluid mosaic model $\Rightarrow$ C

Answer: (C) Go Back to Q 1

Sol 2.

Solution

Concept — Incomplete Dominance in Snapdragons: In incomplete dominance neither allele is fully dominant over the other; the heterozygote shows an intermediate phenotype. The F_1 of $RR \times rr$ gives all pink (Rr). Self-fertilising Rr yields F_2 in ratio $1\,RR : 2\,Rr : 1\,rr$ (red : pink : white).

Step 1 — Working out the F_2 cross:

$$Rr \times Rr \longrightarrow \tfrac{1}{4}\,RR\ (\text{red}) : \tfrac{2}{4}\,Rr\ (\text{pink}) : \tfrac{1}{4}\,rr\ (\text{white})$$

Phenotypic ratio $= 1 : 2 : 1$.

Why other options are wrong:

- Option A: "All red" would require complete dominance, not incomplete

dominance.

- Option C: 3 red : 1 white is the Mendelian ratio for complete dominance, not observed here.
- Option D: All pink is the F_1 result, not F_2.

Final Answer: F_2 ratio is 1 red : 2 pink : 1 white $\Rightarrow$ B

Answer: (B) Go Back to Q 2

Sol 3.

Solution

Concept — Partial Pressures in Pulmonary Gas Exchange: Alveolar air has a composition different from atmospheric air due to mixing with dead-space air and gas exchange. The partial pressure of O_2 (pO_2) in alveolar air is approximately **104 mmHg**, which drives diffusion into pulmonary capillary blood ($pO_2 \approx 40$ mmHg).

Step 1 — Key partial pressure values to memorise:

- Alveolar $pO_2 \approx 104$ mmHg; deoxygenated blood $pO_2 \approx 40$ mmHg.
- Alveolar $pCO_2 \approx 40$ mmHg; deoxygenated blood $pCO_2 \approx 45$ mmHg.
- Atmospheric pressure $= 760$ mmHg (total, not pO_2).

Why other options are wrong:

- Option B (40 mmHg): This is the pO_2 of deoxygenated venous blood arriving at the lung, not alveolar air.
- Option C (45 mmHg): This is the pCO_2 of deoxygenated venous blood.
- Option D (760 mmHg): Total atmospheric pressure, not the partial pressure of O_2.

Final Answer: Alveolar $pO_2 \approx 104$ mmHg $\Rightarrow$ A

Answer: (A) Go Back to Q 3

Sol 4.

Solution

Concept — C4 Carbon Fixation Pathway (Hatch-Slack pathway): In C4 plants, CO_2 is first fixed in mesophyll cells by the enzyme PEP carboxylase (PEP-C), which combines CO_2 with phosphoenolpyruvate (PEP) to form a 4-carbon compound — **oxaloacetate (OAA)** — as the first stable product.

Step 1 — Pathway summary:

(a) Mesophyll cell: $CO_2 + \text{PEP} \xrightarrow{\text{PEP-C}} \text{OAA (4C)}$
(b) OAA $\rightarrow$ Malate (transported to bundle sheath cell)
(c) Bundle sheath: Malate decarboxylated $\rightarrow$ CO_2 + Pyruvate; CO_2 enters Calvin cycle.

Why other options are wrong:

- Option A (3-PGA): This is the first stable product in C3 plants (RuBisCO reaction), not C4.
- Option B (RuBP): RuBP is the CO_2 acceptor in C3 plants, not the product.
- Option C (Glucose): Glucose is the end product of the Calvin cycle after multiple turns, not the first CO_2 fixation product.

Final Answer: The first stable product of CO_2 fixation in C4 plants is OAA $\Rightarrow$ $\boxed{\text{D}}$

Answer: (D) Go Back to Q 4

Sol 5.

Solution

Concept — Characteristics of Viruses: Viruses are acellular, obligate intracellular parasites. Each virus contains only one type of nucleic acid (either DNA or RNA — not both simultaneously), which distinguishes them from all cellular life forms.

