Biology

Higher level

Paper 2

2 hours 30 minutes

Instructions to candidates

- Write your session number in the boxes above.
- Do not open the examination paper until instructed to do so.
- Section A: answer all questions.
- Section B: answer two questions.
- Answers must be written in the answer boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination paper is **[80 marks]**.

Section A

1. Plant hormones play crucial roles in growth regulation and stress responses. The following study investigates mutations affecting auxin transport in maize (Zea mays) and their impact on aluminum stress response.

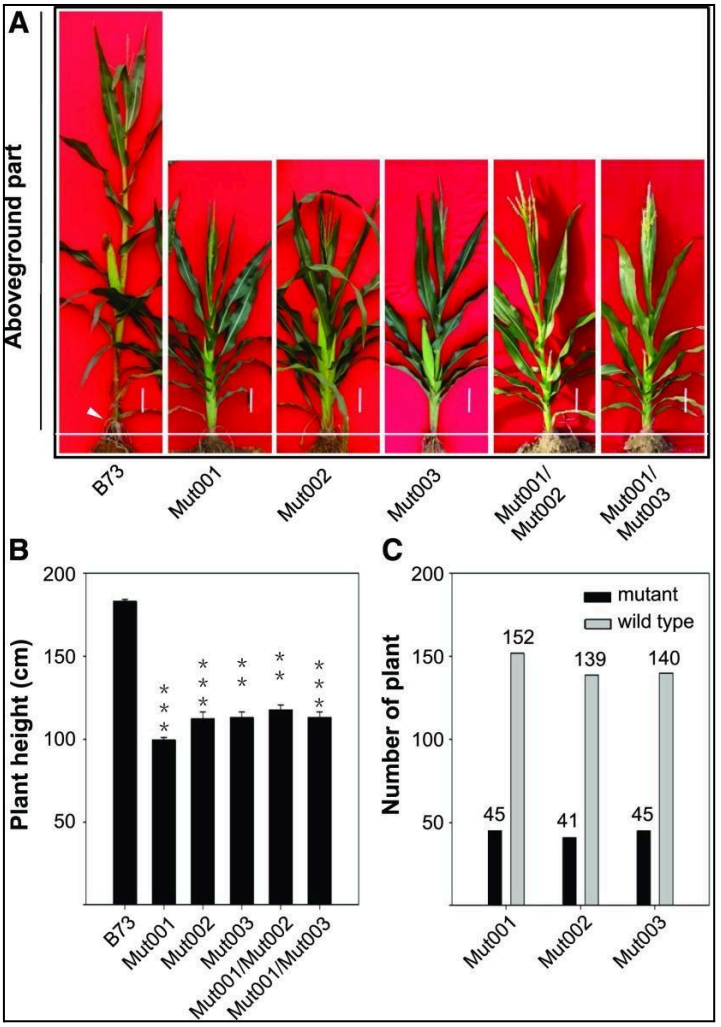

Image 1.

a) Describe two visible phenotypic differences between the wild-type B73 and the Mut001 plants shown in Image 1A. [2]

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b) i) Using data from Image 1B, calculate the percentage decrease in plant height of Mut001 compared to B73. [1]

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ii) State whether the differences in height between B73 and all mutants are statistically significant. [1]

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c) With reference to Image 1C:

i) Calculate the ratio of wild-type to mutant plants for Mut001. [1]

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ii) Suggest what pattern of inheritance these results indicate. [1]

