GCE A LEVEL

1400U30-1

MONDAY, 6 JUNE 2022 – MORNING

BIOLOGY – A2 UNIT 3

ENERGY, HOMEOSTASIS AND THE ENVIRONMENT

2 hours plus your additional time allowance

Surname: _____

First name(s): _____

Centre Number: _____

Candidate Number: 2 _____

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**15**	
2.	**18**	
3.	**8**	
4.	**14**	
5.	**14**	
6.	**12**	
7.	**9**	
Total	**90**	

ADDITIONAL MATERIALS

In addition to this paper, you will require a calculator and a ruler.

ITEMS INCLUDED WITH QUESTION PAPER

A separate Diagram Booklet.

The Diagram Booklet MUST be handed in to the invigilators and sent for marking.

INSTRUCTIONS TO CANDIDATES

Use black ink, black ball – point pen, black felt tip or your usual method.

Write your name, centre number and candidate number in the spaces on the front cover.

Answer ALL questions.

Write your answers in the spaces provided.
If you run out of space, use the additional pages at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part – question.

The assessment of the quality of extended response (QER) will take place in question 7.

The quality of written communication will affect the awarding of marks.

ANSWER ALL QUESTIONS.

1. Look at GRAPH 1.1 for Question 1 in the separate Diagram Booklet.

A student inoculated 900 cm^3 of fresh, sterile nutrient broth with 100 cm^3 of a culture of ESCHERICHIA COLI. She incubated the new culture at 37°C and monitored the concentration of bacteria using a total count with an electronic cell counter. The results are shown in GRAPH 1.1.

continued on the next page . . .

Question 1 continued

1. (a) (i) Calculate the concentration of bacteria in the ORIGINAL culture used to inoculate the broth.

Space for working:

Concentration = _____ cm^{-3}

[2 marks]

continued on the next page . . .

Question 1 (a) continued

1. (a) (ii) Calculate the time taken for the number of bacteria to double, after the number of cells counted by the electronic cell counter had reached $20\,000\ cm^{-3}$.

Space for working:

Time taken for the number of bacteria to double

= _____ minutes

[1 mark]

continued on the next page . . .

Question 1 continued

1. (b) Growth curves for bacteria may be used to model growth in populations of animals, because the same phases of growth are recognisable. The following passage, taken from a website, is a description of one of the phases.

"The accumulation of waste materials, toxic metabolites and inhibitory compounds in the medium shifts the conditions of the medium such as pH and temperature. This creates an unfavourable environment for the bacterial growth. ... the number of cells undergoing division is equal to the number of cell deaths."

continued on the next page . . .

Question 1 (b) continued

1. (b) (i) Identify the phase of growth described in the passage on page 7.

_____

_____

[1 mark]

(ii) Explain why the method used to monitor the number of bacteria meant that the phase identified in part (i) was not seen in GRAPH 1.1.

_____

_____

_____

[1 mark]

continued on the next page . . .

Question 1 (b) continued

1. (b) (iii) List the main steps of a different method of counting bacteria which would allow the phase described in the passage on page 7 to be seen in GRAPH 1.1. Details of aseptic technique are NOT required.

[4 marks]

Question 1 continued

1. (c) Syphilis and gonorrhoea are sexually transmitted diseases (STDs) caused by the bacteria TREPONEMA PALLIDUM and NEISSERIA GONORRHOEAE respectively.

TREPONEMA PALLIDUM is a helically coiled micro – organism usually $6 – 15\ \mu m$ long and $0.1 – 0.2\ \mu m$ wide. It has a plasma membrane and an outer lipopolysaccharide membrane.

NEISSERIA GONORRHOEAE, also known as GONOCOCCUS, is a species of Gram negative cocci.

continued on the next page . . .

Question 1 (c) continued

Using the information given on page 10;

(i) Describe the three – dimensional shape of NEISSERIA GONORRHOEAE cells.

_____

_____

[1 mark]

(ii) State whether TREPONEMA PALLIDUM is Gram positive or Gram negative and explain your choice.

_____

_____

_____

[1 mark]

continued on the next page . . .

Question 1 continued

1. (d) Look at IMAGE 1.2 for Question 1 (d) in the separate Diagram Booklet.

A 21 – year – old man attended a clinic with a painless ulcer on his penis. Bacteria taken from the ulcer were Gram stained.
The results are shown in IMAGE 1.2

(i) State the result of the Gram test shown in IMAGE 1.2 and explain why it does not help distinguish between the two types of STD described in part (c).

_____

_____

_____

[2 marks]

continued on the next page . . .

Question 1 (d) continued

1. (d) (ii) Suggest which of the two types of STD the man is most likely to be suffering from and explain your choice.

_____

_____

_____

[2 marks]

(Total for Question 1 = 15 marks)

2. Loss of suitable habitat by destruction, degradation or fragmentation is the most important cause of species becoming endangered around the world.

(a) (i) Distinguish between the terms endangered and extinct.

[1 mark]

(ii) Apart from habitat loss, name TWO other causes of species extinction.

[2 marks]

Question 2 continued

2. (b) Following a forest fire, given time, the forest will regenerate.

(i) Give the full name of the biological process involved in forest regeneration.

_____

_____

[1 mark]

(ii) Using relevant TECHNICAL TERMS, describe and explain the process of forest regeneration.

_____

_____

_____

_____

_____

_____

_____

[3 marks]

continued on the next page . . .

Question 2 continued

2. (c) Look at IMAGE 2.1 for Question 2 (c) in the separate Diagram Booklet.

Human activity has resulted in the forest landscapes of Europe existing as a mixture of fragments of different ages and sizes. IMAGE 2.1 shows the fragmentation of forests surrounded by developed land. Three fragments of forest P, Q and R are labelled on the 1910 map.

(i) The Hardy – Weinberg principle states that allele frequencies remain constant from generation to generation. Explain TWO reasons why this would not apply to the gene pools of species in fragments P, Q and R.

_____

_____

[2 marks]

2. (c) (ii) List fragments **P**, **Q** and **R** in order of risk of species extinction, from most to least. Explain your answer.

Most risk _____ _____ _____ Least risk

Explanation

[4 marks]

continued on the next page . . .

Question 2 continued

2. (d) As well as gene pool effects, fragmentation exposes species to potentially harmful environmental effects. These are called ‘edge effects’ because conditions at the edge of a forest differ from those further inside.

Look at IMAGE 2.2 for Question 2 (d) in the separate Diagram Booklet. IMAGE 2.2 shows how square forest fragments of different sizes are affected by edge effects.

continued on the next page . . .

Question 2 (d) continued

2. (d) (i) Assuming edge effects extend 35 m into each habitat patch, calculate the percentage of the fragment influenced by the edge effects for the second largest patch.
Write your answer in the space in IMAGE 2.2.

Space for working:

[2 marks]

continued on the next page . . .

Question 2 (d) continued

2. (d) (ii) Describe the trend in the data and suggest TWO abiotic conditions that would differ in the area affected by edge effects.

[3 marks]

(Total for Question 2 = 18 marks)

3. Look at IMAGE 3.1 for Question 3 in the separate Diagram Booklet.

A group of students used the apparatus shown in IMAGE 3.1 to investigate the effect of light intensity on the rate of photosynthesis. The volume of gas was measured after a minute by drawing it up with the syringe and measured using the scale.

Look at TABLE 3.2 for Question 3 in the separate Diagram Booklet.
The students' results are shown in TABLE 3.2

(a) COMPLETE TABLE 3.2 using information from IMAGE 3.1 and the formula for light intensity below:

Light intensity at plant, $I_p = I_l \left(\frac{1}{d^2}\right)$

Where: I_p **= light intensity at plant,**

I_l **= light intensity at lamp,**

d **= distance from lamp in metres**

[3 marks]

Question 3 continued

3. (b) Look at GRAPH 3.3 for Question 3 (b) in the separate Diagram Booklet.

Some of the results were plotted in GRAPH 3.3

The students assumed that the mean volume of gas collected was directly proportional to light intensity.

The equation for their line of best fit is shown above the line.

continued on the next page . . .

Question 3 (b) continued

3. (b) (i) Use the equation given on GRAPH 3.3 and the relevant values from TABLE 3.2 to calculate the mean volume of gas that should have been collected when the lamp was 0.15 m from the plant.

Space for working:

Expected mean volume of gas

= _____ $mm^3\ min^{-1}$

[2 marks]

continued on the next page . . .

Question 3 (b) continued

3. (b) (ii) State ONE environmental factor that should have been maintained at a constant value during the experiment.

_____

_____

_____

[1 mark]

continued on the next page . . .

Question 3 (b) continued

3. (b) (iii) The EXPECTED mean volume of gas collected (calculated from the equation on GRAPH 3.3), when the lamp was 0.05 m from the plant, was 33 105.5 mm^3 min^{-1}

Explain why the expected volume of gas was higher than the volume ACTUALLY collected when the lamp was 0.05 m from the plant (shown in TABLE 3.2).

[2 marks]

(Total for Question 3 = 8 marks)

4. Look at IMAGE 4.1 for Question 4 in the separate Diagram Booklet.

Osmoregulation is carried out by the kidneys, under hormonal control. The regulatory process is represented in IMAGE 4.1

(a) Using your knowledge of homeostasis and the mammalian kidney, identify each of the following shown in IMAGE 4.1:

(i) the source of the nerve impulses;

_____

_____

(ii) the endocrine gland;

_____

_____

(iii) the hormone;

_____

_____

continued on the next page . . .

