Surname	Centre Number	Candidate Number
First name(s)		2

GCE A LEVEL

A400U10-1

O20-A400U10-1

MONDAY, 12 OCTOBER 2020 – MORNING

BIOLOGY – A level component 1
Energy for Life

2 hours

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**20**	
2.	**10**	
3.	**14**	
4.	**18**	
5.	**8**	
6.	**21**	
7.	**9**	
Total	**100**	

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ADDITIONAL MATERIALS

In addition to this examination paper, you will need 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(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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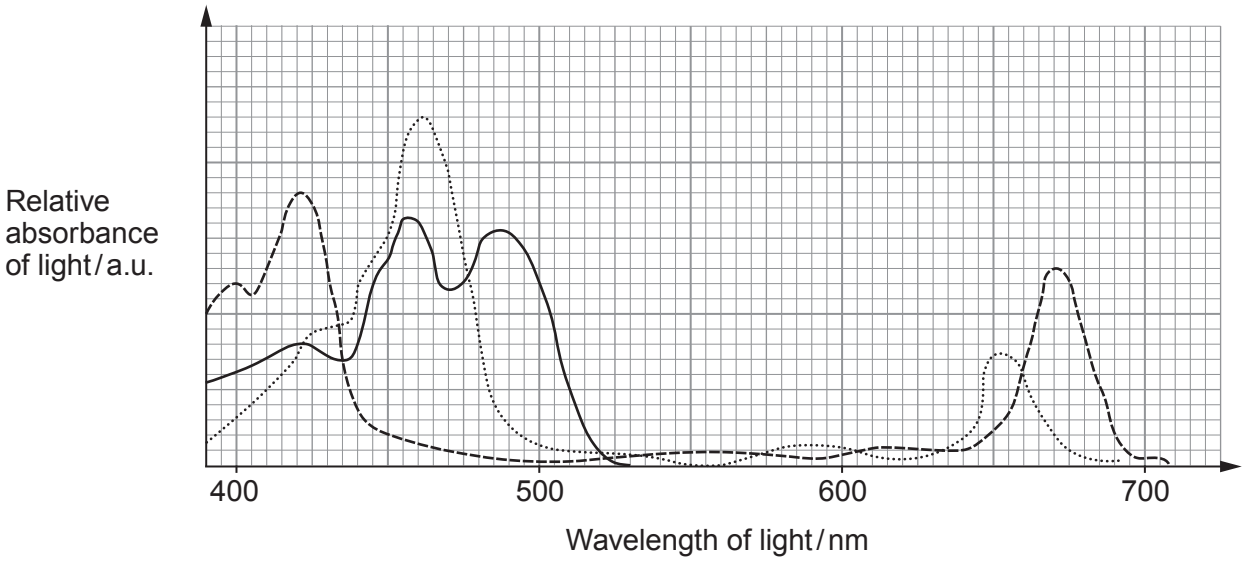
Answer **all** *questions.*

1. Photosynthetic cells are transducers converting light energy into chemical energy. Several photosynthetic pigments are involved in the absorption of light energy. **Image 1.1** is an absorption spectrum showing the relative absorbance of different wavelengths of light energy by different pigments.

Image 1.1



(a) (i) Using information in **image 1.1**, describe the absorption spectrum of **chlorophyll a**. [2]

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(ii) Suggest the advantage to photosynthetic cells of having several different light absorbing pigments. [1]

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Prochlorococcus is a species of cyanobacterium and is the most abundant photosynthetic organism on Earth. Cells of *Prochlorococcus* contain molecules of chlorophyll a and b embedded in photosynthetic membranes.
Image 1.2 and **image 1.3** show a molecular model of a chlorophyll molecule and the arrangement of chlorophyll molecules in the photosynthetic membrane.

