AQA Biology GCSE Student activity

B4.5

Name ..... Class ..... Date .....

Close up on cell membranes

Specification references

- 4.1.1 Cell structure

Aims

The incredibly narrow cell membrane is all that separates the cell interior from its surroundings. You will see that the membrane is a lot more than a single line on a diagram! It is a complex and organised interface between the cell and its surroundings.

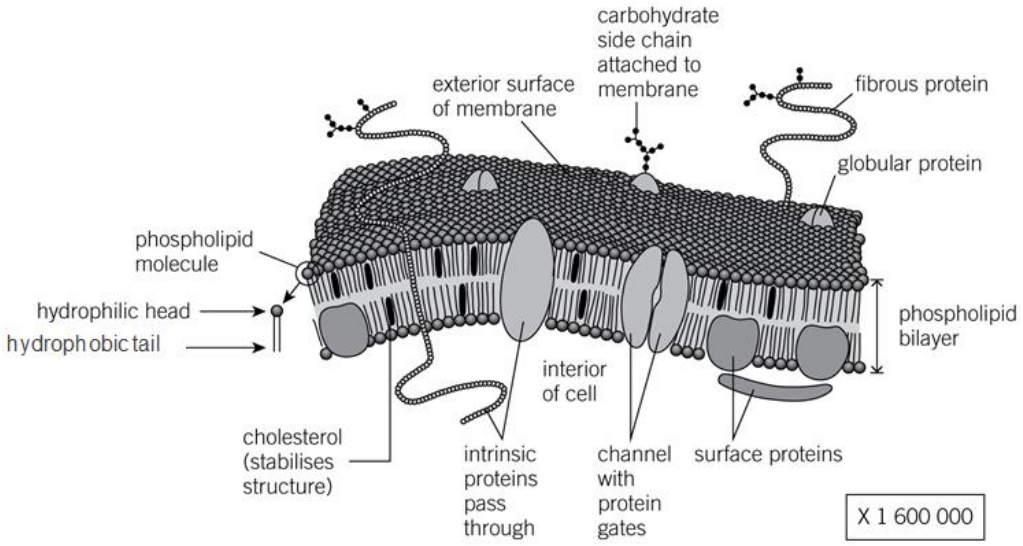
Learning outcomes

After completing this activity, you should be able to:

- practise calculations using image magnification
- understand that the cell membrane is a dynamic, fluid structure
- understand that the cell membrane has components that allow division of labour
- understand some of the actions of the cell membrane components.

Task

Figure 1 shows a diagram explaining the detailed structure of the cell membrane. Use this diagram to help answer the following questions.



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Questions

1 **a** Calculate the actual width of the cell membrane in nanometers (nm), where 1 nm = 10^{-9} mm. Show your working.

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..... (*2 marks*)

b How many layers of membrane would it take to span 1 mm?

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..... (*1 mark*)

2 Nerve cells use energy to open and close protein gates to control the flow of sodium ions. The flow of sodium ions causes an action potential (nerve impulse). Curare is a plant extract which was used as a paralysing poison dart by native South Americans.

a What metabolic reaction in the cell must be targeted by curare?

..... (*1 mark*)

b At rest the inside of a nerve cell is negatively charged and when active it is positively charged. Explain why.

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..... (*2 marks*)

c Suggest a mechanism for the action of curare on muscles.

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..... (*3 marks*)

d Suggest, with a reason, the main causes of death due to curare poisoning.

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..... (*2 marks*)

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3 Look at the phospholipid molecule in Figure 1.

a What is meant by the terms **hydrophobic** and **hydrophilic**?

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(*2 marks*)

b Suggest how these properties of the phospholipid molecules cause the arrangement shown in Figure 1.

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(*2 marks*)

c This arrangement of the phospholipid molecules is automatic and requires no chemical bonds, so the membrane is very mobile, or fluid, hence the name of the structure.

Describe how this fluidity might help a phagocyte white blood cell to ingest a pathogenic bacterium, as seen in Figure 2.

