GCE A LEVEL

1400U30-1

WEDNESDAY, 7 JUNE 2023 – AFTERNOON

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.	**11**	
2.	**11**	
3.	**18**	
4.	**16**	
5.	**15**	
6.	**10**	
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 IMAGE 1.1 for Question 1 in the separate Diagram Booklet.

IMAGE 1.1 shows a simplified summary of the stages in aerobic respiration. The asterisks (*) indicate reactions in which intermediates lose a carbon atom.

The truck symbols in the diagram represent two different coenzymes, coenzyme 1 and coenzyme 2.

Note: coenzyme 1 is involved at several points, only one is shown.

(a) Look at the table for Question 1 (a) in the separate Diagram Booklet.

Name stages A, B and C and state PRECISELY where in a eukaryotic cell each stage takes place.

[3 marks]

continued on the next page . . .

Question 1 continued

1. (b) Name the type of enzyme involved in the reactions marked with asterisks (*) in IMAGE 1.1 and state what happens to the carbon atoms.

Type of enzyme _____

_____

What happens to the carbon atoms

_____

_____

_____

[2 marks]

(c) (i) State the term given to the chemical change occurring in the coenzymes shown in IMAGE 1.1

_____

_____

[1 mark]

continued on the next page . . .

Question 1 (c) continued

1. (c) (ii) I. Identify the TWO coenzymes.

Coenzyme 1

_____

_____

Coenzyme 2

_____

_____

[1 mark]

II. Describe the role of the TWO coenzymes in aerobic respiration and explain why they result in different yields of ATP.

_____

_____

_____

_____

_____

[3 marks]

1. (c) (iii) State the term used to describe the role of oxygen in aerobic respiration.

[1 mark]

(Total for Question 1 = 11 marks)

2. Most terrestrial plants use chlorophylls *a* and *b* to construct pigment – protein complexes which harvest light.

Look at GRAPH 2.1A and GRAPH 2.1B for Question 2 in the separate Diagram Booklet. GRAPH 2.1A shows an absorption spectrum for a terrestrial plant and the GRAPH 2.1B shows corresponding action spectrum.

(a) Describe the relationship between the absorption spectrum and the action spectrum and state a suitable conclusion which explains the relationship.

_____

_____

_____

_____

_____

_____

[2 marks]

continued on the next page . . .

Question 2 continued

2. (b) Different taxa contain different photosynthetic pigments.

Diatoms are aquatic photosynthetic organisms. Their chloroplasts contain chlorophyll *a*, but instead of chlorophyll b they contain chlorophyll c.

Look at GRAPH 2.2 for Question 2 (b) in the separate Diagram Booklet.

GRAPH 2.2 shows the absorption spectrum of chlorophyll c.

(i) Describe the main difference between the absorption spectrum for chlorophyll b shown in GRAPH 2.1A and the absorption spectrum for chlorophyll c shown in GRAPH 2.2.

_____

_____

[1 mark]

continued on the next page . . .

Question 2 (b) continued

2. (b) (ii) With reference to the peaks labelled on the action spectrum in GRAPH 2.1B, predict how the action spectrum for diatoms would differ from that of terrestrial plants.

_____

_____

[1 mark]

continued on the next page . . .

Question 2 continued

2. (c) Look at IMAGE 2.3 for Question 2 (c) in the separate Diagram Booklet.

IMAGE 2.3 shows the depths that different wavelengths of light are able to penetrate water.

Use information from GRAPH 2.2 and IMAGE 2.3 to explain why diatoms living at a depth of 200 m have chlorophyll c instead of chlorophyll b.

_____

_____

_____

_____

_____

[1 mark]

continued on the next page . . .

Question 2 continued

2. (d) Look at IMAGE 2.4 for Question 2 (d) in the separate Diagram Booklet.

IMAGE 2.4 shows an electronmicrograph of a single diatom.

Using information from IMAGE 2.4, classify diatoms into their Domain. Give a reason for your choice.

Domain _____

_____

Reason _____

_____

[2 marks]

continued on the next page . . .

Question 2 continued

2. (e) Diatoms are responsible for about 40% of marine productivity and because the oceans cover about 70% of the Earth's surface they make a great contribution to global productivity. Blue whales feed on tiny crustaceans called krill, by filtering seawater through sheets in their mouths called baleen. Krill feed on diatoms.
Net primary productivity (NPP) for diatoms has been estimated to be $50\ g\ m^{-3}\ day^{-1}$ and secondary productivity for krill has been estimated to be $5\ g\ m^{-3}\ day^{-1}$

continued on the next page . . .

Question 2 (e) continued

Look at IMAGE 2.5 for Question 2 (e) in the separate Diagram Booklet.

IMAGE 2.5 shows a simplified food chain, the numbers shown are in $g\ m^{-3}\ day^{-1}$

R represents respiration and

E represents excretion.

(i) Calculate the rate at which krill use diatom biomass for respiration (R).

Rate = _____ $g\ m^{-3}\ day^{-1}$

[1 mark]

continued on the next page . . .

Question 2 (e) continued

2. (e) (ii) It is estimated that a single blue whale needs to consume $8\,000\ kg$ of biomass per day. The biomass of krill was estimated as $25\ g\ m^{-3}$

Calculate the volume of water a whale needs to filter per day to take in $8\,000\ kg$ of biomass. GIVE YOUR ANSWER IN STANDARD FORM.

Space for working:

Volume of water = _____ $m^3\ day^{-1}$

[3 marks]

(Total for Question 2 = 11 marks)

---

3. ATP is described as the universal energy currency of cells.

(a) (i) Describe why ATP is described as a universal currency.

_____

_____

_____

_____

_____

[2 marks]

continued on the next page . . .

Question 3 (a) continued

3. (a) (ii) Look at IMAGE 3.1 for Question 3 (a) (i) in the separate Diagram Booklet.

IMAGE 3.1 summarises the production and use of ATP in muscle cells.

COMPLETE THE DIAGRAM in IMAGE 3.1

[3 marks]

continued on the next page . . .

Question 3 continued

3. (b) Look at IMAGE 3.2 for Question 3 (b) in the separate Diagram Booklet.

IMAGE 3.2 shows diagrammatic representations of membranes found in two organelles where ATP synthesis takes place.

(i) Name the organelles in which the membranes (shown in IMAGE 3.2) would be found.

A _____

B _____

[1 mark]

continued on the next page . . .

Question 3 (b) continued

3. (b) (ii) In IMAGE 3.2, X, Y and Z represent membranes and compartments found in organelles A and B.

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

COMPLETE THE TABLE 3.3 to name the membranes and compartments represented in IMAGE 3.2 for each organelle.

[3 marks]

continued on the next page . . .

Question 3 (b) continued

3. (b) (iii) Describe how the components in the membrane of organelle B are involved in the synthesis of ATP by chemiosmosis.

[5 marks]

continued on the next page . . .

Question 3 continued

(c) Look at IMAGE 3.4 for Question 3 (c) in the separate Diagram Booklet.

The experiment shown in IMAGE 3.4 is considered to be evidence supporting the chemiosmotic hypothesis. It was carried out on membranes isolated from organelles of type A in IMAGE 3.2 and made into vesicles. The isolated membranes were placed in buffer solutions, the lower the pH the higher the concentration of protons.

Explain why the experiment shown in IMAGE 3.4 supports the chemiosmotic theory.

[4 marks]

(Total for Question 3 = 18 marks)

4. Look at the equation for Question 4 in the separate Diagram Booklet.

The size of any population at a given time is determined by the equation shown.

In field studies which monitor population size over a period of time the number of individuals often stays constant.

(a) Using the terms in brackets from the equation, write another equation which shows the relationship between the terms when the population size remains constant.

_____ = _____

[1 mark]

continued on the next page . . .

Question 4 continued

4. (b) Scientists monitored the population of frogs in a woodland surrounding a pond. The capture-mark-recapture method was used to determine the number of adult frogs, as follows:

- **19 frogs were caught**
- **marked by clipping off one toe**
- **they were then released back into the pond**
- **a week later the scientists collected as many frogs as they could over three consecutive days**
- **the results are shown in TABLE 4.1 provided for Question 4 (b) in the separate Diagram Booklet**
- **captured frogs from the three consecutive days were not released until after the third collection.**

continued on the next page . . .

Question 4 continued

4. (b) (i) From the figures given in the method and TABLE 4.1 estimate the total number of frogs in the woodland, using the following formula:

$$N = \frac{Mn}{m}$$

Where,

- N = **number in population**
- M = **number initially captured and marked**
- n = **total number subsequently captured**
- m = **number of marked individuals recaptured.**

Estimated number of frogs in the woodland

= _____

[2 marks]

Question 4 (b) continued

4. (b) (ii) Explain why the chosen method of marking the frogs might have affected the estimate of the frog population.

_____

_____

_____

[1 mark]

continued on the next page . . .

Question 4 continued

4. (c) Between capture and release the adult frogs were kept, ten to a tank, partially submerged in water collected from the pond. The frogs in one of the tanks developed red patches on their legs. The scientists suspected they were suffering from 'red – leg disease', caused by the bacterium, AEROMONAS HYDROPHILA, a Gram – negative bacillus.

The scientists took a swab from the leg of one of the frogs, performed a Gram stain and examined the sample under the microscope.

Describe the shape and colour of the bacteria they would have seen if the frog had been suffering from red-leg disease.

Shape _____

Colour _____

[2 marks]

continued on the next page . . .

Question 4 continued

4. (d) In order to study the survival rates of the larval stage of the frogs (tadpoles), two smaller ponds of equal volume were created from the existing pond using polyethylene sheets. Pond 1 was stocked with 5000 tadpoles per m^3 and pond 2 was stocked with 1000 tadpoles per m^3

The scientists took 20 samples of water from each pond every ten days and counted the number of tadpoles in each sample. They used the mean counts to calculate the number of tadpoles per m^3

Look at GRAPH 4.2 for Question 4 (d) in the separate Diagram Booklet.
Their results are shown in GRAPH 4.2, the thinner straight lines drawn in red are tangents to the curves.

continued on the next page . . .

Question 4 (d) continued

4. (d) (i) Calculate the rate of decline in number of tadpoles for pond 1 AT DAY 10

GIVE YOUR ANSWER TO TWO SIGNIFICANT FIGURES.

Rate of decline =

_____ **tadpoles** $m^{-3}\ day^{-1}$

[3 marks]

continued on the next page . . .

Question 4 (d) continued

4. (d) (ii) Using the information from GRAPH 4.2 it was concluded that a density – dependent factor was causing the change in the tadpole populations. State the evidence for this conclusion and suggest what the factor might have been.

[3 marks]

continued on the next page . . .

Question 4 continued

4. (e) The scientists also carried out a laboratory experiment to investigate the effect of selection on rate of development as measured by body length.

They used 3 different tanks, which contained 10 dm^3 of water.

- **Tank 1 – low density (1 tadpole per dm^3)**
- **Tank 2 – high density (5 tadpoles per dm^3)**
- **Tank 3 – high density with selection against small individuals (two of the smallest tadpoles were removed each week).**

continued on the next page . . .

Question 4 (e) continued

All tanks were kept under the same environmental conditions.
The length of the tadpoles in each tank was measured every 10 days and a mean calculated.

