Surname	Centre Number	Candidate Number
First name(s)		2

GCE A LEVEL

A400U10-1

S23-A400U10-1

WEDNESDAY, 7 JUNE 2023 – AFTERNOON

BIOLOGY – A level component 1
Energy for Life

2 hours

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**9**	
2.	**17**	
3.	**18**	
4.	**17**	
5.	**17**	
6.	**13**	
7.	**9**	
Total	**100**	

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ADDITIONAL MATERIALS

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

INSTRUCTIONS TO CANDIDATES

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

You may use a pencil for graphs and diagrams only.

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(s) 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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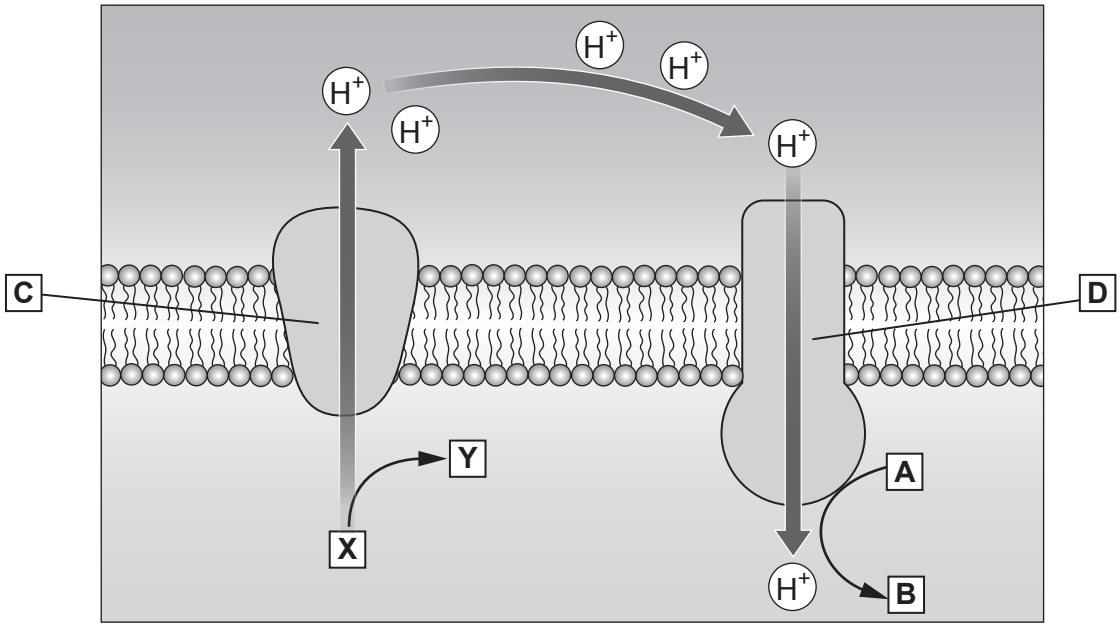
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Answer **all** questions.

1. ATP synthesis involves transferring energy from the flow of protons through an intrinsic protein complex. To enable the flow of protons through this protein complex, other structures are used to create a proton gradient across a membrane. This process is summarised in **Image 1.1**.

Image 1.1



(a) Use **Image 1.1** to answer the following questions.

(i) Name the following:

I. the **general** term for the protein labelled **C**. [1]

.....

II. the enzyme found in protein complex **D**. [1]

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(ii) Explain why protons are moved through structure **C** by a form of active transport but through structure **D** by facilitated diffusion. [2]

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(iii) **X** and **Y** represent a proton donor in two different forms.
Explain why **Y** is the oxidised form of the proton donor. [1]

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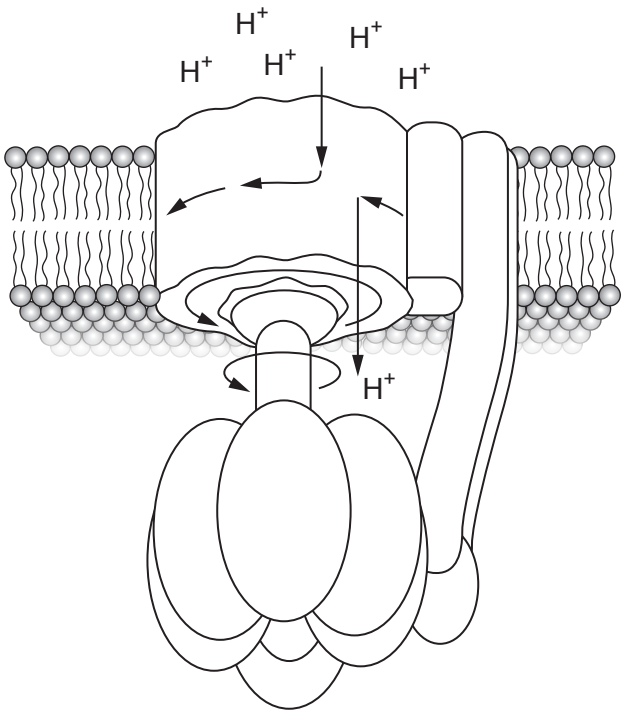
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(b) **Image 1.2** shows a model of the protein complex labelled **D** in **Image 1.1**. These structures are only found in two organelles of eukaryotic cells.

