ARCHBISHOP ILSLEY CATHOLIC SCHOOL

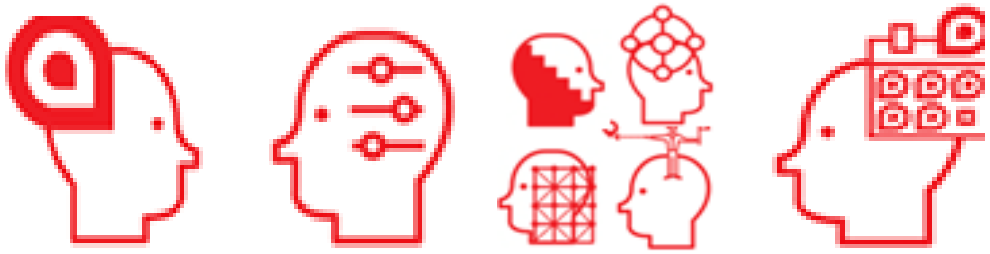
Justus et Tenax Propositi - Just and Firm of Purpose

AQA GCSE Combined / Triple Science

Biology

B4 Bioenergetics

Knowledge and Mastery Book



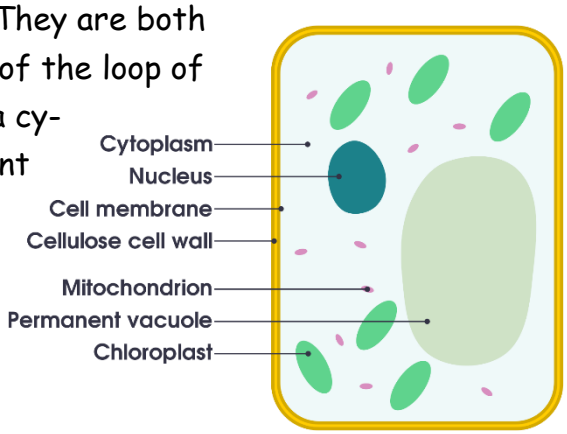
Do not write in this booklet

ALL answers to be written in your exercise book

Lesson 1 Leaf Organisation

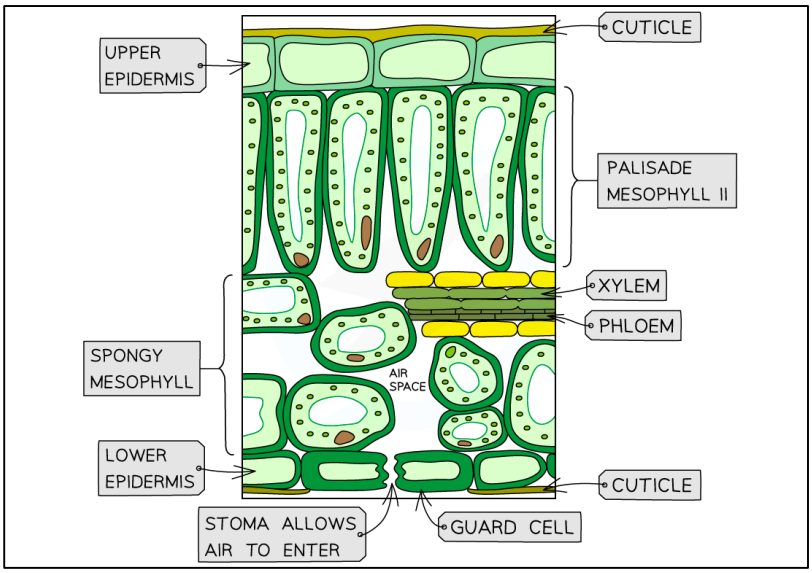
Plant Cell

A plant cell shares many features with an animal cell. They are both Eukaryotic, meaning they both have a nucleus instead of the loop of DNA found in Prokaryotic organisms, they both have a cytoplasm, ribosomes, mitochondria and a cell wall. A plant cell, however, has a few additional structures that enable it to carry out it's functions. A picture of a **generic** (average) plant cell can be seen below.



Leaf Structure

A leaf contains many of these plant cells. Some of them are **specialised** (think back to B1) to do certain roles, and you need to know the functions of all of them. A picture can be seen below.



The **waxy cuticle** is located on the top layer of a leaf. It a waterproof layer that prevents the loss of water from the top of a plant. As a leaf needs to undergo **photosynthesis**, it needs to be facing the sun all of the time- without the waxy cuticle, water would just evaporate off the surface!

The **upper epidermis** is a layer of plant cells that sit below the cuticle. This layers main role is to separate the inside of the leaf's structure from the outside.

Palisade mesophyll are packed full of chloroplasts to absorb as much sunlight as possible as it comes through the upper surface. This is why they are stacked near the surface and arranged vertically- this means many can be working incredibly efficiently.

The **xylem and phloem** are paired in a structure called the **vascular bundle.** The xylem carries water and mineral ions, while the phloem carries sugar.

The **spongy mesophyll** layer contains large air spaces to allow for air and gas exchange, as well as the movement of water.

The **Lower epidermis** does the same ad the upper epidermis, separating the inside of the leaf from the outside, but does it on the lower surface. It also has some gaps known as **stomata** to allow water and air molecules to move in and out of the leaf. These are surrounded by **guard cells** that can open and close these stomata when needed. This layer is also covered by a cuticle, but it does not need to be as thick or waxy as the waxy cuticle on the upper surface.

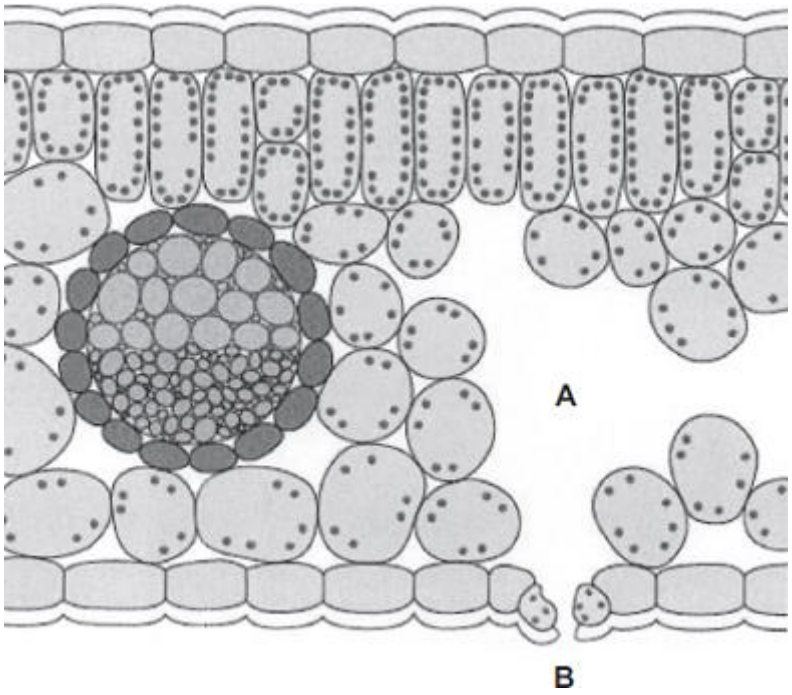
Finally, although not involved with the leaf as such, **meristem** cells are found in the parts of a plant where growth occurs- the cells can differentiate into any cell needed in the plant at the **root and shoot tips**.

