

BIOLOGY PAPER 1

8:30 am – 11:00 am (2 hours 30 minutes)
This paper must be answered in English

GENERAL INSTRUCTIONS

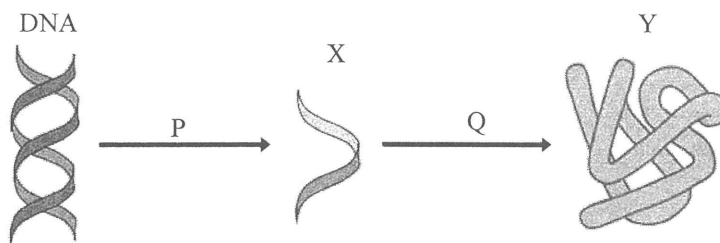
- (1) There are **TWO** sections, A and B, in this Paper. You are advised to finish Section A in about 35 minutes.
- (2) Section A consists of multiple-choice questions in this question paper. Section B contains conventional questions printed separately in Question-Answer Book **B**.
- (3) Answers to Section A should be marked on the Multiple-choice Answer Sheet while answers to Section B should be written in the spaces provided in Question-Answer Book **B**. **The Answer Sheet for Section A and the Question-Answer Book B for Section B will be collected separately at the end of the examination.**

INSTRUCTIONS FOR SECTION A (MULTIPLE-CHOICE QUESTIONS)

- (1) Read carefully the instructions on the Answer Sheet. After the announcement of the start of the examination, you should first stick a barcode label and insert the information required in the spaces provided. No extra time will be given for sticking on the barcode label after the 'Time is up' announcement.
- (2) When told to open this book, you should check that all the questions are there. Look for the words '**END OF SECTION A**' after the last question.
- (3) All questions carry equal marks.
- (4) **ANSWER ALL QUESTIONS.** You are advised to use an HB pencil to mark all the answers on the Answer Sheet, so that wrong marks can be completely erased with a clean rubber. You must mark the answers clearly; otherwise you will lose marks if the answers cannot be captured.
- (5) You should mark only **ONE** answer for each question. If you mark more than one answer, you will receive **NO MARKS** for that question.
- (6) No marks will be deducted for wrong answers.

There are 36 questions in this section.
The diagrams in this section are NOT necessarily drawn to scale.

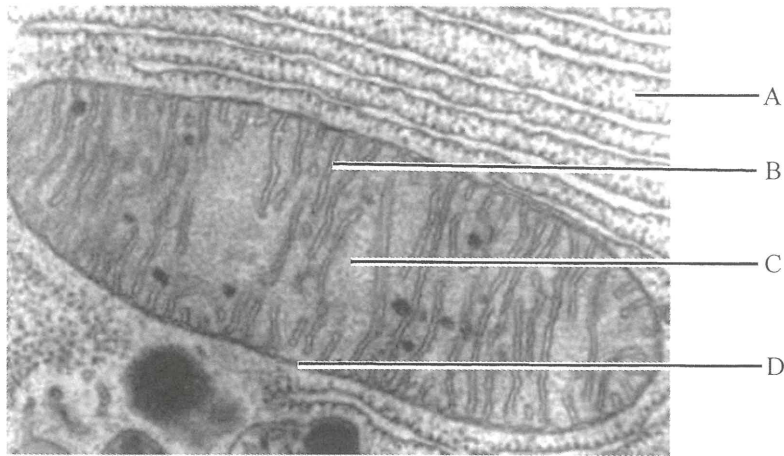
Directions: Questions 1 to 3 refer to the diagram below, which shows the flow of gene expression within a cell:



- X represents
 - a transfer RNA.
 - a DNA template.
 - a ribosomal RNA.
 - a messenger RNA.
- Y could be
 - an enzyme.
 - a hormone.
 - an antibody.
 - (1) and (2) only
 - (1) and (3) only
 - (2) and (3) only
 - (1), (2) and (3)
- Which of the following combinations correctly states what process P is and where process Q takes place?

<i>What process P is</i>	<i>Where process Q takes place</i>
A. translation	cytoplasm
B. translation	nucleus
C. transcription	cytoplasm
D. transcription	nucleus
- Which of the following pairs of molecules contains the greatest amount of stored energy?
 - ADP and NAD
 - ADP and NADH
 - ATP and NAD
 - ATP and NADH

Directions: Questions 5 and 6 refer to the electron micrograph below, which shows a mitochondrion in an animal cell:



5. Which of the following substances passes through D into the mitochondrion during aerobic respiration?

- A. glucose
- B. pyruvate
- C. acetyl-CoA
- D. triose phosphate

6. Anaerobic respiration takes place at

- A. A.
- B. B.
- C. C.
- D. D.

7. Which of the following correctly describe the absorption of amino acids in the small intestine?

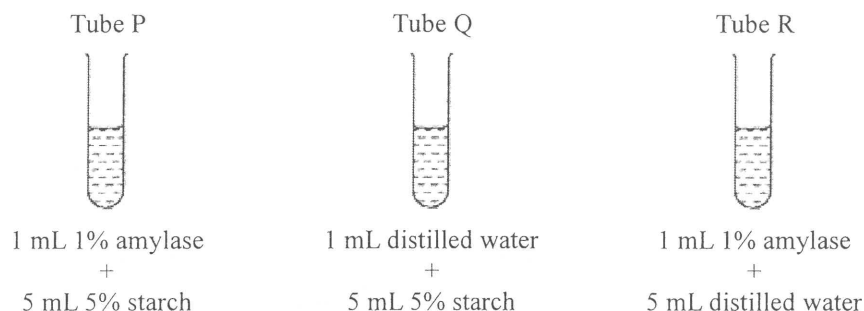
- (1) Amino acids are absorbed into lacteals.
- (2) The absorption is assisted by membrane proteins.
- (3) Amino acids can move along or against a concentration gradient.

- A. (1) and (2) only
- B. (1) and (3) only
- C. (2) and (3) only
- D. (1), (2) and (3)

8. Which of the following combinations correctly lists the requirements of both osmosis and diffusion?

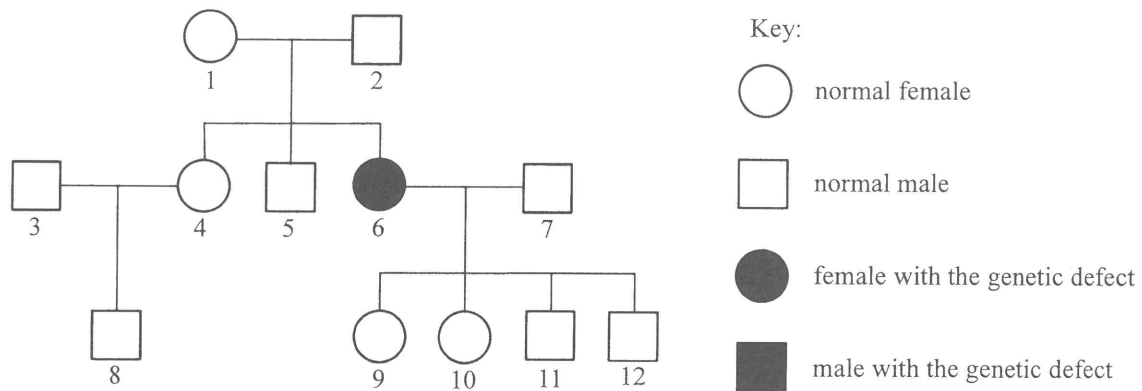
	<i>Concentration gradient</i>	<i>Energy supply</i>	<i>Selectively permeable membrane</i>
A.	Yes	No	Yes
B.	Yes	No	No
C.	No	Yes	Yes
D.	No	Yes	No

