

# X007/701

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NATIONAL  
QUALIFICATIONS  
2008

TUESDAY, 27 MAY  
1.00 PM – 3.30 PM

BIOLOGY  
ADVANCED HIGHER

**SECTION A—Questions 1–25 (25 marks)**

Instructions for completion of Section A are given on *Page two*.

**SECTIONS B AND C**

The answer to each question should be written in ink in the answer book provided. Any additional paper (if used) should be placed inside the front cover of the answer book.

Rough work should be scored through.

**Section B (55 marks)**

All questions should be attempted. Candidates should note that Question 8 contains a choice.

Question 1 is on Pages 10, 11 and 12. Questions 2, 3 and 4 are on Page 13. Pages 12 and 13 are fold-out pages.

**Section C (20 marks)**

Candidates should attempt the questions in **one** unit, **either** Biotechnology **or** Animal Behaviour **or** Physiology, Health and Exercise.



### Read carefully

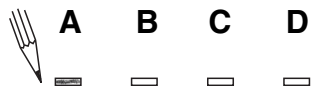
- 1 Check that the answer sheet provided is for **Biology Advanced Higher (Section A)**.
- 2 For this section of the examination you must use an **HB pencil** and, where necessary, an eraser.
- 3 Check that the answer sheet you have been given has **your name, date of birth, SCN** (Scottish Candidate Number) and **Centre Name** printed on it.  
Do not change any of these details.
- 4 If any of this information is wrong, tell the Invigilator immediately.
- 5 If this information is correct, **print** your name and seat number in the boxes provided.
- 6 The answer to each question is **either** A, B, C or D. Decide what your answer is, then, using your pencil, put a horizontal line in the space provided (see sample question below).
- 7 There is **only one correct** answer to each question.
- 8 Any rough working should be done on the question paper or the rough working sheet, **not** on your answer sheet.
- 9 At the end of the exam, put the **answer sheet for Section A inside the front cover of the answer book**.

### Sample Question

Which of the following molecules contains six carbon atoms?

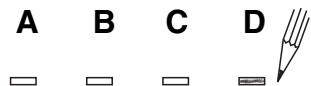
- A Glucose
- B Pyruvic acid
- C Ribulose biphosphate
- D Acetyl coenzyme A

The correct answer is **A**—Glucose. The answer **A** has been clearly marked in **pencil** with a horizontal line (see below).



### Changing an answer

If you decide to change your answer, carefully erase your first answer and using your pencil, fill in the answer you want. The answer below has been changed to **D**.



### SECTION A

All questions in this section should be attempted.

Answers should be given on the separate answer sheet provided.

1. Which of the following genes encode proteins that promote normal cell division?

A Oncogenes  
B Regulatory genes  
C Proliferation genes  
D Anti-proliferation genes

2. The cell cycle is believed to be monitored at checkpoints where specific conditions must be met for the cycle to continue.

Condition 1: chromosome alignment

Condition 2: successful DNA replication

Condition 3: cell size

Which line in the table correctly shows the condition fulfilled at each checkpoint?

	<i>G1</i>	<i>G2</i>	<i>M</i>
A	2	3	1
B	3	1	2
C	2	1	3
D	3	2	1

3. Which line in the table correctly describes the chemical reaction that breaks down a disaccharide into its monomer subunits?

	<i>Type of reaction</i>	<i>Type of bond broken</i>
A	hydrolysis	peptide
B	condensation	glycosidic
C	hydrolysis	glycosidic
D	condensation	peptide

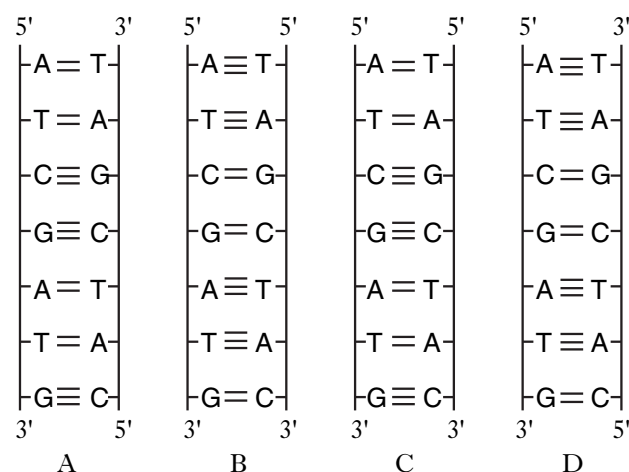
4. An unbranched polysaccharide is made up of glucose monomers joined together by  $\beta(1\rightarrow4)$  linkages. The polysaccharide described could be

A amylose  
B amylopectin  
C glycogen  
D cellulose.

5. Which of the following is a covalent bond that stabilises the tertiary structure of a protein?

A Hydrogen bond  
B Disulphide bond  
C Glycosidic bond  
D Ester linkage

6. In the diagrams below, the sugar-phosphate backbone of a DNA strand is represented by a vertical line showing 5' to 3' polarity. The horizontal lines between bases represent hydrogen bonds.



Which diagram represents correctly a short stretch of a DNA molecule?

7. If ten percent of the bases in a molecule of DNA are adenine, what is the ratio of adenine to guanine in the same molecule?

A 1:1  
B 1:2  
C 1:3  
D 1:4

[Turn over

8. Which line in the table below correctly summarises the movement of sodium and potassium ions into and out of a cell by a sodium-potassium pump?

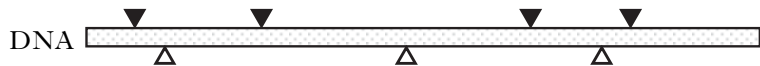
	<i>Potassium ions</i>	<i>Sodium ions</i>
A	in	out
B	in	in
C	out	in
D	out	out

9. Which of the following is a component of the cytoskeleton?
- Phospholipid
  - Tubulin
  - Peptidoglycan
  - Glycoprotein

10. A length of DNA is cut into fragments by the restriction enzymes BamHI and EcoRI

▼ BamHI cut site

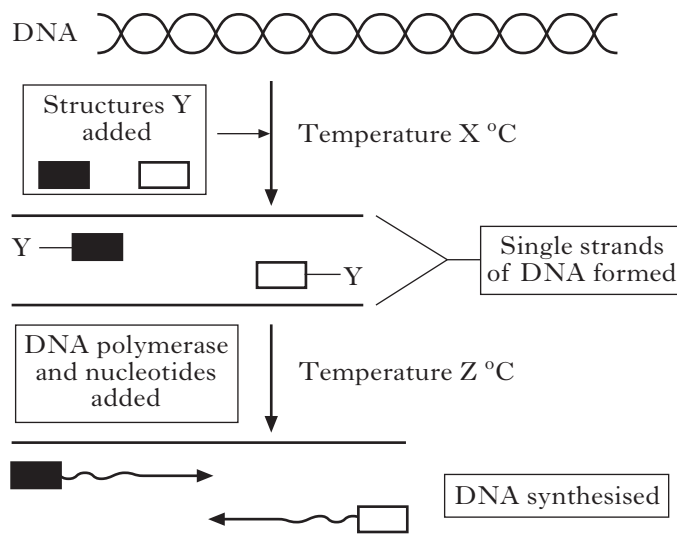
△ EcoRI cut site



Which line in the table below correctly identifies the number of DNA fragments obtained?