Mastery Questions Lesson 1

1. State the function of the waxy cuticle
2. State the function of the upper epidermis
3. State the function of the palisade mesophyll cells
4. State the function of the xylem
5. State the function of the phloem
6. State the function of the spongy mesophyll
7. State the function of the lower epidermis, stomata and guard cells.
8. What are the cells surrounding the stomata known as?
9. What two types of cells make up the vascular bundle?
10. What are the gaps between guard cells called?
11. What are the adaptations of the palisade cells?
12. Why do leaves need a waxy cuticle?
13. What are meristem cells?
14. Where do you find meristem cells?
15. What is the function of meristem cells?
16. What does specialised mean? (previous topic)
17. What does the term generic mean?
18. What is a eukaryotic cell?
19. What are 2 examples of types of eukaryotic cell?
20. What is the main thing that makes a cell eukaryotic?
21. What is an example of a type of prokaryotic cell?
22. What do prokaryotic cells have that make them different?

Q1.

The diagram shows a section through a plant leaf.



(a) Use words from the box to name **two** tissues in the leaf that transport substances around the plant.

epidermis	**mesophyll**	**phloem**	**xylem**

_____ and _____

(1)

(b) Gases *diffuse* between the leaf and the surrounding air.

(i) What is *diffusion*?

_____

_____

_____

_____

(2)

(ii) Name **one** gas that will diffuse from point **A** to point **B** on the diagram on a sunny day.

_____

(1)

(c) Plants have leaves which contain guard cells and palisade cells. Explain how **each** of these kinds of cell assists photosynthesis.

Guard cells _____

_____

_____

_____

(2)

Palisade cells _____

_____

_____

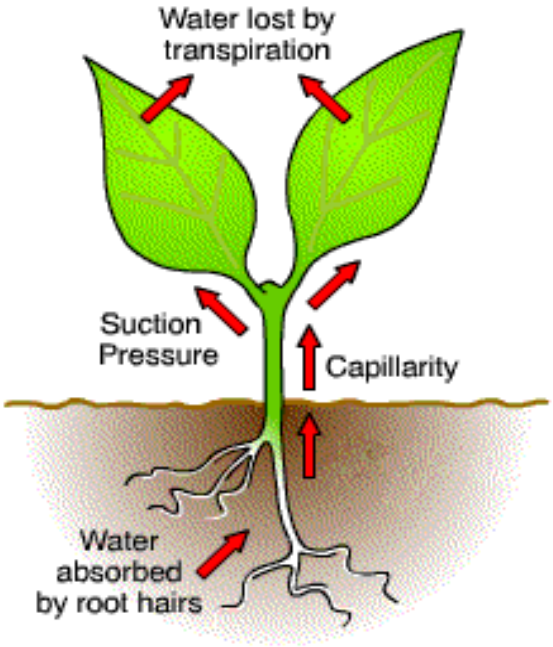
_____

(2)

Lesson 2 Transpiration and Translocation

Transpiration

Transpiration is the loss of water from the aerial parts of a plant. It happens constantly throughout the day. The action of transpiration also gives rise to the **transpiration stream-** this is the flow of water from the roots to the aerial parts, or **up** the plant.



Water is lost through the leaves of the plant as there is a higher concentration in the leaves than there is in the air. Water moves out of the leaves through stomata found on the underside of the leaf. As water is lost from the leaves, this reduces the concentration of water within the leaves.

Water then moves to the leaves from the roots, by travelling up the stem. This then leaves the roots with a lower concentration of water.

Due to the lower concentration of water currently in the roots, water moves from the surrounding soil into the roots.

Guard Cells

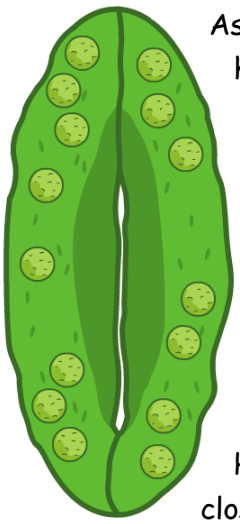


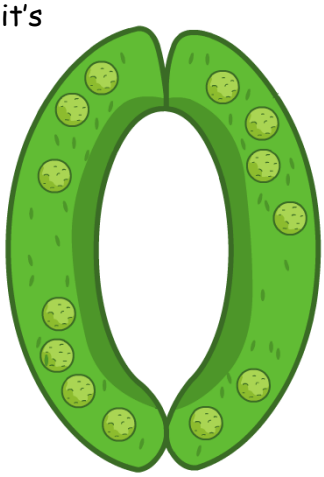
Figure 1: Guard cells closed

As discussed in the previous lesson, the underside of the leaves have small holes called **stomata**. Each stomata is surrounded, and it's price is controlled, by two **guard cells**.

During photosynthesis, low carbon dioxide levels inside the plant cause guard cells to gain water and become **turgid**. This means the cell swells with water, and because one side of a guard cell is thicker than the other, this causes it to bend. They curve open, opening the stoma and allowing gases in and out. Water is also able to evaporate through the stomata.

High carbon dioxide levels cause the guard cells to lose water, closing the stoma as the guard cells become **flaccid** and preventing further water loss.

Figure 2: Guard cells open



Translocation

Translocation is just the movement of dissolved sugars around parts of the plant through the phloem. The only thing that stands out as massively different, apart from this, is while water can travel only from the roots to the leaves translocation can occur both up and down a plant. Sugar can be made in any part of the plant where there is a leaf, and leaves can grow in many different parts of the plant and is needed all over. Whereas water is only received from the roots, therefore only has any need to go up from the bottom of the plant.

Mastery Questions Lesson 2

1. What is transpiration?
2. What is transpiration stream?
3. Which direction does transpiration occur in?
4. Why does water move out of the leaves?
5. What hole does water exit the leaf through?
6. What happens to the concentration of water in the leaves once the water exits?
7. How does water move up the plant?
8. Where does water enter the plant?
9. What tube allows water to move up the plant (previous lesson)
10. What is the name of the cells that surround the stomata?
11. What causes these cells to open?
12. What causes these cells to close?
13. What is the state of the cell when they become open?
14. What is the state of the cell when they are closed?
15. What is translocation?
16. How is translocation different from transpiration?
17. Why can translocation move sugars up **and** down a plant?
18. Where are the sugars made in a plant?
19. Define osmosis (previous topic)
20. **Level 3 question:** Why does increasing carbon dioxide levels decrease the amount of water available to make the guard cells turgid?
21. What feature of the guard cells causes them to bend when they are turgid?

