



GCE A LEVEL



A400U10-1

THURSDAY, 9 JUNE 2022 – AFTERNOON

BIOLOGY – A LEVEL COMPONENT 1

ENERGY FOR LIFE

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.	13	
2.	12	
3.	18	
4.	11	
5.	17	
6.	20	
7.	9	
Total	100	

(Turn over)

ADDITIONAL MATERIALS

In addition to this examination paper, you will need 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. A flask of sterile culture medium was inoculated with a small number of bacterial cells. The number of bacteria per cm^3 of culture medium was monitored at regular intervals using a total count and a viable count.**

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

IMAGE 1.1 shows the results plotted on a graph.

- (a) (i) Look at the table for Question 1 (a) (i) in the separate Diagram Booklet. COMPLETE THE TABLE to name stages A, B and C of the population growth curve shown in IMAGE 1.1 and explain the shape of the growth curve in each stage.**

[3 marks]

continued on the next page . . .

(Turn over)

Question 1 (a) continued

- 1. (a) (ii) Explain the difference between the shape of the decline phase obtained using a total count and a viable count.**

[1 mark]

continued on the next page . . .

(Turn over)

Question 1 (a) continued

- 1. (a) (iii) One method of estimating the number of bacteria is to dilute a sample of the bacterial culture, plate out known volumes onto agar plates and count the number of colonies following incubation. Explain why you could not use this method to collect ALL the data shown in IMAGE 1.1.**

[1 mark]

continued on the next page . . .

(Turn over)

Question 1 continued

- 1. (b) Bacterial cells divide at a constant rate when conditions are optimum.**

The generation time for bacteria is defined as the time for a bacterial population to double in number.

Generation times of different species of bacteria vary from approximately 12 minutes to 30 hours.

- (i) State TWO environmental conditions that could affect the rate of bacterial cell division.**

[1 mark]

continued on the next page . . .

(Turn over)

Question 1 (b) continued

1. (b) (ii) For a culture in which cells divide every **20** minutes, calculate how many cells will be produced after eight hours from a single bacterium.
EXPRESS YOUR ANSWER IN THE FORM 2^n WHERE n = THE NUMBER OF GENERATIONS.

Space for working:

Number of bacteria after eight hours

= _____

[2 marks]

continued on the next page . . .

(Turn over)

Question 1 continued

1. (c) A different method of assessing the growth of bacterial populations is to determine the number of generations of bacteria produced in a given time period.

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

Image 1.2 is a graph.

IMAGE 1.2 shows the number of bacteria per cm^3 present in a culture over a seven hour period.

continued on the next page . . .

Question 1 (c) continued

1. (c) (i) Look at the formula for
Question 1 (c) (i) in the separate
Diagram Booklet.

Use the graph in IMAGE 1.2 and the
formula given to calculate the number
of generations produced per hour
between **2.5** hours and **6** hours.
**EXPRESS YOUR ANSWER TO ONE
DECIMAL PLACE.**

Space for working:

Number of generations per hour

= _____

[3 marks]

continued on the next page . . .

(Turn over)

Question 1 (c) continued

- 1. (c) (ii) Under optimum conditions this species of bacteria should have a generation time of 30 minutes. Using your calculated figure for the number of generations per hour, conclude whether the bacteria in this culture were grown under optimum conditions during this time period. Explain your answer.**

[2 marks]

(Total for Question 1 = 13 marks)

(Turn over)

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

Both ATP and NAD (nicotinamide adenine
dinucleotide) have roles in respiration.

The biochemical structures of ATP and NAD are
shown in IMAGE 2.1.

- (a) (i) Name the THREE biochemical
components found in both
ATP and NAD.

[2 marks]

continued on the next page . . .

(Turn over)

Question 2 (a) continued

2. (a) (ii) State how **ONE** biochemical component of a nucleotide found in **DNA** would differ from **BOTH** of the molecules shown in **IMAGE 2.1**.

[1 mark]

continued on the next page . . .

(Turn over)

Question 2 (a) continued

2. (a) (iii) ATP acts as a common energy source for reactions in the cells of all living organisms. Most ATP in eukaryotic cells is synthesised in the mitochondria. Describe the role of NAD in the synthesis of ATP.

[illegible]

[4 marks]

(Turn over)

Question 2 continued

- 2. (b) Look at IMAGE 2.2 for Question 2 (b) in the separate Diagram Booklet.**
- Some flowers are able to generate heat. The heat is used to evaporate chemicals. In flowers such as the titan arum, AMORPHOPHALLUS TITANUM, shown in IMAGE 2.2, the evaporated chemicals smell like rotting meat. These chemicals attract flies and other insects.**

continued on the next page . . .

Question 2 (b) continued

- 2. (b) (i) The inner membranes of mitochondria in some cells of the flowers are permeable to protons. Using your knowledge of respiration in mitochondria, explain how this enables the flower to generate heat.**

[3 marks]

(Turn over)

Question 2 (b) continued

- 2. (b) (ii) Explain why the generation of heat helps to increase genetic diversity in this species.**

[2 marks]

(Total for Question 2 = 12 marks)

(Turn over)

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

In terrestrial ecosystems the Sun is the ultimate source of energy. The flow of energy through one ecosystem is shown in IMAGE 3.1 where R = respiration. The figures are given in $\text{kJ m}^{-2} \text{ year}^{-1}$.

- (a) The productivity of the producers can be represented as:

$$\text{GPP} = \text{NPP} + R$$

- (i) State what is represented by the following abbreviations:

GPP _____

NPP _____

[1 mark]

continued on the next page . . .

(Turn over)

Question 3 (a) continued

3. (a) (ii) Using figures from IMAGE 3.1,
calculate the following:
- I. The **GPP** of the producers.

Space for working:

GPP = _____ **$\text{kJ m}^{-2} \text{ year}^{-1}$**

[1 mark]

continued on the next page . . .

(Turn over)

Question 3 (a) (ii) continued

3. (a) (ii) II. The **NPP** of the producers.

Space for working:

NPP = _____ $\text{kJ m}^{-2} \text{ year}^{-1}$

[1 mark]

continued on the next page . . .

(Turn over)

Question 3 continued

3. (b) The energy transferred from plants and animals to the decomposers is represented in IMAGE 3.1 by X and Y respectively. For plants, the energy transferred at X is in the form of dead tissue.

(i) Apart from dead tissue, name TWO other processes carried out by herbivores and carnivores that would also transfer energy to decomposers at Y.

I. _____

II. _____

[2 marks]

continued on the next page . . .

(Turn over)

Question 3 (b) continued

3. (b) (ii) Using figures from IMAGE 3.1, calculate the secondary productivity of the herbivores and use this to calculate **R** for this trophic level.

Space for working:

Secondary productivity

= _____ $\text{kJ m}^{-2} \text{ year}^{-1}$

R = _____ $\text{kJ m}^{-2} \text{ year}^{-1}$

[2 marks]

continued on the next page . . .

(Turn over)

Question 3 (b) continued

- 3. (b) (iii) State TWO types of organisms which act as decomposers.**

[1 mark]

- (iv) In the UK, most plants die or shed their leaves in the Autumn. Using your knowledge of the nitrogen cycle, explain why you would expect the nitrogen content of soil to INCREASE DURING THE WINTER but then DECREASE DURING THE SPRING AND SUMMER MONTHS.**

(Turn over)

[4 marks]

continued on the next page . . .

(Turn over)

Question 3 continued

- 3. (c) Net Ecosystem Productivity (NEP)**
is defined as the rate of accumulation
of organic matter in an ecosystem.
It can be calculated as:

$$\text{NEP} = \text{NPP} - R_{\text{heterotrophs}}$$

Look at IMAGE 3.2 for Question 3 (c)
in the separate Diagram Booklet.
IMAGE 3.2 summarises the relationship
between NPP and the rate of respiration
by heterotrophs during the development of
a forest ecosystem.

continued on the next page . . .

