Surname	Centre Number	Candidate Number
Other Names		2

GCE A LEVEL

1400U30-1

S19-1400U30-1

BIOLOGY – A2 unit 3
Energy, Homeostasis and the Environment

MONDAY, 3 JUNE 2019 – AFTERNOON

2 hours

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**15**	
2.	**7**	
3.	**12**	
4.	**20**	
5.	**18**	
6.	**9**	
7.	**9**	
Total	**90**	

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ADDITIONAL MATERIALS

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

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen. Do not use correction fluid.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page 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.

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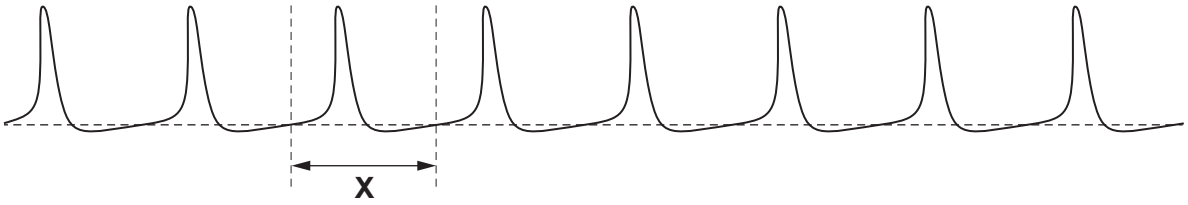
Answer **all** *questions.*

1. *(a)* Scientists applied different constant pressures to a sensory neurone to investigate the production of action potentials.

At the highest pressure the oscilloscope trace of the action potentials looked like this.



The time taken to complete one action potential is marked as **X** on the trace.

There were 120 action potentials produced each second.

(i) How long did each action potential (time **X**) last? Give your answer to the nearest millisecond. [2]

Time for one action potential = ... ms

At the lowest pressure applied the trace appeared as shown below.

(ii) Explain why the trace appeared this way for the lowest pressure. [2]

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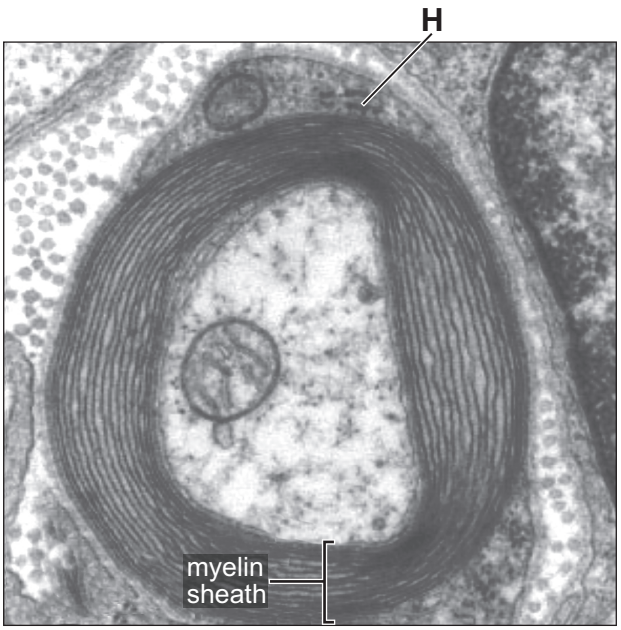
(b) The electron micrograph shows an axon surrounded by myelin sheath.



Cell **H** forms the myelin sheath.

(i) Name cell **H**. [1]

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(ii) Name the main class of biological molecule found in myelin. [1]

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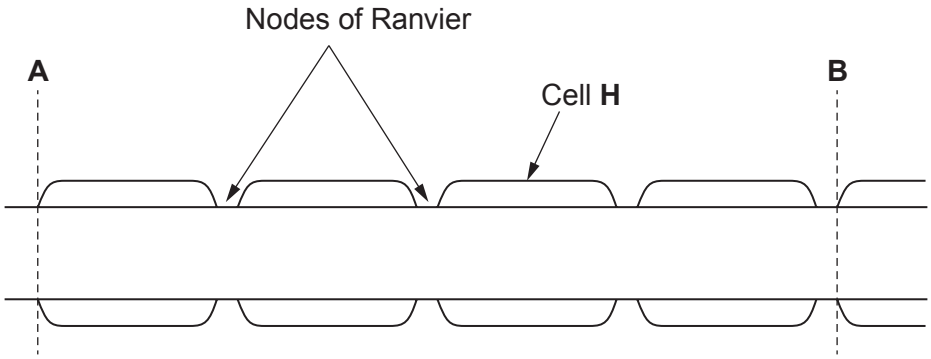
The neurone appears like this when drawn as a side section.



Drawing not to scale

The distance between **A** and **B** is 5150 µm.

The usual figure given for the speed of conduction of an action potential in a myelinated neurone is 1×10^8 µm s^{-1}.

(iii) Calculate the time it would take an action potential to travel from point **A** to point **B** on an actual neurone. Give your answer in standard form in seconds. [3]

Time = ... s

Examiner only

(c) It has been found that organophosphates, which are used in some pesticides, can cause the myelin sheath to become damaged. In people who handle organophosphates, the myelin sheath may degenerate and leave the membrane of the axon exposed.