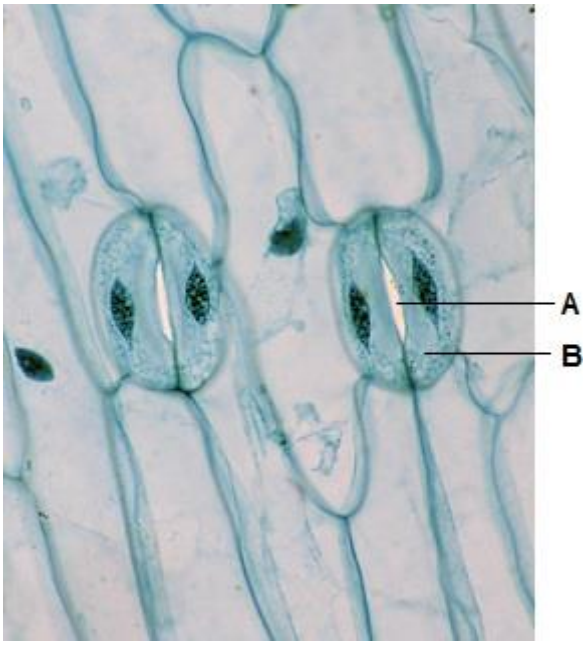
Previous Questions

1. State the function of the waxy cuticle
2. State the function of the upper epidermis
3. State the function of the palisade mesophyll cells
4. State the function of the xylem
5. State the function of the phloem
6. State the function of the spongy mesophyll
7. State the function of the lower epidermis, stomata and guard cells.
8. What are the cells surrounding the stomata known as?
9. What two types of cells make up the vascular bundle?
10. What are the gaps between guard cells called?

Exam Questions Lesson 2

Q1.

The photograph below shows the lower surface of a leaf magnified 800 times.



(a) Name hole **A** in the leaf surface.

_____

(1)

(b) Name cell **B**.

_____

(1)

(c) Cell **B** can lose or gain water.

Complete the sentences.

Choose answers from the box.

	active transport	**condensation**
osmosis	**photosynthesis**	**transpiration**

Cell **B** can gain water by _____ .

Water vapour can escape from the leaf through hole **A**

by _____ .

(2)

(d) Which factors increase the rate of water loss from hole **A**?

Tick **two** boxes.

- Increasing acidity ☐
- Increasing nitrogen concentration ☐
- Increasing oxygen concentration ☐
- Increasing temperature ☐
- Increasing wind speed ☐

(2)

(e) Give **one** reason why the movement of water in a plant is important.

_____

_____

(1)

(f) The African Baobab tree has no leaves for up to 9 months of the year.

Suggest how this helps the tree to survive in an area where there is not much rain.

_____

_____

(1)

Lesson 3 Photosynthesis

Introduction

Photosynthesis an enzyme controlled reaction that occurs in the chloroplast, using the green pigment in there called **chlorophyll**. It uses energy from the sun to convert carbon dioxide and water into glucose and oxygen. It is an **endothermic reaction,** meaning that it takes in energy- and is also the reason why leaves do not heat up due to photosynthesis.

The equation for photosynthesis is:

Carbon Dioxide + Water → Glucose + Oxygen

Chemical equation:

$CO_2 + H_2O \rightarrow C_6H_{12}O_6 + O_2$

Balanced chemical equation:

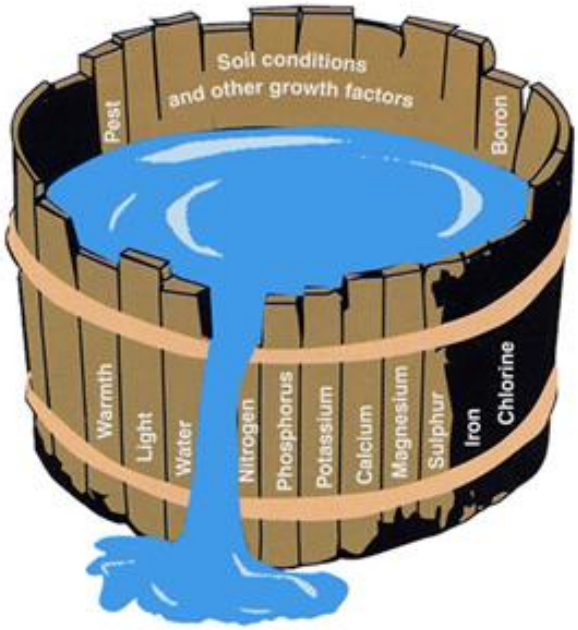
$\mathbf{6}CO_2 + \mathbf{6}H_2O \rightarrow C_6H_{12}O_6 + \mathbf{6}O_2$

Uses of the Products of Photosynthesis

Plants use glucose in five main ways. They can use the glucose in **respiration** to transfer energy from it. They can convert the glucose into cellulose to build **cell walls,** or combine it with nitrate ions to make **amino acids.** Finally, it can be converted into storage molecules – **lipids** like fats and oils, which can be used to help develop the energy storage in seeds, or **starch** molecules that can be used when photosynthesis does not provide enough glucose.

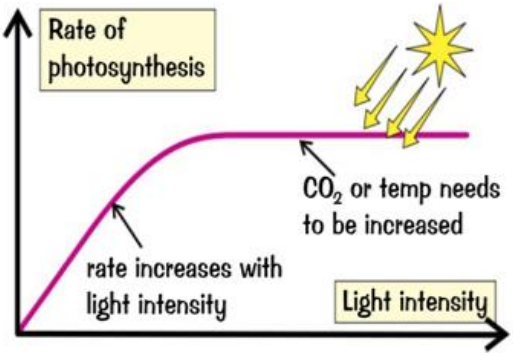
Factors Affecting the Rate of Photosynthesis

A limiting factor is an aspect of a reaction that can reduce ('limit') the rate of a reaction if it is not in a high enough quantity. There are three factors that can affect photosynthesis in such a way: light intensity, as light provides the energy for the reaction; CO_2 levels, as CO_2 is one of the reactants of photosynthesis; and temperature, as photosynthesis is an enzyme controlled reaction and those enzymes need to be kept at a certain temperature to function.



Light Intensity

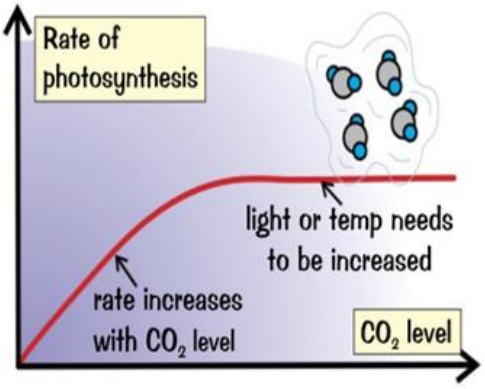
Increasing light levels increases the rate of photosynthesis. Decreasing the light intensity decreases it. At a certain point the graph flattens out. Here, the rate of photosynthesis won't go any faster. This is because light is no longer the limiting factor- something else must be. At this point, either CO_2 or temperature.



Light intensity can be calculated by using the equation:

Light intensity $\propto$ 1 / distance $(d)^2$

What this means is that if you half the distance from the light source, light intensity will be four times greater. This is known as the **Inverse square law**.