Image 1.2



(i) Name the **two** organelles in which structure **D** is found in eukaryotic cells and state precisely where it would be located in each of these organelles. [2]

Name of organelle	Location of structure **D**
.....	.....
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(ii) **Complete the boxes** below to show the reactants and products in the overall reaction that takes place in structure **D**. [1]



(iii) State if this reaction is endergonic or exergonic. Explain your answer. [1]

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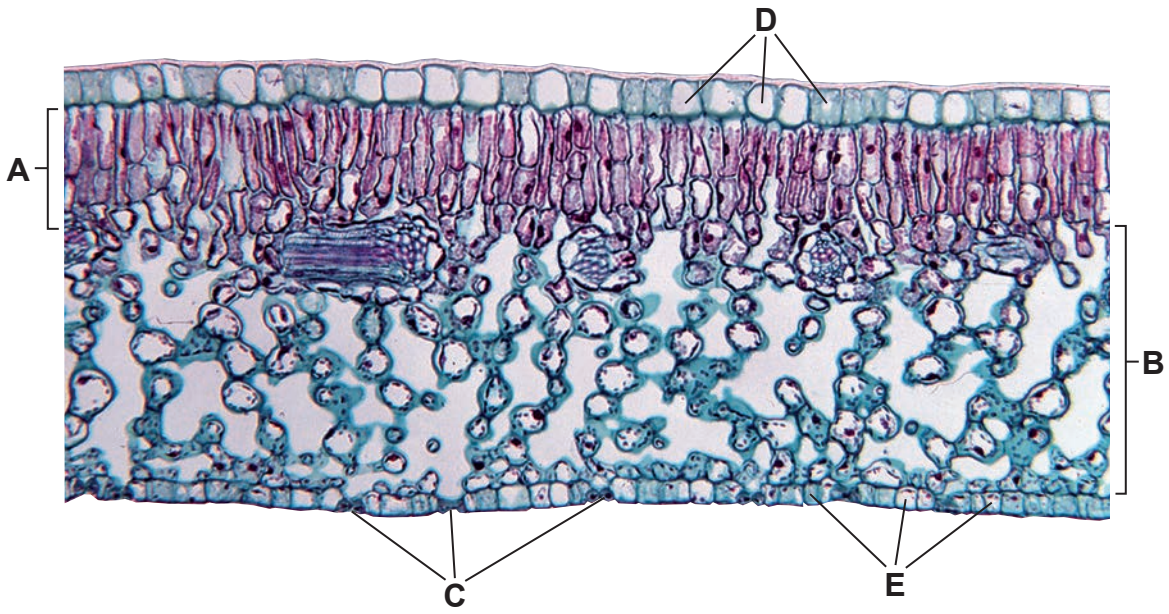
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2. During photosynthesis energy is transduced from light energy to chemical energy. This process takes place mainly in the leaves of a plant. The leaves show many adaptations to absorb the maximum amount of light energy.
Image 2.1 shows a transverse section through a leaf of a privet plant (*Ligustrum*).

Image 2.1



(a) (i) The tissue layer labelled **A** in **Image 2.1** is the main site of photosynthesis in the leaves of this plant. State the name given to this tissue layer. [1]

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(ii) State **one** adaptation shown by tissue layer **B** in **Image 2.1**. Explain the function of this adaptation. [2]

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(iii) Name **one** organelle present in cells of tissue layers **A** and **B** and the structures labelled **C** but **not** present in the cells labelled **D** or **E**. [1]

