

SECTION A

Read carefully

1. Check that the answer sheet provided is for Biology Advanced 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 on 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 the answer book.

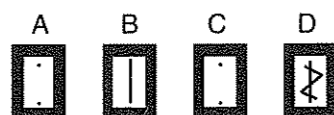
SAMPLE QUESTION

Which of the following molecules contains six carbon atoms?

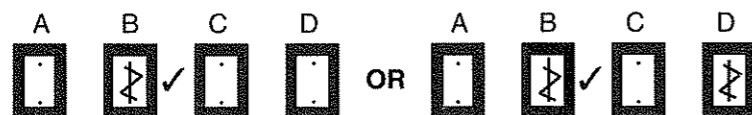
- A Pyruvic acid
- B Glucose
- C Ribulose biphosphate
- D Acetyl co-enzyme A

The correct answer is **B**—glucose. 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:



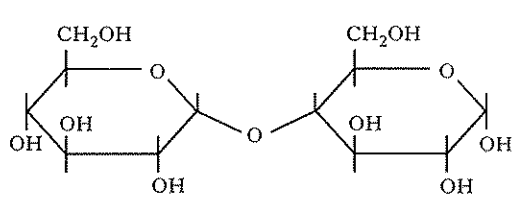
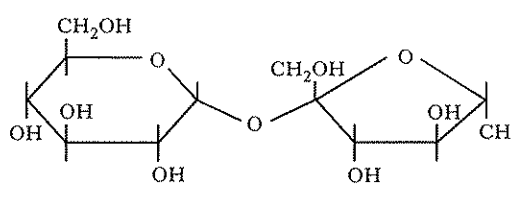
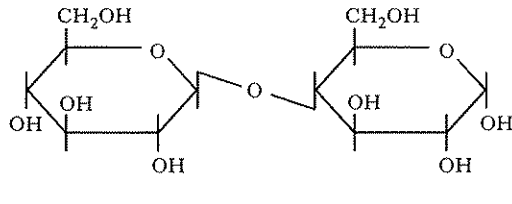
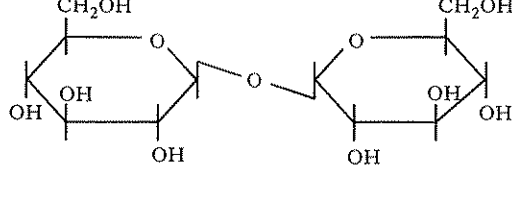
If you want to change back to an answer which has already been scored out, you should **enter a tick (✓)** to the **RIGHT** of the box of your choice, thus:



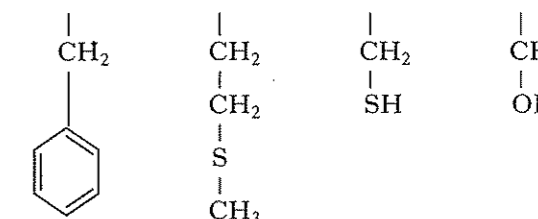
SECTION A

All questions in this section should be attempted.

Answers should be given on the separate answer sheet provided.

1. Which of the following is present in a bacterial cell membrane?
 - A Cellulose
 - B Pectin
 - C Peptidoglycan
 - D Phospholipid
2. Plasmodesmata are structures which link
 - A cell walls in adjacent prokaryotic cells
 - B cell cytoplasm in adjacent prokaryotic cells
 - C cell walls in adjacent eukaryotic cells
 - D cell cytoplasm in adjacent eukaryotic cells.
3. Which of the following represents a molecule with a β 1,4 glycosidic bond?
 - A 
 - B 
 - C 
 - D 

4. The side chains of four amino acids are shown below.



A polar side chain is present in

- A W and X
- B Y and Z
- C X only
- D W, X and Z.

5. Which type of bond is mainly responsible for stabilising the secondary structure of a protein?
 - A Van der Waals
 - B Hydrogen
 - C Peptide
 - D Disulphide
6. An average diploid human cell contains 6×10^9 base pairs of genetic code. Only 3% of this codes for protein. How many base pairs code for protein in a human gamete?
 - A 9.0×10^7
 - B 1.8×10^8
 - C 9.0×10^8
 - D 1.8×10^9

[Turn over

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

	Sodium ions	Potassium ions
A	in	out
B	in	in
C	out	in
D	out	out

8. The total surface area of a red blood cell is about $100 \mu\text{m}^2$. A single sodium-potassium ATPase molecule takes up an area of $1 \times 10^{-4} \mu\text{m}^2$. In total these molecules account for 0.5% of the cell surface area.

