Surname	Centre Number	Candidate Number
First name(s)		2

GCE AS/A LEVEL

2400U10-1

Z22-2400U10-1

FRIDAY, 20 MAY 2022 – AFTERNOON

BIOLOGY – AS unit 1
Basic Biochemistry and Cell Organisation

1 hour 30 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**10**	
2.	**7**	
3.	**11**	
4.	**14**	
5.	**14**	
6.	**15**	
7.	**9**	
Total	**80**	

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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 pages 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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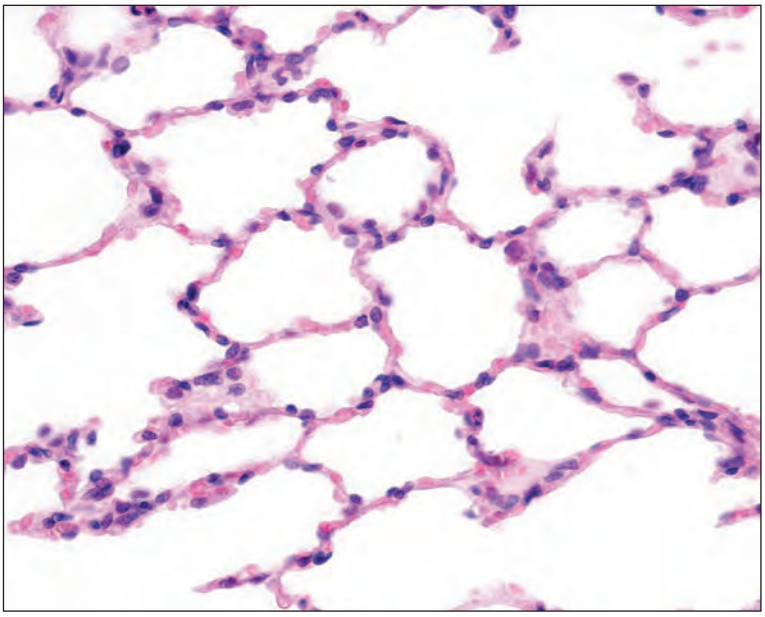
Answer **all** questions.

1. **Image 1.1** shows simple squamous epithelial tissue from the alveoli of the lungs.

Image 1.1



(a) Explain how the shape of the cells is adapted to their function within the tissue. [1]

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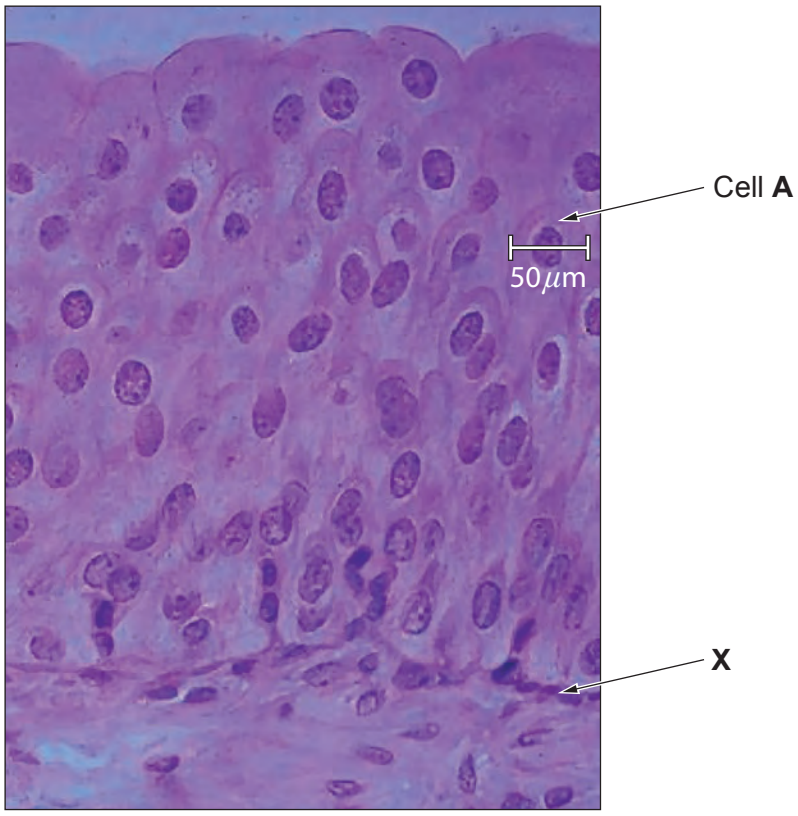
(b) The urinary bladder is lined with stratified epithelial tissue with a variable number of cell layers. **Image 1.2** shows this tissue when the bladder is relatively empty.