Question 3 (c) continued

- 3. (c) (i) A forest is often the final stage in the development of an ecosystem which can then exist for hundreds of years. State the term used to describe the last stage in the development of an ecosystem.**
-

[1 mark]

- (ii) With reference to the terms **GPP** and **R**, explain why the productivity of an ecosystem can be expressed in terms of absorption of carbon dioxide or by the release of carbon dioxide.**
-
-
-
-
-

[2 marks]

(Turn over)

Question 3 (c) continued

- 3. (c) (iii) With reference to the information provided and your knowledge of succession, conclude why Net Ecosystem Productivity eventually approaches zero.**

[3 marks]

(Total for Question 3 = 18 marks)

(Turn over)

4. **Respiration is a catabolic process during which glucose, lipids and proteins can be broken down to release energy. Some of the energy is transferred to chemical energy in the form of ATP.**
- (a) **Theoretically, the energy released from one molecule of glucose by aerobic respiration is sufficient to produce 38 molecules of ATP. The removal of the terminal phosphate group from one ATP molecule by hydrolysis releases 30.6 kJ mol^{-1} . When glucose reacts directly with oxygen $2870.0 \text{ kJ mol}^{-1}$ are released.**

continued on the next page . . .

Question 4 (a) continued

4. (a) (i) Calculate the efficiency of aerobic respiration of glucose. GIVE YOUR ANSWER TO A SUITABLE NUMBER OF DECIMAL PLACES.

Space for working:

Efficiency of aerobic respiration

= _____ %

[2 marks]

continued on the next page . . .

(Turn over)

Question 4 (a) continued

- 4. (a) (ii) State what happens to the energy which is not used to generate ATP.**

[1 mark]

- (iii) Look at TABLE 4.1 for Question 4 (a) (iii) in the separate Diagram Booklet.**

TABLE 4.1 compares figures from the respiration of carbohydrate and lipid.

With reference to the figures in TABLE 4.1:

- I. Explain why the food store in many plant seeds is in the form of a lipid rather than carbohydrate.**

(Turn over)

[2 marks]

4. (a) (iii) II. Suggest why animals living in very dry habitats use lipids to supply their energy rather than carbohydrates.

[1 mark]

continued on the next page . . .

(Turn over)

Question 4 continued

- 4. (b) Look at IMAGE 4.2 for Question 4 (b) in the separate Diagram Booklet.**

IMAGE 4.2 shows a summary of the stages involved in the aerobic respiration of glucose.

- (i) Lipids are digested into glycerol, a three carbon compound, and fatty acids. The fatty acids are then broken down further in the liver into two carbon fragments.**

Using numbers from IMAGE 4.2 indicate where the products of fat digestion could enter the respiratory pathway.

Glycerol _____

Fatty acids _____

[2 marks]

continued on the next page . . .

(Turn over)

Question 4 (b) continued

- 4. (b) (ii) Before proteins can enter the respiratory pathway they must be hydrolysed. Describe how proteins are hydrolysed and suggest which stage of respiration the products of protein hydrolysis are MOST LIKELY to enter.**

[3 marks]

(Total for Question 4 = 11 marks)

(Turn over)

5. Look at IMAGE 5.1 and IMAGE 5.2 for Question 5 in the separate Diagram Booklet.

Yellow rattle, *Rhinanthus minor*, is a plant which is a parasite of grass. It absorbs its nutrients from grass roots.

IMAGE 5.1 shows the flowers of yellow rattle growing in grassland and

IMAGE 5.2 shows a transverse section through a grass root parasitized by yellow rattle.

- (a) (i) USING THE SCALE BAR, calculate the magnification of IMAGE 5.2.

Space for calculation:

Magnification = $\times$ _____

[2 marks]

continued on the next page . . .

(Turn over)

Question 5 (a) continued

5. (a) (ii) Studies have shown that the parasite sucker penetrates the host phloem sieve tubes and host xylem vessels.

I. State the name of the hypothesis that provides an explanation of how sucrose could move from host to parasite tissue.

[1 mark]

continued on the next page . . .

(Turn over)

Question 5 (a) (ii) continued

- 5. (a) (ii) II. Water and minerals move from the host tissues to the parasite vessels through the apoplast and symplast pathways. Explain what is meant by these terms.**

Apoplast pathway

Symplast pathway

[2 marks]

continued on the next page . . .

(Turn over)

Question 5 continued

- 5. (b) Grasslands contain a wide variety of flowering plants which produce flowers at different times of the year.**

The biodiversity of these grasslands decreases when they are invaded by species of fast – growing grass.

Using the information provided, suggest why the introduction of yellow rattle to these grasslands might restore biodiversity.

[3 marks]

continued on the next page . . .

(Turn over)

Question 5 continued

- 5. (c) To investigate whether the introduction of yellow rattle into grassland might restore biodiversity, grassland containing a single species of fast – growing grass was divided into two equal areas, area **A** and area **B****

Area **A was seeded using a mixture of flowering plants and yellow rattle seeds**

Area **B was seeded using the same mixture of flowering plants but with no yellow rattle seeds.**

The abundance and distribution of plant species in areas **A and **B** were determined before seeding and one year after seeding.**

continued on the next page . . .

Question 5 (c) continued

Explain why the following steps were taken when collecting data on the abundance and distribution of plant species in both areas:

- 5. (c) (i) Each area was divided into a grid AND a random number generator used.**

[2 marks]

- (ii) Area B was not seeded with yellow – rattle seeds.**

(Turn over)

[2 marks]

5. (c) (iii) The experiment was conducted
SEVERAL TIMES on grassland
with the same species of
fast – growing grass.

[2 marks]

continued on the next page . . .

(Turn over)

Question 5 continued

5. (d) The data collected from areas **A** and **B** were used to calculate a Simpson's biodiversity index.

TABLE 5.3 below shows the mean values of the Simpson's Diversity Index of areas **A** and **B** before and one year after seeding.

TABLE 5.3

	Value of Simpson's Diversity Index	
	Area A	Area B
Before seeding	0.45	0.46
One year after seeding	0.51	0.47

Based on these data only, it was concluded that seeding grassland with yellow rattle did result in an increase in biodiversity. However, it was decided that more data would be needed to improve confidence in this conclusion.

continued on the next page . . .

(Turn over)

Question 5 (d) continued

Look at the information for Question 5 (d) in the separate Diagram Booklet.

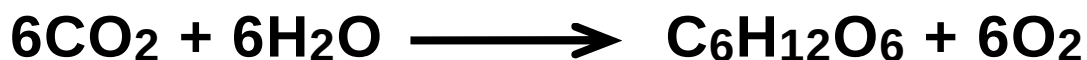
The following modifications to the method were suggested. Complete the table to explain how each change to the method can be justified.

[3 marks]

(Total for Question 5 = 17 marks)

(Turn over)

6. The traditional balanced equation for photosynthesis is given as:



It was once believed that all the oxygen released by photosynthesis came from the carbon dioxide molecules.

- (a) (i) With reference to the equation explain why this statement could be correct.

[2 marks]

continued on the next page . . .

(Turn over)

Question 6 continued

6. (a) (ii) Look at IMAGE 6.1 for Question 6 (a) (ii) in the separate Diagram Booklet. An experiment, shown in IMAGE 6.1, was carried out to confirm the origin of the oxygen molecules released in photosynthesis. In this experiment two suspensions of a photosynthetic unicellular alga, CHLORELLA, were treated as follows:

SUSPENSION A

- provided with water containing a non – radioactive isotope of oxygen (H_2O)
- and carbon dioxide containing a radioactive isotope of oxygen (C^{18}O_2)

SUSPENSION B

- provided with water containing a radioactive isotope of oxygen (H_2^{18}O)
- and carbon dioxide containing a non – radioactive isotope of oxygen (CO_2)

(Turn over)

Question 6 (a) (ii) continued

Using evidence from this experiment and your knowledge of photosynthesis, deduce the actual origin of the atoms in the oxygen molecules. Explain your answer.

[2 marks]

continued on the next page . . .

(Turn over)

Question 6 continued

- 6. (b) Look at IMAGE 6.2 for Question 6 (b) in the separate Diagram Booklet.**
- The light dependent stage of photosynthesis relies on the flow of electrons between different molecules as shown in IMAGE 6.2.**

- (i) State what is represented by the following letters in IMAGE 6.2.**

A _____

B _____

C _____

D _____

continued on the next page . . .

(Turn over)

E and F _____

[3 marks]

6. (b) (ii) State the type of reaction occurring at G. Explain your answer.

[2 marks]

continued on the next page . . .

(Turn over)

Question 6 (b) continued

- 6. (b) (iii) The events shown in IMAGE 6.2 take place in chloroplasts, which act as transducers. With reference to IMAGE 6.2, explain how chloroplasts act as transducers in photosynthesis.**

[1 mark]

continued on the next page . . .