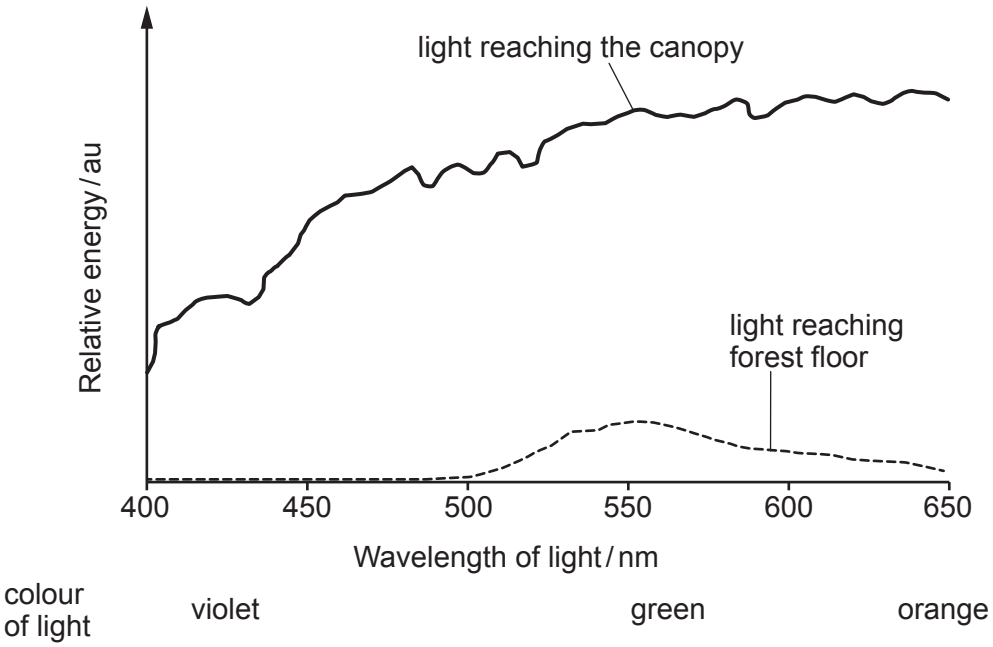
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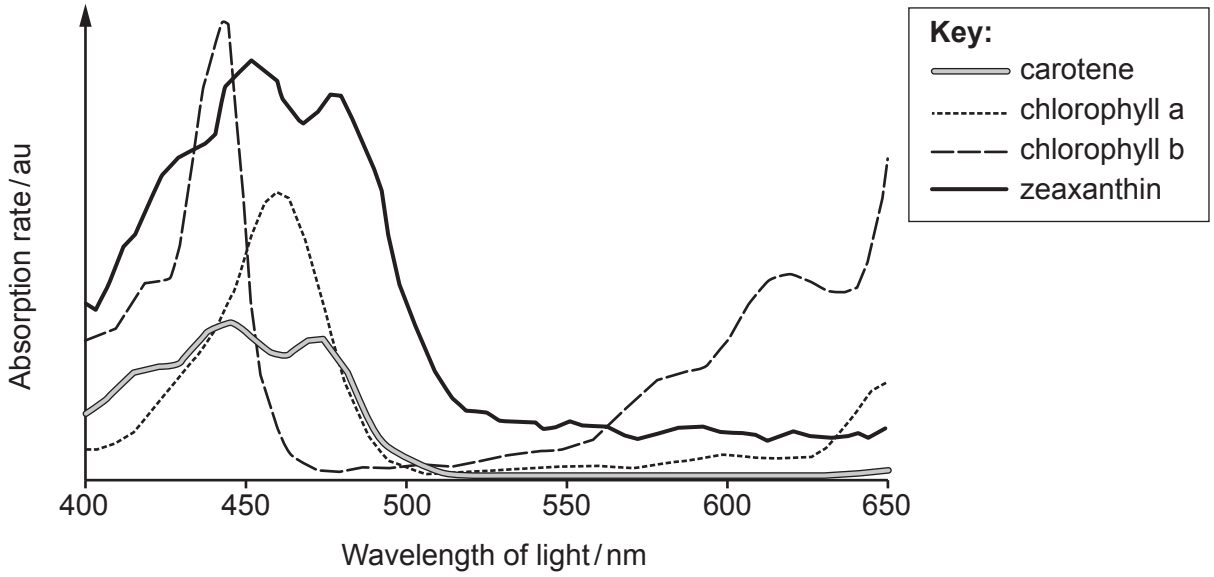
Green plants grow in a wide range of habitats but all need sufficient light to carry out photosynthesis. In shaded parts of a forest, most of the red and blue wavelengths of light are absorbed by leaves in the canopy and the light that reaches plants on the forest floor is mainly in the green/yellow region of the spectrum as shown in **Image 2.2**.

Image 2.2



To increase the efficiency of light absorption, chloroplasts contain a number of photosynthetic pigments. **Image 2.3** shows the absorption spectra of some photosynthetic pigments.

Image 2.3



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(b) Use all the information provided to suggest which **two** photosynthetic pigments might be found in higher concentrations in the leaves of plants growing on the floor of a forest compared to those in the canopy. Explain your answer. [3]

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(c) Intensity of light in some habitats is a limiting factor. Some plants respond to surviving in shade by growing larger leaves. In forests, trees fall into two main categories:

- those that can grow and survive in shade
- those that can only grow and survive in full sunlight, for example at the edges of a forest or in clearings.

Seeds were collected from two trees growing in a forest and germinated. They were then grown under low light intensity for ten days. The total leaf surface area of each seedling after ten days was recorded. Other environmental factors that could affect the growth of the seedlings were kept constant.

(i) State **three** factors that are required for the germination of seeds. [1]

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(ii) Explain why it was important that the seedlings were grown for **ten days** before the total leaf surface area was recorded. [1]

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(iii) The total leaf surface area of the seedlings was determined using the following method:

- cut out and weigh 1 cm^2 of leaf
- weigh all the leaves from the seedling
- divide the mass of the leaves by the mass of 1 cm^2 of leaf

Explain why this method provides a more accurate estimate of the total leaf surface area than drawing around each leaf on pieces of graph paper and then estimating the area covered by the leaf. [2]