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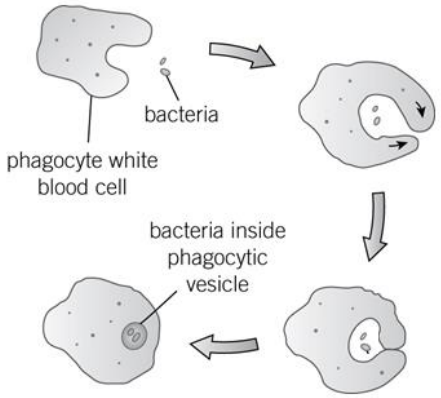
(*2 marks*)



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4 Some of the carbohydrate side chains are called antigens.

a How might these allow the phagocyte to tell the difference between the bacterium and one of your own body cells?

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(*2 marks*)

b Suggest why doctors look very closely at antigens on the cells of transplant organs.

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Helping the heart

Specification references

- B2.2.2 The heart and blood vessels

Aims

The heart is controlled by electrical impulses which originate from a natural pacemaker. When this is faulty using an artificial pacemaker can control the heart's rhythm. It is also possible to replace the heart with an artificial pump. This exercise will enable you to summarise the benefits and drawbacks of each treatment.

Learning outcomes

After completing this worksheet, you should be able to:

- identify the benefits and drawbacks associated with artificial pacemakers
- identify the benefits and drawbacks associated with artificial hearts.

Task

First read Topic B4.4 *Helping the heart* in the student book then read the following background text. Answer the questions that follow.

The heart's rhythm is naturally controlled via nerve impulses which originate in the pacemaker located in the sinoatrial node (SAN) at the top of the right atrium. These impulses travel to the atrioventricular node where they are slightly delayed in order to allow the atria to contract and empty into the ventricles. The impulse then travels

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down the septum of the heart to the apex of the ventricles where a wave of contraction spreads upwards through both ventricles. If the pacemaker is not functioning as it should, the person may suffer from arrhythmias (problems to do with the rate or rhythm of the heartbeat). The heart may beat too fast (tachycardia) or too slow (bradycardia). Atrial fibrillation is an irregular and fast heartbeat, often resulting in palpitations, where the heart feels like it is pounding, fluttering or beating irregularly.

Patients may suffer from sick sinus syndrome, where the SAN doesn't work as it should. They may suffer from bradycardia, tachycardia or both. Implantation of an artificial pacemaker will assist though monitoring the heart rate and sending corrective impulses as required to re-establish an appropriate rhythm. A pacemaker may also be fitted with a defibrillator to prevent cardiac arrest by "rebooting" the heart.

Implanting a pacemaker is a common surgical procedure and is generally very safe. However, risks with such an implantation include swelling, bleeding, bruising and infection at the site of implantation, blood vessel or nerve damage, collapsed lung and adverse reactions to medication given during the procedure. Patients have to avoid strong electrical and magnetic fields, for example, cell phones, microwave ovens, electrical generators or welders. Medical procedures such as magnetic resonance imaging (MRI) cannot be used. A bracelet or necklace with information showing that patients have a pacemaker can be worn.

The demand for donor organs consistently outstrips supply so artificial hearts can be used where there is a risk of death while waiting for a transplant. The benefits of using an artificial heart include restoration of quality of life, and being able to survive until a donor heart becomes available without further deterioration of their condition, which in turn could keep them off the transplant list. Also because they are artificial, that is, not of biological origin, recipients of artificial hearts do not have to take immunosuppressant drugs which have inherent risks such as heightened occurrence of cancer.

One of the major drawbacks with using artificial hearts is the cost, which can be in excess of £150 000. One could argue that this money could be put to better use in a publicly funded health service. Most artificial hearts are large and will only work for people who have a large enough chest cavity. Artificial hearts operate on batteries which have to be recharged frequently so patients must always be near a recharging source. There is a risk of developing blood clots due to the presence of metal and plastic so anticoagulant medication is also needed.

Questions

1 Name and describe the types of arrhythmia identified in the text.

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..... (*3 marks*)

2 Suggest four symptoms a patient with arrhythmia might experience.

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..... (*4 marks*)

3 Explain why patients fitted with pacemakers should be aware of, and avoid, strong electromagnetic fields.

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..... (*1 mark*)

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4 Pacemakers can adjust the rate of stimulation to the heart in response to levels of physical activity. Outline the conditions where this may be necessary and suggest ways in which it might be accomplished.

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..... (*3 marks*)

5 Explain why immunosuppressant drugs may lead to a higher than normal risk of developing cancer.

..... (*1 mark*)

6 Identify the risks associated with anticoagulant drugs that must be taken by artificial heart recipients.

..... (*1 mark*)

7 Explain why it would be beneficial for patients with pacemakers to wear a bracelet or necklace inscribed with that information.