(i) Suggest what would happen to the rate of oxygen consumption for the demyelinated neurone. Explain your answer. [4]

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(ii) Suggest **two** symptoms which could occur in someone who has demyelinated neurones. [2]

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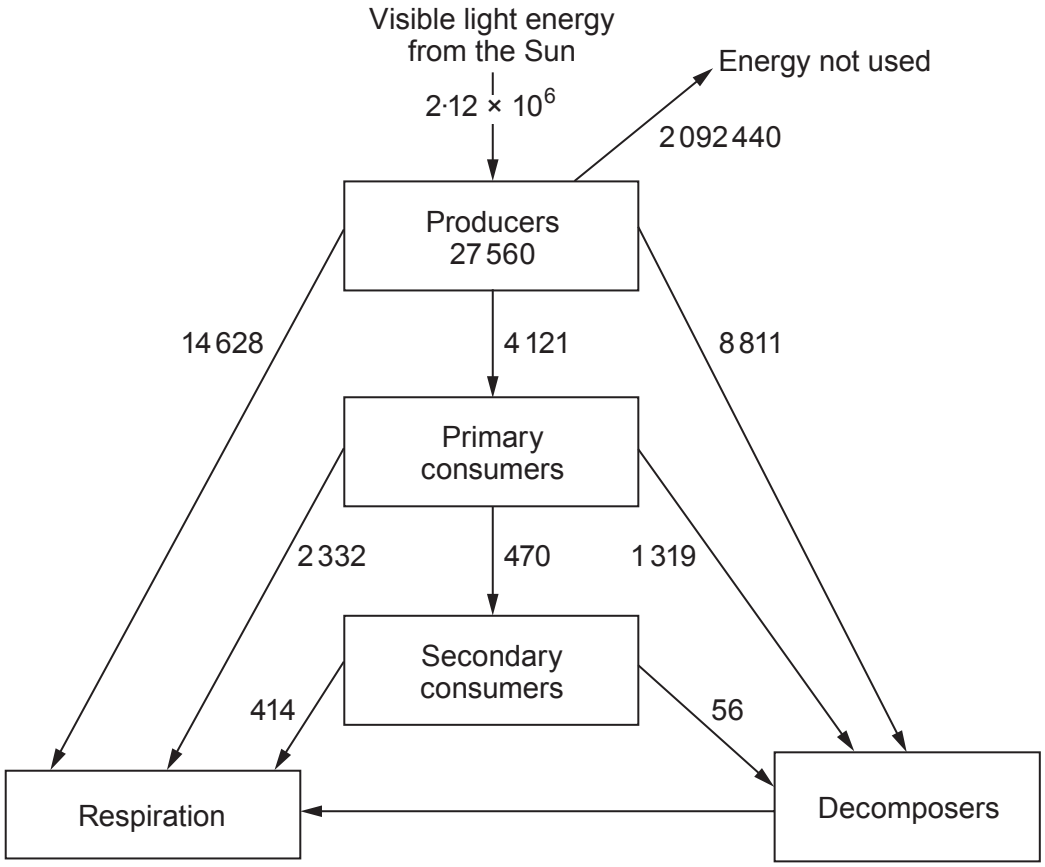
2. The mean energy flow per year through a tropical forest ecosystem in Peru, South America was measured. The results are shown in the diagram below in $kJ\,m^{-2}\ year^{-1}$.



(a) (i) Give **one** reason why not all of the solar energy falling on the producers is used to form biomass. [1]

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(ii) Using the information given in the diagram, calculate the percentage of energy from the Sun that is fixed by photosynthesis. [2]

Percentage of energy = ... %

Examiner only

(b) Planetary boundaries are designed to define a safe operating space for humanity to control the stability of the land, atmosphere and the sea.

One such boundary that has been crossed is the Biodiversity Boundary. This is measured in the number of species becoming extinct per million species per year. The boundary is 10 species but the current loss is over 100 species per year.

In this area of Peru, the rainforest trees are harvested using the strip felling technique. This involves harvesting the trees in an area 50 m wide. That area is then left uncut for forty years allowing natural regeneration of the rainforest; this is a sustainable alternative to felling trees on a mass scale.

The photograph below shows an area of strip felling five years after harvesting.

Explain why this method of tree harvesting is helping to reduce the extinction rate whereas mass felling of trees is not. [4]

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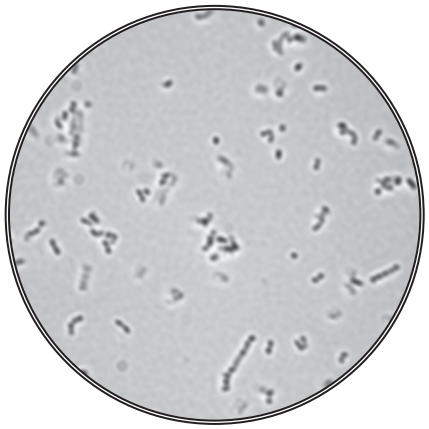
3. The Breed method is a fast and simple way of counting the number of bacteria in a suspension.