(Turn over)

Question 6 (b) continued

- 6. (b) (iv) Look at IMAGE 6.3 for Question 6 (b) (iv) in the separate Diagram Booklet.**

Weeds are commonly controlled by using herbicides. Diuron is a herbicide which binds to a molecule preventing the flow of electrons, as shown by X in IMAGE 6.3.

Using information from IMAGE 6.3, and your knowledge of photosynthesis, suggest how the action of Diuron results in the death of weeds.

[4 marks]

continued on the next page . . .

(Turn over)

Question 6 continued

- 6. (c) DCPIP (2,6 – dichlorophenol – indophenol) is a blue dye which acts as an electron acceptor and becomes colourless when it accepts electrons.**

Look at IMAGE 6.4 for Question 6 (c) in the separate Diagram Booklet.

The flow diagram describes the method used by a student to isolate chloroplasts. IMAGE 6.4 shows a centrifuge tube containing the isolated chloroplasts.

- (i) State the role of the buffer in this experiment.**

[1 mark]

continued on the next page . . .

(Turn over)

Question 6 (c) continued

- 6. (c) (ii) The solution used in the experiment was isotonic to the stroma in the chloroplasts. State the meaning of the term isotonic.**

[1 mark]

continued on the next page . . .

(Turn over)

Question 6 (c) continued

- 6. (c) (iii) The student used the isolated chloroplasts to prove that electrons are released by chlorophyll during photosynthesis.**

Look at TABLE 6.5 for

Question 6 (c) (iii) in the separate Diagram Booklet.

TABLE 6.5 shows how four different experimental tubes were set up, whether they were exposed to light or not and the colour change observed.

Explain why each of the

EXPERIMENTAL TUBES 1 – 4

were included in this investigation and conclude whether the results prove that electrons are released by chlorophyll during photosynthesis or not. Explain your answer.

[4 marks]

(Total for Question 6 = 20 marks)

(Turn over)

7. It has been estimated that **10 million km²** of forest have been lost from the planet since the beginning of the **20th** century. One of the reasons for deforestation is to meet the demands for food for an increasing human population.

Explain how the conversion of forests to areas of intensive human food production using modern agricultural practices often leads to the death of fish and aquatic invertebrates. Describe the harmful impacts of deforestation on the environment and suggest how the conflicts of interest between food production and conservation can be resolved.

[9 marks QER]

(Total for Question 7 = 9 marks)

END OF PAPER

TOTAL 100 MARKS

(Turn over)

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

[illegible]