Image 1.2



(i) Name the structure labelled **X** on **Image 1.2**. [1]

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(ii) State why the cells in **Image 1.2** are referred to as a "tissue". [1]

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(iii) Explain why some of the cells appear not to have a nucleus in **Image 1.2**. [1]

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(iv) With reference to **Image 1.1** and **Image 1.2**, describe the main difference between the two types of epithelial tissue. [1]

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(c) (i) When the bladder is full, the cells become wider and flatter. Suggest how this property of the epithelial tissue allows the bladder to perform its function. [1]

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(ii) The width of cell **A** in **Image 1.2** is 50μm. Cell **A** is shown at 42% of its maximum width.
Calculate the maximum width of this cell. **Give your answer to three significant figures.** [2]

Maximum width = ... μm

(iii) With reference to the actual width of cell **A**, calculate the magnification of **Image 1.2**. [2]

Magnification = × .....

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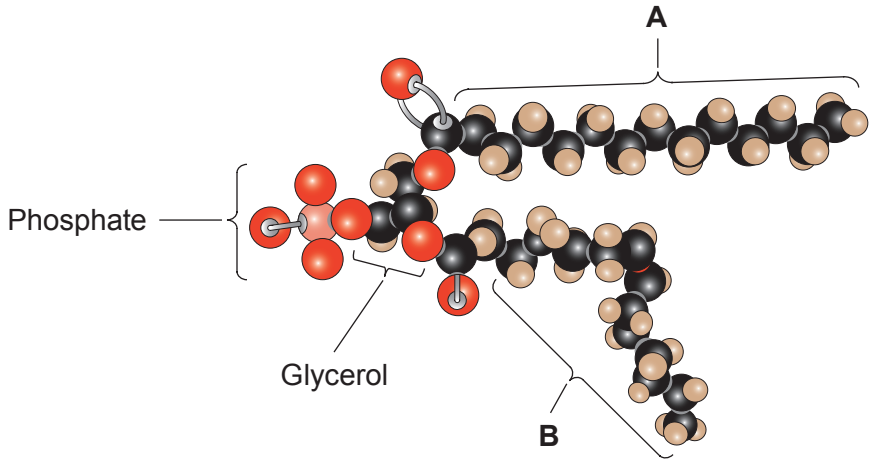
2. (a) **Image 2.1** shows a molecular model of a phospholipid, a component of cell membranes.

Image 2.1



(i) Structures **A** and **B** are both types of fatty acids. Identify both types and explain the difference in their shapes. [2]

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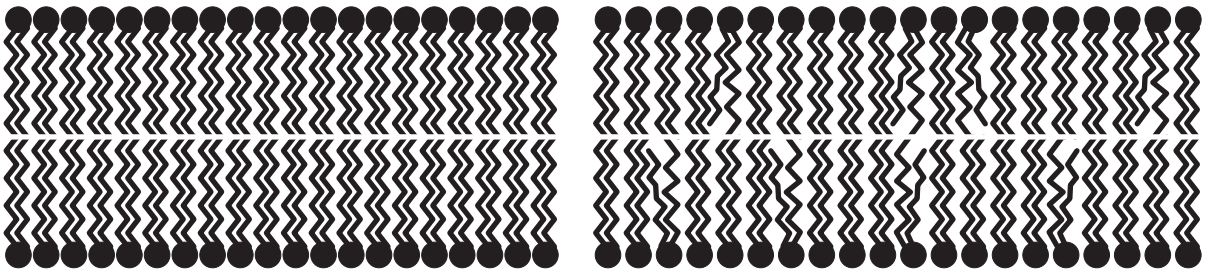
(ii) **Image 2.2** shows two examples of phospholipid bilayers. Membrane **1** has phospholipids containing only type **A** fatty acids and membrane **2** has phospholipids containing both type **A** and type **B**.

Image 2.2

Membrane **1** Membrane **2**



Using the information provided and your own knowledge, explain which membrane you would expect to be more permeable to small molecules. [2]

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(b) (i) Fatty acids are also found as part of triglycerides.