A known volume of the bacterial suspension is spread uniformly over a glass slide covering a specific area. The bacteria are then heat fixed and stained.

The photograph below shows the results of this method as seen through a light microscope.



(a) The average number of cells in the field of view was found to be 156 and the radius of the field of view was 0.09 mm.

Calculate the number of cells in 100 mm^2.

The area of microscopic field of view = πr^2

where π is 3.14 and r is the radius of the field of view. [3]

Number of cells = ...

Examiner only

(b) A scientist used this method to find the number of bacteria in a sample taken from the back of a patient's throat. There were too many bacteria to be able to count down the microscope.

(i) Describe a method that could be used to produce a range of dilutions from the original sample to a 10^{-5} dilution. [3]

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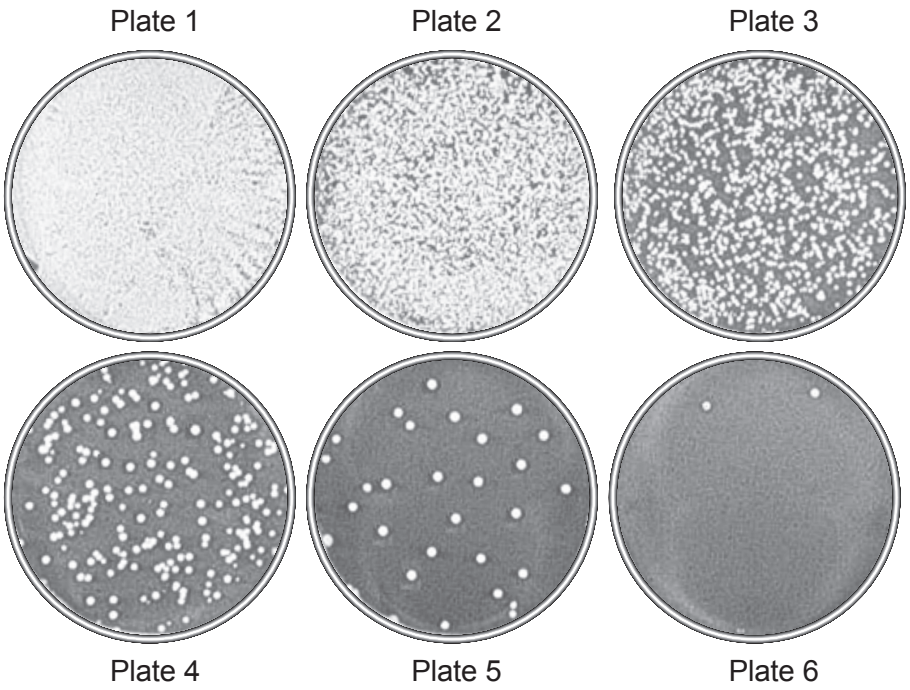
The scientist obtained the following results for a range of dilutions.



(ii) State which number plate should be used and give reasons why the other plates should not be used. [3]

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The scientist was looking for the pathogenic bacterium *Staphylococcus aureus*.

(iii) Give the reason why the bacteria removed from the patient were incubated at 37 ºC not 25 ºC. [1]

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(iv) A sample of the *Staphylococcus* was stained purple by the Gram stain technique. Describe what the purple staining indicates about the structure of the bacterial cell wall. [2]

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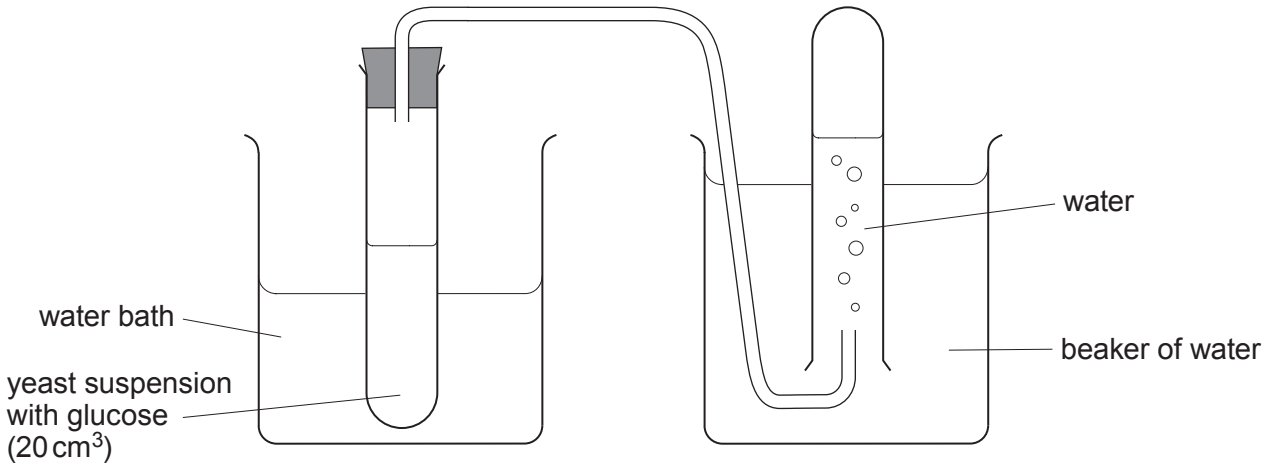
Examiner only

4. *(a)* A group of students carried out the following experiment to investigate the effect of temperature on the rate of aerobic respiration in yeast.