Look at GRAPH 4.3 for Question 4 (e) in the separate Diagram Booklet.
The results of the experiment are shown in GRAPH 4.3

continued on the next page . . .

Question 4 (e) continued

4. (e) (i) With reference to GRAPH 4.3, state TWO conclusions that can be drawn about the effect of density and selection on the rate of development of tadpoles in the three tanks.

_____

_____

_____

_____

_____

_____

[2 marks]

continued on the next page . . .

Question 4 (e) continued

4. (e) (ii) Another group of scientists said that it was not valid to use the results from tank 2 and tank 3 to make a conclusion about the effect of selection. Suggest why it might not be valid to compare these two tanks AND describe how the method could be changed to enable a more valid conclusion to be made.

[2 marks]

(Total for Question 4 = 16 marks)

5. The mammalian kidney has a role in two physiological processes, excretion and homeostasis.

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

IMAGE 5.1 shows a single kidney nephron. The strategy that the kidney uses for excretion is ultrafiltration followed by selective reabsorption.

(a) (i) Use LABELLED LINES on IMAGE 5.1 to show the sites of:

I. ultrafiltration

II. selective reabsorption

[2 marks]

continued on the next page . . .

Question 5 (a) continued

5. (a) (ii) Structures labelled X and Y in IMAGE 5.1 are involved in homeostasis. Name structures X and Y and the homeostatic process in which they are involved.

X _____

Y _____

Homeostatic process

_____

_____

[2 marks]

continued on the next page . . .

Question 5 continued

5. (b) The use of micropipettes has allowed samples of fluid to be withdrawn from specific points along kidney tubules of experimental animals. Samples of filtrate were taken from five positions along the proximal convoluted tubule and the concentrations of urea and chloride ions were measured.

Look at GRAPH 5.2 for Question 5 (b) in the separate Diagram Booklet.
The results are shown in GRAPH 5.2

continued on the next page . . .

Question 5 (b) continued

5. (b) (i) Use GRAPH 5.2 to explain the change in concentrations for urea and chloride ions along the tubule.

[2 marks]

continued on the next page . . .

Question 5 (b) continued

5. (b) (ii) The experiment was repeated but concentrations of glucose were measured with and without oligomycin.

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

Oligomycin is a chemical compound that specifically inhibits respiration. The results are shown in GRAPH 5.3

Use GRAPH 5.3, to explain the change in concentration along the tubule for glucose with AND without the respiratory inhibitor oligomycin.

[4 marks]

continued on the next page . . .

Question 5 continued

5. (c) A third experiment was carried out to study how structure X, shown in IMAGE 5.1, is involved in the formation of urine.

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

IMAGE 5.4 shows regions of tubule on either side of structure X. Samples were withdrawn from two locations, 1 and 2. The concentration of sodium ions (Na^+) was measured in each location.

(i) Explain why these locations were chosen for sampling.

_____

_____

_____

[1 mark]

continued on the next page . . .

Question 5 (c) continued

5. (c) (ii) The Na^+ concentration in the sample taken from LOCATION 1 was higher than the sample taken from LOCATION 2. Use your knowledge of the function of both limbs of the structure in IMAGE 5.4 to explain this result.

[4 marks]

(Total for Question 5 = 15 marks)

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

IMAGE 6.1 shows a natural carbon cycle unaffected by human activity. The arrows represent processes which transfer carbon from one form to another.

(a) (i) Process W involves the fixation of carbon in green plants. Name the TWO reactants involved and the enzyme that catalyses this process.

Reactant 1 _____

Reactant 2 _____

Enzyme _____

_____

[2 marks]

continued on the next page . . .

Question 6 (a) continued

6. (a) (ii) I. On IMAGE 6.1, LABEL ONE OF THE ARROWS with an X to show a process which involves micro – organisms.

II. Explain the role of micro – organisms in this process.

_____

_____

_____

_____

_____

[2 marks]

(iii) ADD AN ARROW LABELLED C to IMAGE 6.1 to represent the transfer of carbon as a result of human activity.

[1 mark]

continued on the next page . . .

Question 6 continued

(b) Nine global systems have been identified as being key regulators of the Earth's stability. Values have been proposed that represent boundaries or thresholds.

Look at TABLE 6.2 and IMAGE 6.3 for Question 6 (b) in the separate Diagram Booklet.

TABLE 6.2 shows two of the nine systems together with their threshold values and current values and IMAGE 6.3 displays the threshold values and current values as a circular graph.

continued on the next page . . .

Question 6 (b) continued

6. (b) (i) Use the information in TABLE 6.2 to name the TWO missing planetary systems labelled Y and Z in IMAGE 6.3

X _____

Y _____

[1 mark]

(ii) Use IMAGE 6.3 to state what the TWO planetary systems in TABLE 6.2 have in common with each other and with the LAND – USE system.

_____

_____

_____

[1 mark]

continued on the next page . . .

Question 6 continued

6. (c) Explain what is meant by a safe operating space for humanity, describe where that is shown in IMAGE 6.3, and describe the consequences of exceeding planetary boundaries.

[3 marks]

(Total for Question 6 = 10 marks)

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

IMAGE 7.1 shows the pathway from a tooth to an area of the brain which generates the sensation of pain. It also shows the site of action of two local anaesthetics used in dentistry. IMAGE 7.2 shows a reflex arc.

Compare and contrast the pathway shown in IMAGE 7.1 with the reflex arc in IMAGE 7.2

Using your knowledge of the generation of action potentials, suggest how anaesthetic A will prevent pain.

Using your knowledge of synaptic transmission, suggest how anaesthetic B could also prevent pain.

[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.