Step 1 — Evaluating the correct statement: Viruses carry only *one* type of genetic material. DNA viruses (e.g., adenovirus, poxvirus) carry DNA; RNA viruses (e.g., influenza, HIV, SARS-CoV-2) carry RNA. No known virus contains both DNA and RNA as its genome.

Why other options are wrong:

- Option A: Viruses lack ribosomes; they hijack the host cell's ribosomes for

protein synthesis.

- Option B: Viruses cannot grow on nutrient agar because they require living host cells to replicate.
- Option D: Not all viruses have a lipid envelope; non-enveloped (naked) viruses (e.g., poliovirus, adenovirus) lack a lipid coat.

Final Answer: Viruses contain either DNA or RNA, never both $\Rightarrow$ C

Answer: (C) Go Back to Q 5

Sol 6.

Solution

Concept — Levels of Protein Structure: Proteins are organised into four levels of structure. The **secondary structure** refers to localised regular folding of the polypeptide backbone, stabilised mainly by hydrogen bonds between backbone amide and carbonyl groups.

Step 1 — Identifying secondary structural elements: The two most common secondary structures are:

- α-helix: right-handed coil with backbone hydrogen bonds.
- β-pleated sheet: extended strands running parallel or antiparallel, with inter-strand hydrogen bonds.

Why other options are wrong:

- Option B (Primary): Primary structure is the linear amino acid sequence; it has no 3-D folding.
- Option C (Tertiary): Tertiary structure is the overall 3-D folding of a single polypeptide chain (disulfide bonds, hydrophobic interactions, etc.).
- Option D (Quaternary): Quaternary structure describes the arrangement of multiple polypeptide subunits (e.g., haemoglobin).

Final Answer: Alpha-helix and beta-pleated sheet are secondary structures $\Rightarrow$ A

Answer: (A) Go Back to Q 6

Sol 7.

Solution

Concept — Eukaryotic RNA Polymerases: Eukaryotes have three main nuclear RNA polymerases, each transcribing different classes of RNA. RNA polymerase II is responsible for synthesising pre-mRNA (heterogeneous nuclear RNA, hnRNA) that is subsequently processed into mature mRNA.

Step 1 — Roles of the three RNA polymerases:

- RNA Pol I: Transcribes large rRNA (28S, 18S, 5.8S) in the nucleolus.
- RNA Pol II: Transcribes pre-mRNA, most snRNA, and some miRNA.
- RNA Pol III: Transcribes tRNA, 5S rRNA, and some small RNAs.

Why other options are wrong:

- Option A (RNA Pol I): Makes ribosomal RNA, not mRNA.
- Option C (RNA Pol III): Makes tRNA and 5S rRNA, not mRNA.
- Option D (Reverse transcriptase): This is a viral enzyme that synthesises DNA from an RNA template; it is not a normal eukaryotic transcription enzyme.

Final Answer: RNA polymerase II transcribes mRNA in eukaryotes $\Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 7

Sol 8.

Solution

Concept — Ionic Basis of Action Potential: An action potential is generated when a stimulus depolarises the membrane beyond the threshold. During the rapid rising (depolarisation) phase, voltage-gated Na^+ channels open, allowing Na^+ to rush *into* the cell driven by both concentration gradient (high outside) and electrical gradient (negative inside). This influx reverses the membrane potential from -70 mV to approximately $+40$ mV.

Step 1 — Sequence of ionic events:

(a) Stimulus $\rightarrow$ threshold reached (≈ -55 mV).
(b) Voltage-gated Na^+ channels open $\rightarrow$ Na^+ inflow $\rightarrow$ depolarisation to $+40$ mV.
(c) Na^+ channels inactivate; voltage-gated K^+ channels open $\rightarrow$ K^+ outflow $\rightarrow$ repolarisation.

(d) Excess K^+ outflow causes brief hyperpolarisation before resting potential restores.

Why other options are wrong:

- Option A (K^+ outflow): K^+ outflow drives *repolarisation*, not depolarisation.
- Option B (Ca^{2+} inflow): Ca^{2+} influx is important in muscle contraction and neurotransmitter release, not the action potential depolarisation phase in neurons.
- Option C (Na^+ outflow): Na^+ flows *into* the cell during depolarisation, not out.