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..... (*2 marks*)

8 Taking the role of a consultant surgeon, write a note to justify the recommendation that a patient should receive an artificial heart.

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..... (*2 marks*)

9 Taking the role of a hospital financial administrator, write a note of guidance justifying limitations of the use of artificial heart surgery.

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..... (*3 marks*)

Close up on the kidney

Specification references:

- B5.3.3 Maintaining water and nitrogen balance in the body
- B4.1.3 Transport in cells
- WS 3.5

Aims

This task is focused on the way the kidney adjusts the water and salt balance in the blood. You will know that a mixture of substances is filtered out of the blood and that most of this is reclaimed by selective reabsorption. But how does the kidney manage to do this? The aim of this task is to focus on the nephron – a clever bit of biological design that makes use of cell membrane transport to ensure your water and salt stay in balance.

Learning outcomes

After completing this worksheet, you should be able to:

- describe how the filtrate is adjusted by selective reabsorption in a nephron
- use the mechanisms of membrane transport to explain the movements of water and soluble molecules between the filtrate and the blood
- understand that the design of the nephron in different animals is associated with environmental adaptation.

Task

Take a look at **Figure 1** showing a kidney in longitudinal section. One of the nephrons (kidney tubules) is enlarged.

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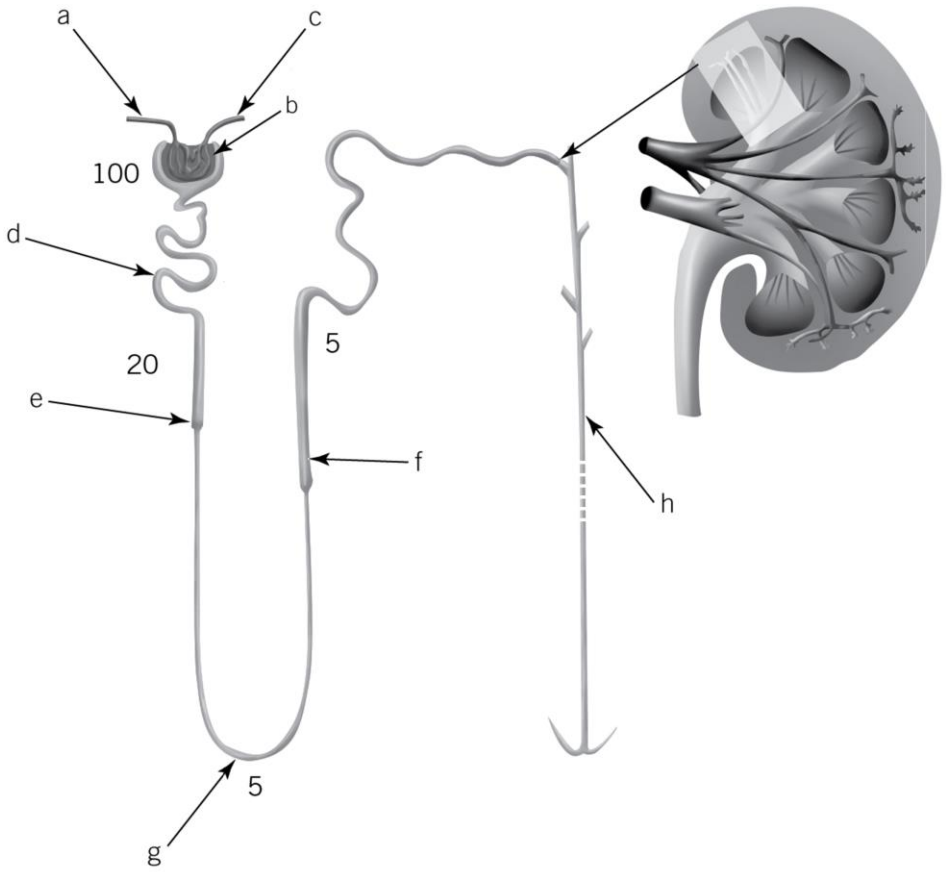

Figure 1

Questions

1 Blood arrives at point **a** and enters a ball of capillaries called a glomerulus **b**. The blood then leaves through a narrower blood vessel at **c**.

a What causes the blood pressure to be slightly raised in structure **b**?

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.....

..... (*2 marks*)

b Name two things that are not filtered out of the blood into the kidney tubule.

