

FOR OFFICIAL USE

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X007/301

Total for
Sections
B and C

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NATIONAL
QUALIFICATIONS
2003

MONDAY, 26 MAY
1.00 PM – 3.30 PM

BIOLOGY
HIGHER

Fill in these boxes and read what is printed below.

Full name of centre

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Town

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Forename(s)

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Surname

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Date of birth

Day Month Year

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Scottish candidate number

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Number of seat

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SECTION A—Questions 1–30 (30 marks)

Instructions for completion of Section A are given on page two.

SECTIONS B AND C (100 marks)

- (a) All questions should be attempted.

(b) It should be noted that in **Section C** questions 1 and 2 each contain a choice.
- The questions may be answered in any order but all answers are to be written in the spaces provided in this answer book, and must be written clearly and legibly in ink.
- Additional space for answers and rough work will be found at the end of the book. If further space is required, supplementary sheets may be obtained from the invigilator and should be inserted inside the **front** cover of this book.
- The numbers of questions must be clearly inserted with any answers written in the additional space.
- Rough work, if any should be necessary, should be written in this book and then scored through when the fair copy has been written.
- Before leaving the examination room you must give this book to the invigilator. If you do not, you may lose all the marks for this paper.



SECTION A

Read carefully

- 1 Check that the answer sheet provided is for Biology Higher (Section A).
- 2 Fill in the details required on the answer sheet.
- 3 In this section a question is answered by indicating the choice A, B, C or D by a stroke made in **ink** in the appropriate place in the answer sheet—see the sample question below.
- 4 For each question there is only **one** correct answer.
- 5 Rough working, if required, should be done only on this question paper—or on the rough working sheet provided—**not** on the answer sheet.
- 6 At the end of the examination the answer sheet for Section A **must** be placed inside the front cover of this answer book.

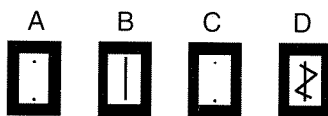
Sample Question

The apparatus used to determine the energy stored in a foodstuff is a

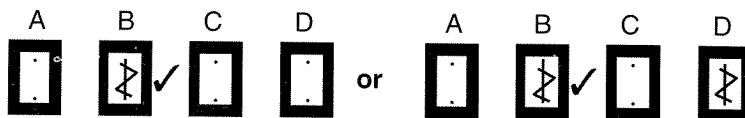
- A respirometer
- B calorimeter
- C klinostat
- D gas burette.

The correct answer is **B**—calorimeter. A **heavy** vertical line should be drawn joining the two dots in the appropriate box in the column headed **B** as shown in the example on the answer sheet.

If, after you have recorded your answer, you decide that you have made an error and wish to make a change, you should cancel the original answer and put a vertical stroke in the box you now consider to be correct. Thus, if you want to change an answer D to an answer B, your answer sheet would look like this:



If you want to change back to an answer which has already been scored out, you should enter a tick (✓) to the **right** of the box of your choice, thus:



SECTION A

All questions in this section should be attempted.

Answers should be given on the separate answer sheet provided.

1. The table below shows the concentrations of three ions found in sea water and in the sap of the cells of a seaweed.

	Ion concentrations (mg l ⁻¹)		
	potassium	sodium	chloride
sea water	0.01	0.55	0.61
cell sap	0.57	0.04	0.60

Which of the following statements is supported by the data in the table?

- A Potassium and sodium ions are taken into the cell by active transport.
 - B Potassium and chloride ions are removed from the cell by diffusion.
 - C Sodium ions are removed from the cell by active transport.
 - D Chloride and sodium ions are removed from the cell by diffusion.
2. A piece of muscle was cut into three strips, X, Y and Z, and treated as described in the table.

Their final lengths were then measured.

Muscle strip	Solution added to muscle	Muscle length (mm)	
		Start	After 10 minutes
X	1% glucose	50	50
Y	1% ATP	50	45
Z	1% ATP boiled and cooled	50	46

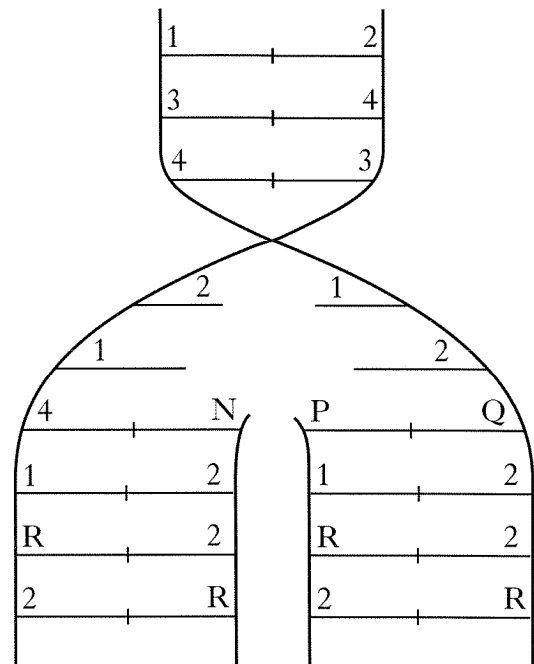
From the data it may be deduced that

- A ATP is not an enzyme
- B muscles contain many mitochondria
- C muscles synthesise ATP in the absence of glucose
- D muscles do not use glucose as a source of energy.

3. DNA controls the activities of a cell by coding for the production of

- A proteins
- B carbohydrates
- C amino acids
- D bases.

4. The diagram below shows part of a DNA molecule during replication. Bases are represented by numbers and letters.



If 1 represents adenine and 3 represents cytosine, which line in the table identifies correctly the bases represented by the letters N, P, Q and R?

	N	P	Q	R
A	guanine	cytosine	guanine	thymine
B	cytosine	guanine	cytosine	adenine
C	guanine	cytosine	cytosine	adenine
D	cytosine	guanine	guanine	adenine

[Turn over

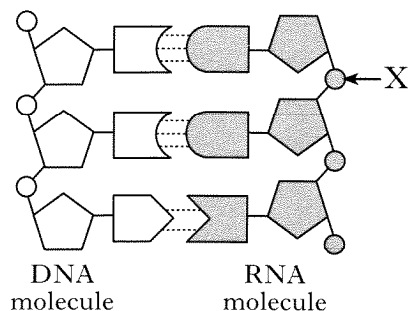
Which line in the table is correct?

	<i>Statement</i>	<i>DNA replication</i>	<i>mRNA synthesis</i>
A	Occurs in the nucleus	TRUE	FALSE
B	Involved in protein synthesis	TRUE	TRUE
C	Requires free nucleotides	TRUE	FALSE
D	Involves complementary base pairing	TRUE	TRUE

6. A fragment of DNA was found to have 60 guanine bases and 30 adenine bases. What is the total number of deoxyribose sugar molecules in this fragment?

