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.

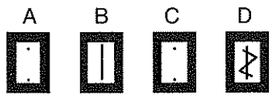
SAMPLE QUESTION

Which of the following molecules contains six carbon atoms?

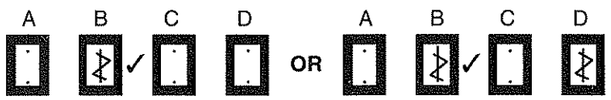
A Pyruvic acid
B Glucose
C Ribulose bisphosphate
D Acetyl co-enzyme A

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. The function of flagella in prokaryotes is

A motility
B active transport
C adhesion
D DNA transfer.

2. Which of the following structures is present in both eukaryotic and prokaryotic cells?

A Mitochondrion
B Chloroplast
C Ribosome
D Nucleoid

3. The key below can be used to identify carbohydrates.

1.	Sugars	go to (2)
	Polysaccharides	go to (4)
2.	Monosaccharides	A
	Disaccharides	go to (3)
3.	Contains only one type of monomer ..	B
	Contains two types of monomer ...	sucrose
4.	Storage function	go to (5)
	Structural function in plants	C
5.	Storage function in animals	D
	Storage function in plants	starch

Which substance could be maltose?

4. Fatty acids and glycerol are joined in a triglyceride by

A hydrogen bonds
B ester linkages
C glycosidic linkages
D peptide bonds.

5. Which of the following is responsible for cell–cell recognition?

A Phospholipid
B Glycoprotein
C Cholesterol
D Peptidoglycan

6. The following reaction occurs in glycolysis.

fructose 6–phosphate ⟶ fructose 1,6–bisphosphate

Which type of enzyme would catalyse this reaction?

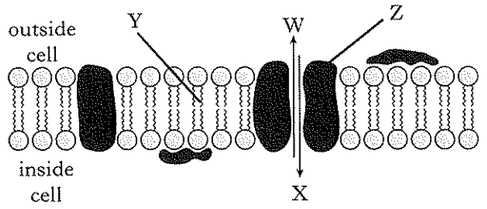
A Protease
B Polymerase
C ATPase
D Kinase

7. Not all cells respond to testosterone because

A the hormone crosses the plasma membrane of target cells only
B the hormone directly inhibits the transcription of certain genes
C only target cells possess the necessary regulatory proteins
D only target cells possess the genes necessary for the response.

[Turn over

Questions **8** and **9** refer to the following diagram of the sodium–potassium pump.



8. Which line in the table correctly identifies the labels?

	W	X	Y	Z
A	Sodium ions	Potassium ions	Protein	Phospholipid
B	Potassium ions	Sodium ions	Protein	Phospholipid
C	Sodium ions	Potassium ions	Phospholipid	Protein
D	Potassium ions	Sodium ions	Phospholipid	Protein

9. This pump moves ions in the ratio 3 sodium: 2 potassium.

5000 of these ions are pumped across the membrane every ten seconds. The number of potassium ions moved across in one second is

A 200

B 500

C 2000

D 3000.

Questions **10** and **11** refer to the following information.

ONPG is a colourless substrate for the enzyme β–galactosidase.

$$\text{ONPG} \xrightarrow[\beta\text{–galactosidase}]{} \text{galactose + ONP (yellow)}$$

The table shows the results of an investigation into the effect of inhibitor X and inhibitor Y on β–galactosidase at different substrate concentrations.

The greater the absorbance, the more active the enzyme.

ONPG concentration (%)	*Absorbance*	
	Inhibitor X	*Inhibitor Y*
0·25	0·17	0·05
0·50	0·25	0·05
0·75	0·34	0·04
1·00	0·50	0·06

10. Which of the following conclusions can be drawn from the results for inhibitor X?

A An increase in enzyme concentration increases enzyme activity.

B An increase in inhibitor concentration decreases enzyme activity.

C A three-fold increase in substrate concentration doubles the enzyme activity.

D Doubling the substrate concentration gives a three-fold increase in enzyme activity.

11. The results suggest that the inhibition by

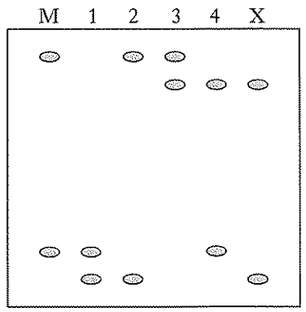
A inhibitor X is competitive and reversible

B inhibitor Y is competitive and reversible

C both inhibitors are non-competitive and non-reversible

D both inhibitors are competitive.