.....

..... (*2 marks*)

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2 The urine filtrate enters the flared end of the nephron. Active transport is used to pump the glucose back into the blood from area **d**.

a What is meant by the term active transport?

.....

.....

..... (*3 marks*)

b How will the removal of the glucose change the concentration of the filtrate inside the nephron at **d**?

..... (*1 mark*)

3 The u-bend is called the loop of Henle. The descending part **e** is permeable to water but the ascending part **f** is waterproof. Salt is moved back into the blood from the ascending part of the loop of Henle.

a What effect will the movement of salt at part **f** have on the filtrate at point **e**?

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..... (*3 marks*)

b the numbers in **Figure 1** show the percentage of filtrate left in the nephron at different points. Explain the change in volume that occurred in the tubule at **d**.

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.....

..... (*2 marks*)

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4 Describe and explain how the concentration of the filtrate changes as it passes from point **e** to point **f** along the loop of Henle.

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..... (*4 marks*)

5 What is the significance of parts **f** and **h** being impermeable to water?

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..... (*3 marks*)

6 The loop of Henle is very long in a camel but very short in a beaver. Suggest how this difference is of adaptive significance to the two animals

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Ventilation

Specification reference

- B2.2.2 The heart and blood vessels

Aims

This activity aims to support your understanding of the structure and function of the lungs and the process of ventilation.

Learning outcomes

After completing this activity, you should be able to:

- list the main structures of the gas exchange system
- state that gas exchange happens in the alveoli
- use data in the form of percentages to describe the differences in the composition of inhaled and exhaled air
- describe the function of the main structures of the gas exchange system
- describe how alveoli are adapted
- describe the processes of ventilation and gas exchange
- explain in detail how adaptations of alveoli result in efficient gas exchange
- explain the differences between the composition of inhaled and exhaled air.

Task

Step 1 Label the main structures in the gas exchange system shown in the Figure on the next page.

Step 2 Describe the function of each structure.

Step 3 Explain how an alveolus is adapted to perform its function. You may want to draw a labelled diagram.

You can refer to Topic B4.5 in the student book to help you with this task.

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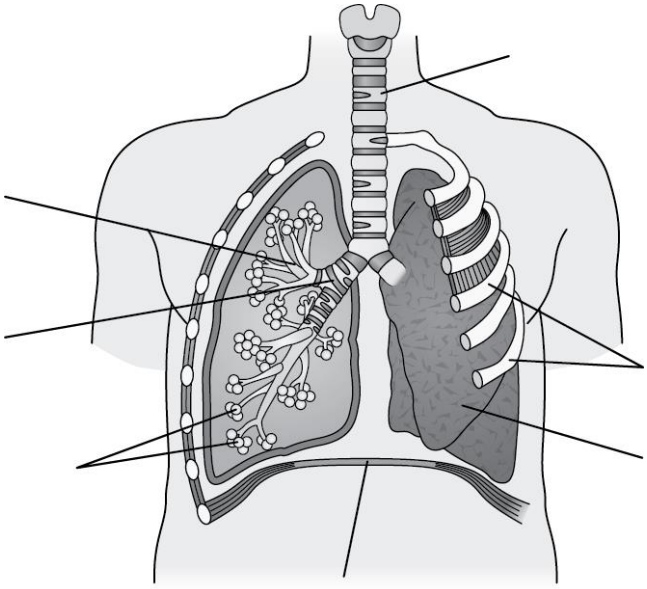

The process of breathing in (inhalation) and out (exhalation) involves several groups of muscles in the chest working together. The air passes through a sequence of different tubes on its way to the lungs.

Step 4 Sort the statements below into two groups – those that describe the stages of inhalation and those that describe the stages of exhalation. Then put each group into the correct sequence. Write each statement in the Table provided.