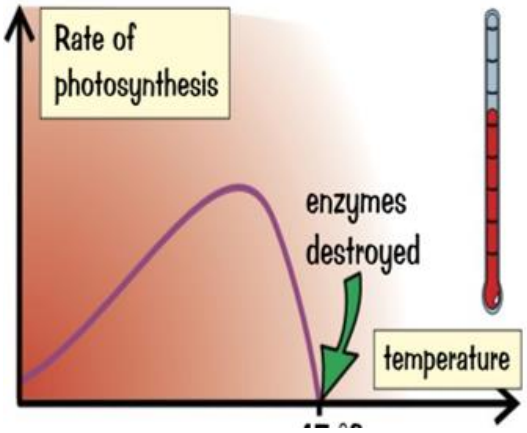


Carbon Dioxide

The more CO_2, the faster the rate of photosynthesis. This means CO_2 is a limiting factor here. As with light, after a certain point, increasing CO_2 levels does not increase the rate of photosynthesis as it is not a limiting factor any more. At this point, light or temperature must need to be increased. The graph here has the same pattern as light intensity- it rises for a time before it **plateaus**.

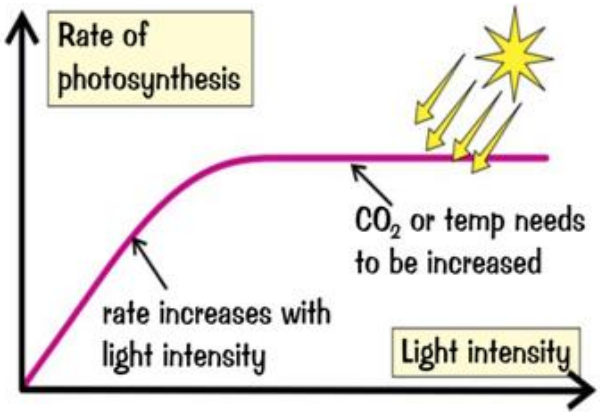
Temperature

Usually, if the temperature is the limiting factor it's because it is too low, as the enzymes that run photosynthesis work more slowly at lower temperatures. It will increase as the temperature gets closer to the optimum, but at too high a temperature the enzymes become damaged and **denatures**. After this point, the rate of photosynthesis will very quickly plummet.



Lesson 3 Mastery Questions

1. Where does photosynthesis happen?
2. What is the name of the pigment that photosynthesis happens in?
3. Is photosynthesis endothermic or exothermic?
4. What are the products of photosynthesis?
5. What are the reactants of photosynthesis?
6. What is the word equation for photosynthesis?
7. What is the symbol equation for photosynthesis?
8. What is the balanced symbol equation for photosynthesis?
9. How many ways can plants use glucose?
10. State the ways in which plants can use glucose
11. What is a limiting factor?
12. What are the three limiting factors of photosynthesis?
13. How does temperature affect the rate of photosynthesis?
14. What happens to enzymes when they get too warm?
15. How can light intensity affect the rate of photosynthesis?
16. What does it mean on this graph when the rate of photosynthesis *plateaus* (flattens out)
17. How does carbon dioxide concentration affect the rate of photosynthesis?
18. What is the equation for the inverse square law?
19. What happens to light intensity when you half the distance of the light source?
20. Why does the rate of photosynthesis decrease after an enzyme reaches it's optimum temperature?



Previous Questions

1. Why can translocation move sugars up **and** down a plant?
2. Where are the sugars made in a plant?
3. Define osmosis (previous topic)
4. **Level 3 question:** Why does increasing carbon dioxide levels decrease the amount of water available to make the guard cells turgid?
5. What feature of the guard cells causes them to bend when they are turgid?

Lesson 3 Exam Questions

Q1.

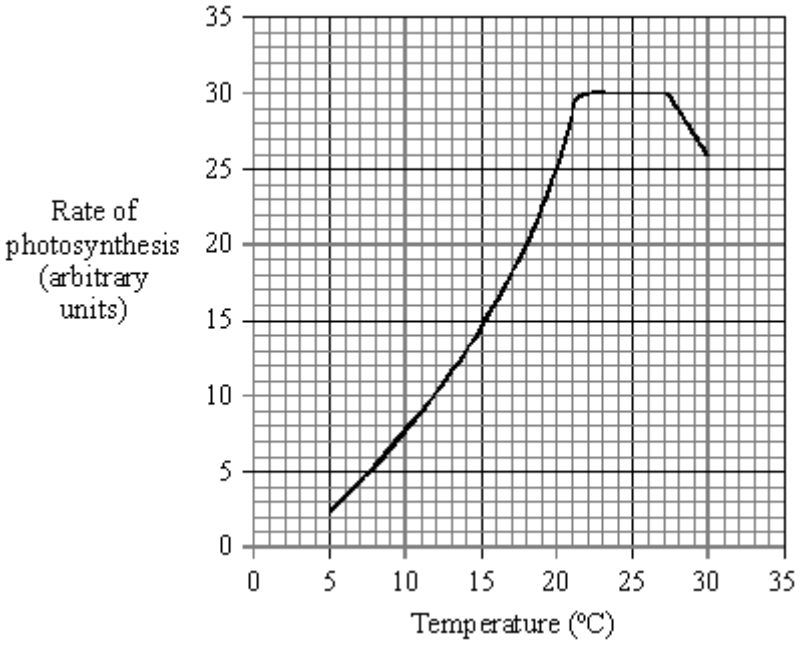
Green plants make food in their leaves.

(a) From where do the leaves get the energy that they need to make food?

_____

(1)

(b) The graph shows the effect of temperature on the rate of photosynthesis.



(i) Between which temperatures is the rate of photosynthesis fastest?

_____ and _____ °C

(1)

(ii) Suggest why the rate of photosynthesis stays the same between these two temperatures.

_____

_____

_____

_____

(2)

(iii) A greenhouse owner wants to grow lettuces as quickly and cheaply as possible in winter.

Using the graph, state what temperature he should keep his greenhouse in order to grow the lettuces as quickly and cheaply as possible?

_____ °C

Explain your answer.