Final Answer: Rapid depolarisation is caused by inflow of Na^+ ions $\Rightarrow$ D

Answer: (D) Go Back to Q 8

Sol 9.

Solution

Concept — Ecological Succession: Succession is the predictable, directional change in community structure over time. When a *bare, lifeless substrate* (e.g., exposed rock, new volcanic island) is colonised for the first time, the process is called **primary succession**. It begins with pioneer species (lichens, mosses) and progresses through a series of seral stages to a stable climax community.

Step 1 — Primary vs. secondary succession: Primary succession starts on substrates with no previous life and no soil; it is slow (hundreds to thousands of years). Secondary succession occurs where a community was destroyed but soil/seed bank remains (e.g., after a forest fire), and is therefore faster.

Why other options are wrong:

- Option A (Secondary succession): Requires pre-existing soil and organic matter — not applicable to bare rock.
- Option B (Retrogressive succession): A backward succession where a community degrades to an earlier seral stage; opposite direction to the scenario.
- Option D (Biotic succession): Not a standard ecological term; biotic factors *drive* succession but this is not the name of the process.

Final Answer: Bare rock $\rightarrow$ climax community via primary succession $\Rightarrow$ C

Answer: (C) Go Back to Q 9

Sol 10.

Solution

Concept — Endosperm Ploidy in Angiosperms: In flowering plants, double fertilisation produces two structures: the **zygote** (2n, from egg + sperm) and the **endosperm** (3n, from central cell with two polar nuclei + sperm). The endosperm is therefore *triploid*.

Step 1 — Double fertilisation:

$$\text{Egg (n)} + \text{Sperm (n)} \rightarrow \text{Zygote (2n)}$$

$$\text{Central cell: 2 polar nuclei (2n)} + \text{Second sperm (n)} \rightarrow \text{Endosperm (3n)}$$

Why other options are wrong:

- Option B (Diploid): The embryo is diploid, but the endosperm is not.
- Option C (Haploid): Haploid tissues include pollen grains and the egg cell before fertilisation.
- Option D (Tetraploid): No standard angiosperm structure produced by normal double fertilisation is tetraploid.

Final Answer: Endosperm of angiosperms is triploid (3n) $\Rightarrow$ A

Answer: (A) Go Back to Q 10

Sol 11.

Solution

Concept — Hardy-Weinberg Equilibrium: Under HWE, allele and genotype frequencies remain constant across generations. If p = frequency of dominant allele and q = frequency of recessive allele, then $p + q = 1$ and genotype frequencies are p^2 (AA) : $2pq$ (Aa) : q^2 (aa).

Step 1 — Calculating heterozygote frequency:

$$q = 0.3 \implies p = 1 - 0.3 = 0.7$$

$$2pq = 2 \times 0.7 \times 0.3 = 2 \times 0.21 = \mathbf{0.42}$$

Why other options are wrong:

- Option A (0.09): This is $q^2 = (0.3)^2$, the frequency of homozygous recessives.

- Option C (0.49): This is $p^2 = (0.7)^2$, the frequency of homozygous dominants.
- Option D (0.30): This equals q (the allele frequency), not the genotype frequency.

Final Answer: Frequency of heterozygotes $2pq = 0.42 \Rightarrow \boxed{\text{B}}$

Answer: (B) Go Back to Q 11

Sol 12.

Solution

Concept — Restriction Endonucleases: Restriction enzymes are bacterial enzymes that cut double-stranded DNA at specific short sequences (typically 4–8 bp) known as **palindromic sequences** — sequences that read the same on both strands in the $5' \to 3'$ direction (e.g., $5'$-GAATTC-$3'$ for *EcoRI*).

Step 1 — Example of a palindrome:

$$5'\text{-GAATTC-}3' \quad \text{and} \quad 3'\text{-CTTAAG-}5'$$

Reading the complement strand $5' \to 3'$: GAATTC — identical sequence, hence palindromic.