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

GCE A LEVEL

1400U30-1

WEDNESDAY, 7 JUNE 2023 – AFTERNOON

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: _____

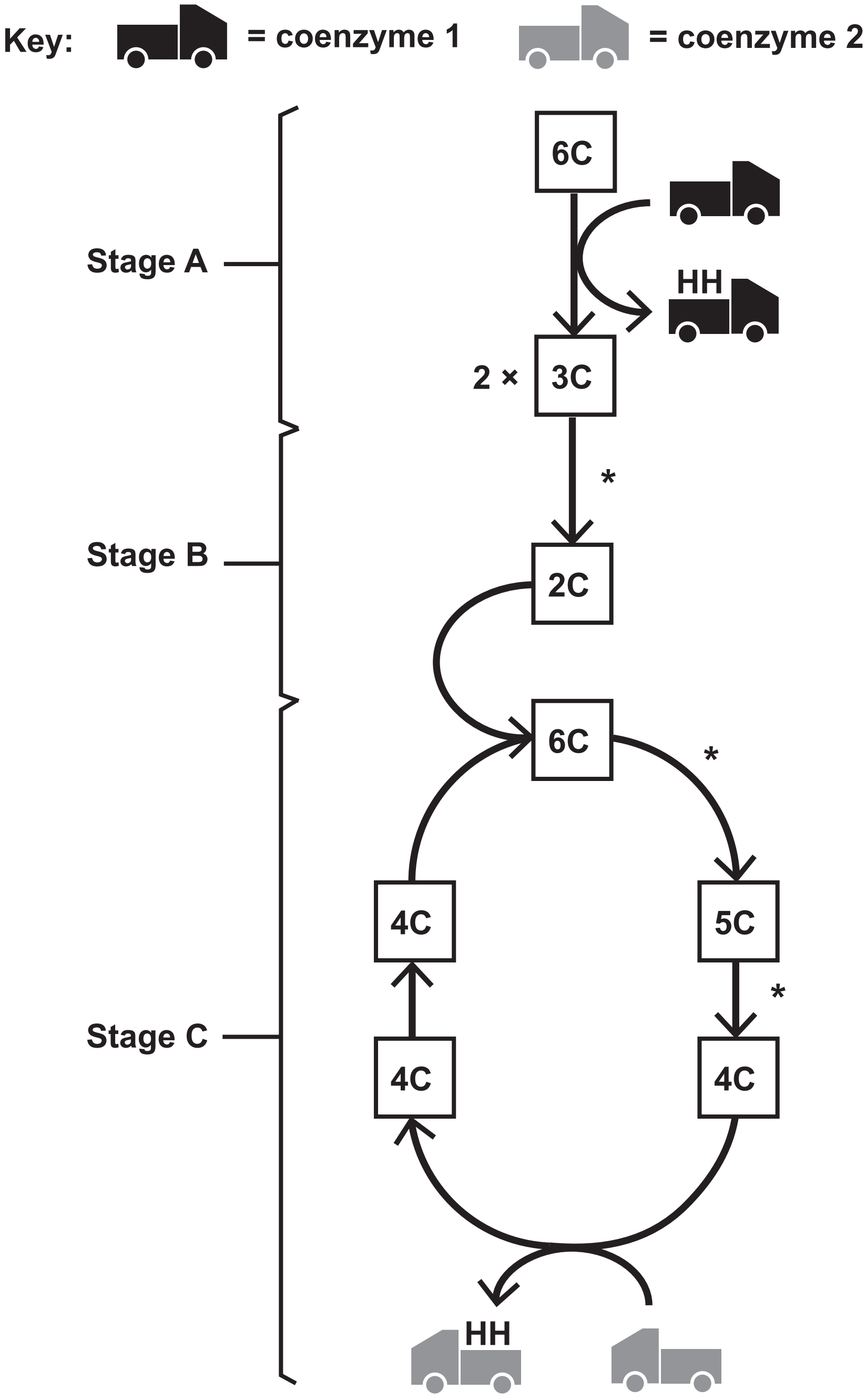
First name(s): _____

Centre Number: _____

Candidate Number: 2 _____

Question 1

IMAGE 1.1



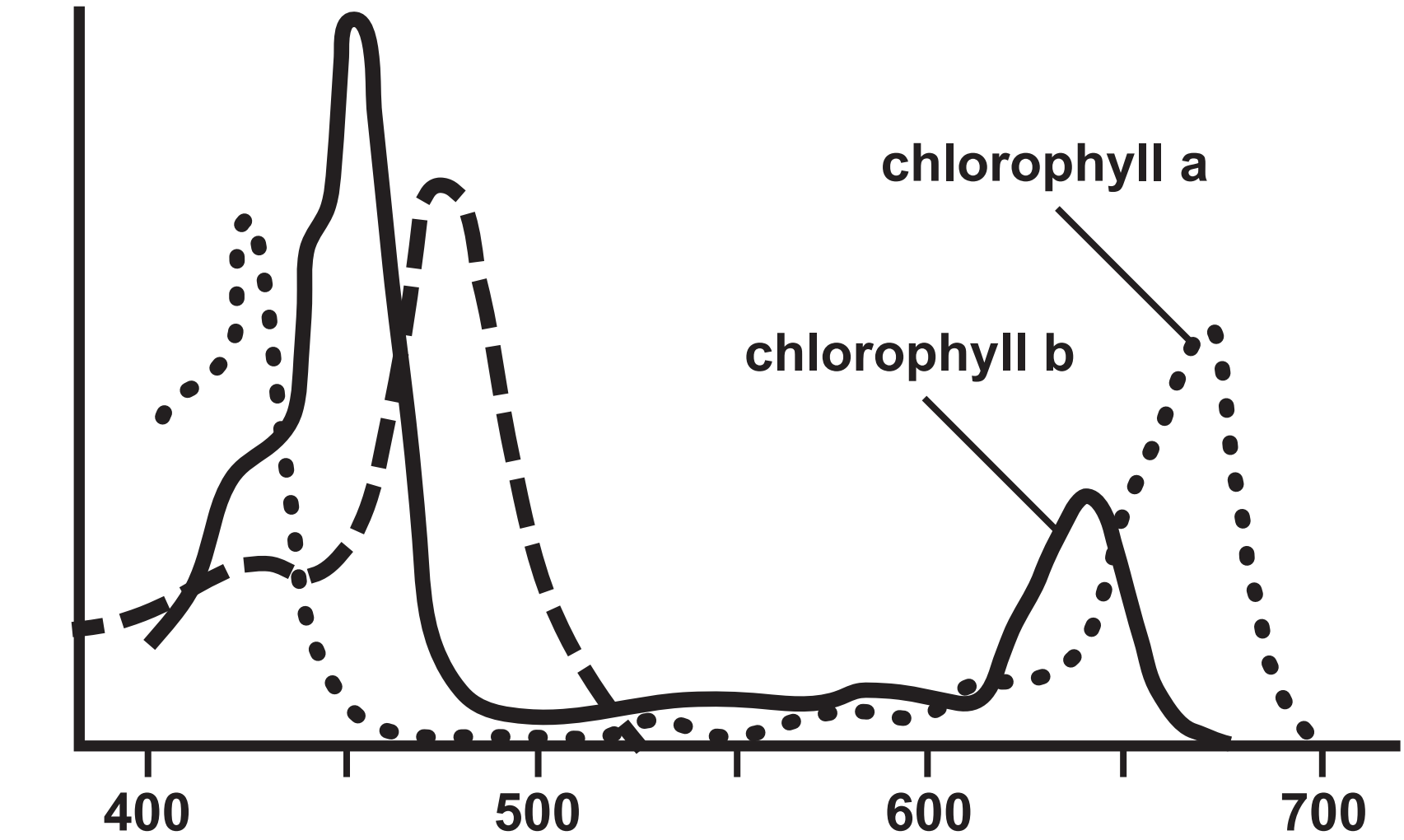
Question 1 (a)

Table

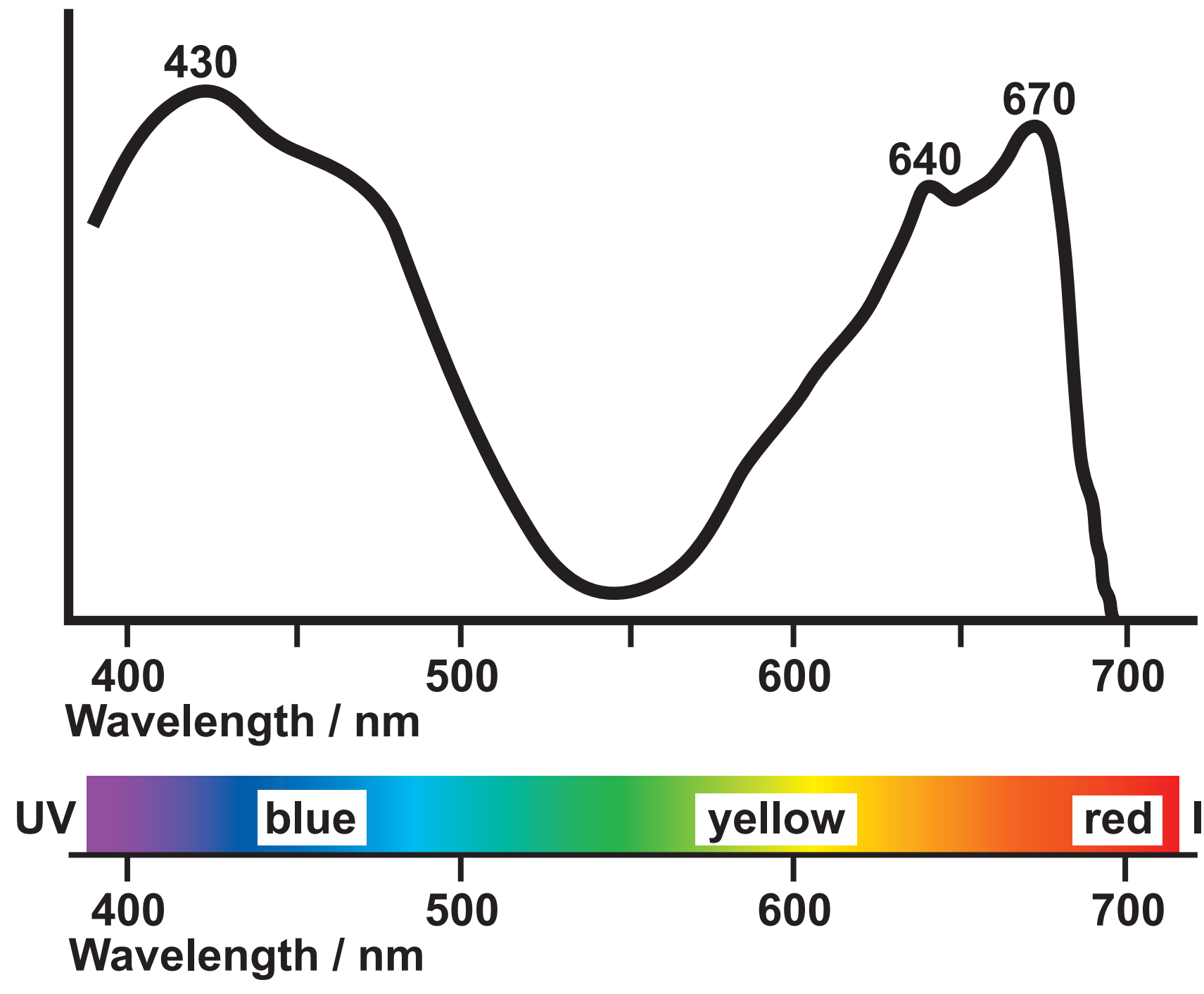
Stage	Name	Location
A	_____ _____	_____ _____
B	_____ _____	_____ _____
C	_____ _____	_____ _____

Question 2

GRAPH 2.1A - ABSORPTION SPECTRUM

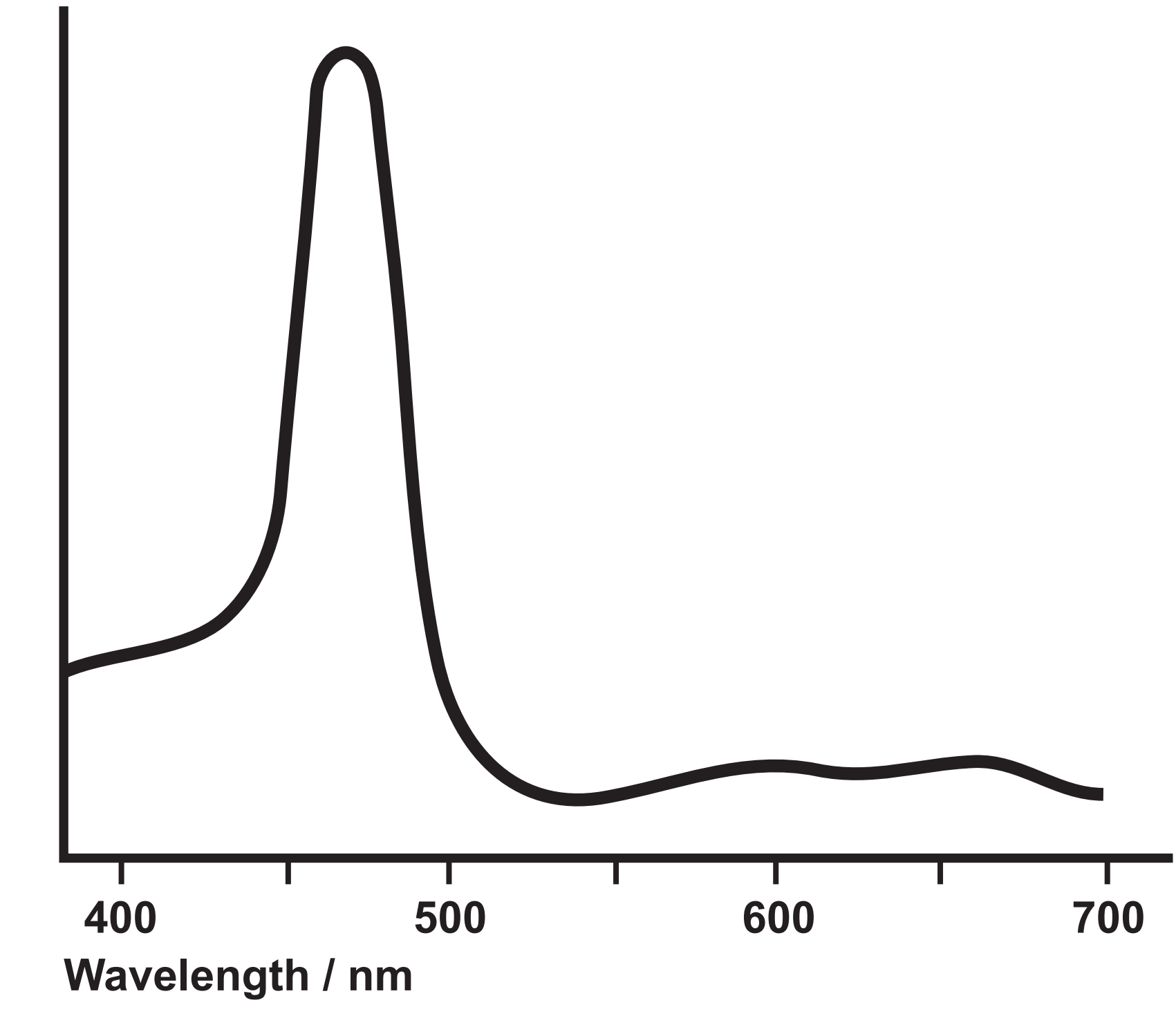


GRAPH 2.1B - ACTION SPECTRUM



Question 2 (b)