GCE A LEVEL



A400U10-1

THURSDAY, 9 JUNE 2022 – AFTERNOON

BIOLOGY – A LEVEL COMPONENT 1

ENERGY FOR LIFE

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

Diagram Booklet

Surname: _____

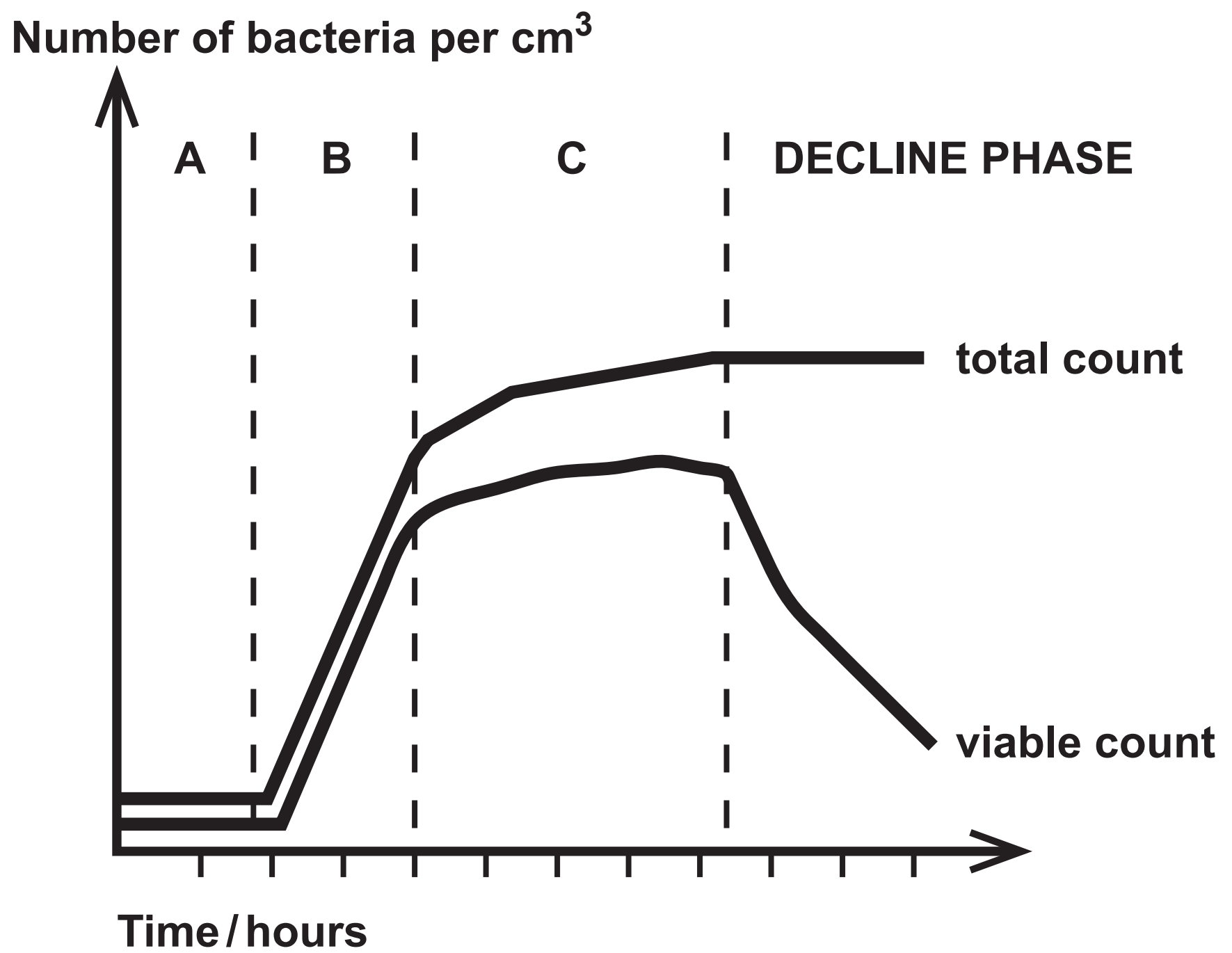
First name(s): _____

Centre Number: _____

Candidate Number: 2 _____

Question 1

IMAGE 1.1



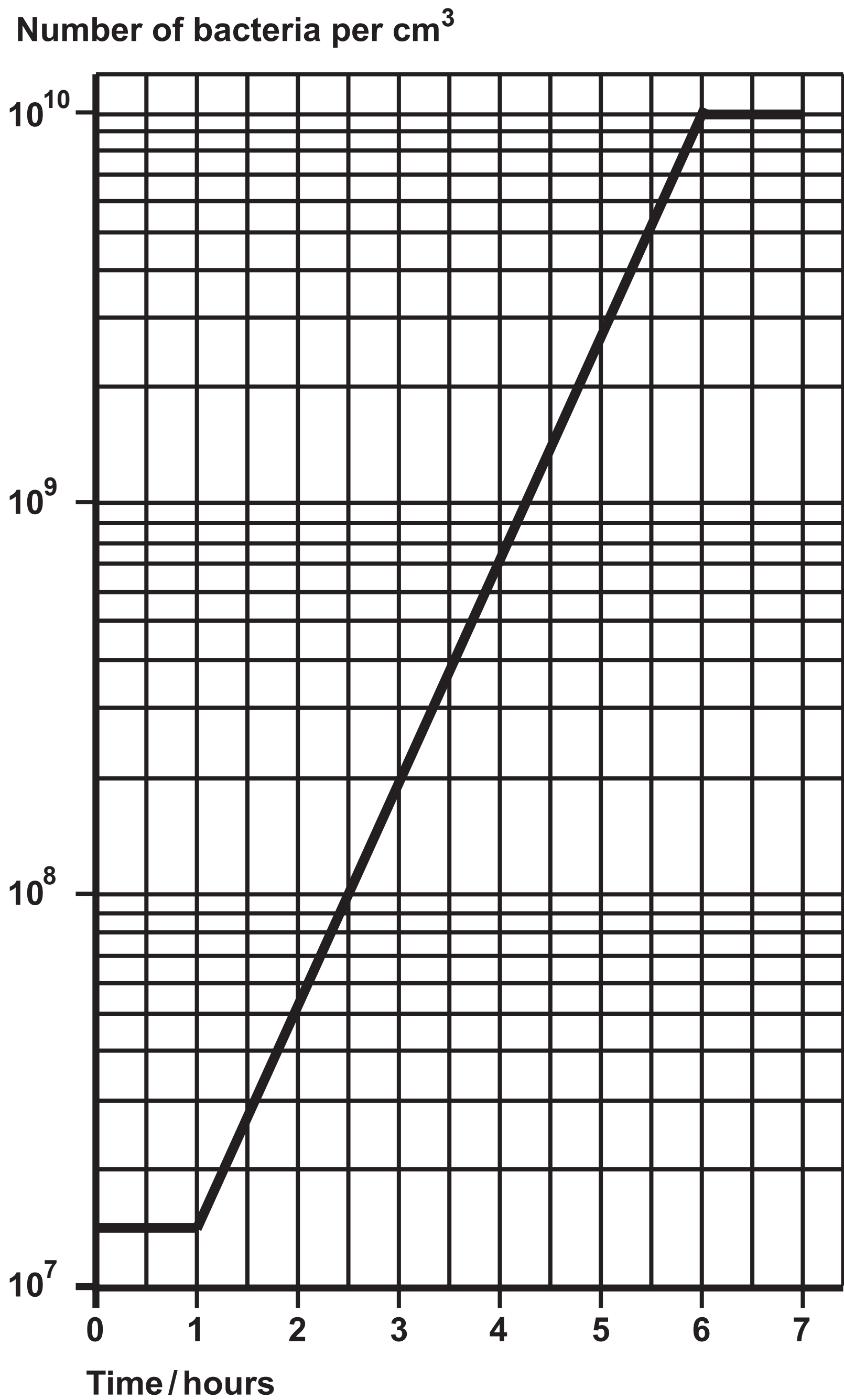
Question 1 (a) (i)

Table

STAGE	NAME OF STAGE	EXPLANATION OF THE SHAPE OF THE POPULATION GROWTH CURVE
A		
B		
C		

Question 1 (c)

IMAGE 1.2



Question 1 (c) (i)

Information

$$\text{Number of generations per hour} = \frac{\log_{10}[X_t] - \log_{10}[X_0]}{0.301 \times t}$$

Where:

X_t = number of bacteria per cm^3 at the end of the growth period

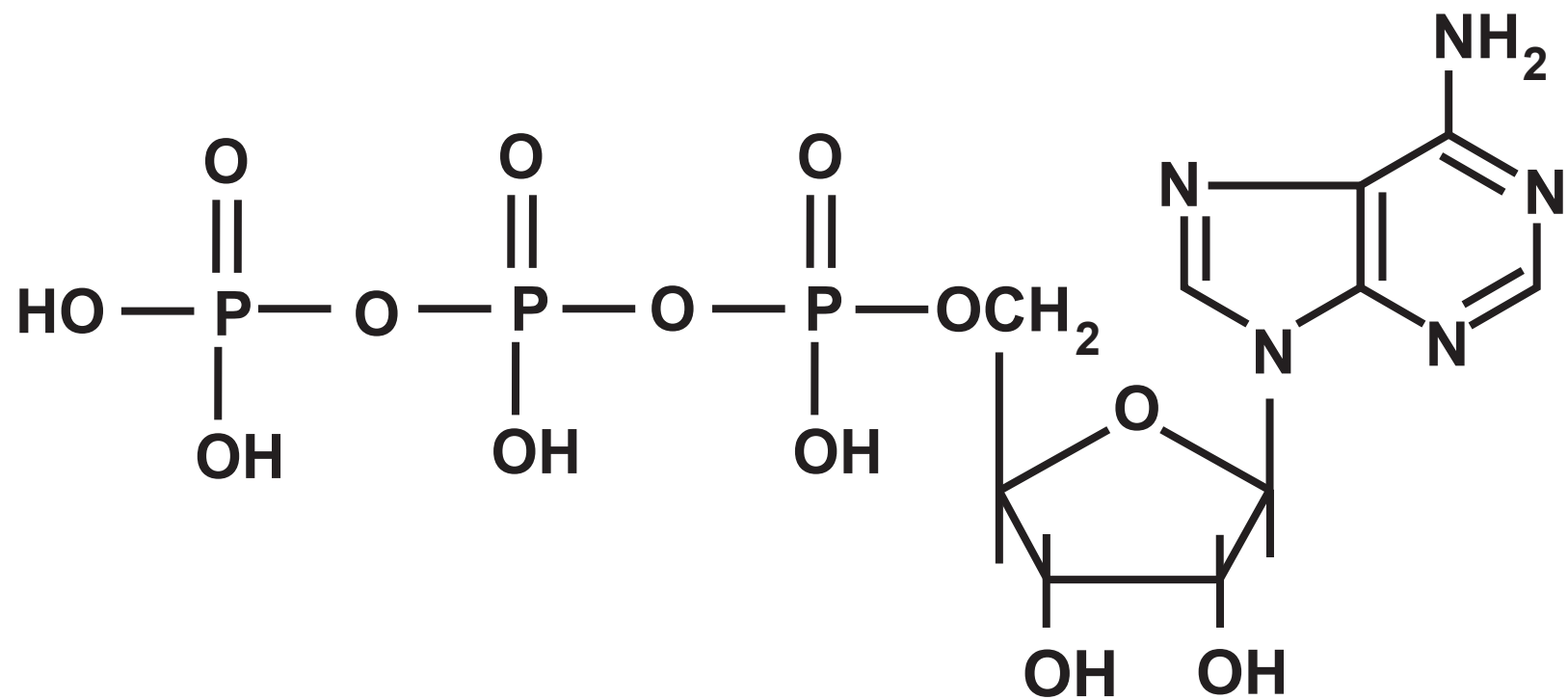
X_0 = number of bacteria per cm^3 at the start of the growth period

t = length of growth period in hours

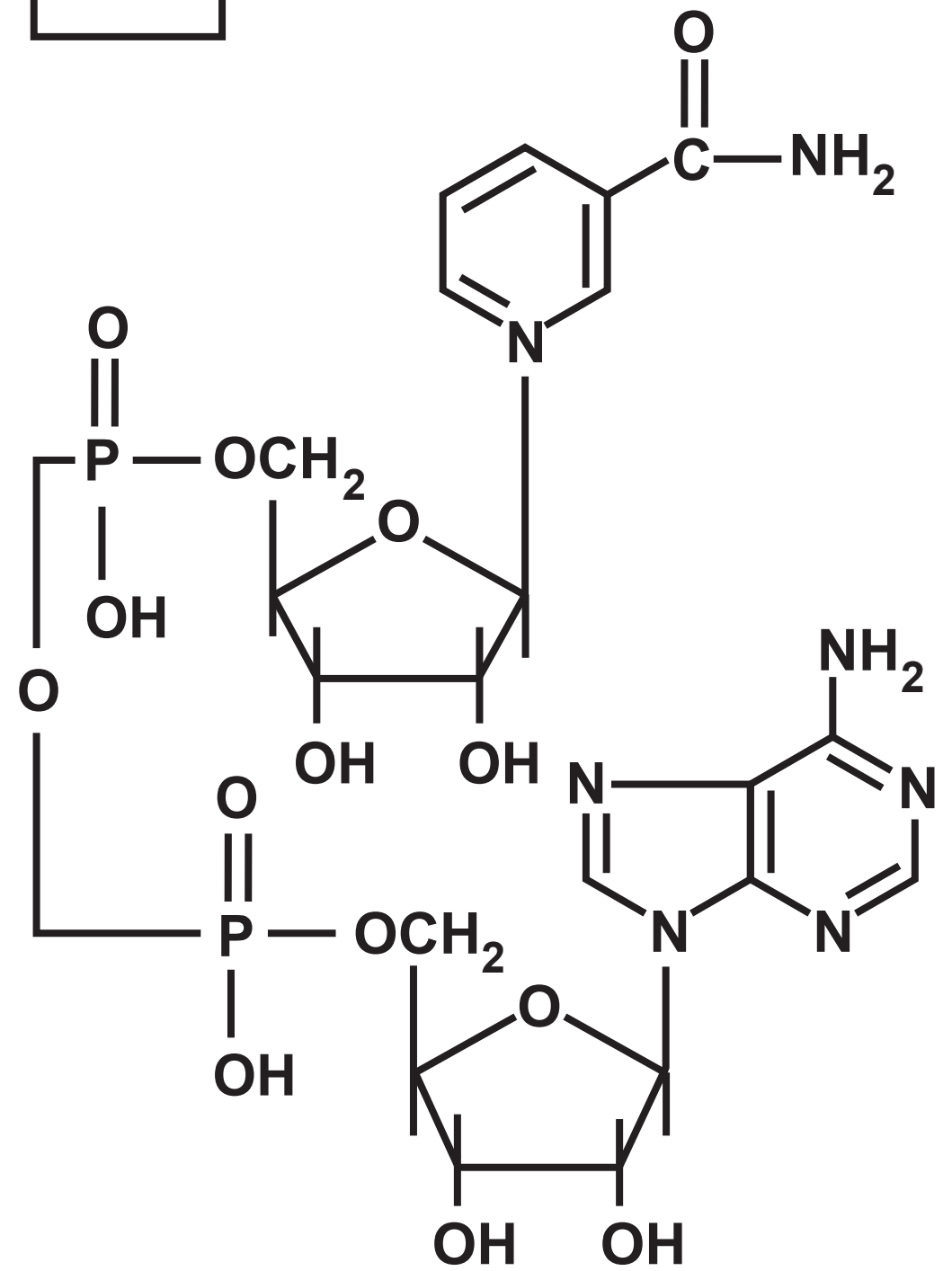
Question 2 (a)