Image 1.2

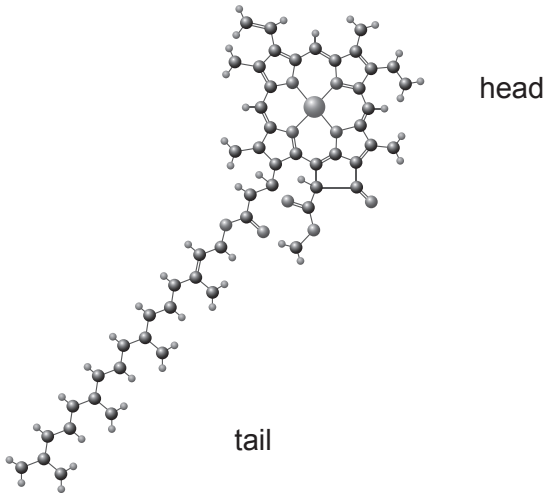
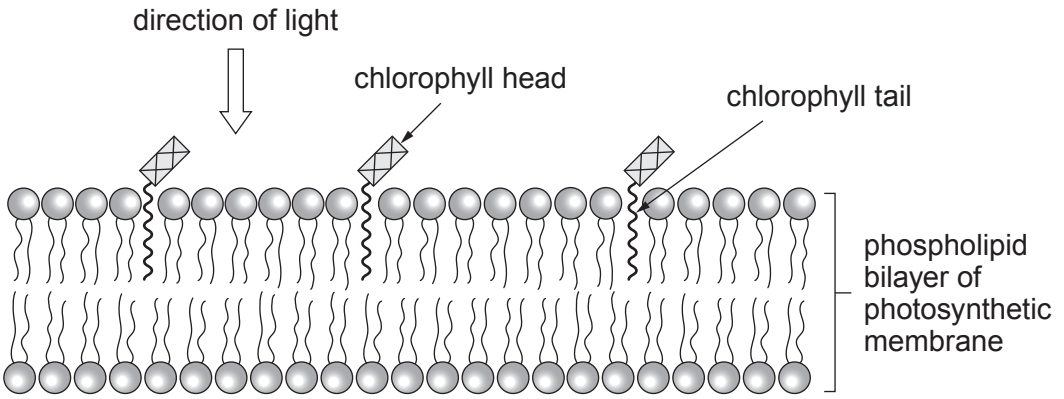


Image 1.3



(b) (i) State **one** element, other than carbon, hydrogen and oxygen, that is found in the chlorophyll molecule. [1]

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(ii) Use **image 1.2** and **image 1.3** to explain how the properties of the head and tail of the chlorophyll molecule result in its position in the photosynthetic membrane. Suggest an advantage of the position of the chlorophyll molecules. [3]

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(c) In the light dependent stage of photosynthesis, molecules of chlorophyll a emit electrons. Describe how these electrons are replaced in non-cyclic photophosphorylation. [2]

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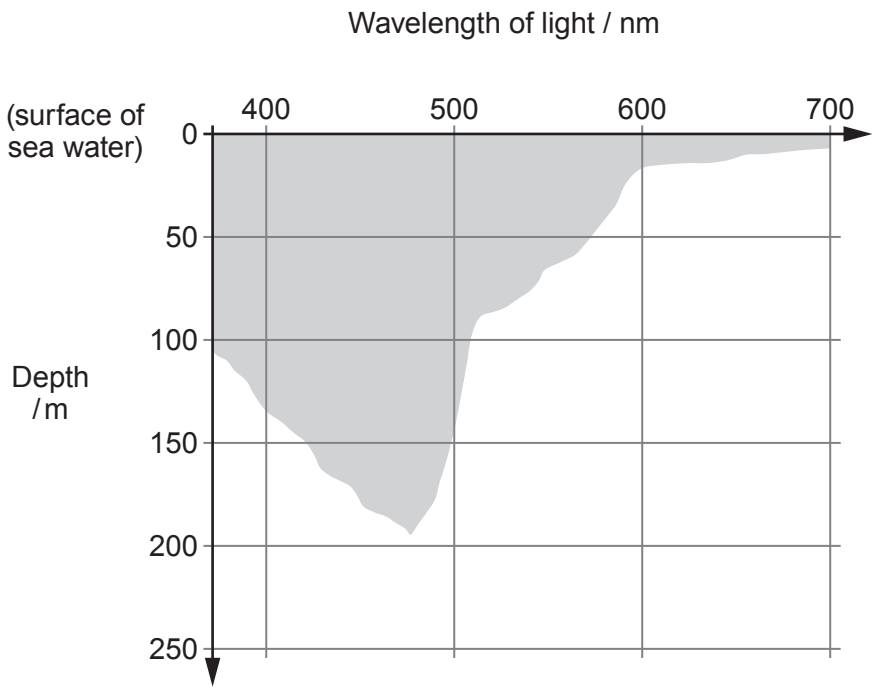
(d) *Prochlorococcus* is found at depths between 0 and 200 m in oceans around the world. Different proportions of chlorophyll a and chlorophyll b are produced by *Prochlorococcus* at different depths. **Image 1.4** shows the depth to which different wavelengths of light penetrate seawater.

