Surname	Centre Number	Candidate Number
Other Names		2

GCE AS

B400U10-1

S19-B400U10-1

BIOLOGY – AS component 1
Basic Biochemistry and Cell Organisation

TUESDAY, 21 MAY 2019 – AFTERNOON

1 hours 30 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**9**	
2.	**10**	
3.	**12**	
4.	**15**	
5.	**9**	
6.	**11**	
7.	**9**	
Total	**75**	

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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.

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 quality of extended response (QER) will take place in question **7**.

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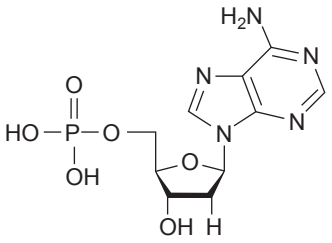
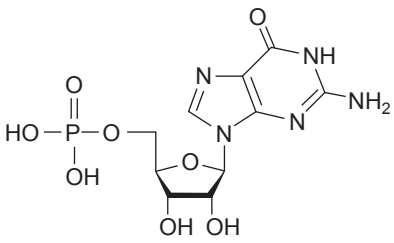
Answer **all** *questions.*

1. Nucleic acids and related molecules are found in all forms of life on Earth. The diagrams below show the structural formulae of three molecules called nucleotides.

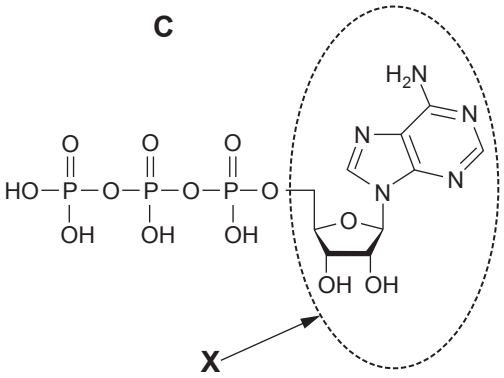
A



B



C



(a) (i) Identify the **type** of nitrogenous base found in all three molecules. [1]

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(ii) Explain why molecule **C** is sometimes referred to as the *universal energy currency*. Include reference to the structure of the molecule in your answer. [3]

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(iii) Name the **region** of molecule **C** labelled **X** on the diagram. Use this information to identify the base found in molecule **B**. [2]

X .....

Base in molecule **B** .....

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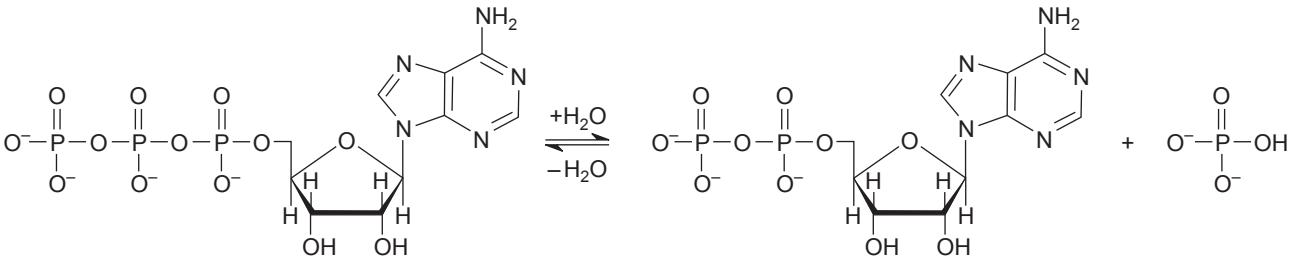
(b) Molecule **C** is mainly synthesised in two organelles found in eukaryotic cells as shown in the equation below.



(i) Name **two** organelles which synthesise molecule **C**. [1]

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(ii) State whether the synthesis of molecule **C** is endergonic or exergonic. Explain your answer. [1]

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(iii) The removal of all three phosphate groups from molecule **C** one after the other would release a total of 75.4 kJ mol^{-1} of energy. Assuming the removal of the first and second phosphate groups yield the same quantity of energy, calculate the available energy stored in the bond between the third phosphate and the pentose sugar. [1]

Available energy = ... kJ mol^{-1}

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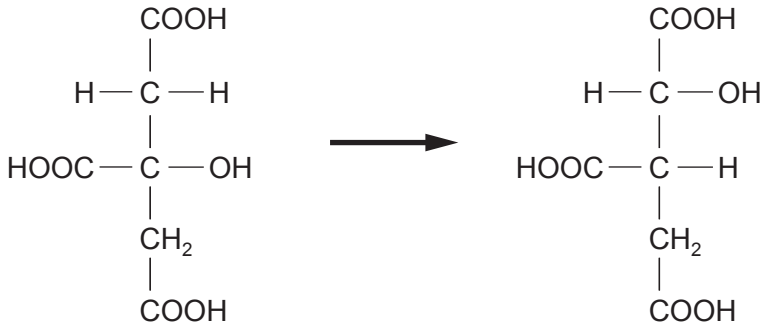
2. Citrate and isocitrate are two of the molecules found in a metabolic pathway in mitochondria. The structures of these molecules are shown below.