Question 4 (a) continued

4. (a) (iv) the precise location of the target cells.

_____

_____

[4 marks]

continued on the next page . . .

Question 4 continued

4. (b) Explain how the hormone involved in the process shown in IMAGE 4.1 affects the target cells and how it prevents excessive water loss.

[3 marks]

continued on the next page . . .

Question 4 continued

4. (c) Look at IMAGE 4.2 for Question 4 (c) in the separate Diagram Booklet.

The release of the hormone is brought about by the arrival of a nerve impulse. This is similar to the way in which neurotransmitters are released.
The process is shown in IMAGE 4.2

Using all the relevant information from both IMAGES 4.1 and 4.2 describe how the hormone molecules are released from the end of the neurosecretory cell.

[5 marks]

continued on the next page . . .

Question 4 continued

4. (d) Haemodialysis is one method of treating kidney failure.

Between dialysis sessions patients retain fluid and gain weight. Excess fluid is removed during the next dialysis session to return the patient to their target weight.

Explain why it is important to remove excess fluid during haemodialysis.

[2 marks]

(Total for Question 4 = 14 marks)

5. Look at IMAGE 5.1 for Question 5 in the separate Diagram Booklet.

IMAGE 5.1 summarises experiments carried out by Melvin Calvin to investigate the 'LIGHT – INDEPENDENT' reactions of photosynthesis.

(a) Calvin placed the lollipop apparatus in bright light, even though he was studying 'LIGHT – INDEPENDENT' reactions. Using your knowledge of how the products of the 'LIGHT – DEPENDENT' reactions are used in the 'LIGHT – INDEPENDENT' reaction, explain why he placed the apparatus in bright light.

_____

_____

_____

[2 marks]

5. (b) (i) Look at IMAGE 5.2, Diagram 1 and Diagram 2 for Question 5 (b) (i) in the separate Diagram Booklet.
IMAGE 5.2 shows EXPERIMENT 1.

The autoradiograms in IMAGE 5.2 EXPERIMENT 1 illustrate some of Calvin's results.

The times shown are the times at which the samples were dropped into hot alcohol.

continued on the next page . . .

Question 5 (b) (i) continued

Look at the sequences for Question 5 (b) (i) in the separate Diagram Booklet.

Using evidence from IMAGE 5.2, identify which of the sequences of reactions shown is most likely to be correct. Explain your answer.

_____

_____

_____

_____

_____

_____

[2 marks]

continued on the next page . . .

Question 5 (b) continued

5. (b) (ii) Look at IMAGE 5.3 for Question 5 (b) (ii) in the separate Diagram Booklet.

IMAGE 5.3 shows EXPERIMENT 2.

EXPERIMENT 2 was carried out using exactly the same method as EXPERIMENT 1, except that the mineral solution used contained no nitrate ions. The results are shown in IMAGE 5.3.

Interpret the results of EXPERIMENT 2 to explain the difference between the 15 – second autoradiograms from EXPERIMENTS 1 and 2 and suggest the nature of compound X shown on the 15 – SECOND autoradiogram in EXPERIMENT 1.

_____

_____

[2 marks]

continued on the next page . . .

Question 5 continued

5. (c) Look at IMAGE 5.4 for Question 5 (c) in the separate Diagram Booklet.

In Cyanobacteria the carbon fixing reaction, catalysed by RuBisCO, is carried out in micro – compartments called carboxysomes. Scientists have used genetic engineering techniques to produce maize plant cells which have carboxysomes.
IMAGE 5.4 shows part of such an engineered cell.

(i) With reference to IMAGE 5.4, describe precisely where the carboxysome is located.

_____

_____

[1 mark]

continued on the next page . . .

Question 5 (c) continued

5. (c) (ii) USE THE SCALE BAR to calculate the length, X – X, of the carboxysome in μm.

Space for working:

Length = _____ μm

[2 marks]

continued on the next page . . .

Question 5 continued

5. (d) In addition to RuBisCO, carboxysomes contain the enzyme carbonic anhydrase. Having carbonic anhydrase inside ENHANCES UPTAKE OF CARBON DIOXIDE by catalysing its combination with water.

(i) Suggest an advantage to farmers of introducing carboxysomes into crop plants. Explain your answer.

_____

_____

_____

_____

_____

_____

[2 marks]

continued on the next page . . .

Question 5 (d) continued

5. (d) (ii) Predict the effect that widespread use of crops engineered to contain carboxysomes might have on the carbon cycle and explain the impact this effect might have on the prospects for endangered species.

[3 marks]

(Total for Question 5 = 14 marks)

6. The chemical reactions carried out by living organisms are collectively called metabolism. Respiration is an essential part of metabolism in all living organisms.

(a) With reference to TWO specific cell activities explain why ALL living organisms must carry out respiration.

_____

_____

_____

_____

_____

[2 marks]

continued on the next page . . .

Question 6 continued

6. (b) Look at IMAGE 6.1 for Question 6 (b) in the separate Diagram Booklet.

Glucose is an important fuel in almost all living organisms and is processed in the same way in all cells. Fructose is less commonly used as a fuel in cells but is present in the human diet.
The way cells process these two HEXOSE sugars is compared in IMAGE 6.1

continued on the next page . . .

Question 6 (b) continued

State the net number of molecules of ATP formed when ONE molecule of each of the following compounds is processed to lactate. Note: two molecules of triose phosphate are formed from each hexose molecule processed.

I. Glucose (C6)

_____

II. Fructose phosphate (C6)

_____

III. Sucrose (C12)

_____

[3 marks]

continued on the next page . . .

Question 6 continued

6. (c) (i) Describe the conditions inside a cell which would determine whether pyruvate is converted to lactate or acetyl CoA.

_____

_____

_____

[1 mark]

continued on the next page . . .

Question 6 (c) continued

6. (c) (ii) Answer the following questions about the conversion of pyruvate to lactate.

I. Name the type of chemical reaction the pyruvate undergoes.

_____

II. Describe the part played by the coenzyme NAD.

_____

III. Name the type of chemical reaction the coenzyme undergoes.

_____

[3 marks]

continued on the next page . . .

Question 6 continued

6. (d) When glucose is used as the respiratory substrate, the rate of glycolysis can be controlled to meet the demands of a cell for ATP. Fructose metabolism is not controlled: IMAGE 6.1 shows how fructose skips the main control step of glycolysis.

When this happens acetyl CoA accumulates more quickly than it can enter the Krebs cycle; this causes a subsequent build – up of triose phosphate.

(i) Using information from IMAGE 6.1, name the product of triose phosphate oxidation.

_____

_____

[1 mark]

continued on the next page . . .

Question 6 (d) continued

6. (d) (ii) With reference to IMAGE 6.1, explain why accumulation of acetyl CoA might lead to obesity.

[2 marks]

(Total for Question 6 = 12 marks)

7. Look at IMAGE 7.1, IMAGE 7.2 and IMAGE 7.3 for Question 7 in the separate Diagram Booklet.

The impact of an intensive agricultural practice is illustrated in the aerial photograph (IMAGE 7.1) and map (IMAGE 7.2).

IMAGE 7.3 shows the results of an experiment in which plants that do not produce root nodules in the wild were genetically modified.

Describe and explain how agricultural practice resulted in the environmental impact shown in IMAGES 7.1 and 7.2

Explain the results of the experiment to compare growth of wild type and genetically modified plants shown in IMAGE 7.3

Suggest how growing crops genetically modified in this way might lessen the environmental impact of intensive agriculture.

[9 marks QER]

(Total for Question 7 = 9 marks)

END OF PAPER

TOTAL 90 MARKS

Question number	Additional pages, if required. Write the question number(s) in the left-hand margin.

Question number	Additional pages, if required. Write the question number(s) in the left - hand margin.

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BIOLOGY – A2 UNIT 3

ENERGY, HOMEOSTASIS AND THE ENVIRONMENT

The Diagram Booklet MUST be handed in to the invigilators and sent for marking.

