

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.

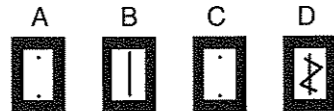
SAMPLE QUESTION

Which of the following molecules contains six carbon atoms?

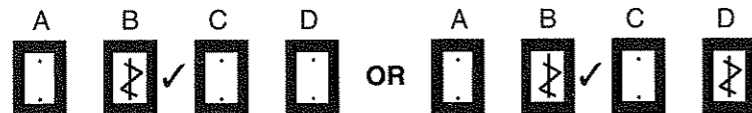
- A Pyruvic acid
- B Glucose
- C Ribulose biphosphate
- D Acetyl co-enzyme A

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:

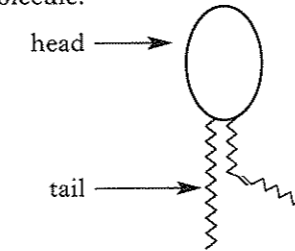


SECTION A

All questions in this section should be attempted.

Answers should be given on the separate answer sheet provided.

1. The diagram represents a phospholipid molecule.



Which of the following describes correctly the structure of a phospholipid molecule?

- A The "head" contains glycerol and is hydrophilic.
- B The "head" contains phosphate and is hydrophobic.
- C The "tail" contains fatty acids and is hydrophilic.
- D The "tail" contains phosphate and is hydrophobic.

2. The chemical formulae for three fatty acids are given below:

Palmitic acid $\text{CH}_3(\text{CH}_2)_{14}\text{COOH}$

Oleic acid $\text{CH}_3(\text{CH}_2)_7\text{CH}=\text{CH}(\text{CH}_2)_7\text{COOH}$

Linoleic acid $\text{CH}_3(\text{CH}_2\text{CH}=\text{CH})_3(\text{CH}_2)_7\text{COOH}$

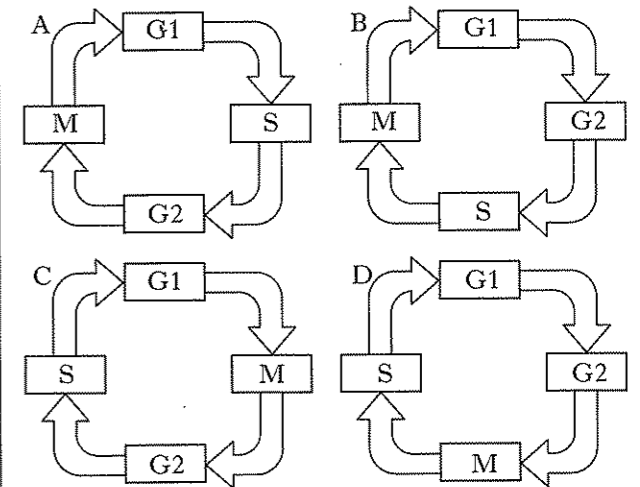
Which line in the table describes correctly the three fatty acids?

	Palmitic acid	Oleic acid	Linoleic acid
A	Unsaturated	Saturated	Polyunsaturated
B	Polyunsaturated	Saturated	Unsaturated
C	Saturated	Unsaturated	Polyunsaturated
D	Unsaturated	Polyunsaturated	Saturated

3. Which of the following cell structures are found only in plants?

- A Mitochondria
- B Plasmodesmata
- C Lysosomes
- D Cell walls

4. Which of the following correctly represents the cell cycle?



5. When a population of cells is examined, the percentage of cells in the M phase is termed the mitotic index. What is the mitotic index for the following population of cells?

Phase of mitosis	Number of cells
Interphase	450
Prophase	25
Metaphase	15
Anaphase	5
Telophase	5

- A 3%
- B 10%
- C 11%
- D 90%

6. In plant tissue culture, which of the following occurs as a result of nuclear totipotency?

- A Calluses fail to form.
- B Protoplasts can be fused together.
- C Whole plants can be regenerated.
- D Recombinant DNA is easily taken up.