A yeast suspension containing glucose, made up in pH 7 buffer, was added to a boiling tube. The apparatus was set up as shown below.



The boiling tube was placed in a water bath at 10 °C. The apparatus was left for three minutes. The students then counted the number of bubbles released every minute for five minutes.

The students repeated the procedure at 5 °C intervals from 15 °C to 40 °C, each time using fresh yeast suspension with glucose from the same batch. Oxygen was available to the yeast throughout the experiment.

(i) State the dependent variable in this experiment. [1]

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(ii) Explain why the number of bubbles may decrease if a fresh yeast suspension with glucose was not used for each repeat. [1]

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(iii) When investigating the rate of respiration, counting the number of bubbles is a limitation.
Explain this limitation and suggest how it can be overcome. [2]

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Examiner only

(iv) State the effect of respiration at 30 ºC on the pH of the yeast suspension in the absence of a buffer. Explain your answer. [2]

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(v) The students then carried out the procedure with sucrose replacing the glucose in the yeast suspension.
The initial rate of respiration was found to be lower when sucrose was used as the substrate instead of glucose. Suggest why this may happen. [2]

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(vi) ATP is a more useful immediate energy source for cell metabolism than either glucose or sucrose. Explain why ATP is described as an *universal energy currency*. [2]

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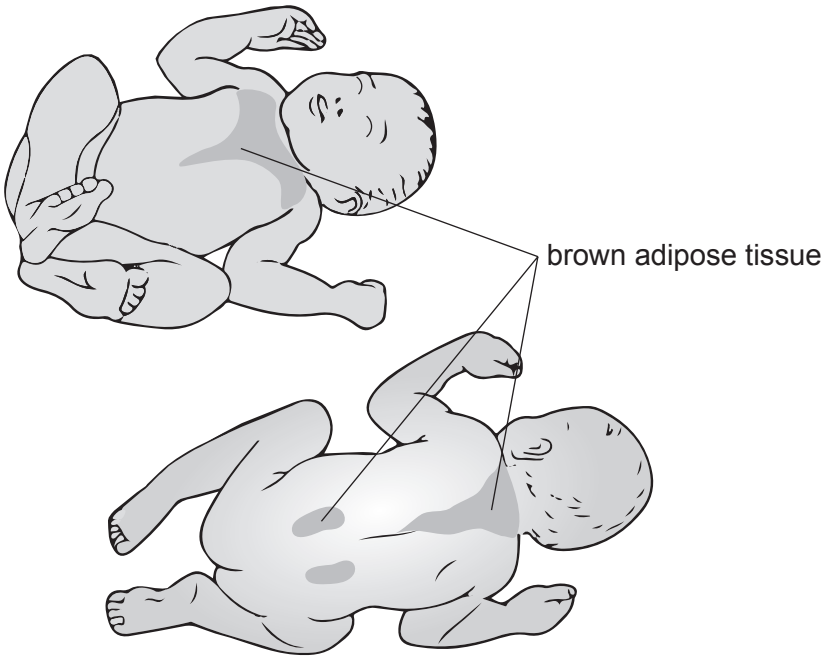
(b) A group of scientists investigated the rate of respiration in brown adipose tissue. There is a high proportion of this tissue in newborn babies as shown below.



The cells in brown adipose tissue contain a much higher number of mitochondria than the cells of white adipose tissue; this gives the brown adipose tissue its colour.

The scientists isolated mitochondria from brown adipose tissue cells and used them to investigate some aspects of respiration. The mitochondria were placed in a solution with pyruvate as the respiratory substrate. An oxygen electrode was used to monitor the concentration of oxygen present in the solution.

(i) Explain why pyruvate was used as a respiratory substrate rather than glucose. [3]

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Examiner only

(ii) When ADP was added to the solution, the concentration of oxygen present dropped by 40%. Explain this observation. [2]

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(c) (i) State what happens to the energy that is not incorporated into ATP during respiration and the benefit of this to a newborn baby. [2]

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Adipose tissue samples can be fixed and cut into sections to be viewed through a microscope. The number of capillary lumens can be counted in a given area along with the number of fat cells (adipocytes). The results are expressed as number of capillaries per adipocyte.

The table below gives the capillary density in brown adipose tissue and white adipose tissue.