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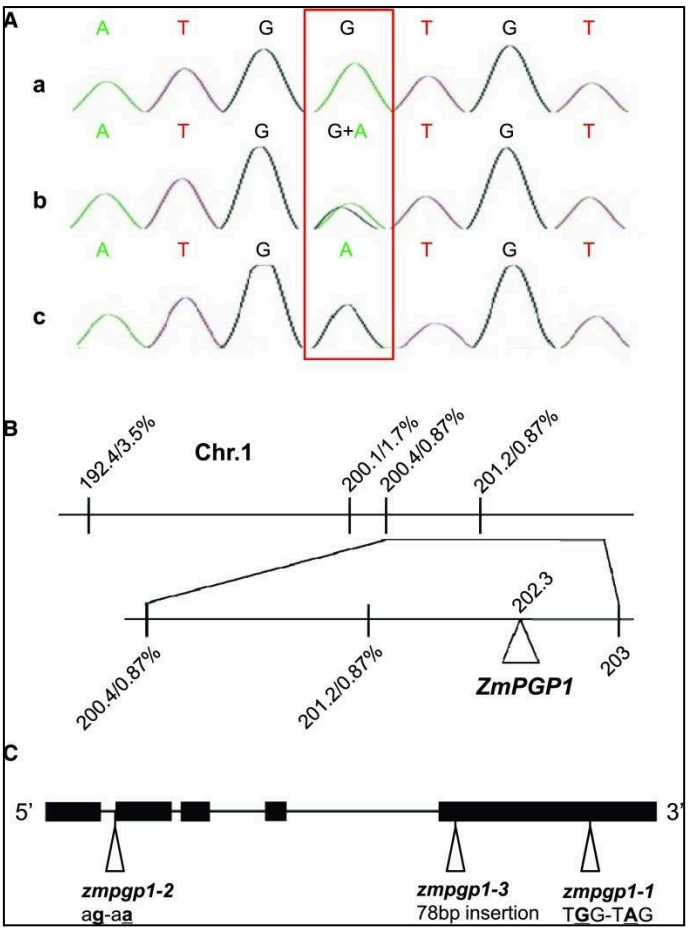

Image 2.

d) i) Identify what the red box in Image 2A highlights. [1]

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ii) Explain what this tells us about the genetic status of this individual. [1]

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e) Outline the relationship between auxin and plant cell elongation based on the information provided and your knowledge of plant hormones. [2]

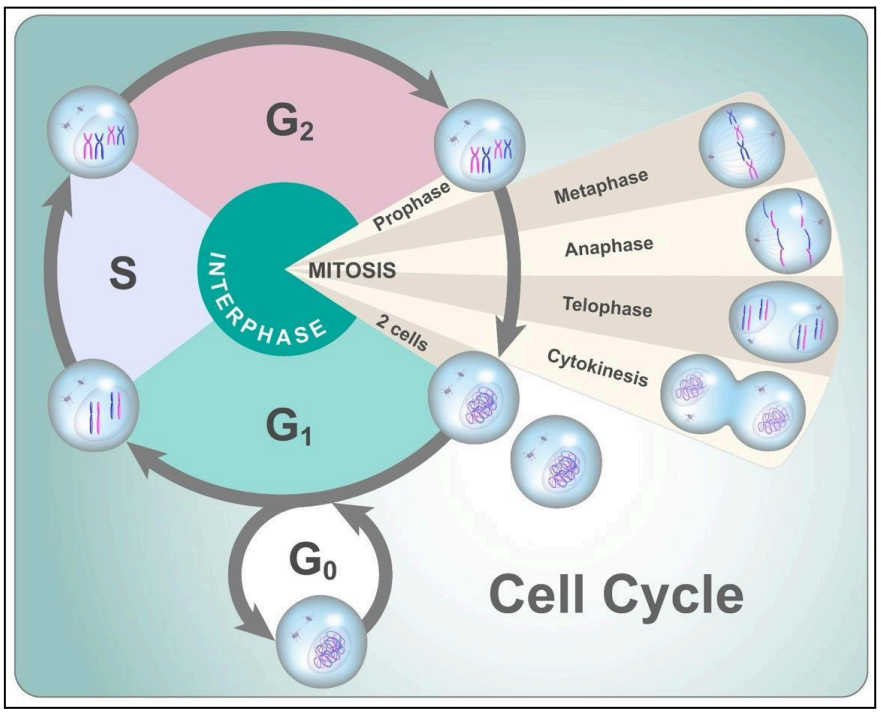
f) The text states: "In maize, Al stress is associated with reduced auxin accumulation in root tips, a process that is regulated by ZmPGP1 and thus causes inhibition of root growth."