	<i>DNA cut by BamHI only</i>	<i>DNA cut by EcoRI only</i>	<i>DNA cut by both BamHI and EcoRI</i>
A	5	4	8
B	4	5	8
C	5	4	9
D	4	5	9

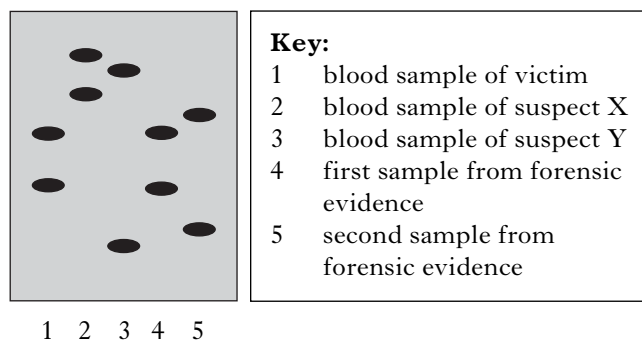
11. The diagram below outlines the stages involved in the polymerase chain reaction.



Which line in the table correctly identifies temperature X and the structures labelled Y?

	<i>Temperature X (°C)</i>	<i>Structure Y</i>
A	55	probe
B	95	primer
C	55	primer
D	95	probe

12. The result of profiling various DNA samples in a criminal investigation is shown below.

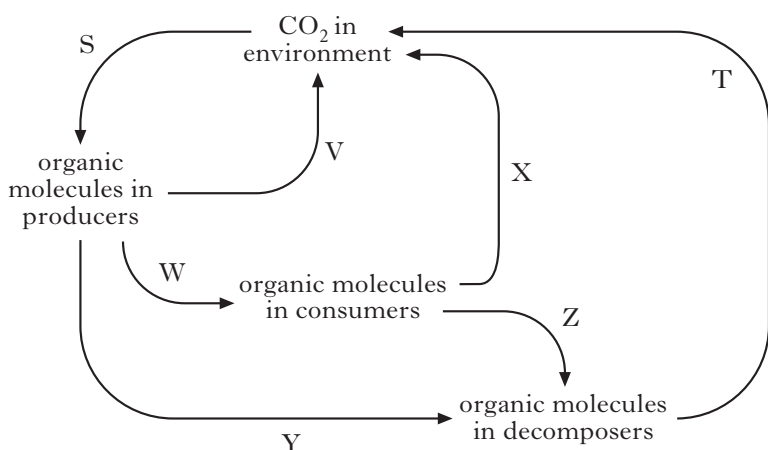


Which of the following could the DNA analyst conclude about the crime?

- Only suspect X was involved
- Only suspect Y was involved
- Suspects X and Y were both involved
- Neither suspect X nor Y was involved

13. Which of the following micro-organisms is responsible for the conversion of nitrite to nitrate in soil?
- A *Nitrobacter*  
 B *Pseudomonas*  
 C *Nitrosomonas*  
 D *Rhizobium*

Questions 14 and 15 relate to the diagram below, which shows the recycling of carbon in the environment.



14. Which line in the table below describes correctly the processes that are occurring at stages S, V and W?

	<i>Transformation</i>	<i>Fixation</i>	<i>Respiration</i>
A	W	S	V
B	W	V	S
C	V	S	W
D	S	W	V

15. Coral bleaching could increase if process S is
- A greater than V + X + T  
 B greater than W + Y + Z  
 C less than W + Y + Z  
 D less than V + X + T.

16. Which line in the table matches a group of organisms correctly with their type of nutrition?

	<i>Group of organisms</i>	<i>Type of nutrition</i>
A	producers	heterotrophic
B	consumers	autotrophic
C	decomposers	autotrophic
D	consumers	heterotrophic

17. Population size can be estimated using the following formula:

$$P = \frac{n_1 \times n_2}{n_3}$$

where P = population estimate

$n_1$  = number first captured, marked and released

$n_2$  = total number in second capture

$n_3$  = number of marked individuals recaptured.

In a survey to estimate a woodlice population, the following data were obtained:

Woodlice captured, marked and released = 40  
 Marked woodlice in second capture = 12  
 Unmarked woodlice in second capture = 48

The estimated population of the woodlice was

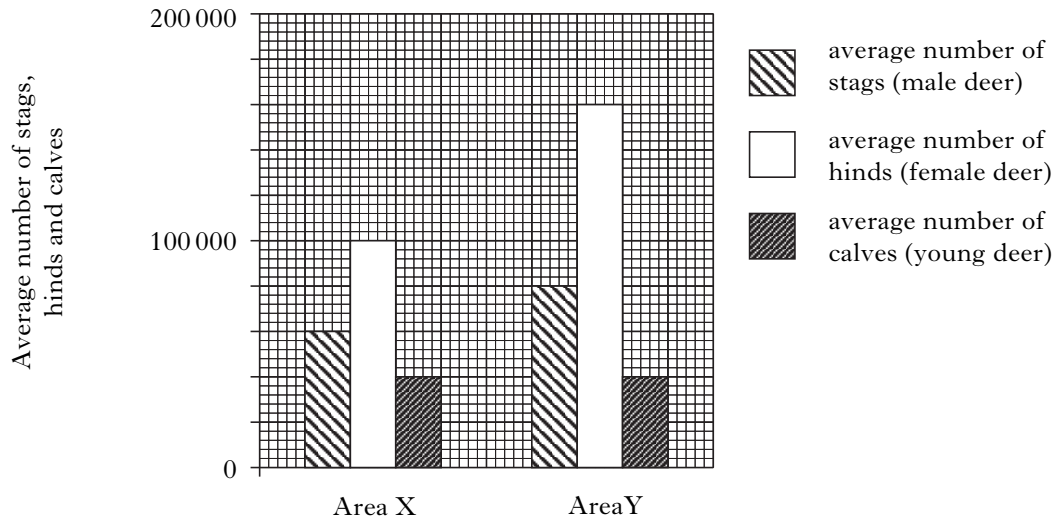
- A 100  
 B 160  
 C 200  
 D 1920.

18. Which of the following is a density-independent effect?

- A A decrease in temperature increasing the abundance of a tree species.  
 B An increase in food supply increasing the abundance of a herbivore.  
 C A decrease in predators increasing the abundance of a prey species.  
 D An increase in competitors decreasing the yield of a crop species.

[Turn over

19. The figure shows the results of red deer population surveys in two areas of the same size.



Which line in the table below correctly shows the effect of a change in population density on the birth rate of red deer?

	Population density	Proportion of hinds having calves
A	increases	decreases
B	decreases	decreases
C	increases	increases
D	decreases	stays the same

20. Parasitism is a form of symbiosis. A parasite that is facultative

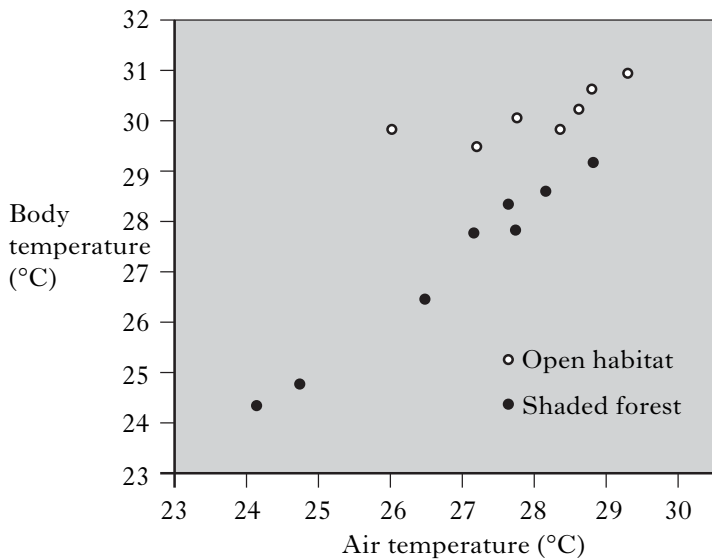
- A benefits from its host but does not harm it
- B can be associated with a host but can also live independently
- C is passed to its main host from a secondary host
- D has a relationship with its host from which both benefit.