State how triglycerides differ from phospholipids in their structure and in their function in cells. [2]

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(ii) State how the relative proportions of type **A** and **B** fatty acids in the diet can affect human health. [1]

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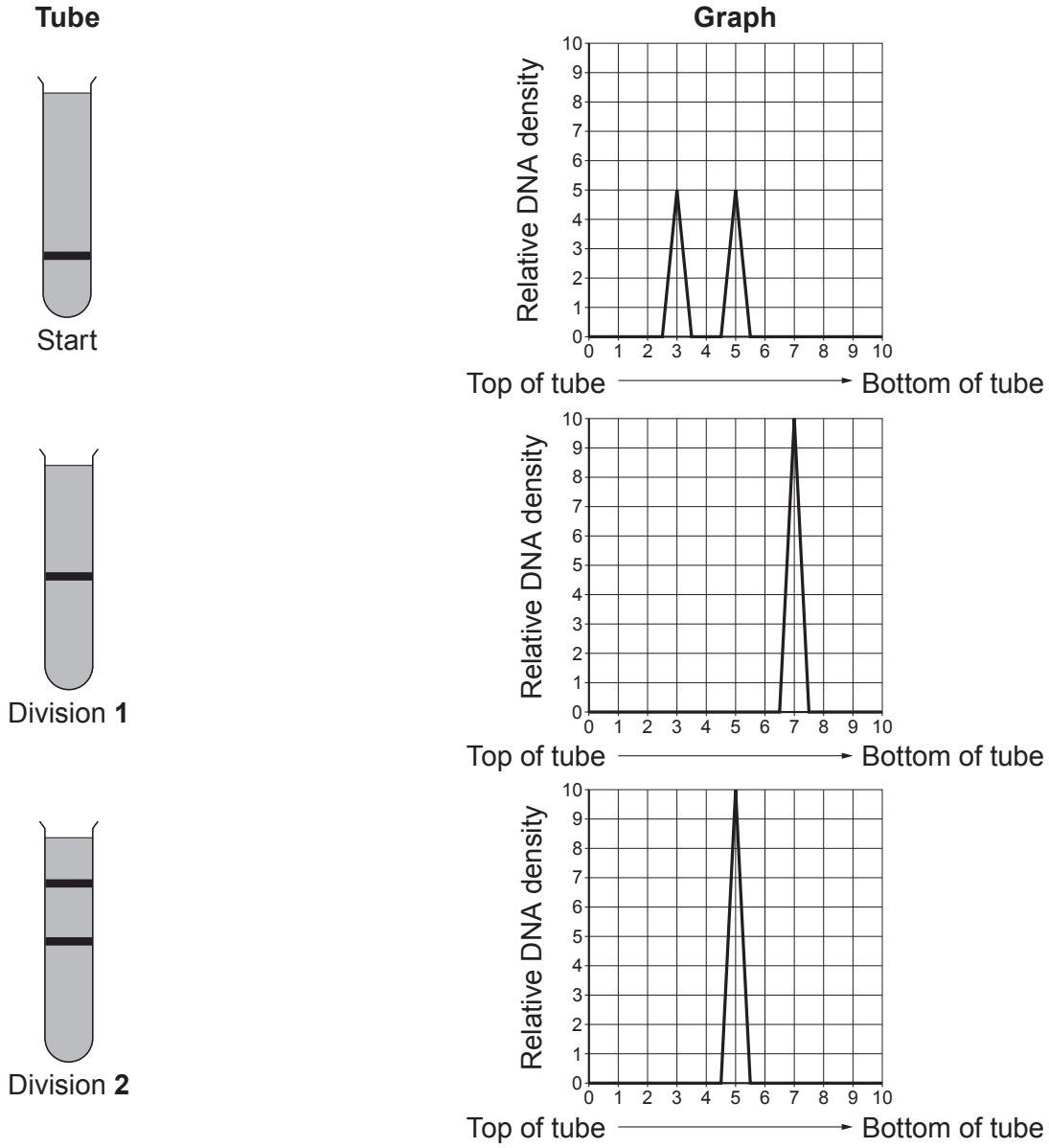
3. (a) In 1958 Meselson and Stahl conducted an investigation into DNA replication.

- Bacteria were grown in a culture medium that contained only the heavy isotope of nitrogen, ^{15}N. After many generations, the bacterial DNA contained only the heavy isotope of nitrogen.
- Some of the bacteria were then transferred to another culture medium containing only the lighter isotope of nitrogen, ^{14}N.
- DNA was extracted from the bacteria and centrifuged at the **start** (before cell division), and then after **1**, **2** and **3** cell divisions. Heavier DNA was found towards the bottom of the tube after centrifuging.

Image 3.1 shows the distribution of DNA in the tubes at the start and after Division **1** and Division **2**. The graphs represent the relative densities of DNA but they are not in the correct order.