Citrate **Isocitrate**

(a) Explain why these molecules are termed **structural isomers**. [1]

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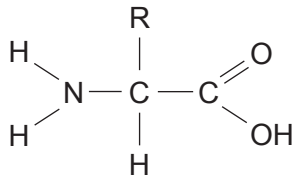
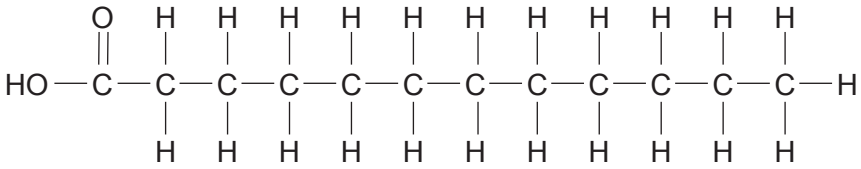
The –COOH group is found in several different biological molecules. Two of these molecules are shown below.

X



Y



(b) (i) Name the type of molecules **X** and **Y**. [1]

X .....

Y .....

(ii) State what is represented by **–R** in molecule **X**. [1]

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Molecule **Y** is found as a component of a group of molecules that are involved in energy storage and thermal insulation in many organisms.

(iii) Name this group of molecules and describe how you would test for their presence in a sample of food. [3]

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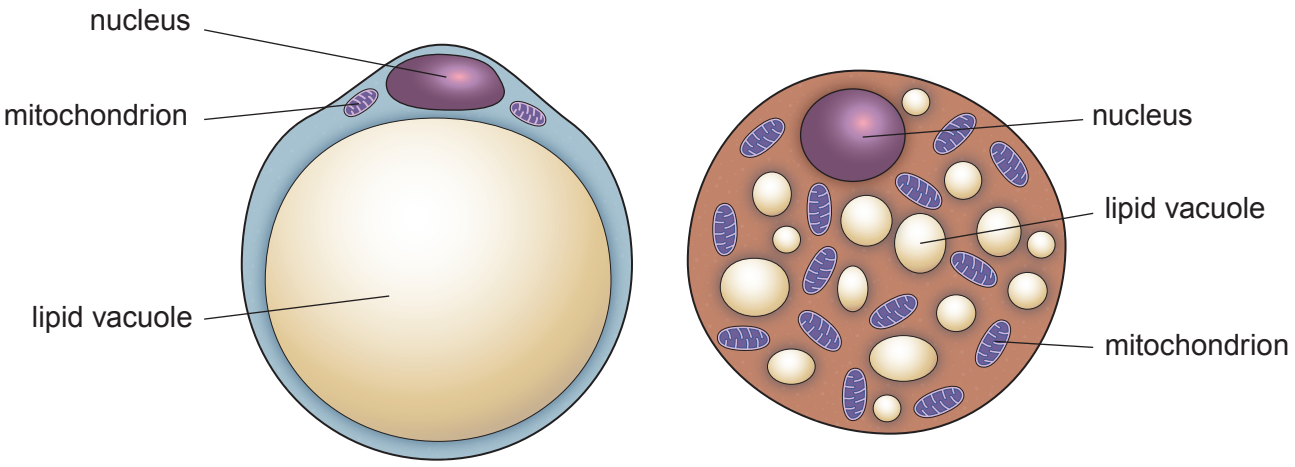
Adipose tissue is found in mammals in two different forms: white adipose tissue and brown adipose tissue. The distribution of each form varies depending upon the species. Seals, which live in cold water, have a thick layer of white adipose tissue under their skin. In addition, other areas of a seal's body have a high proportion of brown adipose tissue.

Drawings of the cells that make up each type of adipose tissue are shown below.



white fat cell **brown fat cell**

(iv) The diameter of the lipid vacuole in the white fat cell measured 80 μm. Calculate the volume of the lipid vacuole located in the white fat cell. Use the formula given. [2]

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

π = 3.14

Volume = ... μm^3

(v) Brown and white fat cells in seals help them survive in **cold** water. Using the information provided, suggest how the structure of each type of fat cell is an adaptation for the survival of the seal. Explain your answer. [2]