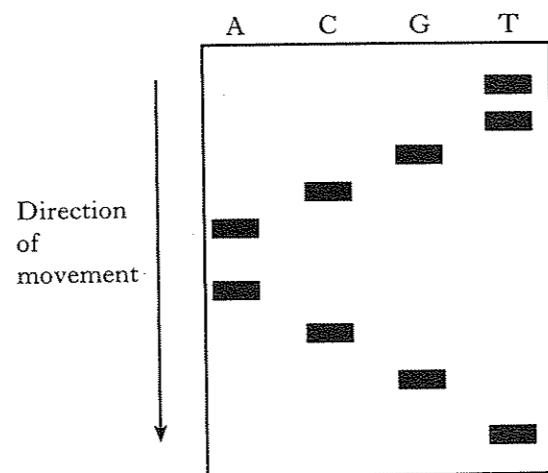
Approximately how many of these molecules are there on the surface of one red blood cell?

- A 500
 B 1000
 C 5000
 D 10000
9. Covalent modification can be used to regulate enzyme activity. Which of the following is an example of covalent modification?
- A Addition of a phosphate group by a kinase enzyme
 B Binding of an inhibitor to the active site
 C End product inhibition
 D Allosteric modulation

10. To which group of signalling molecules does testosterone belong?

- A Extracellular hydrophobic
 B Extracellular hydrophilic
 C Peptide hormones
 D Neurotransmitters

11. When sequencing a strand of DNA, DNA fragments are separated by electrophoresis. Larger fragments move more slowly through the gel than the smaller fragments and the gel is normally "read" starting with the smallest fragment. A diagram of the resulting gel is shown below.



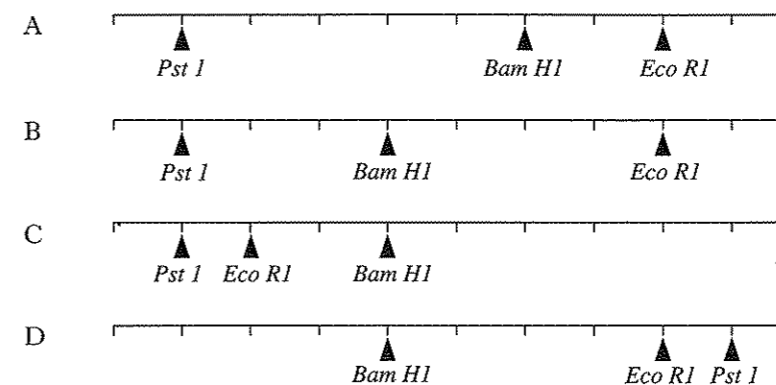
What is the base sequence of the DNA strand?

- A TGCAACGTT
 B TTGCAACGT
 C ACGTTGCAA
 D AACGTTGCA

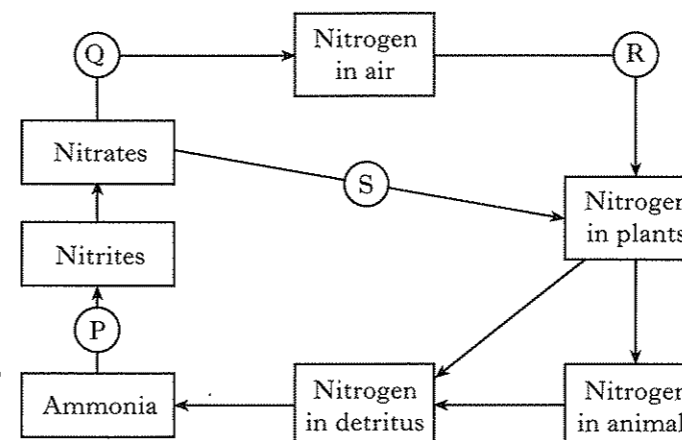
12. A piece of DNA ten kilobase pairs (kbp) long was digested using different pairs of the restriction enzymes *Bam* H1, *Eco* R1 and *Pst* 1. The results are shown in the table.