Image 1.4



Using **image 1.1** and **image 1.4**, explain why *Prochlorococcus* cells found at depths between 150 metres – 200 metres produce chlorophyll b but not chlorophyll a. [2]

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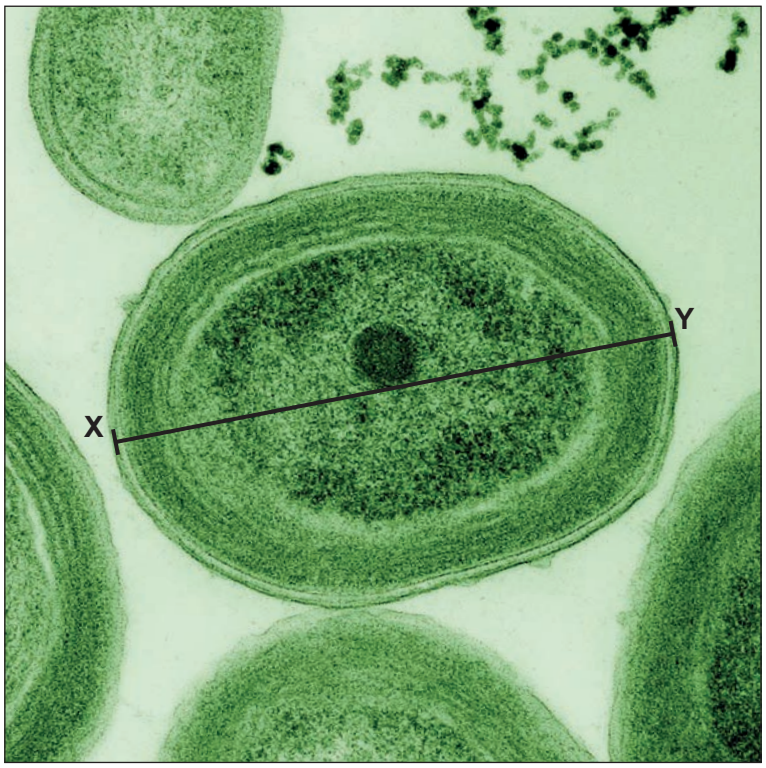
(e) *Prochlorococcus* is found in enormous numbers even in nutrient poor waters. **Image 1.5** shows a photomicrograph of a *Prochlorococcus* cell.

Image 1.5



X-**Y** = 0.6 μm

(i) Calculate the surface area : volume ratio of a *Prochlorococcus* cell which has a radius of 0.3 μm.
Express your ratio to the nearest whole numbers. [3]

Surface area of a sphere = $4\pi r^2$.

Volume of a sphere = $\frac{4}{3}\pi r^3$

$\pi = 3.14$

Surface area : volume ratio = ... : .....

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(ii) With reference to the **size of the organism**, explain how *Prochlorococcus* is able to gain sufficient minerals from nutrient poor waters. [3]

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(f) *Prochlorococcus* stains red when using the Gram staining technique.

(i) **Complete the flow chart** below which shows the stages in the Gram staining technique. [2]

Fixation

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Stain with .....

↓

Iodine treatment

↓

Washed and decolourised with .....

↓

Counterstain

(ii) Explain what this staining technique indicates about the structure of the cell wall of *Prochlorococcus*. [1]

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2. RuBisCO is the most abundant enzyme on Earth. Each RuBisCO molecule is made of eight **identical** long chain polypeptides and eight **identical** short chain polypeptides.

(a) (i) RuBisCO shows all four levels of protein structure. Briefly describe what is meant by the following terms: [2]

Primary structure .....

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Secondary structure .....

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Tertiary structure .....

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Quaternary structure .....

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The genetic code for the long chain polypeptides is found in the chloroplast genome and the genetic code for the short chain polypeptides is found in the nucleus.

(ii) State **two** features of the genetic code. [2]

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(iii) State how many genes code for the polypeptides found in a RuBisCO molecule. [1]

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(b) RuBisCO is responsible for carbon fixation in the Calvin cycle.

(i) State the names of the **two** substrates that form an enzyme-substrate complex with RuBisCO. [2]

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(ii) State the names of the following molecules:

I. the first 3-carbon phosphorylated **sugar** produced by the Calvin cycle; [1]

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II. **one** organic molecule formed from the product of the Calvin cycle with the addition of nitrogen **and** phosphorus; [1]

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III. **one** organic molecule formed from the product of the Calvin cycle with the addition of nitrogen **and** sulphur. [1]

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3. *(a)* Metabolism is a combination of anabolic reactions which build up molecules and catabolic reactions which break them down. Give **one** example where ATP is used in: [2]

an anabolic reaction; .....

a catabolic reaction. .....

(b) With reference to the production of ATP:

(i) state what is meant by substrate level phosphorylation; [2]

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(ii) outline the process of chemiosmosis in an animal cell. [3]

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(c) High levels of ATP within a cell cause the non-competitive inhibition of several enzymes involved in ATP synthesis.

