Surname	Centre Number	Candidate Number
First name(s)		2

GCE A LEVEL

S25-1400U30-1

1400U30-1

THURSDAY, 5 JUNE 2025 – AFTERNOON

BIOLOGY – A2 unit 3
Energy, Homeostasis and the Environment

2 hours

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	8	
2.	12	
3.	13	
4.	17	
5.	14	
6.	17	
7.	9	
Total	90	

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01

ADDITIONAL MATERIALS

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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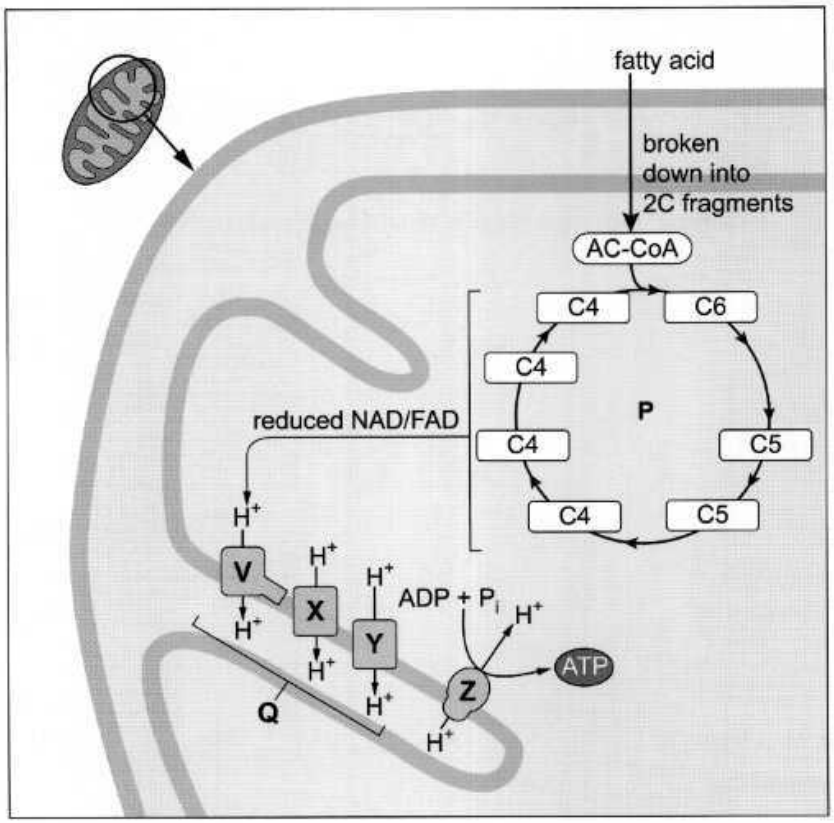
Examiner only

Answer **all** questions.

1. Following digestion of lipids, fatty acids become available as an energy source. **Image 1** shows how fatty acids are metabolised in cells.

Image 1



(a) Name the following shown in **Image 1**: [2]

the organelle where fatty acid metabolism takes place;

.....

the pathway labelled **P**;

.....

the pathway labelled **Q**;

.....

the enzyme contained in the structure labelled **Z**.

.....

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(b) During fatty acid metabolism fatty acids are broken down to 2-carbon fragments. Each 2-carbon fragment is converted to one molecule of acetyl CoA. The acetyl CoA enters pathway **P**.
State how many molecules of the following compounds will be generated from **one** molecule of acetyl CoA **directly** from pathway **P**. [1]

Reduced NAD .....

Reduced FAD .....

ATP .....

(c) (i) Describe what is represented by the **arrows** on the following structures in **Image 1**.

I. Proteins: **V**, **X** and **Y**; [2]

.....

.....

.....

II. Structure **Z**. [2]

.....

.....

.....

.....

(ii) Water is formed as part of pathway **Q**.
State the role of oxygen in this pathway. [1]

.....

.....

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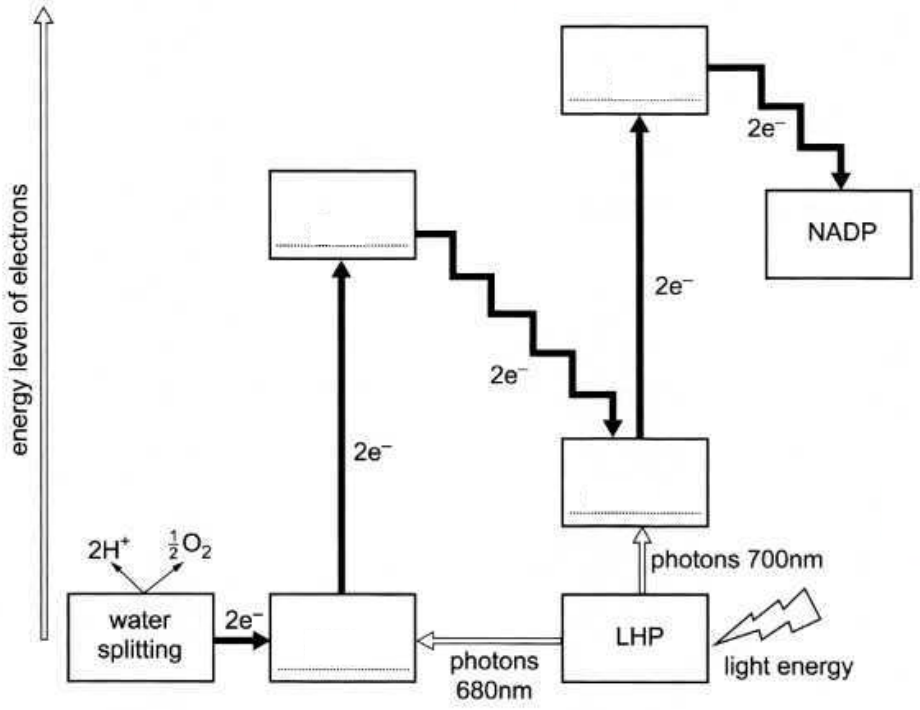
2. (a) One theory for the process of non-cyclic photophosphorylation is summarised in **Image 2.1**.