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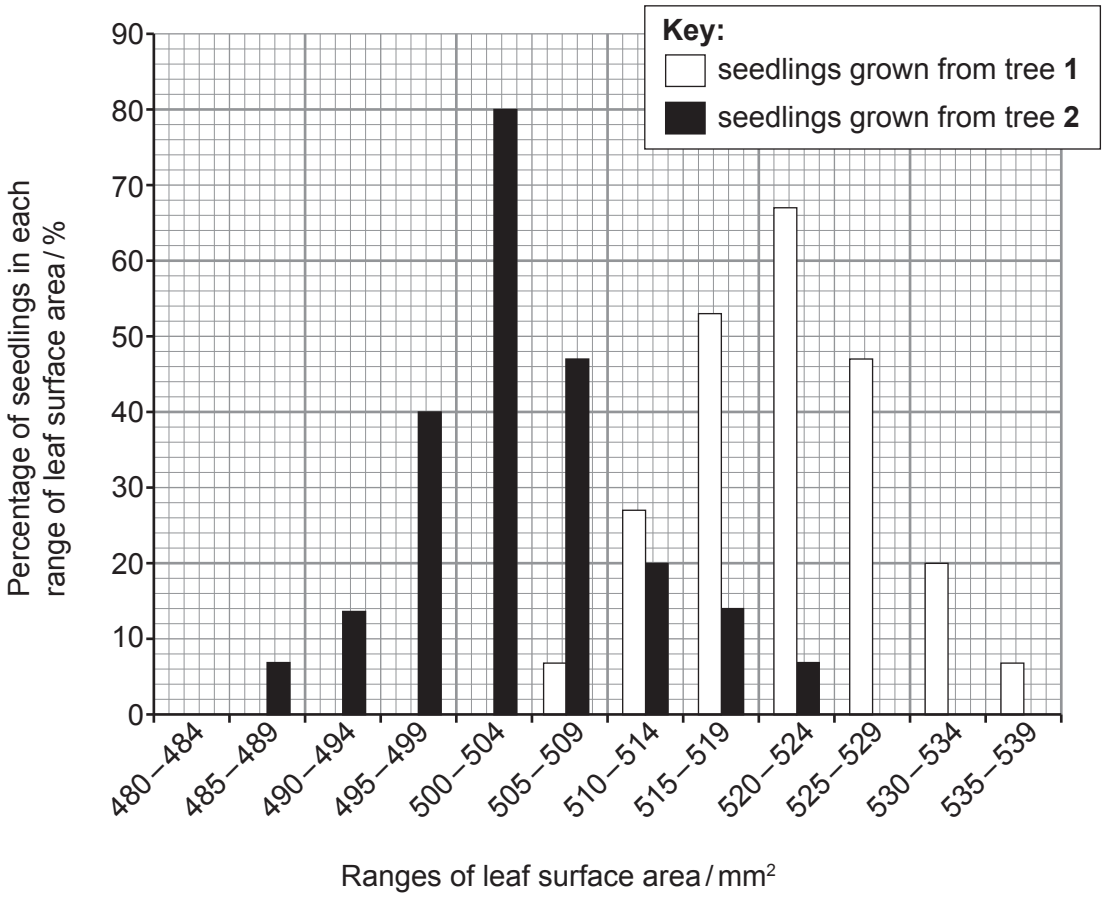
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The total leaf surface area (to the nearest mm^2) of the seedlings grown from each tree was grouped into 5 mm^2 ranges and the percentage of the seedlings in each leaf range calculated. A frequency histogram was plotted of the results. This is shown in **Graph 2.4**.

Graph 2.4



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(d) (i) State the 5 mm^2 range of leaf surface area in which the modal value would be found for the seedlings grown from each tree. [1]

modal value tree **1** = ... – ..... mm^2

modal value tree **2** = ... – ..... mm^2

(ii) The mean leaf surface areas of the seedlings grown from each tree were:

Tree **1** 522 mm^2
Tree **2** 504 mm^2

With reference to the information provided give **two** ways in which the data from both trees show a normal distribution. [2]

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(iii) Use **Graph 2.4** to conclude which tree was more likely to have been growing under the tree canopy. Use your knowledge of **leaf adaptations** to give **two** reasons to explain your answer. [3]

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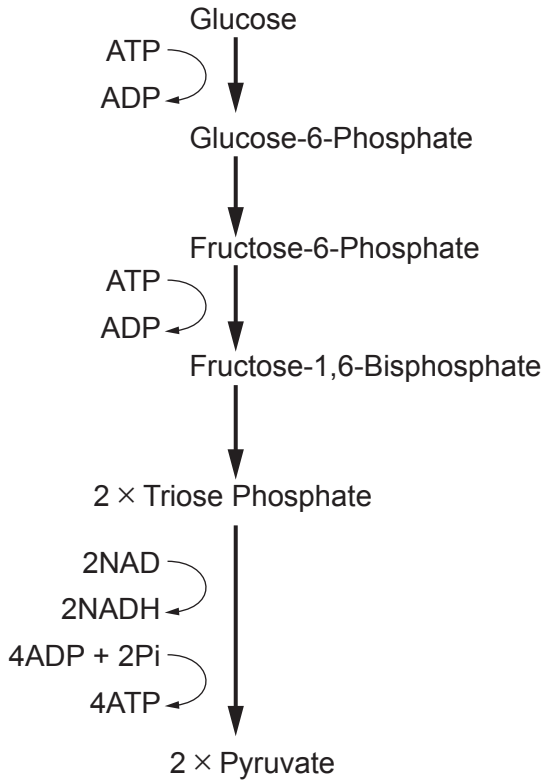
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3. Glycolysis is the first stage of respiration and is oxygen-independent. It takes place in the cytoplasm and enables a wide range of respiratory substrates to be used as energy sources.

Image 3.1 shows some stages of glycolysis.

Image 3.1



(a) The enzyme hexokinase catalyses the addition of a phosphate group to a molecule of glucose and can accept both alpha and beta glucose isomers as substrates. The enzyme acts through an induced fit mechanism.

(i) Describe the difference between the alpha (α) and beta (β) isomers of glucose. [1]

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(ii) Explain how the induced fit mechanism enables hexokinase to accept both isomers as substrates. [2]

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(iii) Hexokinase includes a magnesium ion to catalyse the addition of a phosphate group to glucose.
State **one** other use of magnesium ions in eukaryotic cells. [1]

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(b) Some ATP is produced directly in glycolysis. More ATP is produced as a result of glycolysis via the electron transport chain.

