OCR
RECOGNISING ACHIEVEMENT

OXFORD CAMBRIDGE AND RSA EXAMINATIONS
Advanced GCE

BIOLOGY 2806/01

Unifying Concepts in Biology

Tuesday **22 JUNE 2004** Morning 1 hour 15 minutes

Candidates answer on the question paper.
Additional materials:
Electronic calculator
Ruler (cm/mm)

Candidate Name	Centre Number	Candidate Number

TIME 1 hour 15 minutes

INSTRUCTIONS TO CANDIDATES

- Write your name in the space above.
- Write your Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Write your answers, in blue or black ink, in the spaces provided on the question paper.
- Read each question carefully before starting your answer.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [ ] at the end of each question or part question.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You may use an electronic calculator.
- You are advised to show all the steps in any calculations.

FOR EXAMINER'S USE		
Qu	Max.	Mark
1	15	
2	11	
3	11	
4	11	
5	12	
TOTAL	60	

This question paper consists of 15 printed pages and 1 blank page.

Registered Charity Number: 1066969
[Turn over

Answer **all** the questions.

1 A heart muscle fibre is a chain of cells that are firmly joined together. The cytoplasm contains many mitochondria. Cytoplasmic bridges join each muscle fibre to its neighbours, forming a three-dimensional network. The spaces within the network are occupied by many blood capillaries and nerve endings.

Fig. 1.1 shows two heart muscle fibres.