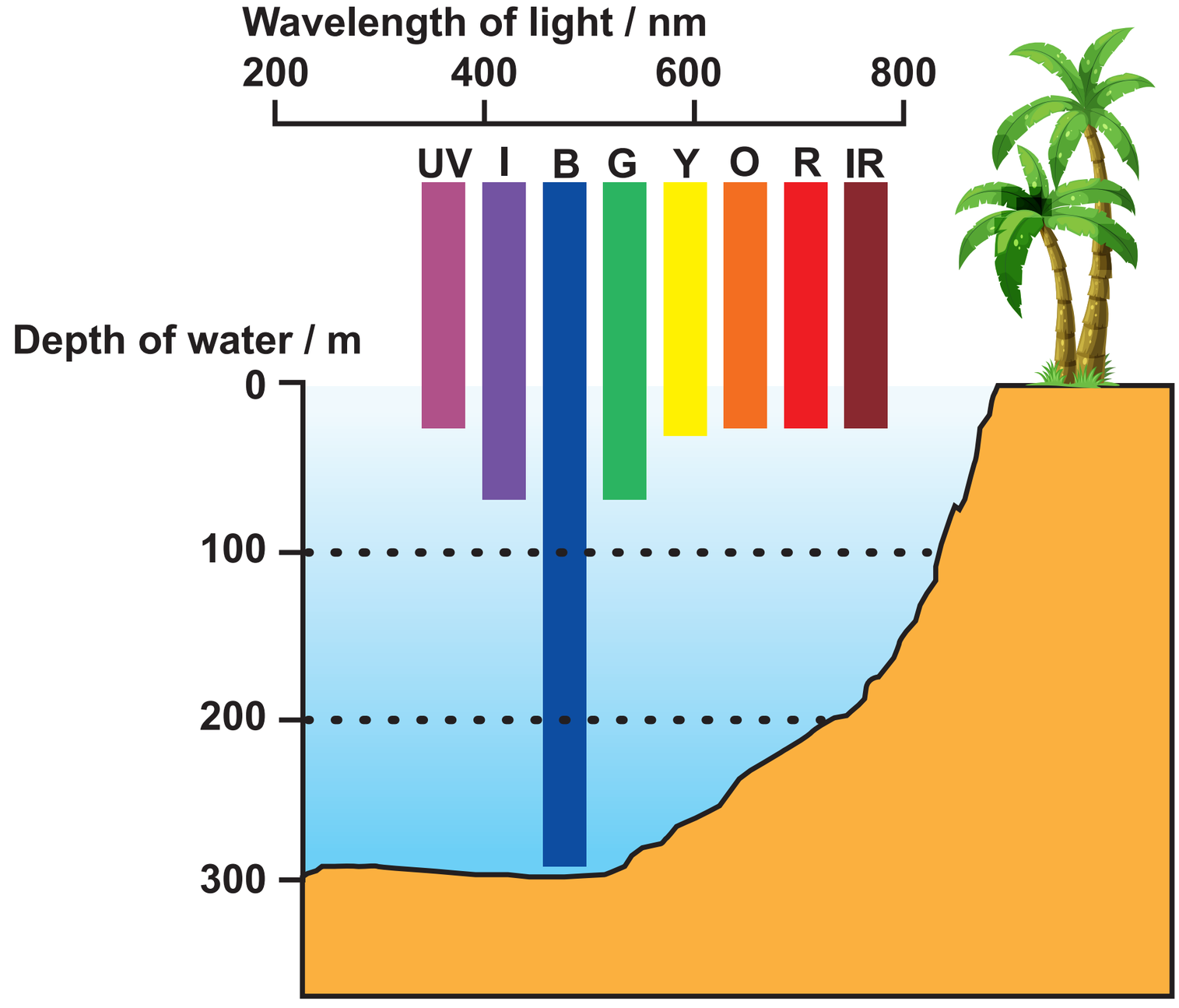
GRAPH 2.2



Question 2 (c)

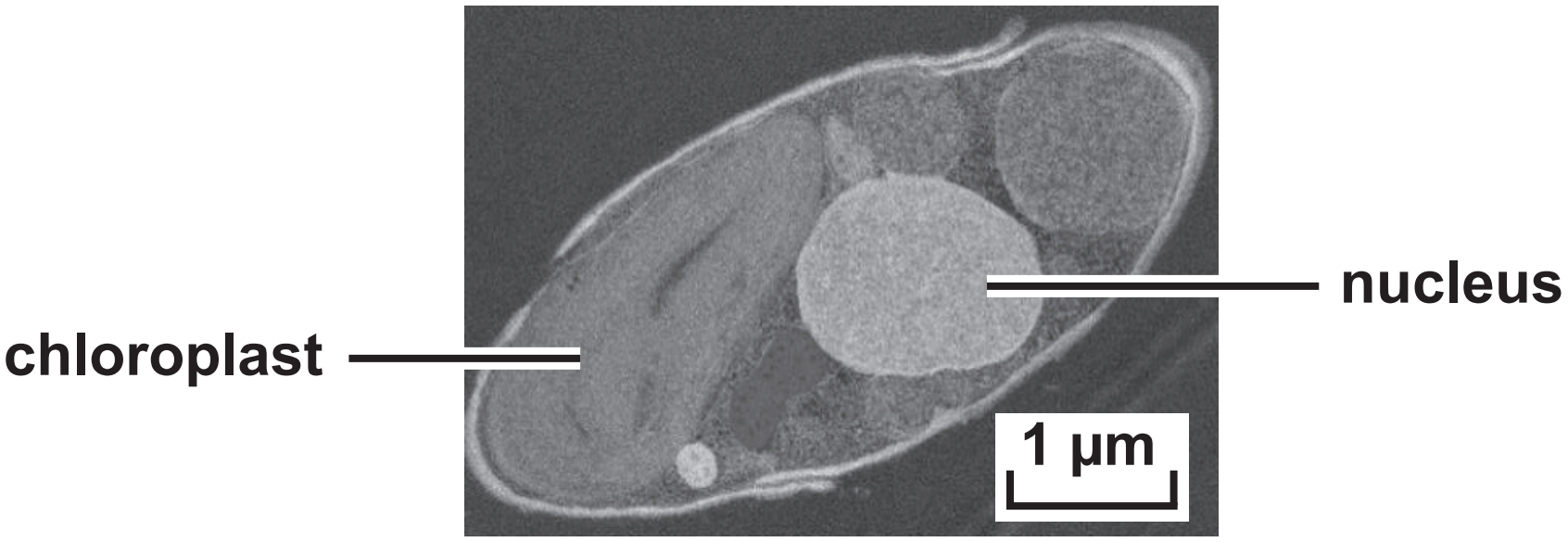
IMAGE 2.3

Key:
UV = ultraviolet
I = indigo
B = blue
G = green
Y = yellow
O = orange
R = red
IR = infrared



Question 2 (d)

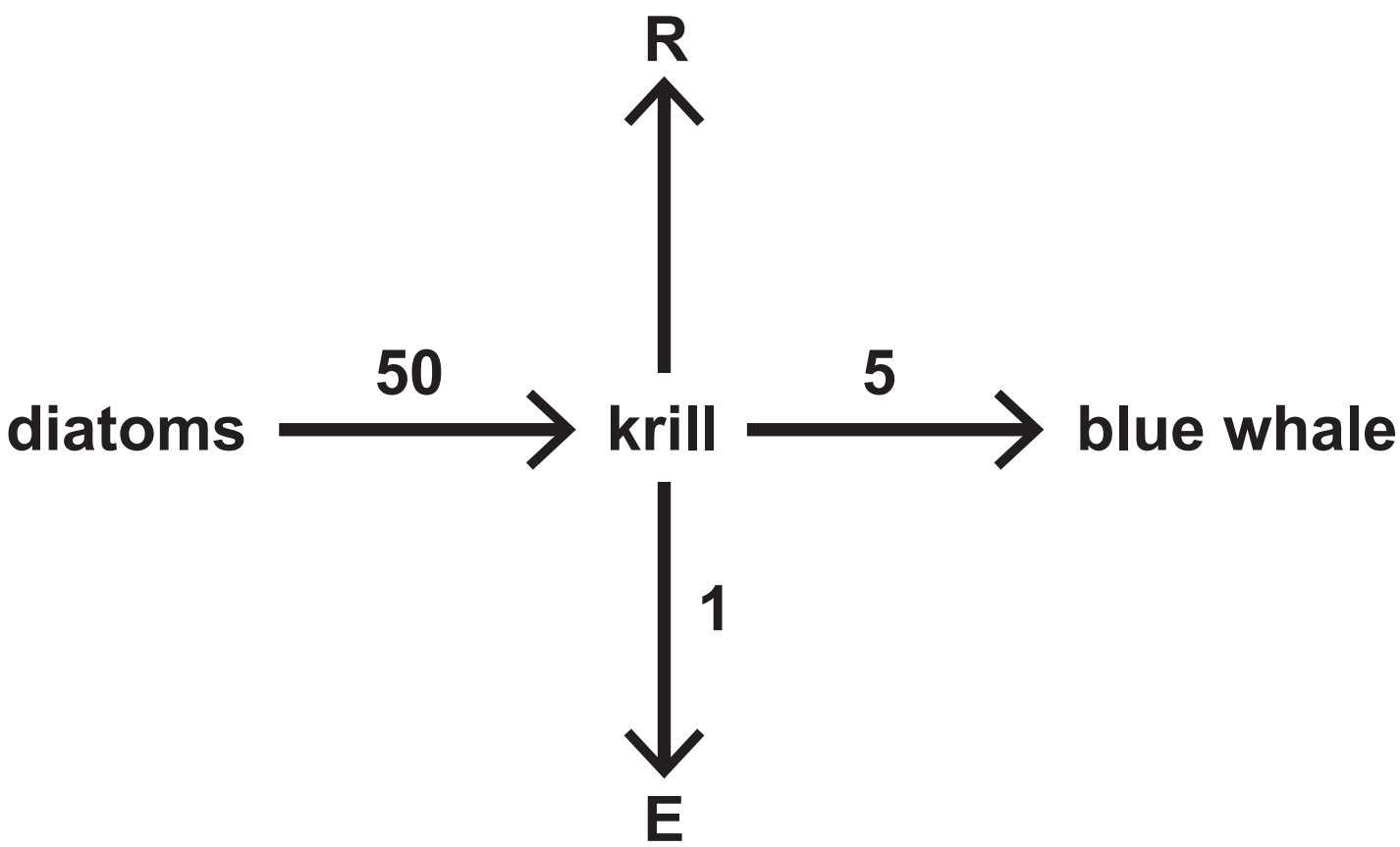
IMAGE 2.4



Question 2 (e)