A	30
B	45
C	90
D	180

7. The diagram represents part of a molecule of DNA on which a molecule of RNA is being synthesised.



What does component X represent?

- A Ribose sugar
B Deoxyribose sugar
C Phosphate
D Ribose phosphate

8. The sequence of triplets on a strand of DNA is shown below.

ATTACACCGTACCAATAG

During translation of mRNA made from the above sequence, how many of the tRNA anticodons will have at least one uracil base?

A	3
B	4
C	5
D	7

9. The function of tRNA in cell metabolism is to

- A transport amino acids to be used in synthesis
- B carry codons to the ribosomes
- C synthesise proteins
- D transcribe the DNA code.

10. Which of the following identifies correctly the sequence in which organelles become involved in the production of an enzyme for secretion?

- A Nucleus → Ribosomes → Golgi Apparatus → Rough ER
- B Ribosomes → Vesicles → Rough ER → Golgi Apparatus
- C Nucleus → Rough ER → Vesicles → Ribosomes
- D Ribosomes → Rough ER → Golgi Apparatus → Vesicles

11. In a pea plant, the alleles for plant height and petal colour are located on separate chromosomes. The dominant alleles are for tallness and pink petals; the corresponding recessive alleles are for dwarfness and white petals. A heterozygous plant was crossed with a plant recessive for both characteristics. If 320 progeny resulted, what would be the predicted number of tall, white plants?

A	20
B	60
C	80
D	180

12. The relative positions of the genes M, N, O and P on a chromosome were determined by the analysis of percentage recombination. The results are shown in the table.

<i>Genes</i>	<i>Percentage recombination</i>
M and O	5
N and O	16
N and P	8
M and P	19

The correct order of genes on the chromosomes is

- A O M P N
B O M N P
C M O N P
D M N O P.
13. The base sequence of a short piece of DNA is shown below.

A G C T T A C G

During replication, an inversion mutation occurred on the complementary strand synthesised on this piece of DNA.

Which of the following is the mutated complementary strand?

A T C G A A T G A

B A G C T T A G C

C T C G A A T C G

D T C G A A T G C

14. In a diploid organism with the genotype HhMmNNKK, how many genetically distinct types of gamete would be produced?
- A 2
B 4
C 8
D 16

15. Scientists visiting a group of four islands, P, Q, R and S, found similar spiders on each island. They carried out tests to see if the spiders from different islands would interbreed.

The results are summarised in the table below.

(✓ indicates successful interbreeding. ✗ indicates that fertile young were not produced.)

		Spiders from			
		P	Q	R	S
Spiders from	P	✓	✓	✗	✗
	Q	✓	✓	✗	✗
	R	✗	✗	✓	✗
	S	✗	✗	✗	✓

How many species of spider were present on the four islands?

- A One
B Two
C Three
D Four
16. In sexual reproduction, which of the following is **not** a source of genetic variation?
- A Non-disjunction
B Linkage
C Mutation
D Crossing over
17. Which of the following statements regarding polyploidy is correct?
- A It is more common in animals than in plants.
B It is the term used to describe the four haploid cells formed at the end of meiosis.
C It can produce individuals with increased vigour.
D It always results from non-disjunction of chromosomes.

[Turn over

18. In genetic engineering, endonucleases are used to
- A join fragments of DNA together
 - B cut DNA molecules into fragments
 - C close plasmid rings
 - D remove cell walls for somatic fusion.

19. Which of the following is a plant response to invasion by a foreign organism?

- A Increased production of tannin
- B Engulfing of invaders by specialised cells
- C Production of antibodies
- D Closing of stomata

20. Which of the following adaptations allows a plant to tolerate grazing by herbivores?

- A Thick waxy cuticle
- B Leaves reduced to spines
- C Low meristems
- D Thorny stems

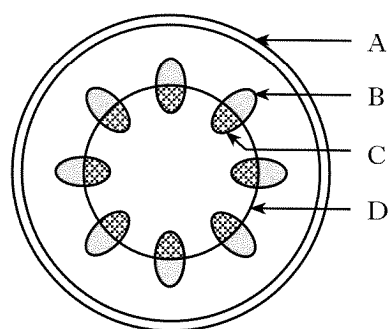
Question 21 is at the top of the next column

21. In which of the following do **both** adaptations reduce the rate of water loss from a plant?

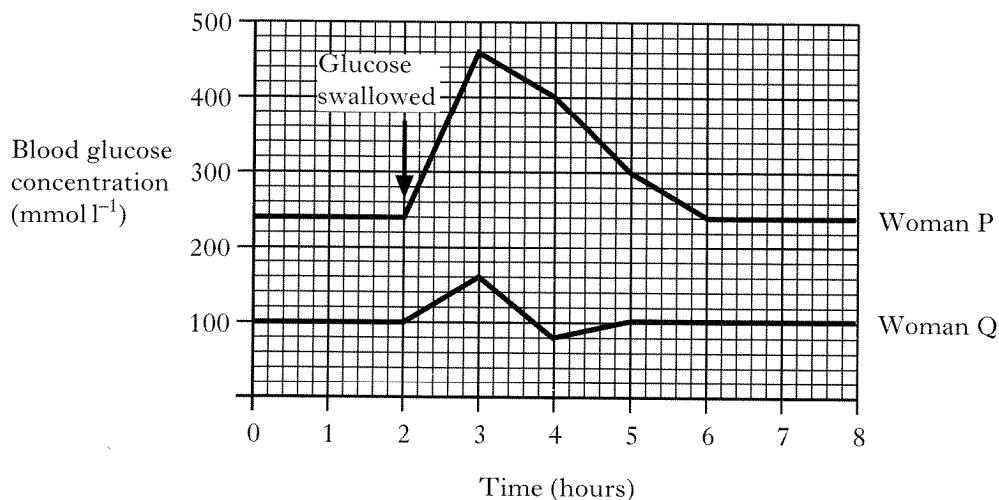
- A Thin cuticle and rolled leaf
- B Rolled leaf and sunken stomata
- C Sunken stomata and large surface area
- D Thin cuticle and needle-shaped leaves

22. The diagram below shows a transverse section through a plant stem.

In which region would cambium cells be found?



23. The graph below shows the blood glucose concentrations of two women before and after each swallowed 50 g of glucose.



When did the rate of change of blood glucose concentration of the two women differ most?

- A Between hours 2 and 3
- B Between hours 3 and 4
- C Between hours 4 and 5
- D Between hours 5 and 6

24. During the germination of barley grains, the plant growth substance GA (Gibberellic Acid) promotes the synthesis of the enzyme α -amylase in the

- A aleurone layer
- B endosperm
- C embryo
- D cotyledon.

25. Which of the following statements about the plant growth substances IAA (Indole Acetic Acid) and GA (Gibberellic Acid) is correct?