i) Explain how a mutation in an auxin transporter could affect plant growth. [2]

ii) Compare the response to aluminum stress in maize versus Arabidopsis as described in the text. [2]

g) Using your understanding of natural selection, suggest one advantage that these mutations might provide to maize plants growing in aluminum-rich soils. [2]

2. The diagrams illustrate changes in the cell during different stages of the cell cycle.



a) i) Identify two structural changes preparing the cell for mitosis. [2]

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ii) Explain why organelle duplication occurs primarily in G1 rather than S phase. [2]

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b) A researcher treats cells with a drug that inhibits protein synthesis:

i) Predict which cell cycle phase would be most affected. [1]

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ii) Justify how this would impact the cell's ability to enter mitosis. [2]

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c) A student claims liver cells spend less time in G1 than these epithelial cells. Give your opinion. [2]

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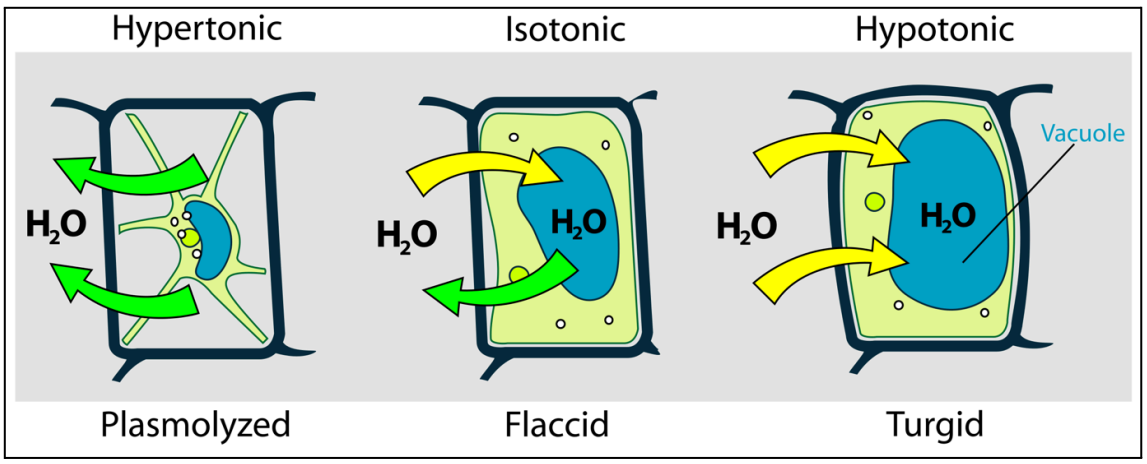
3. The diagram shows a plant cell immersed in solutions of different sucrose concentrations.



a) Using the diagram:

i) Explain the direction of water movement in each condition using water potential concepts. [2]

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ii) Identify which image represents **ψw = 0 kPa** and justify your choice. [1]

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b) Table below showing measured ψ▒ (solute potential) and ψ▒ (pressure potential) values for each condition.

Condition	**ψ▒ (solute potential)**	**ψ▒ (pressure potential)**
Hypotonic solution	-450 kPa	+300 kPa
Isotonic solution	-300 kPa	+100 kPa
Hypertonic solution	-150 kPa	0 kPa

i) Calculate **ψw (water potential)** for the turgid cell when **ψ▒ = -450 kPa** and **ψ▒ = +300 kPa**. [1]

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ii) Predict what would happen to **ψ▒** if this cell was placed in **distilled water (ψw = 0 kPa)**. [2]