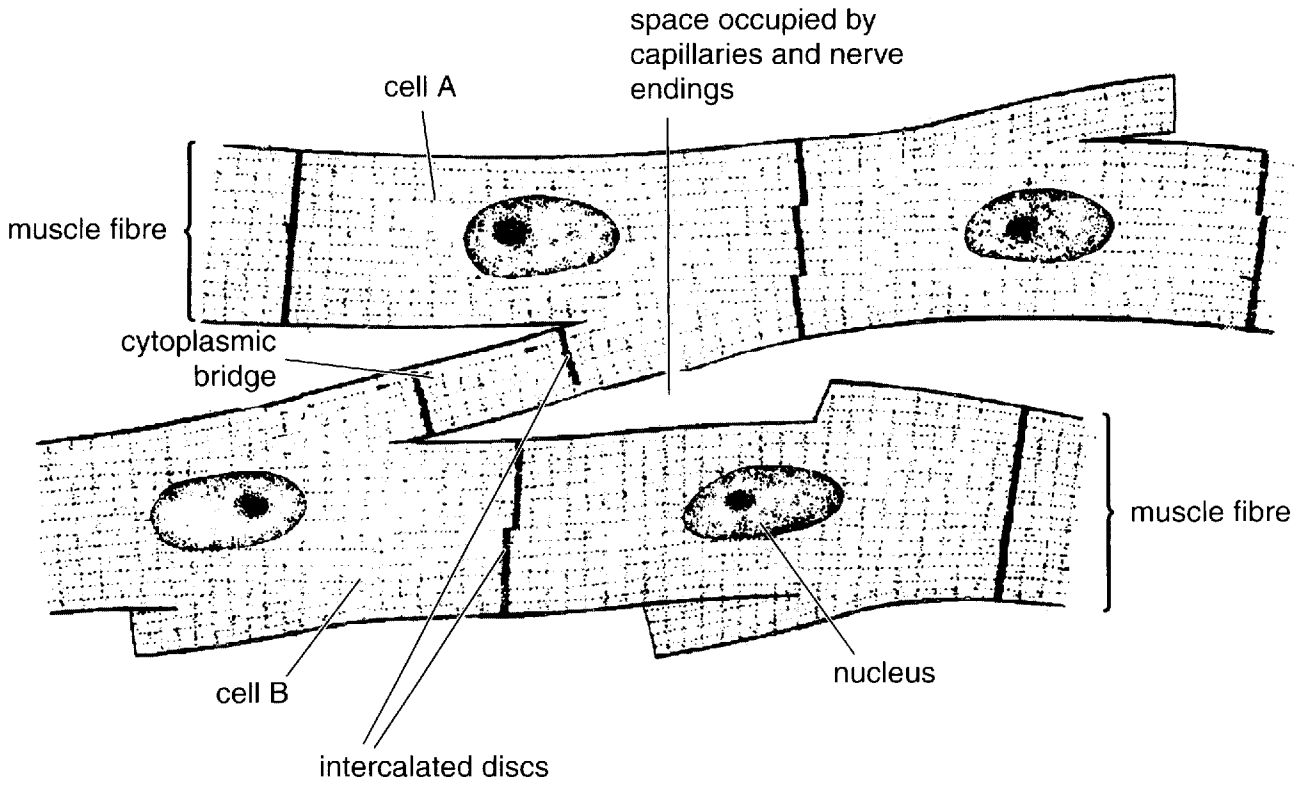

Fig. 1.1

(a) Explain why heart muscle cells have numerous mitochondria.

.....

.....

.....[2]

(b) The nerve endings occupying the space between the muscle fibres do not synapse with individual muscle cells but release either acetylcholine (ACh) or noradrenaline into the tissue fluid. ACh and noradrenaline enter the blood through capillaries near a nerve ending and leave the blood as it moves further away from the nerve ending. This distributes the substances throughout the muscle tissue.

(i) State the general name given to substances, such as ACh and noradrenaline, produced by nerve endings.

.....[1]

(ii) Suggest how these substances enter and leave capillaries.

.....

.....

.....[2]

(c) The contraction of a heart muscle cell requires an action potential to occur across its surface membrane. Action potentials propagate between neighbouring muscle cells through the intercalated discs, which are freely permeable to ions. In this way, impulses, accompanied by contraction, spread through the muscle.

(i) Outline the events that occur when an area of cell surface membrane undergoes an action potential.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....[5]

[Turn over

(ii) Explain the importance of cytoplasmic bridges between the heart muscle fibres for the contraction of the heart.

.....

.....

.....[2]

(d) When the volume of blood in the body increases, there is a general rise in resting blood pressure. Heart muscle cells in the walls of the atria detect this and respond by secreting a hormone into the blood. This hormone stimulates the kidneys to excrete more water and more sodium ions.

Explain how the mechanism described above is an example of negative feedback. You may use a flow diagram to help answer this question.

.....

.....

.....

.....

.....

.....

.....

.....

[3]

[Total: 15]

2 In an investigation into the genetic diversity of sheep in the UK, blood samples from several thousand individuals of many different breeds were analysed. Two distinct types of haemoglobin were found which differed in solubility and which had different amino acid compositions.

- Haemoglobin type one (**Hb-I**) was more common in breeds that originated in the lowlands.
- Haemoglobin type two (**Hb-II**) was more common in breeds that originated in the hills.

Biologists followed up this investigation by analysing a breed of sheep that originated in the lowlands. In a sample of 300 of these sheep:

- 71% had blood with haemoglobin **Hb-I** only,
- 26% had both **Hb-I** and **Hb-II**,
- 3% had **Hb-II** only.

Table 2.1 shows the haemoglobin types of parents and offspring from the same sample of lowland sheep.

Table 2.1

haemoglobin type of parents		number of lambs with haemoglobin type		
male	female	**Hb-I** only	both **Hb-I** and **Hb-II**	**Hb-II** only
Hb-I only	both **Hb-I** and **Hb-II**	7	9	0
both **Hb-I** and **Hb-II**	**Hb-I only**	18	17	0
both **Hb-I** and **Hb-II**	both **Hb-I** and **Hb-II**	3	4	5
Hb-I only	**Hb-I** only	79	0	0

(a) Using the information provided and the data from Table 2.1,

(i) explain why the two haemoglobin types must be determined by two alleles which are codominant;

.....

.....

.....

.....[2]

(ii) predict the haemoglobin phenotype of a lamb if both its parents had **Hb-II** only.