Image 2.1



(i) **Use the abbreviations** given in **Table 2.2** to **label the four components** shown as rectangles in **Image 2.1**.
You may use each term once, more than once or not at all. [2]

Table 2.2

Component	Abbreviation
Chloroplast Stroma	CS
Electron Acceptor	EA
Light harvesting pigments	LHP
Photosystem I	PSI
Photosystem II	PSII

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(ii) For each pair of electrons passing through the process two molecules of ATP are produced.

Draw and label an arrow on **Image 2.1** to show where **and** how ATP is produced. [2]

(iii) State the biological term for the process labelled water splitting in **Image 2.1**. [1]

.....

(iv) Describe what happens to the following products of water splitting.

I. Protons (hydrogen ions); [1]

.....

.....

II. Oxygen atoms. [1]

.....

.....

(v) Describe how the energy from the photons shown in **Image 2.1** would be used in photophosphorylation. [1]

.....

.....

Examiner only

(b) Powdery mildew is a disease of wheat, caused by the fungus *Blumeria graminis*. The fungus infects leaves and feeds off the products of photosynthesis.
Some varieties of wheat show resistance to the fungus. **At the site of infection** in these varieties, reduced NADP is not produced. This is because the genes that code for an enzyme involved in reducing NADP are switched off.

Use your knowledge of the light dependent and light independent reactions to explain how switching off the gene for this enzyme could limit the ability of the fungus to grow in a wheat plant. [4]

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3. **Image 3.1A** shows three planes of section of the human body. **Image 3.1B** shows a section through the human abdomen.

Image 3.1A

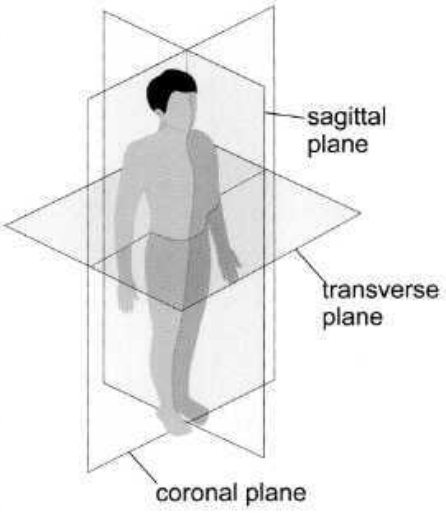
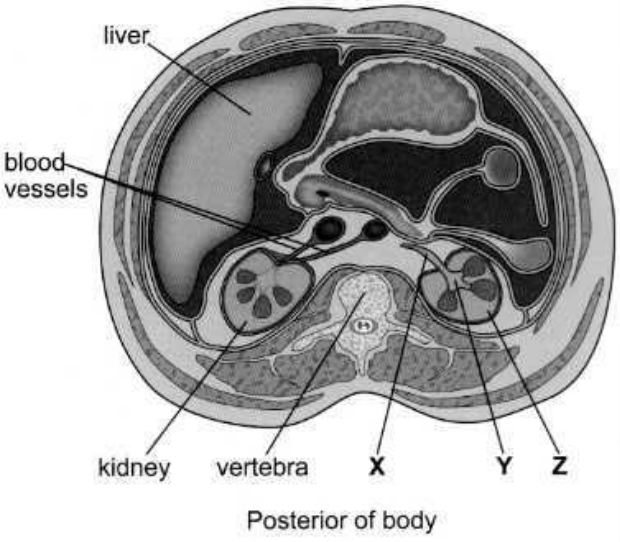


Image 3.1B



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(a) Answer the following questions about the section through the abdomen shown in **Image 3.1B**.

(i) Identify the plane of the section shown in **Image 3.1B**. [1]

.....

(ii) Name the **two** blood vessels labelled in **Image 3.1B**. [1]

.....

.....

(iii) State which of the regions of the kidney, labelled **X**, **Y** or **Z**, on **Image 3.1B** is the site of ultrafiltration. [1]

.....

The filtration barrier in a nephron has three components. **Image 3.2** shows a diagrammatic representation of the three components. The values given represent the effective pore size of each component.