Diagram Booklet

Surname: _____

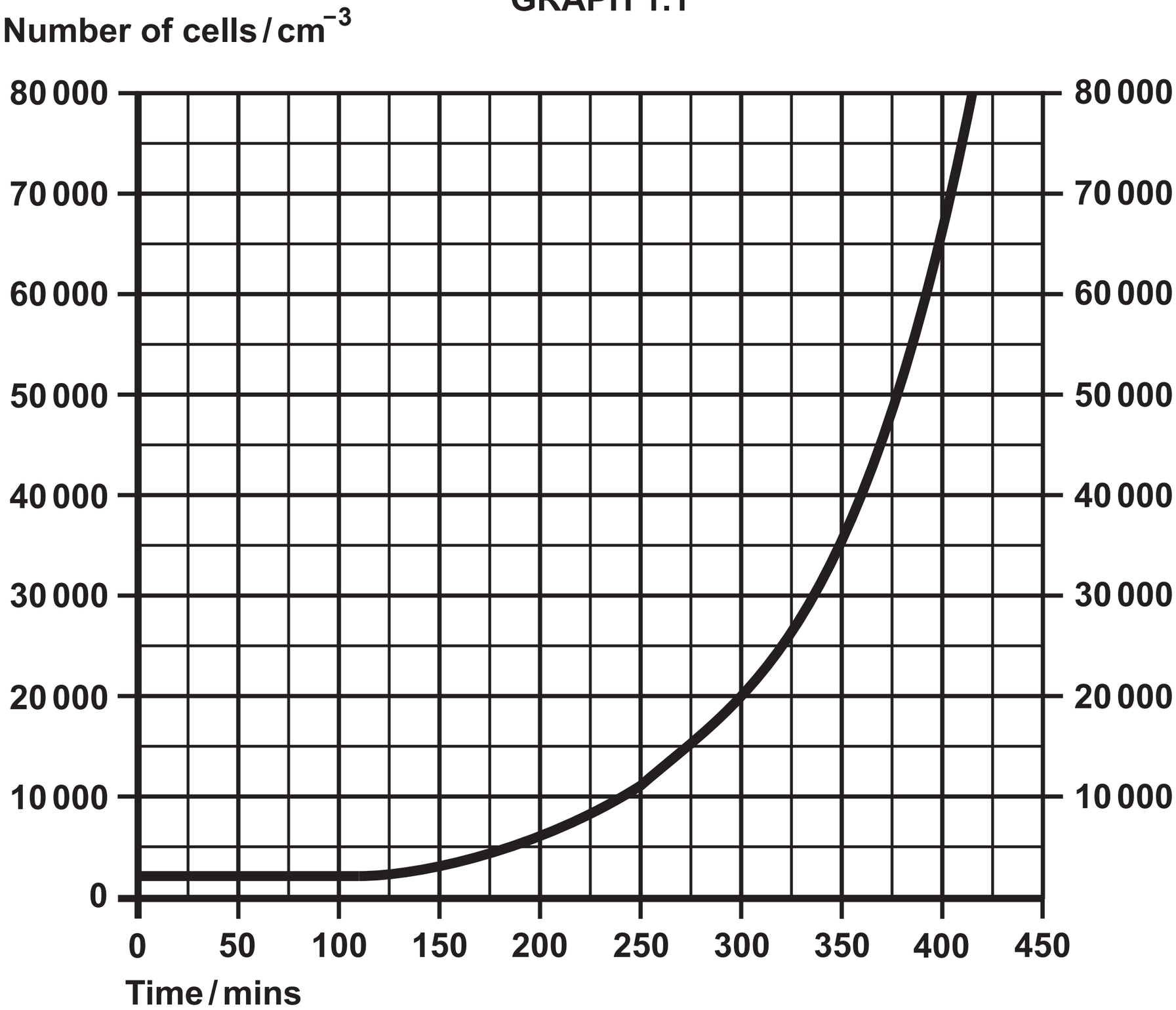
First name(s): _____

Centre Number: _____

Candidate Number: 2 _____

Question 1

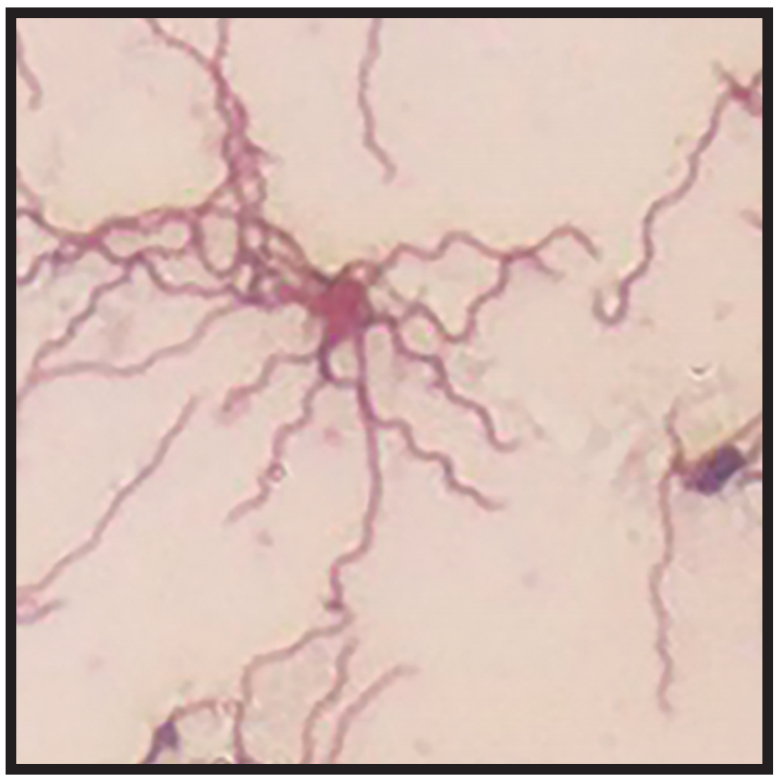
GRAPH 1.1



Question 1 (d)

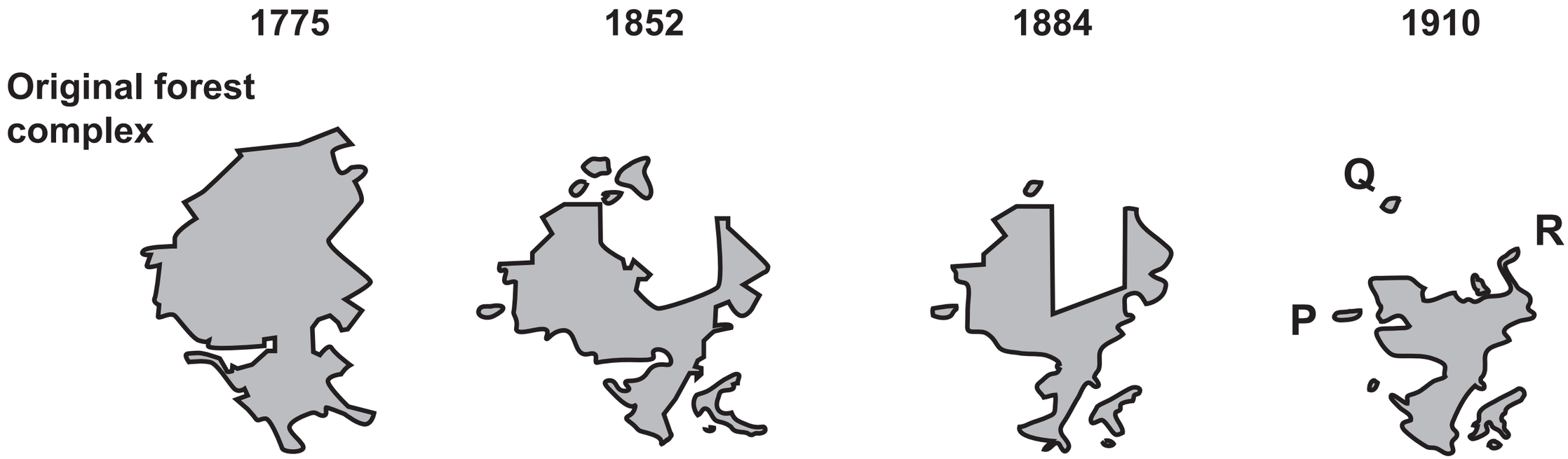
IMAGE 1.2

NOTE: The bacteria all stained pink.



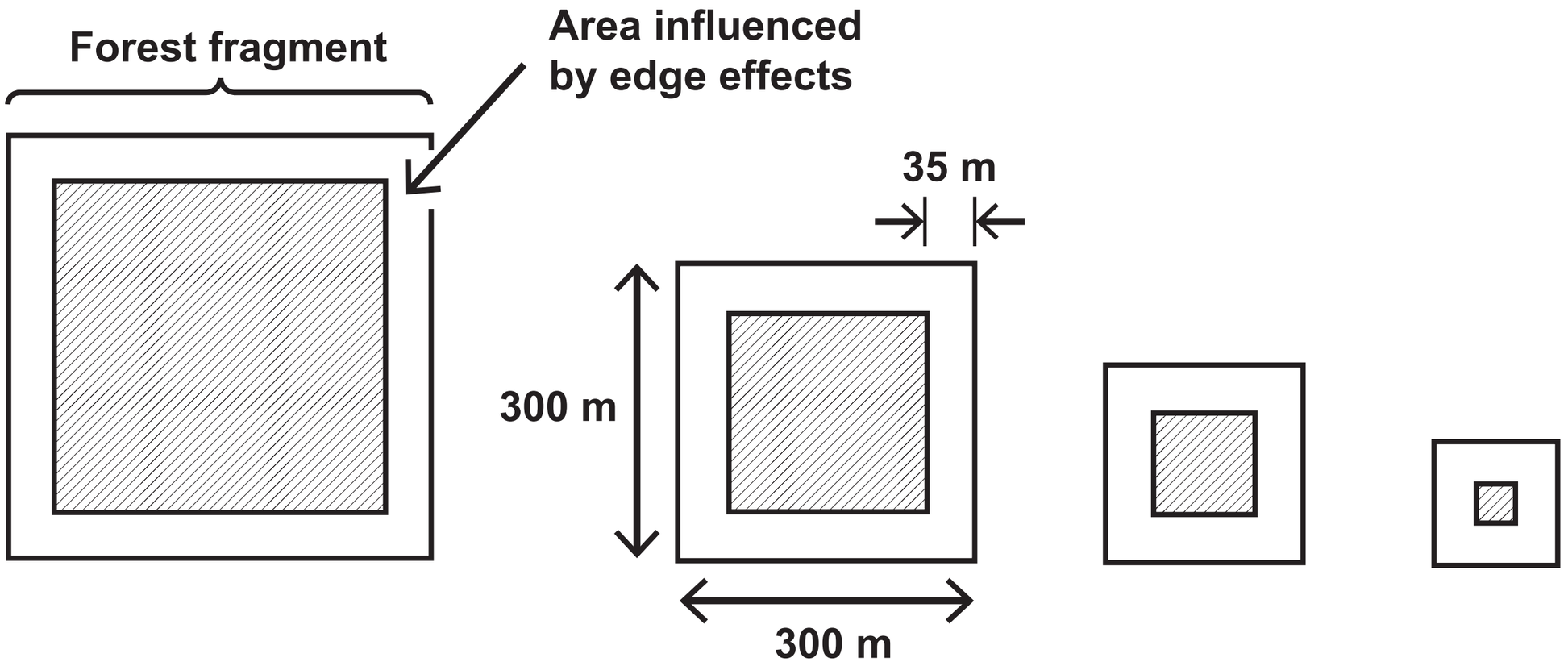
Question 2 (c)