[Turn over

7. In which of the following do both copies of the gene require a mutation for cancer to develop?

- A Oncogenes
- B Proto-oncogenes
- C Proliferation genes
- D Anti-proliferation genes

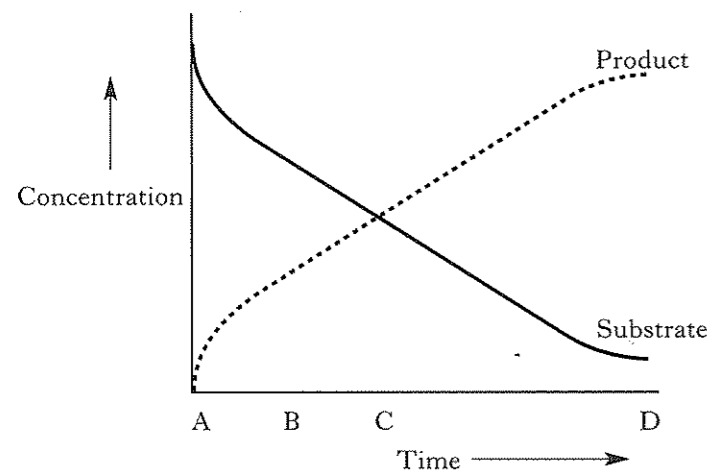
8. The table below shows the percentage of each base in a single strand of DNA.

Adenine	Thymine	Guanine	Cytosine
30	26	19	25

Which line in the table shows the percentage of each base in the RNA transcribed from this section of DNA?

	Adenine	Thymine	Guanine	Cytosine	Uracil
A	26	0	19	25	30
B	26	0	25	19	30
C	30	26	19	25	0
D	0	30	25	19	26

9. The graph below shows the relationship between the concentrations of substrate and product in an enzyme-controlled reaction.

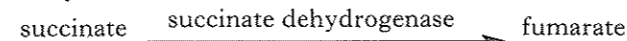


At which of the times shown is the rate of reaction at its greatest?

10. The change in shape of the active site of an enzyme, when its substrate binds, is called

- A specificity
- B induced fit
- C positive modulation
- D covalent modification.

11. The reaction shown below is part of the Krebs cycle.



This reaction is inhibited by malonate, a substance not involved in the Krebs cycle.

Increasing the concentration of succinate when the inhibitor is present increases the rate of fumarate production.

Which of the following describes the effect of malonate on succinate dehydrogenase?

- A Competitive inhibition
- B Non-competitive inhibition
- C End-product inhibition
- D Allosteric inhibition

12. A protein's net charge is equal to the number of positively charged amino acids minus the number of negatively charged amino acids.

Table 1 shows the charge of amino acids at a certain pH.

Table 1

Positively charged	Negatively charged
arginine	tyrosine
lysine	cysteine
histidine	glutamate
	aspartate

Table 2 shows the number of each amino acid in a protein.

Table 2

Amino acid	Number
arginine	13
lysine	19
histidine	2
tyrosine	7
cysteine	2
glutamate	20
aspartate	9

Assuming that each amino acid carries a single positive or negative charge, what is the protein's net charge at the same pH?

- A + 38
- B + 4
- C - 4
- D - 34

13. In polypeptide chains, the amino acid alanine has no charge. Its functional group is

- A acidic
- B basic
- C polar
- D nonpolar.

14. Productivity in freshwater ecosystems is often limited by phosphorus. This is because phosphates

- A have low solubility in fresh water
- B are pollutants of fresh water
- C have many functions in aquatic animals
- D are rapidly taken up by aquatic plants.

15. On coral reefs there are special areas where small fish called cleaner wrasse remove dead skin and fungi from inside the mouths of large fish such as groupers. Another fish mimics the colour and behaviour of the cleaner wrasse. When the grouper allows the mimic inside its mouth, the mimic bites off pieces of flesh.

For both cleaner and mimic to be successful

- A there must be similar numbers of each
- B the cleaner must be common and the mimic rare
- C the cleaner must be rare and the mimic common
- D both species must be rare.

16. A parasitic fungus which is able to change its mode of nutrition after the death of its host is said to be

- A facultative
- B resistant
- C obligate
- D symbiotic.

17. The malarial parasite is taken up from human blood by a mosquito. The parasite undergoes part of its life cycle in the mosquito, producing infective stages. These are then passed on to new hosts when the mosquito next takes a blood meal.

In the life cycle of the malarial parasite, the human acts as a

- A secondary host
- B primary host
- C vector
- D resistant stage.

18. The table below shows information about plants in fenced and unfenced grassland plots after 2 years. The plots were fenced to exclude voles which feed mainly on annual grasses.