Directions: Questions 9 and 10 refer to the diagram below, which shows three set-ups used in the study of the activity of amylase:



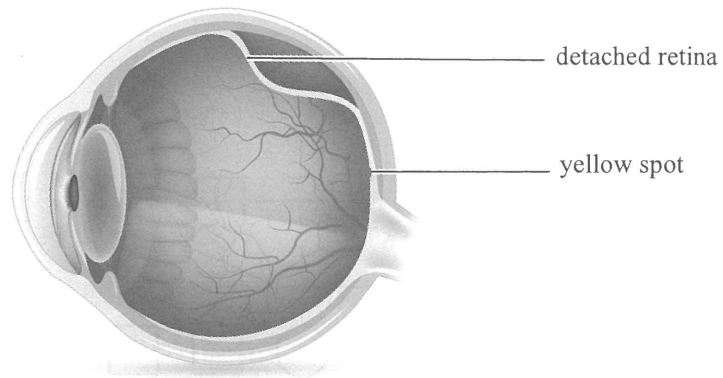
9. We can conclude the action of amylase on starch by comparing the results of tubes
- A. P and Q only.
 - B. P and R only.
 - C. Q and R only.
 - D. P, Q and R.
10. If the following tests are conducted on the reaction mixture of tube P, which test(s) will give the same result at the beginning of the experiment and after 10 minutes?
- (1) iodine test
 - (2) albutix paper
 - (3) Benedict's test
- A. (1) only
 - B. (2) only
 - C. (1) and (3) only
 - D. (2) and (3) only
11. The human ABO blood group system is controlled by multiple alleles. Alleles I^A and I^B lead to the presence of antigens A and B on the surface of red blood cells respectively. Allele i leads to the absence of antigens A and B on the surface of red blood cells. How many genotypes are involved in the ABO blood group system?
- A. 3
 - B. 4
 - C. 6
 - D. 8
12. A pair of identical twins were adopted by two different families. After the twins grow up, which of the following descriptions about them will most likely apply?
- A. They have different shapes of earlobe.
 - B. They have the same pattern of fingerprint.
 - C. They have different degrees of short sightedness.
 - D. They have the same number of freckles on their faces.

Directions: Questions 13 to 15 refer to the pedigree below, which shows the inheritance of a certain genetic defect controlled by a pair of alleles.

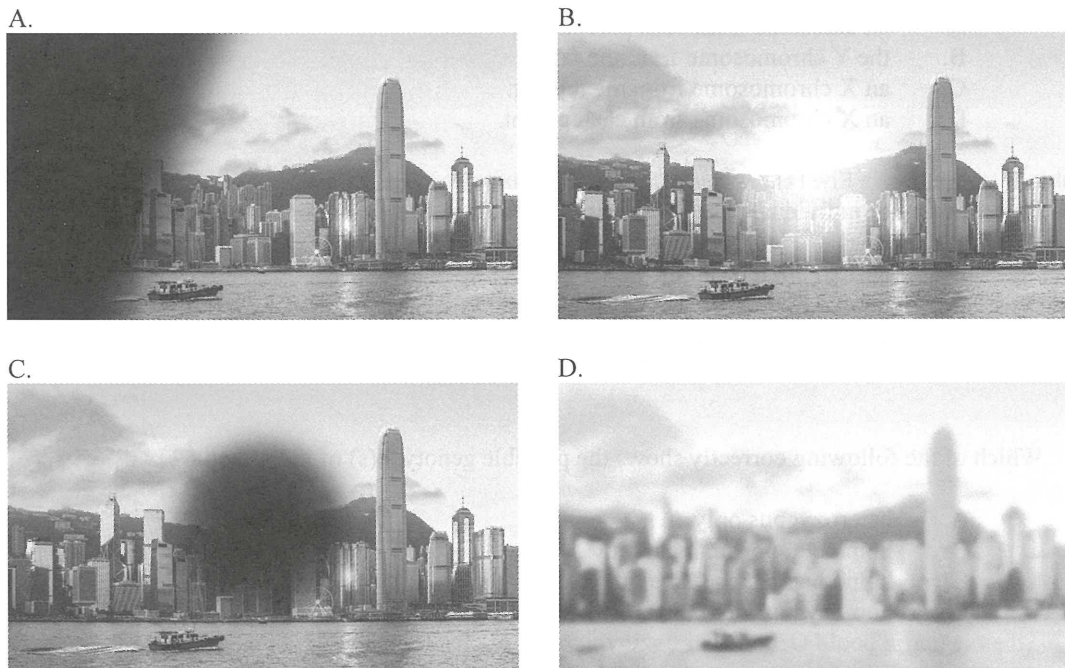


13. The phenotype of individual 6 can be explained by the fact that this individual received a defective allele on
- an autosome from each parent.
 - the Y chromosome from the father.
 - an X chromosome from the mother.
 - an X chromosome from each parent.
14. The offspring of individuals 6 and 7 are normal because each receives a
- normal allele from the father.
 - normal allele from each parent.
 - defective allele from the father.
 - defective allele from the mother.
15. Which of the following correctly shows the possible genotype(s) of individual 8?
- heterozygous only
 - homozygous dominant only
 - homozygous recessive only
 - homozygous dominant and heterozygous
16. In the crossing of a red-flowered plant with a white-flowered plant, half of the F₁ offspring were red-flowered and the other half were white-flowered. When the F₁ white-flowered plants were self-crossed, all the F₂ offspring were white-flowered. What can be concluded?
- The red-flowered parental plant was homozygous.
 - The white-flowered parental plant was heterozygous.
 - White flower is the dominant character in this species of plant.
 - Red flower is the dominant character in this species of plant.
17. Although Mendel proposed that the characteristics of the pea plants were controlled by a pair of 'heredity factors', it was not recognised during his lifetime. His idea was later accepted in the early 20th century because it was supported by
- the theory of natural selection.
 - the same patterns of inheritance in fruit flies.
 - the behaviours of chromosomes in cell division.
 - the discovery of the double helix structure of DNA.