Image 3.2

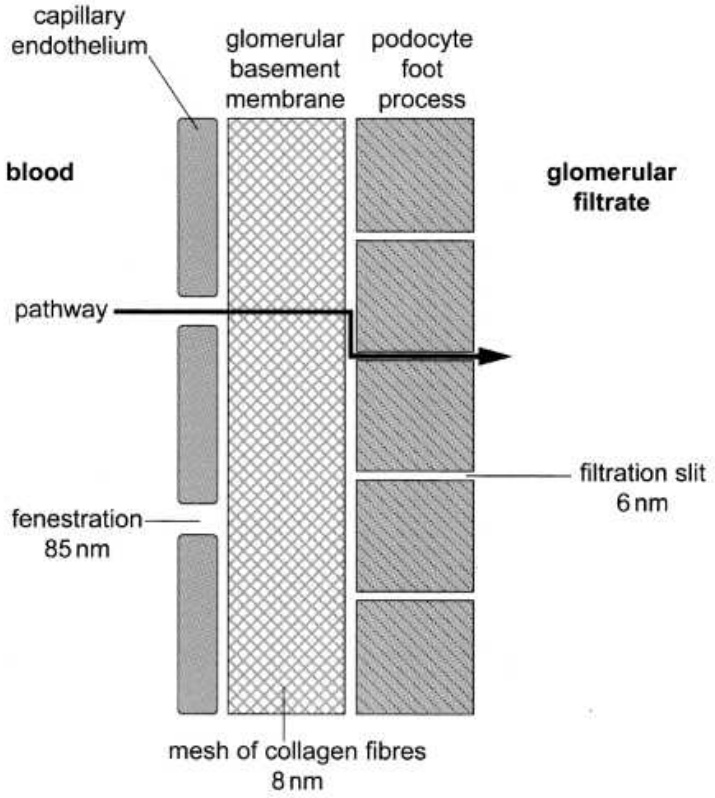

Diagram not drawn to scale

Table 3.3 shows the diameters of some components of blood.

Table 3.3

Component	Diameter / nm
red blood cells	7000
albumin (plasma protein)	7.1
glucose	1.0

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(b) With reference to **Image 3.2** and **Table 3.3**, complete **Table 3.4** to explain the presence or absence of albumin and glucose in the glomerular filtrate. [2]

Table 3.4

Component of blood	Present in glomerular filtrate	Reason
albumin	no	....
glucose	yes	....

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Question continued overleaf

Examiner only

(c) (i) The total length of the capillaries in a single glomerulus is 95 mm, and one kidney contains one million glomeruli. The mean radius of glomerular capillaries is 0.002 mm.

Use the formula below to calculate the total area of the capillary walls in one kidney. **Give your answer in standard form.** [3]

Area of capillary walls in one kidney = $2\pi rln$.

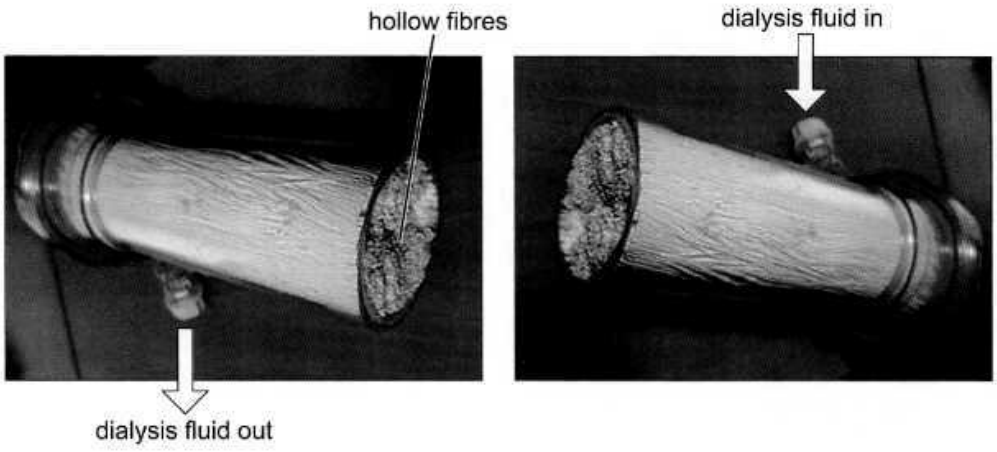
where
π = 3.14,
r = radius,
l = length of capillaries in a single glomerulus,
n = the number of glomeruli in a kidney

Total area of the capillary walls in one kidney = ... mm^2

Image 3.5 shows a part of a filter from a dialysis machine cut in half. It contains about 10 000 hollow fibres which form the filtration membrane.

The estimated total area of the filtration membrane in the dialysis machine is 2.2 m^2 (1 m^2 = 1 × 10^6 mm^2).

Image 3.5



3cii : 0

Examiner only

(ii) Give **one** reason why the estimate of the area for the dialysis filter is likely to be more accurate than the calculated area for the capillary walls of the kidney. [1]

.....

.....

.....

(iii) Explain why having a large surface area is important in ultrafiltration. [1]

.....

.....

.....

(d) Alport syndrome is a genetic condition that results in the thickening of the basement membranes in the glomeruli. It is caused by an X-linked recessive allele.

(i) Suggest how the filtration rate would be affected in Alport syndrome.
Explain your answer. [1]

.....

.....

(ii) State what is meant by the term X-linked.
Explain why males are more likely to have Alport syndrome than females. [2]

.....

.....

.....