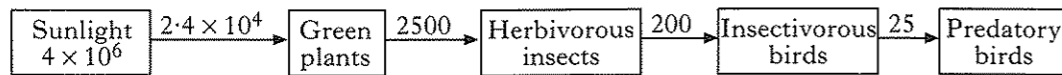
	Biomass (units)	
	Fenced plots	Unfenced plots
Annual grasses	120	60
Other plants	40	80

When voles are absent

- A the biomass of annual grasses increases by 50%
- B the biomass of annual grasses decreases by 50%
- C the biomass of other plants increases by 100%
- D the biomass of other plants decreases by 50%.

[Turn over

Questions 19 and 20 refer to the following diagram which shows the annual flow of energy through a terrestrial ecosystem. The units are kJ m^{-2} .



19. The organisms at trophic level 3 are

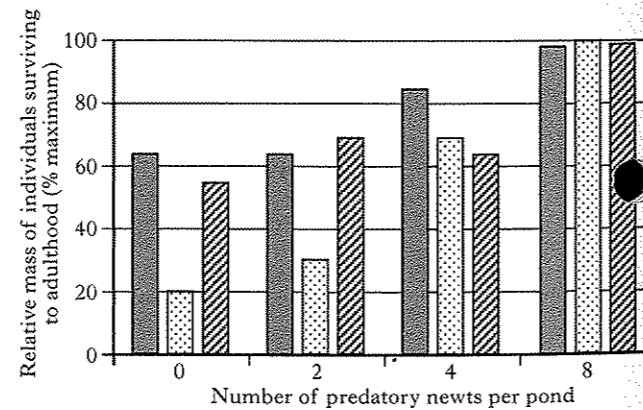
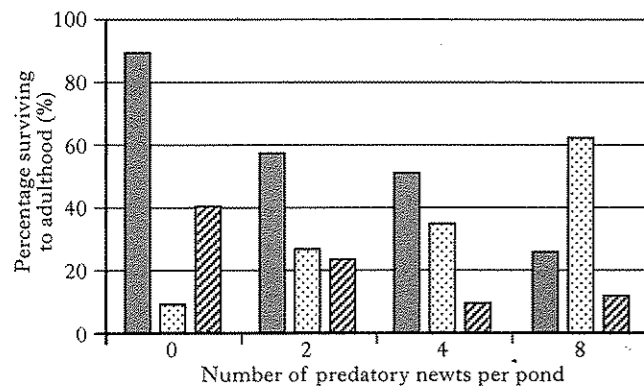
- A producers
- B primary consumers
- C secondary consumers
- D tertiary consumers.

20. The efficiency of energy transfer through the trophic levels

- A increases
- B decreases
- C stays the same
- D decreases and then increases.

21. The charts below show results obtained in a study of three species of tadpoles in ponds containing predatory newts.

KEY
Scaphiopus (toad)
Hyla (frog)
Bufo (toad)



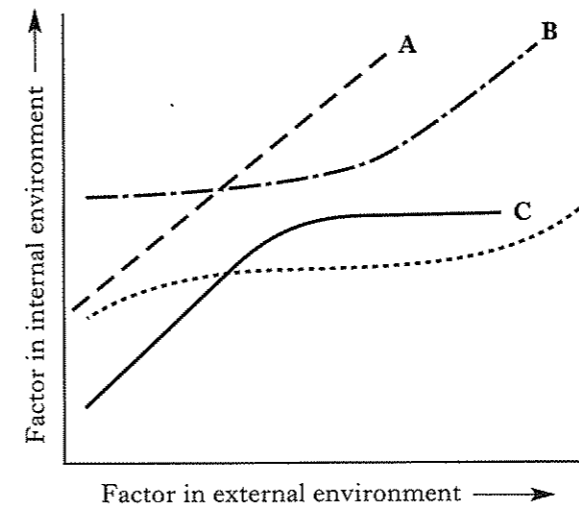
Which of the following statements **cannot** be justified by the data shown?

- A Increasing the density of predators increases the survival of weaker competitors.
- B Increasing the density of predators increases the growth of surviving prey individuals.
- C Increasing the density of predators improves the supply of food for frog tadpoles.
- D Increasing the density of predators increases competition between prey species.

22. Evidence for biological magnification in an ecosystem could be obtained by measuring the concentration of a pollutant in

- A an animal throughout its life
- B water over a period of time
- C different species at one trophic level
- D organisms at different trophic levels.

23. The figure below shows the general relationships between the internal environment and variation in the external environment of four animals.



Which animal is the most effective regulator?