IMAGE 2.1



Question 2 (d)

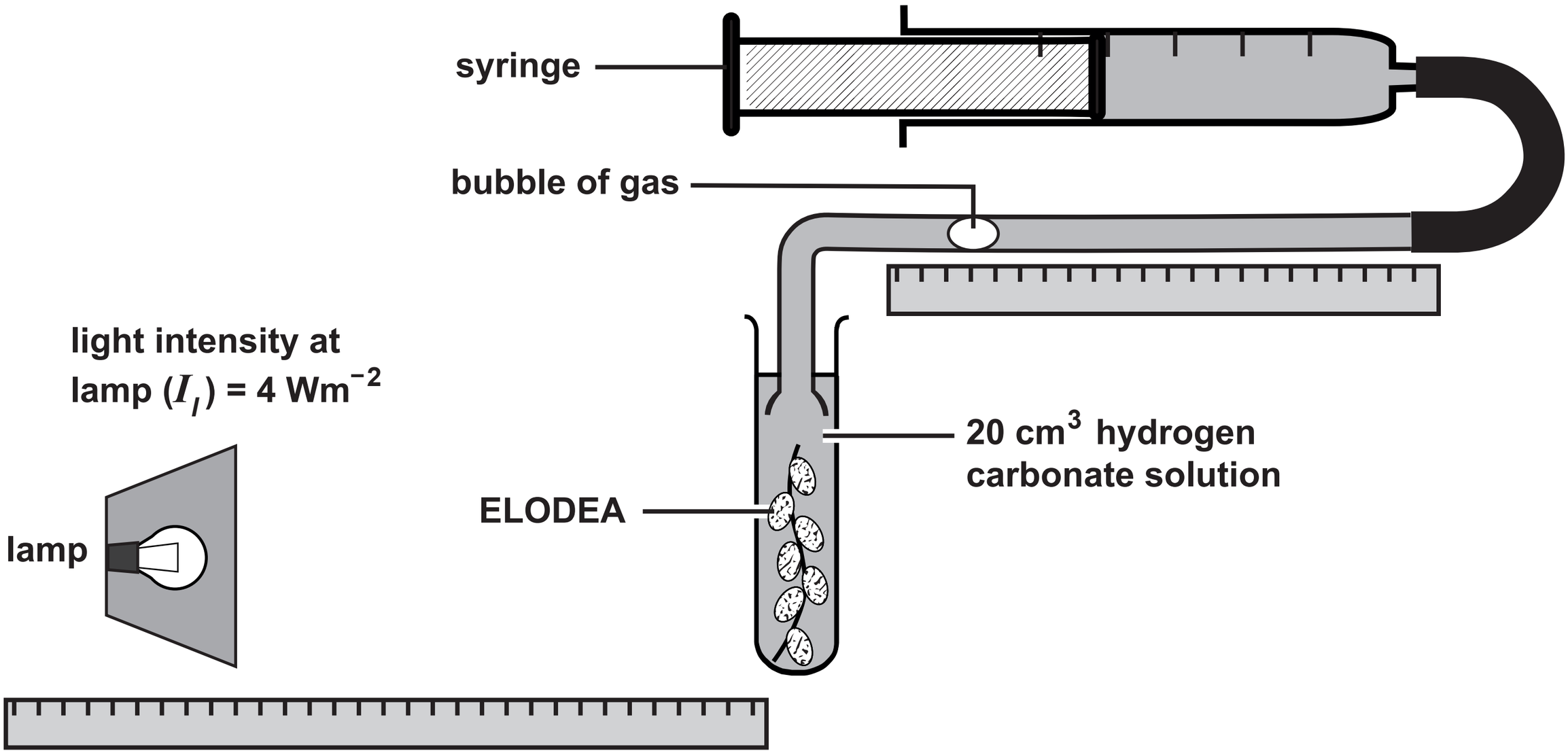
IMAGE 2.2



Percentage of the fragment influenced by edge effects:	**30.6%**		**64.0%**	**88.8%**

Question 3

IMAGE 3.1



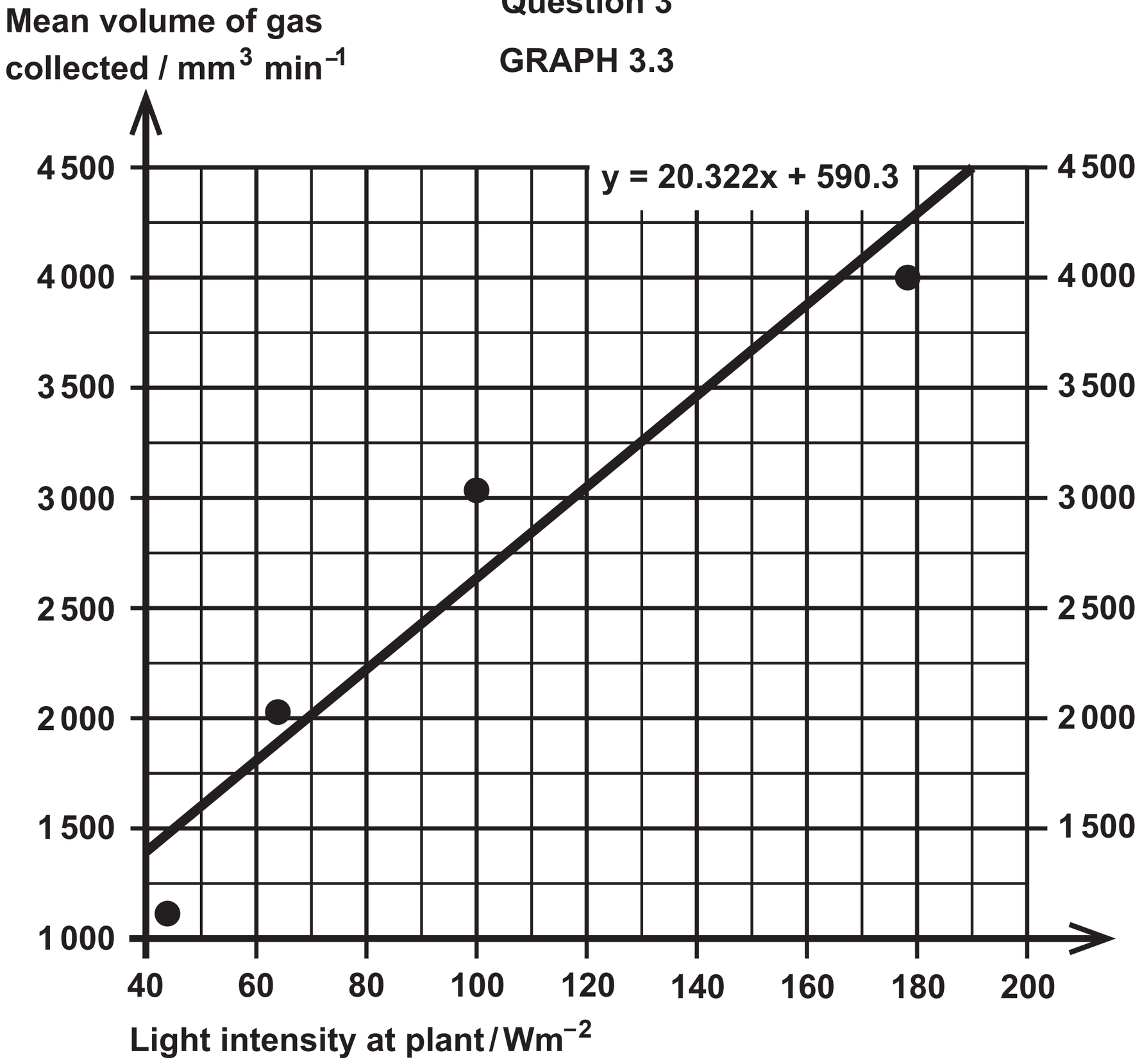
Question 3

TABLE 3.2

Distance from lamp / m	Distance from lamp^2 / m^2	Light intensity at plant / Wm^{-2}	Volume of gas / mm^3 min^{-1}			
			Trial 1	Trial 2	Trial 3	mean
0.30	0.0900	44	1222	978	1098	1099
0.25	0.0625	64	2098	1897	2134	2043
0.20	0.0400	100	3302	2788	3100	3063
0.15	0.0225	178	4012	3876	4100	3996
0.10			3998	3887	4100	3995
0.05	0.0025	1600	4011	3888	3998	3966