Adipose tissue type	Number of capillaries per adipocyte
white	0.4
brown	0.8

(ii) Explain how the data in the table above shows that having a higher proportion of brown fat is of benefit to the baby. [3]

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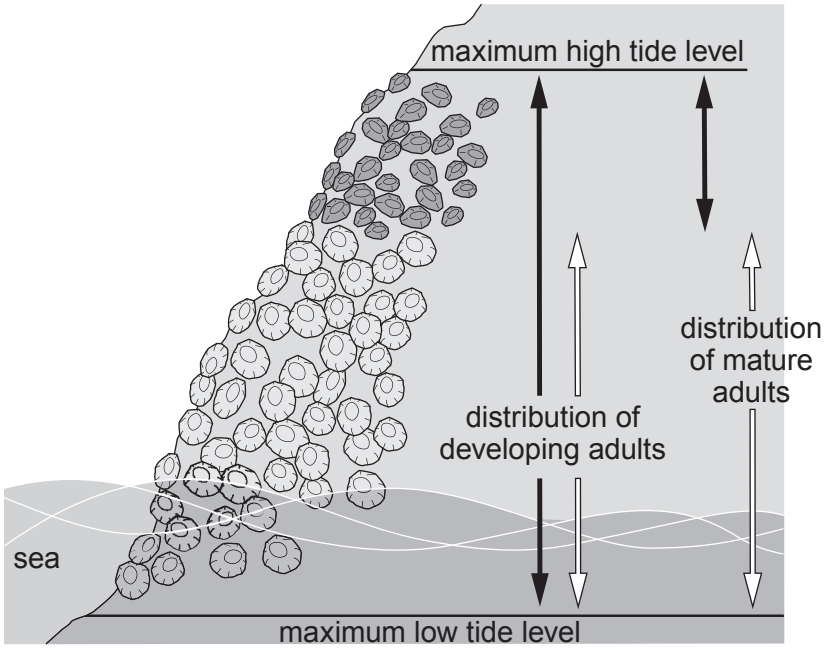
Turn over.

5. Barnacles are marine animals related to crabs and lobsters. They have an external shell made of several plates. They live in shallow tidal waters and the adults are attached permanently to a hard surface. They feed by filtering particles from the water using their modified feathery legs. When they reproduce, they produce larvae which swim in the sea until they attach to a hard surface and begin to grow into adults.

Barnacles are commonly found on rocky shores around the coast of Wales. The two most common species are *Semibalanus balanoides* and *Chthamalus stellatus*.

A rocky shore was studied and the distribution of these species was found as shown in the diagram.

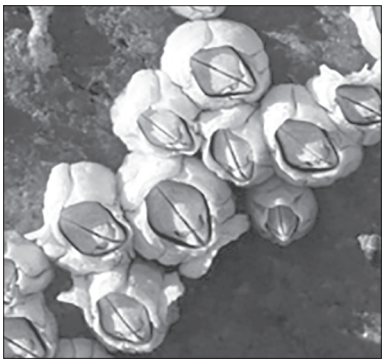


Distribution of *Chthamalus stellatus*

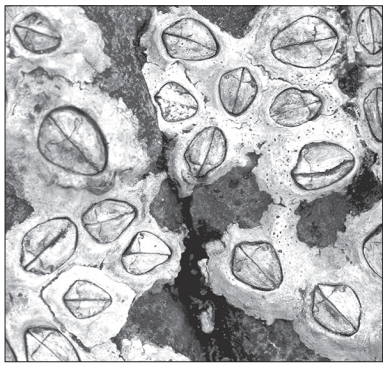
Distribution of *Semibalanus balanoides*

Chthamalus stellatus

Semibalanus balanoides



Chthamalus stellatus



Semibalanus balanoides

Examiner only

(a) Near the maximum high tide level only *Chthamalus* barnacle larvae develop into adults.

(i) State the type of competition occurring in this area and what the mature adults could be competing for. [2]

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(ii) Scientists removed *Chthamalus* from the upper area continually for several weeks and observed that *Semibalanus* did not colonise this area. Suggest a possible explanation why *Semibalanus* cannot colonise this area. [1]

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(iii) Scientists then removed *Semibalanus* from the lower area continually for several weeks and observed that *Chthamalus* were found in this cleared area. Give an explanation for this observation. [2]

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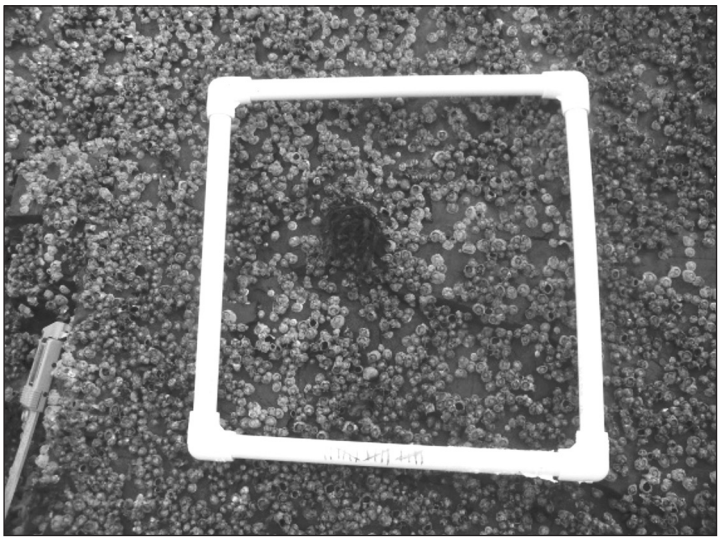
Examiner only

In 2005, 100 life-sized human sculptures were installed, at different distances between low and high tide marks, on a sandy beach near Liverpool. A year later it was noticed that some of these structures had become covered in barnacles. All of the barnacles belonged to the species *Austrominius modestus*. The photographs below show one of the statues and a 0.1 m × 0.1 m quadrat being used on the statue.