24. Suspended metabolism of insects in response to the adverse environmental conditions of winter is a form of

- A predictive dormancy called aestivation
- B predictive dormancy called diapause
- C consequential dormancy called diapause
- D consequential dormancy called hibernation.

25. Coral bleaching is the result of an increase in

- A nutrient concentration
- B seawater temperature
- C populations of zooxanthellae
- D ultraviolet radiation.

[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. Cystic fibrosis (CF) is an inherited disorder in which epithelial cells, such as those lining the airways, secrete an unusually thick mucus. CF is caused by mutations in the cystic fibrosis transmembrane conductance regulator gene, or **CFTR** gene, which lead to a decrease in movement of chloride ions (Cl^-) out of cells. The movement of chloride ions can be detected by a small change in voltage (ΔPD) across the plasma membrane. The greater the movement of chloride ions the greater the ΔPD .

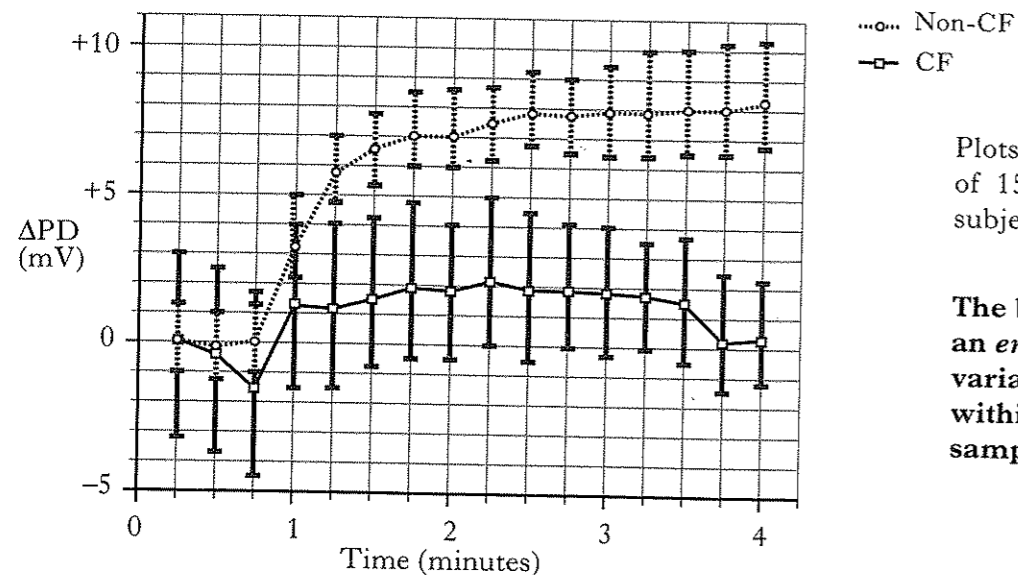
One of the CFTR mutations results in transmembrane chloride channels that fail to open as they should when phosphorylated. In a study to demonstrate the effect of this malfunction, epithelial cells in the nose were bathed in a solution lacking chloride ions and exposed to a drug, **isoprenaline**, that causes chloride channels to open if they are functioning normally. Figure 1 shows how the nasal epithelium in CF and non-CF individuals responded to the isoprenaline procedure.

Trials have been carried out on new ways to treat CF. Some of these involved the use of small lipid droplets called **liposomes** to deliver copies of the normal CFTR gene into epithelial cells of the airways.

One study used a randomised, double-blind procedure. In this type of experimental design, the subjects are not told which of the treatments they are receiving and researchers are not told which treatment they are giving. Four CF patients were given a **placebo**, in this case liposomes containing only water, while another four CF patients were given "active" liposomes containing 400 mg of the normal CFTR gene. To judge how much chloride channel function had been restored, the response of nasal epithelium to the isoprenaline procedure was measured both before the liposomes were given and again two days later. Results for each group are shown in Figures 2A and 2B.

In a second study, three groups of subjects were used; an untreated non-CF group, a CF group receiving placebo liposomes and a CF group receiving active liposomes. The response of epithelial cells to the isoprenaline procedure was measured as in the previous study, both before treatment and two days later. Mean values of ΔPD for the groups are shown in the Table.

Figure 1: Response of epithelial cells to the isoprenaline procedure over 4 minutes.



Plots are the mean response of 15 CF and 15 non-CF subjects.

The bar on each plot is an **error bar** showing the variation in values within the group at each sampling time.