21. The marine iguana (*Amblyrhynchus cristatus*) of the Galapagos Islands basks in the sunshine before swimming for food in the cold sea water. Which line of the table correctly describes the iguana and its temperature regulating mechanism?

	Type of organism	Mechanism
A	homeothermic	behavioural
B	homeothermic	physiological
C	poikilothermic	behavioural
D	poikilothermic	physiological

22. The Puerto Rican lizard *Anolis cristatellus* is found both in shaded forests and in open sunlit areas.

The graph below shows the relationship between air temperature and body temperature of lizards occupying each habitat.



Which line in the table shows the response of the lizards to changes in air temperature in each habitat?

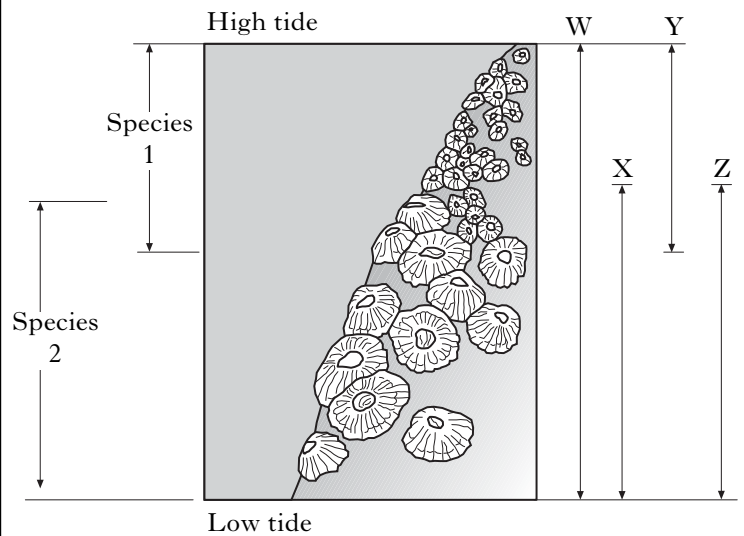
	<i>Open habitat</i>	<i>Shaded forest habitat</i>
A	regulation	regulation
B	regulation	conformation
C	conformation	conformation
D	conformation	regulation

23. Common terns (*Sterna hirundo*) feed on fish and nest colonially on land. Nesting terns often attempt to steal fish from neighbouring terns in their colony.

What term describes correctly this type of competitive interaction?

- A Exploitation competition
- B Interference competition
- C Competitive exclusion
- D Resource partitioning

24. The diagram below shows the distribution of two species of barnacle. The fundamental and realised niches of the two species are shown by the vertical lines W, X, Y and Z. The realised niche of species 2 is line Z.



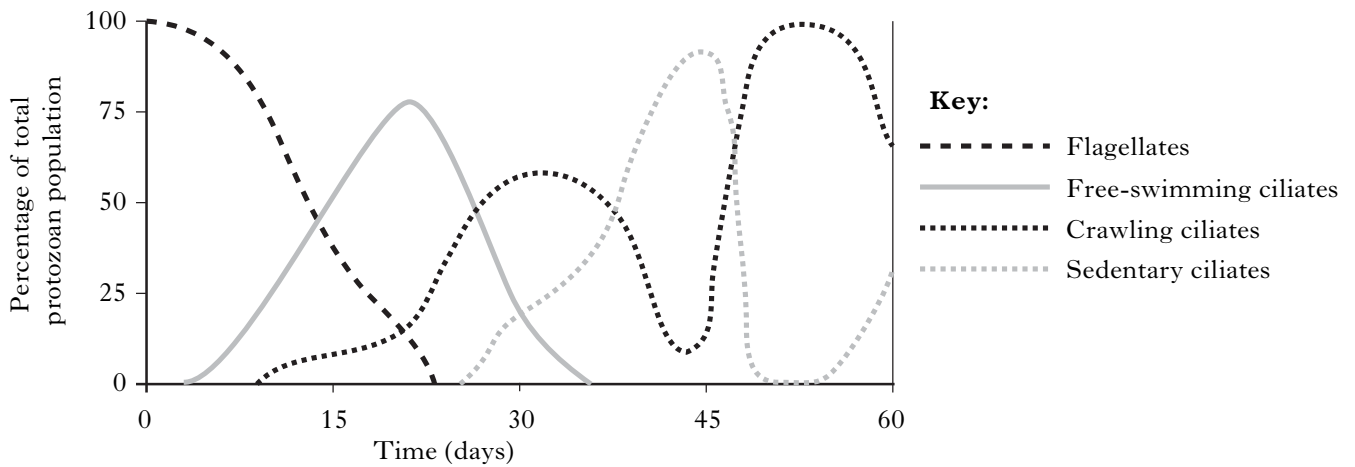
Which line in the table below identifies correctly the other niches?

	<i>Fundamental niche of species 1</i>	<i>Fundamental niche of species 2</i>	<i>Realised niche of species 1</i>
A	W	X	Y
B	Y	X	W
C	W	Y	X
D	X	W	Y

[Turn over

25. Flagellates and ciliates are aerobic, unicellular organisms that feed on bacteria. Commonly referred to as protozoa, they are used in the *activated sludge* process to break down sewage. Different species of ciliates have different lifestyles—free-swimming, crawling and sedentary (attached by a stalk to the surface). There are typically 50 000 ciliates per  $\text{cm}^3$  of sludge sample.

The graph shows succession in the development of activated sludge.



On which day in the succession would a sample contain 30 000 per  $\text{cm}^3$  crawling and 10 000 per  $\text{cm}^3$  free-swimming ciliates?