Scientists selected sculptures to look at the distribution of the barnacles at different positions on the shore.

(b) (i) Describe the method by which reliable data would have been collected. [4]

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Examiner only

(ii) If there is decreased salinity in the surrounding water (e.g. in an estuary) *Austrominius* are able to carry out active transport to remove sodium ions from their cells. Explain why they would be unable to survive if this did not occur. [3]

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(c) Two varieties of *Austrominius* were found on one of the sculptures.

(i) A sample of DNA was taken from each of the varieties. State the technique that could be used to show the relatedness of the two varieties of barnacles. [1]

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(ii) State **two** possible causes of increased DNA mutation rate. [1]

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Examiner only

(d) *Austrominius modestus* is a species of barnacle that was found only in Australasia up to 100 years ago. The first recorded sighting of it in the UK was in 1946. In 2014, a survey of sixteen harbours in Wales found *Austrominius* in all of the harbours surveyed. It is now classified as an *"invasive species"*.

At the time of the survey there were just a few *Austrominius* barnacles in each of the harbours.

State why the Welsh Government is concerned about the presence of *Austrominius* in the harbours. Your answer should include environmental and economic concerns. [4]

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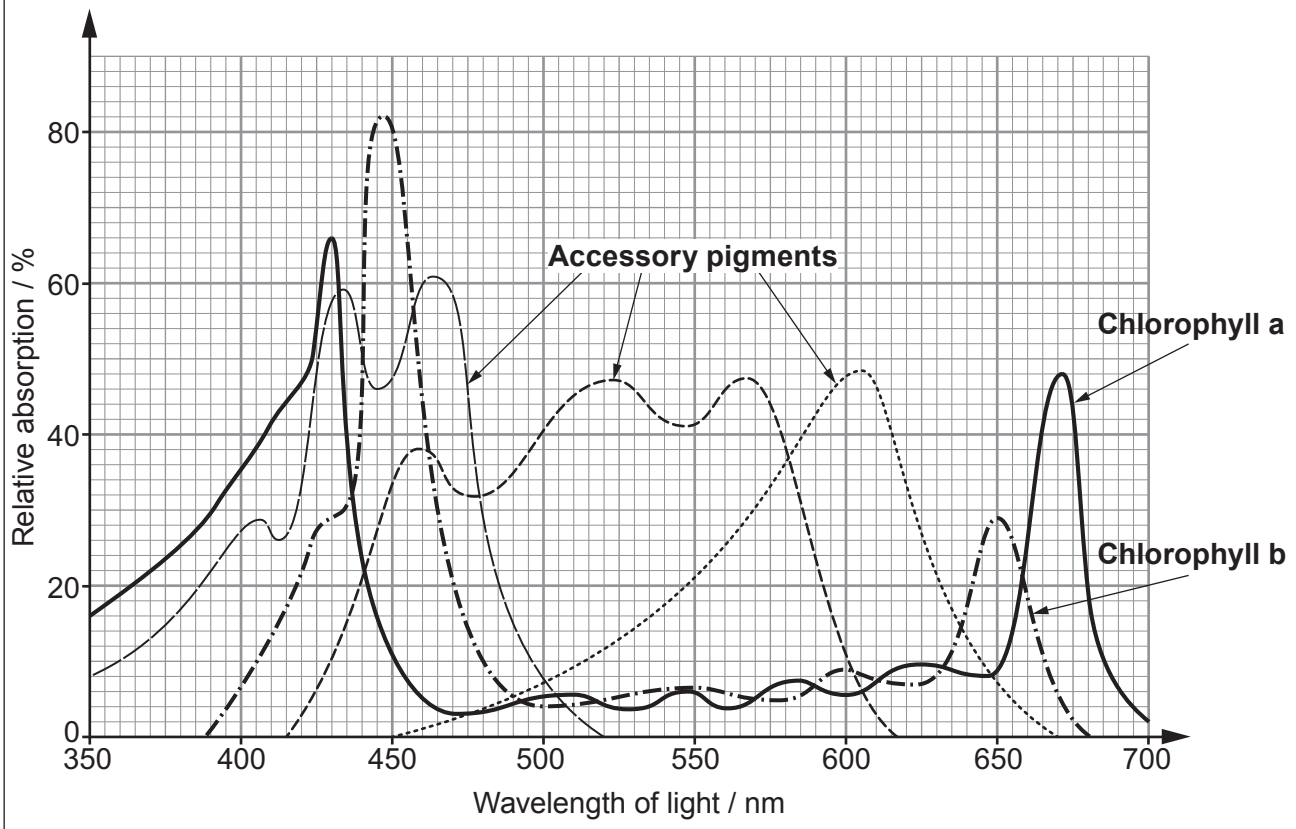
6. *(a)* Chlorophyll a, Chlorophyll b and other accessory pigments, absorb light energy for use in photosynthesis.