(i) Name the process by which ATP is produced directly in glycolysis. [1]

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(ii) Use **Image 3.1** to explain why there is a **net yield** of 2 ATP produced directly in glycolysis. [2]

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(iii) Identify **one** type of enzyme involved in the conversion of triose phosphate to pyruvate and state the function of this type of enzyme. [2]

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(iv) Describe what happens to pyruvate in animal cells under anaerobic conditions. [1]

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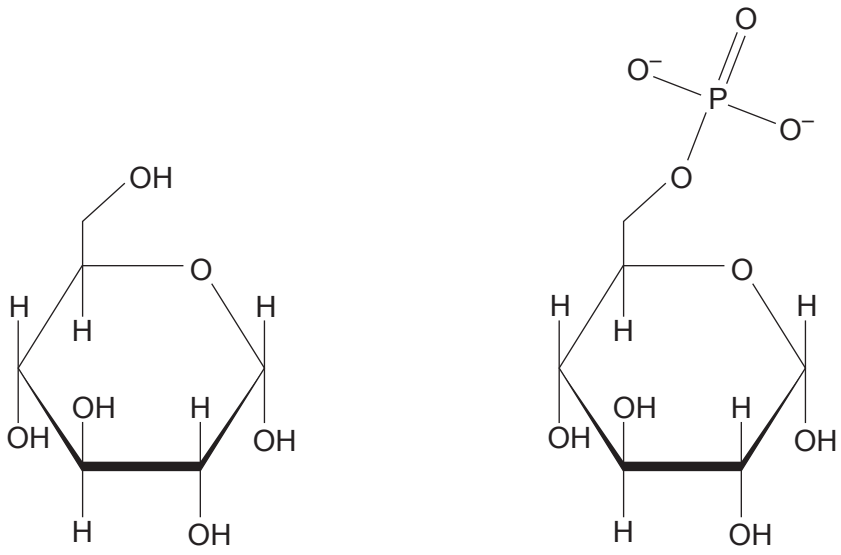
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(c) At rest, blood glucose concentration is usually low and hexokinase catalyses the conversion of glucose to glucose-6-phosphate. An increased concentration of glucose-6-phosphate inhibits hexokinase. **Image 3.2** shows the molecular structure of glucose and glucose-6-phosphate.

Image 3.2



glucose

glucose-6-phosphate

Use **Image 3.2** to conclude and explain how glucose-6-phosphate could inhibit hexokinase. [3]

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(d) **Table 3.3** shows the blood glucose ranges for a non-diabetic, a pre-diabetic (high risk of developing diabetes) and a diabetic, 12 hours before eating and two hours after eating. The blood glucose concentrations are recorded as mg per decilitre (mg/dL).

Table 3.3

Time of glucose test	Blood glucose concentration / mg/dL		
	Non-diabetic	Pre-diabetic	Diabetic
12 hours before eating	< 100	100 to 125	≥ 126
two hours after eating	< 140	140 to 199	≥ 200

(i) Following 12 hours without eating, a blood test was carried out on an adult with a total blood volume of 4.8 dm^3 and total blood glucose mass of 4.6 g. Use the formula below to calculate the blood glucose concentration of this patient.
Give your answer to the nearest mg/dL. [3]

$$\text{blood glucose concentration / mg/dL} = \frac{\text{mass of glucose (mg)}}{18} \times \frac{\text{volume of blood } (dm^3)}{10}$$

Blood glucose concentration = ... mg/dL

(ii) The same patient was tested again two hours after eating. The result was 199 mg/dL.
Use the value of the blood glucose concentration two hours after eating to evaluate the risk of this patient developing diabetes. [2]

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4. Instructions for setting up a new freshwater aquarium are given below.

- Fill the aquarium with water.
- Use an air pump to aerate the water and use an aquarium heater to reach a constant temperature of 28°C.
- Add a small amount of fish food every three days for at least 45 days (the fish food is added as a source of nitrogen compounds and bacteria which decay the food).
- Before each addition of food, test the water in the aquarium for the presence and concentration of ammonia, nitrite and nitrate.

IMPORTANT: Do not add fish until ammonia and nitrite are not detected in the water of the aquarium.

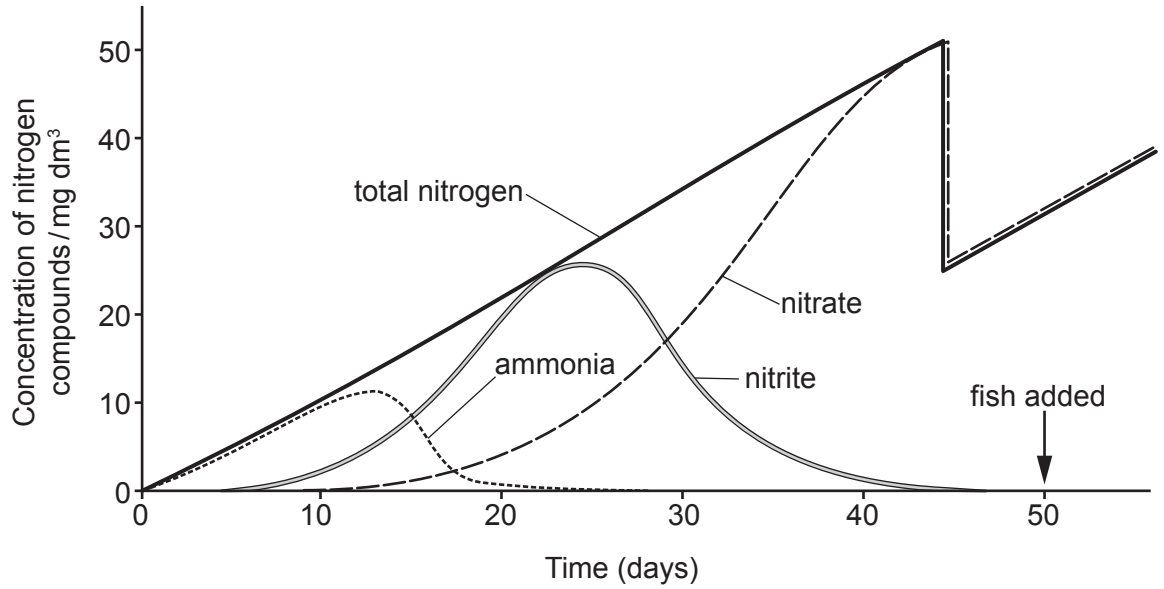
(a) (i) Name **two types** of compounds in the fish food that contain nitrogen atoms. [2]