_____

_____

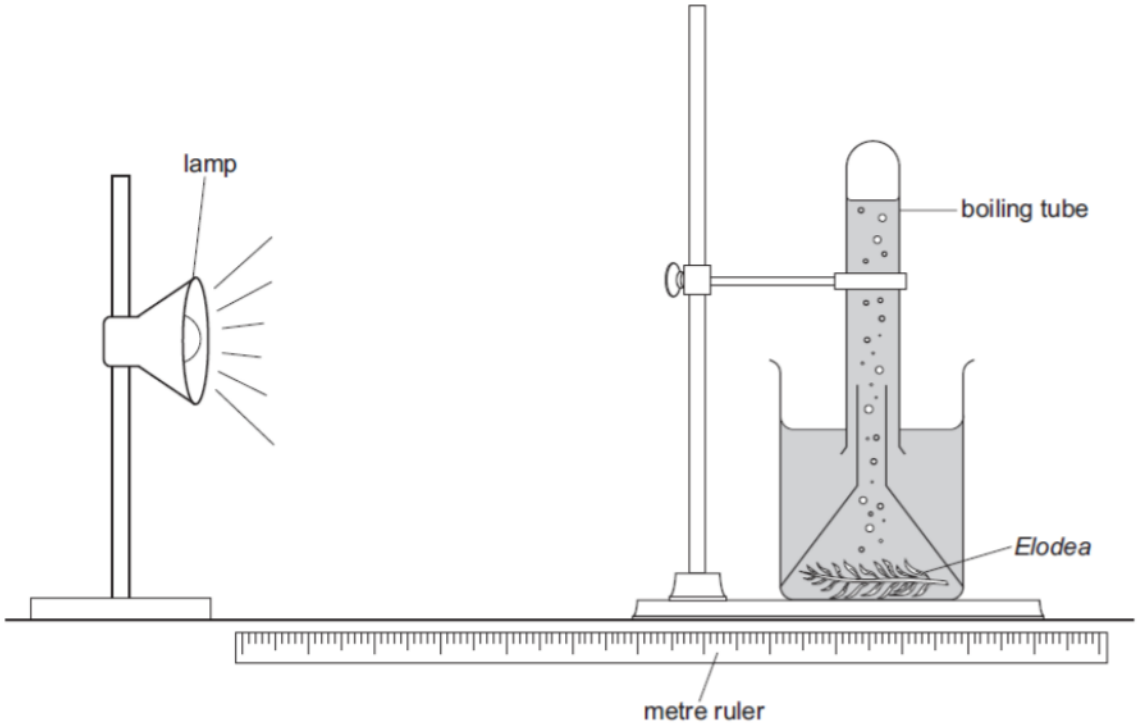
_____

_____

(3)

(Total 7 marks)

Lesson 4+5 Pondweed Required Practical



Measuring Photosynthesis

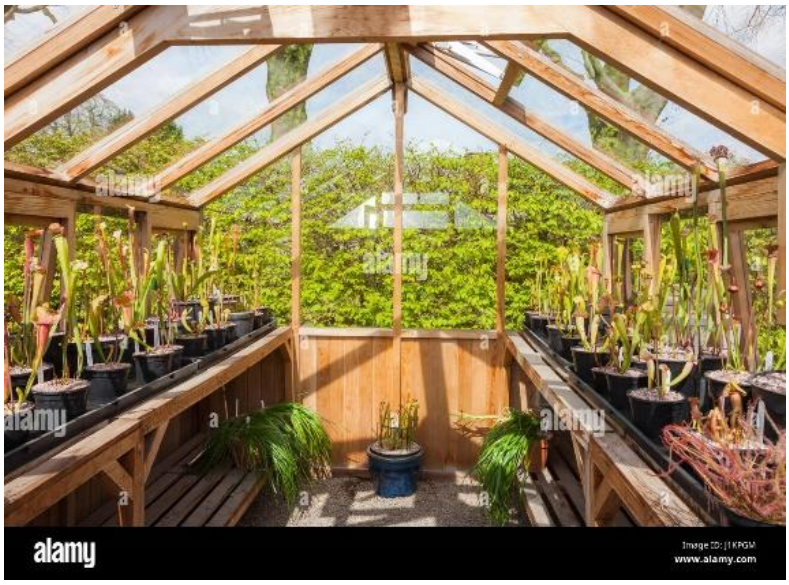
Photosynthesis can be measured by using the equipment pictured above. This experiment uses the distance of the light bulb from the pondweed (scientific name *Elodea*) to change light intensity, based on the **inverse square law** (as distance from the source of light increases, light intensity decreases), and uses the number of bubbles produced to calculate the rate of photosynthesis- the larger the number of bubbles, the higher the rate of photosynthesis.

Method

1. Set up the equipment as the picture above shows.
2. Place your bulb 10cm away from the pondweed. It must start here, as if it starts at 0cm it will get too warm.
3. Give the pondweed 2 minutes at this light intensity to **acclimatise** (get used to the conditions)
4. Count the number of bubbles produced in this amount of time
5. Move the light 10cm back, and repeat the experiment

Ideal conditions for Photosynthesis

Photosynthesis has very specific conditions that are needed in order for it to occur, and those conditions cannot always be naturally met- e.g., it may be winter and light intensity is lower, or even just a cloudy day. However, it was discovered that we are able to artificially simulate the conditions that plants need- even climate specific plants that could not normally be grown in certain countries. We do this through the use of a green house.



Green houses can be kept at the ideal temperature for photosynthesis even during winter, provided they use heating elements. CO_2 can be artificially pumped in to ensure it remains at the right concentration, an **irrigation system** can be used to water the plants to ensure they go without water, lights can be used to simulate sunlight and allow photosynthesis in the dark, etc. All of this means we are able to allow the growth of plants in conditions that they would not ordinarily be able to survive in.

One of the main downsides of this is cost- the amount of money put into maintaining this environment must be kept level, so they might not always be kept at the exact optimum temperature, or gas concentration, but they are close enough so that they make more money from the use of the green house than they spend trying to keep it running.

Lesson 4-5 Mastery Questions

1. For the experiment 'Measuring Photosynthesis', state the independent variable.
2. For the experiment 'Measuring Photosynthesis', state the dependent variable.
3. For the experiment 'Measuring Photosynthesis', state the control variable.
4. Why don't we put the lamp at 0cm from the plant?
5. Why do we leave the pondweed for 2 minutes?
6. What are factors that might make it difficult to get the optimum levels of photosynthesis?
7. How can we change the environment of a plant artificially?
8. How can we keep temperatures the same for plants?
9. How can we keep CO_2 levels the same for plants?
10. What can an irrigation system be used for?
11. What is the main downside for greenhouses?
12. What are the ideal conditions for photosynthesis?
13. Write a method for measuring photosynthesis.
14. What can allow us to artificially simulate the conditions a plant needs?
15. What does the inverse square law state?

Previous Mastery Question

1. How does temperature affect the rate of photosynthesis?
2. What happens to enzymes when they get too warm?
3. How can light intensity affect the rate of photosynthesis?
4. What does it mean on this graph when the rate of photosynthesis *plateaus* (flattens out)
5. How does carbon dioxide concentration affect the rate of photosynthesis?
6. What is the equation for the inverse square law?
7. What happens to light intensity when you half the distance of the light source?
8. Why does the rate of photosynthesis decrease after an enzyme reaches it's optimum temperature?
9. Why does the rate of photosynthesis decrease after an enzyme reaches it's optimum temperature?
10. Where does photosynthesis happen?

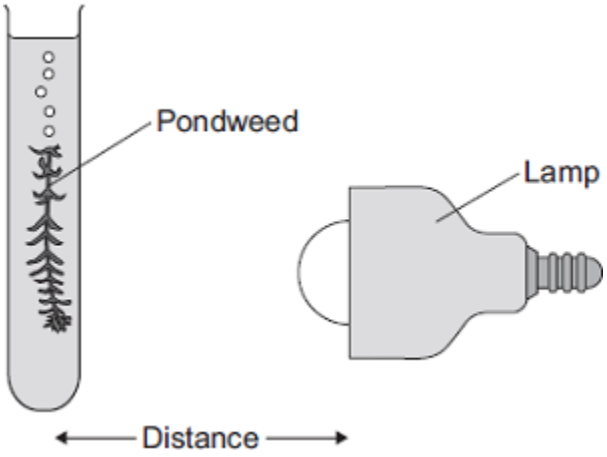
Lesson 4-5 Exam Questions

Q1.