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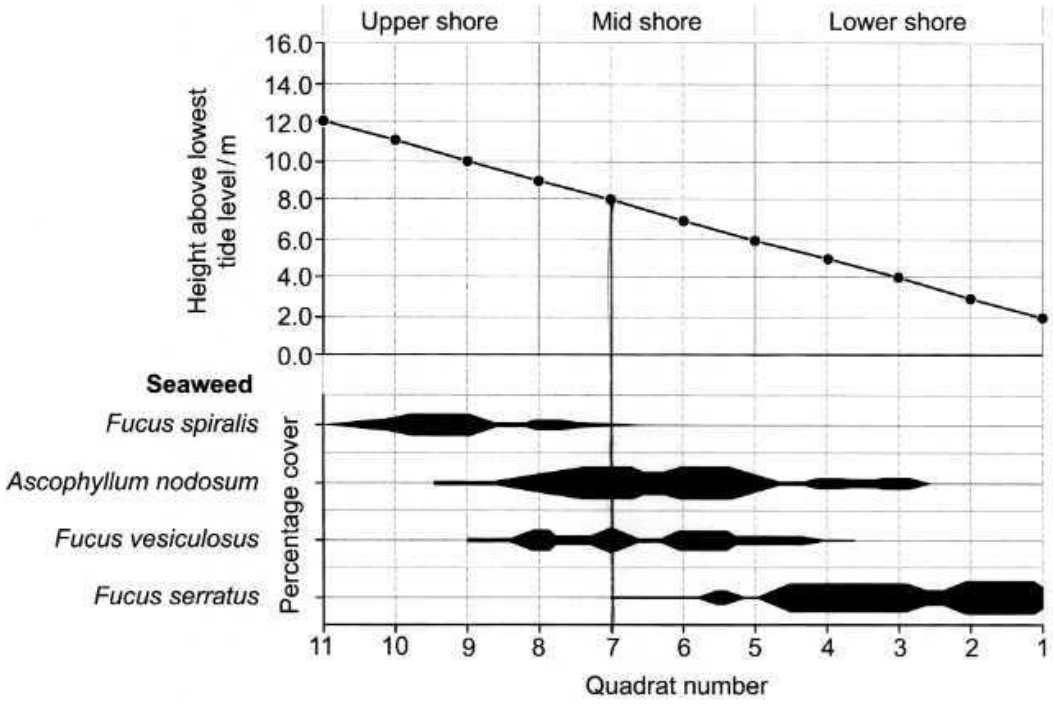
Examin only

4. Students studied the abundance and distribution of some species of seaweed on a rocky shore using a belt transect.

(a) State what is meant by the term transect.
Explain why a transect is preferred over random distribution of quadrats in this situation. [2]

Image 4.1 shows the shore profile and the students' results in the form of kite diagrams. Each quadrat was placed one vertical metre up the shore from the preceding quadrat.

Image 4.1

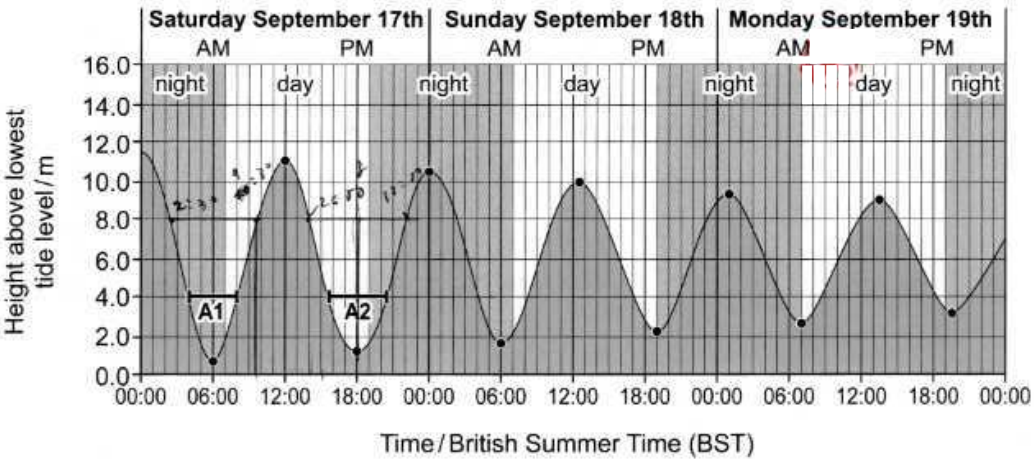


(b) Use **Image 4.1** to describe the distribution of the **three** species of seaweed that belong to the same genus across the upper, mid and lower shore. [1]

Examiner only

(c) The students collected their data on one day in September. **Image 4.2** shows the heights of the tides on three consecutive days in September in the Severn Estuary.

Image 4.2



(i) The students decided to start their survey at **05:30 on September 17th**.

I. Use **Image 4.2** to suggest why they selected that day to carry out their survey. [1]

.....

.....

II. Suggest **one** difficulty the students would have encountered by starting at 05:30am. [1]

.....

.....

One of the challenges for organisms on a rocky shore is that for part of the time they are exposed to the air. Organisms living at different heights on the shore are exposed for different lengths of time.

The bars labelled **A1** and **A2** in **Image 4.2**, show that organisms living in **quadrat 3** at 4 m above lowest tide would be exposed to air for a total of 9 hours on September 17th.