Explain how an ATP molecule could act as a non-competitive inhibitor. [2]

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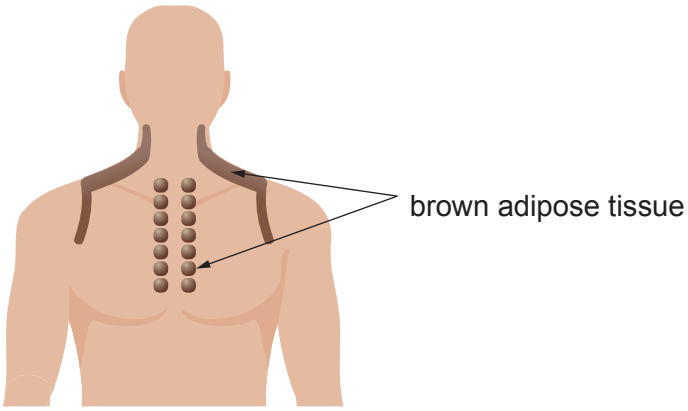
(d) There are two types of adipose (fat) tissue in humans, white adipose tissue and brown adipose tissue (BAT).

The function of BAT is to generate heat. In adult humans it is found in the neck, shoulders and chest, as shown in **image 3.1**.

Image 3.1



In the inner mitochondrial membrane of BAT cells there is a protein which makes the membrane permeable to protons. When there is a fall in body temperature the concentration of this protein in the membrane increases and more heat is generated.
Capsaicin is a chemical found in red chili peppers. It makes the inner mitochondrial membrane of BAT cells more permeable to protons.

(i) Explain how capsaicin reduces ATP production by BAT cells. [2]

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(ii) Using all the information provided, suggest why eating red chili peppers causes sweating and reddening to the neck, shoulders and chest. [3]

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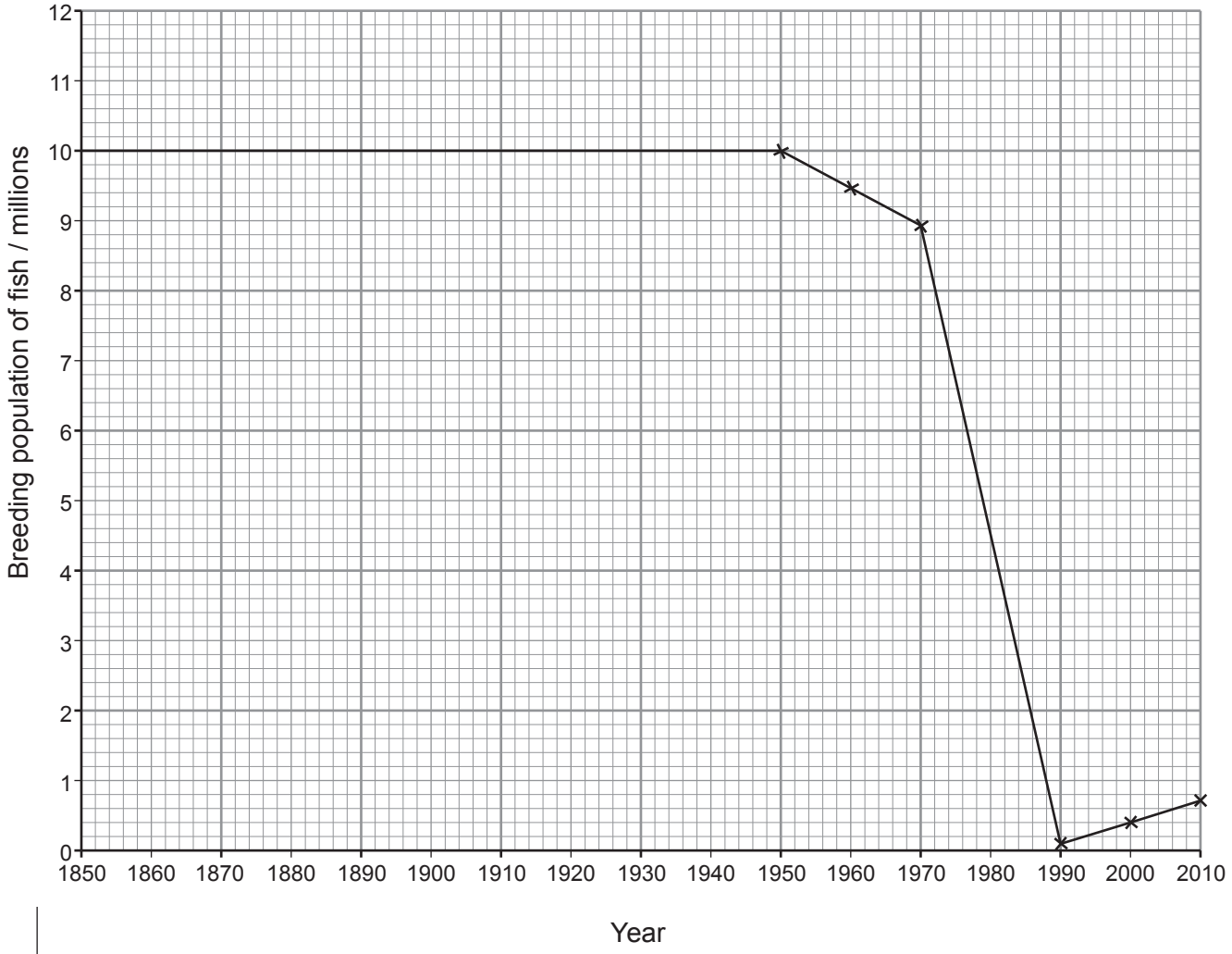
4. The Grand Banks is an area of sea off the coast of Newfoundland in Canada. Cod have been fished in the area for hundreds of years.