IMAGE 2.1

ATP



NAD



Question 2 (b)

IMAGE 2.2

The titan arum [*AMORPHOPHALLUS TITANUM*]

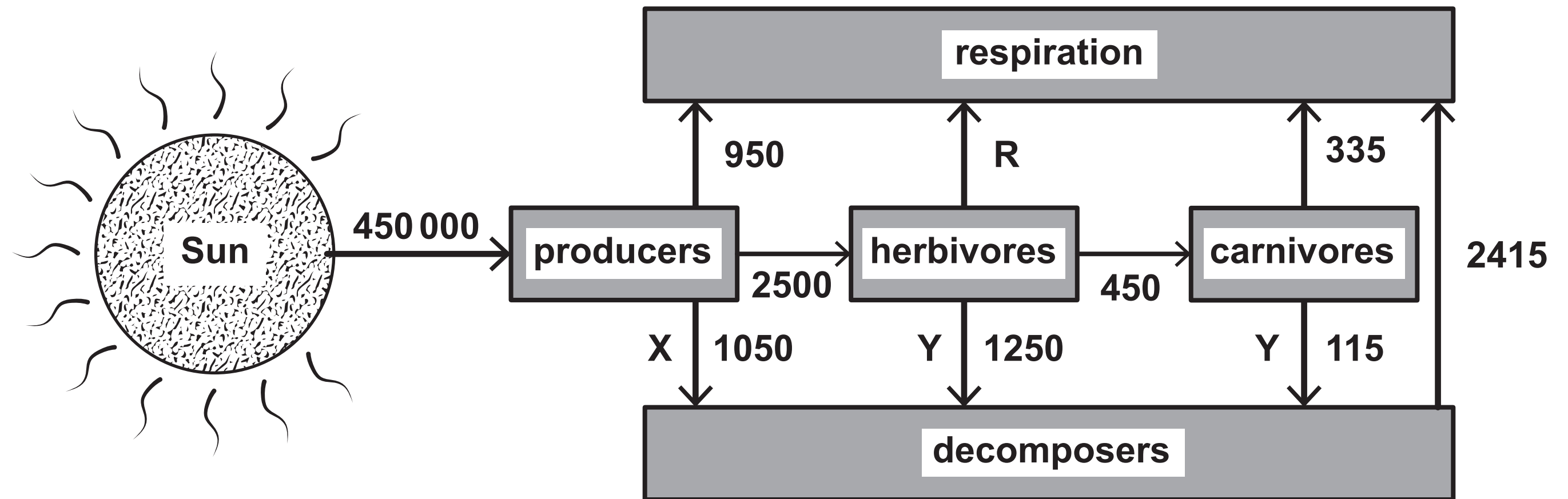


Question 3

IMAGE 3.1

R = respiration

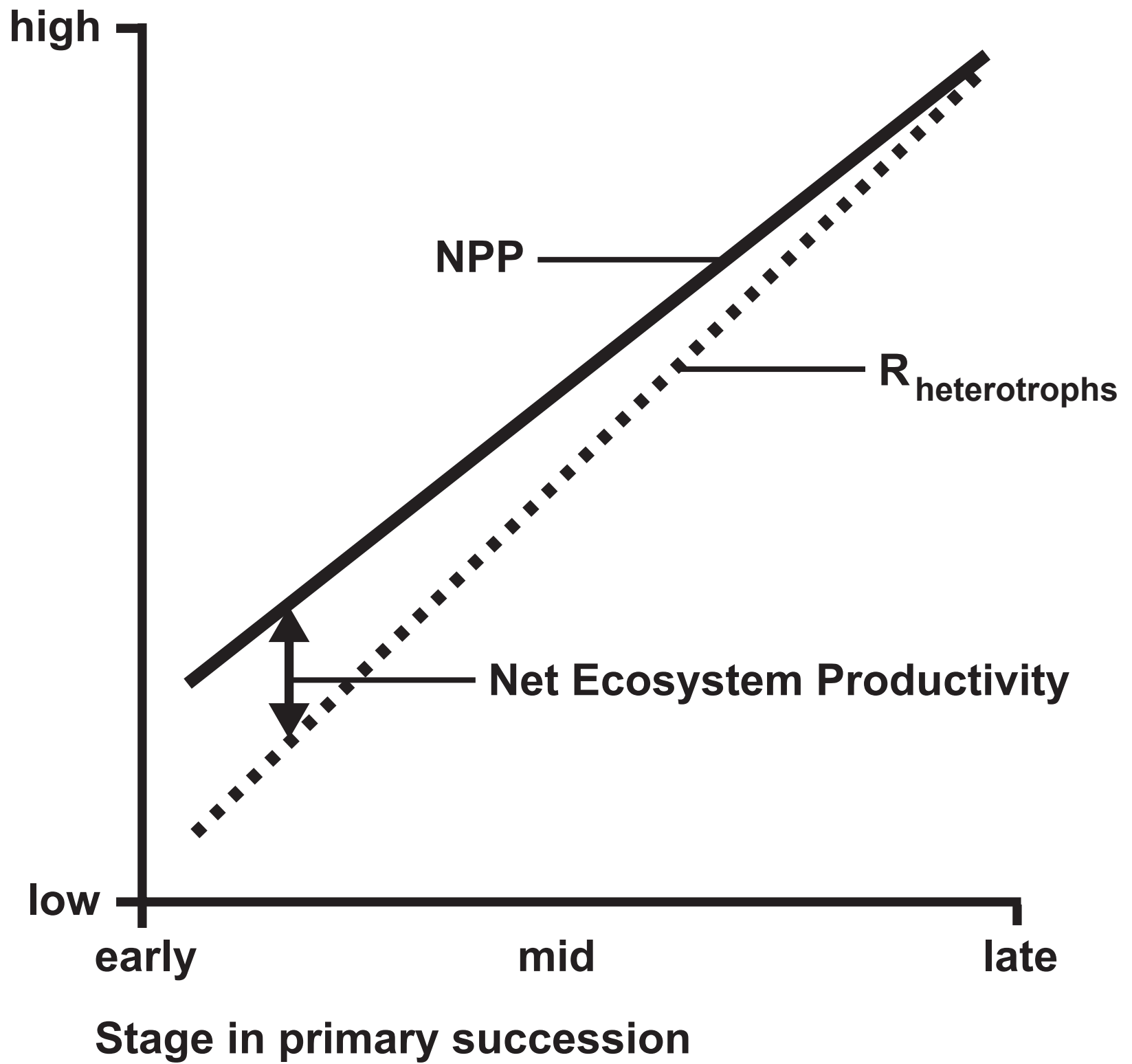
All figures are given in $\text{kJm}^{-2} \text{year}^{-1}$



Question 3 (c)

IMAGE 3.2

Mass of carbon absorbed or
released / g carbon $\text{kJm}^{-2} \text{ year}^{-1}$