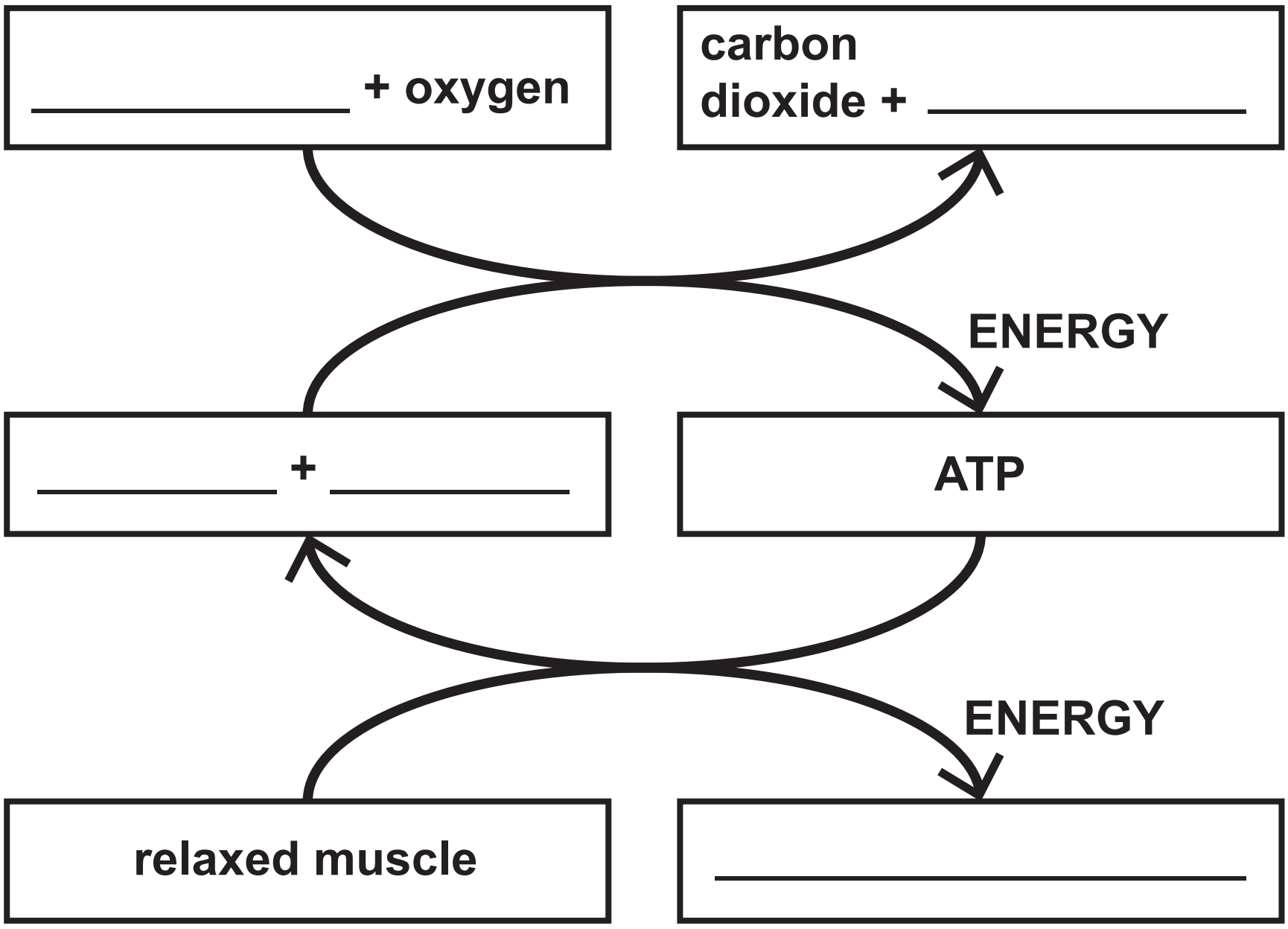
IMAGE 2.5

Key:
R represents respiration
E represents excretion
numbers are in g m^{-3} day^{-1}



Question 3 (a) (ii)

IMAGE 3.1

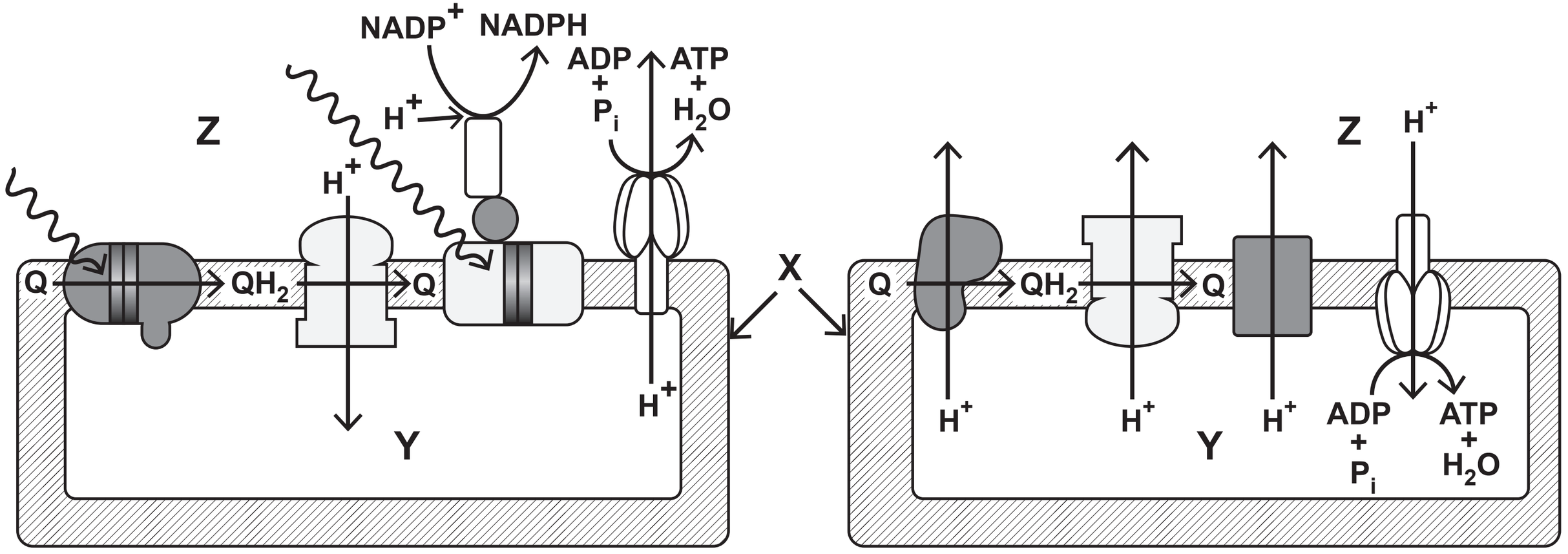


Question 3 (b)

IMAGE 3.2

MEMBRANE FOUND IN ORGANELLE A

MEMBRANE FOUND IN ORGANELLE B



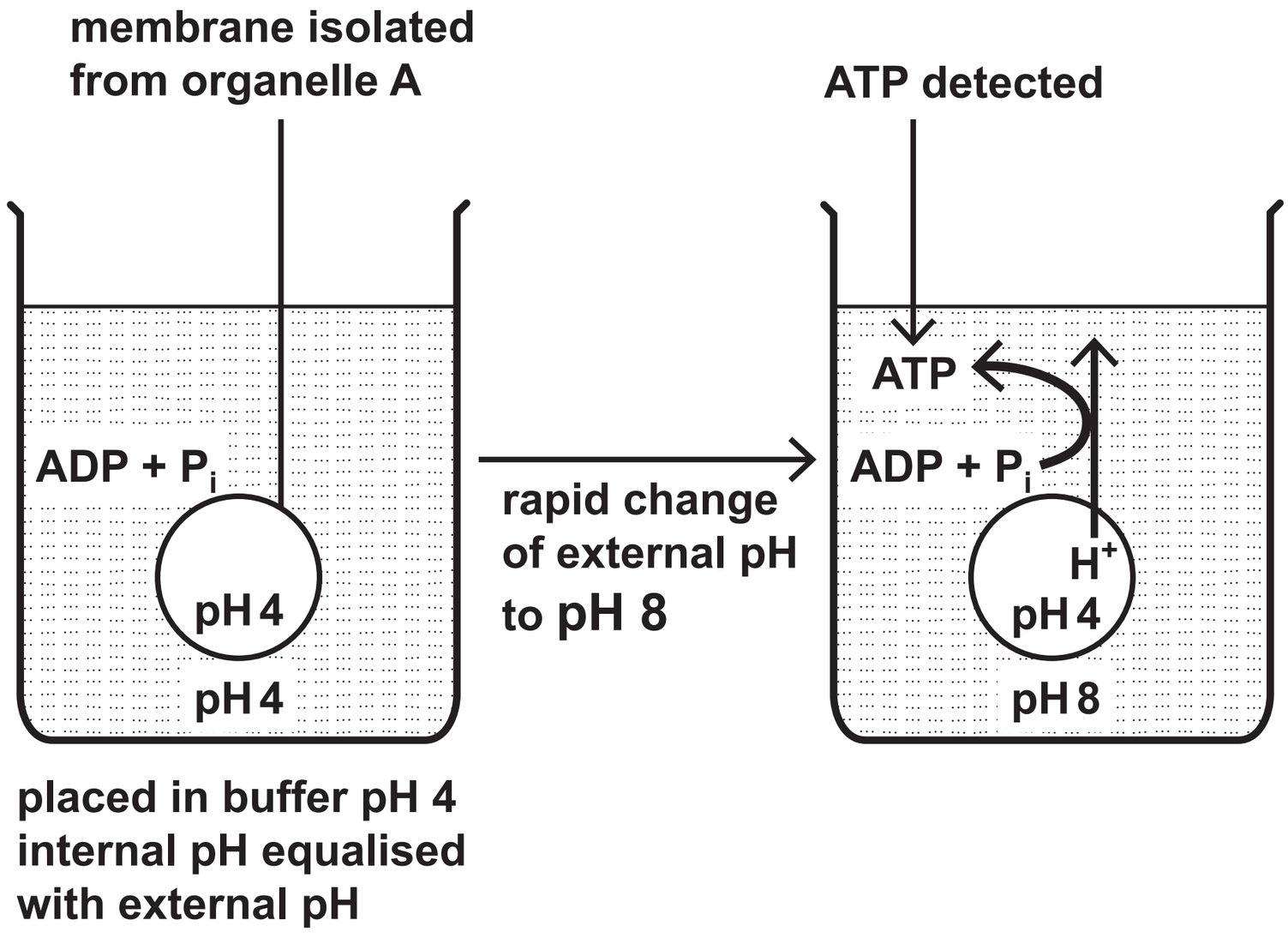
Question 3 (b) (ii)

TABLE 3.3

	Name of membrane / compartment		
Letter	**Part represented in image**	**Organelle A**	**Organelle B**
X	**membrane**	_____	_____
Y	**compartment enclosed by membrane**	_____	_____
Z	**compartment surrounding membrane**	_____	_____

Question 3 (c)

IMAGE 3.4



Question 4

Equation

Number of individuals = (birth rate + immigration) – (death rate + emigration)

Question 4 (a)