- A An increase in IAA content of a leaf promotes leaf abscission.
- B A decrease in IAA content of a leaf promotes leaf abscission.
- C An increase in GA content of a leaf promotes leaf abscission.
- D A decrease in GA content of a leaf promotes leaf abscission.

26. Which line in the table below identifies correctly the sites of production of the hormones ADH and glucagon?

	<i>ADH</i>	<i>Glucagon</i>
A	Pituitary gland	Liver
B	Kidney	Liver
C	Kidney	Pancreas
D	Pituitary gland	Pancreas

27. Which one of the following factors that can limit rabbit population size is density independent?

- A Viral disease
- B The population of foxes
- C The biomass of the grass
- D High rainfall

28. Which of the following best defines "population density"?

- A The number of individuals present per unit area of a habitat
- B The number of individual organisms present in a habitat
- C A group of individuals of the same species which make up part of an ecosystem
- D The maximum number of individuals which the resources of the environment can support

29. Which of the following does **not** occur during succession from a pioneer community of plants to a climax community?

- A Soil fertility increases.
- B Larger plants replace smaller plants.
- C An increasing intensity of light reaches ground-dwelling plants.
- D Each successive community makes the habitat less favourable for itself.

30. Dietary deficiency of vitamin D causes rickets. This effect is due to

- A poor uptake of phosphate into growing bones
- B poor calcium absorption from the intestine
- C low vitamin D content in the bones
- D loss of calcium from the bones.

Candidates are reminded that the answer sheet MUST be returned INSIDE the front cover of this answer book.

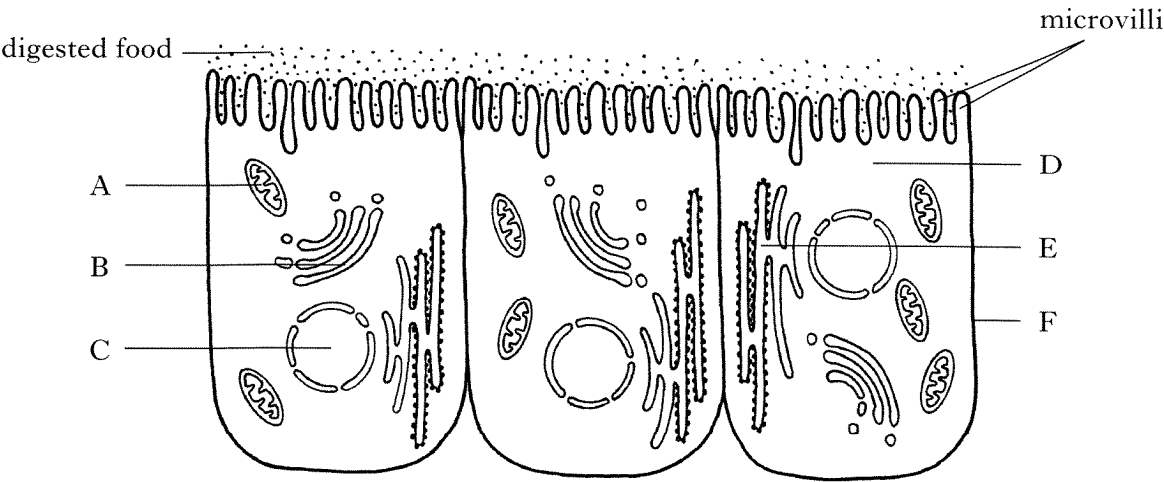
[Turn over

SECTION B

Marks

All questions in this section should be attempted.

1. (a) The diagram below represents cells in the lining of the small intestine of a mammal.



- (i) The table below gives information about organelles shown in the diagram.

Complete the table by inserting the appropriate letters, names and functions.

Letter	Name of organelle	Function
E	Rough endoplasmic reticulum	
		Site of aerobic respiration
B	Golgi apparatus	
		Site of mRNA synthesis

3

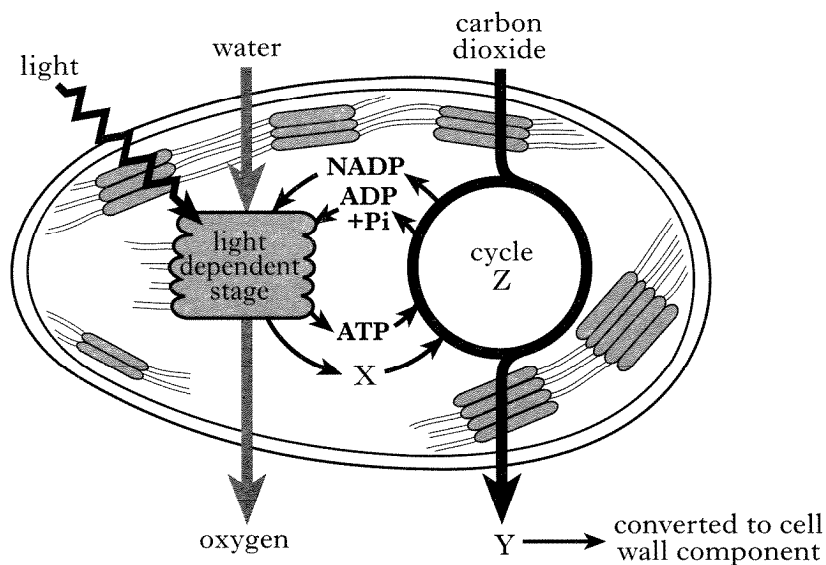
- (ii) Suggest a reason for the presence of microvilli in this type of cell.

2

1. (continued)

Marks

- (b) The diagram below summarises the process of photosynthesis in a chloroplast.



- (i) Name molecules X and Y.

X _____

Y _____

1

- (ii) State the exact location of the light dependent stage within a chloroplast.

1

- (iii) Name cycle Z.

1

- (iv) Name the cell wall component referred to in the diagram.