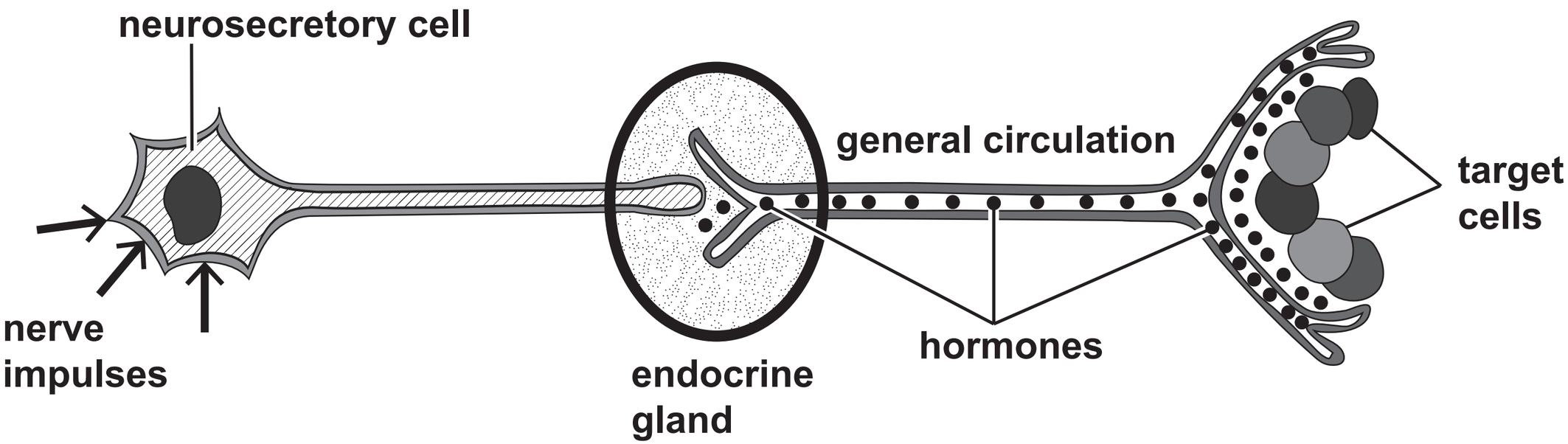
Question 3

GRAPH 3.3



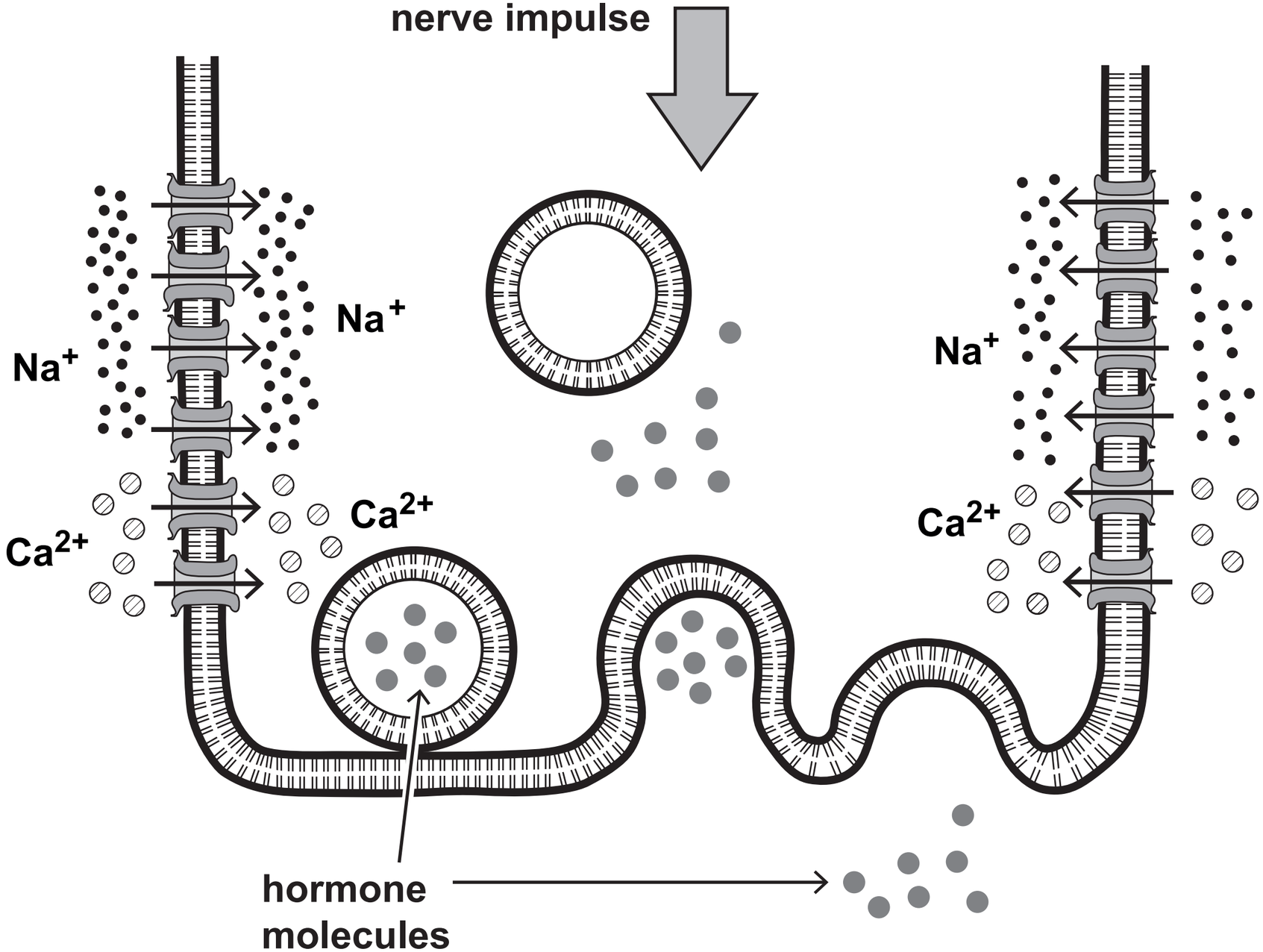
Question 4

IMAGE 4.1



Question 4

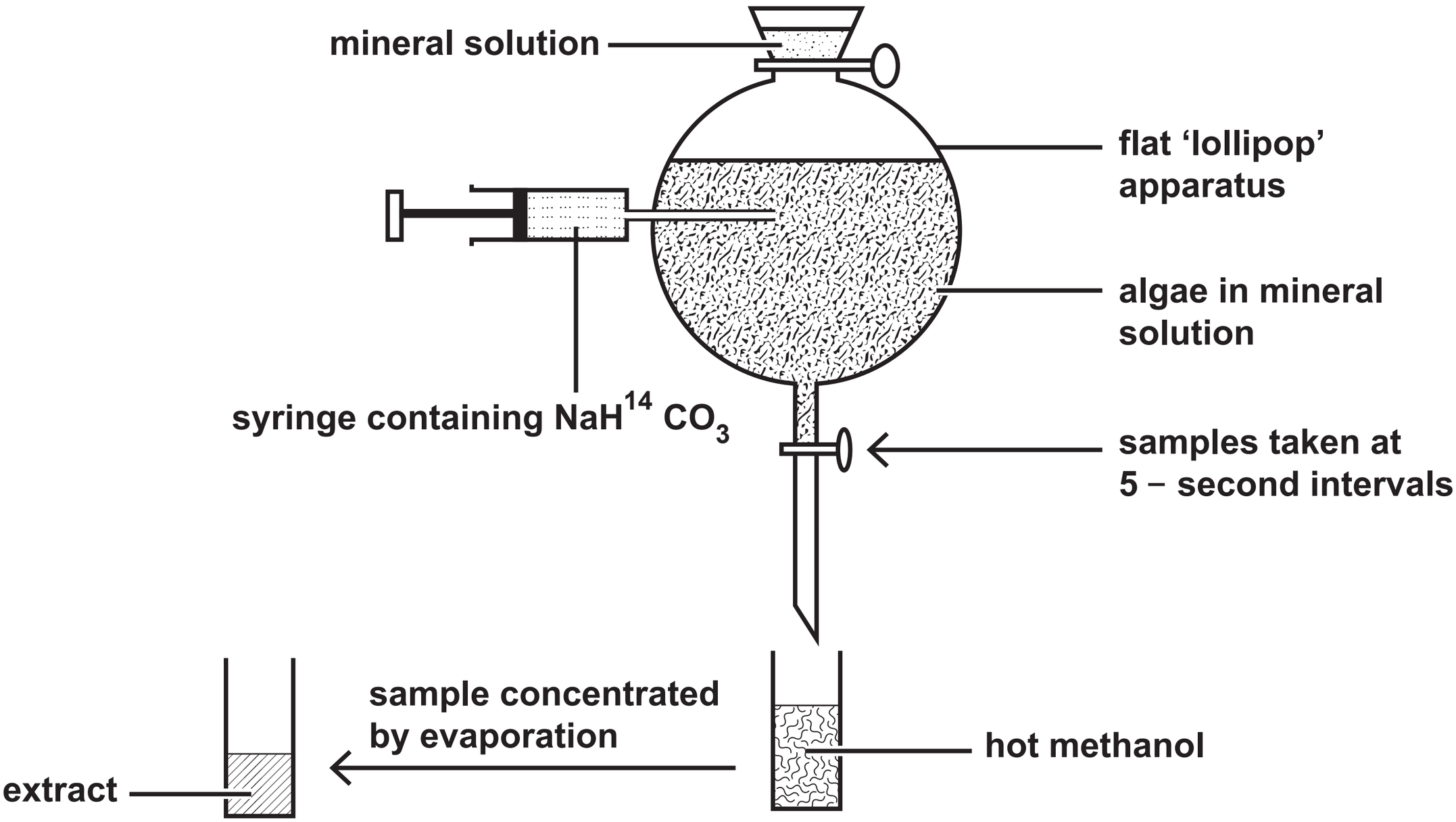
IMAGE 4.2



Question 5

IMAGE 5.1

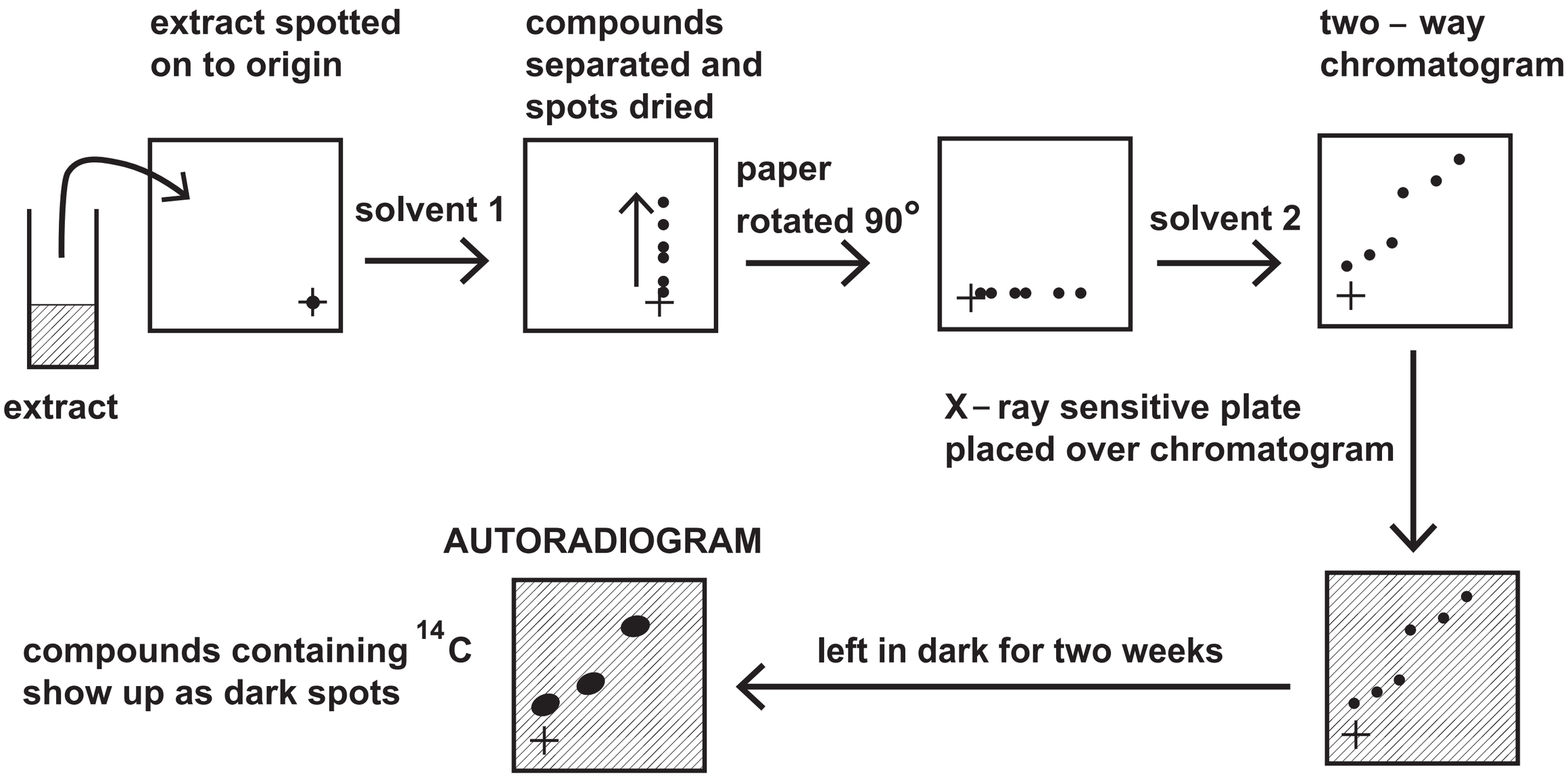
Diagram 1



Question 5

IMAGE 5.1

Diagram 2

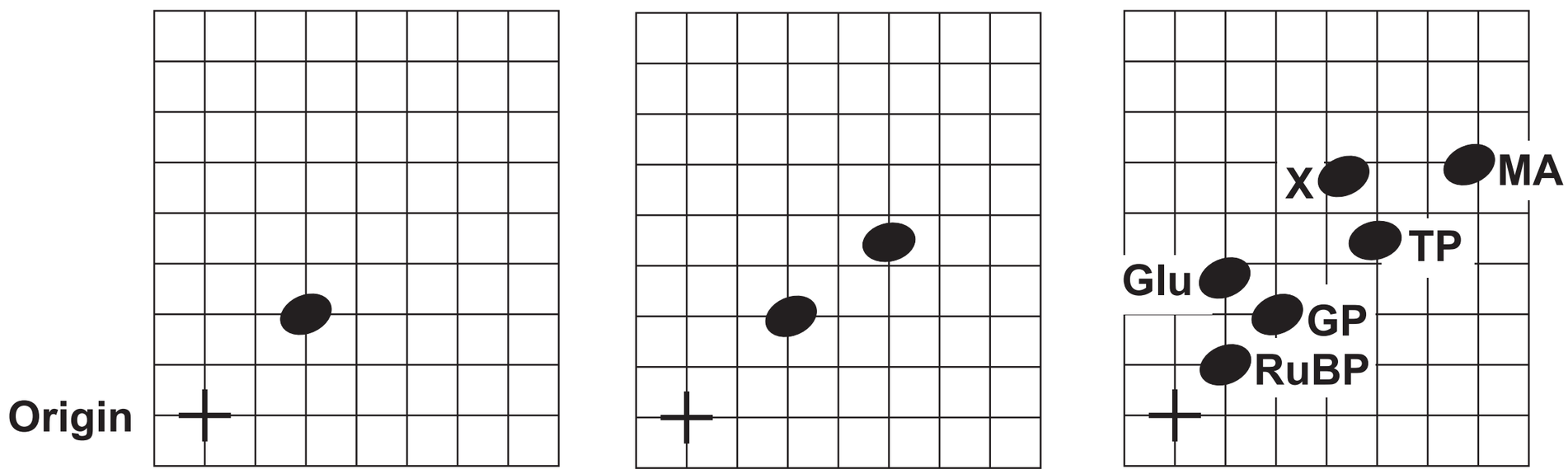


Question 5

IMAGE 5.2

EXPERIMENT 1:
Samples taken at short intervals from injection of $NaH^{14}CO_3$