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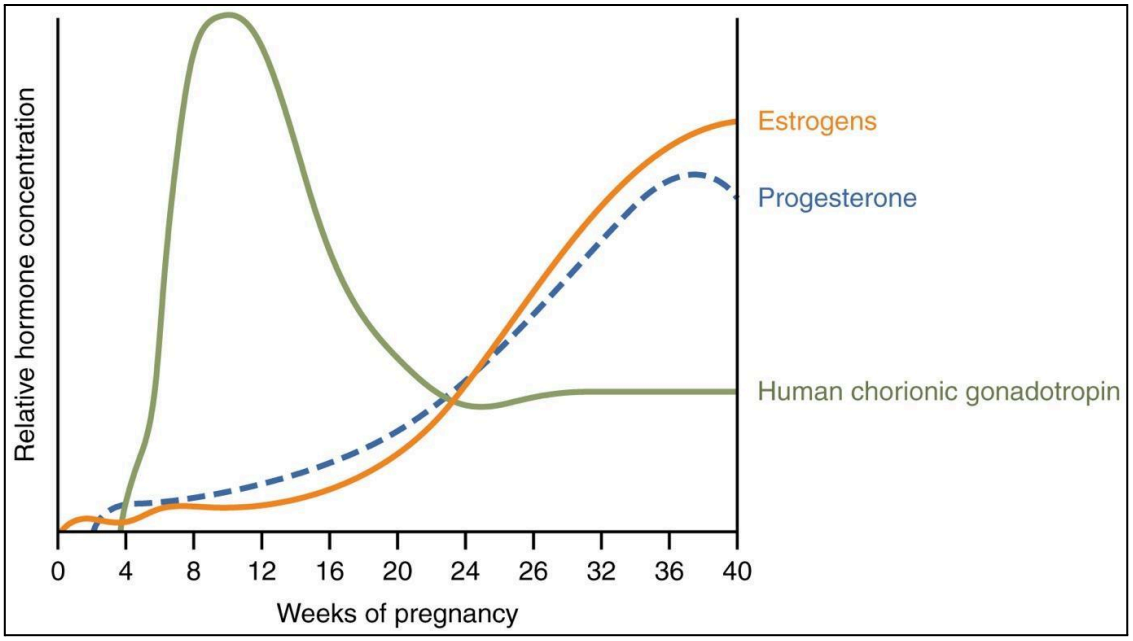
4. The graph below shows hormonal changes during pregnancy.



a) Describe the pattern of hCG secretion during the first trimester. [1]

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b) Comparing the hormones:

i) Calculate the approximate week when progesterone exceeds hCG concentration. [1]

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ii) Suggest why both estrogen and progesterone are needed to maintain pregnancy. [2]

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c) A patient at week 8 has unusually low hCG. Predict two possible clinical implications. [2]

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5. **Table** comparing organ blood flow (mL/min) in three physiological states:

Organ	Sleep	Rest	Exercise
Skeletal muscle	750	1200	12,000
Gut	1400	1100	600
Brain	750	750	750
Kidneys	1100	1000	500

a) Calculate the percentage decrease in renal blood flow during exercise compared to rest. Show the working. [2]

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b) Justify why cerebral blood flow remains nearly constant across all states. [1]

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c) Outline how the kidneys compensate for reduced perfusion during prolonged exercise. [1]