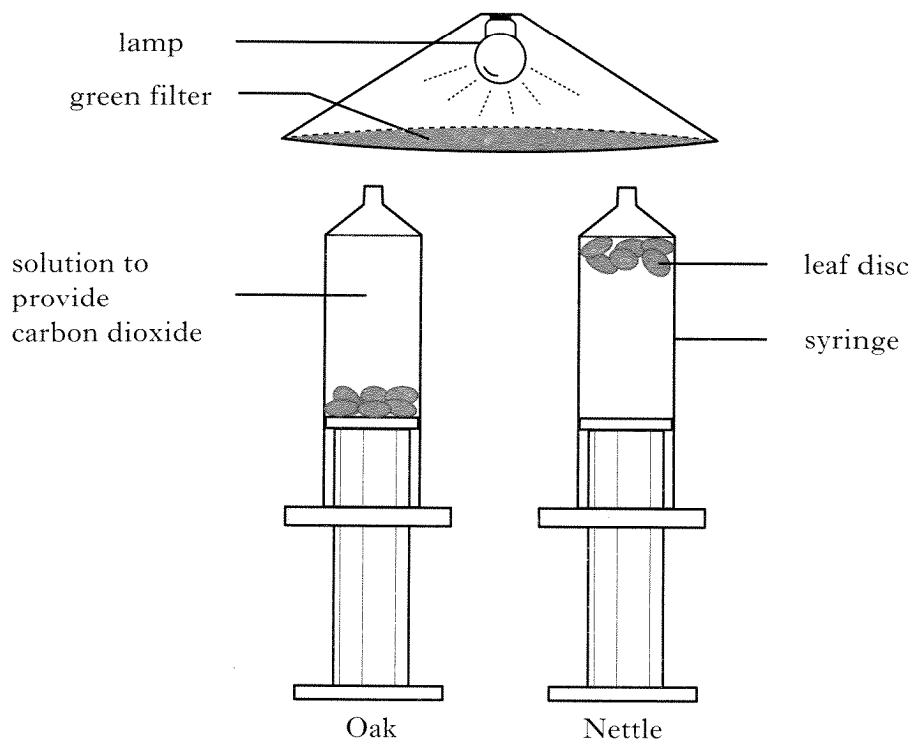
1

[Turn over]

2. An investigation was carried out to compare photosynthesis in oak and nettle leaves. Marks

Six discs were cut from each type of leaf and placed in syringes containing a solution that provided carbon dioxide. A procedure was used to remove air from the leaf discs to make them sink. The apparatus was placed in a darkened room. The discs were then illuminated with a lamp covered with a green filter. Leaf discs which carried out photosynthesis floated.

The positions of the discs one hour later are shown in the diagram below.



- (a) Suggest a reason why the investigation was carried out in a darkened room.

1

- (b) Explain why it was good experimental procedure to use six discs from each plant.

1

2. (continued)*Marks*

- (c) In setting up the investigation, precautions were taken to ensure that the results obtained would be valid.

Give **one** precaution relating to the preparation of the leaf discs and **one** precaution relating to the solution that provided carbon dioxide.

Leaf discs _____

1

Solution that provided carbon dioxide _____

1

- (d) Suggest a reason why the leaf discs which carried out photosynthesis floated.

1

- (e) Nettles are shade plants which grow beneath sun plants such as oak trees.
Explain how the results show that nettles are well adapted as shade plants.

2

- (f) What name is given to the light intensity at which the carbon dioxide uptake for photosynthesis is equal to the carbon dioxide output from respiration?

1**[Turn over**

2. (continued)

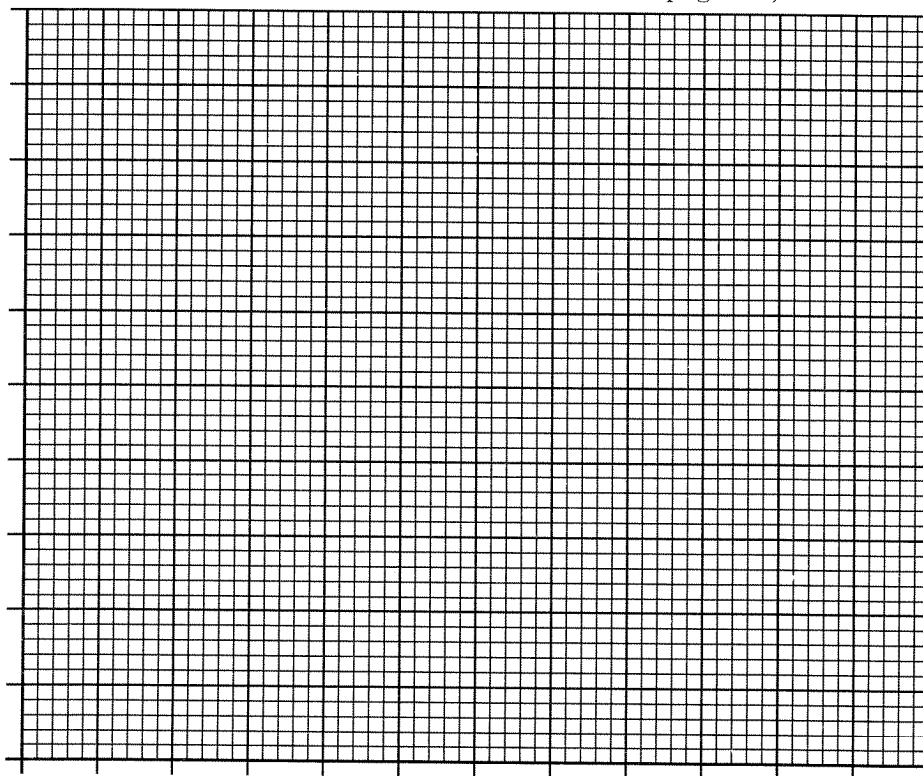
Marks

- (g) In another investigation, the rate of photosynthesis by nettle leaf discs was measured at different light intensities. The results are shown in the table.

<i>Light intensity</i> (kilolux)	<i>Rate of photosynthesis by nettle leaf discs</i> (units)
10	2
20	26
30	58
40	89
50	92
60	92

Plot a line graph to show the rate of photosynthesis by nettle leaf discs at different light intensities. Use appropriate scales to fill most of the graph paper.

(Additional graph paper, if required, can be found on page 32.)



2

- (h) From the table, predict how the rate of photosynthesis at a light intensity of 50 kilolux could be affected by an increase in carbon dioxide concentration. Justify your answer.

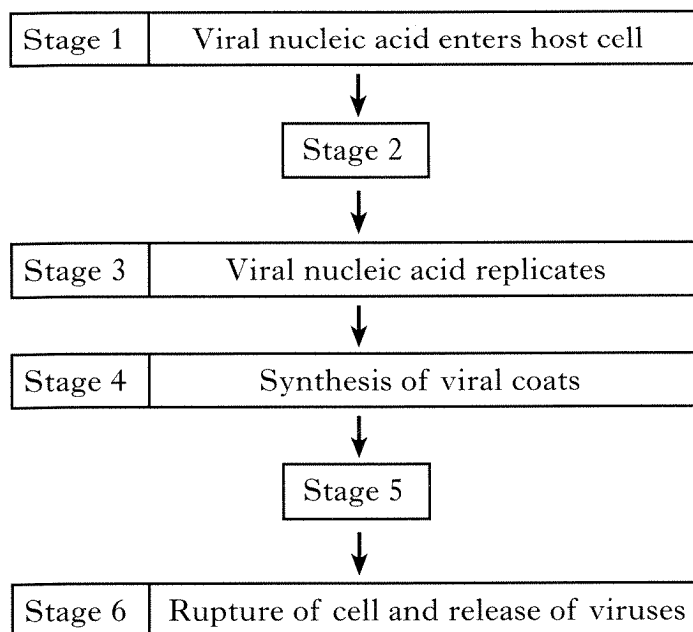
Effect on the rate of photosynthesis _____

Justification _____

1

3. The stages shown below take place when a human cell is invaded by an influenza virus.

Marks



- (a) Describe the processes that occur during Stages 2 and 5.