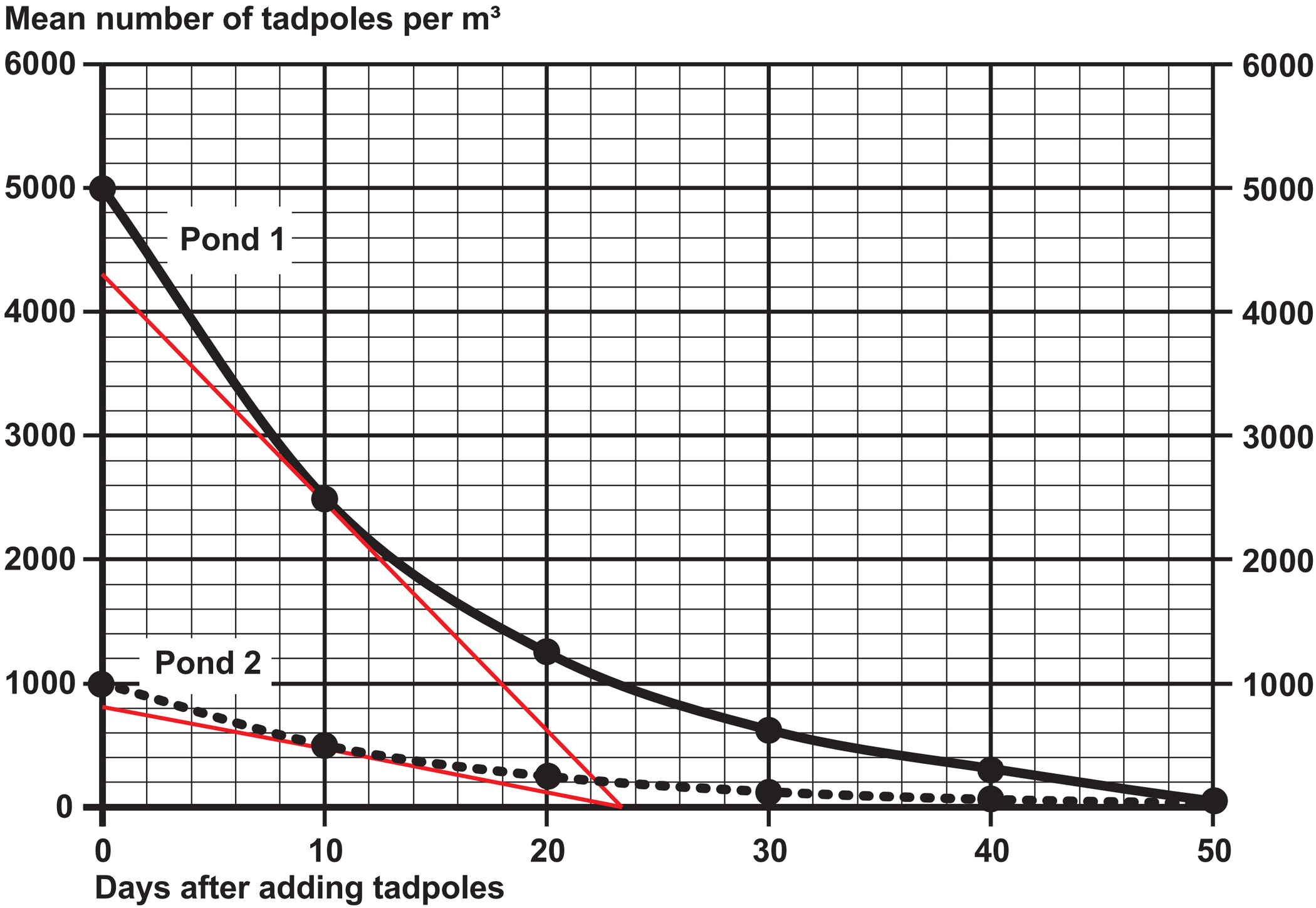
TABLE 4.1

Result of collections following release of marked frogs

Date	Total no. of frogs captured	No. of marked frogs
Day 1	48	5
Day 2	45	5
Day 3	50	7
Total	143	17

Question 4 (d)

GRAPH 4.2



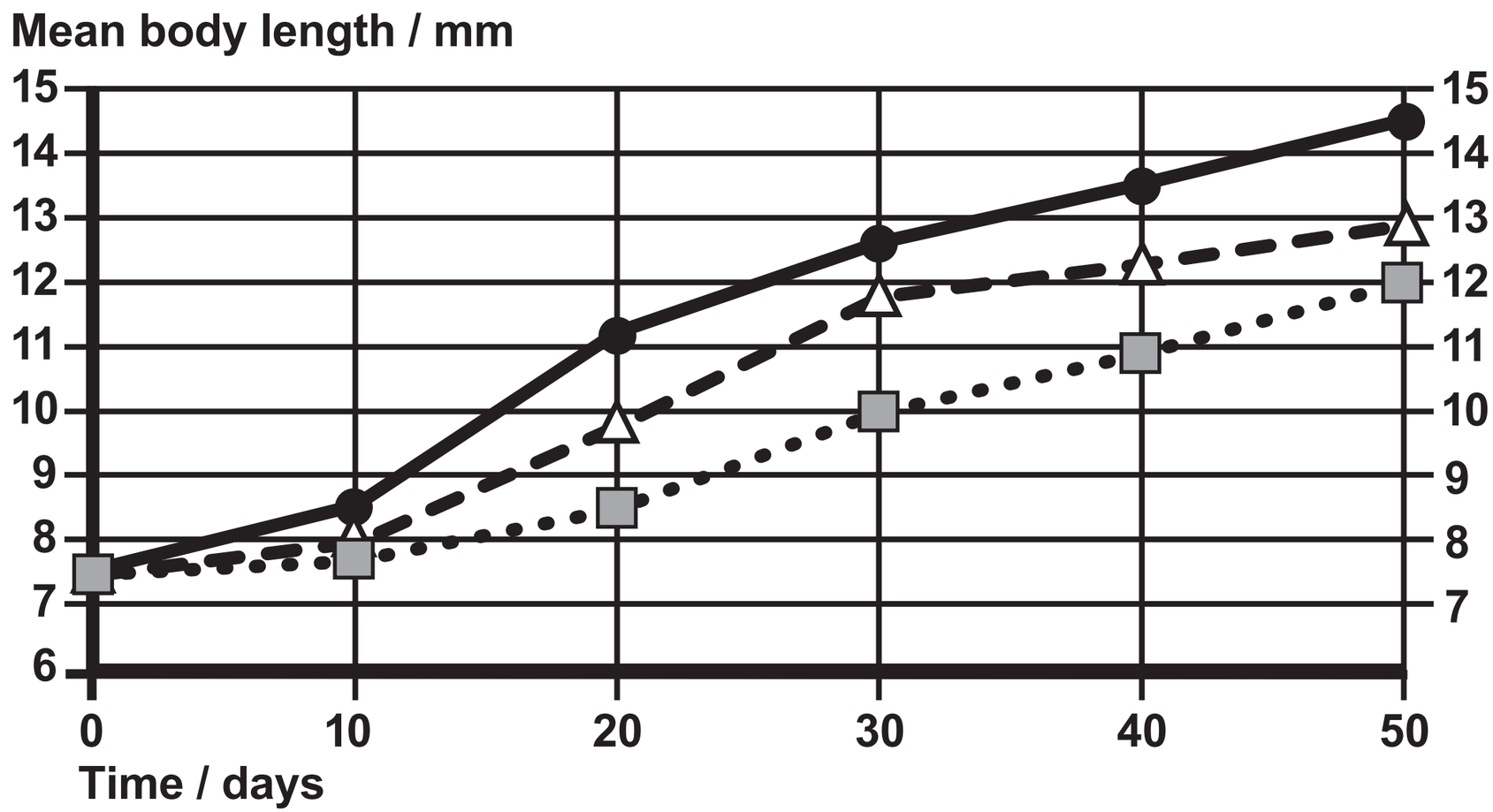
Question 4 (e)