18. The diagram below shows an early stage of an eye defect:

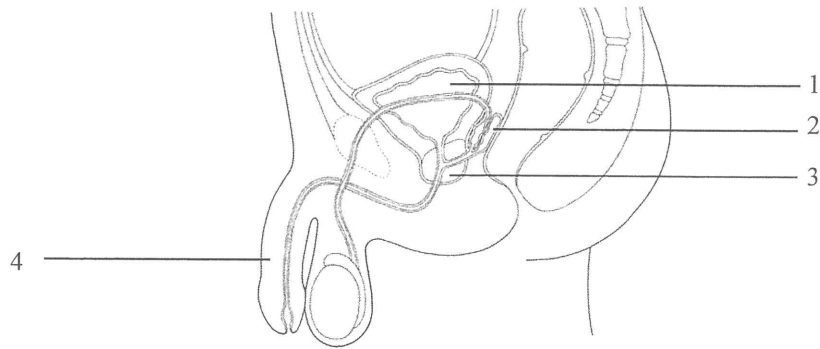


If a person suffers from this eye defect, which of the following diagrams is the most likely vision perceived by this person?



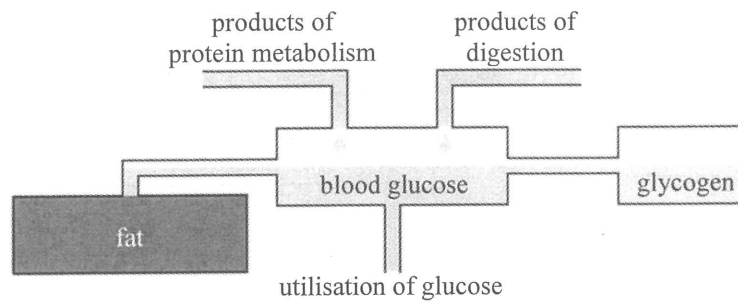
19. Which of the following segments of the alimentary canal absorbs the largest amount of water?
- the oesophagus
 - the stomach
 - the small intestine
 - the large intestine
20. Carbon dioxide produced in the small intestine is passed to the lungs for gas exchange. Which of the following correctly shows the transport route of the carbon dioxide?
- small intestine → lungs
 - small intestine → liver → lungs
 - small intestine → heart → lungs
 - small intestine → liver → heart → lungs

Directions: Questions 21 and 22 refer to the diagram below, which shows the male reproductive system and its associated structures:



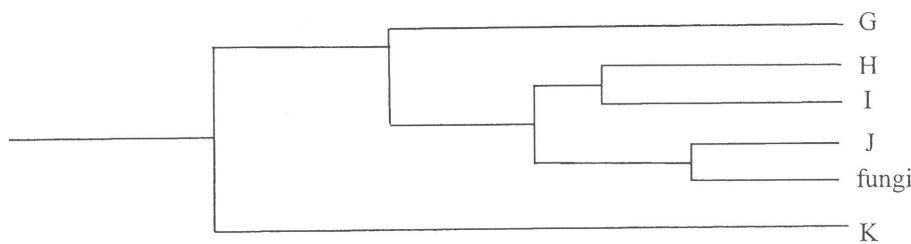
21. Which of the labelled structures are responsible for producing seminal fluid?
- 1 and 2 only
 - 1 and 3 only
 - 2 and 3 only
 - 1, 2 and 3
22. With reference to structure 4 above, which of the following structures of flowering plants has a similar function?
- style
 - anther
 - filament
 - pollen tube
23. Which of the following correctly describe the functions of the intervertebral disc?
- It prevents the wearing of the vertebrae.
 - It encloses the spinal cord.
 - It allows the bending of the vertebral column during movement.
- (1) and (2) only
 - (1) and (3) only
 - (2) and (3) only
 - (1), (2) and (3)
24. Which of the following types of cells can be found in the tissue fluid?
- B cell
 - T cell
 - phagocyte
- (1) and (2) only
 - (1) and (3) only
 - (2) and (3) only
 - (1), (2) and (3)
25. Which of the following is **not** the first line of defence against the invasion of pathogens in humans?
- saliva
 - sweat
 - mucus
 - lymph

Directions: Questions 26 and 27 refer to the model below, which shows the regulation of blood glucose level in humans:



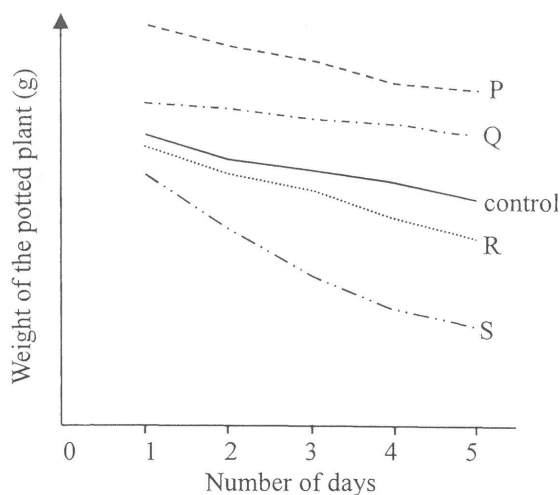
26. A student adds the following remarks to this model. Which remark is *incorrect*?
- Glycogen can be stored in muscles.
 - Insulin converts glucose to glycogen for storage.
 - The products of digestion take the form of simple sugars.
 - The products of protein metabolism come from the liver.
27. When the blood glucose level is higher than normal, which of the following changes is *incorrect*?
- The utilisation of glucose will increase.
 - The conversion of fat to glycogen will increase.
 - The conversion of blood glucose to fat will increase.
 - The conversion of blood glucose to glycogen will increase.

Directions: Questions 28 and 29 refer to the diagram below, which shows an evolutionary tree demonstrating the phylogenetic relationship of the six kingdoms:



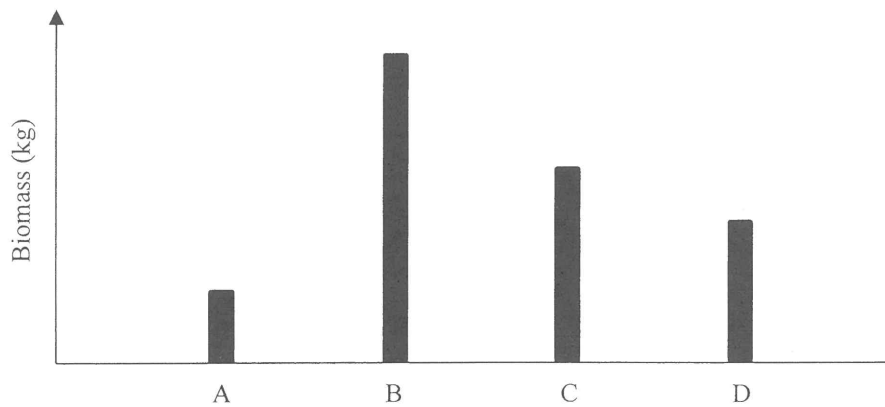
28. Which of the following combinations correctly shows the kingdoms represented by G, J and K in the evolutionary tree?
- | | G | J | K |
|----|-----------------|----------|------------|
| A. | Archaeobacteria | Animalia | Eubacteria |
| B. | Archaeobacteria | Plantae | Eubacteria |
| C. | Eubacteria | Plantae | Protista |
| D. | Eubacteria | Animalia | Protista |
29. Which of the following pairs of organisms belongs to the same domain?
- G and K
 - G and H
 - H and J
 - J and K

Directions: Questions 30 and 31 refer to the graph below, which shows the effect of environmental conditions on the transpiration rate of a potted plant placed in a small room. The weight of the potted plant was recorded daily at noon for five consecutive days (control experiment). The experiment was repeated by changing one of the environmental conditions: increased light intensity, increased air current, increased relative humidity, or increased temperature.