- A 15
- B 20
- C 30
- D 35

[END OF SECTION A]

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



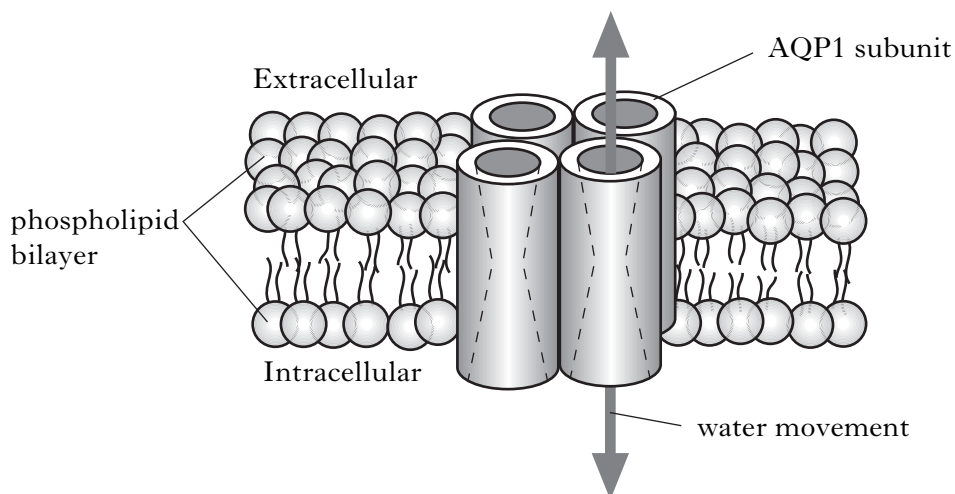
**[Turn over for Section B on *Page ten***

## SECTION B

**All questions in this section should be attempted.  
All answers must be written clearly and legibly in ink.**

- In 1992, a membrane protein called *aquaporin-1* (AQP1) was found to function exclusively as a channel for the passage of water molecules. The AQP1 molecule spans the phospholipid bilayer; each of its four linked subunits is a separate water channel (Figure 1).

**Figure 1: Aquaporin-1 in a membrane**



Early experiments were designed to determine the role of these protein channels in water movement. Researchers removed the contents of red blood cells to leave structures consisting of only the plasma membranes; these are known as “red cell ghosts”. The ghosts were filled with solutions containing radioactive water and the concentration gradient across the membrane was varied. The rate at which water molecules moved out of the ghosts was measured in isotonic and hypertonic external solutions, before and after a treatment that inactivates AQP1.

From their results, summarised in the Table, the researchers concluded that the very rapid transfer of water across membranes during osmosis was through the AQP1 channels.

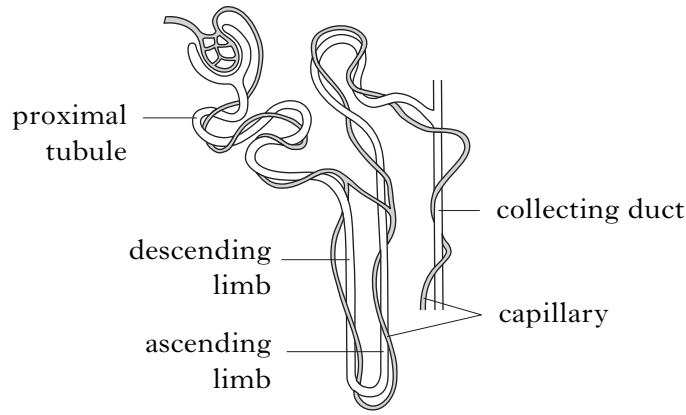
**Table: Rate of water movement across ghost membranes**

<i>External solution</i>	<i>Rate of water movement (units s<sup>-1</sup>)</i>	
	<i>Untreated AQP1</i>	<i>Treated AQP1</i>
Isotonic	2.5	1.0
Hypertonic	20	1.8

Recent studies have shown that several different aquaporins exist and they are present in a number of organs including eyes, brain, lungs and kidneys; all of them are important in water transport across membranes. In kidneys, they are found in some parts of the nephrons (Figure 2) where they have a role in water balance.

**Question 1 (continued)**

**Figure 2: Nephron**



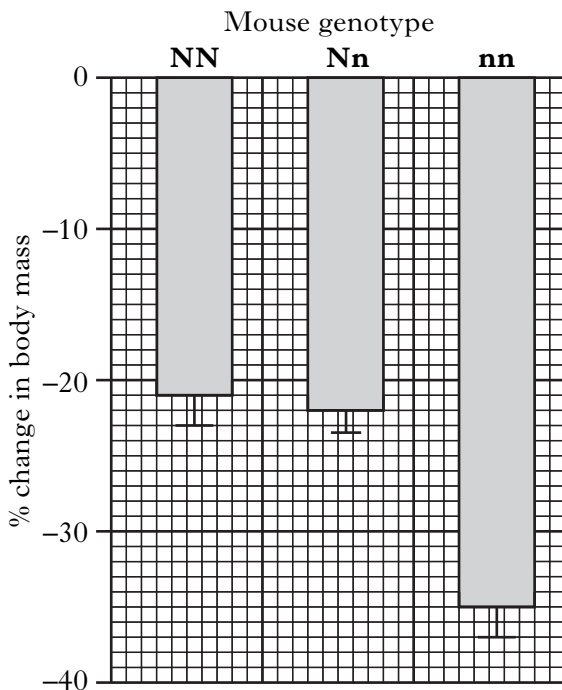
AQP1 is present only in the cells lining the proximal tubule, descending limb and in the capillaries associated with the nephron. About 70% of the water entering the nephron is reabsorbed here. A different aquaporin, AQP2, is present in cells of the collecting duct. The number of AQP2 molecules active at a cell surface increases with the concentration of antidiuretic hormone (ADH) in blood. ADH secretion is increased so that more water is reabsorbed into the capillaries from urine in the duct.

To study the importance of aquaporins in kidney function, three groups of mice with different genotypes were selected.

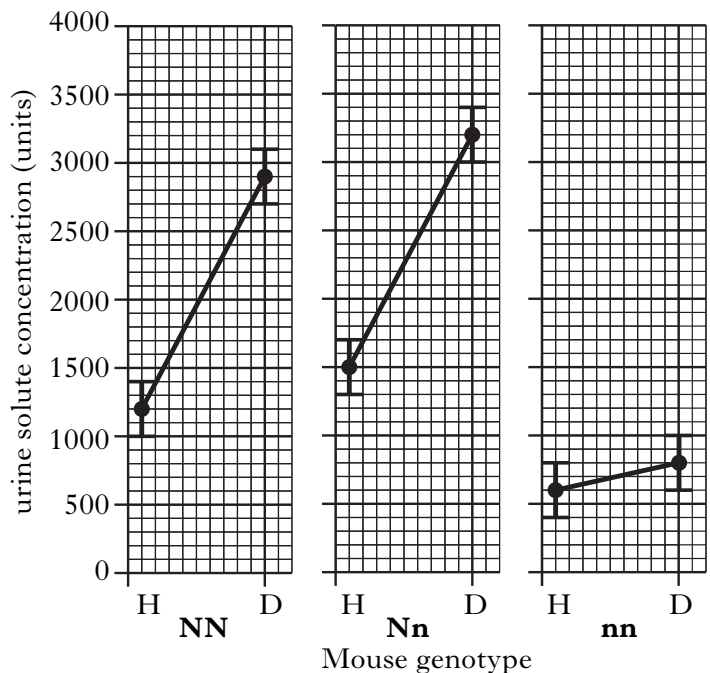
- Group 1: genotype NN: homozygous for the presence of AQP1;
- Group 2: genotype Nn: heterozygous;
- Group 3: genotype nn: homozygous recessive; AQP1 absent.

Body mass and urine solute concentration were measured before and after a period without water. The results are shown in Figure 3 and Figure 4.