.....[1]

[Turn over

(b) Blood samples were taken from sheep that had been resting. The samples came from one of the veins that return blood from the leg muscles to the heart.

Analysis revealed that the mean percentage saturation of haemoglobin with oxygen in the blood samples from sheep with **Hb-I** only was 72% while the mean for sheep with **Hb-II** only was 87%.

Describe **and** explain how these results would have been different if the blood samples had been taken from sheep caught after being chased around a field.

.....

.....

.....

.....

.....[2]

(c) These results prompted the biologists to plot dissociation curves for each type of haemoglobin. These curves are shown in Fig. 2.1.

(i) Determine from the graphs the percentage saturation of each type of haemoglobin at an oxygen partial pressure of 6.0 kPa.

Hb-I ..... **Hb-II** .....[1]

(ii) Using the information given in Fig. 2.1, explain the differences in frequency of haemoglobin type found in different breeds of sheep in the UK, as mentioned in the first paragraph of this question.

.....

.....

.....

.....

.....

.....[3]

(iii) Explain why the carbon dioxide concentrations of haemoglobin samples must be kept constant when measuring the percentage saturation of the samples with oxygen.

.....

.....

.....[2]

[Total: 11]

For Examiner's Use

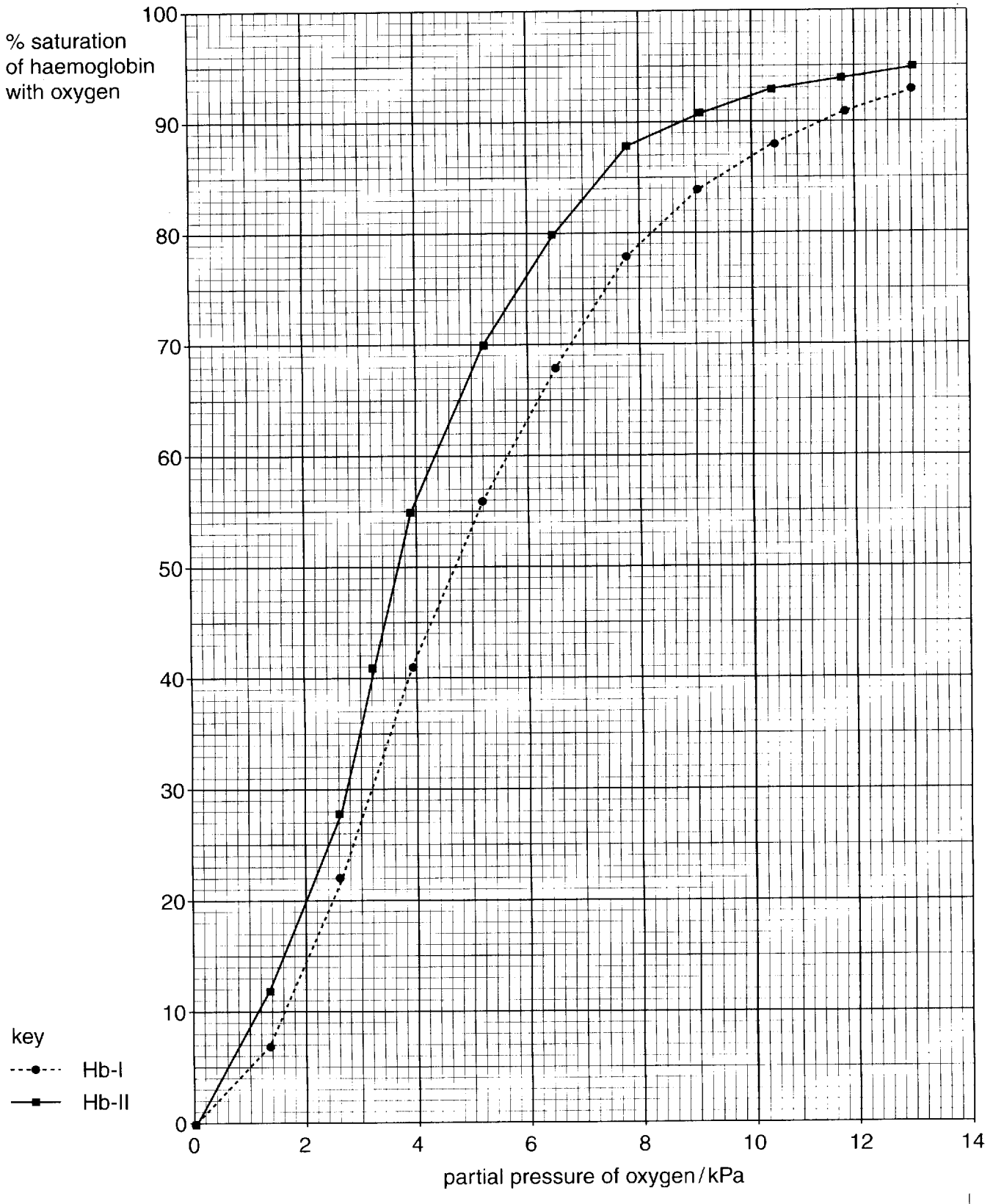

Fig. 2.1

[Turn over

3 *Nicotiana attenuata (N. attenuata)* is a wild species of tobacco plant that grows in woodlands in North America. The plant is often found growing at the site of a recent forest fire, where the soil is rich in ammonium ions and nitrate ions. Germination of its seeds is stimulated by chemicals produced when cellulose burns. The population of *N. attenuata* reaches a peak in the year following a fire.

(a) (i) Explain why soil is rich in ammonium ions and nitrate ions in the year following a forest fire.

.....

.....

.....

.....[2]

(ii) Explain why a population of *N. attenuata* is likely to decline after the peak following a fire.

.....

.....

.....

.....

.....[2]