	Restriction enzymes used		
	<i>Bam</i> H1 <i>Eco</i> R1	<i>Bam</i> H1 <i>Pst</i> 1	<i>Eco</i> R1 <i>Pst</i> 1
Lengths of DNA fragments (kbp)	4 4 2	6 3 1	7 2 1

Which of the following restriction maps can be drawn from the results?



Questions 13 and 14 refer to the diagram below which represents part of the nitrogen cycle.



13. Which line in the table correctly identifies the processes represented by the letters P, Q and R?

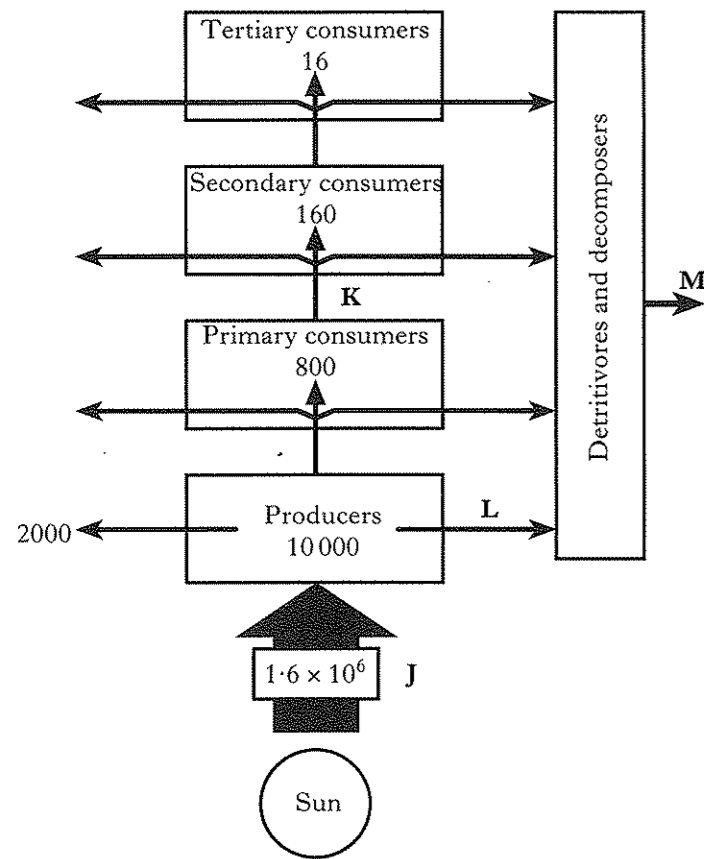
	P	Q	R
A	Nitrification	Denitrification	Nitrogen fixation
B	Denitrification	Nitrification	Nitrogen fixation
C	Nitrogen fixation	Denitrification	Nitrification
D	Nitrification	Nitrogen fixation	Denitrification

14. Which process is likely to involve activity of the enzyme nitrogenase?

- A P
 B Q
 C R
 D S

[Turn over

Questions 15, 16 and 17 refer to the following diagram which shows energy flow through an ecosystem. The values in boxes represent production at each trophic level ($\text{kJ m}^{-2} \text{ yr}^{-1}$).



15. Which labelled arrow represents energy flow in the form of heat?

- A J
- B K
- C L
- D M

16. Net primary production in this ecosystem is

- A $800 \text{ kJ m}^{-2} \text{ yr}^{-1}$
- B $2000 \text{ kJ m}^{-2} \text{ yr}^{-1}$
- C $8000 \text{ kJ m}^{-2} \text{ yr}^{-1}$
- D $10000 \text{ kJ m}^{-2} \text{ yr}^{-1}$

17. What proportion of the solar energy received by plants is found in the tertiary consumers?

- A 0.0001%
- B 0.001%
- C 0.01%
- D 0.1%

18. Which of the following statements best describes a detritivore?

- A Micro-organism with external enzymatic digestion
- B Micro-organism with internal enzymatic digestion
- C Invertebrate with external enzymatic digestion
- D Invertebrate with internal enzymatic digestion

19. In the table below the signs refer to the effects of interaction on the populations of two interacting species. The effects may be positive (+), negative (-) or neutral (0).