12. The DNA profile shown below was prepared using a single locus probe to determine if man X was the father of all four children. The samples shown are for the mother (M), four children (1–4) and man (X).



Which of the children have a different father?

A 1 and 2

B 2 and 3

C 3 and 4

D None of them

13. Net primary productivity in an ecosystem is the result of the activities of

A autotrophs

B heterotrophs

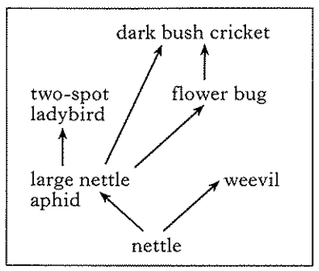
C detritivores

D decomposers.

Questions **14**, **15** and **16** refer to the following information.

The diagram shows a food web in a heathland ecosystem.

The table shows data obtained from an investigation into the mass and population density of the organisms in the food web.



Species	*Mean mass of organism* (g)	*Population density* (number m^{-2})
dark bush cricket	0·10	4
two-spot ladybird	0·03	20
flower bug	0·04	50
large nettle aphid	0·002	5420
weevil	0·005	3250
nettle	40·0	25

14. Which of the following populations in the food web has the largest biomass?

A Dark bush cricket

B Two-spot ladybird

C Weevil

D Large nettle aphid

15. The biomass of the primary consumer level is

A 5·41 g m^{-2}

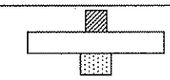
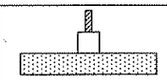
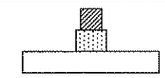
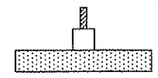
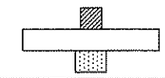
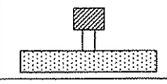
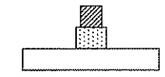
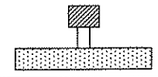
B 10·84 g m^{-2}

C 16·25 g m^{-2}

D 27·09 g m^{-2}.

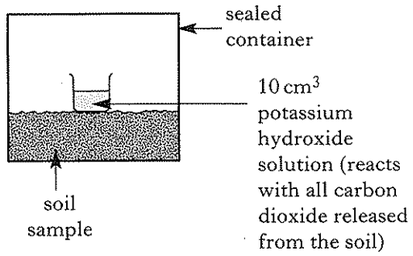
16. Which pair of diagrams in the table below correctly identifies the pyramids of number and biomass for the following food chain? (Pyramids not drawn to scale.)

nettle → large nettle aphid → two-spot ladybird

	Pyramid Type	
	Number	*Biomass*
A		
B		
C		
D		

Key: large nettle aphid; nettle; two-spot ladybird

17. The apparatus below was set up to compare the rates of respiration by decomposers in four soil samples.



After one day, the volume of hydrochloric acid needed to neutralise any potassium hydroxide left over was measured.

When the experiment was repeated with a fifth soil sample, it was found that **all** the potassium hydroxide had reacted with carbon dioxide released from the soil.

Before a valid calculation of respiration rate in this soil could be made, the experiment would have to be repeated

A at a higher temperature

B with a smaller mass of soil

C with a more dilute potassium hydroxide solution

D over a long period of time.

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

A An increase in competitors decreasing the yield of a crop species

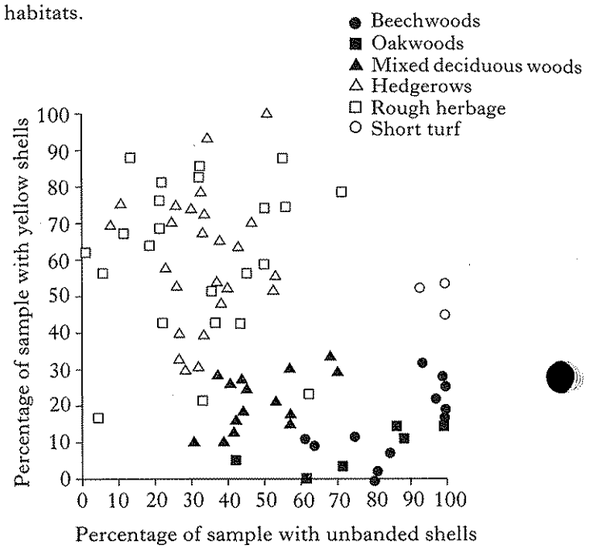
B An increase in food supply increasing the abundance of a herbivore

C A decrease in predators increasing the abundance of a prey species

D A decrease in temperature increasing the abundance of a tree species

Questions **19, 20** and **21** are based on the scattergram below which shows the distribution of different forms (morphs) of the snail *Cepaea nemoralis* in different habitats.