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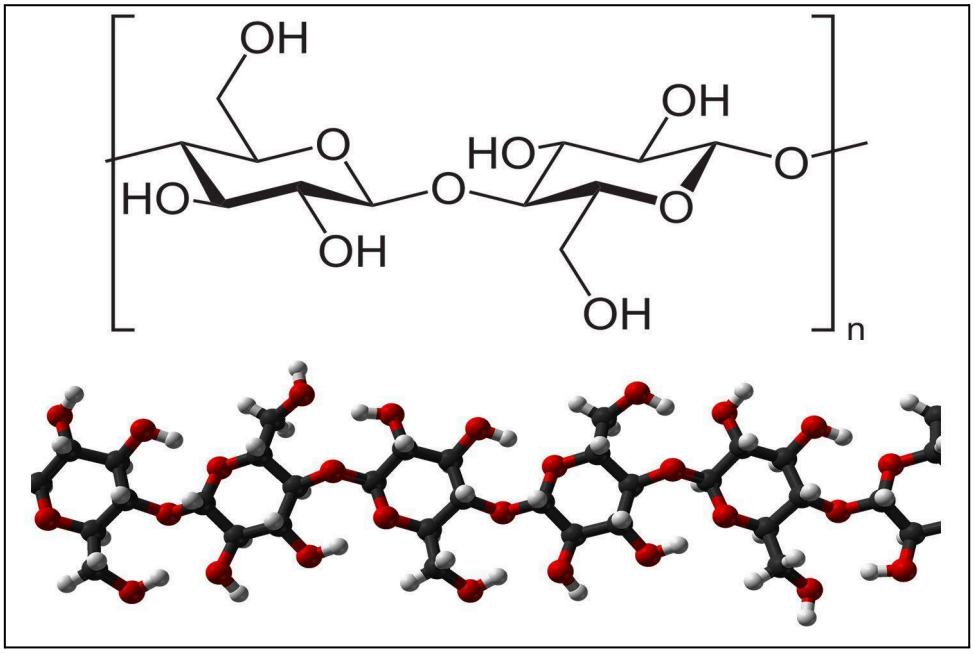
6. The structure of plant cell walls involves the polysaccharide shown in the image below. It is composed of β-glucose units linked by β-1,4-glycosidic bonds.



a) List two properties that make it an effective material for providing structural support in plant cell walls. [2]

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b) Humans lack the enzymes to directly break down this polysaccharide. However, some herbivores are capable of digesting it. Explain. [2]

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7. A population of 1000 moths was surveyed for wing color (alleles: A=dark, a=light). The observed genotype frequencies are shown below.

Genotype	Number of Individuals
AA	640
Aa	320
aa	40

(a) Using the table:

(i) Calculate the frequency of allele *a* (*q*). Show your working. [2]

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(ii) Determine if this population is in Hardy-Weinberg equilibrium by comparing observed vs. expected heterozygous (Aa) frequencies. [2]

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(b) State **one** condition required for Hardy-Weinberg equilibrium that might be violated in this moth population. [1]

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Section B

Answer **two questions**. One additional mark is available for the construction of your answers for each question.

8. Scientific progress often relies on technological innovations and rigorous data analysis, as demonstrated by mid-20th-century discoveries in molecular biology.

(a) State Chargaff's rules and describe how his data varied across species. [4]

(b) Analyze how Chargaff's rules informed the Watson-Crick model, referencing three specific contributions. Discuss why Chargaff's data alone were insufficient to determine the double-helix structure. [7]

(c) Evaluate the impact of the Hershey-Chase experiment on the field of genetics, considering both its strengths and limitations. [4]

9. Modern tools like dichotomous keys and DNA barcoding are revolutionizing how biologists classify and conserve biodiversity.

(a) Design a dichotomous key for three local plant species, using two observable morphological traits per step. [4]

(b) Compare 3 aspects of the utility of dichotomous keys and DNA barcoding in species identification, including one limitation of each method. [7]

(c) Analyze why the biological species concept may fail to define bacterial species, given their ability to exchange plasmids. [4]

10. Eukaryotic cells have evolved specialized compartmentalization to optimize cellular functions, with distinct membrane-bound organelles playing critical roles.

(a) Explain two functional benefits of the nucleus having a double membrane structure. [4]

(b) Compare the roles of free ribosomes and rough endoplasmic reticulum (RER) in protein synthesis, including the destination of their products. [4]

(c) Describe how the Golgi apparatus modifies and packages proteins for secretion, using two examples. [7]