**Figure 3: % change in body mass of mice after a period without water**



**Figure 4: Urine solute concentration before (H) and after (D) a period without water**



[Question 1 continues on *Page twelve*]

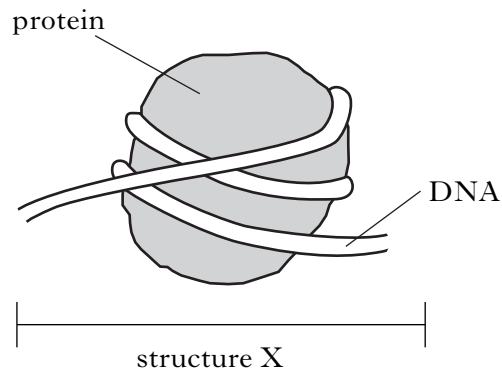
**Question 1 (continued)**

- (a) (i) What term describes a protein that is embedded in a membrane rather than attached to the surface? **1**
- (ii) With reference to aquaporin, explain what is meant by the quaternary structure of a protein. **1**
- (b) Refer to the experimental work using red cell ghosts.
- (i) Suggest an explanation for the use of radioactive water in the solutions placed in the ghosts. **1**
- (ii) The Table shows that in isotonic conditions when AQP1 has been treated, water molecules flow out of the ghost cells at a rate of  $1.0 \text{ units s}^{-1}$ .  
Explain why there would be no overall change in cell volume in these conditions. **1**
- (iii) Aquaporins were inactivated by phosphorylation.  
Which type of enzyme adds phosphate to a protein? **1**
- (iv) Use data from the Table to show that functioning aquaporins can increase water flow across a membrane by over 1000%. **2**
- (c) (i) Figure 3 shows that homozygous recessive mice lost about 35% of their body mass during the period when they had no water supply.  
Explain how these results may lead to the conclusion that the homozygous recessive mice lost abnormally high amounts of water in their urine. **2**
- (ii) Refer to Figure 3 and Figure 4. Use the data to show that heterozygous mice are producing enough AQP1 molecules for normal osmoregulation. **3**
- (d) Humans with a condition called *nephrogenic diabetes insipidus* (NDI) have normal AQP1 and ADH production but have non-functioning AQP2.
- (i) Predict the effect of a period of dehydration on urine production by individuals with NDI compared to individuals without NDI. **1**
- (ii) Explain your prediction. **1**
- (14)**

**[Questions 2, 3 and 4 are on fold-out Page thirteen]**

2. (a) (i) Identify structure X shown in the diagram below.

1



(ii) Why is the binding of DNA to this type of protein so important for eukaryotic cells?

2

(b) In the production of transgenic plants, the genome of a plant species can be modified by incubating protoplasts with engineered plasmids.

(i) Name the prokaryotic species used as the source of these plasmids.

1

(ii) Describe how protoplasts are produced from isolated plant cells.

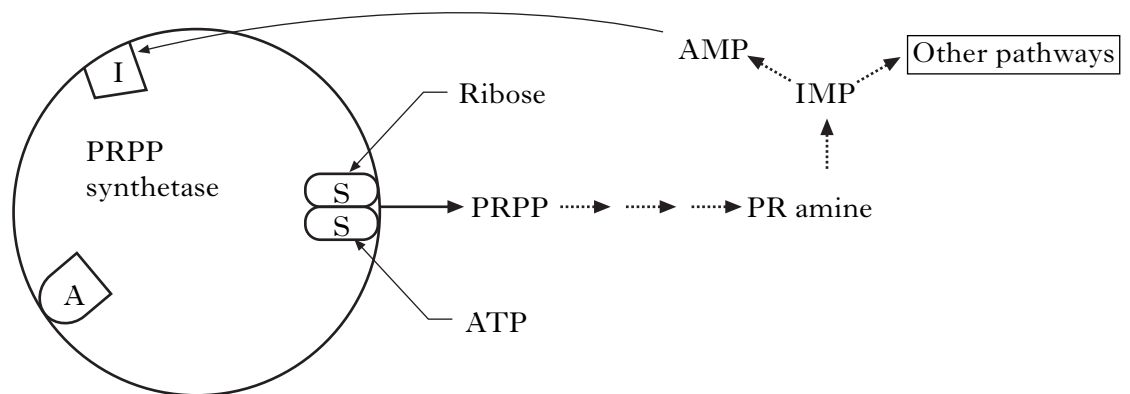
1

(5)

3. Describe the general structure of steroids and their function in cell signalling.

(4)

4. The diagram below represents an enzyme, PRPP synthetase, involved at the start of the biochemical pathway that produces nucleotides. In the active site there are two positions (S) where the substrate molecules, ribose and ATP, bind and react. Position I is an inhibitor binding site and position A is an activator binding site.



(a) What is meant by induced fit when referring to enzyme action?

1

(b) Explain why PRPP synthetase is described as an allosteric enzyme.

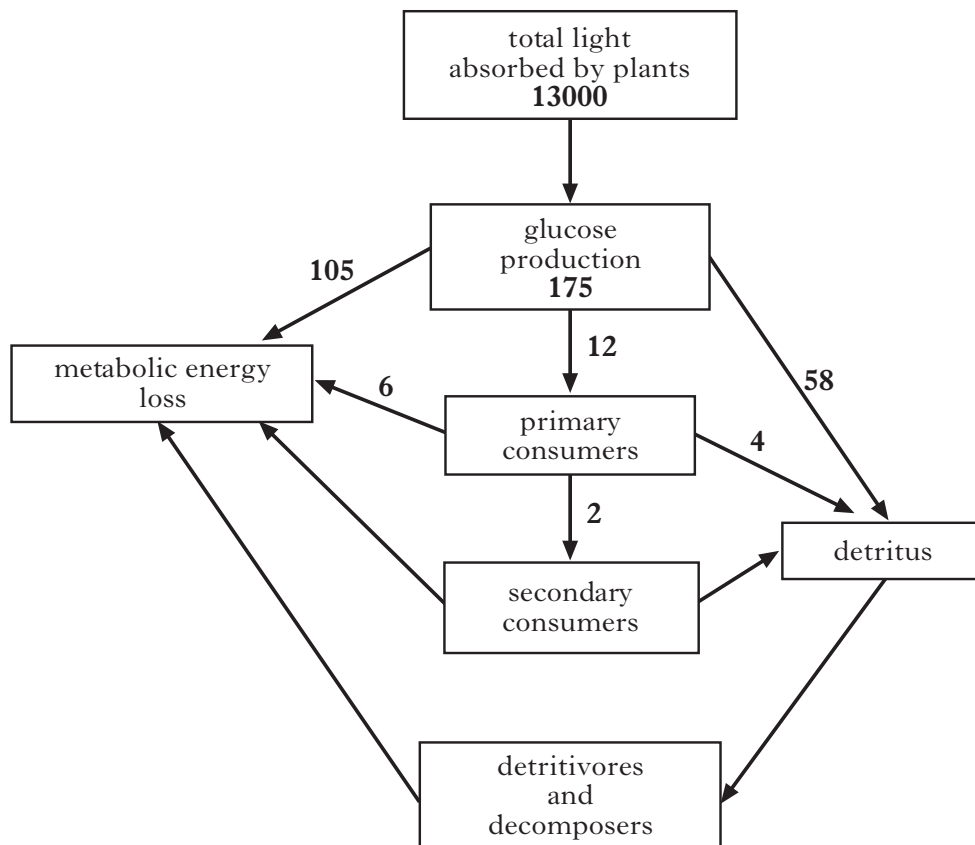
1

(c) Describe the effect of AMP formation on the metabolic pathway.