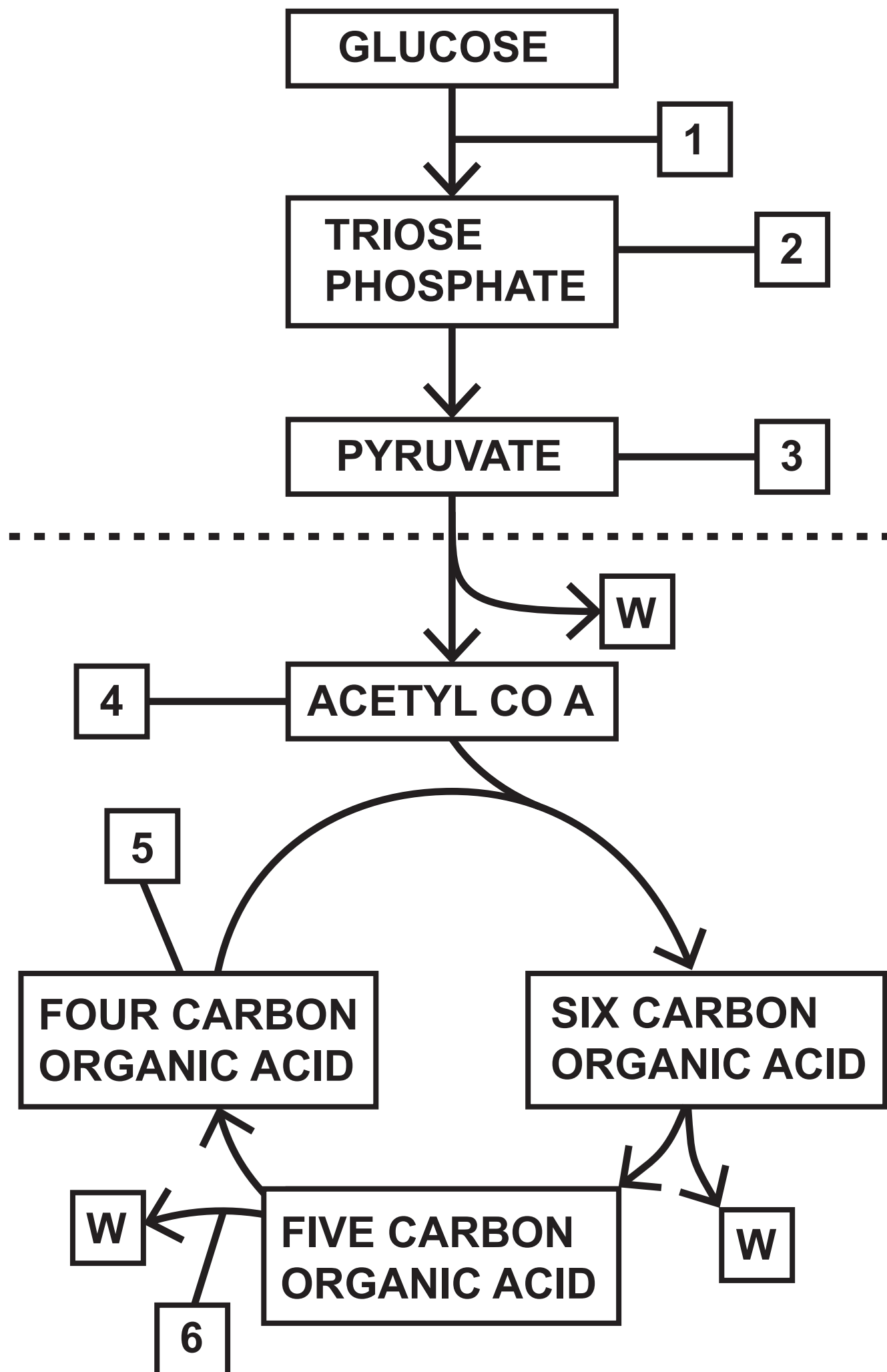
Question 4 (a) (iii)

TABLE 4.1

Energy source	Energy released / kJ g^{-1} food	Metabolic water produced / g g^{-1} food	Oxygen consumed / $\text{dm}^3 \text{g}^{-1}$ food
Carbohydrate	17.2	0.56	0.83
Lipid	38.9	1.07	2.02

Question 4 (b)

IMAGE 4.2



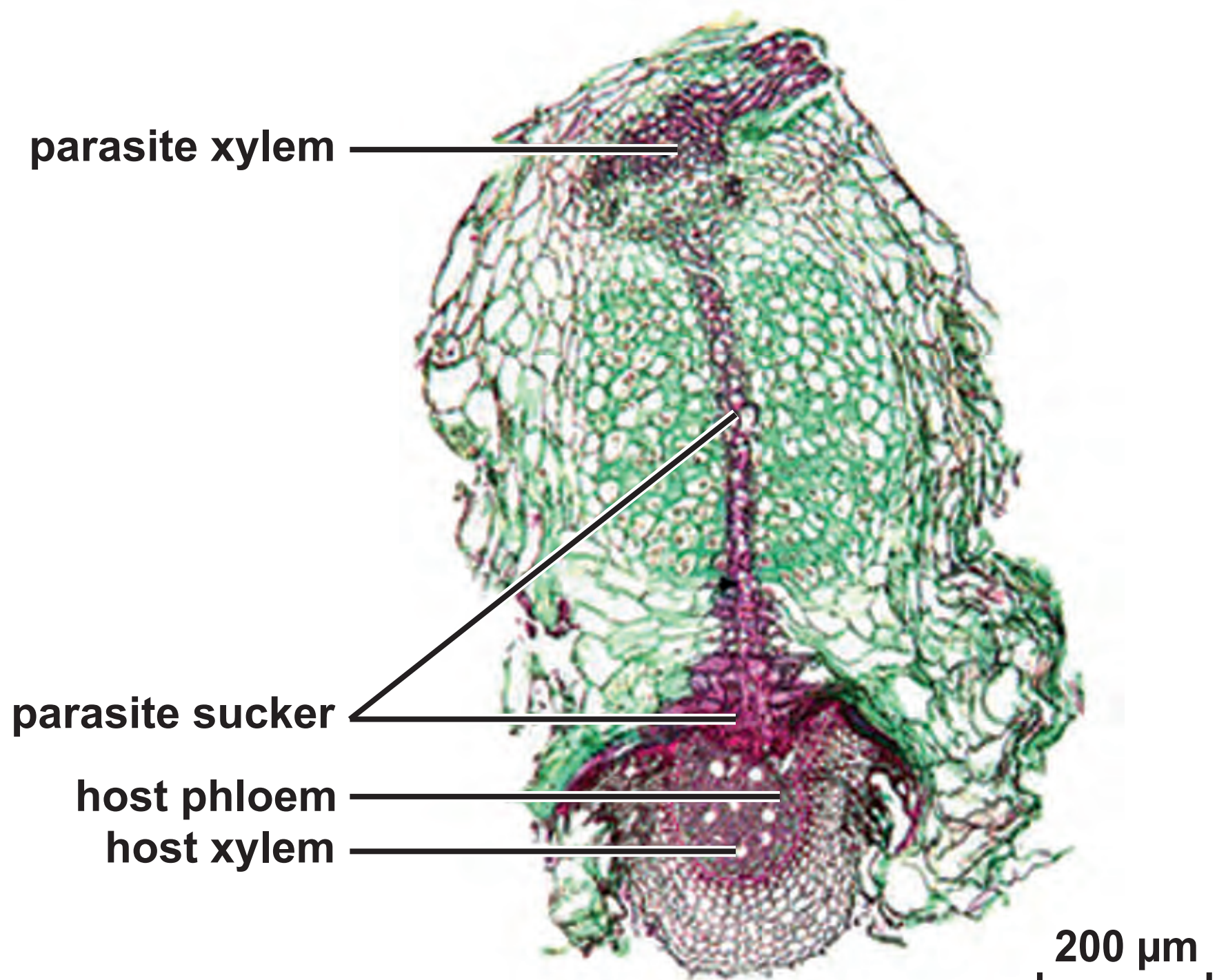
Question 5

IMAGE 5.1



Question 5

IMAGE 5.2



Question 5 (d)