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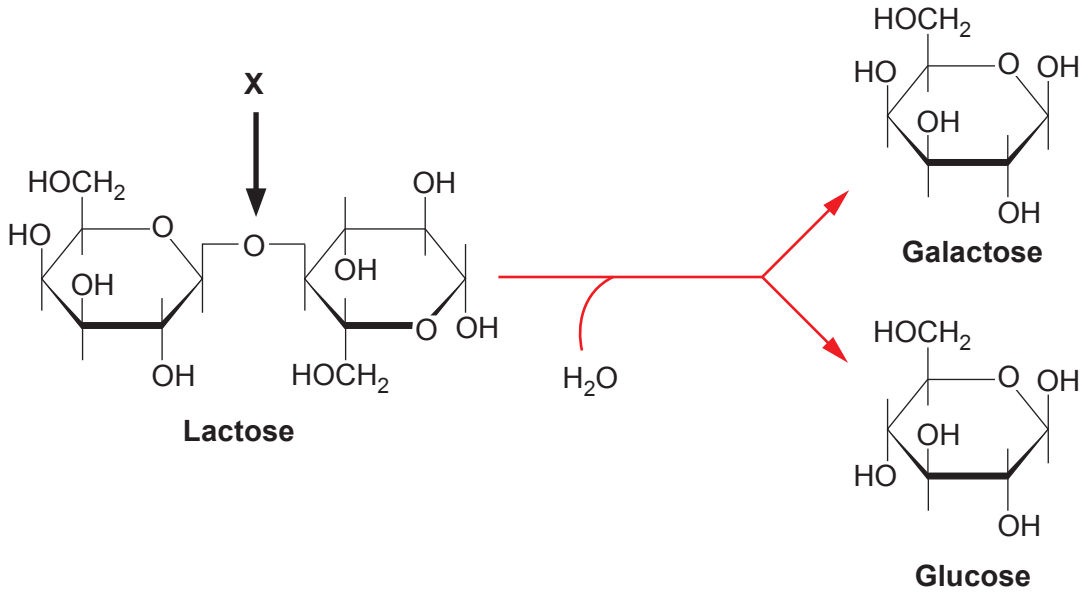
3. Some people cannot drink cow's milk as they are lactose intolerant. They lack the enzyme lactase that catalyses the breakdown of lactose into galactose and glucose.



(a) (i) If lactase is present, bond **X** is broken in this reaction. Name this type of bond and the type of reaction that breaks this bond. [2]

Bond X .....

Reaction .....

(ii) Explain how you can identify that the isomer of glucose shown in the diagram above is β-glucose. [1]

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(b) (i) The rate of enzyme activity can be altered by the presence of inhibitors.

Explain why galactose can act as a competitive inhibitor of lactase. [1]

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Students investigated the effect of inhibition of lactase by galactose.
They added a fixed concentration of lactase to different concentrations of lactose solution and measured the rate of monosaccharide formation. The experiment was repeated with a fixed concentration of galactose added to the lactose solutions. All volumes used were controlled for each solution in both experiments.

The results are shown below.

Concentration of lactose / mmol dm^{-3}	**Rate of monosaccharide formation / mmol dm^{-3} minute^{-1}**	
	Experiment 1 (without galactose)	**Experiment 2 (with galactose)**
0.00	0.000	0.000
0.10	0.115	0.050
0.30	0.176	0.130
0.50	0.190	0.180
0.70	0.190	0.190

(ii) The results for Experiment 1 have been plotted on the graph paper below.

Plot the results for Experiment 2 **on the same axes**. [2]

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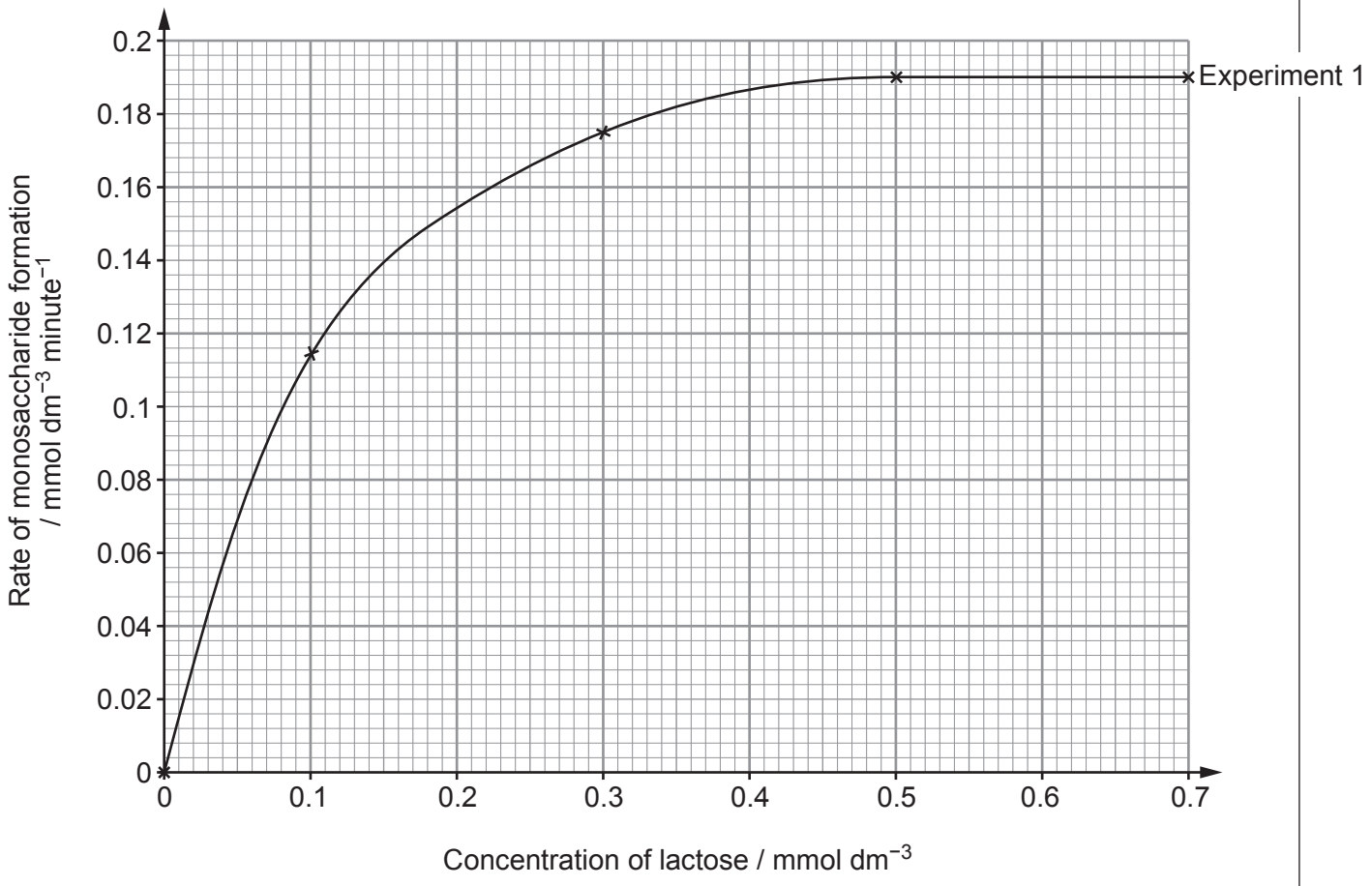