Stage 2 _____

1

Stage 5 _____

1

- (b) Name the cell organelle at which the viral coats are synthesised during Stage 4.

1

- (c) During a viral infection, a type of white blood cell is stimulated to make antibodies which inactivate the viruses.

- (i) Name this type of white blood cell.

1

- (ii) What feature of viruses stimulates these cells to make antibodies?

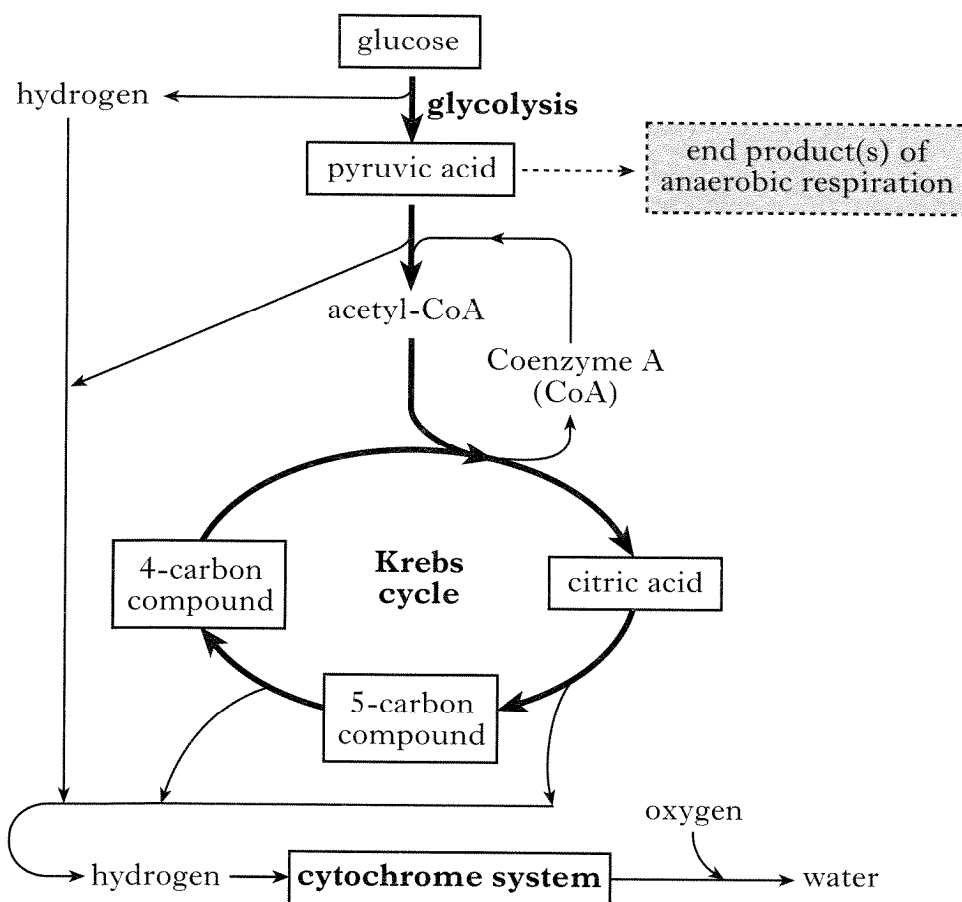
1

- (iii) New strains of influenza virus appear regularly. Suggest why antibodies produced against one strain of virus are not effective against another strain.

1

4. An outline of the process of respiration is shown in the diagram below.

Marks



- (a) Apart from glucose and enzymes, what chemical substance is essential for glycolysis to occur?

_____ 1

- (b) Name the end-product(s) of anaerobic respiration in an animal cell and a plant cell.

(i) Animal cell _____ 1

(ii) Plant cell _____ 1

- (c) Name the carrier that transfers hydrogen to the cytochrome system.

_____ 1

Marks

4. (continued)

- (d) Explain why the cytochrome system cannot function in anaerobic conditions.

1

- (e) The energy content of glucose is 2900 kJ mol^{-1} and during aerobic respiration 1178 kJ mol^{-1} of this energy is stored in ATP.

Calculate the percentage of the energy content of glucose that is stored in ATP.

Space for calculation

_____ %

1

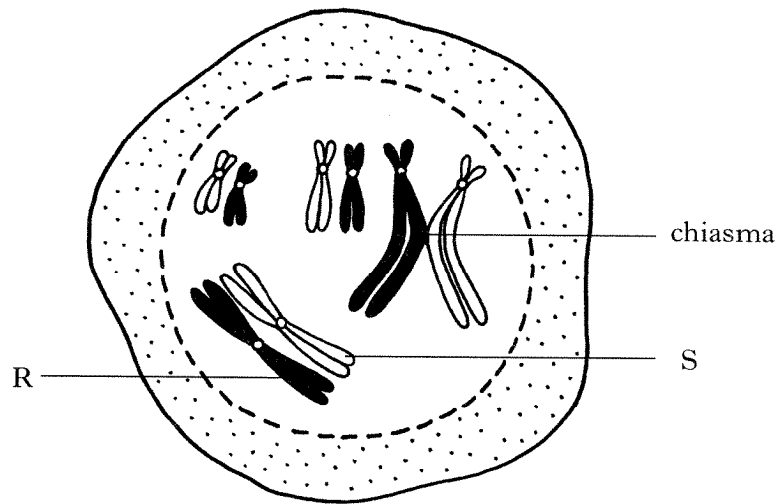
- (f) Which stage of respiration releases **most** energy for use by the cell?

1

[Turn over]

Marks

5. The diagram below represents a stage of meiosis in a cell from a female fruit fly, *Drosophila*.



- (a) Name the tissue from which this cell was taken.

1

- (b) What is the haploid number of this species?

1

- (c) Chromosomes R and S are homologous. Apart from their appearance, state **one** similarity between homologous chromosomes.

1

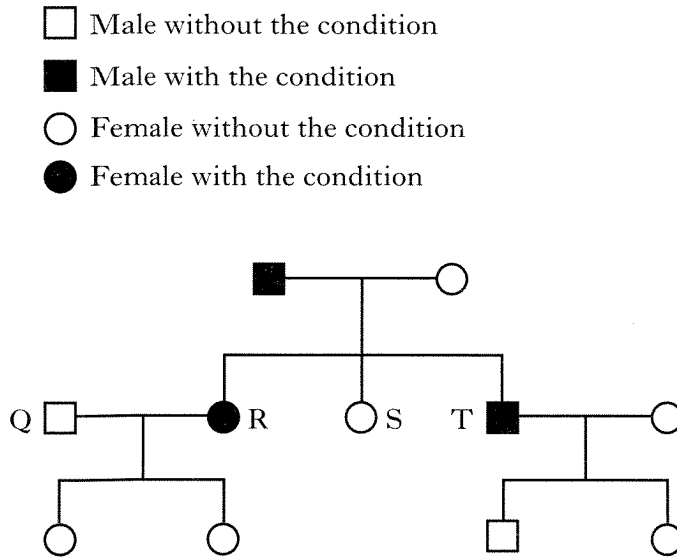
- (d) Explain the importance of chiasmata formation.