Cepaea has shells which may be either yellow or brown and may have either a banded or unbanded pattern. The scattergram shows frequencies of different colours and banding patterns in different habitats.



19. The habitat most favourable to brown, unbanded snails appears to be

A beechwoods

B hedgerows

C mixed deciduous woods

D short turf.

20. Which of the following pairs of habitats supports similar distributions of snail morphs?

A Hedgerows and beechwoods

B Rough herbage and short turf

C Oakwoods and mixed deciduous woods

D Hedgerows and rough herbage

21. Samples show that there are often good matches between the snails and the backgrounds of the different soils and vegetation. The snails' markings and colouration are showing

A aposematic colouration

B Mullerian mimicry

C crypsis

D Batesian mimicry.

22. Tiny crustaceans called copepods live inside the tentacles of a tropical sea anemone. These crustaceans feed on nutrients within the anemone but do it no harm.

This is an example of

A commensalism

B competition

C parasitism

D mutualism.

23. Which of the following types of succession will never lead to a climax community?

A Allogenic

B Autogenic

C Secondary

D Degradative

24. Which of the following is a problem associated with phosphate enrichment?

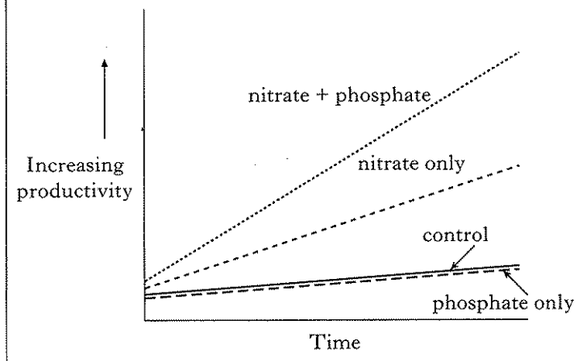
A Bioaccumulation

B Algal bloom

C Coral bleaching

D Biological magnification

25. The graph shows how productivity in a marsh was affected by the experimental addition of nitrate and phosphate. Neither was added in the control experiment.



Which statement is supported by the graph?

A Productivity in the control is limited by both nitrate and phosphate.

B Phosphate can limit productivity if enough nitrate is available.

C Phosphate limits productivity in the control experiment.

D Productivity in the marsh is never limited by phosphate.

[END OF SECTION A]

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

[Turn over

SECTION B

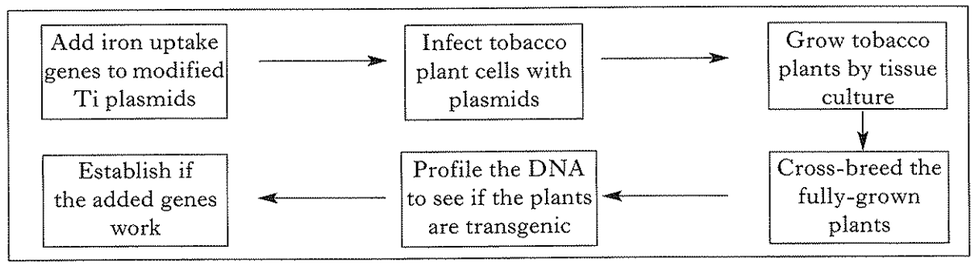
Both questions in this section should be attempted.

Cell and Molecular Biology

1. *Agrobacterium tumefaciens* is a type of bacterium that causes a disease of plants resulting in tumour-like growths at the stem base. These abnormal growths in infected plants are caused by the tumour inducing or **Ti plasmid** of the bacterium. Genes from the plasmid are inserted into a chromosome in the infected plant cells. Ti plasmids have now been modified for laboratory use so that they no longer cause the disease but can still be used to insert genes of commercial interest into a plant's genome.