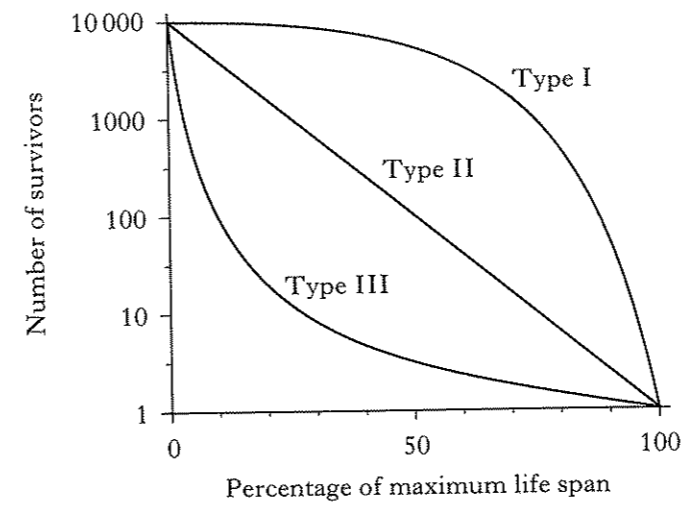
Which line correctly represents the effects of predation and parasitism?

	Predation		Parasitism	
	Species 1	Species 2	Species 1	Species 2
A	+	-	+	0
B	+	0	+	-
C	+	-	+	-
D	+	0	+	0

20. Two or more unrelated and unpalatable species are protected from predation by their close resemblance to each other. This is called

- A Batesian mimicry
- B Mullerian mimicry
- C warning colouration
- D camouflage.

21. The curves below represent three patterns of survival found in different organisms.



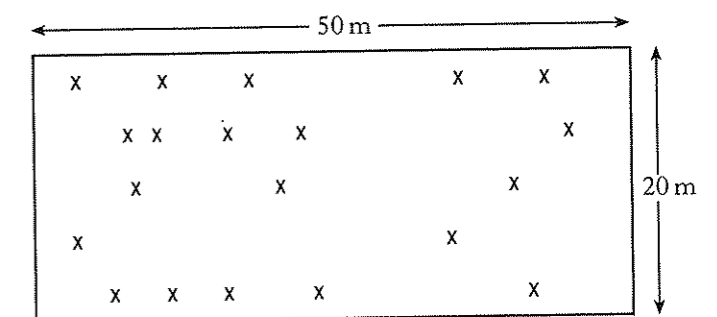
Which of the following comparisons is correct?

	Higher mortality in younger members of population	Higher mortality in older members of population
A	Type I	Type III
B	Type I	Type II
C	Type III	Type II
D	Type III	Type I

22. The table describes features of different types of competition. Which line is **not** correct?

	Type of competition	Feature
A	Interference	Preventing the sharing of a resource
B	Exploitation	Consuming different resources
C	Interspecific	Involving different species
D	Intraspecific	Involving a single species

23. Each cross in the plan below shows the position of a ragwort plant in a field.



The population density of ragwort is

- A 0.02 m^{-2}
- B 0.05 m^{-2}
- C 0.2 m^{-2}
- D 0.5 m^{-2} .

24. Which of the following is a likely outcome of monoculture?

- A Increase in field size
- B Decrease in the use of fertilisers
- C Decrease in mineral leaching
- D Increase in the number of available habitats

[Turn over

25. The table shows the number of seedlings of a shrub growing at different distances from the nearest mature plant.

	<i>Distance from nearest mature plant (cm)</i>						
	0-9	10-19	20-29	30-39	40-49	50-59	60-69
Number of seedlings in March	22	77	41	33	8	7	6
Number of seedlings in July	11	23	11	8	6	5	5
Percentage survival	50	30	27	24	75	71	83

Which of the following statements is correct?

- A The percentage mortality decreases with increasing distance from the nearest mature plant.
- B The percentage mortality increases with increasing distance from the nearest mature plant.
- C The percentage mortality is greater than the percentage survival when the distance from the nearest mature plant is greater than 39 cm.
- D The percentage mortality is less than the percentage survival when the distance from the nearest mature plant is greater than 39 cm.