(i) **Draw lines** on **Image 3.1** to match up the tubes with the correct graphs. [1]

Image 3.1



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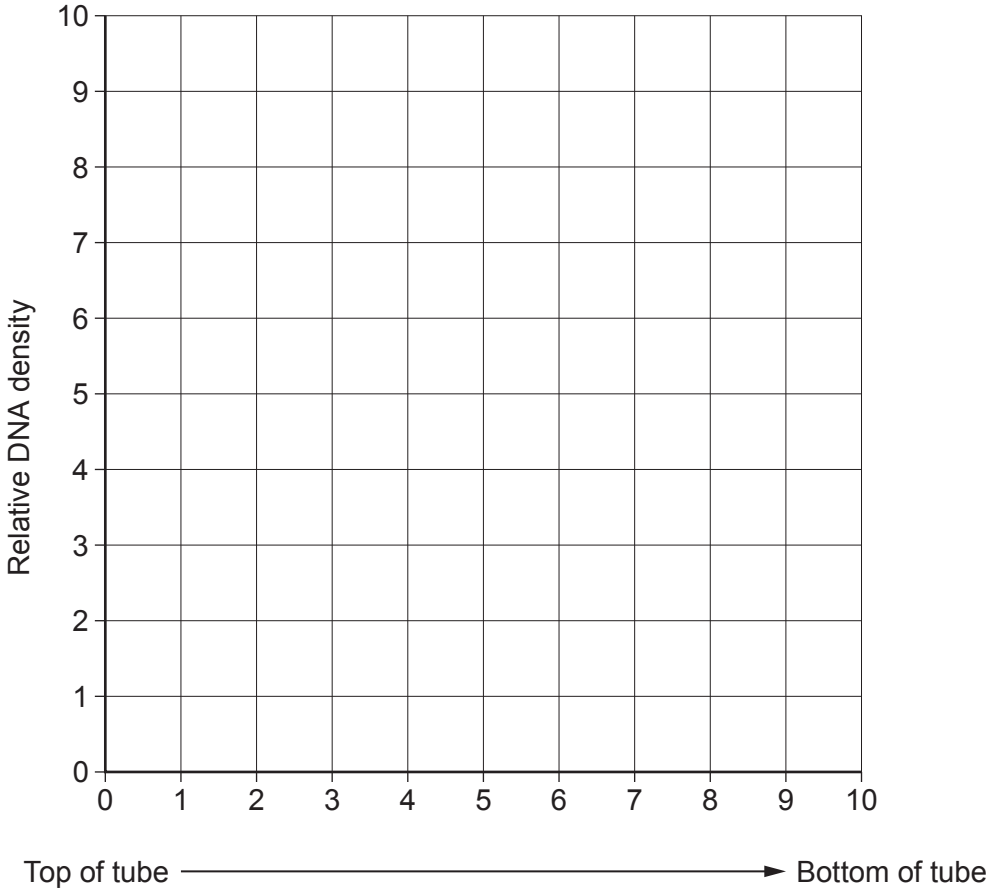
(ii) On **Image 3.2 sketch the graph** you would expect to see for Division **3**. [3]

Image 3.2



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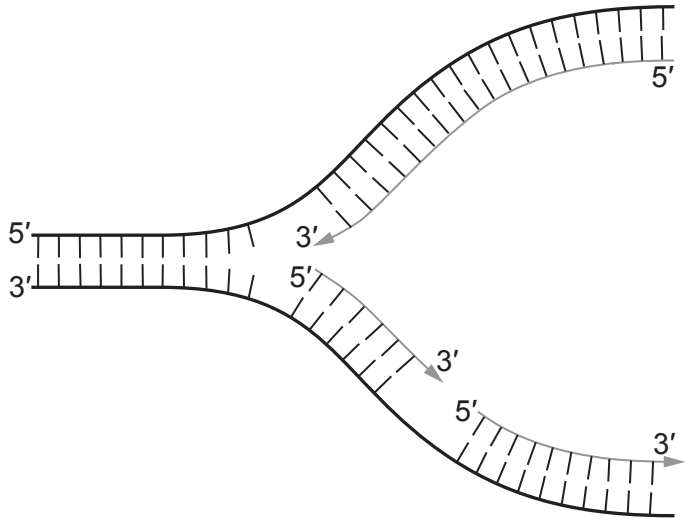
(b) **Image 3.3** shows a DNA replication fork.