(ii) Use information from **Images 4.1** and **4.2** to calculate how many hours the organisms living in **quadrat 7** would be exposed to air on September 17th. **Draw lines** on **Image 4.2** to show how you arrived at your answer. [2]

Time exposed to air in quadrat 7 = ... hours

Examiner only

(d) **Image 4.3** shows photographs of two of the species of seaweed included in the study. Unlike higher plants, seaweeds do not have roots, stems and leaves. Instead, they have a flattened body called a thallus (plural, thalli).

Image 4.3

Twisted wrack – *Fucus spiralis*

Serrated wrack – *Fucus serratus*

The thallus of *F. spiralis* is curled whereas the thallus of *F. serratus* is flat.
Explain how the curled thallus of *F. spiralis* is an adaptation to increased exposure to air. [2]

.....

.....

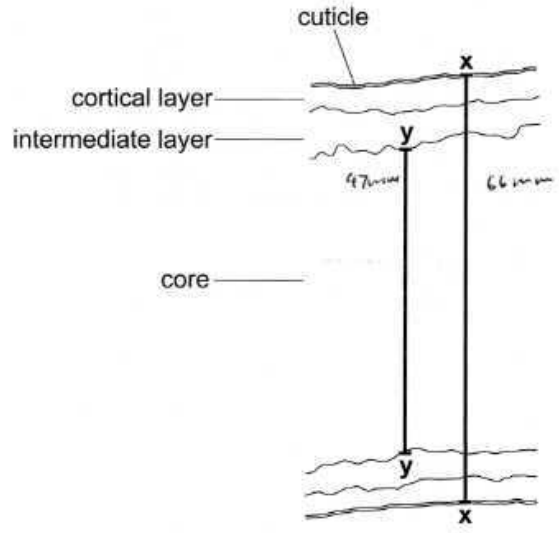
.....

.....

Examiner only

(e) The internal structure of a seaweed thallus might also provide adaptations to reduce the effect of exposure to air. **Image 4.4** is a low power plan of a cross-section through the thallus of a seaweed.

Image 4.4



actual thickness x–x = 330 µm
actual thickness y–y = 198 µm

(i) Measure distance **x–x** on the low power plan and calculate the magnification of the drawing. [2]

Space for working

Magnification = × .....

(ii) Use the actual thicknesses of **x–x** and **y–y** shown in the box on **Image 4.4** to calculate the percentage of the thallus that is made up of core. [2]

Percentage of thallus made up of core = ...

Examiner only

(f) One student suggested that the core could act as a water store. Seaweeds adapted to longer periods of exposure to air would have a thicker core. The student made the following plan to test their suggestion.

- Place one quadrat on the upper shore and one quadrat on the lower shore.
- Collect 15 thalli from each quadrat.
- Prepare a transverse section of each thallus and examine using a microscope.
- Calculate the mean percentage of thallus made up of core for each quadrat.
- Carry out a statistical test to find out if there is a significant difference between the mean percentage of thallus made up of core for each quadrat.

(i) State an appropriate statistical test that could be used to determine whether the difference between two means is significant. [1]

.....

(ii) Use the information given above to state the Null Hypothesis for their test. [1]

.....

.....

(iii) Suggest **two** ways that the student's plan could be improved to increase confidence in their results. [2]

.....

.....

.....

.....

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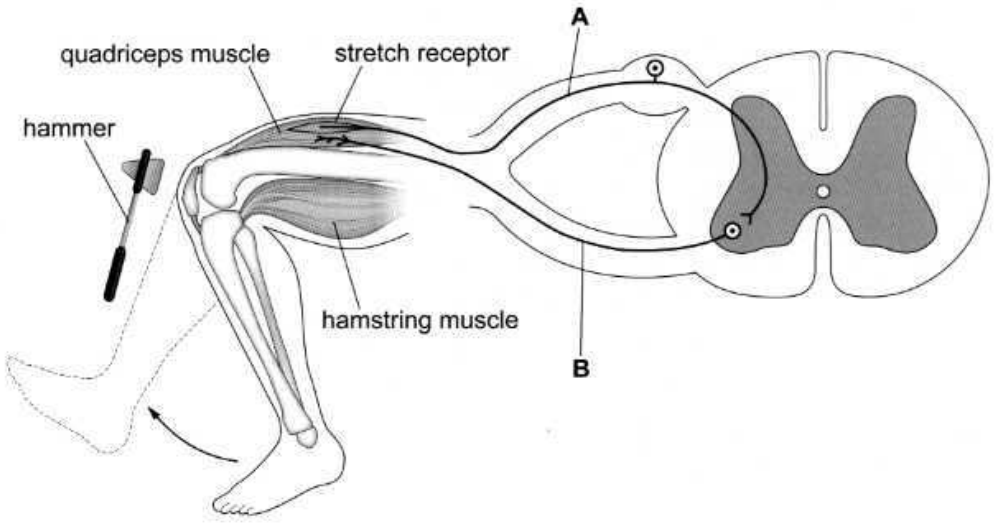
Examiner only

5. Reflex actions are defined as being rapid and automatic. **Image 5.1** shows the reflex arc involved in the knee-jerk reflex.