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

[END OF SECTION A]

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

SECTION B

Both questions in this section should be attempted.

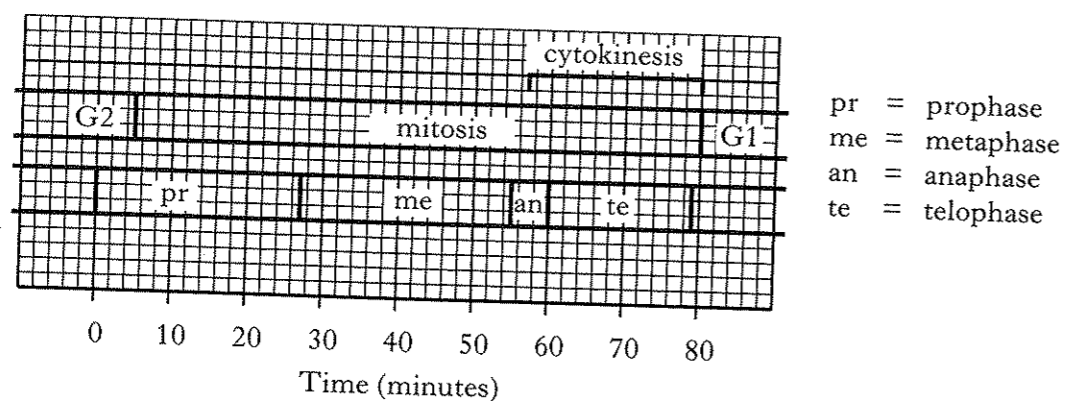
Cell and Molecular Biology

- The cell cycle represents the life of a cell as a series of four phases; one phase (M) is mitosis while the other three occur between one mitosis and the next. Animal cells in culture can complete the whole cycle in about 24 hours. Figure 1 below shows the duration of events in M phase.

Cultured cells can be stained with dye that becomes fluorescent (emits light) when it binds to DNA so the emission from each cell is proportional to its DNA content. Cell culture can be passed through an instrument that can measure both the fluorescence value from individual cells and count how many cells of each value are present. Figure 2 shows the distribution of cells across all phases of the cell cycle in a population of normal human cells.

Studies of cell cultures have revealed that progress between phases of the cell cycle is normally controlled by "checkpoints". If these fail then tumours can develop. Table 1 shows the results of cell counts from normal human tissue, where the stages of mitosis are scored separately from cells in interphase. Table 2 shows the results obtained when tumour cells from the same person are cultured.

Figure 1: Duration of events in M phase of the cell cycle in cultured normal human cells.



[Question 1 continues on Page eleven]

Question 1 (continued)

Figure 2: Distribution of cells in the cell cycle sorted by their relative DNA content.

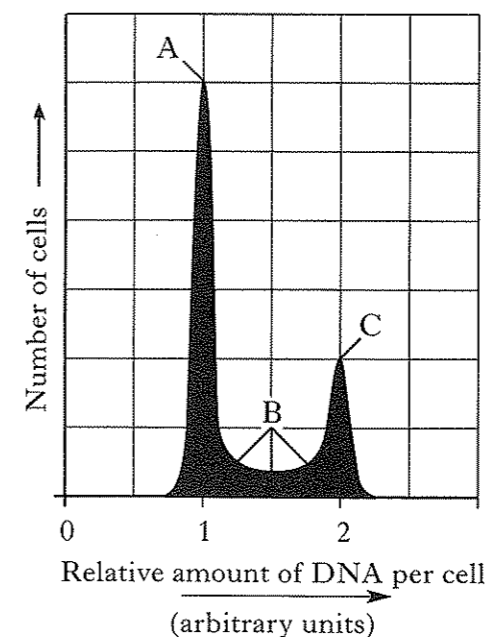


Table 1: Distribution of cells at interphase and different stages of mitosis from a culture of normal human tissue.

Stage	Number of cells	% of cells at each stage	% of mitotic cells in each stage of mitosis
Interphase	924	87.3	-
Prophase	46	4.4	34
Metaphase	48	4.5	36
Anaphase	8	0.8	6
Telophase	32	3.0	24

Table 2: Distribution of cells at interphase and different stages of mitosis from a culture of human tumour tissue.