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Graph 4 shows the concentration of three nitrogen-containing compounds found in the water samples from the aquarium.

Graph 4



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(ii) Use your knowledge of the nitrogen cycle to explain the sequence of the appearance of ammonia, nitrite and nitrate as shown in **Graph 4**. [4]

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(iii) Explain why the water was continually aerated. [2]

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(iv) Suggest a possible explanation for the change in nitrate concentration at day 45. [1]

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(b) Ammonia and nitrite ions are highly toxic; nitrate ions are less toxic but can still cause harm to fish in high concentrations.

(i) Suggest what would happen to the concentration of nitrate ions if plants were grown in the aquarium. Explain why this would happen. [2]

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(ii) Suggest why the concentration of nitrogen containing compounds may increase if too many fish are introduced into an aquarium. [3]

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(c) The aquarium was kept on a windowsill in bright sunlight. Two weeks after the introduction of fish to the aquarium the water turned green and the fish died. Suggest why the fish died and explain your answer. [3]

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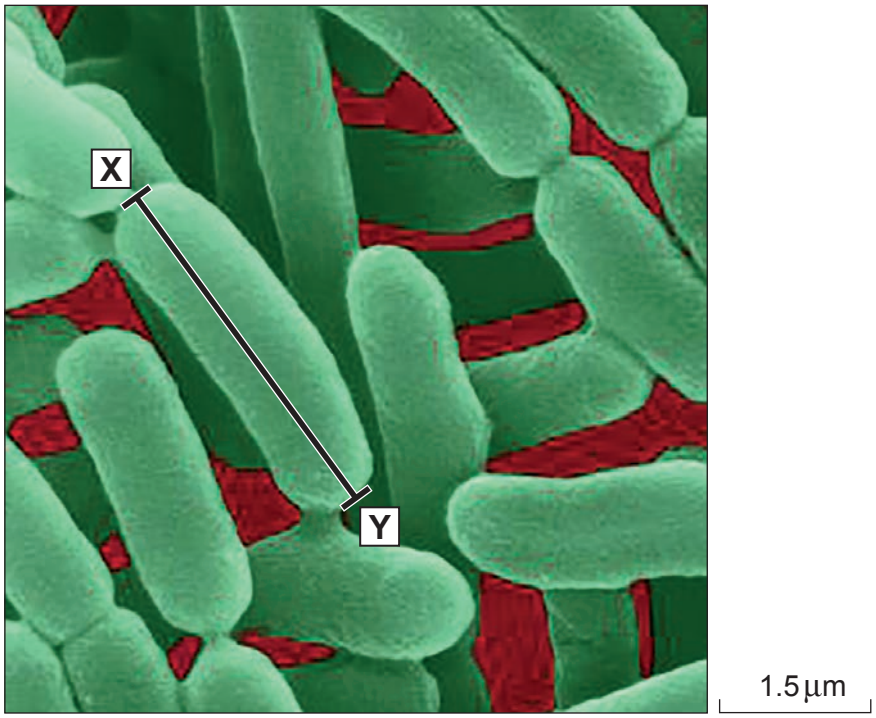
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5. *Salmonella enterica* is a bacterium with many different forms. Some forms of this bacterium are serious human pathogens, causing diarrhoea and vomiting; in some cases, infection with this pathogen can be fatal. **Image 5.1** shows a scanning electron micrograph (SEM) of some *Salmonella* bacteria.

Image 5.1



(a) Calculate the length of **one** bacterium along the line marked **X–Y** on **Image 5.1**.
Give your answer in µm to one decimal place. [2]

Length of bacterium = ... µm

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(b) A sample of faeces from a patient with diarrhoea and vomiting was examined for the presence of *Salmonella* bacteria. Rod-shaped bacteria were observed which stained red using Gram-staining. These bacteria were cultured and were found to be facultative anaerobes.