1

Marks

6. In humans, the allele for red-green colour deficiency (b) is sex-linked and recessive to the normal allele (B).

The family tree diagram below shows how the condition was inherited.



- (a) Give the genotypes of individuals S and T.

(i) S _____

1

(ii) T _____

1

- (b) If individuals Q and R have a son, what is the chance that he will inherit the condition?

Space for calculation

Chance _____

1

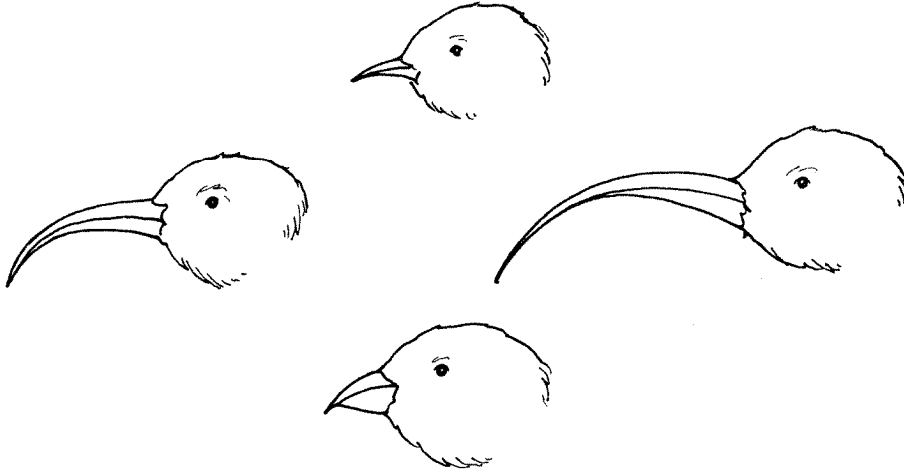
- (c) Explain why individual R has the condition although her mother was unaffected.

1

[Turn over

Marks

7. Hawaii is a group of islands isolated in the Pacific Ocean.
Different species of Honeycreeper birds live on these islands.
The heads of four species of Honeycreeper are shown below.



- (a) (i) Explain how the information given about Honeycreeper species supports the statement that they occupy different niches.

1

- (ii) What further information would be needed about the four species of Honeycreeper to conclude that they had evolved by adaptive radiation?

1

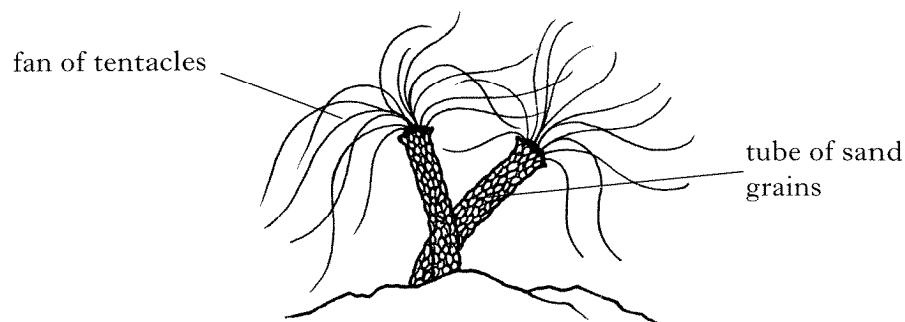
- (b) The Honeycreeper species have evolved in geographical isolation.

Name **one** other type of isolating barrier involved in the evolution of new species.

1

Marks

8. The marine worm *Sabella* lives in a tube made out of sand grains from which it projects a fan of tentacles for feeding.



- (a) If the worm is disturbed, the fan is immediately withdrawn into the tube. The fan re-emerges a few minutes later.

- (i) Name the type of behaviour illustrated by the withdrawal response.

1

- (ii) What is the advantage to the worm of withdrawing its tentacles in response to a disturbance?

1

- (b) If a harmless stimulus occurs repeatedly, the withdrawal response eventually ceases.

- (i) Name the type of behaviour illustrated by this modified response.

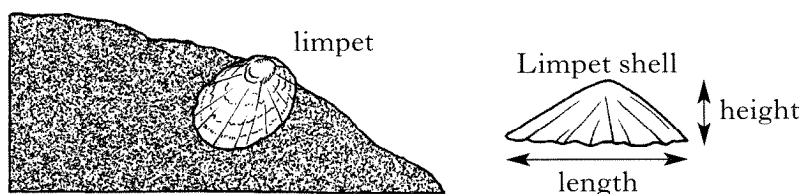
1

- (ii) What is the advantage to the worm of this modified response?

1

[Turn over]

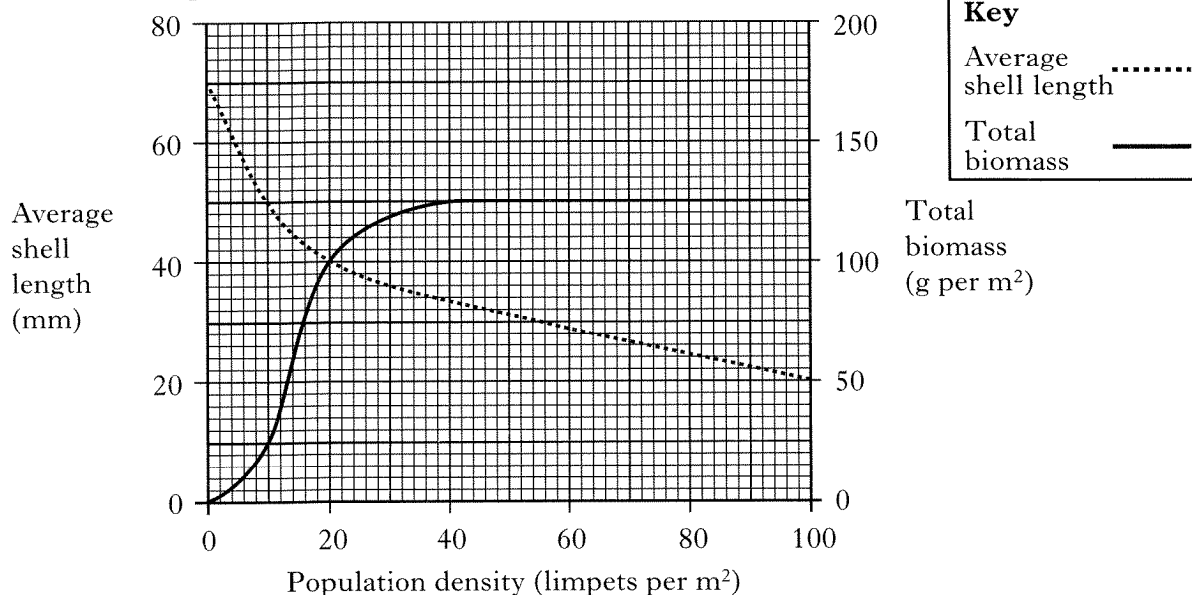
9. Limpets (*Patella*) feed by grazing on algae growing on rocks at the seashore.