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(iii) Explain how the results show that galactose acts as a competitive inhibitor of lactase. [2]

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(iv) Describe how the graph would look if galactose was a non-competitive inhibitor of lactase. [1]

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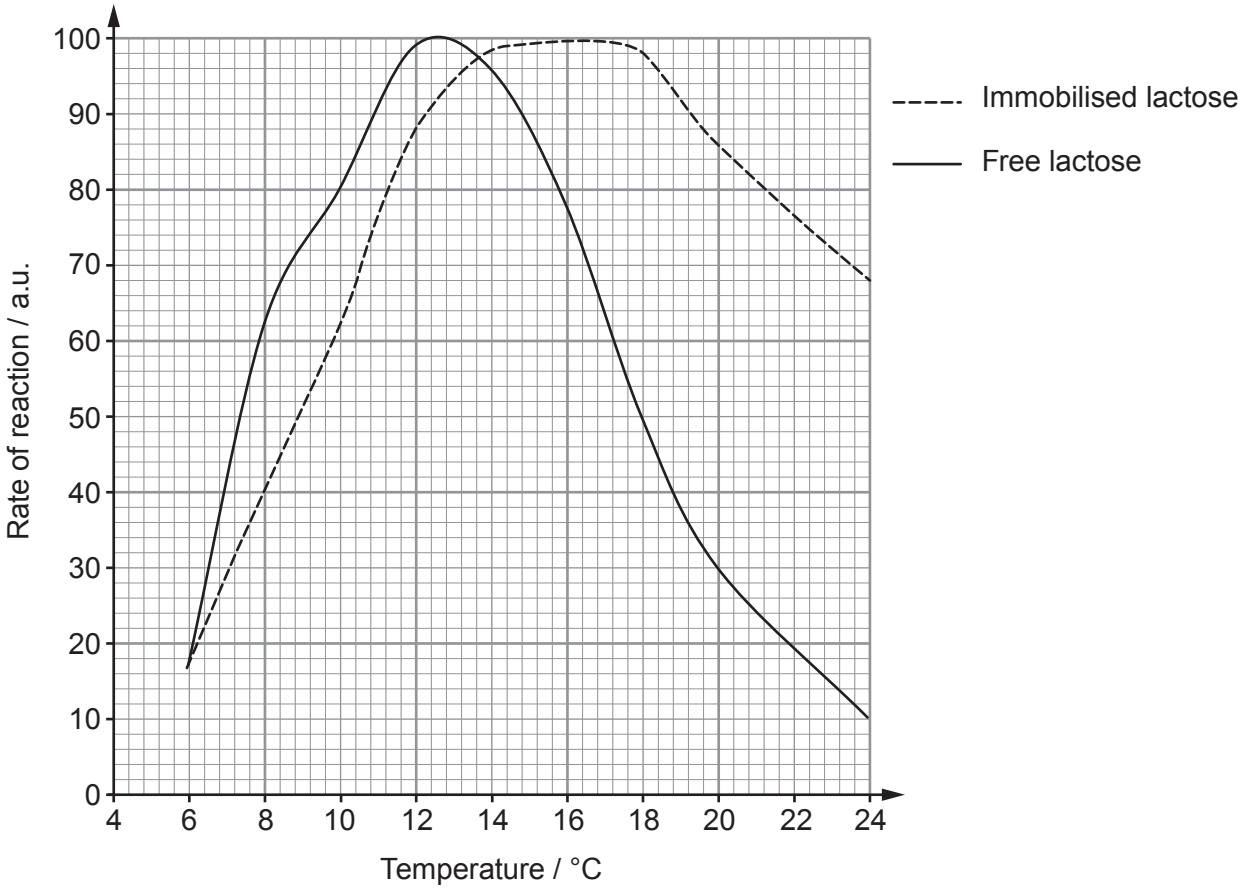
(c) Lactose free milk can be produced using bacterial lactase which has been immobilised in beads made from an inert substance, such as alginate.
An experiment was carried out to compare the activity of free and immobilised lactase at different temperatures. The results are shown in the graph below.