(b) The roots of *N. attenuata* synthesise nicotine, which is transported to the stems and leaves where it is stored. Nicotine deters herbivores from eating the leaves.

Each molecule of nicotine has two nitrogen atoms, so a plant that produces large quantities of nicotine is expected to have less nitrogen available for the synthesis of amino acid molecules.

Explain why the synthesis of fewer amino acid molecules limits growth and reproduction of these plants.

.....

.....

.....

.....

.....

.....

.....[3]

(c) *N. attenuata* plants produce more nicotine after their leaves have been punctured, for example by the jaws of biting insects. However, if a leaf is cut off close to the stem with a sharp blade, there is no significant stimulation of nicotine production.

In an investigation, *N. attenuata* plants were grown in a greenhouse in soils obtained from forests.

The plants **either** had some of their leaves punctured to imitate insect feeding **or** had one leaf removed with a sharp blade.

The seed production and nicotine content of the plants were measured. The results of the investigation are shown in Table 3.1.

Table 3.1

	mean number of seeds per plant		mean nicotine content as % of total dry mass	
	plants with leaf removed	plants with punctured leaves	plants with leaf removed	plants with punctured leaves
soil from recently burned forest	6 000	4 500	1.09	1.37
soil from forest not recently burned	2 600	1 100	0.67	0.98

(i) Explain why plants with one leaf removed were used as controls rather than intact plants.

.....

.....[1]

(ii) Comment on the data in Table 3.1.

.....

.....

.....

.....

.....

.....

.....

.....[3]

[Total: 11]

[Turn over

4 The pH of blood plasma remains very close to 7.4 in healthy people. If it falls below 6.8 or rises above 7.8, death usually results. This remarkable pH stability is possible because haemoglobin, hydrogencarbonate ions and plasma proteins are all able to absorb hydrogen ions when the pH starts to fall and release hydrogen ions when it starts to rise. The blood is thus partly responsible for its own homeostasis. In spite of this stability, the pH of body fluids tends to fall during exercise.