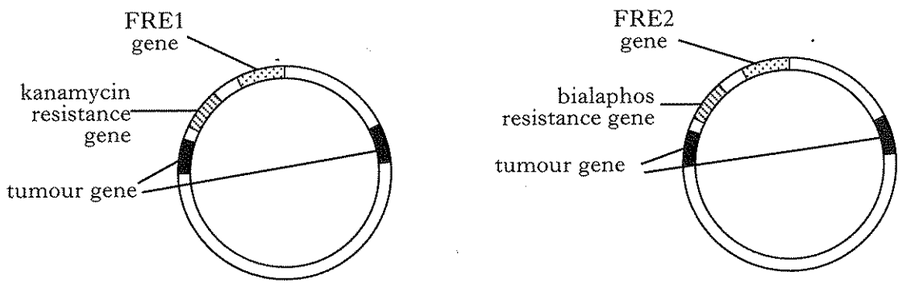
   The aim of the research outlined below was to create transgenic tobacco plants with an increased ability to absorb iron from the soil. Modified Ti plasmids were used to transfer the iron uptake genes found in yeast cells into tobacco plants. Iron is an important nutrient for plants; it is absorbed in the roots and transported to the leaves where it is essential for the formation of chlorophyll. The study had several steps, shown as a flow diagram in Figure 1.

Figure 1: Steps in the production of transgenic tobacco plants.



FRE1 and FRE2 are two genes in yeast cells that code for proteins responsible for the absorption of iron across the plasma membrane. The FRE genes were isolated and inserted into separate Ti plasmids, each alongside a different toxin-resistance gene to act as a **marker** gene. FRE1 was linked to the gene for resistance to the toxin kanamycin. FRE 2 was linked to the gene for resistance to the toxin bialaphos. Diagrams of the plasmids are shown in Figure 2. These modified plasmids were returned to *Agrobacterium tumefaciens* cells, which were then cultured to produce two strains of the bacteria.

Figure 2: Modified Ti plasmids.



Tobacco plant tissue was incubated with each strain of bacterium and then transferred to tissue culture media to which the appropriate toxins had been added. Plants surviving the toxins were grown on in pots.

Question 1 (continued)

Two groups of plants were produced to begin with, one resistant to kanamycin (group KA) and the other resistant to bialaphos (group BI). These plants were then cross-bred to produce a third group of plants resistant to both toxins (group KA+BI). Plants from all three groups were tested for the presence of FRE genes and for the effects of the genes on iron absorption. Control plants were tested at the same time. DNA profiles, shown in Figure 3, proved that the genes were now present in the plants.

Figure 3: Profiling gels of tobacco plant DNA.

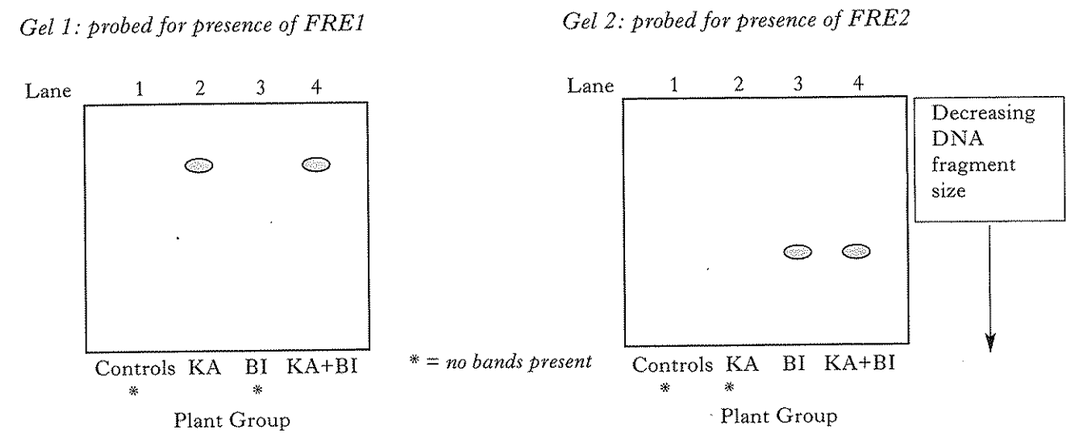


Figure 4 shows iron absorption by root samples from the different plant groups grown in conditions where iron is easily absorbed ("high" iron). Figure 5 compares the iron content of leaves after the plants were grown in "high" iron and "low" (difficult to absorb) iron conditions.