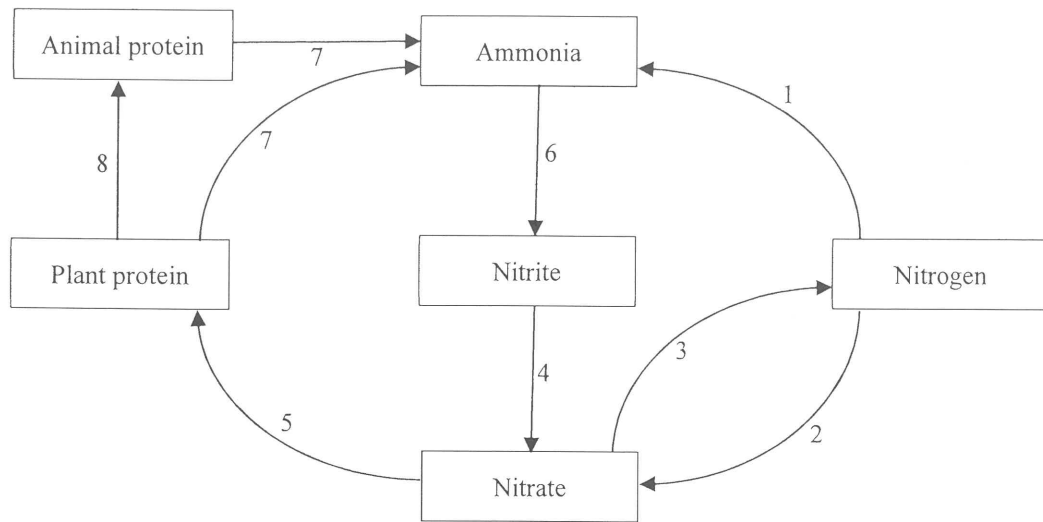
30. Which of the following lines represents the results with an increased relative humidity?
- P
 - Q
 - R
 - S
31. In the above study, which of the following steps is necessary?
- Remove any fallen leaves.
 - Wrap the pot with a plastic bag.
 - Water the plant every day in the morning.
 - Smear vaseline on the lower epidermis of the leaves.
32. During primary succession in a terrestrial habitat, which of the following descriptions about the ecosystem is *incorrect*?
- The nutrient level of the soil decreases.
 - The complexity of the food web increases.
 - The abundance of non-vascular plants decreases.
 - The energy available to the community increases.

Directions: Questions 33 and 34 refer to the following graph, which shows the biomasses of four populations forming a food chain in a terrestrial habitat:



33. Which population is most likely the autotrophs in this habitat?
- A. A
 - B. B
 - C. C
 - D. D
34. What would you expect to happen if the number of individuals in population D decreased?
- A. The number of individuals in population A would increase.
 - B. The number of individuals in population C would decrease.
 - C. The amount of energy passed to population A would decrease.
 - D. The amount of energy passed to population C would increase.

Directions: Questions 35 and 36 refers to the diagram below, which shows some natural processes involved in the nitrogen cycle:



35. Process 2 refers to

- A. lightning.
- B. nitrification.
- C. denitrification.
- D. nitrogen fixation.

36. Which of the following pairs of processes involves the action of bacteria?

- A. 1 and 5
- B. 2 and 6
- C. 3 and 7
- D. 4 and 8

END OF SECTION A

Go on to Question-Answer Book B for questions on Section B

BIOLOGY PAPER 1

SECTION B: Question-Answer Book B

This paper must be answered in English

INSTRUCTIONS FOR SECTION B

- (1) After the announcement of the start of the examination, you should first write your Candidate Number in the space provided on Page 1 and stick barcode labels in the spaces provided on Pages 1, 3, 5, 7 and 9.
- (2) Refer to the general instructions on the cover of the Question Paper for Section A.
- (3) Answer **ALL** questions.
- (4) Write your answers in the spaces provided in this Question-Answer Book. Do not write in the margins. Answers written in the margins will not be marked.
- (5) Supplementary answer sheets will be supplied on request. Write your candidate number, mark the question number box and stick a barcode label on each sheet, and fasten them with string **INSIDE** this Question-Answer Book.
- (6) Present your answers in paragraphs wherever appropriate.
- (7) The diagrams in this section are **NOT** necessarily drawn to scale.
- (8) No extra time will be given to candidates for sticking on the barcode labels or filling in the question number boxes after the 'Time is up' announcement.

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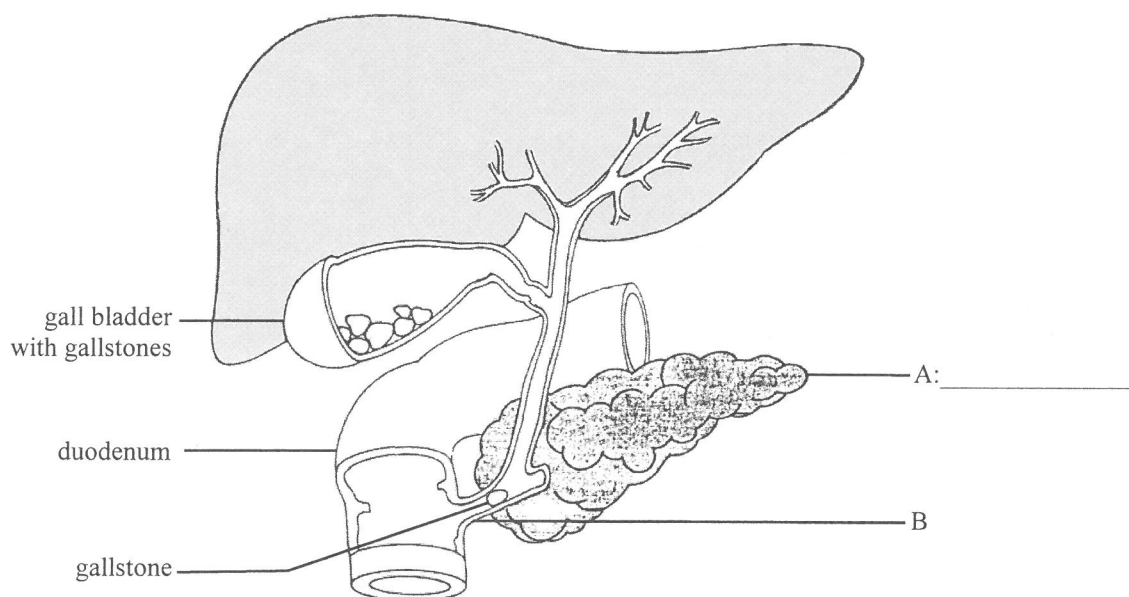
Candidate Number



SECTION B

Answer ALL questions. Write your answers in the spaces provided.