Image 3.3



(i) On **Image 3.3**, mark the position of **one** molecule of DNA polymerase with the letter **X**. [1]

(ii) Describe the role of DNA helicase in this process. [1]

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(iii) Explain how **Image 3.3** shows that DNA is replicated by a semi-conservative mechanism. [2]

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(c) DNA polymerase has a proof-reading function, this means that it will check that it has replicated the DNA correctly and repair it if it is incorrectly synthesised.
Use your knowledge of protein synthesis to suggest the importance of the proof-reading role to the organism. [3]

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4. Beetroot contains a red pigment called betalain, which is stored within the cell vacuole. When the cell membranes are disrupted the pigment leaks out into the surrounding solution, colouring it red.

Some students investigated the permeability of the membranes of beetroot cells. A colorimeter was used to measure the absorbance of the surrounding solution. The absorbance of the solution is proportional to the concentration of betalain.

The students made the following prediction:

"The absorbance recorded will be directly proportional to the temperature of incubation."

The experiment was carried out as follows:

- 6 cubes of fresh beetroot were washed in cold water for 1 minute.
- The cubes were transferred into separate boiling tubes, each containing 20 cm^3 of water.
- The boiling tubes were incubated for 10 minutes in beakers at different temperatures which were maintained with the addition of hot or cold water.
- 3 cm^3 of water from around the beetroot cubes was removed and a colorimeter was used to measure the absorbance, at 540 nm, of each solution.

The experiment was repeated three times, the results are shown in **Table 4.1**.

Table 4.1

Incubation temperature / °C	Absorbance at 540nm / a.u.			
	Experiment 1	Experiment 2	Experiment 3	Mean
10	12	15	21	16
30	15	20	19	18
40	18	22	32	24
60	51	68	71	63
70	95	96	97	96
80	98	98	98	98

(a) (i) State which temperature provided the most reliable results and use your knowledge of cell structure to explain why this might be the case. [2]

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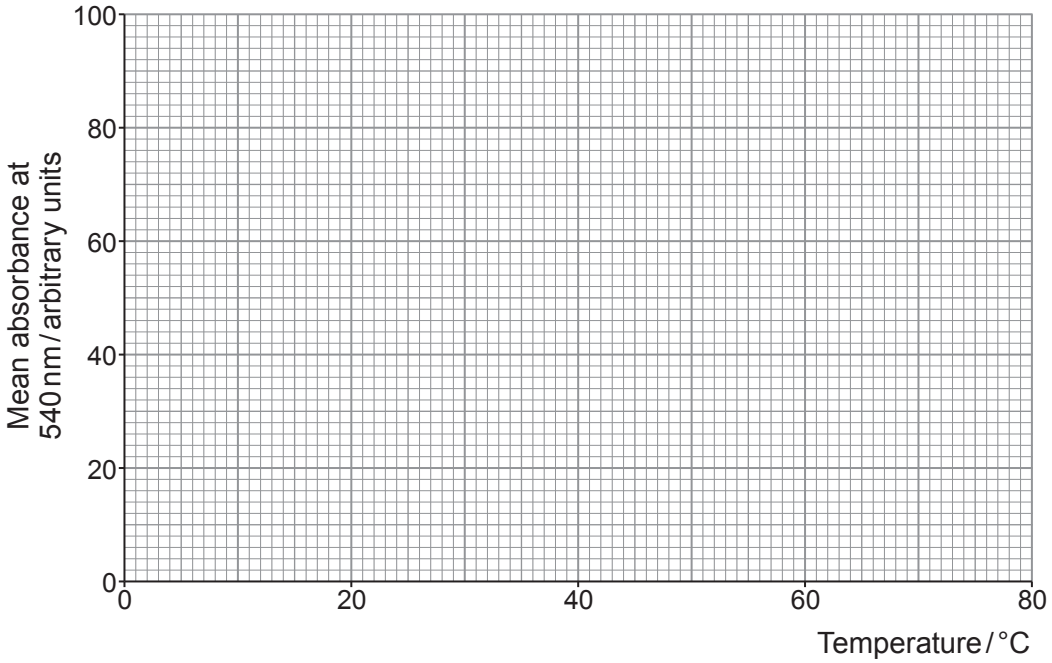
(ii) Plot the mean results from **Table 4.1** on **Graph 4.2**. [3]

Graph 4.2



(iii) Explain why the students' prediction was not entirely correct. [1]

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(iv) Use your knowledge of cell membrane structure to explain the shape of **Graph 4.2**. [2]