During the 1900s there were significant improvements in fishing techniques. By 1968, the number of cod caught had increased and 800 000 tons of cod were landed in that year alone. This represented 60% of the total cod population of reproductive age.

By 1992 the population had dropped to less than 1% of earlier levels and cod fishing was banned in the Grand Banks by the Canadian Government.

Image 4.1 shows the estimated breeding population of cod in the Grand Banks between 1850 and 2010.

Image 4.1



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(a) With reference to **human activity**, explain the shape of the estimated population graph shown in **image 4.1** between the following dates: [3]

1850 to 1950;

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1970 to 1990;

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1990 to 2010.

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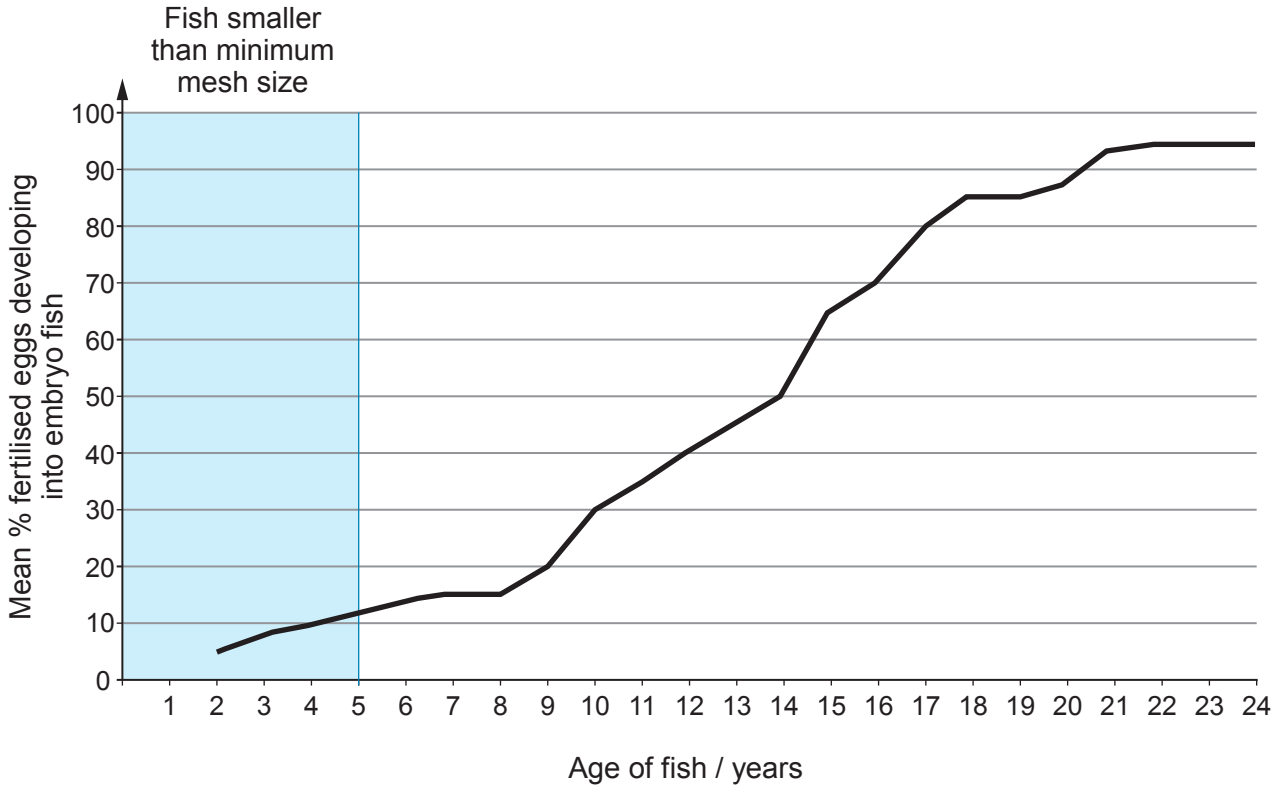
Turn over.

(b) Cod continue to grow throughout their lives. The older the cod, the larger they will be. **Image 4.2** and **image 4.3** show how the age of cod affects the number of eggs released and the mean percentage of fertilised eggs developing into embryos.