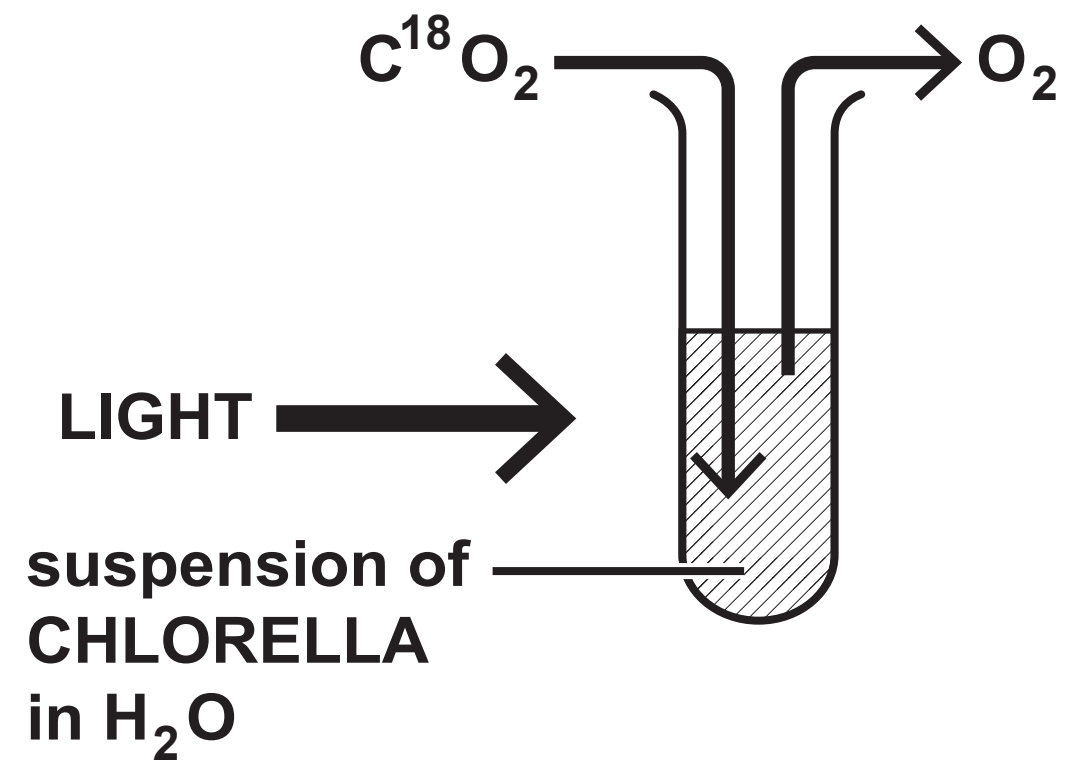
Information

Change	Justification
Calculate the biodiversity index again five years after seeding	
Calculate the biodiversity index a number of different times in the same year	
Carry out the investigation in different areas with different fast-growing grass species	

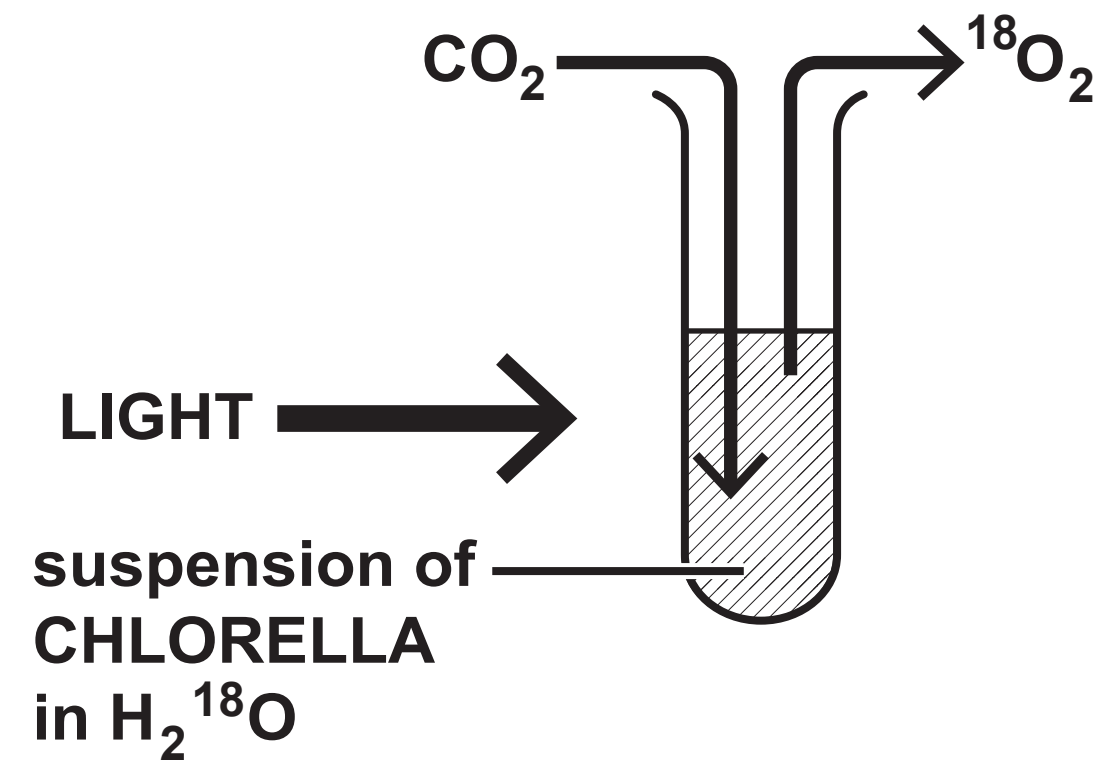
Question 6

IMAGE 6.1

SUSPENSION A



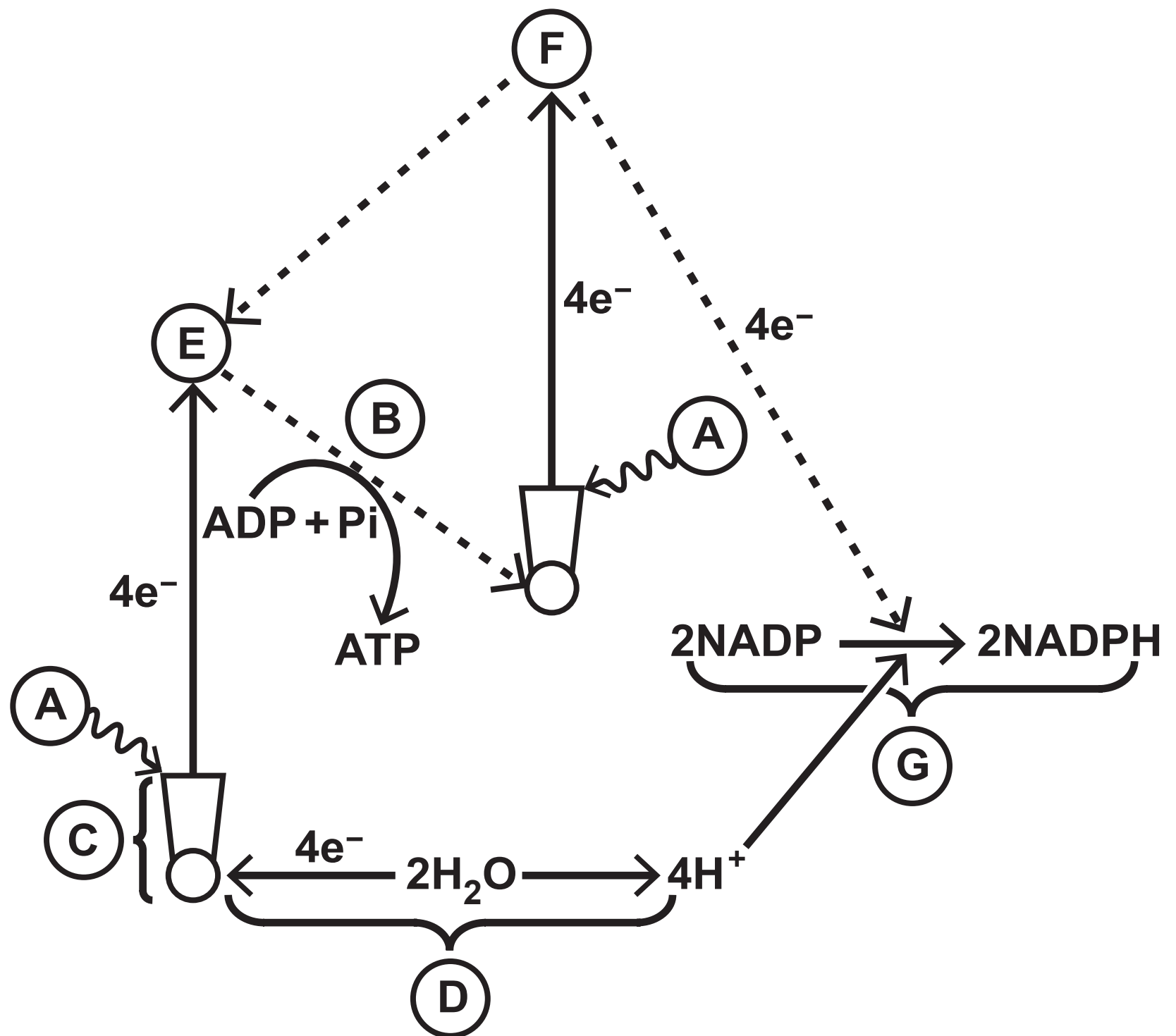
SUSPENSION B



Question 6 (b)