1. The diagram below shows the presence of gallstones in some parts of the human digestive system:



- (a) Label structure A. (1 mark)
- (b) With reference to *two* components of the secretion released from duct B, explain how the condition shown in the above diagram would lead to a decrease in the rate of fat digestion. (4 marks)

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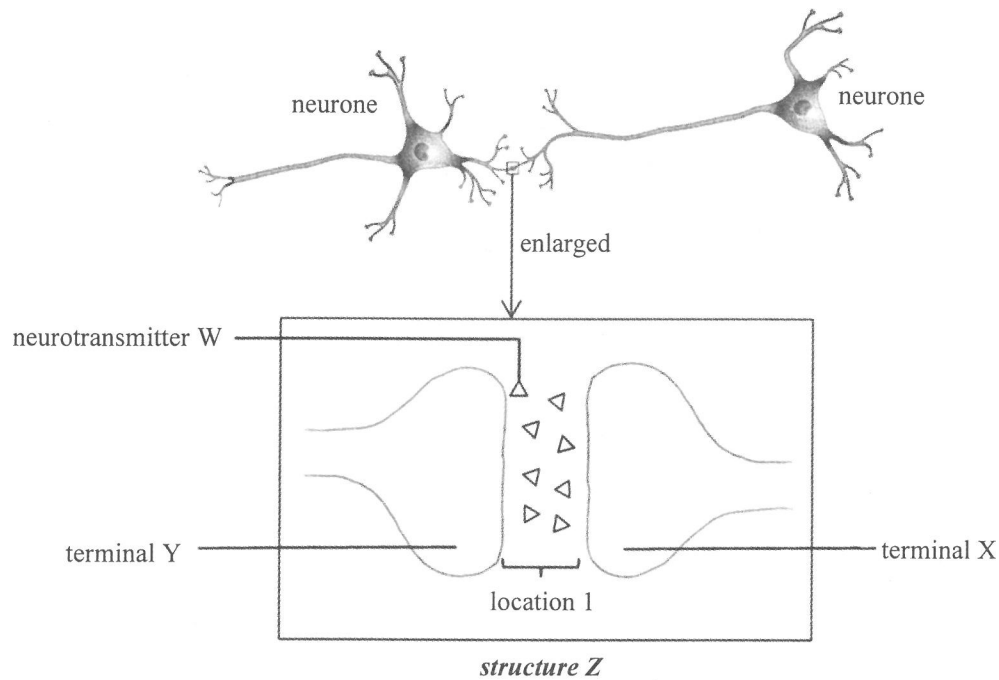
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2. The diagram below shows two adjacent neurones. When a nerve impulse arrives at structure Z, the amount of neurotransmitter W at location 1 increases.



- (a) Name structure Z. (1 mark)

- (b) (i) Neurotransmitter W at location 1 is released from one of the terminals of structure Z. Which terminal (X or Y) releases neurotransmitter W? (1 mark)

- (ii) Describe how the neurotransmitter W at location 1 can bring about the transmission of nerve impulses at structure Z. (2 marks)

- (c) What is the significance of the process in (b) to the transmission of nerve impulses? (1 mark)

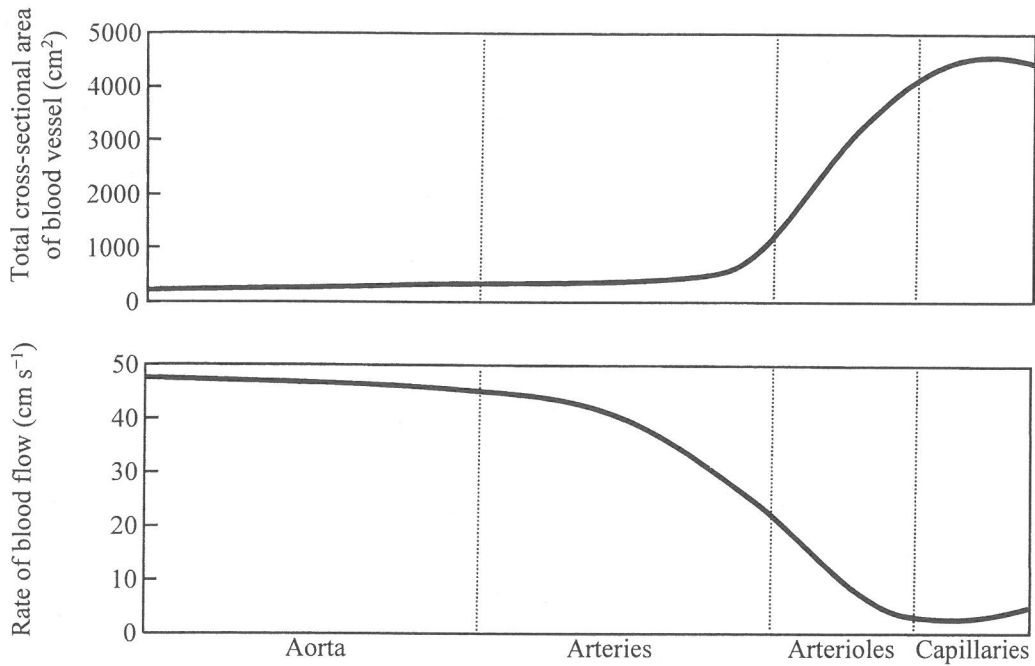
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3. (a) The graph below shows the total cross-sectional area and the rate of blood flow of different types of blood vessels:



- (i) Describe the overall relationship between the total cross-sectional area of blood vessels and the rate of blood flow. (1 mark)