(i) Explain why the immobilised lactase works at its maximum rate over a wider range of temperatures than the free lactase. [2]

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(ii) Explain why the substance used to immobilise the lactase must be inert. [1]

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Turn over.

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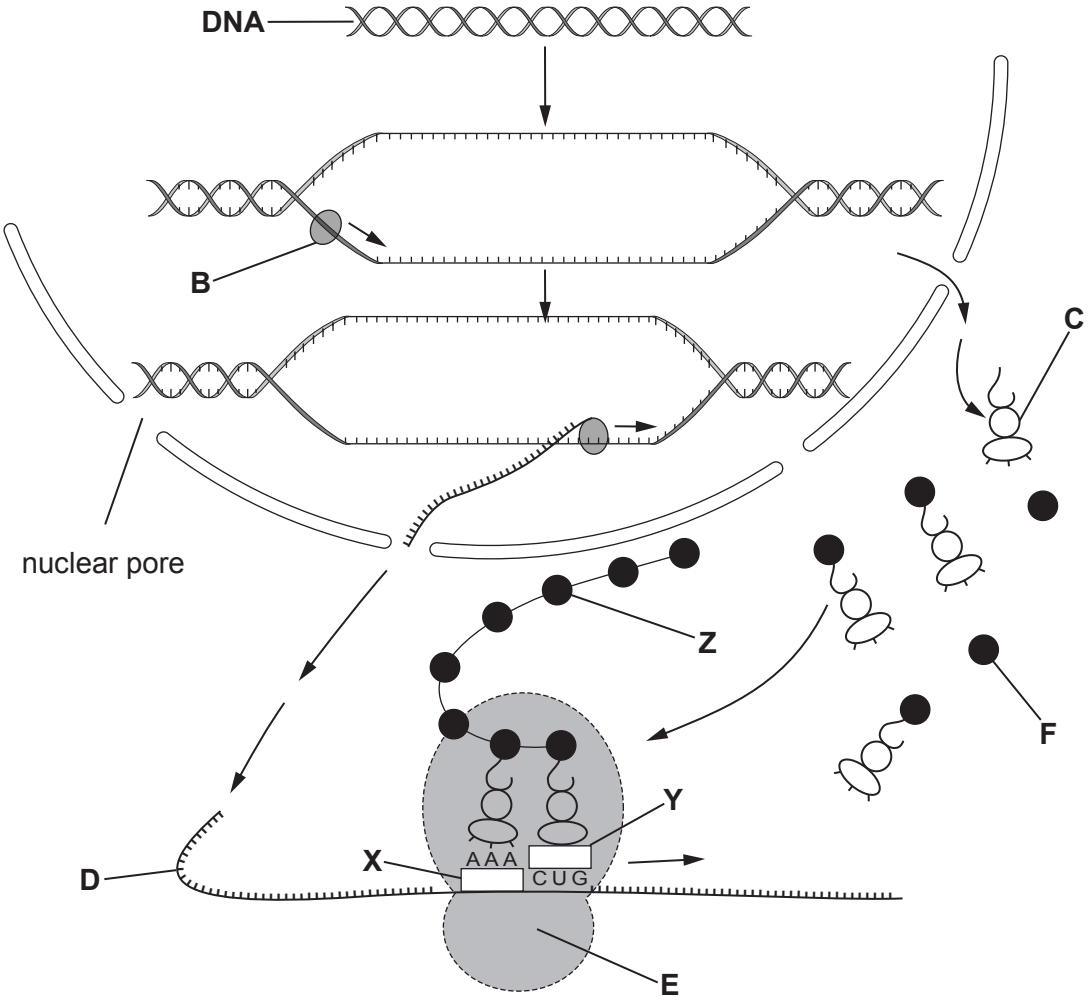
4. The diagram below summarises the process of protein synthesis which involves both DNA and RNA.



(a) Use some of the letters from the diagram to identify the following molecules involved in protein synthesis. [1]

mRNA .....

tRNA .....

rRNA .....

(b) (i) The structures labelled **X** and **Y** on the diagram are sequences of bases. Complete the table below. [2]

Base Sequence	Name of the sequence	Bases in the sequence
X	.....	.....
Y	.....	.....

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(ii) Describe and explain how a change in the base sequence of **X** could affect the primary structure of molecule **Z**. [3]

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(c) It was originally proposed that **one gene** carried the code for **one enzyme**. This was revised to become the **one gene – one protein** hypothesis. It is now known as, the **one gene – one polypeptide** hypothesis.