(a) Explain why proteins are able to **both** absorb **and** release hydrogen ions.

.....

.....

.....

.....[2]

(b) State why the pH of body fluids tends to fall during exercise.

.....

.....[1]

For Examiner's Use

(c) In this question, one mark is available for the quality of written communication.

Explain why the homeostasis of body fluids in mammals is important.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....[7]

Quality of Written Communication [1]

[Total: 11]

[Turn over

5 The ability of yeasts or bacteria to use a substrate for respiration can be tested using the method illustrated in Fig. 5.1. If the substrate can be used for respiration, carbon dioxide is produced and forms a bubble in the test tube. The height of the bubble is measured. When the tube is completely full of gas, the bubble height is 150 mm.

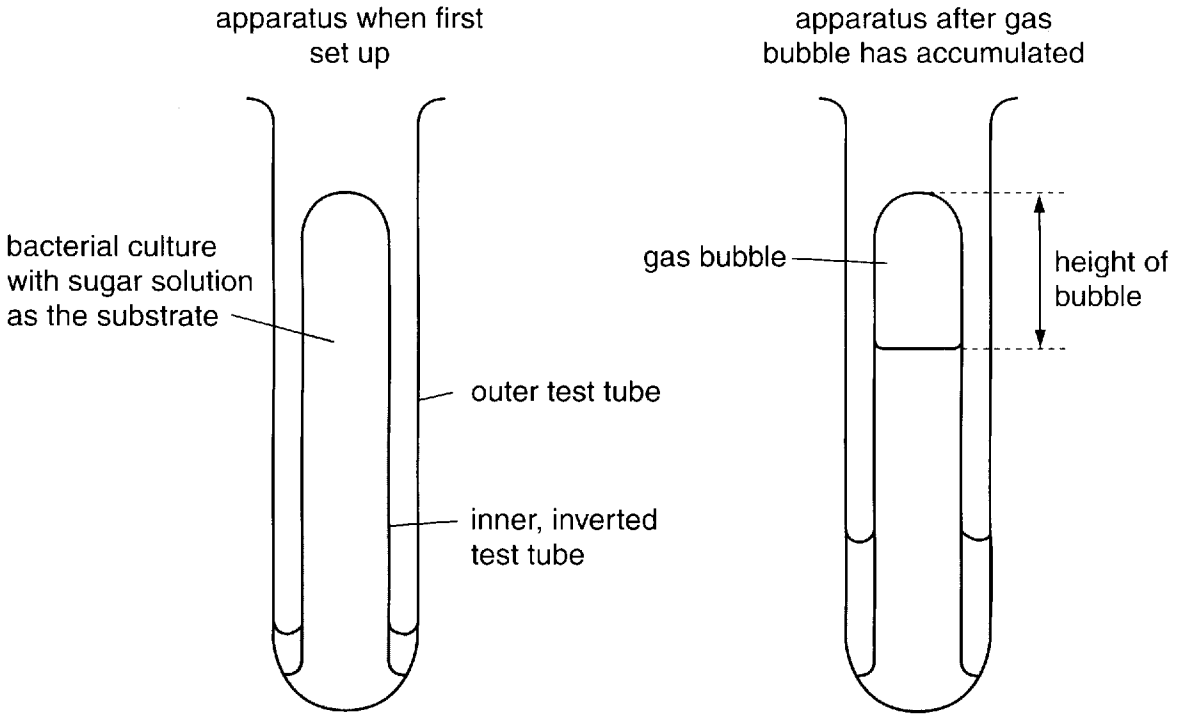

Fig. 5.1

This method was used to investigate a culture of the bacterium *Escherichia coli* (*E. coli*). Different sugar solutions were used in many replicate sets of apparatus. Care was taken to prevent other microorganisms from contaminating the solutions. The results of the investigation are summarised in Table 5.1.