Stage	Number of cells	% of cells at each stage	% of mitotic cells in each stage of mitosis
Interphase	60	42.9	-
Prophase	17	12.1	21
Metaphase	32	22.9	40
Anaphase	16	11.4	20
Telophase	15	10.7	19

[Question 1 continues on Page twelve]

Question 1 (continued)

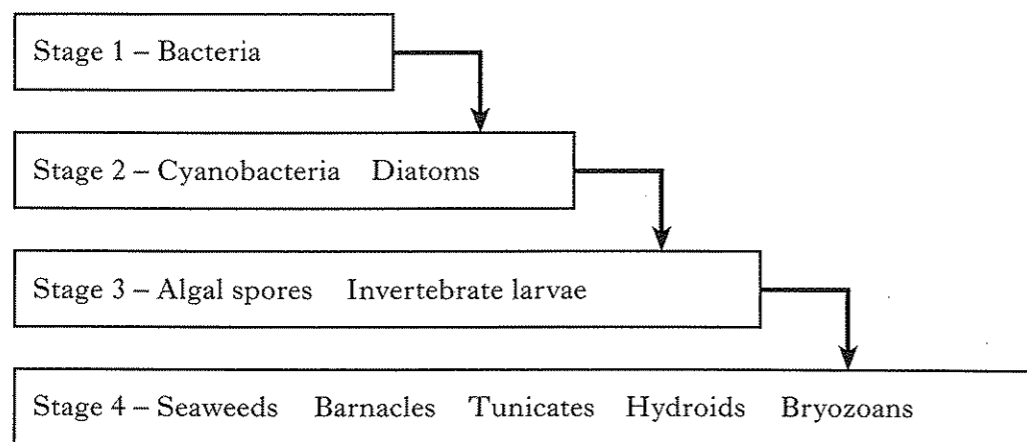
Marks

- (a) Checkpoints occur in G1, G2 and M. What events are triggered by the M checkpoint? 1
- (b) The mitotic index of a cell sample is the percentage of cells undergoing mitosis. Calculate the mitotic index of the normal cells from human tissue. 1
- (c) Mitosis involves microtubules.
- (i) Name the protein from which microtubules are constructed. 1
 - (ii) Give one role of microtubules in mitosis. 1
 - (iii) In which cell structure are microtubules anchored? 1
- (d) Use information from Figure 1 to describe how the timing of cytokinesis relates to the events occurring in mitosis. 2
- (e) Use the data provided to support the hypothesis that the percentage of cells counted in each stage of mitosis can give a good indication of the percentage of time each stage lasts. 2
- (f) (i) Cells are engaged in DNA replication in region B of Figure 2.
In which phase of the cell cycle are these cells? 1
- (ii) In which two phases of the cell cycle are cells in region C of Figure 2. 1
- (g) What term is used for a proliferation gene that promotes tumour formation? 1
- (h) Using information from Tables 1 and 2, give **two** effects of the tumour promoting gene on cell division. 2
- (i) Why is it important to use percentage values when comparing data from the normal and tumour cell cultures? 1
- (15)**

[Question 2 begins on fold-out Page thirteen

2. Structures such as boat hulls, when submerged in sea-water, become "fouled" by a variety of different organisms. Predictable changes occur in this colonisation as shown in Figure 1.

Figure 1: Changes in community during the "fouling" of submerged boat hulls.



These communities are of major economic significance because fouled boat hulls have a much higher resistance to movement through water, reducing speed and raising fuel consumption.

Anti-fouling paints, when applied to boat hulls, are designed to release toxic chemicals to kill any organisms settling on the surface. Tributyltin (TBT) compounds have been used in marine anti-fouling paints since the mid-60s. During the 1980s, however, relatively high levels of TBT were recorded in coastal waters and TBT was shown to have harmful effects on molluscs such as dog whelks (*Nucella lapillus*).

Female dog whelks show signs of exposure to TBT by becoming masculinised; they develop male sex organs such as a penis and a sperm duct. This effect, known as "imposex", can occur at concentrations less than 1 ng l⁻¹ which is below the level of TBT detection by chemical methods. Imposex is irreversible in individual animals and increases sterility and mortality in female dog whelks.