The graph below shows the absorption spectrum for each of these pigments.



(i) Which wavelength of light is most effectively absorbed by Chlorophyll b? [1]

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(ii) Why are accessory pigments present in the chloroplast? [1]

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(b) Green sulfur bacteria are obligate anaerobes that are found in hot volcanic springs.

(i) State what is meant by the term "*obligate anaerobe*". [1]

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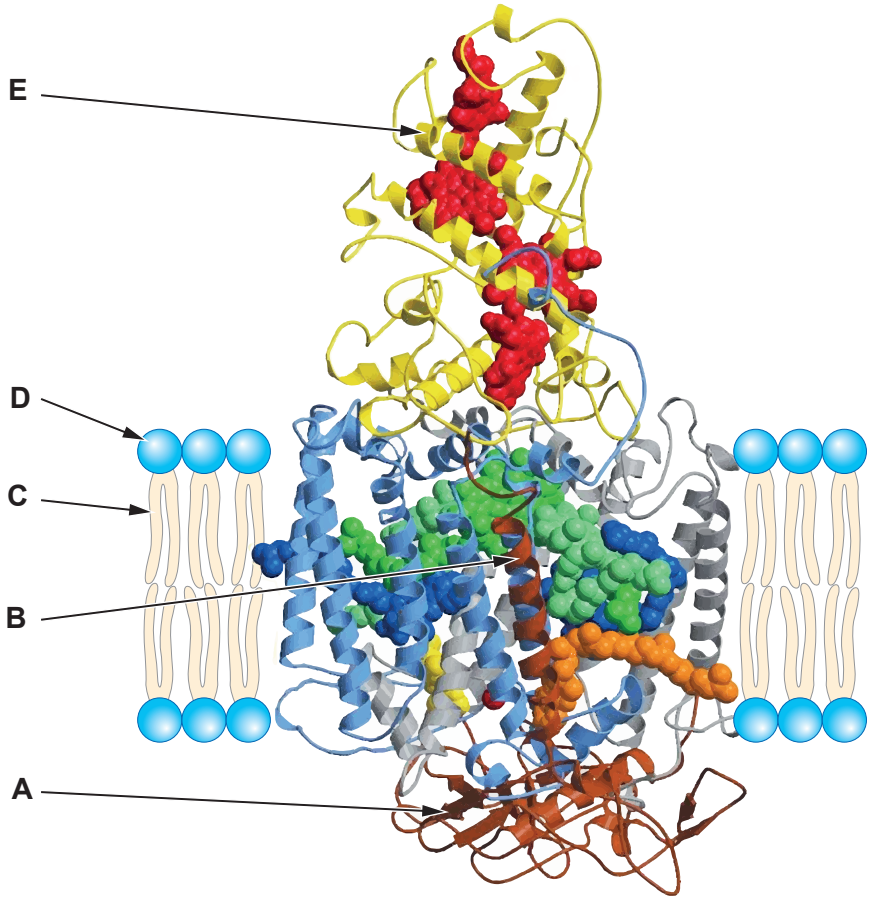
Examiner only

Green sulfur bacteria are able to photosynthesise but they are different from green plants. Their plasma membranes are evolved to carry out the process.

A membrane protein complex (photosystem) contains the photosynthetic pigments. A model of this protein is shown in the diagram below.



(ii) Part of the protein is hydrophobic. Identify which letter (**A-E**) was used to label a region of the protein that would have hydrophobic properties. Explain your answer. [2]

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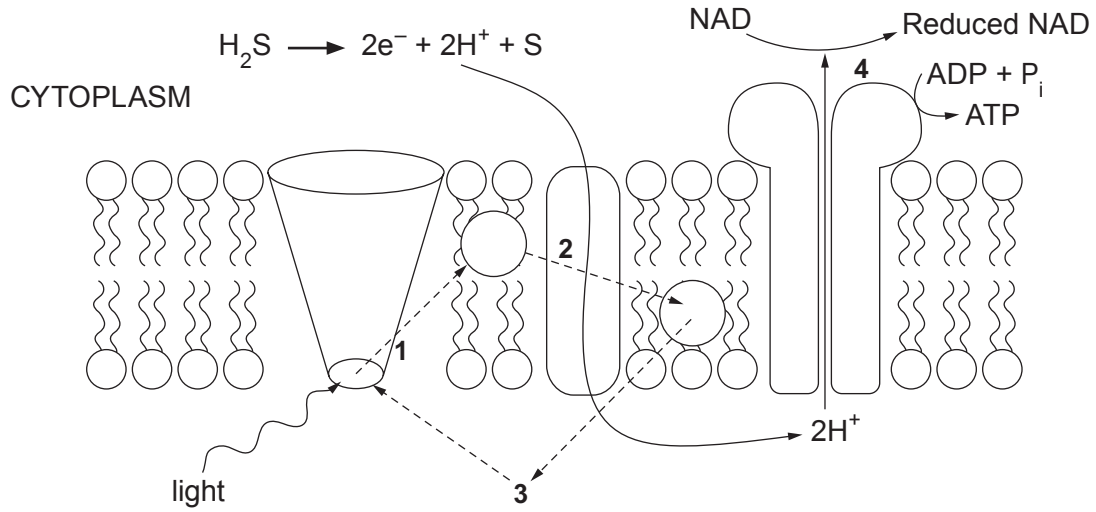
The diagram below shows a representation of the plasma membrane from the green sulfur bacterium *Chlorobium*. The reaction centre of this photosystem contains bacteriochlorophyll, a type of carotenoid.