Some students investigated the effect of light intensity on the rate of photosynthesis.

They used the apparatus shown in **Diagram 1**.

Diagram 1



The students:

- placed the lamp 10 cm from the pondweed
- counted the number of bubbles of gas released from the pondweed in 1 minute
- repeated this for different distances between the lamp and the pondweed.

(a) The lamp gives out heat as well as light.

What could the students do to make sure that heat from the lamp did **not** affect the rate of photosynthesis?

_____

_____

(1)

(b) The table shows the students' results.

Distance in cm	Number of bubbles per minute
10	84
15	84
20	76
40	52
50	26

(i) At distances between 15 cm and 50 cm, light was a limiting factor for photosynthesis.

What evidence is there for this in the table?

_____

_____

(1)

(ii) Give **one** factor that could have limited the rate of photosynthesis when the distance was between 10 cm and 15 cm.

_____

(1)

Lesson 6 Respiration and Metabolism

Metabolism

Metabolism is the term used for all the chemical reactions that go on inside the body of an organism. This could be breaking down molecules or building molecules, and respiration and photosynthesis are examples of these processes.

Respiration

Respiration is the process of transferring energy from the breakdown of glucose. It occurs in every cell in both animals and plants, and is an exothermic reaction, so it releases energy. There are two types, aerobic and anaerobic. Both the word and symbol equation for both are written below:

- **Aerobic Respiration: Water + Carbon Dioxide → Glucose + Oxygen**

$$H_2O + CO_2 \rightarrow C_6H_{12}O_6 + O_2$$

- **Anaerobic Respiration: Glucose → Lactic Acid**

$$C_6H_{12}O_6 \rightarrow C_3H_6O_3$$

Respiration transfers energy from glucose. Energy in this case is not a included in the word or symbol equation but it is still a product of this reaction. The energy released from this reaction can be used for:

- Build up larger molecules from smaller ones (glucose to starch, glucogen or cellulose)
- In animals, for use in movement- that can be contractions of muscles to move the organism around or even contractions to beat the heart.
- In mammals and birds, and other warm blooded animals, to keep them warm.

Hand-Clenching Demo

Speed of hand clenching	Time taken before it hurts (max. 3 minutes)

Sitting at a desk, holding your hand in the air, clench and unclench your fist once every 3 seconds. Record how long it takes before it becomes too difficult to keep doing this - this is the point where your muscles are fatigued. Rest for a short while and repeat this process, each time changing the rate at which you're clenching and unclenching your fist.

Task

1. Why does your arm start to hurt during this demo?
2. Why does your arm slowly start to feel better as this happens?

Fermentation

Fermentation is the process of anaerobic respiration in plants and yeast cells, as well as some other microorganisms. The chemical and word equation for both is shown below:

- Fermentation: Glucose → Ethanol + Carbon Dioxide

$$C_6H_{12}O_6 \rightarrow C_2H_5OH + CO_2$$

The products of fermentation can be used by humans to make various different products- the CO_2 can be used to cause bread to rise, and the ethanol can be collected to be used in various alcoholic drinks.

Lesson 6 Mastery Questions

1. What is metabolism?
2. What is respiration?
3. What are the two types of respiration?
4. What is the word equation for aerobic respiration?
5. What is the symbol equation for aerobic respiration?
6. What is the word equation for anaerobic respiration?
7. What is the symbol equation for anaerobic respiration?
8. What can the energy released during respiration be used for?
9. What is fermentation?
10. What is the word equation for fermentation?
11. What is the symbol equation for fermentation?
12. What can the CO_2 produced here be used for?
13. What can the ethanol produced here be used for?
14. Why does your hand hurt after clenching it for a while?
15. Why does your hand begin to feel OK again after a while?

Previous Mastery Questions

1. For the experiment 'Measuring Photosynthesis', state the independent variable.
2. For the experiment 'Measuring Photosynthesis', state the dependent variable.
3. For the experiment 'Measuring Photosynthesis', state the control variable.
4. Why don't we put the lamp at 0cm from the plant?
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7. How can we change the environment of a plant artificially?
8. How can we keep temperatures the same for plants?
9. How can we keep CO_2 levels the same for plants?
10. What can an irrigation system be used for?

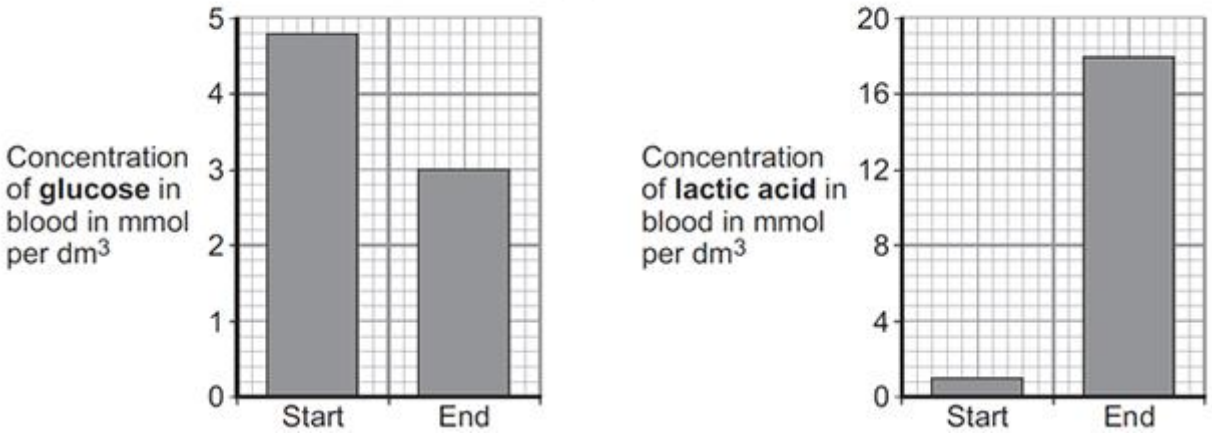
Lesson 6 Exam Questions

Q1.

An athlete ran as fast as he could until he was exhausted.

(a) **Figure 1** shows the concentrations of glucose and of lactic acid in the athlete's blood at the start and at the end of the run.

Figure 1



(i) Lactic acid is made during anaerobic respiration.

What does anaerobic mean?

_____

_____

(1)

(ii) Give evidence from **Figure 1** that the athlete respired anaerobically during the run.