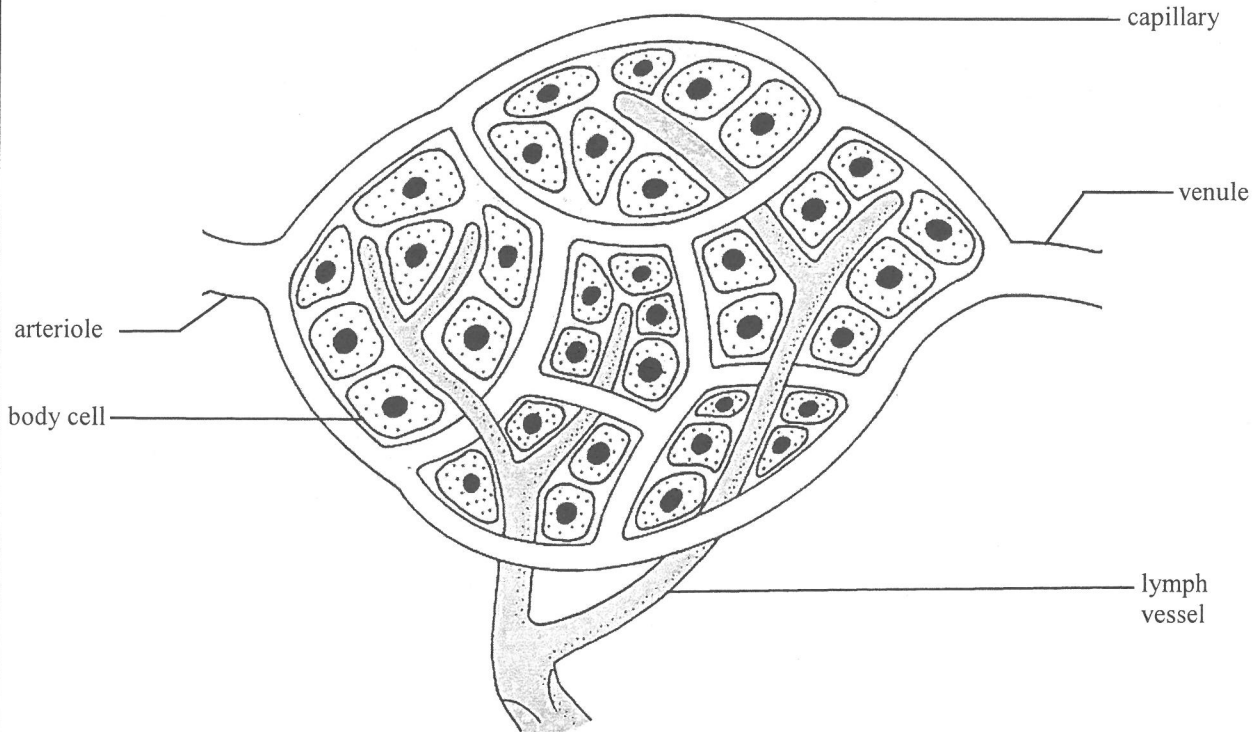
- (ii) Explain how the relationship described in (i) can facilitate the material exchange that takes place in the capillaries. (2 marks)

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(b) The following schematic diagram illustrates a capillary network and the associated structures:



With reference to *two* features of the capillary network illustrated in the above diagram, explain the importance of these features to the material exchange in the capillary network. (4 marks)

<i>Features illustrated in the diagram</i>	<i>Importance to the material exchange</i>

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4. Glycogen and a disaccharide named trehalose are two common types of energy reserve found in insect species A. An experiment was conducted to study the energy reserve used for flying in this insect species. Three groups of insect species A were respectively injected with equal volumes of physiological saline, an inhibitor of trehalose-digesting enzyme and an inhibitor of glycogen-digesting enzyme. The insects were then stimulated to fly until they were exhausted. The flight time of each individual was recorded in the following table:

Solution injected	Samples of insect species A	Flight time (s)	Mean flight time (s)
physiological saline	1	150	165.6
	2	138	
	3	168	
	4	210	
	5	162	
inhibitor of trehalose-digesting enzyme	6	42	
	7	78	
	8	114	
	9	90	
	10	102	
inhibitor of glycogen-digesting enzyme	11	132	
	12	192	
	13	174	
	14	162	
	15	156	

- (a) Complete the above table by calculating the mean flight time (to the nearest 1 decimal place) for the groups injected with the respective inhibitors. (1 mark)
- (b) With reference to the aim of the experiment, what conclusions can you draw from the data? Explain your answer. (4 marks)

- (c) Among individual insects, suggest *one* difference which led to different flight times within each group. (1 mark)

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5. A student prepared cells of an onion root tip for observing cell division under a light microscope.

(a) What type of cell division is likely to take place in the root tip of an onion? Explain your answer. (2 marks)

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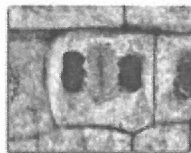
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(b) Suggest *one* necessary step to make the chromosomes observable under a light microscope. (1 mark)

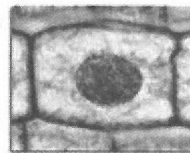
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(c) Some events of the cell division are randomly shown in the following photomicrographs:



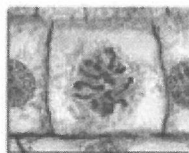
V



W



X



Y



Z

(i) Starting with photomicrograph W, arrange the photomicrographs in the correct order to show the sequence of events in cell division. (1 mark)

W → → → →

(ii) A normal onion root cell has 16 chromosomes. Complete the following table to show the number of chromosomes and chromatids in photomicrographs Y and Z. (2 marks)

Photomicrograph	Number of chromosomes	Number of chromatids
Y		
Z		

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6. Pathogen X is a pathogen that infects humans. Research has discovered an antigen Y present on the surface of pathogen X. Using recombinant DNA technology, antigen Y can be produced and serves as a vaccine to induce immunity against pathogen X.

(a) Explain how the injection of antigen Y can induce immunity against pathogen X. (4 marks)

(b) Other than the use of recombinant DNA technology, suggest another way to produce a vaccine. (1 mark)

(c) Refer to the codon table below, answer the questions that follow:

UUU	Phe	UCU	Ser	UAU	Tyr	UGU	Cys
UUC		UCC		UAC		UGC	
UUA	Leu	UCA	STOP codon	UAA	STOP codon	UGA	STOP codon
UUG		UCG		UAG		UGG	
CUU	Leu	CCU	Pro	CAU	His	CGU	Arg
CUC		CCC		CAC		CGC	
CUA		CCA		CAA	Gln	CGA	
CUG		CCG		CAG		CGG	
AUU	Ile	ACU	Thr	AAU	Asn	AGU	Ser
AUC		ACC		AAC		AGC	
AUA		ACA		AAA	Lys	AGA	
AUG	Met	ACG	AAG	AGG		Arg	
GUU	Val	GCU	Ala	GAU	Asp	GGU	Gly
GUC		GCC		GAC		GGC	
GUA		GCA		GAA	Glu	GGA	
GUG		GCG		GAG		GGG	

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- (i) The starting sequence of the coding strand of the gene which encodes antigen Y is shown below:

ATG GCC ATA AAT TGC TGT

Referring to the codon table, write the corresponding amino acid sequence of the coding strand shown above. (2 marks)

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- (ii) Over the years, mutation has occurred in the gene encoding antigen Y in different strains of pathogen X. The variations in the starting sequence of this gene are shown below:

original strain: ATG GCC ATA AAT TGC TGT

strain P: ATG GCC ATA AAT TGC TGC

strain Q: ATG GCC ATA AAT TGA TGT

strain R: ATG GCT ATA AAC TGC TGT

One of these strains has the ability to infect people who have been injected with the vaccine containing antigen Y. With reference to the codon table, which strain (P, Q or R) will that be? Explain your answer. (4 marks)