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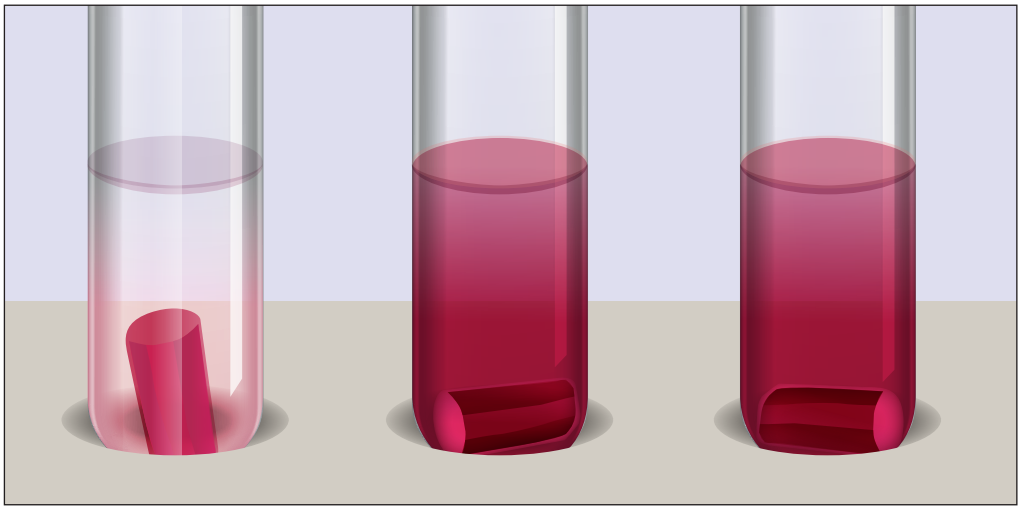
(b) Another group of students investigated how the type of surrounding solution affected the permeability of membranes in beetroot. They tested water, acid and ethanol. **Image 4.3** shows the experiment after incubation at 20 °C for 10 minutes.

Image 4.3



Water Acid Ethanol

(i) Using your knowledge of the structure of membranes, conclude how both **acid** and **ethanol** affect the membrane and explain the appearance of the solution in these tubes. [3]

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(ii) The students also noted that the beetroot in the water had increased in size. Explain this observation. [3]

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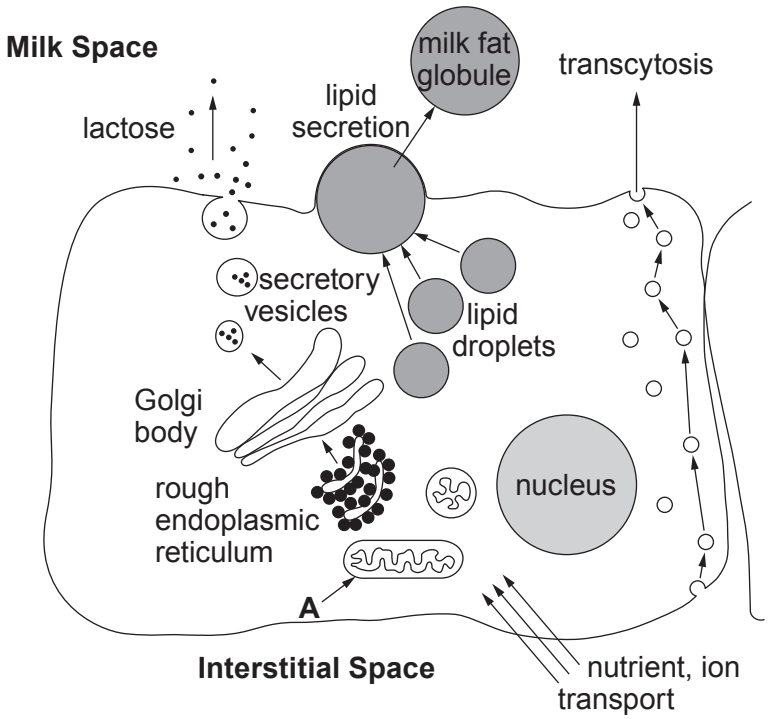
5. Human milk contains all the nutrients a young baby needs in exactly the right proportions. It is formed in the mammary glands by small groups of milk-producing cells in structures called lobules. These cells absorb molecules from the blood and use them to synthesise the lipids, carbohydrates and proteins found in milk. **Image 5.1** shows a milk producing cell.