IMAGE 6.2

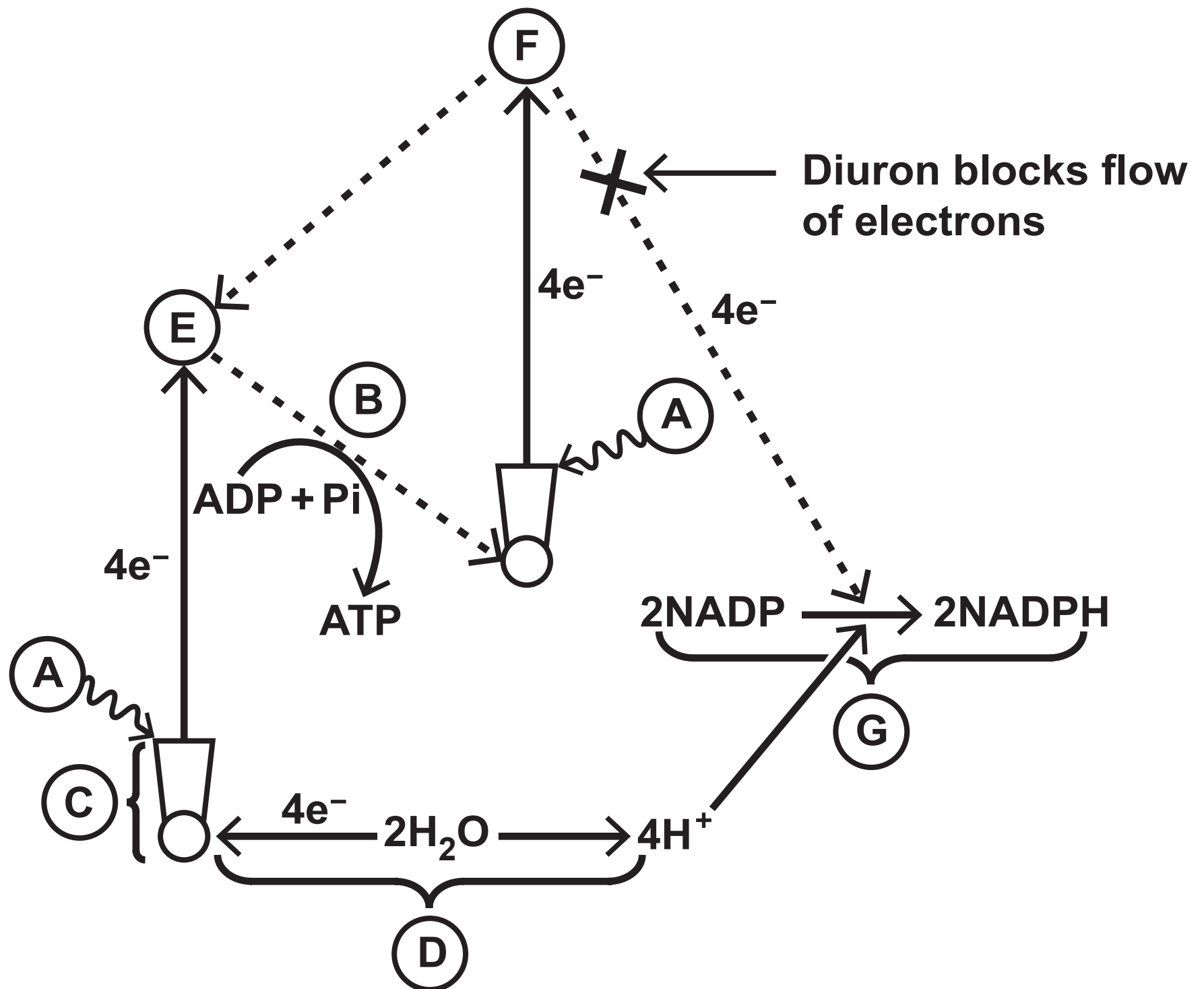
e^- = electron



Question 6 (b)

IMAGE 6.3

e^- = electron



Question 6 (c)

IMAGE 6.4

METHOD

Grind spinach leaves in an ice - cold solution of sucrose and buffer.



Filter extract.



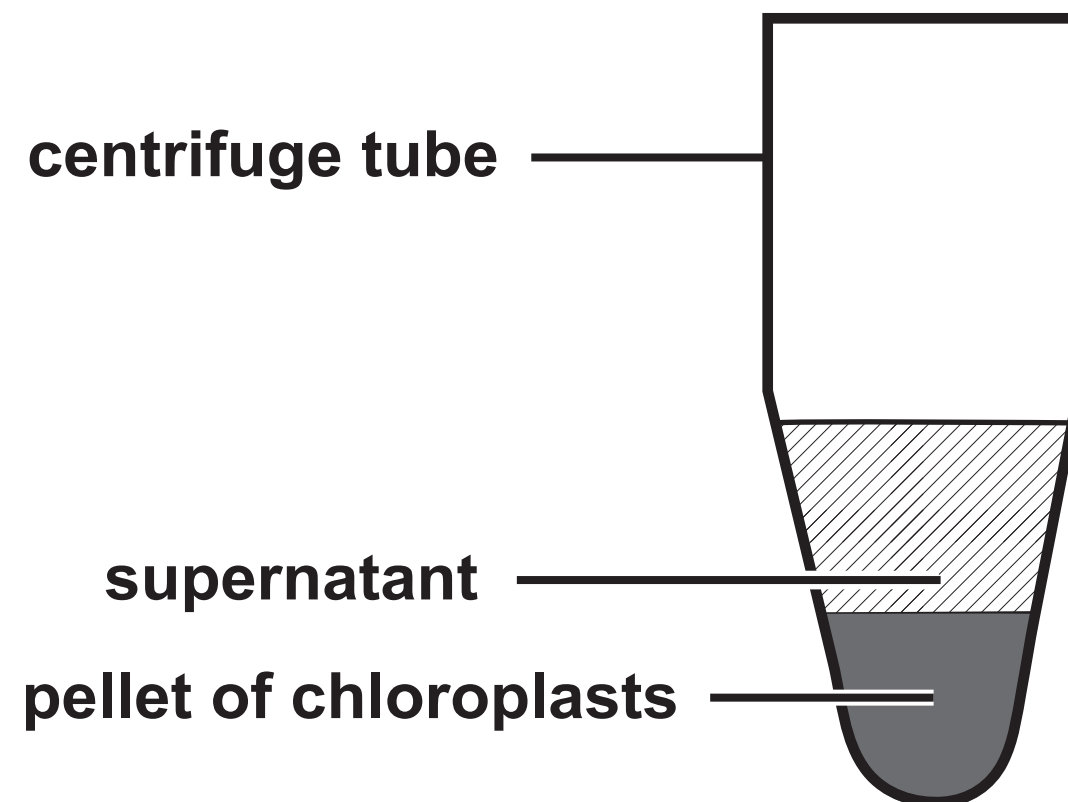
Centrifuge to obtain a small pellet of chloroplasts.



Separate pellet from supernatant.



Re - suspend the chloroplasts and keep cool.



Question 6 (c) (iii)

TABLE 6.5

Tube	Volume/cm ³				Light or no light	DCPIP colour change
	suspended chloroplasts	supernatant	sucrose and buffer solution	DCPIP solution		
1	0.5			5	light	blue to colourless
2			0.5	5	light	no colour change
3	0.5			5	no light	no colour change
4		0.5		5	light	no colour change