Using your knowledge of protein structure and function explain why the two previous versions of this hypothesis are no longer accepted. [2]

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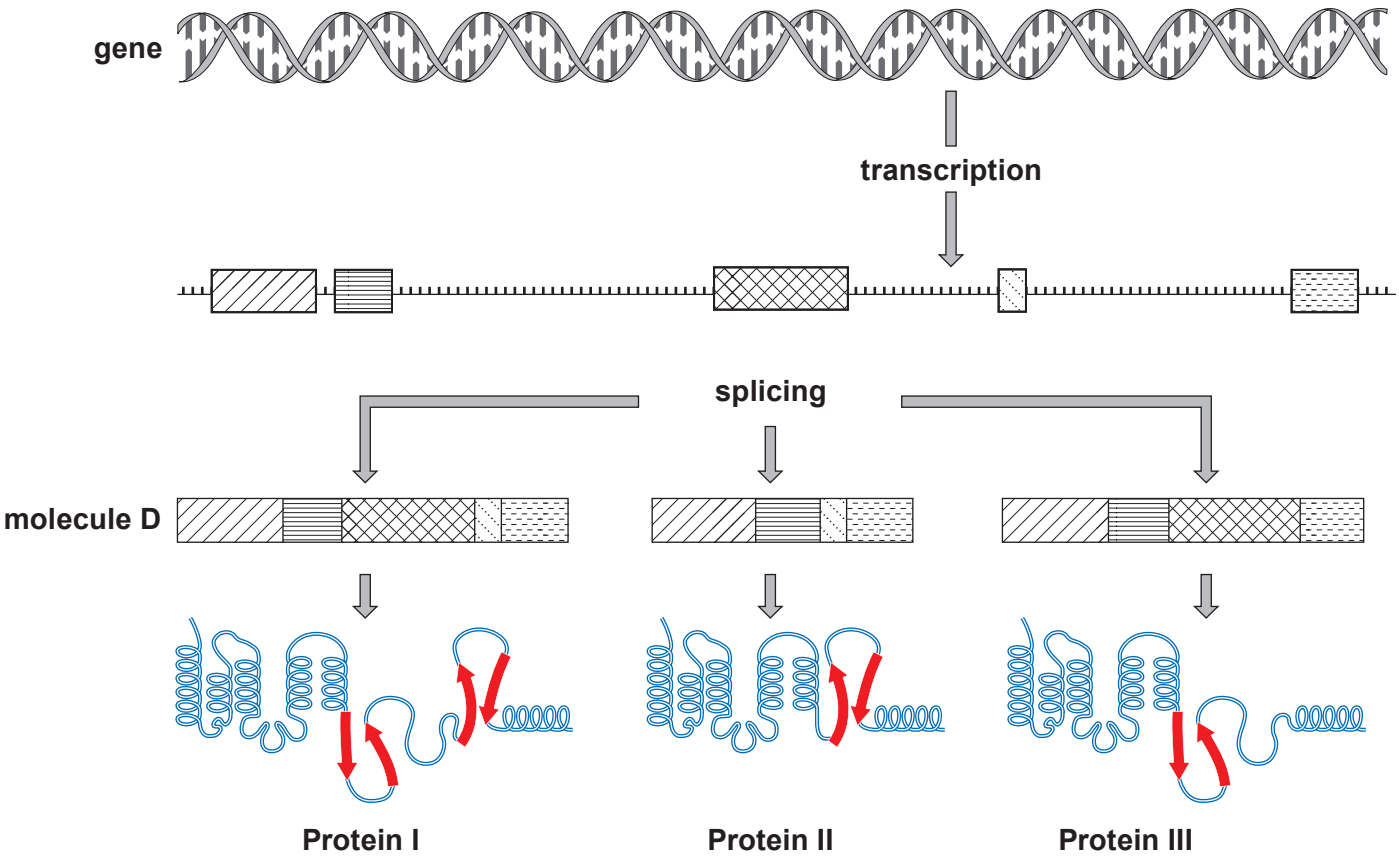
In the 1960s, it was estimated that the human genome contained more than 2 000 000 genes. Analysis has since shown that much of the genome is made up of non-coding regions and that the coding regions contain about 20 000 genes that code for polypeptides. However, over 1 000 000 different polypeptides are produced by our cells.

The diagram below shows how different proteins can be produced from the same gene.



(d) Describe the process of transcription. [3]

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(e) (i) State the names given to the: [1]

coding regions .....

non-coding regions .....

(ii) With reference to the gene shown in the diagram and your own knowledge of protein synthesis, explain how **different** proteins can be produced from a single gene. [3]

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5. Brown seaweeds of many types grow on rocks around the shores of the UK. One of these species is called *Fucus vesiculosus*.

It is classified in the Kingdom Protoctista even though its cells contain chlorophyll.

(a) Name the domain to which *F. vesiculosus* belongs and list the **other** Kingdoms of organisms found in this domain. [2]

Domain .....

Other Kingdoms in this domain .....