Image 5.1



Lactose is synthesised in the Golgi body and is transported in vesicles through the cytoplasm. The vesicles increase in diameter as they move towards the plasma membrane. The vesicle membranes fuse with the plasma membrane and the vesicles empty their contents out of the cell. Lipids are also secreted in droplets.

(a) Use the information provided and your own knowledge to answer the following questions.

(i) State the name of the process by which the vesicles empty their contents out of the milk-producing cell. [1]

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(ii) Identify the organelle labelled **A** and explain its role in the function of this cell. [2]

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(iii) Use **Image 5.1** to suggest how the cell avoids a continual increase in the area of its cell surface membrane. [1]

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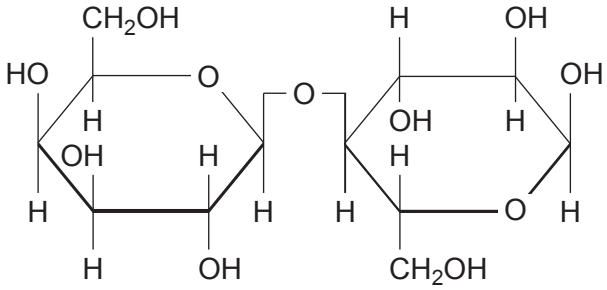
(b) The main carbohydrate in milk is lactose. **Image 5.2** shows a molecule of lactose.

Image 5.2



(i) **Complete Image 5.2** to show the digestion of lactose. [2]

(ii) State:

I. the type of reaction; [1]

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II. the names of the products of digestion of lactose. [1]

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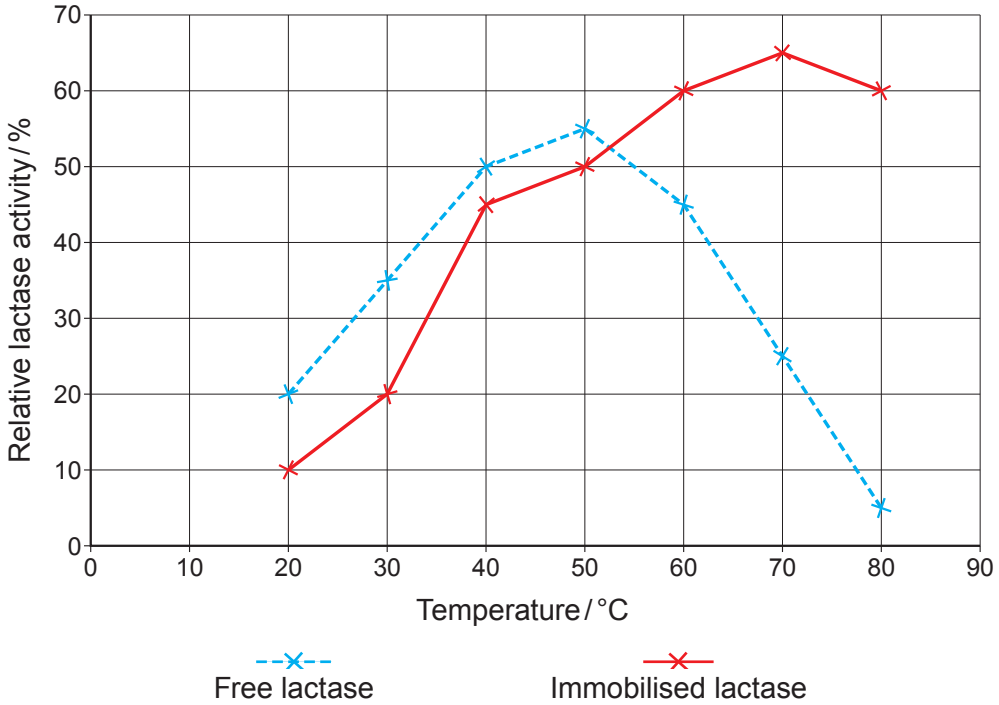
(c) Some people are lactose intolerant and in recent years it has been possible to produce lactose free milk and milk products using the enzyme lactase. One way to do this is to pour the milk through a column of alginate beads containing immobilised lactase. **Graph 5.3** shows the activity of free lactase and immobilised lactase at different temperatures.

Graph 5.3



(i) Using **Graph 5.3** and your own knowledge, compare the relative lactase activity of the free and immobilised lactase at the following temperatures. Explain each answer.