Key: Glu = glucose, RuBP = ribulose bisphosphate, GP = glycerate – 3 – phosphate, TP = triose phosphate, MA = malic acid



Question 5 (b) (i)

Sequences

A Ribulose Bisphosphate ⟶ Triose Phosphate ⟶ Glycerate – 3 – Phosphate

B Glycerate – 3 – Phosphate ⟶ Triose Phosphate ⟶ Ribulose Bisphosphate

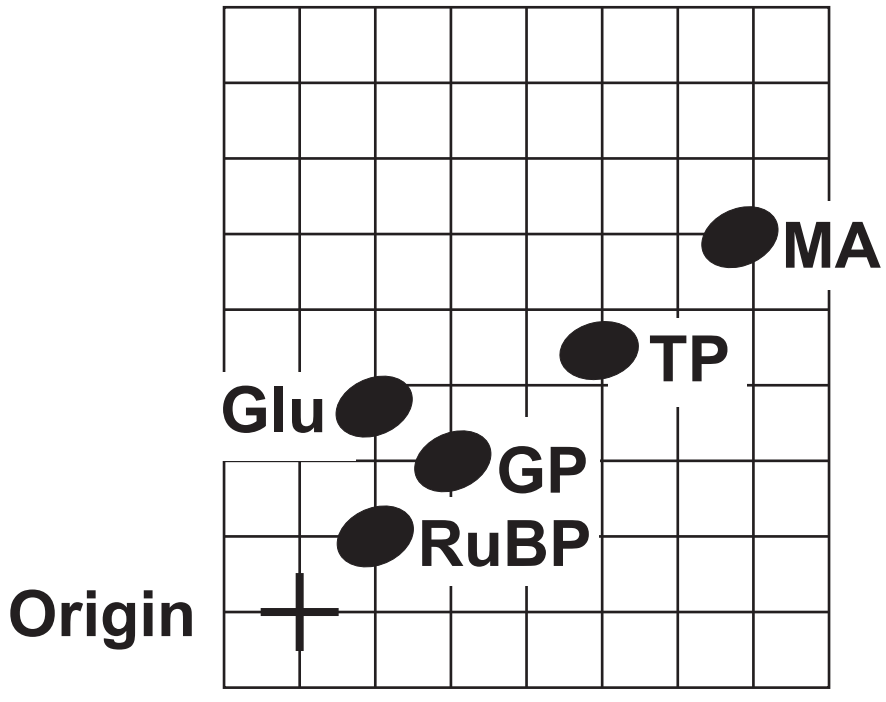
C Triose Phosphate ⟶ Glycerate – 3 – Phosphate ⟶ Ribulose Bisphosphate