Image 5.1



(a) (i) Use **Image 5.1** to name the effector and the part of the Central Nervous System (CNS) involved in this reflex. [1]

Effector .....

Part of CNS .....

(ii) Name the types of neurones labelled **A** and **B**. [1]

A .....

B .....

(iii) Explain, in terms of the structures visible in **Image 5.1**, why this reflex is **rapid** and **automatic**. [2]

.....

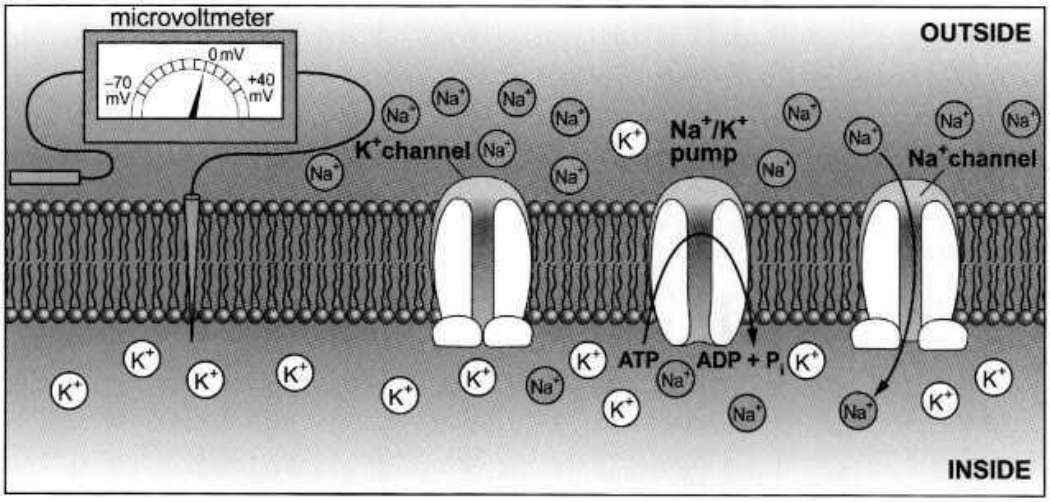
.....

.....

Examiner only

(b) **Image 5.2** shows a stage in the generation of an action potential across the cell membrane of a neurone.

Image 5.2



(i) Name the stage of the action potential shown in **Image 5.2**. [1]

.....

(ii) Describe how you would expect the needle on the microvoltmeter to move as this stage progresses. [1]

.....

(iii) Explain the roles of potassium ion channels and sodium ion channels in the generation of an action potential. [2]

.....

.....

.....

.....

(iv) Explain the role of the sodium-potassium ion pump in returning the cell membrane of the neurone to its resting potential. [2]

.....

.....

.....

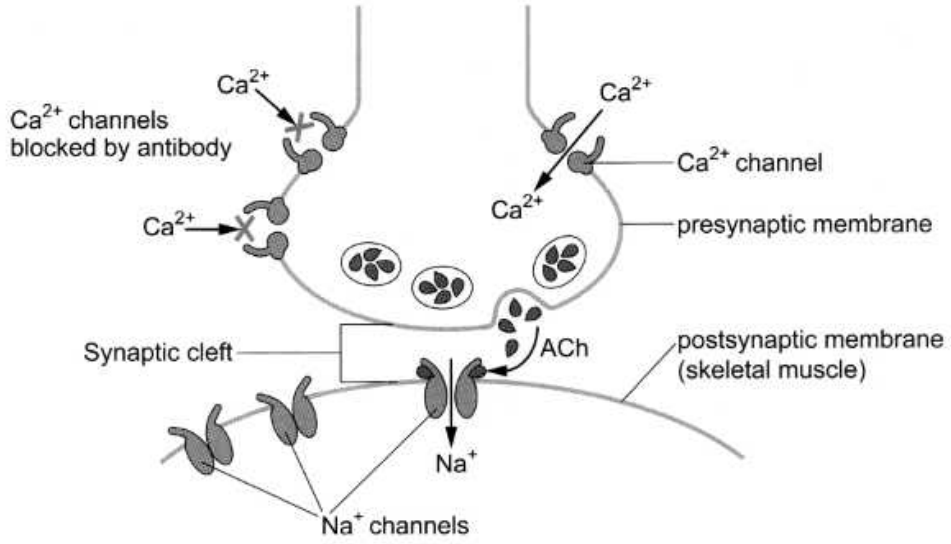
.....

Examiner only

(c) Synapses between neurones and muscles are called neuromuscular junctions. When a nerve impulse reaches a neuromuscular junction, it triggers the release of acetylcholine (ACh) as in many other synapses.

Lambert Eaton Syndrome (LES) is an autoimmune disease in which a person produces antibodies that block some calcium ion channels in the presynaptic membranes of neuromuscular junctions as shown in **Image 5.3**.

Image 5.3



To diagnose LES, doctors test for knee-jerk reflexes.

Explain why someone with LES has no knee-jerk reflexes. [4]

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6. Bacterial resistance to antibiotics is a serious concern in modern medicine so a great deal of research is being carried out to discover new antibiotics.