(i) State the term used to describe rod-shaped bacteria. [1]

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(ii) Explain what is meant by the term facultative anaerobe. [1]

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(iii) Explain what information about the **structure** of *Salmonella* bacteria is provided by the result of Gram-staining. [1]

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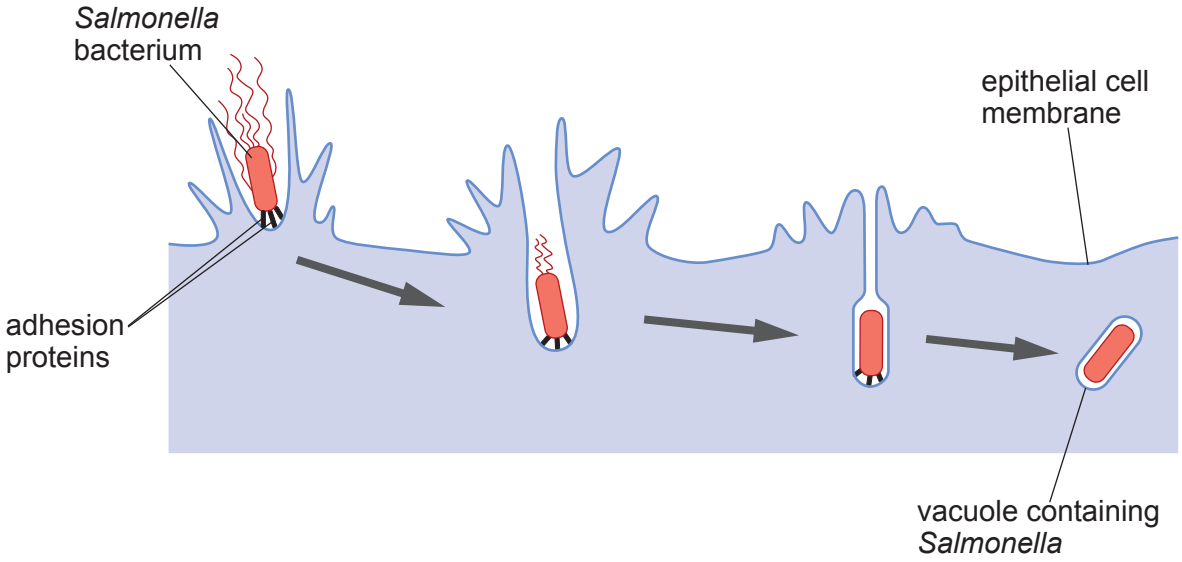
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Salmonella enterica is an intracellular pathogen. **Image 5.2** shows stages in the entry of *Salmonella* bacteria into an epithelial cell lining the gut.

Image 5.2



(c) Name the process by which these bacteria enter cells and explain why ATP is needed for this to take place. [2]

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(d) *Salmonella* can be highly pathogenic and so strict aseptic conditions must be used when transferring samples containing this bacterium from the container with a faecal sample to an agar plate for culturing.
Describe and explain **two** precautions that must be taken when inoculating an agar plate with faeces that might contain *Salmonella*. [2]

Precaution	Explanation
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(e) *Salmonella* infections are estimated to affect up to 1.3 billion people and are responsible for nearly 3 million deaths each year. Many foods have been found to contain low levels of *Salmonella* bacteria, including salad leaves and nuts.

One study carried out on one type of raw nut in the USA found the following results:

- 4153 samples were tested for the presence of viable *Salmonella* bacteria
- 101 of the samples tested positive for the bacteria

Calculate the percentage of samples that tested positive for *Salmonella*. **Give your answer to an appropriate number of decimal places.** [2]

Percentage with *Salmonella* = ...

(f) The most probable number (MPN) of bacteria in each of the 101 positive samples was estimated using the following method:

- 0.25 g of sample was broken down in 1 cm^3 of sterile culture medium and placed in a sterile, capped, tube
- the tube was incubated at 35°C for 24 hours
- the tube was tested for the presence of bacterial growth
- this method was repeated to give a total of 10 results for the sample

(i) Explain why this is a method of producing a viable count. [1]

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(ii) A total of 1010 tubes were prepared from the 101 samples of nuts that tested positive for *Salmonella*.
Of these, 260 tubes tested positive for the presence of *Salmonella* and 750 tested negative.

Use the formula below to calculate the MPN of *Salmonella* bacteria per gram in the food sample if each tube contained 0.25 g of nuts. [3]

$$\text{MPN } \textit{Salmonella} \text{ per gram} = \frac{P}{\sqrt{(N \times T)}}$$

where P = the number of tubes showing bacterial growth
N = the total mass (g) of sample tested in all of the negative tubes
T = the total mass (g) of sample in all of the tubes.

MPN *Salmonella* = ... g^{-1}

(iii) It has been estimated that a person needs to ingest 10^6 *Salmonella* bacteria to cause the symptoms of food poisoning.
Use your calculated value of the MPN of *Salmonella* to conclude whether eating this food puts a person at high risk of developing *Salmonella* food poisoning. [2]

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6. The first UK motorway opened in 1958 and was just over 13 km long. By 2017 there were 3800 km of motorway in the UK. Despite the high pollution levels on motorways, they have become havens for wildlife, especially plants, mainly because pedestrians are not allowed on motorways.

In some areas, the verges have been used to establish colonies of endangered species as part of local conservation efforts and some verges have been planted or seeded with wildflowers to increase biodiversity. Natural colonisation has also taken place with native species. Many wildflowers are adapted to growing in soils with low fertility. The soil at the edge of motorways is often of poor quality and provides ideal habitats for these plants.

(a) (i) During motorway construction the verges are usually left as bare soil. Explain why subsequent colonisation of these verges can be described as secondary succession. [2]

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(ii) Long-term management of motorway verges often involves cutting the vegetation back to ground level in early Spring and again in August / September.