Why other options are wrong:

- Option A (Promoters): Promoters are regulatory sequences where RNA polymerase binds to initiate transcription.
- Option B (Enhancers): Enhancers are cis-regulatory elements that increase transcription levels; not recognition sites for restriction enzymes.
- Option C (Telomeres): Telomeres are repetitive DNA sequences at chromosome ends that protect against degradation.

Final Answer: Restriction enzymes cut at palindromic sequences $\Rightarrow \boxed{\text{D}}$

Answer: (D) Go Back to Q 12

Sol 13.

Solution

Concept — Essential Mineral Nutrients in Plants: Plant nutrients are classified as **macronutrients** (required in large amounts, $> 0.1\%$ dry weight) and **micronutrients** (required in trace amounts). Macronutrients include C, H, O, N, P, K, Ca, S, and **Mg**.

Step 1 — Role of Magnesium: Magnesium is a macronutrient. It is the central atom in the chlorophyll molecule and also activates many enzymes in cellular metabolism (e.g., kinases, ATPases). Plants require Mg in relatively large amounts compared to micronutrients.

Why other options are wrong:

- Option A (Iron): Iron is a *micronutrient*; required in very small amounts (component of cytochromes and nitrogenase).
- Option B (Manganese): Manganese is a micronutrient; involved in photolysis of water (photosystem II).
- Option D (Zinc): Zinc is a micronutrient; activates carbonic anhydrase and auxin biosynthesis.

Final Answer: Magnesium is a macronutrient required by plants $\Rightarrow \boxed{\text{C}}$

Answer: (C) Go Back to Q 13

Sol 14.

Solution

Concept — Pancreatic Endocrine Cells and Insulin: The endocrine portion of the pancreas consists of the islets of Langerhans, which contain different cell types secreting different hormones. **Beta (β) cells** constitute $\approx 70\%$ of the islet cells and secrete **insulin**, which lowers blood glucose by promoting glucose uptake and glycogen synthesis.

Step 1 — Islet cell types and their hormones:

- β (Beta) cells: secrete **insulin** (hypoglycaemic).
- α (Alpha) cells: secrete **glucagon** (hyperglycaemic).
- δ (Delta) cells: secrete **somatostatin** (inhibits both insulin and glucagon).
- Acinar cells: exocrine; secrete digestive enzymes (not hormones).

Why other options are wrong:

- Option B (Alpha cells): Alpha cells secrete glucagon, which raises blood glucose — opposite effect to insulin.
- Option C (Delta cells): Delta cells secrete somatostatin, a regulatory hormone.
- Option D (Acinar cells): Acinar cells are exocrine and produce digestive enzymes like amylase and lipase.

Final Answer: Insulin is secreted by Beta cells of islets of Langerhans $\Rightarrow$ A

Answer: (A) Go Back to Q 14

Sol 15.

Solution

Concept — Crossing Over during Meiosis I: During prophase I of meiosis, homologous chromosomes pair up (synapsis) to form bivalents. At the tetrad stage, non-sister chromatids from the two homologues physically exchange segments at points called **chiasmata**. This process is called **crossing over** and is the molecular basis of recombination, increasing genetic diversity in offspring.

Step 1 — Key events of Prophase I:

(a) *Leptotene*: Chromosomes condense.
(b) *Zygotene*: Homologues begin to pair (synapsis).
(c) *Pachytene*: Crossing over occurs between non-sister chromatids.
(d) *Diplotene*: Chiasmata become visible.
(e) *Diakinesis*: Chromosomes maximally condensed, nuclear envelope breaks down.

Why other options are wrong:

- Option A (Synapsis): Synapsis is the pairing of homologous chromosomes, which *precedes* crossing over; it does not describe the exchange of material.
- Option C (Disjunction): Disjunction is the separation of chromosomes at anaphase I (or II), not the exchange of segments.
- Option D (Translocation): Translocation is a chromosomal mutation where a segment moves to a non-homologous chromosome; it is not the meiotic exchange between homologues.

Final Answer: Exchange of genetic material between non-sister chromatids is called crossing over $\Rightarrow$ B

Answer: (B) Go Back to Q 15

Answer Key

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