Question 5

IMAGE 5.3

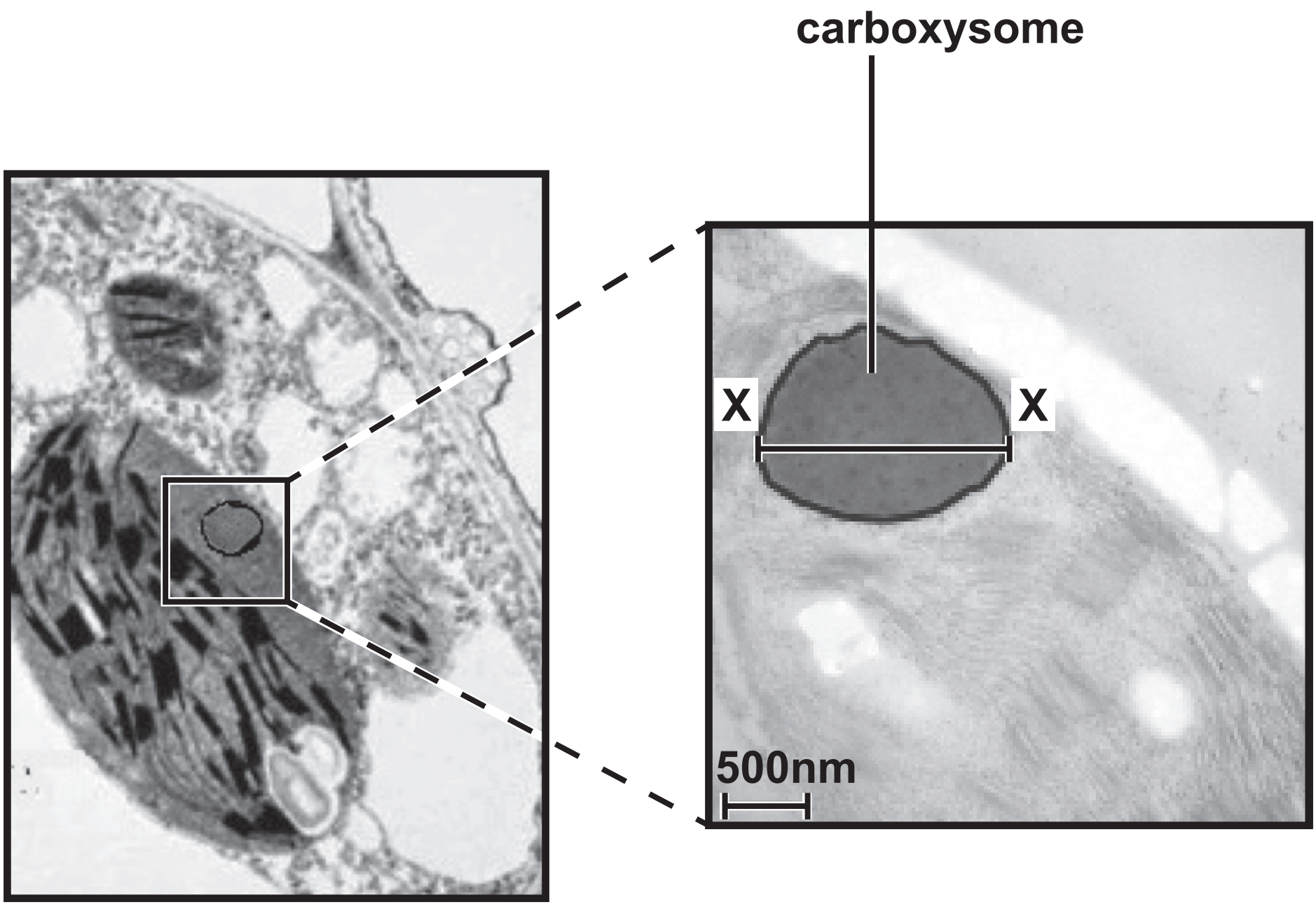
EXPERIMENT 2:
Mineral solution lacking nitrate.