2

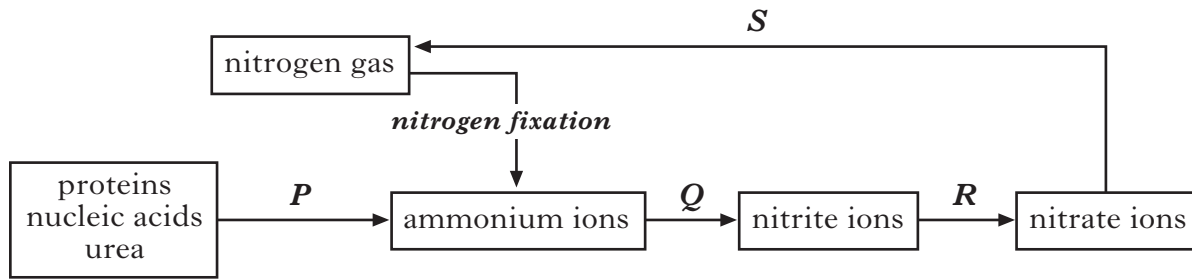
(4)

5. The diagram below shows energy flow through a deciduous forest ecosystem. Units are  $\text{kJ m}^{-2} \text{ day}^{-1}$ .



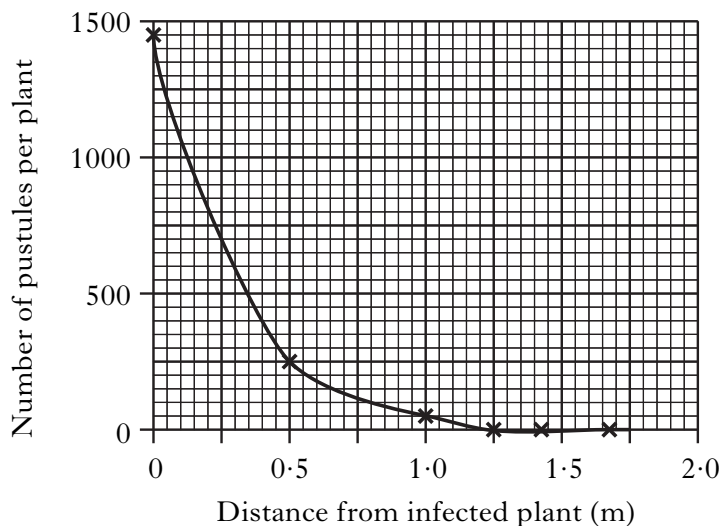
- (a) Calculate the percentage of light energy that is captured in photosynthesis by the forest plants. 1
- (b) What is the value for net primary productivity (NPP) in this ecosystem? 1
- (c) Ten percent is often quoted as a typical value for ecological efficiency. Use the data to show that this value does not always apply to energy transfer between trophic levels. 1
- (d) In what form is the energy lost from metabolism? 1
- (e) Compare the use of digestive enzymes by detritivores and decomposers. 1
- (5)**

6. The figure below shows processes in the nitrogen cycle that rely on the activities of micro-organisms.



- (a) The bacteria responsible for processes Q and R are *obligate aerobes*.  
 What does this term suggest about their metabolic requirements? 1
- (b) Nitrogen fixation is often the product of a prokaryote–eukaryote symbiosis. It depends on the action of an enzyme system that functions best in anaerobic conditions.
- (i) Identify a prokaryote involved in such an interaction. 1
- (ii) Name the enzyme responsible for nitrogen fixation. 1
- (iii) What is the role of leghaemoglobin in this interaction? 1
- (c) State the likely effect of process S on soil fertility in aerobic conditions. 1
- (5)**
7. Rust fungi are pathogens of many monocultures. In infected plants, *pustules* are formed that are responsible for the spread of infection.

The figure below shows the spread of a rust fungus from a single infected plant.



- (a) Define the term monoculture. 1
- (b) What do the data suggest about the spacing needed to prevent the fungus infection from spreading? 1
- (c) Apart from altering spacing, suggest another way of growing rust-free crops. 1
- (3)**

8. Answer **either A or B**.

*Marks*

**A.** Discuss how ecosystems may be affected by the following:

- |                                    |   |
|------------------------------------|---|
| (i) phosphate enrichment;          | 5 |
| (ii) exotic species;               | 4 |
| (iii) persistent toxic pollutants. | 6 |

**OR**

**(15)**

**B.** Discuss the roles of the following in the survival of organisms:

- |                  |   |
|------------------|---|
| (i) dormancy;    | 7 |
| (ii) mimicry;    | 4 |
| (iii) mutualism. | 4 |

**(15)**

*[END OF SECTION B]*





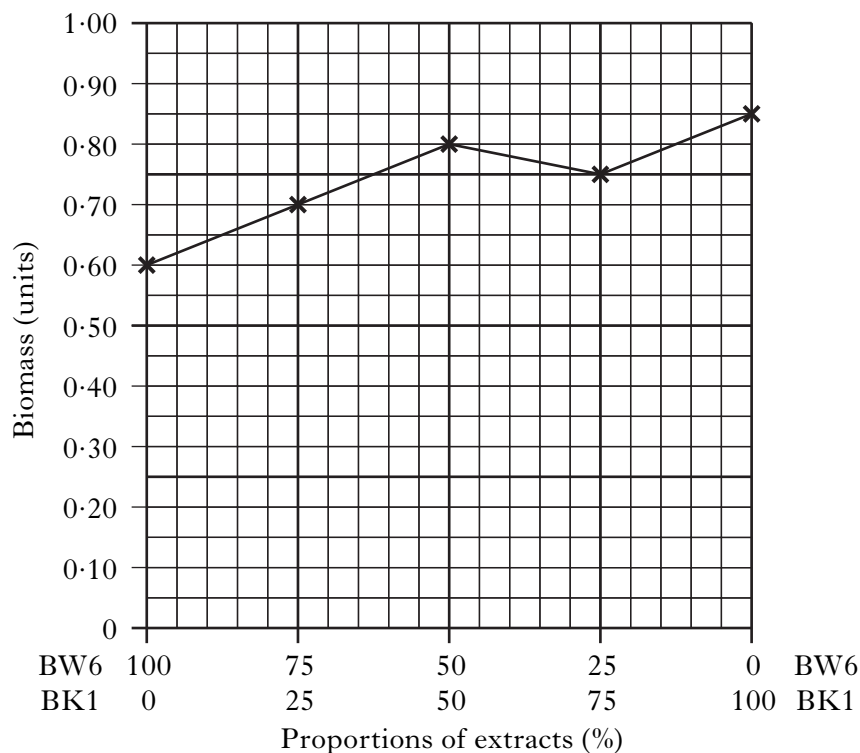
2. Explain how genetic modification of the “*flavrsvr*” tomato plant has resulted in fruit with longer shelf life. (4)

3. (a) The nitrogen content of two yeast extracts, BW6 and BK1, is shown in the Table below.

	Yeast extract	
	BW6	BK1
Total nitrogen (g/100 g)	7.1	11.9
% of nitrogen as amino acids	34	56

The figure below shows the effect on the growth of the bacterium *Lactobacillus casei* of adding different proportions of BW6 and BK1.