Figure 4: Iron absorption by roots of plants grown in "high" iron conditions.

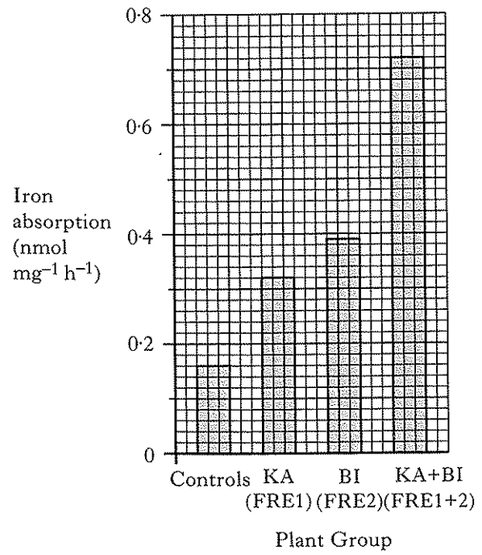


Figure 5: Iron content of leaf tissue of plants in "high" iron and "low" iron conditions.

	Iron concentration (µg/g dry mass)	
Plant Group	*"High" Iron*	*"Low" Iron*
Controls	129	26
KA (FRE1)	154	31
BI (FRE2)	199	43
KA+BI (FRE1+2)	223	41

[Question 1 continues on *Page ten*

Question 1 (continued)

Marks

(*a*) What are plasmids? 1

(*b*) FRE1 and FRE2 code for proteins present in the plasma membrane of yeast cells.

Give **two** functions of membrane proteins. 2

(*c*) (i) DNA extracted from all the groups of plants for profiling was digested by the same two enzymes, EcoRV and XbaI.

What term is used to describe enzymes such as EcoRV and XbaI? 1

(ii) Name the procedure used to separate the DNA fragments in the gels. 1

(iii) Which process could be used to amplify DNA fragments? 1

(*d*) Control plants were used to ensure the validity of the study.

Suggest **one** way in which the control plants would have been different from the experimental plants. 1

(*e*) Explain how the DNA profiles confirm:

(i) that plants selected for toxin resistance are also transgenic for FRE genes; 2

(ii) that the cross-breeding of KA resistant and BI resistant plants has successfully combined both FRE genes into the plant genome. 1

(*f*) (i) Draw **one** conclusion from the information in Figure 4. 1

(ii) Use data in Figure 4 to justify your answer. 1

(*g*) Refer to the data in Figure 5.

(i) For plants grown in "high" iron conditions, calculate the percentage increase in iron concentration of leaves when both FRE1 and FRE2 are present. 1

(ii) Use the data to compare the impact of the FRE2 gene on plants grown in the two iron conditions. 1

(*h*) A critic of the study claims that "to boost leaf iron concentration it would be better to alter the soil than to engineer the plants".

How can data in Figure 5 be used to support this position? 1

(15)

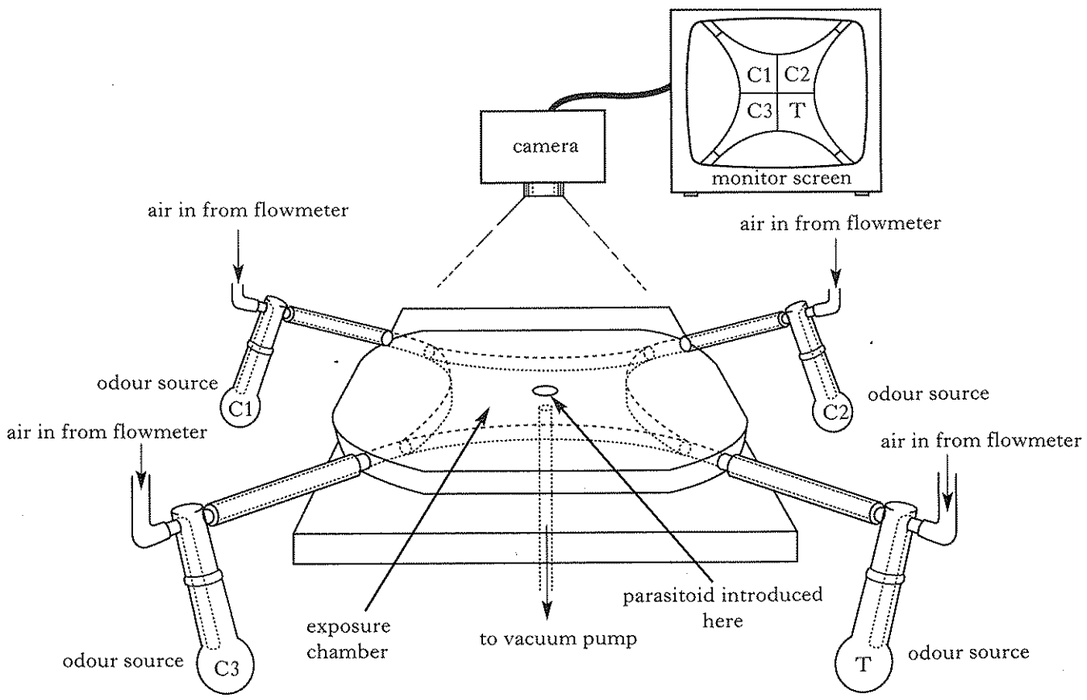
[Question 2 begins on fold-out *Page eleven*