External intercostal muscles contract	External intercostal muscles relax	Volume of the chest increases
Air is forced out of the lungs	Diaphragm flattens	Air is drawn into the lungs
Volume of the chest decreases	Internal intercostal muscles relax	Ribs move downwards and in
Pressure inside the chest increases	Diaphragm moves upwards	Internal intercostal muscles contract
Ribs move upwards and out		Pressure inside the chest decreases

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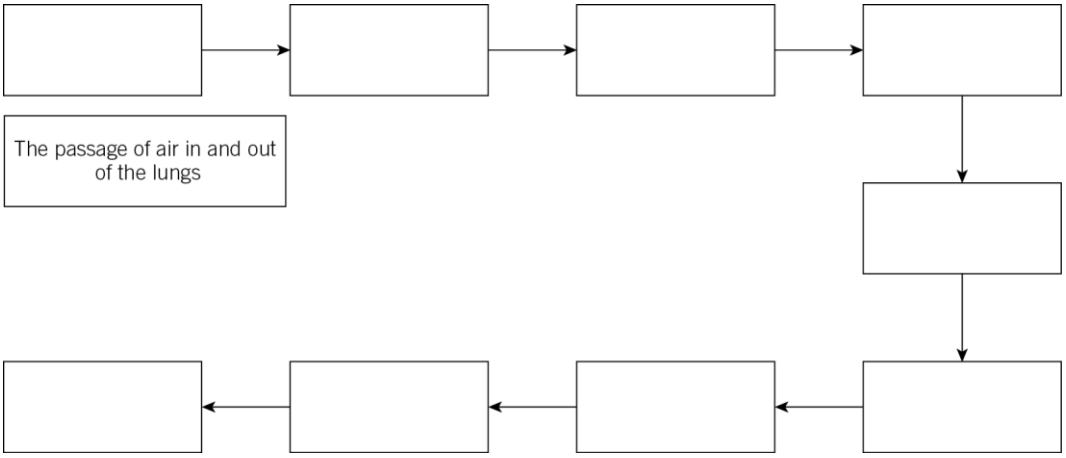
Inhalation	Exhalation

Questions

1 Using the words provided, fill in the boxes in the flow diagram below to show the sequence of structures that the air passes through on its way into and out of the lungs. You will need to use most of the words more than once.

alveoli *trachea* *nose* *bronchi* *bronchioles*



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2 Link each structure with its function in ventilation:

Diaphragm	Contract to pull the ribcage up and outwards
Intercostal muscles	Sheet of muscle that contracts to increase the volume of your chest cavity
Alveoli	Maintain concentration of gases between lungs and blood to maximise gas exchange
Capillaries	Increase surface area of the lung to maximise gas exchange

3 **a** Describe what happens during exhalation.

b State and explain **one** similarity and **one** difference between the composition of inhaled air and exhaled air.

4 Explain in detail how the lungs are adapted to maximise gas exchange.

A biochemistry detective story

Specification references

- B4.1.1 Photosynthetic reaction
- B4.1.2 Rate of photosynthesis
- B4.1.3 Uses of glucose from photosynthesis
- MS 1a, 1c, 2a, 3d
- WS 1.2, 2.2, 3.3, 3.5, 4.6

Aims

The aim of this task is to extend your understanding of the biochemistry of photosynthesis by using some experimental data to introduce some of the detail you will encounter at A level.

Learning outcomes

After completing this worksheet, you should be able to:

- calculate R_f values from chromatograms
- understand that photosynthesis is a complex set of reactions that occurs in a sequence

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- recall that the product of photosynthesis is transported to other areas in a plant and converted to new compounds.

Setting the scene

In 1961 Melvin Calvin received a Nobel Prize for his work on photosynthesis. He used radioisotopes of carbon (^{14}C) to trace the sequence of reactions leading to the production of sugars in photosynthesis. To do this, he used chromatography to separate the compounds present in samples of photosynthesising algae after set time intervals following their exposure to a source of radioactive carbon. The radioactive carbon was detected in each compound by laying the chromatography paper precisely over photographic film. The radiation caused a small dark spot to be exposed on the film, showing where each compound was.

The experimental sequence was as follows:

- place algae in reaction vessel
- introduce radioactive carbon source
- switch on light and start timer immediately
- after set time drop the algae into hot ethanol
- extract and analyse chemicals in algae samples.

Worked example

To calculate an R_f value measure the total distance moved by the solvent. Next measure the total distance moved by the compound. Measure to the centre of the spot formed by the compound. Find R_f by using:

$$R_f = \frac{\text{distance moved by the compound}}{\text{distance moved by the solvent front}}$$

Task

Figure 1 shows some diagrams of Calvin's chromatograms. They show the compounds found in the algae after 5, 10, 30, and 120 seconds of photosynthesis. The origin and the solvent front are marked.