Time: 15 seconds



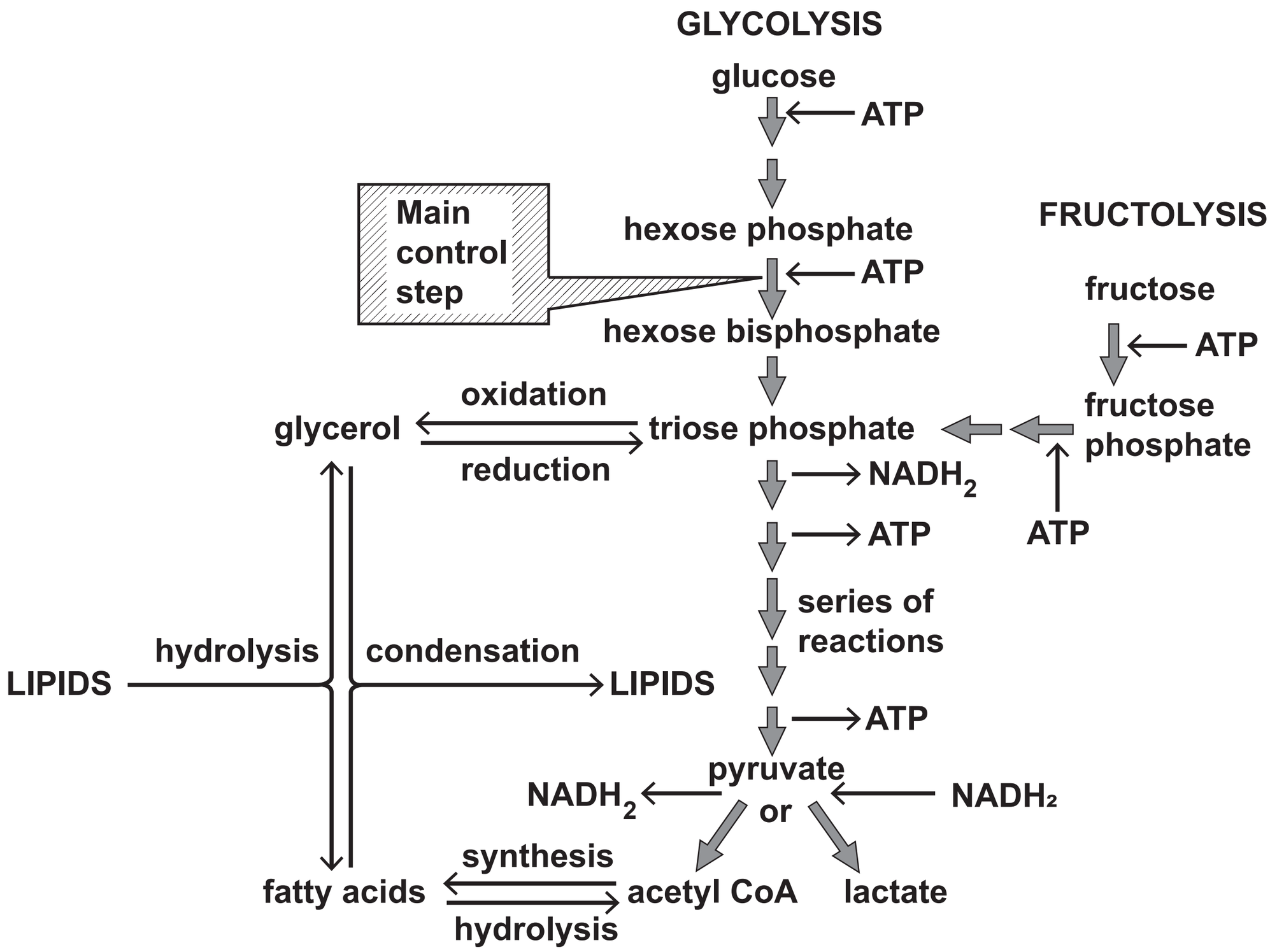
Question 5

IMAGE 5.4



Question 6

IMAGE 6.1



Question 7

IMAGE 7.1

Image of the north bank of the Mississippi river

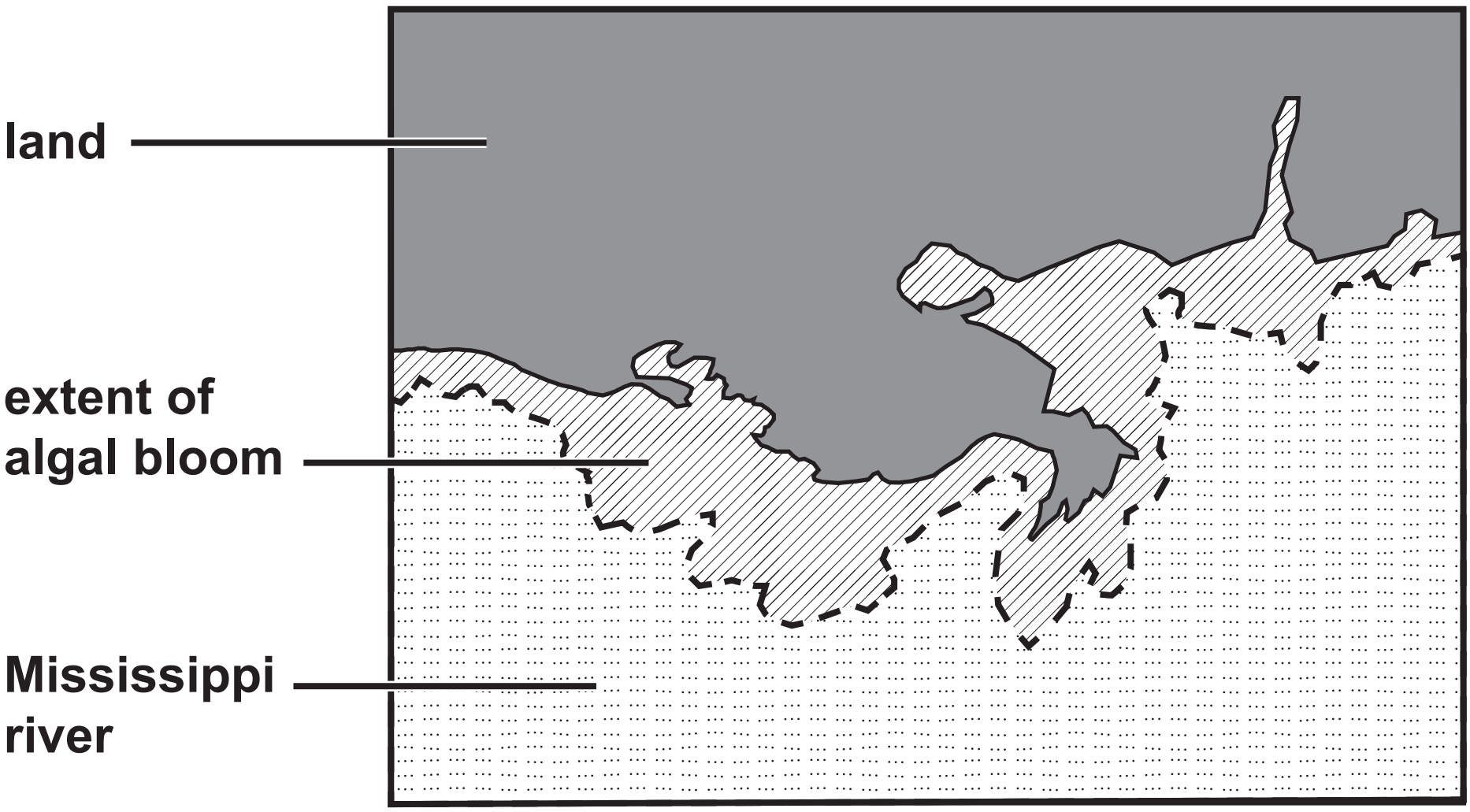
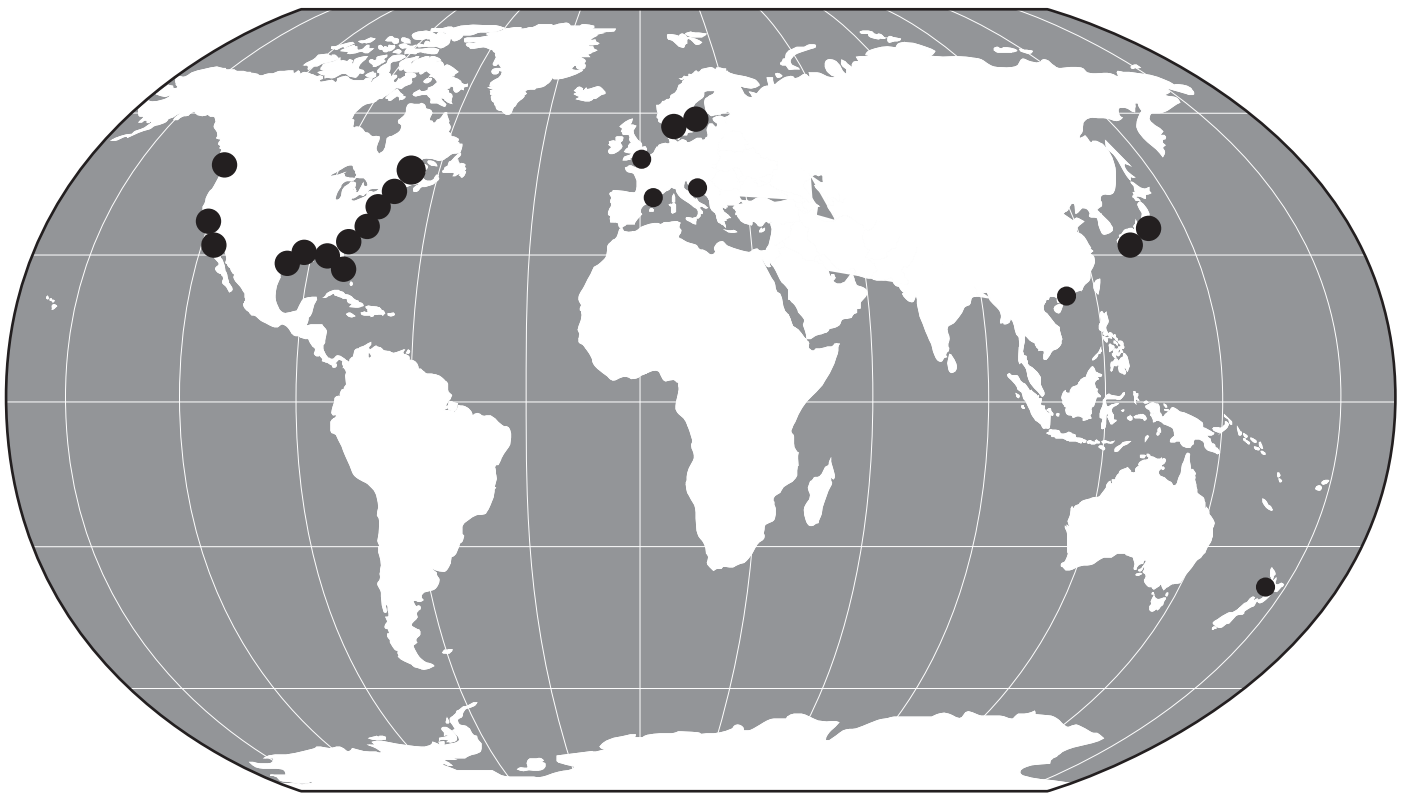


IMAGE 7.2

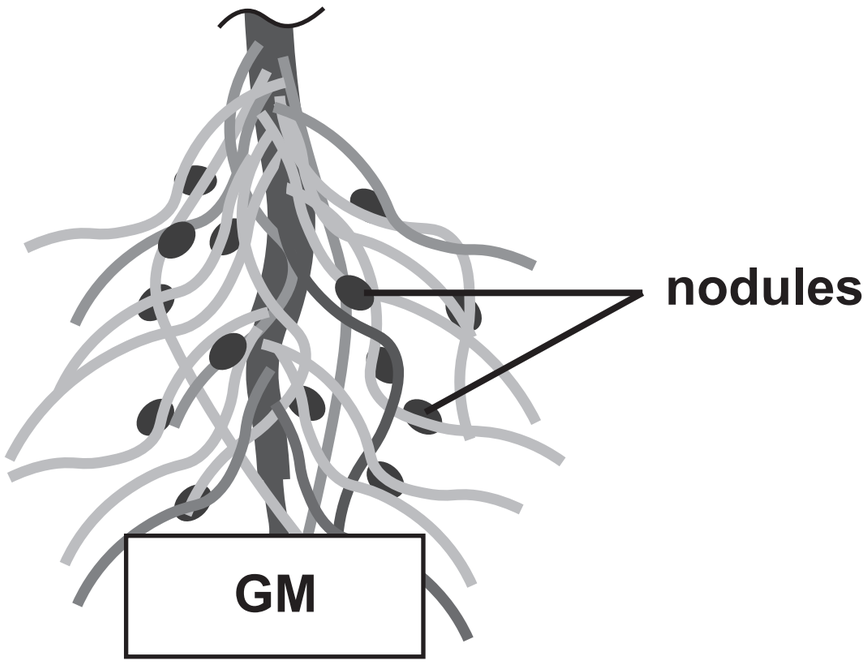
Aquatic dead zones across the world, shown as black dots on the map



Question 7

IMAGE 7.3

Roots of genetically modified plants



Wild type and genetically modified plants grown in low nitrate medium