2. Many plants can protect themselves against being eaten by using indirect forms of defence. During feeding, the oral secretions produced by insects may stimulate the plant to release volatile compounds into the air. These compounds, called **synomones**, can attract enemies of the insect herbivores such as predators and **parasitoids**. Parasitoids are insects which lay eggs inside other insects. These eggs hatch into larvae which then devour the host. Free-living parasitoid adults use their olfactory (smell) sense to detect the synomones.

   The effects of synomones have benefits for both the plant and the parasitoid. One study has shown that even the act of egg-laying by insect herbivores may stimulate synomone production. This **tri-trophic** study involved Scots pine (*Pinus sylvestris*), a sawfly herbivore (*Diprion pini*) of the pine and an egg parasitoid wasp (*Chrysonotomyia ruforum*) which lays its own eggs inside the eggs of its sawfly host.

   An olfactometer (see Figure 1) was used to test parasitoid reactions to any synomones released by Scots pine twigs. Sawfly eggs were added to Scots pine twigs and left for 72 hours. The twigs were then placed in odour source bottle T in the olfactometer. At the start of each test, a female parasitoid was placed in the exposure chamber of the olfactometer. The time spent walking in each of the four fields (see monitor screen in Figure 1) was recorded during a period of 600 seconds. The procedure was repeated using twigs without eggs.

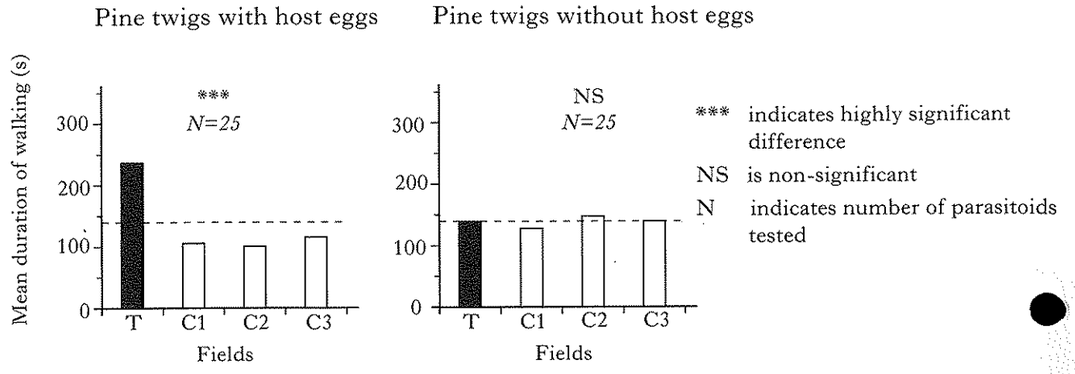
Figure 1: Perspective view of the olfactometer. Air is drawn by the vacuum pump through the exposure chamber equally from four sources. It flows towards the centre of the chamber and down to the pump. The rate of airflow is carefully regulated to prevent the mixing of air from different sources.