Figure 2 shows the results of an experiment designed to investigate the effect of TBT on the degree of imposex in female dog whelks as measured by calculating the relative penis size index (RPSI) using the following formula.

$$RPSI = \frac{(\text{mean length of female penis})^3}{(\text{mean length of male penis})^3} \times 100$$

Legislation banning the use of TBT on small boats (less than 25 m) was introduced in 1987. Figure 3 shows study sites used on the Isle of Cumbrae (Scotland) to carry out a survey on dog whelk populations in 1988 and 1993. Table 1 shows some of the results obtained.

Question 2 (continued)

Figure 2: Effect of tributyltin on the degree of imposex (RPSI) in female dog whelks.

(1 nanogram (ng) = 10⁻⁹ grams)

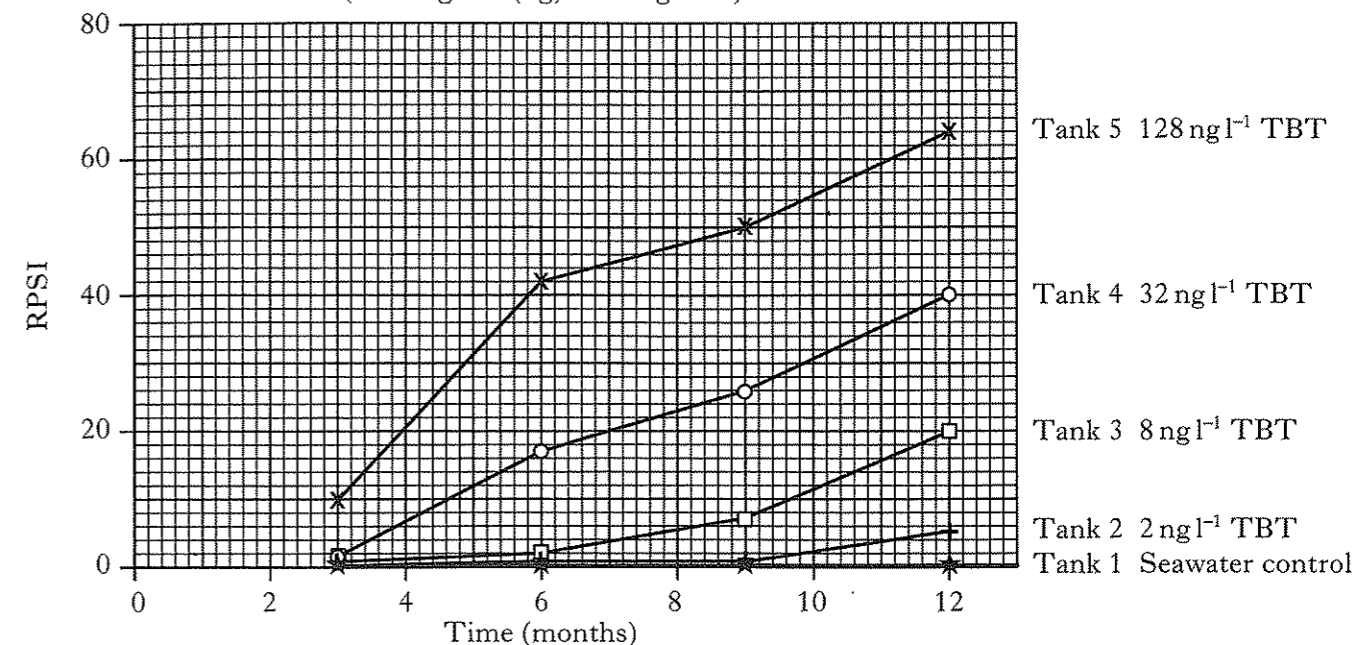


Figure 3: Study sites on the Isle of Cumbrae.