Image 4.2

Image 4.3



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There is a minimum mesh size for the nets used for trawling for cod so that only larger fish are caught.

(i) Evaluate the effectiveness of using this minimum mesh size in allowing the recovery of the cod population. [4]

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(ii) Other than restricting the mesh size of nets, give **two** methods which are used to prevent overfishing. [1]

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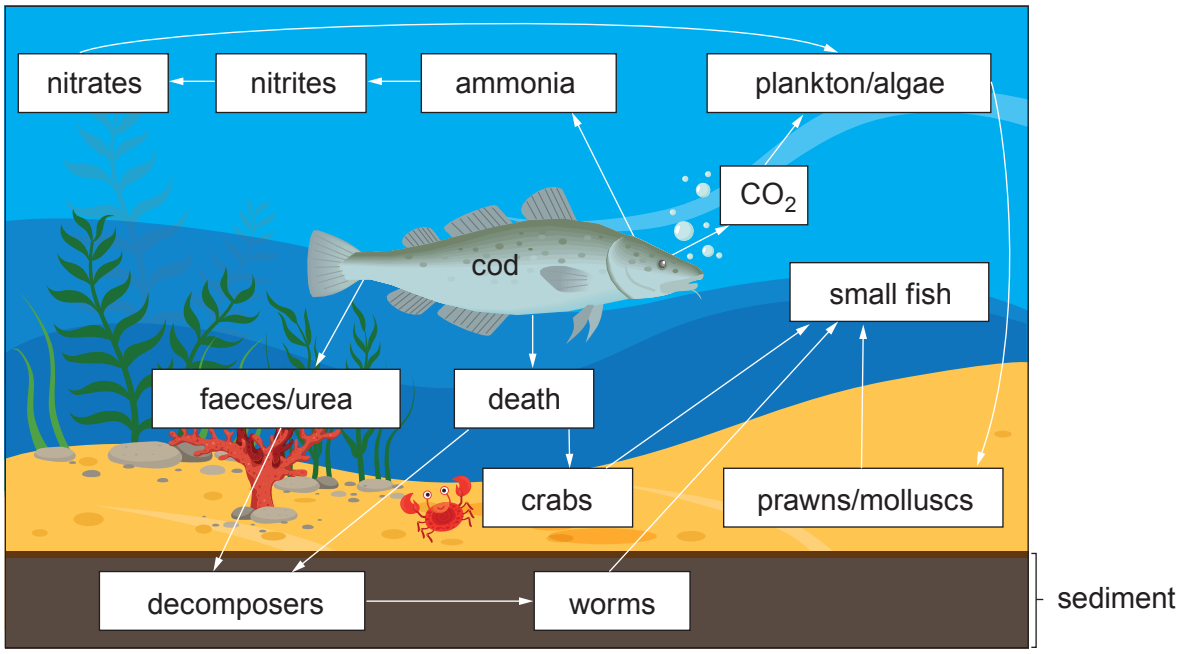
As the wild cod numbers are decreasing, cod are now being farmed, which can have major impacts on their local ecosystems. **Image 4.4** below shows the relationship between the cod and its natural environment.

Image 4.4



(c) Use **image 4.4** and your knowledge of fish farming to conclude how fish farming can impact the ecosystem in the surrounding areas. [5]

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(d) Bottom trawling involves dragging very large weighted nets along the sea bed. The heavy equipment used in bottom trawling destroys the seabed, as shown in **image 4.5**.

Image 4.5

Before bottom trawling

Same area 2 days after bottom trawling

Following bottom trawling, organisms repopulate the area. Identify the type of succession that results in the repopulation **and** give **two** reasons for your answer. [3]

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(e) Planetary boundaries attempt to quantify and set a safe limit for the environmental impact of human activity. The boundary limit for CO_2 in the atmosphere was set at 350 ppm by volume, the current value is in excess of 400 ppm by volume.
State **and** explain **one** effect that increased CO_2 has had on the **marine** environment. [2]