Question 1 (continued)

Figure 2A: Response to the isoprenaline procedure in group receiving placebo liposomes.

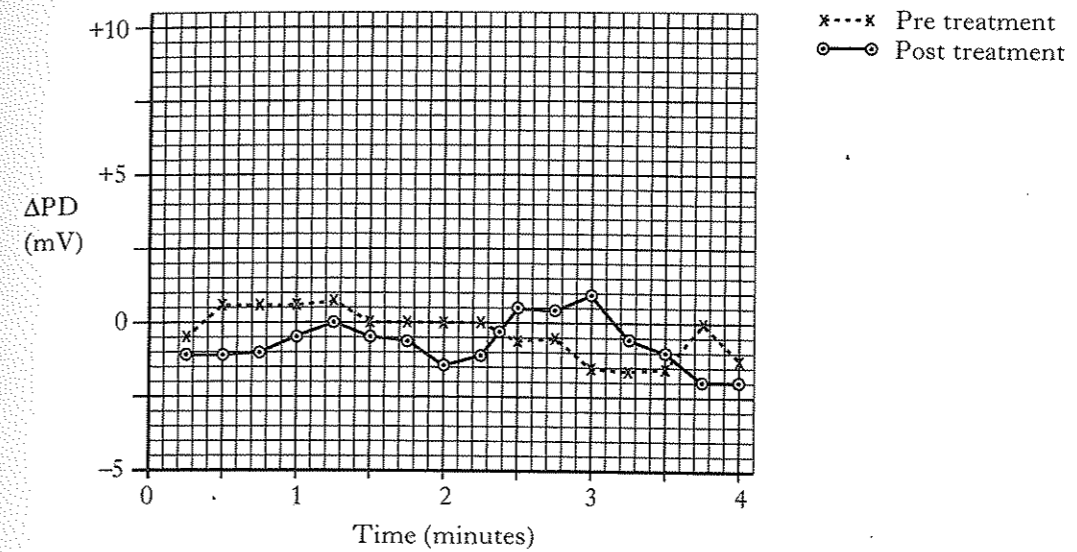


Figure 2B: Response to the isoprenaline procedure in group receiving active liposomes.

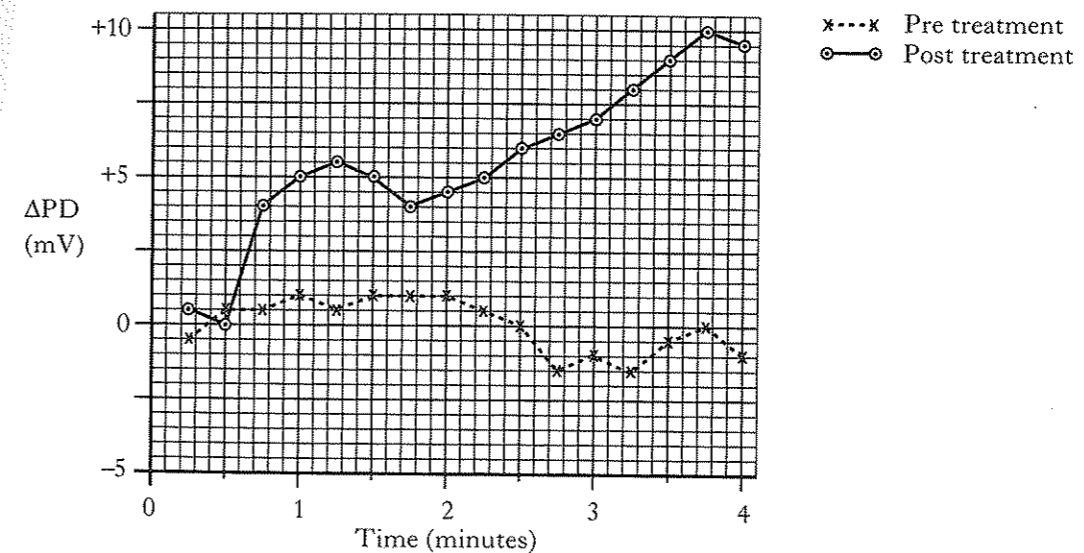


Table: Mean response to isoprenaline procedure of three treatment groups.