(a) Microbiologists tested the effectiveness of four antibiotics (**A–D**) by measuring their Minimum Inhibitory Concentration (MIC). This is the lowest concentration of an antibiotic that will inhibit the visible growth of a micro-organism. This is done using a microdilution plate, as shown in **Image 6.1A**. **Image 6.1B** shows a side view of the microdilution plate and the concentrations of antibiotics produced in the different wells.

Image 6.1A

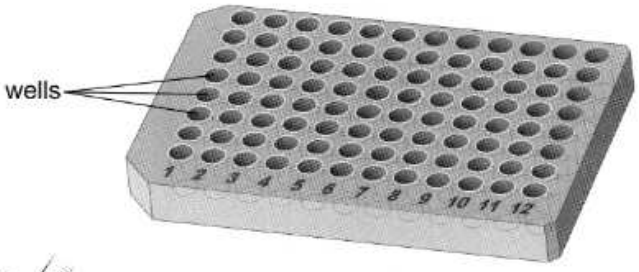
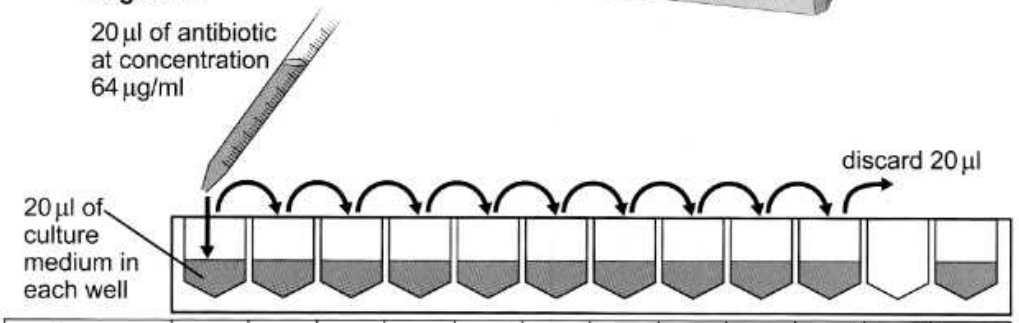


Image 6.1B



well	1	2	3	4	5	6	7	8	9	10	11	12
concentration µg/ml	32	16	8	4	2	1	0.5	0.25	0.125	0.0625		control

The method used is shown below:

1. Place 20 µl of culture medium in wells 1–10 of a microdilution plate.
2. Add 20 µl of antibiotics at concentration 64 µg/ml to well 1.
3. Transfer 20 µl from well 1 to well 2 and repeat to produce the concentrations shown in **Image 6.1B**.
4. Add 5 µl of a culture of the bacterial strain to wells 1–10.
5. Add 10 µl of culture medium, 10 µl of distilled water and 5 µl of a culture of the bacterial strain to well 12.
6. Repeat Steps 1–5 for two more rows in the microdilution plate.
7. Incubate plates at 37 °C for 24 hours.
8. Determine MIC by finding the lowest concentration at which no bacterial growth was seen in the well.

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Answer the following questions about the experiment.

(i) State the purpose of the culture medium. [1]

.....

(ii) I. Use the volumes specified in **Image 6.1B** to describe how the concentration of antibiotic was produced in **well 1**. [2]

.....

.....

.....

.....

II. Name the method by which the different concentrations are produced. [1]

.....

(iii) I. Explain why **well 12** was set up using the volumes stated in **step 5** of the method. [1]

.....

.....

II. Explain the purpose of **well 12** in this experiment. [1]

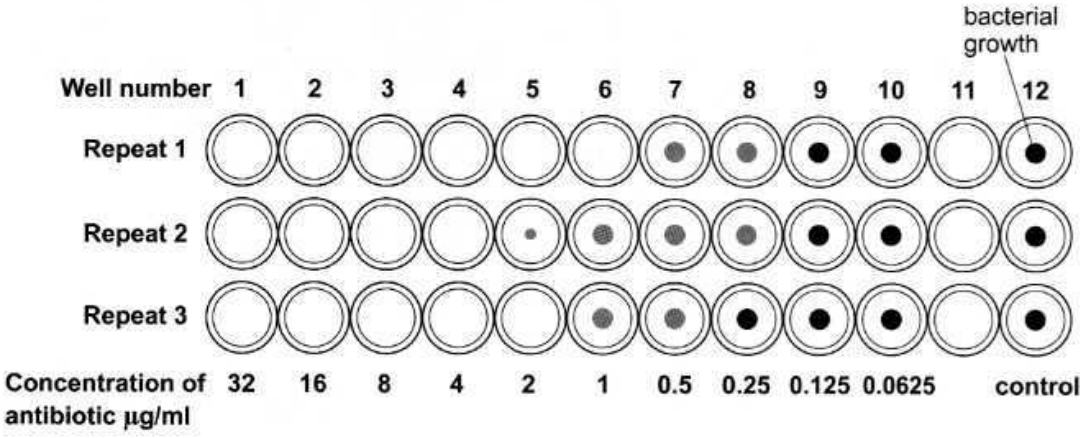
.....

.....

Examiner only

The method described on page 20 was used to determine the MIC of antibiotic **C** against *E. coli* and *S. aureus*. The results for *E. coli* are shown in **Image 6.2**.