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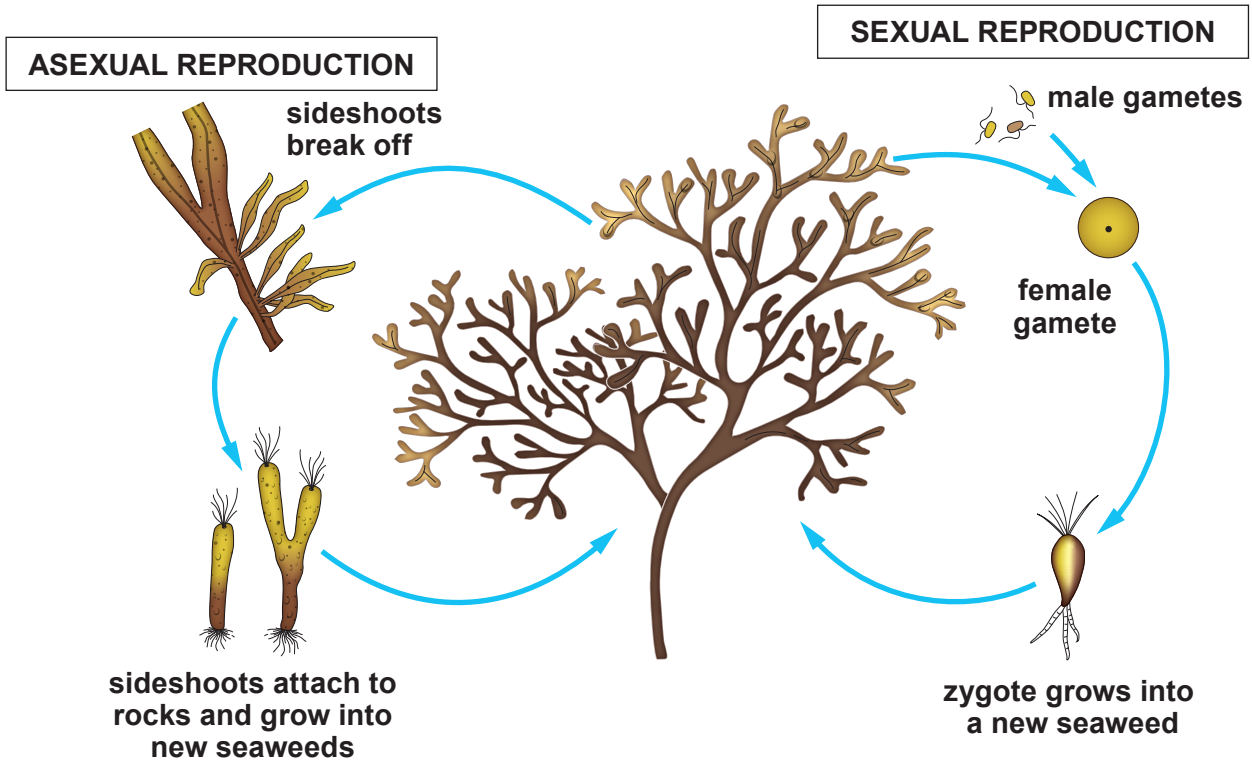
(b) This type of seaweed can reproduce both sexually and asexually as shown in the diagram below.



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During sexual reproduction gametes are produced in specialised structures.
The process involves both meiosis and mitosis:

- In the production of female gametes, one cell divides first by meiosis which is followed by a single mitotic division.
- In the production of male gametes, one cell divides first by meiosis which is followed by four mitotic divisions.

(i) Calculate the number of male and female gametes produced from one cell. [2]

Number of female gametes = ...

Number of male gametes = ...

(ii) Suggest why gamete production in *F. vesiculosus* involves both meiosis and mitosis. [2]

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(iii) Explain why new seaweeds produced by sexual reproduction would be genetically different to each other and different to those produced by asexual reproduction. [3]

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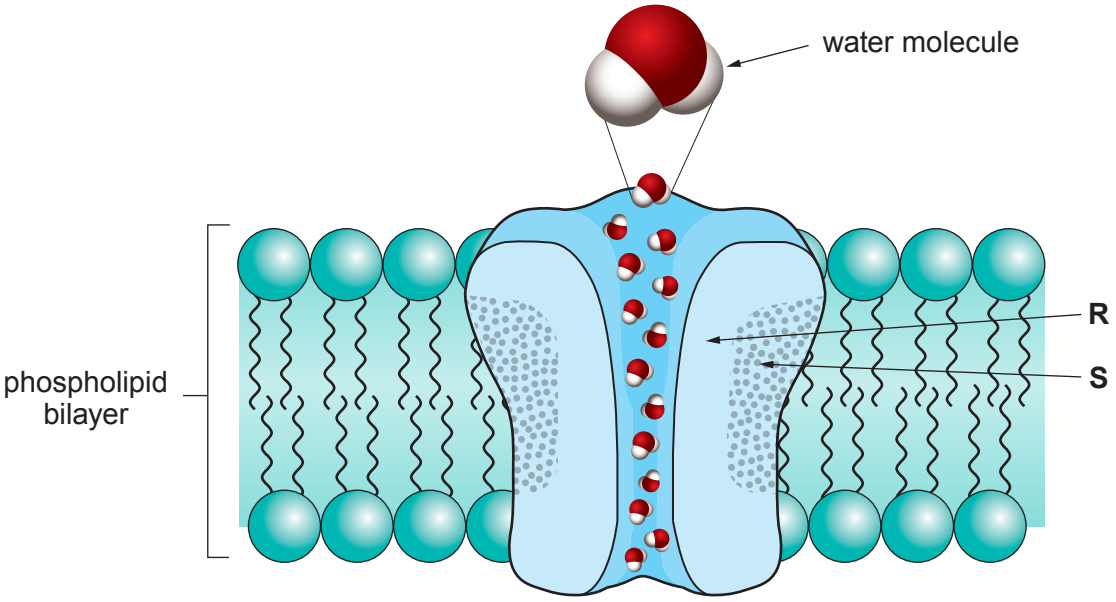
6. The presence of aquaporin proteins in cell membranes speed up the movement of water molecules by osmosis. The diagram below shows water molecules travelling through an aquaporin in the plasma membrane of a cell.