Marks

Graph 1 below shows the effects of limpet population density on the average shell length and total biomass.

Graph 1



- (a) What is the total biomass at a population density of 10 limpets per m²?

_____ g per m²

1

- (b) Identify the population density range (limpets per m²) in which the total biomass increases most rapidly.

Tick the correct box.

0–10 ☐ 10–20 ☐ 20–30 ☐ 30–40 ☐ 40–50 ☐

1

- (c) Calculate the average mass of one limpet when the population density is 20 per m².

Space for calculation

Average mass _____ g

1

- (d) Use values from Graph 1 to describe the effect of increasing population density on the total biomass of limpets.

2

9. (continued)

- (e) Explain how intraspecific competition causes the trend in average shell length shown in Graph 1.

Marks

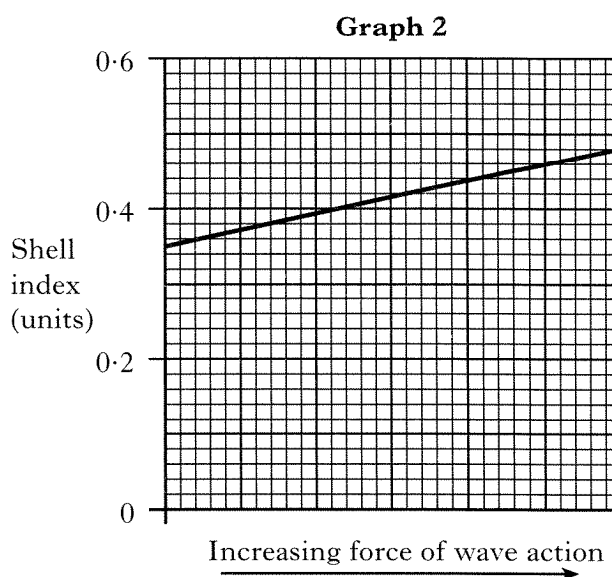
1

- (f) The table below shows information about limpets on shore A which is sheltered and on shore B which is exposed to strong wave action.

Graph 2 below shows the effect of wave action on limpet shell index.

$$\text{Limpet shell index} = \frac{\text{shell height}}{\text{shell length}}$$

Shore A (sheltered)		Shore B (exposed)	
Shell height (mm)	Shell length (mm)	Shell height (mm)	Shell length (mm)
16	52	9	21
19	54	11	26
20	55	14	31
21	56	16	34
22	57	17	35
23	58	17	36
26	60	—	—
Average = 21	Average =	Average = 14	Average =



- (i) **Complete the table** by calculating the average shell length of limpets on both shores.

Space for calculation

1

- (ii) Express as the **simplest whole number ratio** the average shell height for shore A and shore B.

Space for calculation

Ratio _____ : _____

1

- (iii) A limpet shell collected on one of the shores had a length of 43 mm and a height of 20 mm. Use Graph 2 to identify which shore it came from and justify your choice.

Tick (✓) the correct box

Shore A ☐

Shore B ☐

Justification _____

1

10. (a) The grid below shows adaptations of bony fish for osmoregulation.

Marks

A	few, small glomeruli	B	active secretion of salts by gills	C	high filtration rate in kidney
D	active uptake of salts by gills	E	low filtration rate in kidney	F	many, large glomeruli

Use **letters** from the grid to answer the following questions.

- (i) Which **three** adaptations would be found in freshwater fish?

Letters _____, _____ and _____.

1

- (ii) Which **two** adaptations would result in the production of a small volume of urine?

Letters _____ and _____.

1

- (b) The table shows some adaptations of a desert mammal which help to conserve water.

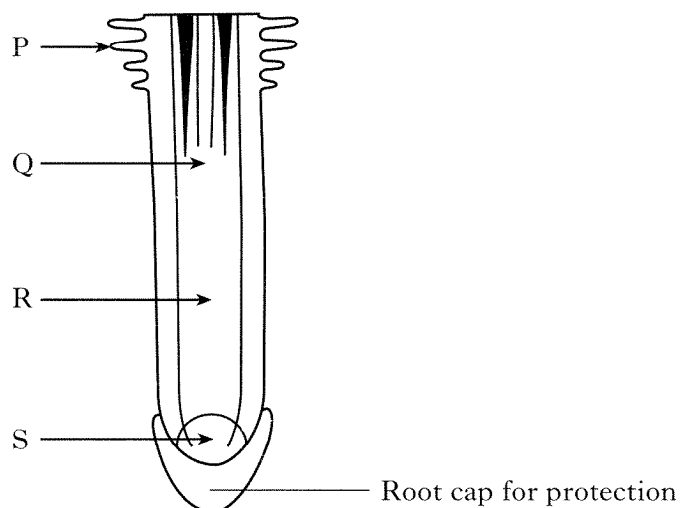
For each adaptation, tick (✓) the correct box to show whether it is behavioural **or** physiological.

<i>Adaptation</i>	<i>Behavioural</i>	<i>Physiological</i>
High level of blood ADH		
Lives in underground burrow		
Nocturnal foraging		
Absence of sweating		

2

11. (a) The diagram below shows a section through part of a root.

Marks



- (i) Which letter shows the position of a meristem?

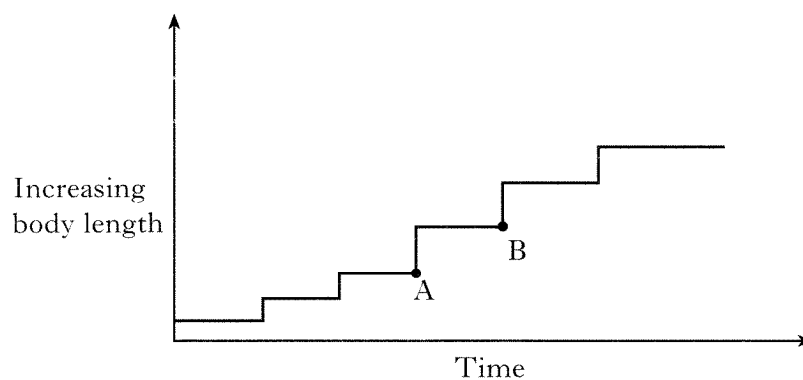
Letter _____

1

- (ii) Name a cell process responsible for increase in length of a root.

1

- (b) The diagram below shows the growth pattern of a locust.