I. Explain why cutting the vegetation in this way on a regular basis prevents succession reaching a climax community. [1]

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II. The cut vegetation is removed from the verges. Conclude how this increases the biodiversity of wildflowers in motorway verges. [3]

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(b) Bees and wasps are important pollinators of plants grown to supply food for people and animals; 75% of food crops are pollinated by insects including bees and wasps. There has been an estimated 33.3% decrease in the population size of insects between 1980 and 2013.

A study was carried out in Europe to determine if road-side verges increase the biodiversity of bees and wasps. The method is summarised below:

- each sample site was divided into a grid
- using the grid, specialised traps of four different colours, white, yellow, turquoise and pink, were placed so as to avoid bias
- specimens of insects caught in the traps were stored in 96% ethanol and taken to a laboratory for identification

(i) Describe how the grid could have been used to reduce bias when placing the traps. [1]

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(ii) Suggest why different coloured traps were used. [1]

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(iii) Suggest **one** ethical and **one** ecological concern regarding the method used to store and identify the bees and wasps collected. [2]

ethical

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ecological

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(iv) In this study, 14 roadside verges were sampled. Each site was bordered by arable land where a variety of crops were being grown.
Calculation of a diversity index indicated that there was a high biodiversity of bees and wasps present in the verges along this road.
It was concluded that roadside verges do increase the biodiversity of bees and wasps.

Use all the information provided, including the method used to collect the data, to evaluate this conclusion. [3]

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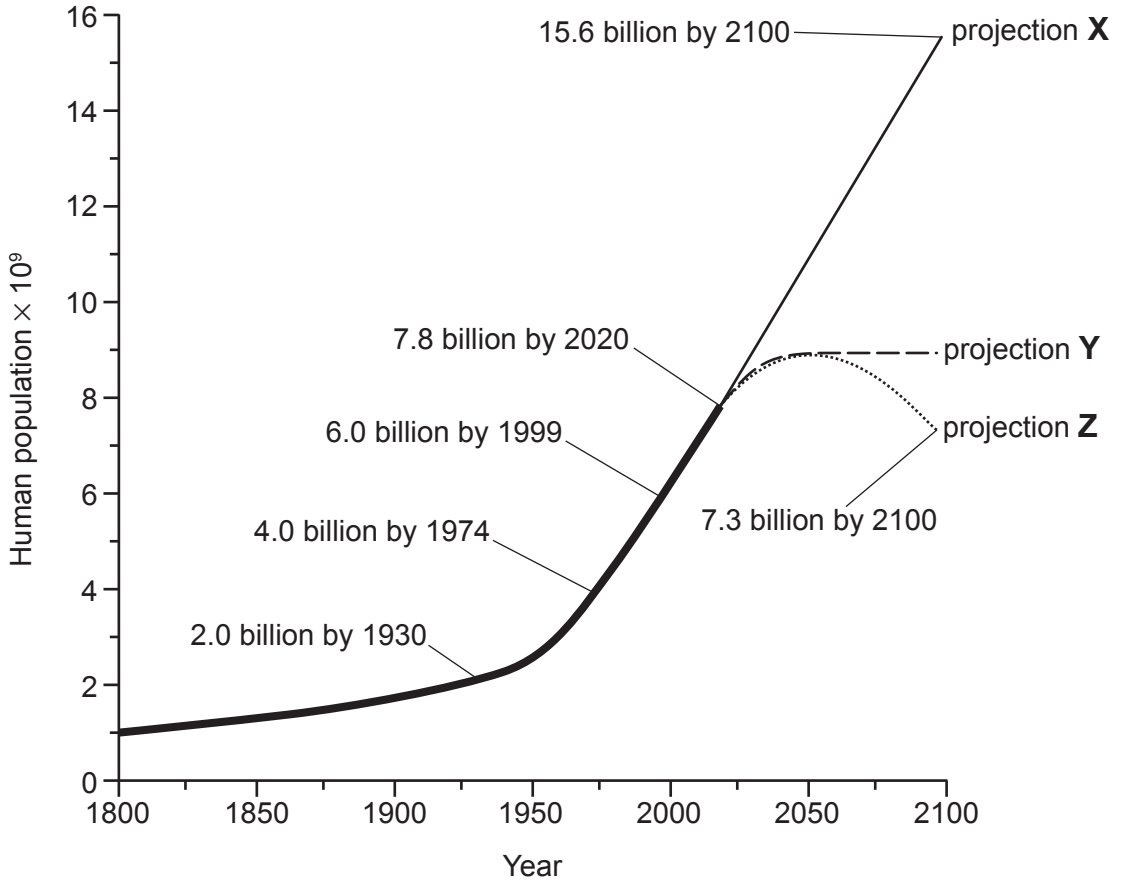
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7. **Graph 7** shows how the human population has changed since 1800. It also shows three projections of how the world population might change by the end of the 21st century.

Graph 7



At present, population scientists believe that projection **X** is the most likely world population by 2100.

State what is meant by density-dependent and density-independent factors and explain how these factors might account for the change in the human population growth curve between 1800 and 2020.
Use the population growth curves shown in **Graph 7** to explain what projections **X**, **Y** and **Z** represent in terms of human population size.
Suggest how the climate change planetary boundary might be affected if projection **Z** becomes reality. [9 QER]

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