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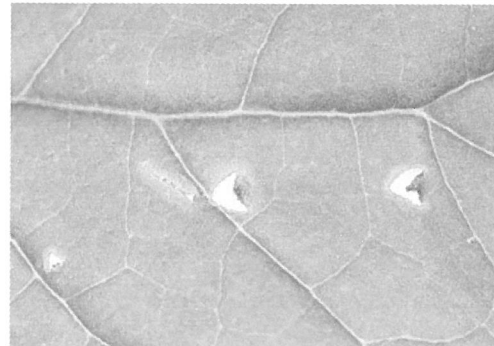
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7. (a) In flowering plants, environmental stress (i.e. under adverse conditions) in general can induce flowering. Explain why this flowering response can increase the chance of survival of flowering plants. (3 marks)

- (b) Recently, scientists observed that bees cut tiny holes in leaves with their mouthparts (as shown in the photographs below) but did not consume or transport the leaf fragments:



It has been hypothesised that bees induce flowering by imposing a mechanical stress on the flowering plants. To test this hypothesis, three groups of tomato plants at the same developmental stage (without floral buds) were subjected to the following treatments respectively:

1. Bees cut tiny holes in leaves (bee damage)
2. Similar holes in leaves were cut by using forceps (mechanical damage)
3. Intact leaves without treatment (no damage)

The time taken for flowering of each group of these tomato plants after the respective the treatment was recorded.

- (i) If the above hypothesis is correct, what would be the predicted results? (1 mark)

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Answers written in the margins will not be marked.

(ii) The table below shows the time taken for flowering of these tomato plants after the treatments:

	Bee damage	Mechanical damage	No damage
Average time taken for flowering after the treatment (days)	38	56	70

With reference to the data shown in the table, discuss if the data support the hypothesis that bees induce flowering by imposing a mechanical stress on the flowering plants. (4 marks)

(c) When bees establish a new colony, they will inflict more leaf damage to the surrounding flowering plants if the colony is in an area with insufficient supply of pollen. What is the advantage of this behaviour to the bees? (1 mark)

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Answers written in the margins will not be marked.

8. The table below shows the average blade area, blade thickness and thickness of the palisade mesophyll of leaves collected from the upper and lower regions of a tree species:

Location of leaves	Average blade area (cm ²)	Average blade thickness (µm)	Average thickness of palisade mesophyll (µm)
Upper region	62	177	45
Lower region	72	152	33

- (a) Compare the average blade area of leaves from the upper region and that from the lower region. With respect to the difference in surface area, suggest *one* adaptive advantage of the leaves from the lower region. (2 marks)

- (b) (i) Compare the average thickness of the palisade mesophyll of leaves from the upper region and that from the lower region. (1 mark)

- (ii) Between the two types of leaves, suggest *one* possible structural difference which would lead to the difference stated in (b)(i). (1 mark)

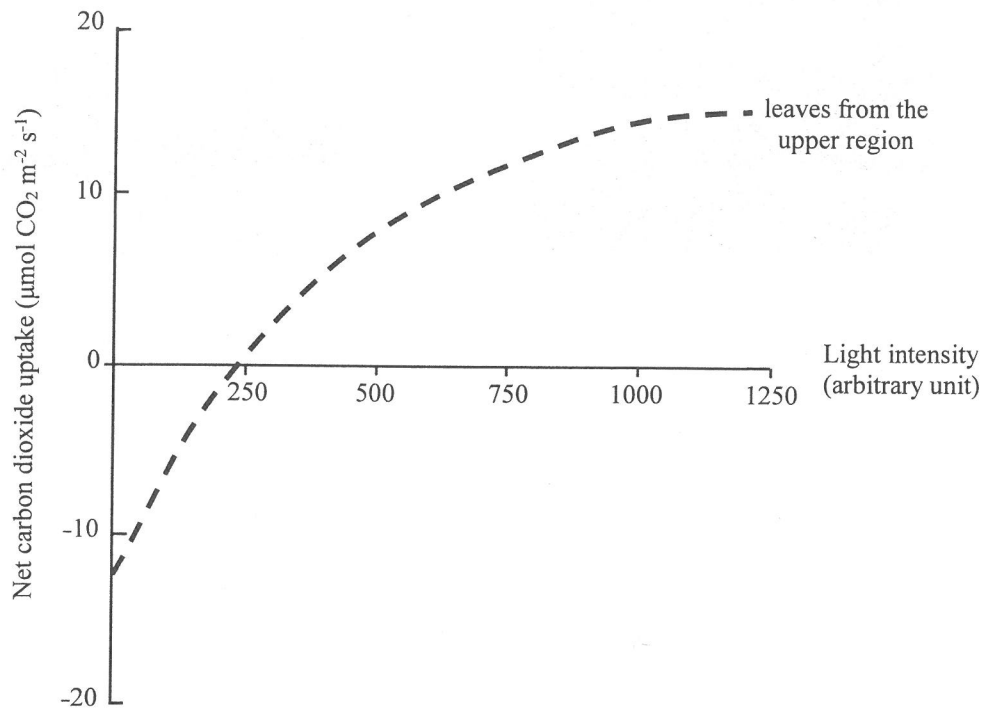
- (iii) How would you confirm your answer in (b)(ii)? (2 marks)

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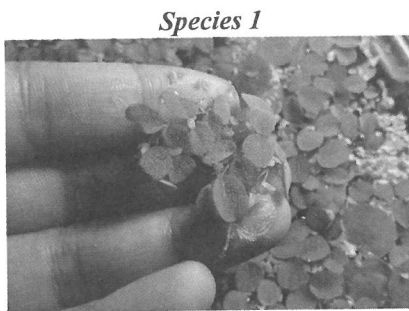
- (c) Leaves at different regions of a tree are adapted to different light intensities. The graph below shows the change in the net carbon dioxide uptake by leaves from the upper region of a tree at different light intensities:



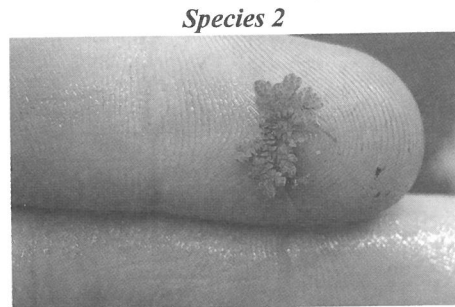
- (i) Why are there negative values for net carbon dioxide uptake? (1 mark)

- (ii) On the above graph, sketch a line to show the change in net carbon dioxide uptake by leaves from the lower region of a tree at different light intensities. (2 marks)
 (Note: Neglect the difference in the average blade area between the two types of leaves when you sketch the line.)