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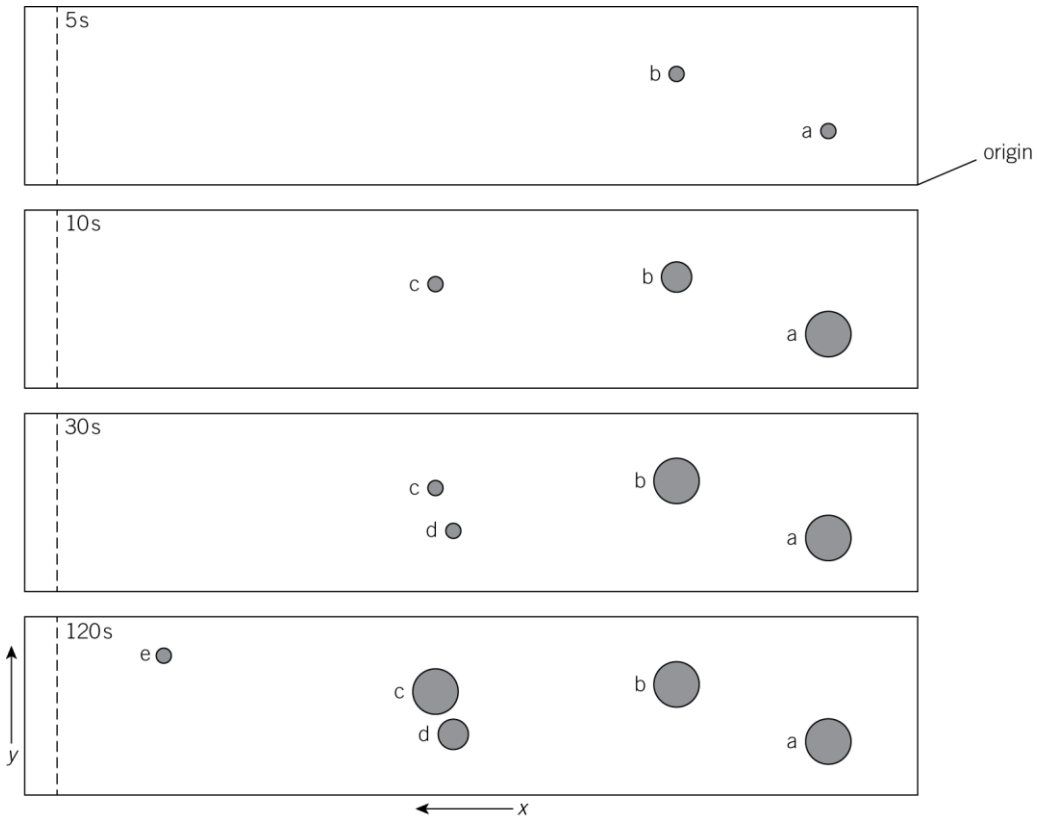

Table 1

Compound	Number of carbon atoms	R_f value
ribulose bisphosphate	5	0.08
glycerate phosphate	3	0.23
triose phosphate	3	0.46
glucose	6	0.44
sucrose	12	0.78

Questions

1 Write a balanced symbol equation for photosynthesis.

..... (*2 marks*)

2 **a** Suggest two controls that Calvin could have used in his experiment.

.....

..... (*2 marks*)

b Suggest why the hot ethanol stage is used.

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..... (*2 marks*)

3 Use the diagrams in Figure 1 to find the R_f values of the compounds labelled a–e. Give your answers to two decimal places.

a R_f = ...

b R_f = ...

c R_f = ...

d R_f = ...

e R_f = ... (*5 marks*)

4 Describe the changes in the compound indicated by the spot labelled b over the 120 s period of the experiment.

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..... (*3 marks*)

5 Use Table 1 to identify the compounds represented by the spots.

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..... (*5 marks*)

6 Use the data to reconstruct the order in which the compounds are formed.

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..... (*2 marks*)

7 **a** Table 1 shows how many carbon atoms there are in each compound. Use the information in Table 1 to explain the number of carbon atoms in the sucrose.

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..... (*2 marks*)

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b If a similar experiment was done with a geranium plant and the radioactive sucrose was transported away from the leaf, identify two compounds that might subsequently be found to contain radioactive carbon and where they could be in the plant.

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..... (*4 marks*)

Student follow-up

Compare the numbers of carbon atoms in the ribulose bisphosphate and the next compound formed. Using your answer from Question **1**, can you suggest how to balance the equation to get