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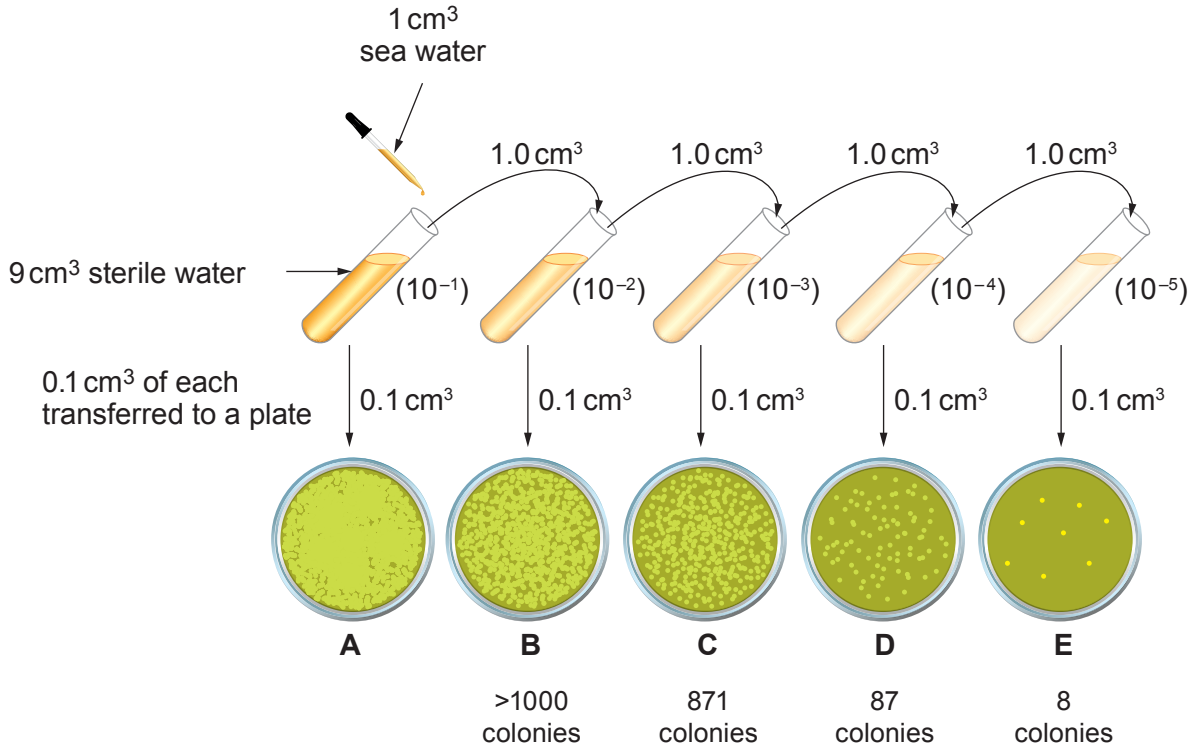
5. The quality of bathing water at designated coastal resorts is monitored. The number of bacteria present is assessed by using serial dilutions of sea water, plating, incubating and counting the colonies as shown in **image 5.1**.

Image 5.1



(a) (i) Use the number of colonies on plate **D** to calculate how many bacteria there are in 1 cm³ of the original sample of water. [1]

Number of colonies = ...

(ii) Explain why the number of colonies on plates **C** and **E** would not be used to calculate the number of bacteria. [2]

C .....

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E .....

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(b) Explain why it is essential that the plates are all cultured using exactly the same culture medium and incubation period. [2]

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(c) At the end of the investigation all plates were autoclaved. State **one** condition produced by the autoclave which results in the sterilisation of the plates. [1]

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(d) Water quality can be determined by the number of human gut bacteria present. Suggest **two** suitable conditions for incubation in order to culture human gut bacteria. [2]

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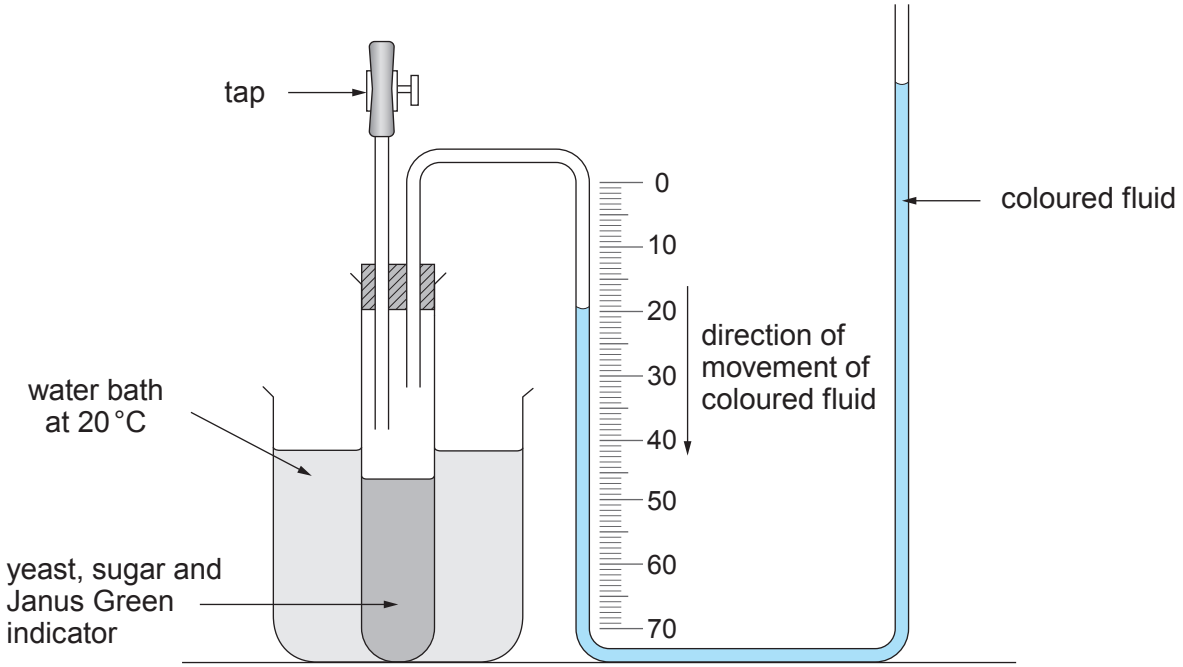
6. **Image 6.1** shows the apparatus which can be used to measure the production or absorption of gases during respiration. The apparatus relies on changes in pressure to move the coloured fluid along the tube.