9. The photographs below show the appearances of two species of free-floating, freshwater plants, Species 1 and Species 2:



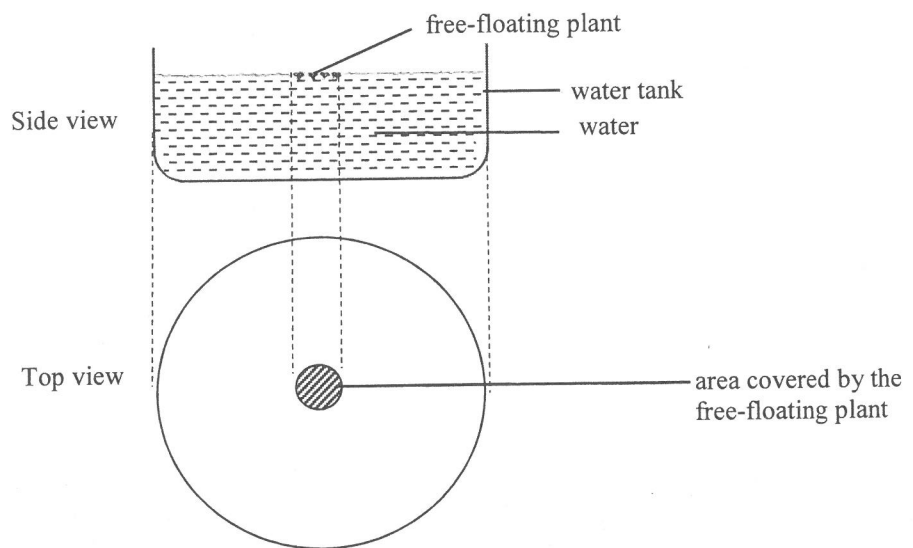
(0.58 X)



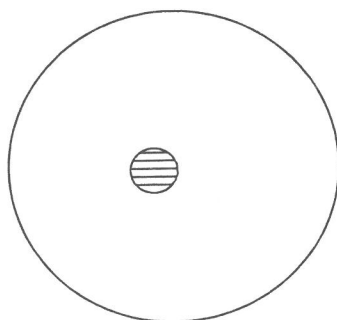
(1.5 X)

To study the interaction between these two plant species, each species was grown either alone or together with another species in a water tank for 50 days. Each species covered 10% of the area of water surface at the beginning of the experiment. The experimental set-up and design are shown in the following diagrams:

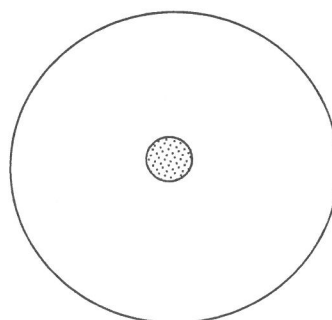
Experimental set-up:



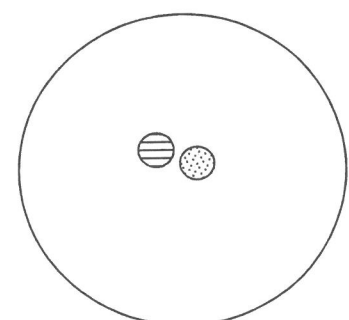
Experimental design (top view):



Species 1 grown alone



Species 2 grown alone



Species 1 and 2 grown together

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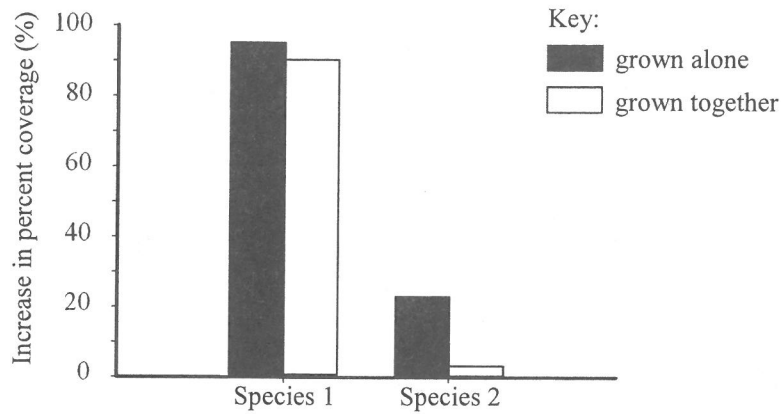
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The percent coverage of each plant species was measured at the beginning and at the end of the experiment. The increases in the percent coverage are shown below:



- (a) With reference to the aim of the experiment, what conclusions can be drawn about the interaction between Species 1 and 2? Explain your answer. (4 marks)

Conclusion 1:

Conclusion 2:

- (b) With reference to the photographs of Species 1 and 2, suggest an explanation for the difference in the percent coverage of the two plant species when they were grown together. (2 marks)

- (c) The table below shows two other methods of measuring plant growth and whether these methods would be feasible in this experiment. Complete the table by giving justifications for the feasibility of the methods. (2 marks)

<i>Method</i>	<i>Feasibility</i>	<i>Justifications</i>
Fresh weight	Feasible	
Number of leaves	Not feasible	

Answers written in the margins will not be marked.

10. In humans, breast milk provides not only nutrients but also protective effects to infants. Recently, scientists discovered a new constituent of breast milk: short RNA fragments enclosed in vesicles. Scientists have very diverse views about the roles of these short RNA fragments. The following are two of the hypotheses:

Hypothesis 1: the short RNA fragments serve as food particles

Hypothesis 2: the short RNA fragments regulate gene expression in infants

(a) To test Hypothesis 1, scientists performed an experiment of *in vitro* digestion of breast milk. The method is shown below:

Method of *in vitro* digestion with 20 mL of fresh breast milk

Step 1	Addition of hydrochloric acid solution
Step 2	Addition of enzyme mixture 1
Step 3	Incubation at 37°C for 20 minutes
Step 4	Addition of sodium hydrogen carbonate solution
Step 5	Addition of enzyme mixture 2
Step 6	Incubation at 37°C for 30 minutes
Step 7	Incubation at 85°C for 3 minutes
Step 8	Measurement of the level of short RNA fragments and nucleotides

(i) With reference to the digestion in the human body, what is the importance of Step 1 and Step 4 to the experimental design of this *in vitro* experiment? (3 marks)

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(ii) What is the purpose of Step 7? (1 mark)

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(iii) After the *in vitro* digestion, the level of short RNA fragments in the reaction mixture was similar to that of fresh breast milk and no nucleotides were detected. Explain why the results disprove Hypothesis 1. (2 marks)

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- (b) Scientists will ask scientific questions when designing experiments to test Hypothesis 2. Suggest *one* example of these scientific questions. (1 mark)

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You are required to present your answer to the following question in essay form. Criteria for marking will include relevant content, logical presentation and clarity of expression.

11. Variations are important to the continuity of a population. Discuss how these variations are brought about within a population and how variations can enable the population to cope with the diverse environmental conditions and environmental changes over time. (11 marks)

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