(a) (i) Explain why water molecules cannot easily diffuse through the phospholipid bilayer. [1]

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(ii) Identify which region of the aquaporin molecule labelled **R** and **S** is non-polar. Explain how you arrived at your answer. [1]

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(b) Water passes from one plant cell to another down a water potential gradient.
Water potential is affected by two opposing forces, pressure potential (ψ_p) and solute potential (ψ_s).

$$\psi_{cell} = \psi_p + \psi_s$$

A practical was carried out to determine the water potential of red onion cells by placing red onion tissue in different concentrations of sucrose solution and observing them under a microscope. The total number of cells in the field of view was counted together with the number of plasmolysed cells. The percentage of plasmolysed cells was then calculated for each concentration of sucrose solution.

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The results are shown in the table.

Concentration of sucrose solution / mol dm^{-3}	Solute potential / kPa	Plasmolysed cells / %
0.1	−269	2
0.2	−526	12
0.3	−790	18
0.4	−1052	36
0.5	−1322	56
0.6	−1596	70
0.7	−1882	81
0.8	−2180	98
0.9	−2580	100

(i) Explain why the water potential of the cell can be assumed to be equal to the solute potential of the solution that causes 50 % plasmolysis. [1]

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(ii) Use the results in the table to estimate a value for the water potential of the onion tissue. [1]

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(iii) Outline how the data in the table could be used to determine a more accurate estimate of the onion tissue water potential. [2]

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(iv) State how the procedure could be modified to improve reliability and accuracy. [2]

Reliability .....

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Accuracy .....

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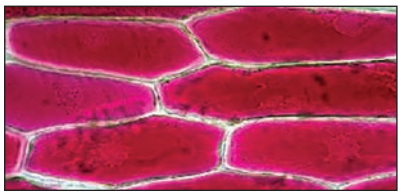
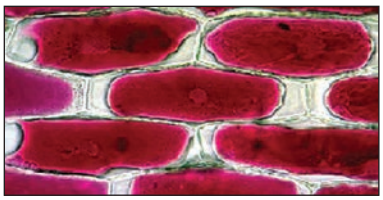
Photographs of some of the cells from the red onion tissue used in the investigation are shown below.

S



T



(v) State the terms used to describe the cells above. [1]

S .....

T .....

(vi) Red onion tissue was placed in a solution with a solute potential of −1800 kPa. After 30 minutes, the cells appeared like those shown in **T** above. Explain this observation. [2]

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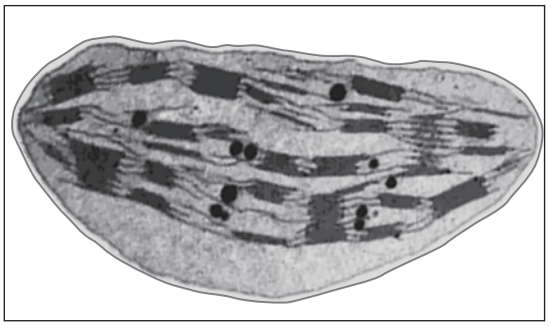
7. A symbiotic relationship is the interaction between two different species living in close physical association to the advantage of both.

In 1967, Lynn Margulis proposed the theory of endosymbiosis and suggested that mitochondria and chloroplasts evolved from free-living prokaryotes that were taken into other prokaryotic cells by endocytosis to form the first eukaryotic cells.

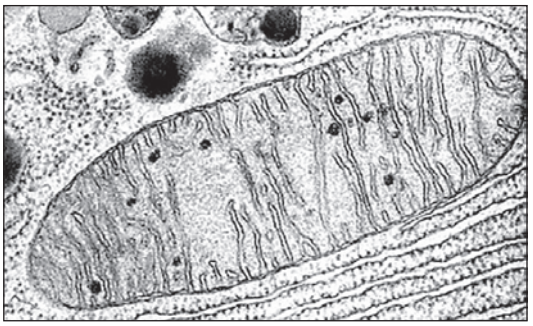
The electron micrographs below show the detailed structure of a chloroplast and a mitochondrion.

Chloroplast



1 µm

Mitochondrion



0.5 µm

Compare the structures of mitochondria and chloroplasts to prokaryotes.

Describe and explain how the double membrane observed in both organelles was formed, and how this supports the theory of endosymbiosis.

Suggest the advantages of this symbiotic relationship to the mitochondria, the chloroplasts and the newly formed eukaryotic cell. [9 QER]

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For continuation only.