1. Electrons are excited and released from the reaction centre containing bacteriochlorophyll.
2. The electrons are passed down a series of carriers which fuel a proton pump.
3. The electrons are passed back to the reaction centre.
4. Protons diffuse back into the cytoplasm and reduce NAD. ATP is formed.

(c) Using the information above and your own knowledge, describe the differences between the light-dependent reaction in green plants compared with green sulfur bacteria. [4]

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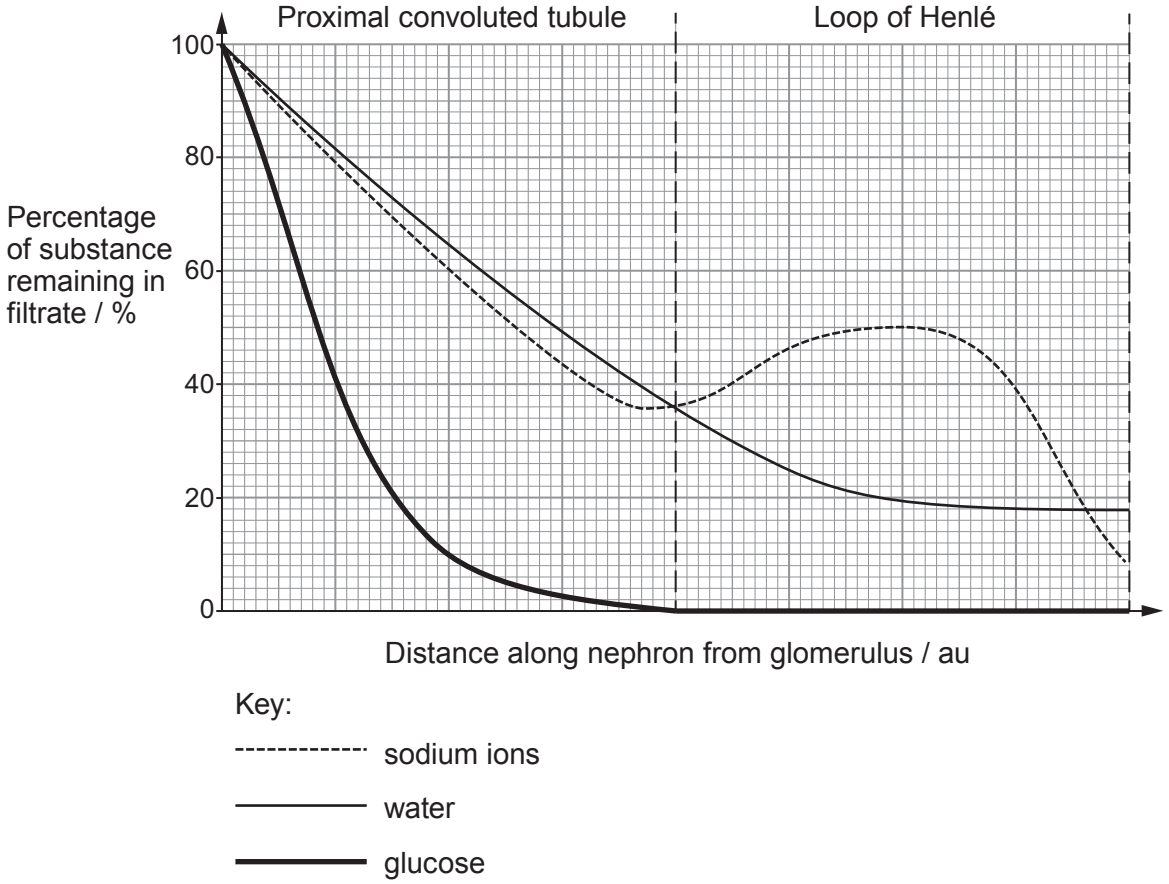
Examiner only

7. The kidneys have an important role to play in the removal of urea and homeostasis in the body. Along the length of a nephron there are mechanisms which regulate the balance of water and dissolved solutes in the blood.

The graph below illustrates the changes in the percentage of sodium ions, glucose and water remaining in the filtrate as it passes from the start of the proximal convoluted tubule to the end of the loop of Henlé.



Use the information from the graph to explain the changes in the filtrate as it passes through a nephron from the proximal convoluted tubule to the end of the loop of Henlé. [9 QER]

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END OF PAPER

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

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