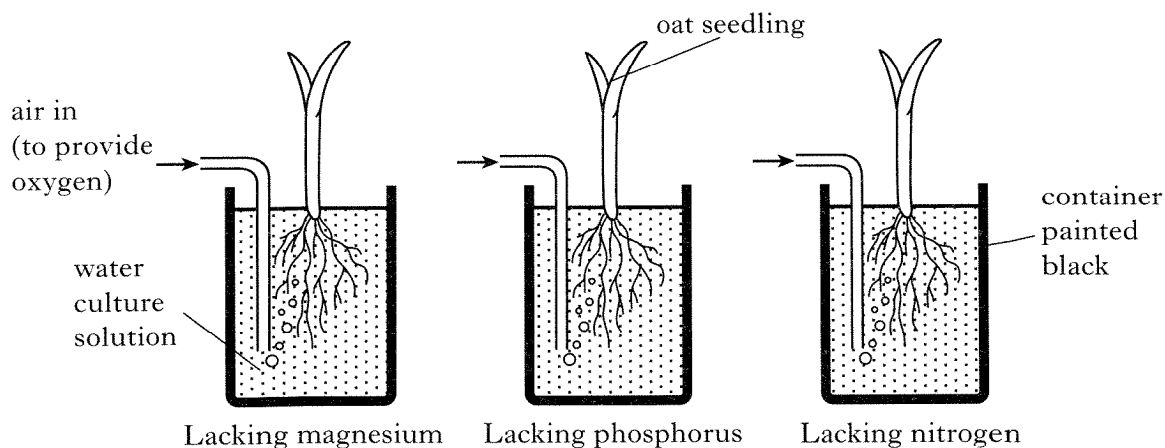
Explain the reason for the shape of the growth pattern between A and B.

2

[Turn over

12. The diagram below shows the apparatus used to investigate the growth of oat seedlings in water culture solutions. Each solution lacks one element required for normal growth.

The containers were painted black to prevent algal growth.



- (a) Describe a suitable control for this experiment.

1

- (b) Suggest a reason why algal growth should be prevented in the culture solutions during the investigation.

1

- (c) The table below shows the elements investigated and symptoms of their deficiency.

Place ticks (✓) in the correct boxes to match each element with the symptoms of its deficiency.

Element	Symptoms of deficiency	
	Leaf bases red	Chlorotic leaves
Magnesium		
Phosphorus		
Nitrogen		

2

12. (continued)*Marks*

- (d) Name a magnesium containing molecule found in oat seedlings.

1

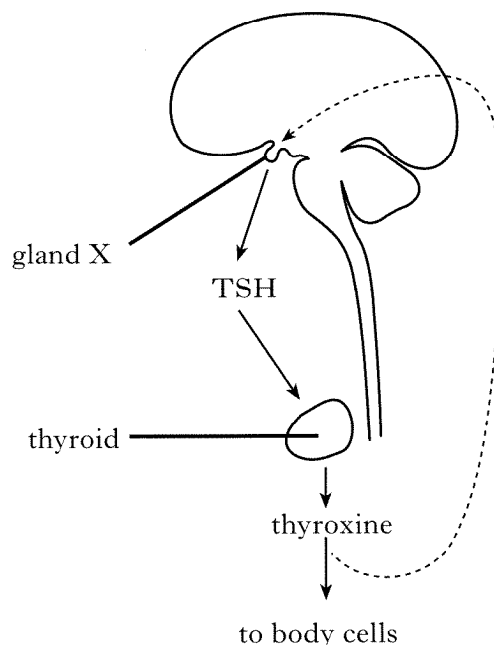
- (e) Explain why the uptake of elements by oat seedling roots is dependent on the availability of oxygen.

2**[Turn over]**

Marks

13. The production of thyroxine in mammals is controlled by the hormone TSH. Thyroxine controls metabolic rate in body cells and has a negative feedback effect on gland X.

The diagram below shows the relationship between TSH and thyroxine production.



- (a) Name gland X.

1

- (b) In an investigation into the effect of thyroxine, groups of rats of similar mass were treated as follows.

Group A were fed a normal diet.

Group B were fed a normal diet plus thyroxine.

Group C were fed a normal diet plus an inhibitor of thyroxine production.

The table below shows the average hourly oxygen consumption in cm^3 per gram of body mass in rats from each group.

Group	Average hourly oxygen consumption (cm^3g^{-1})
A	1.6
B	2.8
C	1.2

- (i) Explain how the results in the table support the statement that an increase in metabolic rate leads to an increase in oxygen consumption.

2

13. (b) (continued)

Marks

- (ii) What evidence suggests that rats fed a normal diet make thyroxine?

1

- (iii) How would the level of TSH production in group A compare with group C?

1

- (iv) Calculate the percentage decrease in oxygen consumption which results from feeding the thyroxine inhibitor to rats.

Space for calculation

_____ % decrease

1

- (v) The table below relates to aspects of the appearance and behaviour of rats in groups B and C.

<i>Group</i>	<i>Appearance of ears and feet</i>	<i>Behaviour</i>
B	Pink	Lie stretched out
C	Pale	Lie curled up with feet tucked in

Complete the following sentences by underlining **one** of the alternatives in each pair.

- 1 Compared with rats in group B, the rats in group C have a $\left\{ \begin{array}{l} \text{lower} \\ \text{higher} \end{array} \right\}$ metabolic rate and show $\left\{ \begin{array}{l} \text{dilation} \\ \text{constriction} \end{array} \right\}$ of skin blood vessels.

1

- 2 The behaviour of rats in group C allows them to $\left\{ \begin{array}{l} \text{lose} \\ \text{conserve} \end{array} \right\}$ body heat.

1

[Turn over]

SECTION C

Marks

Both questions in this section should be attempted.

Note that each question contains a choice.

Questions 1 and 2 should be attempted on the blank pages which follow.

Supplementary sheets, if required, may be obtained from the invigilator.

Labelled diagrams may be used where appropriate.

1. Answer **either** A or B.

A. Give an account of gene mutation under the following headings:

(i) the occurrence of mutant alleles and the effect of mutagenic agents; 3

(ii) types of gene mutation and how they alter amino acid sequences. 7

(10)

OR

B. Give an account of water movement through plants under the following headings:

(i) the transpiration stream; 8

(ii) importance of the transpiration stream. 2

(10)

In question 2, ONE mark is available for coherence and ONE mark is available for relevance.

2. Answer **either** A or B.

A. Give an account of the mechanisms and importance of temperature regulation in endotherms. (10)

OR

B. Give an account of the effect of light on shoot growth and development, and on the timing of flowering in plants and breeding in animals. (10)

[END OF QUESTION PAPER]

SPACE FOR ANSWERS

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SPACE FOR ANSWERS

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SPACE FOR ANSWERS

SPACE FOR ANSWERS

ADDITIONAL GRAPH PAPER FOR QUESTION 2(g)