GRAPH 4.3

Key: = low density

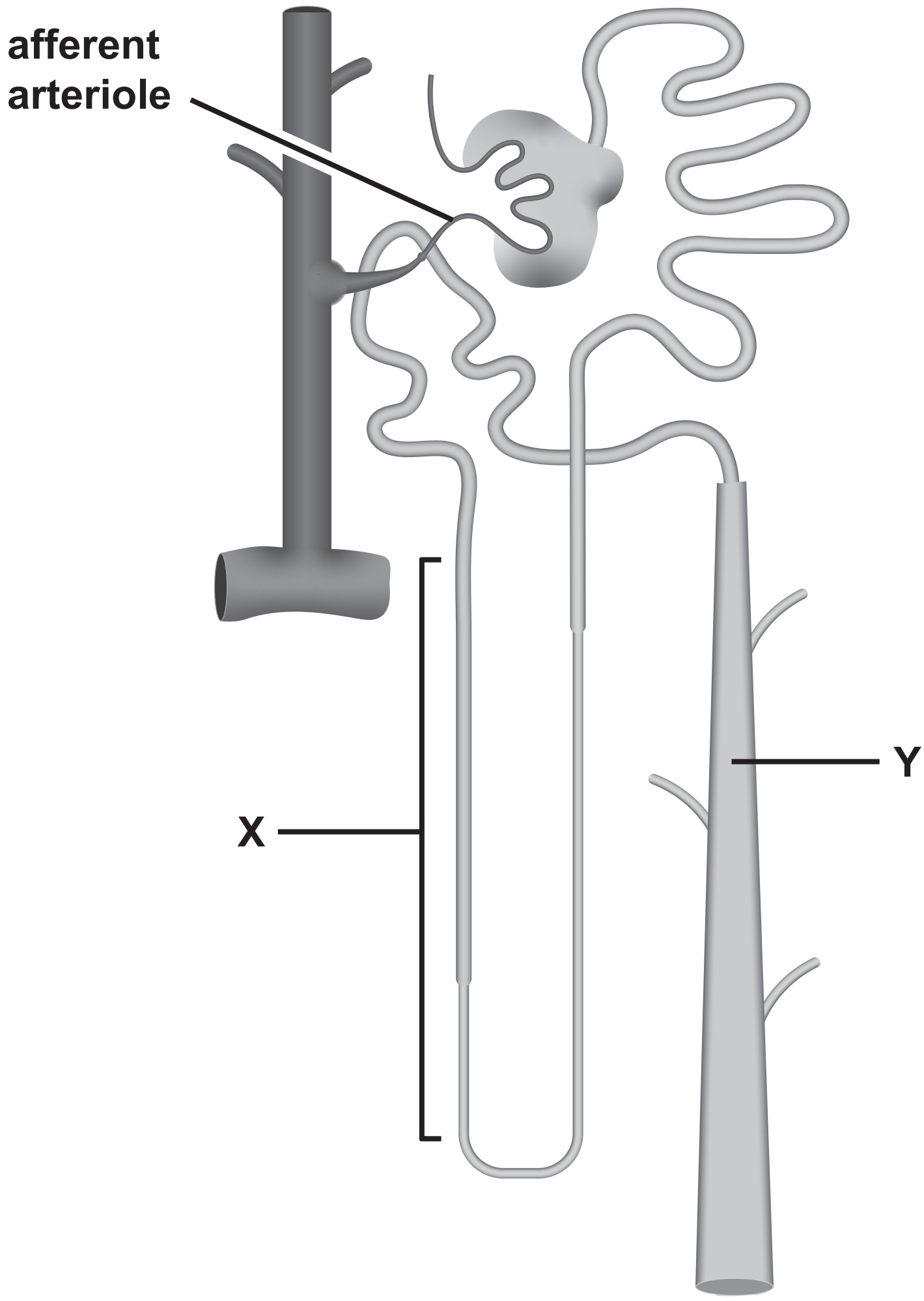
= high density with selection

= high density



Question 5

IMAGE 5.1

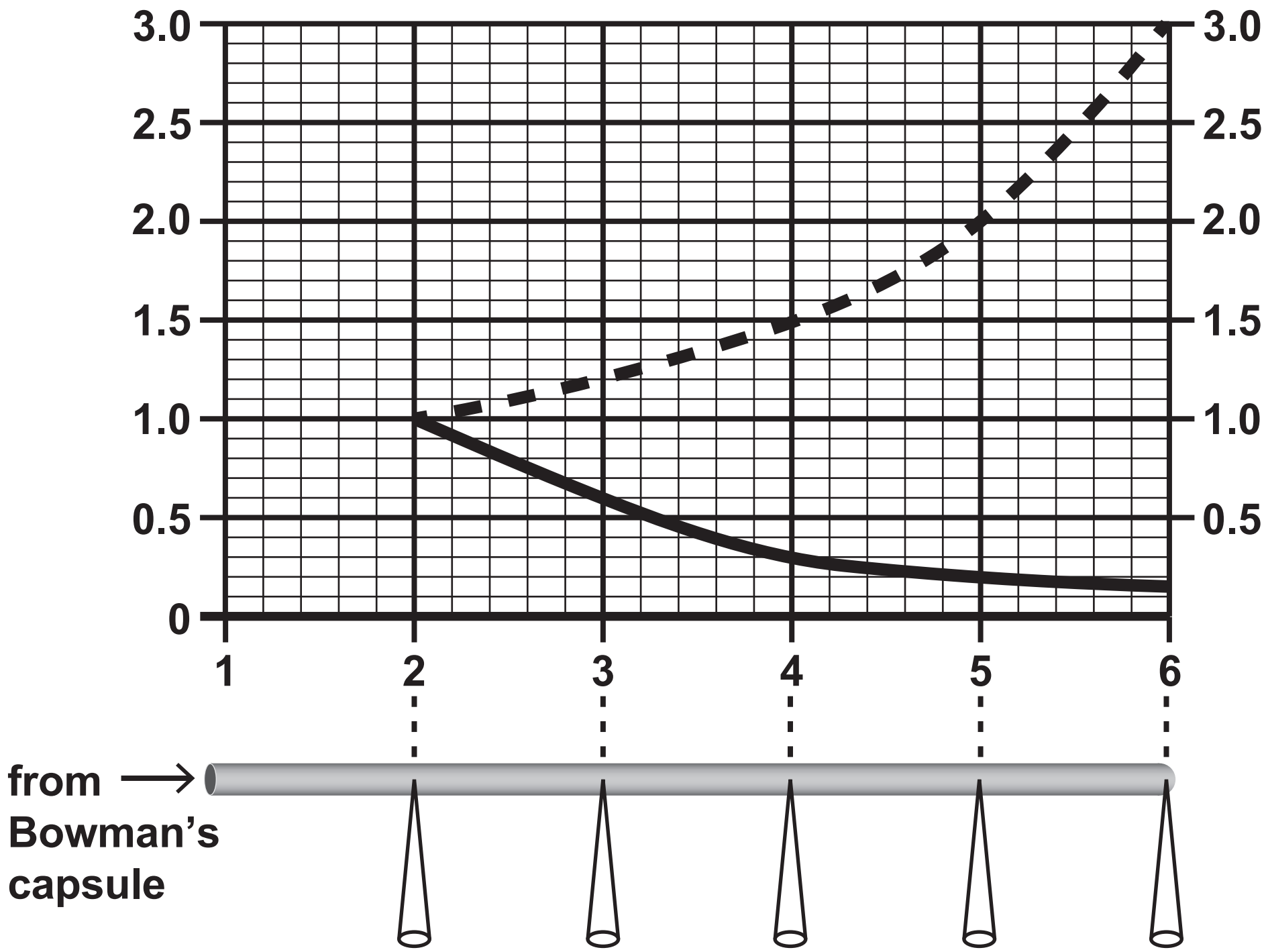


Question 5 (b)

GRAPH 5.2

Key: - - - = urea

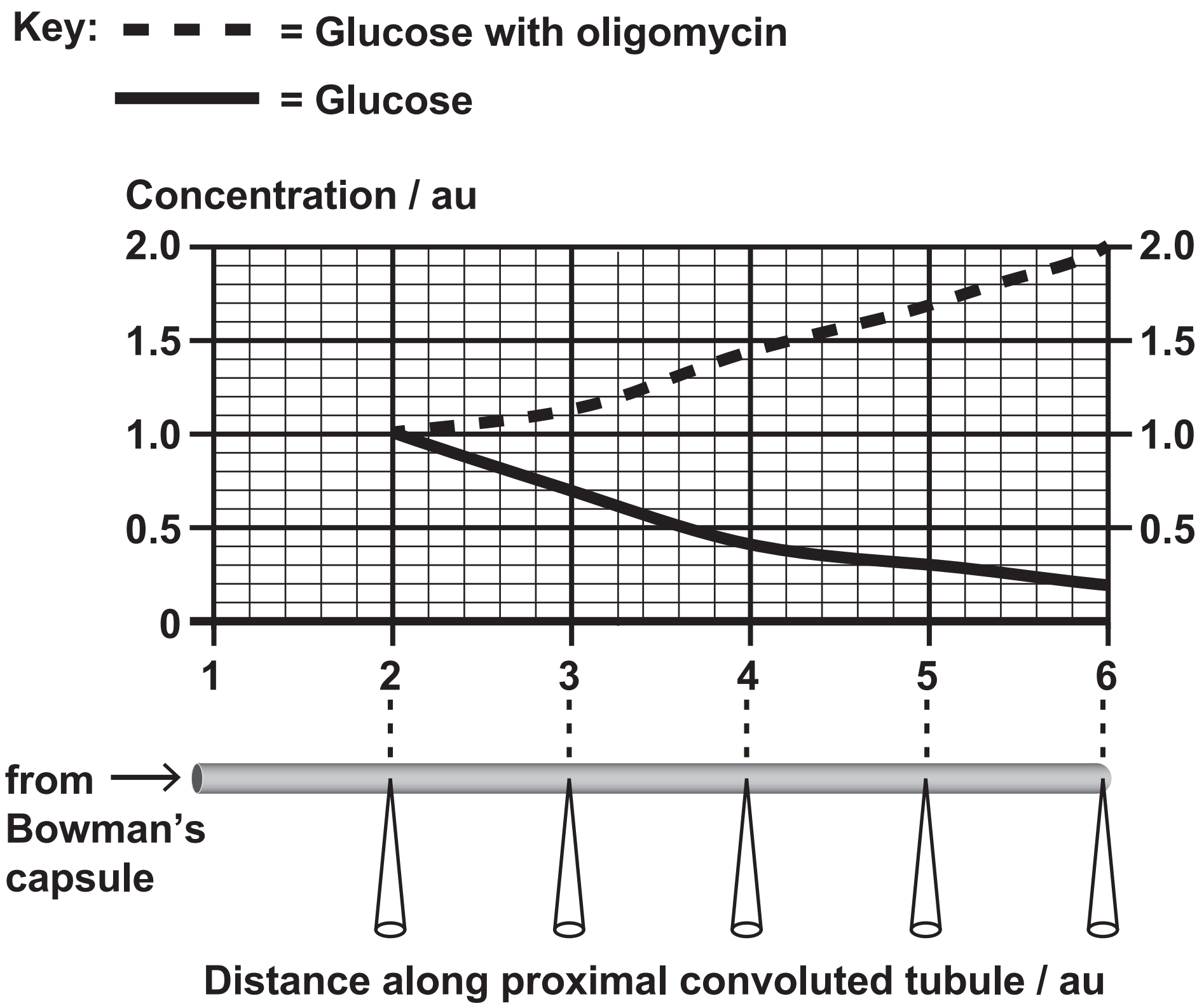
——— = chloride



Distance along proximal convoluted tubule / au

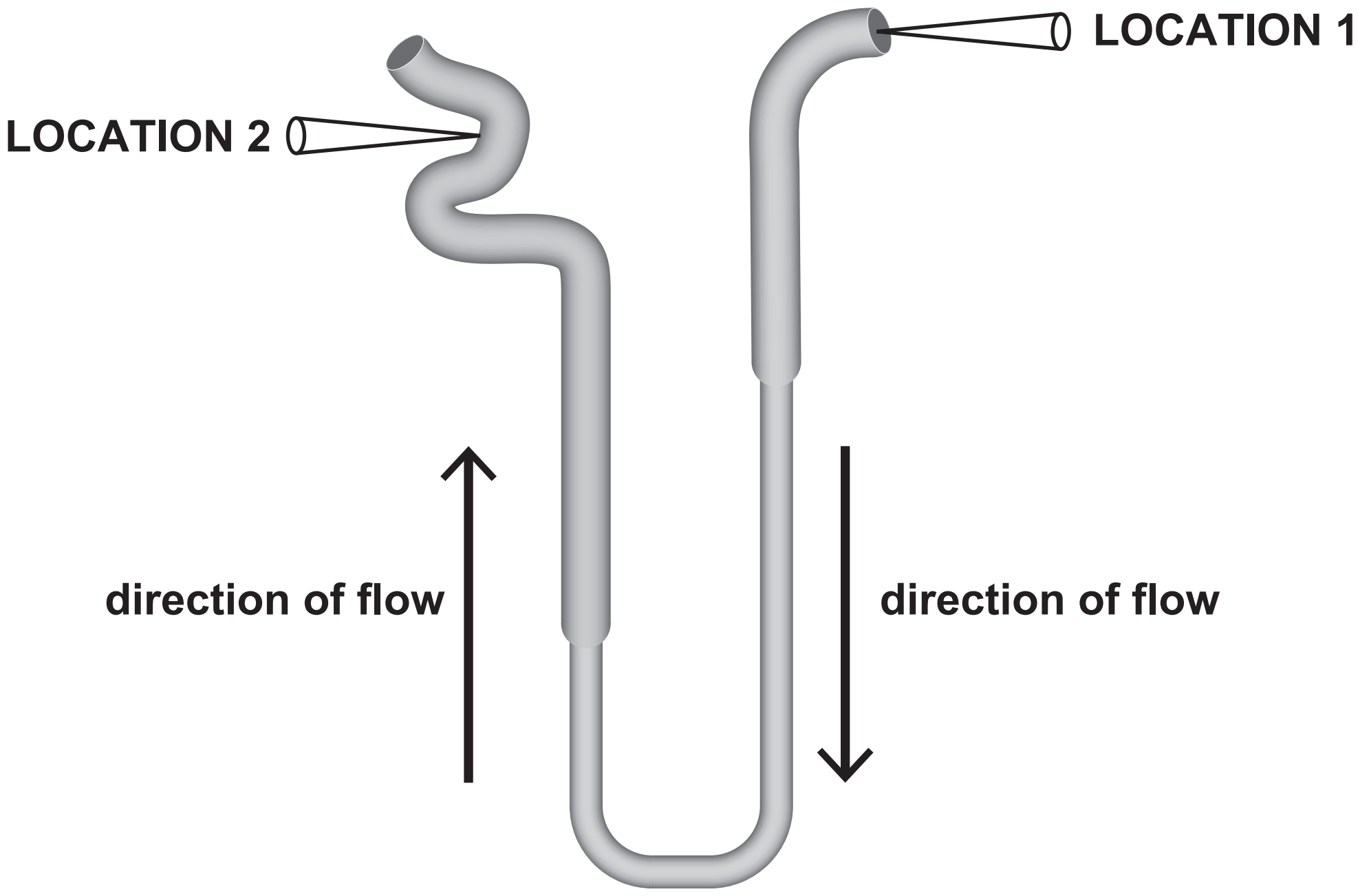
Question 5 (b) (ii)