ΔPD (mV) after four minutes				
CF group given placebo liposomes		CF group given active liposomes		Non-CF group untreated
Before	After	Before	After	
-1	-2	-2	+2	+16

[Question 1 continues on Page ten]

Question 1 (continued)

Marks

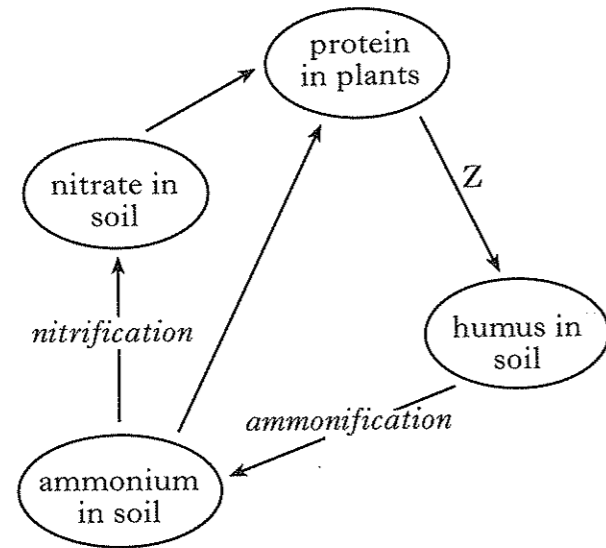
- (a) (i) What type of enzyme causes the opening of chloride channels? 1
- (ii) Explain why a protein channel is required for chloride ions to cross the plasma membrane. 2
- (iii) The researchers bathed epithelial cells in a solution lacking chloride ions. How does this maximise the diffusion of chloride ions? 1
- (b) Refer to Figure 1.
- (i) Explain why there is almost no response to the isoprenaline procedure in the CF group. 2
- (ii) What evidence is there to show that the first statistically significant difference in ΔPD between the two groups occurs at 1.25 minutes? 1
- (c) In what way is the liposome strategy an example of gene therapy? 1
- (d) The first liposome study is described as “randomised, double-blind”.
- (i) What are the key features of a *double-blind* study? 1
- (ii) Suggest how this aspect of the study improves its validity. 1
- (iii) What evidence is there from Figures 2A and 2B that the allocation of the CF subjects to the two treatment groups has been random? 1
- (e) Suggest a reason why the investigators waited for two days after the liposome treatments before checking for an improvement in chloride transport. 1
- (f) How do the data from Figures 1 and 2 support the following conclusion? 1
- “DNA from the active liposomes restored normal levels of chloride transport.”
- (g) (i) In the Table, the mean ΔPD measure in the placebo group shows a net change of 1 mV after treatment. Calculate the percentage of normal function apparently restored by active liposomes. 1
- (ii) What additional information would be required about the results shown in the Table to be confident that the active liposomes have had an effect? 1

(15)

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

2. Before the 1950s, much agricultural land was permanent pasture which showed high species diversity. Changes in agricultural methods have reduced species diversity. It is thought that there are two practices responsible for this reduction; improving drainage by lowering groundwater level and increasing the use of fertilisers. Both practices affect decomposition and the recycling of nitrogen. Some stages of the nitrogen cycle are represented in Figure 1.

Figure 1: Stages of nitrogen cycling.



In recent years, farmers have been encouraged to take land out of cultivation. Different ways of managing this land have been studied with the aim of restoring the original species diversity. In one study, a plot of land had no fertiliser applied after 1982. The plot was then managed by cutting the plants for hay once a year. The species diversity was estimated over a period of 14 years by counting the total number of plant species present just before hay-making in July. The above-ground biomass was determined at the same time by cutting 1 m² samples of plants at the soil surface. These were dried in an oven and weighed. The results are shown in Figure 2.

Another study investigated the effects of raising groundwater level on ammonification and nitrification. Two areas of a pasture were selected. In one of these, the groundwater level was raised to make a "wet compartment", while no changes were imposed on the other area leaving it as a "dry compartment". Between March 1989 and March 1990, the ammonium and nitrate concentrations were measured in samples of soil collected from both compartments. These concentrations were used to calculate corresponding rates of ammonification and nitrification. The results are shown in Figure 3.

Question 2 (continued)

Figure 2: Changes in biomass and number of plant species after fertiliser application was stopped in 1982.