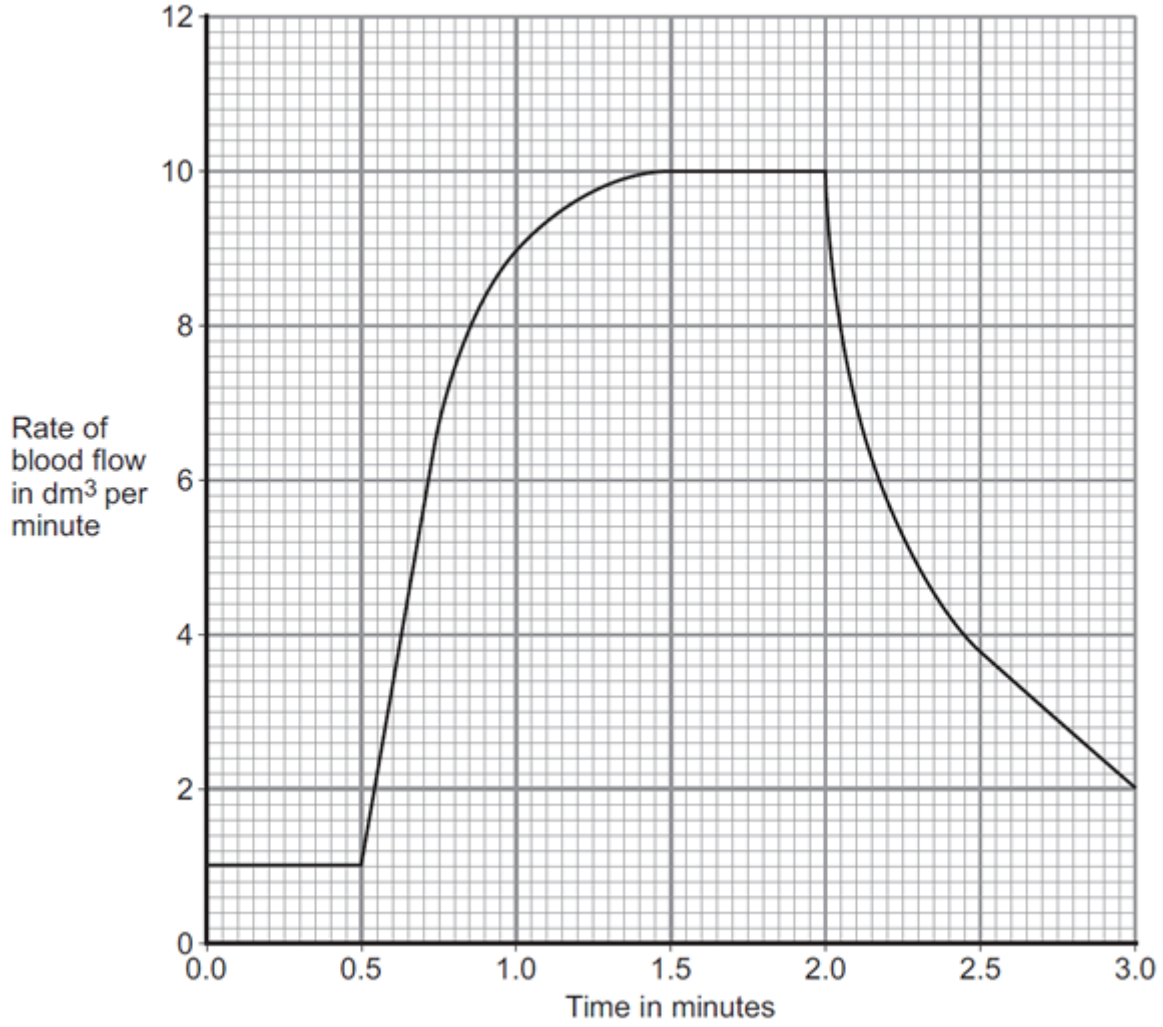
_____

_____

(1)

(b) **Figure 2** shows the effect of running on the rate of blood flow through the athlete's muscles.

Figure 2



(i) For how many minutes did the athlete run?

Time = _____ minutes

(1)

(ii) Describe what happens to the rate of blood flow through the athlete's muscles during the run.

Use data from **Figure 2** in your answer.

_____

_____

_____

_____

(2)

(iii) Explain how the change in blood flow to the athlete's muscles helps him to run.

(4)

(Total 9 marks)

Lesson 7 Exercise

Respiration During Exercise

Muscles need energy from respiration to contract. Aerobic respiration will occur in cells that have both oxygen and glucose supplied to them- this is supplied to the blood. More exercise means more oxygen and glucose is needed, which means breathing rate will increase to supply the body with the oxygen it needs and heart rate will increase to get that oxygen to areas around the body that need them -namely, muscle cells.

The body cannot always get enough oxygen, however. Under these conditions anaerobic respiration will occur. This is not as efficient and does not release as much energy as aerobic, however it is useful for when oxygen levels are low as it means respiration does not just stop. Due to anaerobic respiration being the incomplete breakdown of glucose into 6 molecules of carbon dioxide and 6 molecules of water, it forms **lactic acid** instead. This can build up in muscles and cause pain, and leads to something known as an **oxygen debt.**

Oxygen Debt

The oxygen debt is **the amount of extra oxygen needed to react with the lactic acid built up during exercise.** Remember:

- Anaerobic respiration produces 2 molecules of lactic acid
- Aerobic respiration produces molecules of water and carbon dioxide, but needs oxygen
- Therefore, once oxygen is present it reacts with the lactic acid to form carbon dioxide and water
    - (This is not balanced, just a general overview).

Breathing rate and heart rate both remain high following exercise due to the lactic acid- breathing rate staying high keeps high amounts of oxygen moving in and heart rate remaining high delivers this extra oxygen to the regions of the body that need it.

Your body can also deal with increased lactic acid by blood carrying it to the liver where 2 molecules of it can be converted back into one molecule of glucose.

Scientific Study of Exercise

You can carry out an experiment to test how exercise affects your body.

Task

Plan a study for testing the effect of exercise on the body

1. What is your hypothesis?
2. What is your independent variable (what you are changing)?
3. What is your dependent variable (what are you measuring)?
4. What is your control variable?
5. Write a method for this practical
6. Draw up a results table
7. [When the practical is completed] What can you conclude from your experiment? Was your hypothesis right or wrong?

Lesson 7 Mastery

1. Why do muscles need energy?
2. What supplies glucose and oxygen to the muscles?
3. What happens to breathing rate when exercising?
4. Why does this happen to breathing rate?
5. What happens to heart rate when exercising?
6. Why does this happen to heart rate?
7. What cells will need oxygen and glucose the most during exercise?
8. What builds up in the muscles during anaerobic respiration?
9. What is an oxygen debt?
10. How does oxygen reach with lactic acid to break it down?
11. What organ can also break down lactic acid?
12. Why does breathing rate stay high after exercise?
13. Why does heart rate stay high after exercise?
14. How are glucose and oxygen delivered to the muscle cells?
15. Which produces more energy, anaerobic or aerobic respiration?
16. Under what conditions is aerobic respiration useful?
17. What is the balanced symbol equation for aerobic respiration?
18. What is an independent variable?
19. What is a dependent variable?
20. What is a control variable?

Previous Mastery Questions

1. What is metabolism?
2. What is respiration?
3. What are the two types of respiration?
4. What is the word equation for aerobic respiration?
5. What is the symbol equation for aerobic respiration?
6. What is the word equation for anaerobic respiration?
7. What is the symbol equation for anaerobic respiration?
8. What can the energy released during respiration be used for?
9. What is fermentation?
10. What is the word equation for fermentation?

Lesson 7 Exam Questions

Q1.

Two students investigated the effect of exercise on breathing rate.

Breathing rate was measured by counting the number of times a student breathed in during 1 minute.

This is the method used.