GRAPH 5.3



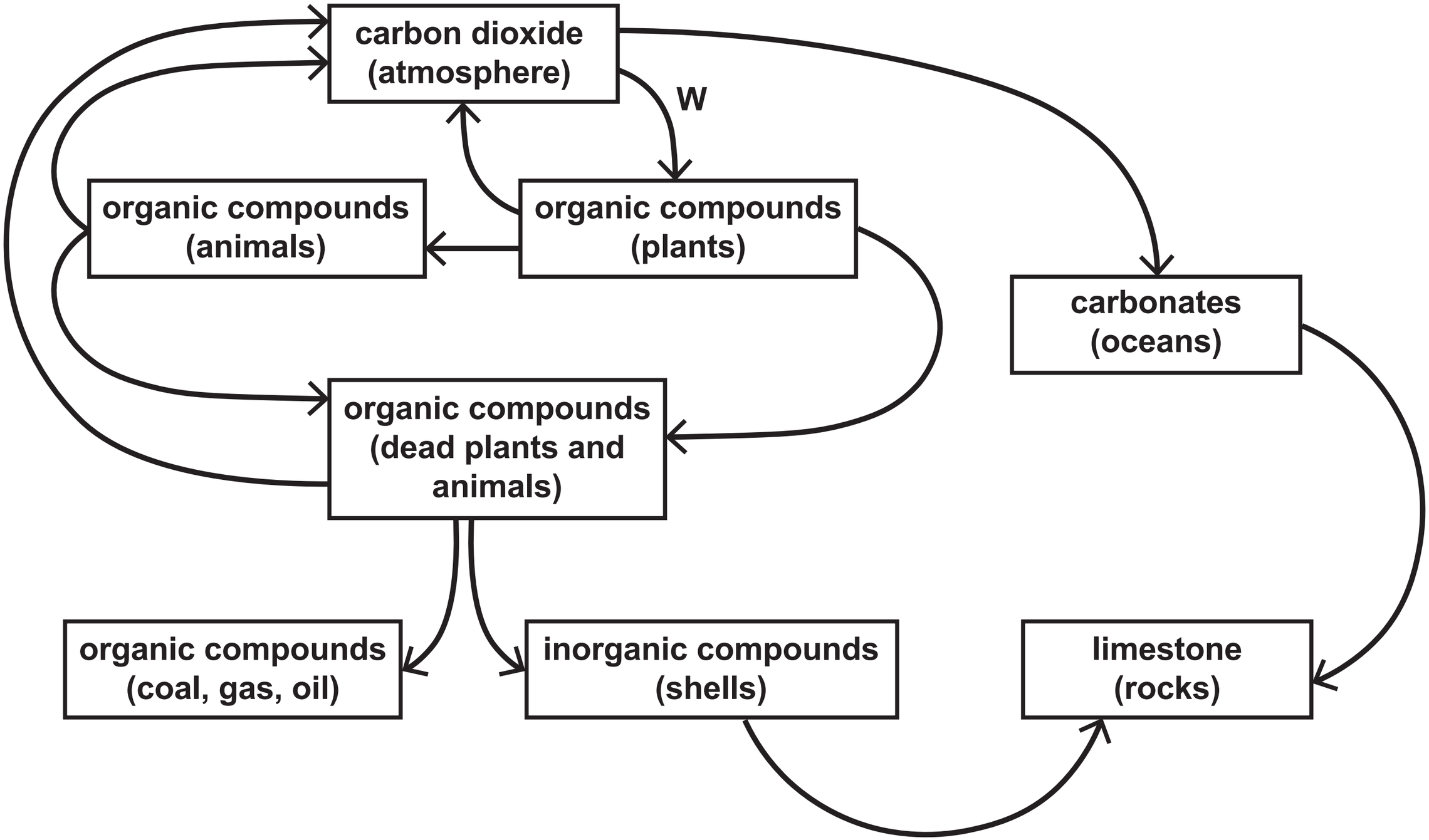
Question 5 (c)

IMAGE 5.4



Question 6

IMAGE 6.1



Question 6 (b)

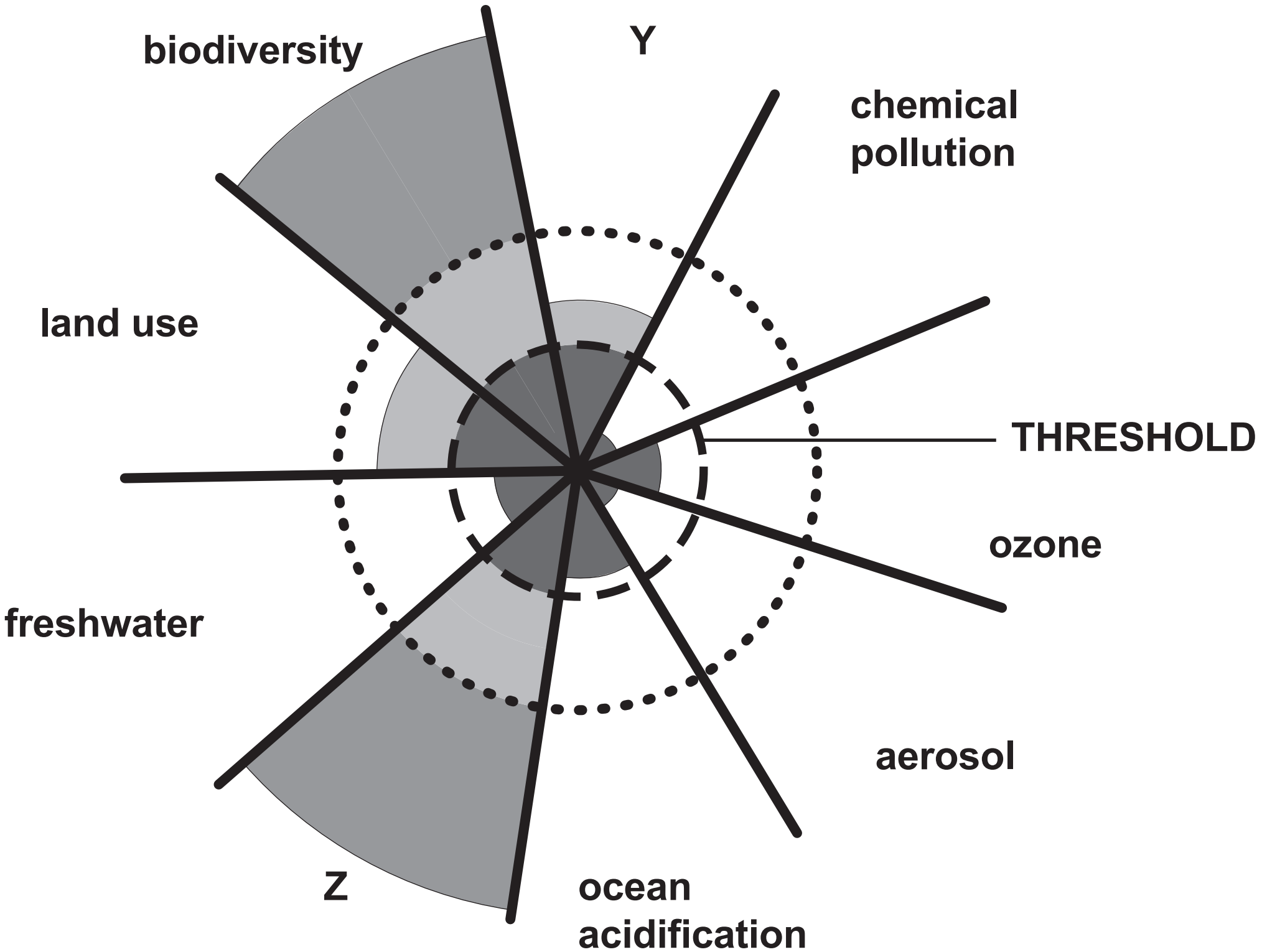
TABLE 6.2

Planetary Boundaries

Planetary system	Parameters	Threshold values	Current value
Climate change	Atmospheric carbon dioxide concentration (ppm by volume)	350	387
Nitrogen	How much nitrogen is removed from the atmosphere for human use (tonnes $\times 10^6$ / year)	35	121

Question 6 (b)

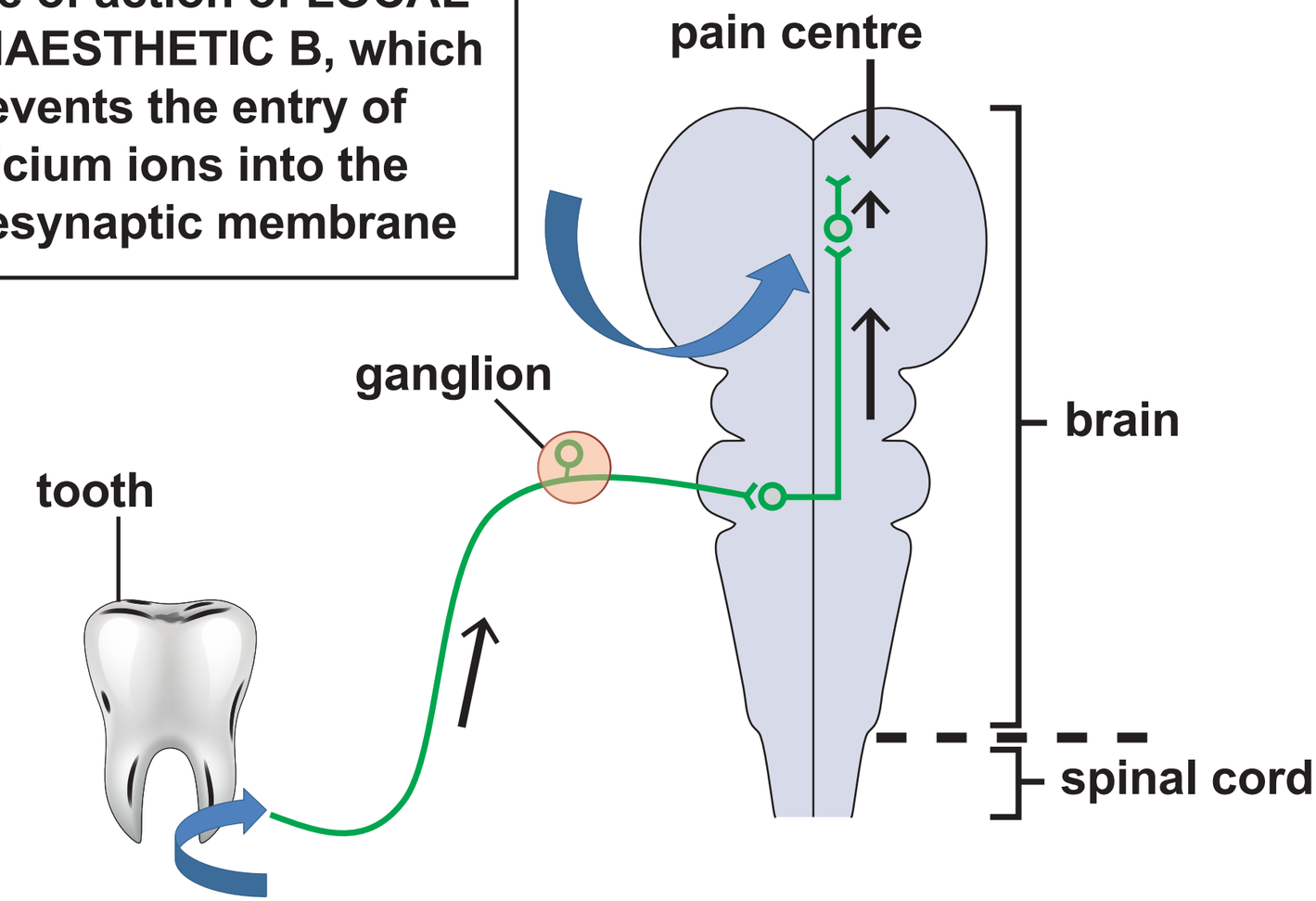
IMAGE 6.3



Question 7

IMAGE 7.1

Site of action of LOCAL ANAESTHETIC B, which prevents the entry of calcium ions into the presynaptic membrane



Site of action of LOCAL ANAESTHETIC A, which prevents the passage of sodium ions into neurons

Question 7

IMAGE 7.2