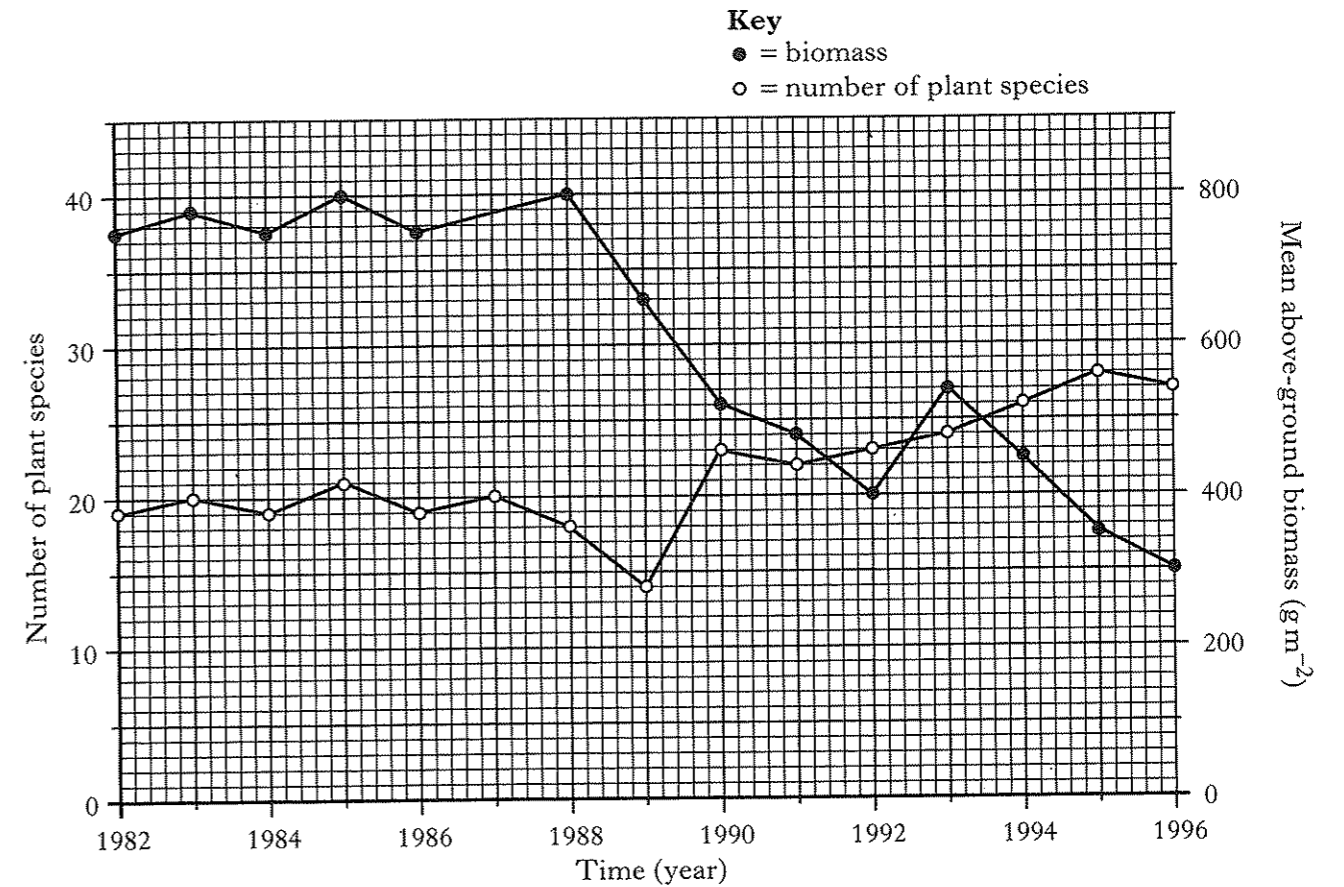
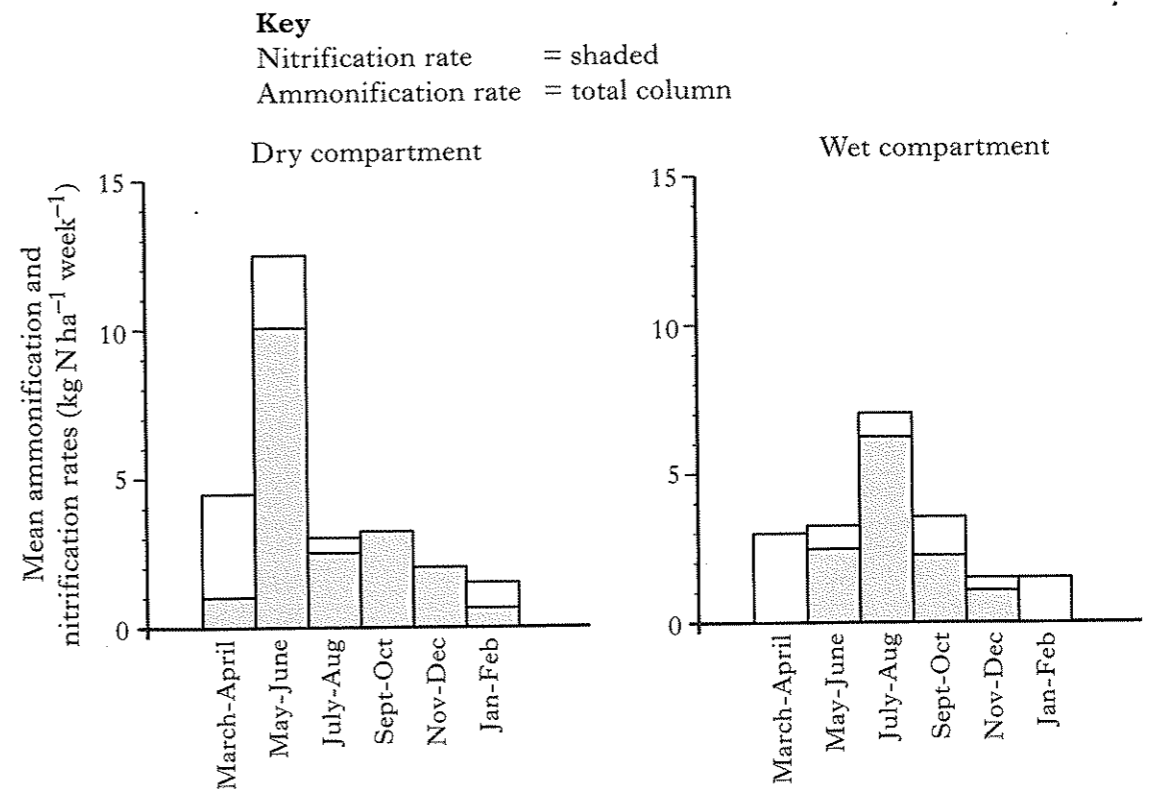