Question 2 (continued)

Significantly longer periods of walking in the test field (T) than in the three control fields (C1, C2, C3) were taken to indicate attraction to a released odour. The results of these tests are shown in Figure 2 where the dashed line represents the expected duration of walking in any field if there is no response to an odour source.

Figure 2: Responses of egg parasitoid (*Chrysonotomyia ruforum*) to volatile compounds released from pine twigs with and without sawfly eggs.



Further similar experiments were carried out to determine which aspect of egg-laying by the sawflies induced synomone production. Three different treatments were carried out, as follows, 72 hours before the twigs were introduced into the olfactometer.

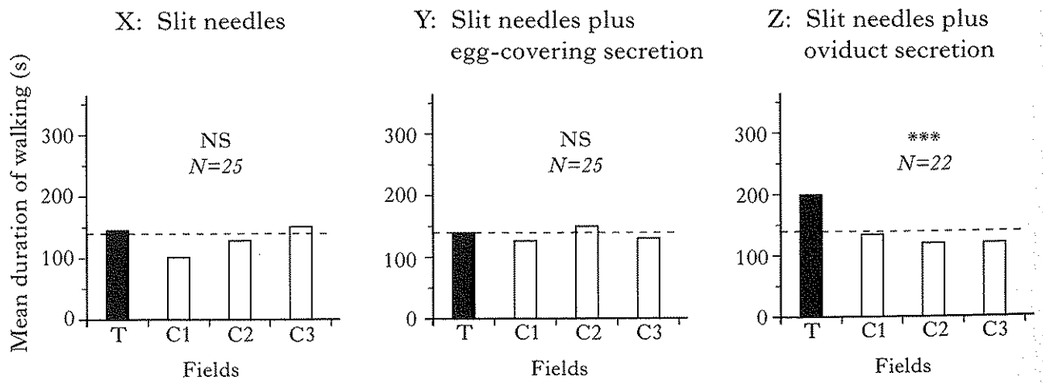
Treatment X: needles on a pine twig were slit using a scalpel to mimic the damage caused by female sawflies when laying eggs.

Treatment Y: needles on a pine twig were slit and treated with the egg-covering secretion of the female sawfly.

Treatment Z: needles on a pine twig were slit and treated with the oviduct secretion of the female sawfly.

The results of these tests are shown in Figure 3.

Figure 3: Responses of egg parasitoid (*Chrysonotomyia ruforum*) to volatile compounds released from Scots pine twigs after different treatments.



Question 2 (continued)

(*a*) This research is concerned with plant defence chemicals called synomones.

(i) State why this form of defence is "indirect". **1**

(ii) Indicate how these chemicals benefit both the plant and the parasitoid. **2**

(*b*) Why is this study described as tri-trophic? **1**

(*c*) Refer to the procedure involving the olfactometer illustrated in Figure 1.

(i) Why were only female parasitoids used? **1**

(ii) Suggest why twigs were kept for 72 hours after treatment before being placed in the olfactometer. **1**

(iii) Suggest **one** precaution necessary to ensure that the experimental procedure was valid. **1**

(*d*) With reference to the data shown in Figure 2:

(i) explain why the bars in each chart do not add up to 600 seconds; **1**

(ii) describe the evidence which suggests that egg-laying attracts parasitoid wasps. **2**

(*e*) What conclusions can be drawn from each of the treatments shown in Figure 3 regarding the production of synomones during egg-laying by the sawfly? **2**

(*f*) Describe how the parasitoid interaction between *Diprion pini* and *Chrysonotomyia ruforum* differs from:

(i) parasitism; **1**

(ii) predation. **1**

(*g*) Host/parasitoid relationships are highly specific. What long-term process is responsible for this specificity? **1**

(15)

[END OF SECTION B]

[Turn over for Section C on *Page fourteen*

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. Discuss the cell cycle under the following headings:

(i) the sequence of events in the cell cycle; **5**

(ii) how the cell cycle is controlled; **6**

(iii) how abnormal cell division can arise. **4**

(15)

OR

B. Compare the methods used to grow mammalian cells and plant tissue in culture. **(15)**

Environmental Biology

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

A. Discuss the circulation of nutrients in ecosystems under the following headings:

(i) decomposition of organic matter; **5**

(ii) the role of bacteria in chemical transformations in the nitrogen cycle. **10**

(15)

OR

B. Discuss the effects of intensive food production on ecosystems. **(15)**