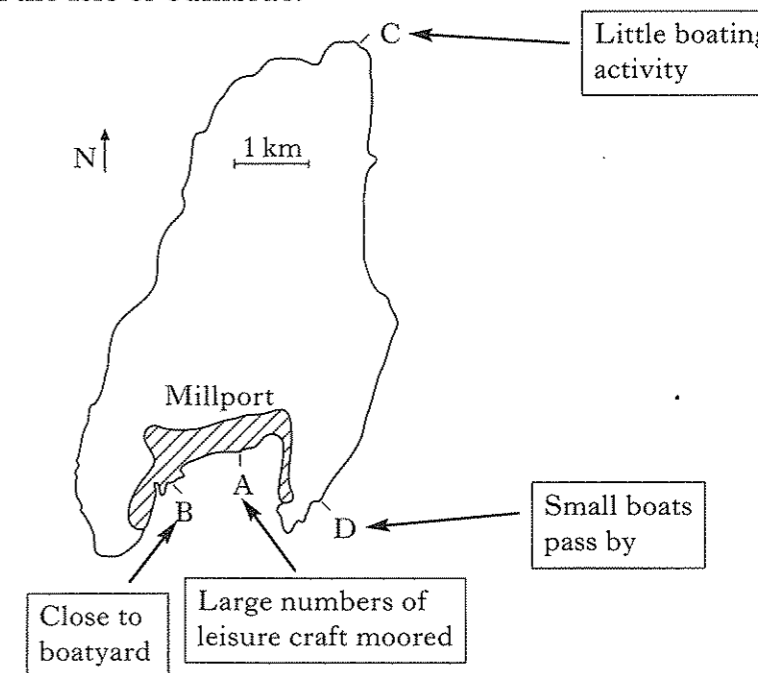


Table 1: Results obtained from surveys on dog whelk populations on the Isle of Cumbrae in 1988 and 1993.

	Year	Site A	Site B	Site C	Site D
Abundance (number m ⁻²)	1988	0	4	19	12
	1993	41	16	63	31
Sex ratio (number m/f)	1988	-	1.7	1.1	1.2
	1993	1.2	1.0	1.0	0.9
Percentage females with imposex	1988	-	100	90	100
	1993	55	93	46	56
RPSI	1988	-	50.7	6.0	15.3
	1993	7.4	3.5	3.1	1.7

Question 2 (continued)

- (a) (i) Why may the changes in community shown in Figure 1 be described as a *primary* succession? 1
- (ii) State **one** way in which the events shown in Figure 1 are characteristic of a biological succession. 1
- (b) State **two** general conclusions that can be drawn from the data shown in Figure 2. 2
- (c) Calculate the RPSI for a dog whelk population in which males have a mean penis length of 4.0 mm and females have a mean penis length of 3.0 mm. 1
- (d) Use the information shown by Figure 3 and Table 1 to support a hypothesis linking TBT contamination with boating activity. 2
- (e) Use the information in Table 1 to:
- (i) explain why the data for Site A appear to be incomplete; 1
- (ii) explain how the sex ratio data for Site B suggest that the dog whelk populations are showing signs of recovery from TBT pollution; 1
- (iii) state **two** other pieces of evidence which suggest that the ban on the use of TBT has been successful. 2
- (f) Explain why dog whelks may be useful indicators of very low levels of TBT pollution. 1
- (g) The concentration of TBT in dog whelk tissues is usually much higher than in their prey species.
What name is given to this increase in concentration? 1
- (h) Explain how the reduction in fouling could have beneficial consequences for the greenhouse effect and global warming. 2
- (15)

[END OF SECTION B]

[Turn over for Section C on Page sixteen

SECTION C

Both questions in this section should be attempted.

Note that each question contains a choice.

Labelled diagrams may be used where appropriate.

Cell and Molecular Biology

Marks

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

A. Describe the structure of triglycerides (triacylglycerols), phospholipids and steroids. Explain how the structure of these molecules relates to their functions.

(15)

OR

B. (i) Briefly describe the structure of a DNA molecule.

5

(ii) Give an account of the procedures involved when DNA profiling is used to compare two samples of DNA.

10
(15)

Environmental Biology

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

A. "Organisms respond to changes in the external environment."

Discuss this statement under the following headings:

(i) dormancy;

(ii) conformers and regulators.

(15)

OR

B. Discuss the costs and benefits of different types of biotic interaction and symbiotic relationships to the organisms involved.

(15)