1. Measure the breathing rate at rest before exercise.
2. Run on the spot for 5 minutes.
3. Measure the breathing rate every minute during exercise.
4. Measure the breathing rate every minute after exercise for 10 minutes.

(a) The students had different breathing rates at rest.

Suggest **two** factors that could cause the students' breathing rates at rest to be different.

1 _____

_____

2 _____

_____

(2)

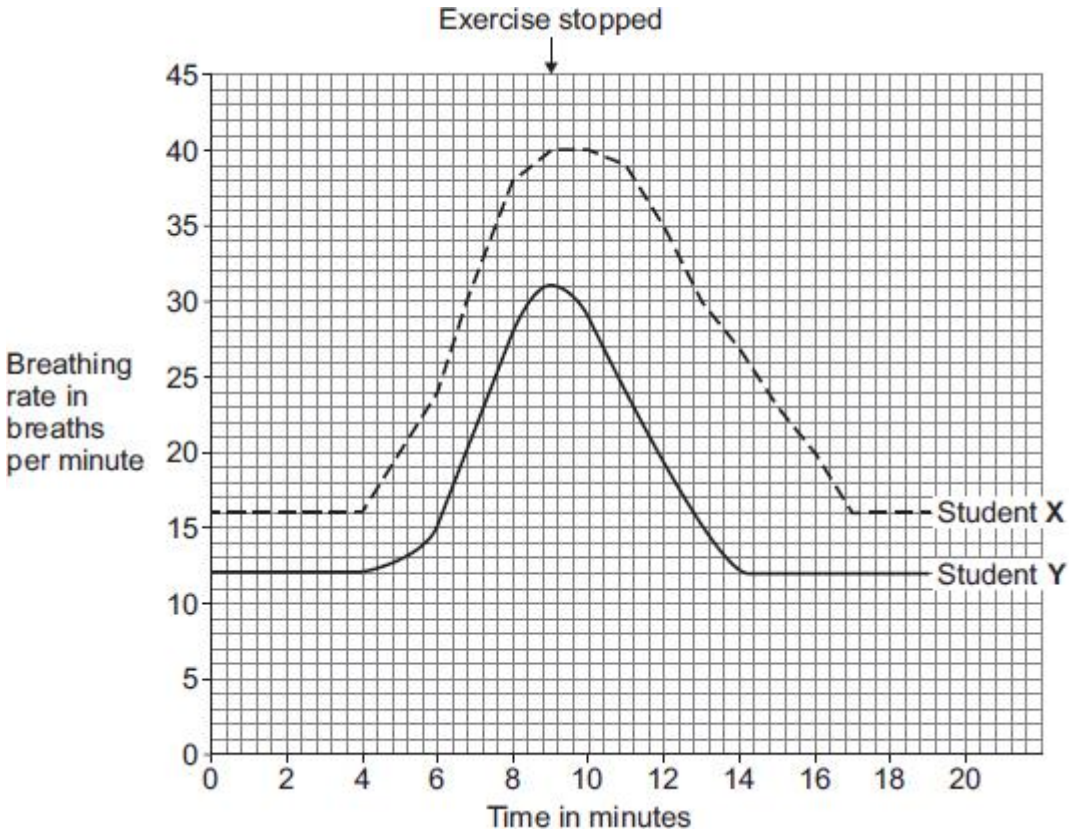
(b) Suggest **one** reason why the measurements for breathing rate may **not** be accurate.

_____

_____

(1)

The graph below shows the results.



(c) What time did the students start exercising?

Use the graph above.

Time exercise started = _____ minutes

(1)

(d) Describe **two** differences between the results of student **X** and of student **Y**.

Use the graph above.

1 _____

_____

2 _____

_____

(2)

(e) Why does breathing rate change during exercise?

Tick (✓) **one** box.

To increase the uptake of carbon dioxide **and** oxygen from the air	☐
To increase the uptake of carbon dioxide from the air	☐
To increase the uptake of oxygen from the air	☐

(1)

(f) The breathing rate of the students stayed high after the exercise stopped.

Why does breathing rate stay high after exercise has stopped?

Tick (✓) **one** box.

To break down amino acids	☐
To break down fatty acids	☐
To break down lactic acid	☐

(1)

(g) Give **one** other change that happens in the body during exercise.

Do **not** refer to breathing rate.

_____

_____

(1)

(Total 9 marks)

Q2.

After running for several minutes, an athlete's leg muscles began to ache.
This ache was caused by a high concentration of lactic acid in the muscles.

(a) The equation shows how lactic acid is made: glucose ⟶ lactic acid (+ energy)

Name the process that makes lactic acid in the athlete's muscles.

_____

(1)

(b) Scientists investigated the production of lactic acid by an athlete running at different speeds.

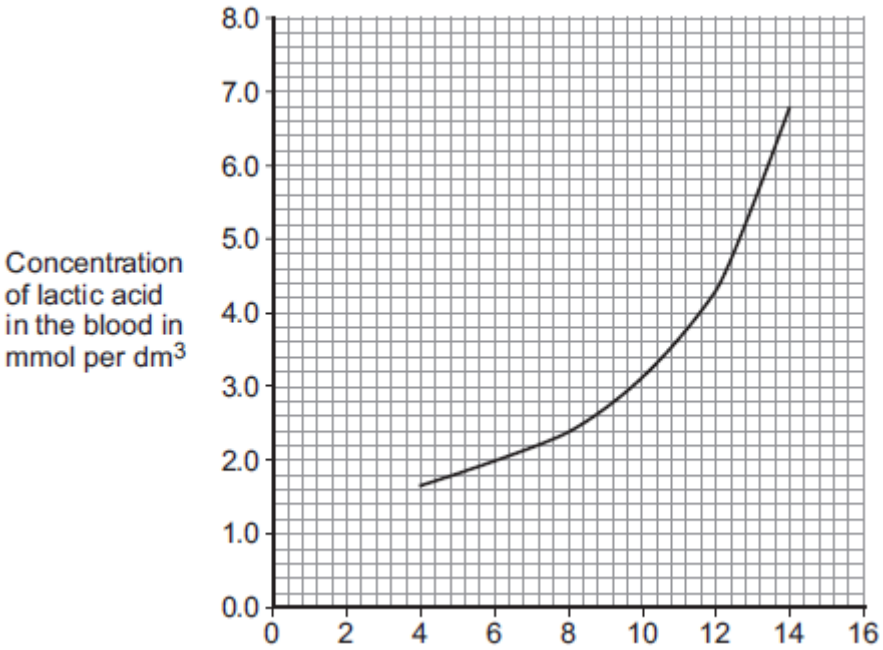
In the investigation:

- the athlete ran on the treadmill at 4 km per hour
- the scientists measured the concentration of lactic acid in the athlete's blood after 2 minutes of running.

The investigation was repeated for different running speeds.

Figure 2 shows the scientists' results.

Figure 2



(i) How much more lactic acid was there in the athlete's blood when he ran at 14 km per hour than when he ran at 8 km per hour?

_____

_____

Answer = _____ mmol per dm^3

(2)

(ii) Why is more lactic acid made in the muscles when running at 14 km per hour than when running at 8 km per hour?

_____

_____

_____

_____

(3)

(Total 6 marks)