**Figure: Effect of varying proportions of BW6 and BK1 on the growth of *L. casei***



(i) Use the data to describe the effect of varying the proportions of the extracts on the growth of the bacterium. 2

(ii) Suggest a reason for this effect on *L. casei*. 1

(b) Give one agricultural use of *Lactobacillus* species. 1

(4)

4. Different yeast species are cultured to create large quantities of yeast cell biomass. Some of the biomass is destined for activities such as brewing and baking while much of the biomass is treated to bring about autolysis. The *autolysate* produced has a variety of uses, for example as a nutrient source in fermentation media.

(a) What is meant by the term *autolysis*?

1

(b) State **two** factors that could influence the characteristics of yeast autolysate.

2

(c) Yeast extract is prepared from the autolysate.

State one use of yeast extract in the food industry.

1

(4)

(20)

[End of *Biotechnology* questions. *Animal Behaviour* questions start on Page 20]

[Turn over

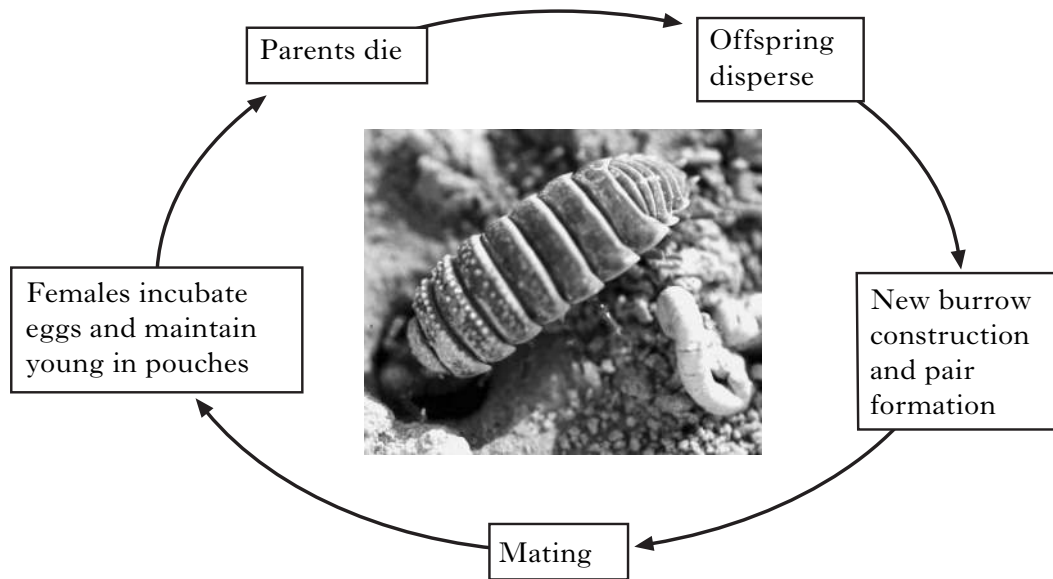
SECTION C (continued)

Marks

Animal Behaviour

1. The woodlouse *Hemilepistus reaumuri* lives in deserts. To avoid drying out, it digs a burrow from which it ventures each day to forage.

Figure: Life cycle of *H. reaumuri*



- (a) After dispersal, both males and females can begin new burrows, or they can attempt to pair with an existing burrower.

Why are larger males more successful than smaller ones in pair formation with a female that has already started a burrow? 1

- (b) Suggest proximate and ultimate causes for burrow digging in this species. 2

- (c) For *H. reaumuri*, state one reason why the parental investment of females is higher than that of males. 1

- (d) After foraging, these woodlice show an *innate* ability to navigate straight back to their burrows.

What is meant by the term innate? 1

- (e) State the effect of an increased encounter rate and a reduced handling time on the duration of foraging. 1

(6)

2. The fire ant *Solenopsis invicta* is a social insect found in South America. A study of kin selection showed that colonies of *S. invicta* can have either of two distinct social structures, *compact* colonies or *sprawling* colonies.

Compact colonies contain ants that are all produced by a single female, the queen. The workers in compact colonies are loyal to the queen and are aggressive towards intruders. In contrast, large sprawling colonies, which are becoming more common, are formed from many interconnected nests inhabited by many queens.

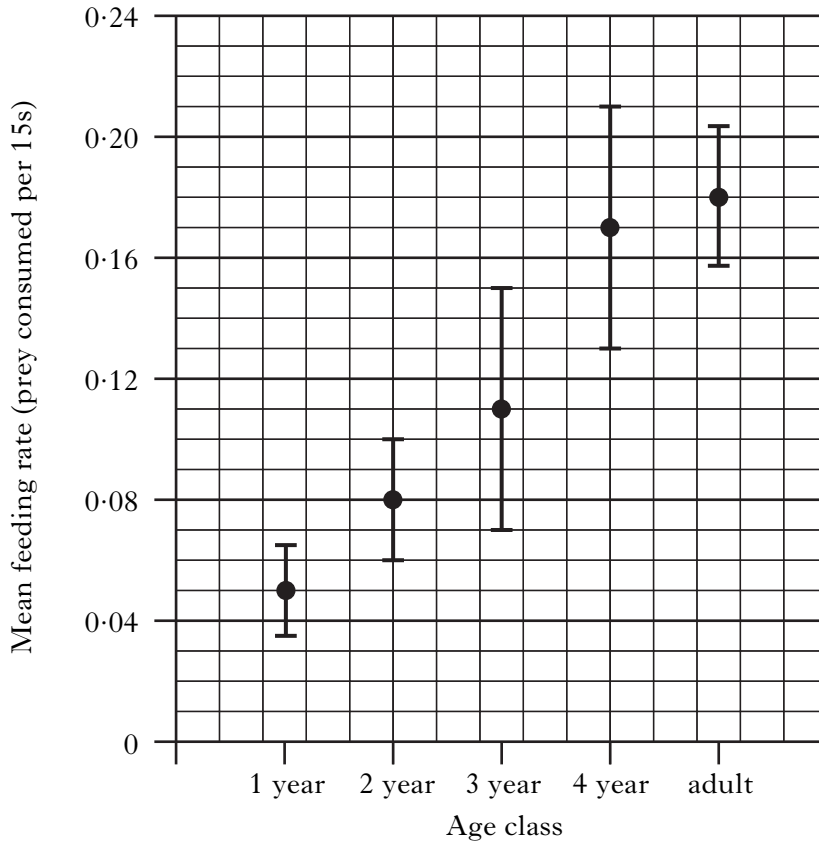
The difference in social structure depends on the presence or absence of allele B of the gene *GP-9*. Ants with the B allele produce a receptor protein that enables them to distinguish the odours of ants from different genetic backgrounds.

- (a) What is meant by the term *kin selection*? 1
- (b) Allele B is only found in compact colonies.  
 Explain how the absence of allele B has led to the formation of the sprawling colony. 2
- (c) Give another example of a single gene effect. 1
- (4)**
3. Discuss the role of dispersal in the avoidance of inbreeding in birds and mammals.  
 Why is it important for animals to avoid inbreeding and how is this achieved? (4)

**[Turn over**

4. The success of herring gull (*Larus argentatus*) foraging behaviour was studied using video recordings. Herring gulls have adult plumage after 4 years; the age of younger birds can be determined by other visible characteristics.

The Figure shows the mean feeding rates for herring gulls in different age classes.