Image 6.2



(iv) I. For each of the repeats **1**, **2** and **3**, find the lowest **concentration** of antibiotic **C** that inhibits the growth of *E. coli*. [1]

Repeat 1 ..... µg/ml

Repeat 2 ..... µg/ml

Repeat 3 ..... µg/ml

II. Calculate the mean value for MIC in µg/ml. [1]

Mean MIC = ... µg/ml

(v) Describe **one** limitation of this method for determining MIC. [1]

.....

.....

Examiner only

(b) The method on page 20 was also used to find the MIC for antibiotics **A** , **B** and **D**. The MIC for the four antibiotics against *E. coli* and *S. aureus* are shown in **Table 6.3**.

Table 6.3

Antibiotic	Minimum Inhibitory Concentration / μM	
	E. coli	*S. aureus*
A	16.13	>64.52
B	>67.01	>67.01
C	1.17	18.71
D	8.19	>65.50

(i) With reference to the results in **Table 6.3**, state which antibiotic (**A–D**) shows most promise as a potential new treatment. Explain your answer. [1]

Antibiotic .....

.....

.....

(ii) *E. coli* is Gram negative, but *S. aureus* is Gram positive.

I. Describe **one** difference between the cell walls of the two types of bacteria. [1]

.....

.....

.....

.....

II. Suggest how the difference in the cell walls might account for the MICs shown in **Table 6.3** for antibiotics **A**, **C** and **D**. [1]

.....

.....

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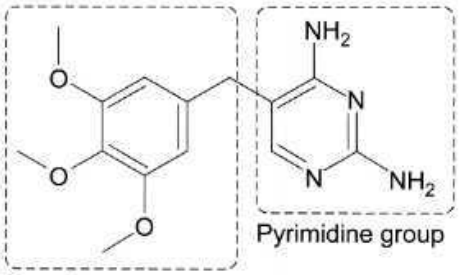
(c) Trimethoprim (TMP) is an antibiotic that affects DNA synthesis. Compound **X** has been identified as a possible new antibiotic. **Image 6.4** shows the chemical structures of trimethoprim and compound **X**.

Image 6.4

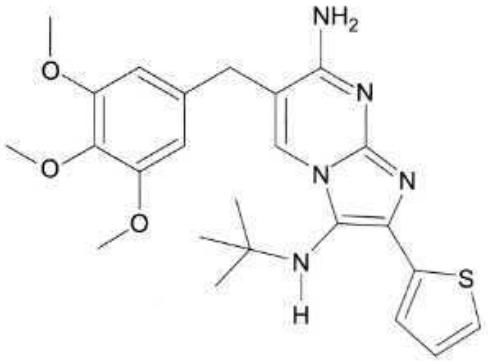
Trimethoprim



Pyrimidine group

Benzyl group

Compound X



(i) Name **one** pyrimidine that could be found in a **DNA** nucleotide. [1]

.....

(ii) TMP is a competitive inhibitor of dihydrofolate reductase, which is an enzyme involved in DNA synthesis.
With reference to **Image 6.4**, explain how compound **X** might also inhibit dihydrofolate reductase. [2]

.....

.....

.....

.....

(iii) Compound **X** was extracted from a plant discovered growing in a tropical rainforest.
Explain the importance of conserving plant species such as this. [2]

.....

.....

.....

.....

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7. To achieve sustainable fishing, political decisions were made to develop a policy to conserve fish stocks. This policy included:

- methods for regulating fishing;
- monitoring fish populations;
- targets for achieving sustainable fish populations in marine waters.

Two criteria are used to assess whether the targets for sustainable fish populations in marine waters have been met. These criteria are:

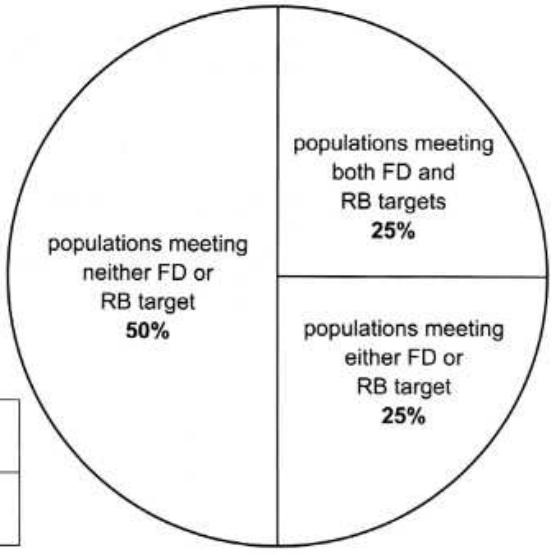
1. Level of exploitation, measured as the biomass of fish caught – Fish Deaths (**FD**).

2. Reproductive capacity, measured as the biomass of reproducing fish – Reproductive Biomass (**RB**).

The results of monitoring commercial fish populations in the North Sea are shown in **Image 7**.

Image 7

Percentage of fish populations in the North Sea meeting sustainable fishing targets.



Number of known fish populations	56
Number of populations monitored	48

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Describe the measures that could be included in a policy to reduce overfishing.

Use your knowledge of population density to explain the scientific basis for choosing the two criteria (**1.** and **2.**) listed opposite.

Use data from **Image 7** to evaluate the effectiveness of the policy to regulate fishing in the North Sea. [9 QER]

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END OF PAPER

9

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

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