Figure 3: Ammonification and nitrification rates over one year.



Question 2 (continued)

Marks

- (a) Refer to Figure 1.
- (i) What general name is given to the invertebrates that carry out process Z? 1
 - (ii) State the chemical transformations that occur during nitrification and name bacteria responsible for each transformation. 2
- (b) Above-ground biomass was measured in this study to compare net primary productivity (NPP) in the two compartments.
- (i) What is meant by net primary productivity (NPP)? 1
 - (ii) Explain why the use of this measurement does not provide an accurate value for NPP. 1
- (c)
- (i) Use the data in Figure 2 to support the hypothesis that adding fertiliser decreases species diversity. 2
 - (ii) Suggest one possible explanation for the biomass showing little change in the early years of the study. 1
- (d) Use Figure 3 to describe the effects of raising the groundwater level on the rates of nitrification throughout the year. 3
- (e) What effect might raising groundwater level have on species diversity? Support your answer with evidence from both Figures 2 and 3. 3
- (f) Why does raising groundwater level lead to an increase in the rate of denitrification? 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. Describe the biology of the cytoskeleton under the following headings:

- | | |
|---|-------------|
| (i) composition and functions; | 8 |
| (ii) relationship with the plasma membrane; | 2 |
| (iii) movement of chromosomes. | 5 |
| | (15) |

OR

B. Describe the mechanisms by which the following materials cross the plasma membrane:

- | | |
|--------------------------------|-------------|
| (i) sodium and potassium; | 5 |
| (ii) a named peptide hormone; | 5 |
| (iii) a named steroid hormone. | 5 |
| | (15) |

Environmental Biology

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

A. Distinguish between density-dependent and density-independent factors that affect populations.

- | | |
|---|-------------|
| Describe the concept of niche and the effects of different types of competition using appropriate examples. | 5 |
| | 10 |
| | (15) |

OR

B. Discuss air pollution resulting from human activities under the following headings:

- | | |
|--|-------------|
| (i) use of fossil fuels; | 4 |
| (ii) the greenhouse effect; | 7 |
| (iii) impact on abundance and distribution of species. | 4 |
| | (15) |