- (a) (i) Identify **two** age classes between which there is a significant difference in foraging success. 1
- (ii) Suggest an explanation for the trend seen in the feeding rate. 1
- (iii) An adult feeding at 0.18 prey per 15 seconds takes 83 seconds to capture one prey item.  
How long would it take a one-year-old to capture one prey item? 1
- (b) Suggest **one** advantage of using video recording for this analysis. 1
- (c) Describe **two** ways in which herring gulls have successfully adapted to human influence. 2
- (6)**
- (20)**

[End of Animal Behaviour questions. Physiology, Health and Exercise questions start on Page 23]

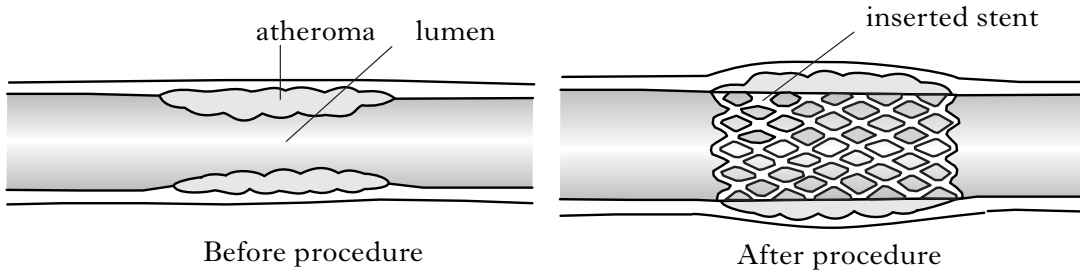
**SECTION C (continued)**

Marks

Physiology, Health and Exercise

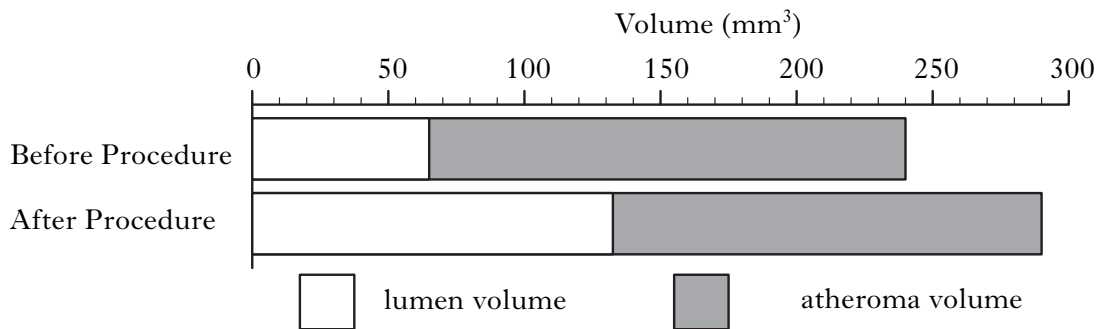
1. A stent is a narrow, wire mesh tube that can be inserted into a blood vessel. It may be used to treat atherosclerosis in the blood vessels of the heart. Figure 1 shows a blood vessel before and after the procedure to insert a stent.

**Figure 1**



- (a) Name the blood vessels that deliver blood to the myocardium. 1
- (b) Describe how *atherosclerosis* develops. 2
- (c) Figure 2 shows the volume changes in a blood vessel in the heart as a result of a stent being fitted.

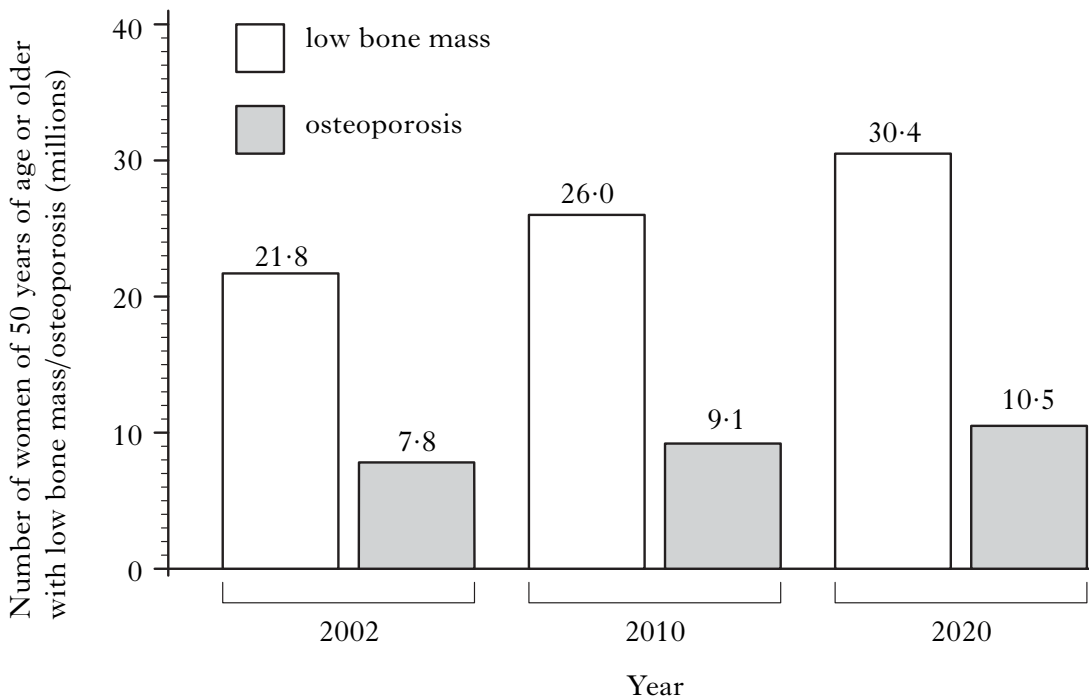
**Figure 2**



- (i) Use the data to explain how the procedure achieves increased blood flow. 2
- (ii) What term is used for the chest pain relieved by this procedure? 1
- (6)**

**[Turn over**

2. The data show trends expected in the numbers of American women who have low bone mass and who will go on to develop osteoporosis.



- (a) Give one feature of osteoporosis other than low bone mass. 1
- (b) Explain why the study focuses on women of 50 years of age or older. 1
- (c) Authors of the research claimed that:  
*“In future, fewer American women with hip problems will eventually go on to develop osteoporosis.”*
- (i) Suggest how critics could use the data provided to contradict this claim. 1
- (ii) How did the authors use the data to arrive at their conclusion? 1
- (d) Explain why American teenagers would be advised to take up jogging rather than swimming to reduce the risk of osteoporosis. 2
- (6)**



3. (a) The table shows data relating to four members of a group trying to achieve different weight-loss targets. The energy deficit value indicates the severity of their intended diet. Dietary weight loss is assumed to be from fat loss.

A negative energy balance of 29.4 MJ is required to lose 1 kg.

<i>Group member</i>	<i>Present weight</i> (kg)	<i>Target weight</i> (kg)	<i>Energy deficit</i> (MJ/day)
A	96	91	2
B	121	113	3
C	104	98	2
D	92	82	3

- (i) How many days will individual **D** take to reach the target weight? 1
- (ii) Individual **A** is 1.74m in height. Calculate this individual's body mass index (BMI). 1
- (b) Explain why being "overweight" does not always mean that someone is unhealthy. 1
- (c) Name a method of measuring body composition. 1
- (4)**
4. Discuss the use of exercise testing in the assessment of aerobic fitness. **(4)**
- (20)**

[END OF QUESTION PAPER]

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