Image 6.1



A student used this apparatus to compare the rate of **anaerobic** respiration in yeast using different sugars as the respiratory substrate.

Janus Green indicator is blue if oxygen is present and pink if no oxygen is present.

- Janus Green indicator is added to the yeast and sugar in a test tube as shown above.
- The apparatus is left with the tap open for 5 minutes.
- After this time the tap is closed.
- Once the solution turns pink, the time for the meniscus to move 10 mm is recorded.
- The time for the meniscus to travel 10 mm is repeated a further four times.
- All controlled variables are the same for each sugar and for each repeat.

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(a) Explain the following:

(i) The tap is open when the apparatus is assembled. [1]

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(ii) The tap is not closed until 5 minutes after setting up. [1]

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(iii) No readings are taken before the Janus Green indicator changes to pink. [1]

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(b) Explain why you would expect the meniscus to move in the direction of the arrow. [2]

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(c) Suggest a suitable control experiment **and** explain why a control is necessary. [3]

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(d) (i) The results when glucose was used as the substrate are shown in the table below. Use the table and formula to calculate the standard deviation for the glucose results. [3]

Time for meniscus to travel 10 mm /seconds	Deviation from mean $x - \bar{x}$	Deviation from mean squared $(x - \bar{x})^2$
254		
246		
255		
253		
252		
Mean = 252		$\sum(x - \bar{x})^2$ =

The formula for standard deviation is:

$$\sqrt{\frac{\sum(x - \bar{x})^2}{n - 1}}$$

where

x = individual result $\bar{x}$ = mean result

n = number of trials $\sum$ = sum of

Standard deviation = ...

(ii) **Complete the following table** which shows the results of the experiment for all three sugars. [3]

.....	.....						
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Mean	Standard deviation
glucose	254	246	255	253	252	252	.....
fructose	170	208	214	265	270	225	42.0
sucrose	370	376	388	379	390	381	8.4

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(iii) State what standard deviation indicates about data **and** comment on the values for the three sugars in this experiment. [3]

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(e) Explain why the respiratory rate is much slower when yeast uses sucrose as the respiratory substrate. [2]

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(f) Predict what would happen to the position of the meniscus if the yeast was only carrying out **aerobic** respiration. Explain your answer. [2]

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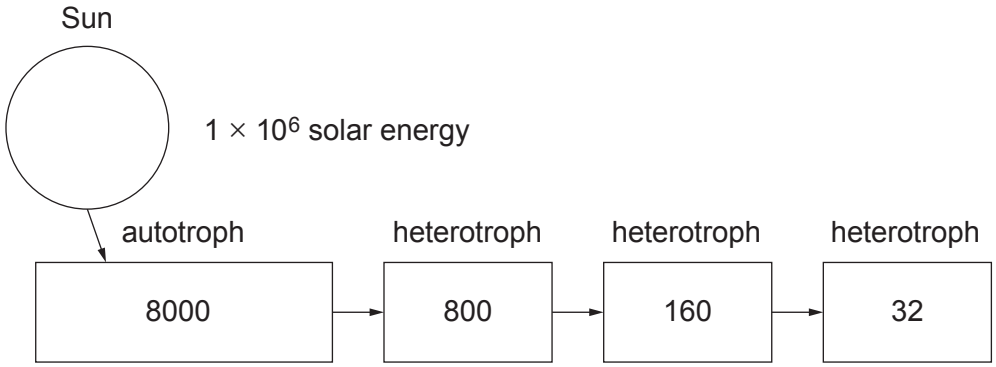
7. The diagram below shows the flow of energy through an ecosystem.



Figures represent $kJ\,m^{-2}\,yr^{-1}$

Using the diagram, explain what is meant by the flow of energy through an ecosystem and why energy is lost at each stage.

Explain why the efficiency of transfer might change at each stage.

Suggest ways by which farmers can improve the efficiency of the transfer between each level.
[9 QER]

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END OF PAPER

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

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