Table 5.1

solution	mean height of gas bubble in test tube /mm	
	after 2 hours	after 24 hours
no sugar (distilled water)	8	12
glucose	150	150
fructose	150	150
arabinose	12	140
maltose	150	150
sucrose	150	150
lactose	11	150

For Examiner's Use

(a) State **three** variables which would need to be controlled in this investigation.

1 .....

2 .....

3 .....[3]

(b) Do the results support the hypothesis that *E. coli* is unable to store a carbohydrate, such as glycogen, for use in respiration? Explain your answer.

.....

.....

.....[1]

(c) **(i)** Describe the results for the different sugars tested.

.....

.....

.....

.....

.....

.....[2]

(ii) Explain the different results obtained for glucose and lactose.

.....

.....

.....

.....

.....

.....[2]

Question 5 continues on the next page

(d) *E. coli* cells require the amino acid tryptophan. This can be obtained either from the growth medium or it can be synthesised by the cells. Tryptophan synthesis requires four different enzymes.

Fig. 5.2 shows the way in which the production of enzymes used in tryptophan synthesis is regulated. A group of genes regulated in this way is called an operon.

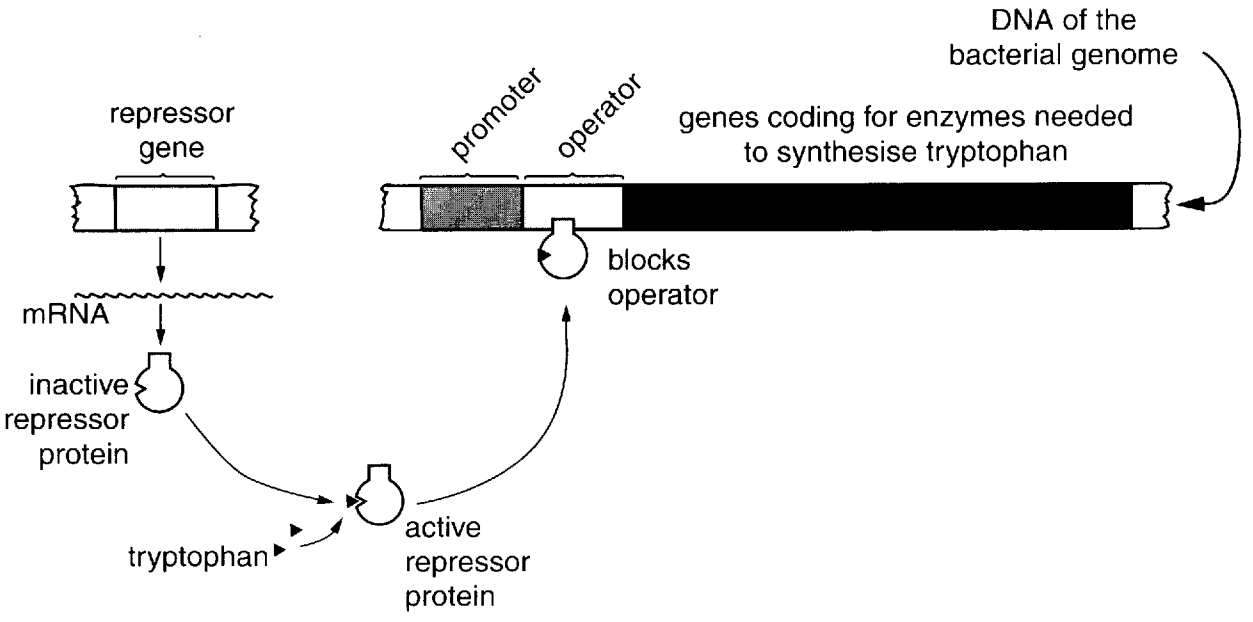

Fig. 5.2

(i) Explain why the production of enzymes by bacterial cells must be regulated.

.....

.....

.....

.....[2]

(ii) State **one** difference and **one** similarity between the operon shown in Fig. 5.2 and the *lac* operon.

similarity .....

.....

difference .....

.....[2]

[Total: 12]

END OF QUESTION PAPER