I. Below 50 °C. [2]

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II. Above 50 °C. [3]

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(ii) Lactose is a reducing sugar. Explain why it is not possible to use Benedict's reagent to monitor the progress of the digestion of lactose by lactase. [1]

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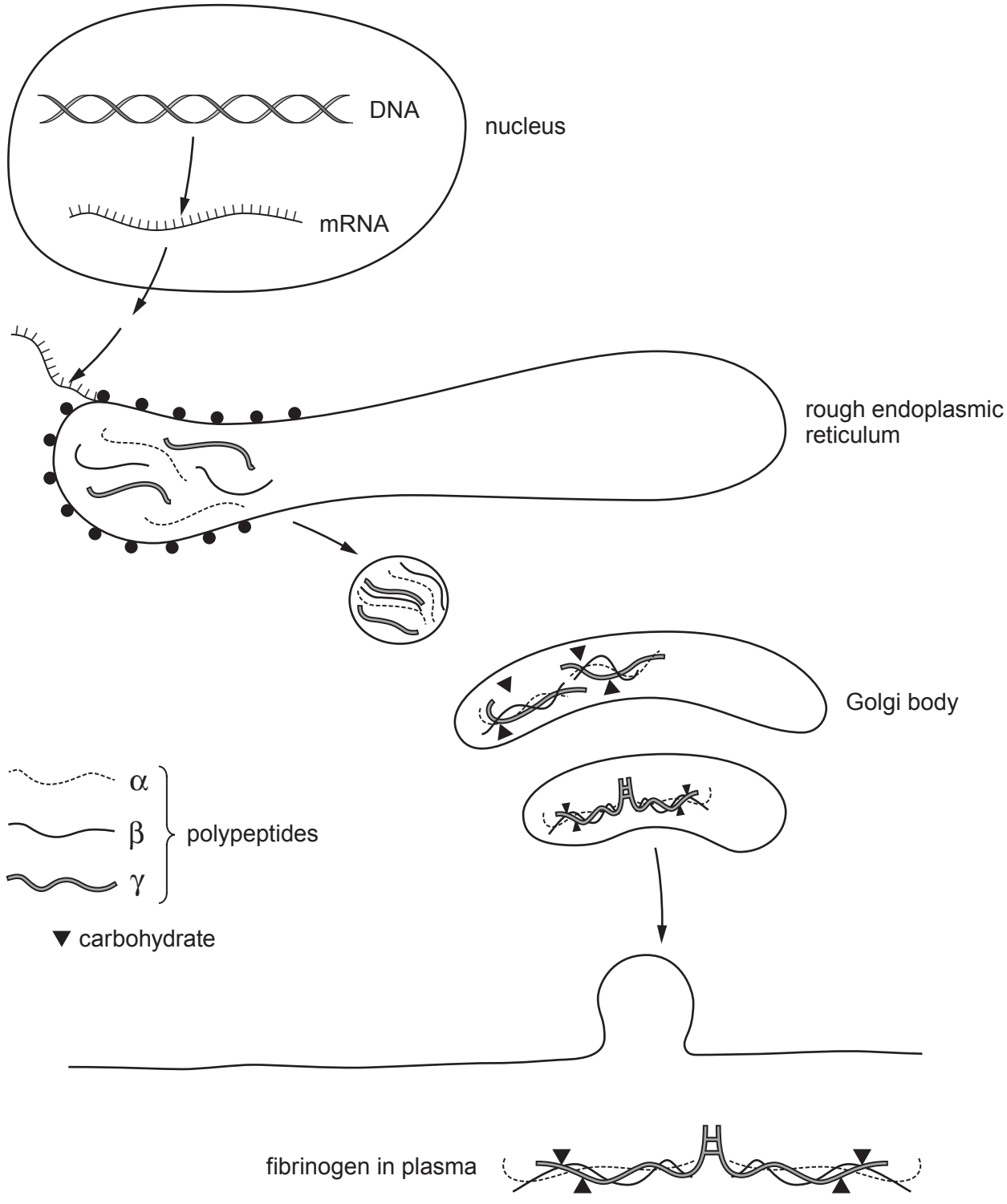
6. Fibrinogen is a soluble glycoprotein produced in liver cells and secreted into the plasma. It contains three types of polypeptide chain.

Image 6.1 shows the formation and secretion of fibrinogen.

Image 6.1



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(a) Use **Image 6.1** and your knowledge of proteins and protein synthesis to answer the following questions.

(i) Name the highest level of protein structure shown by fibrinogen. [1]

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(ii) Explain the role of the rough endoplasmic reticulum in the production of fibrinogen. [2]

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(iii) Suggest the role of the Golgi body in the production of fibrinogen. [2]

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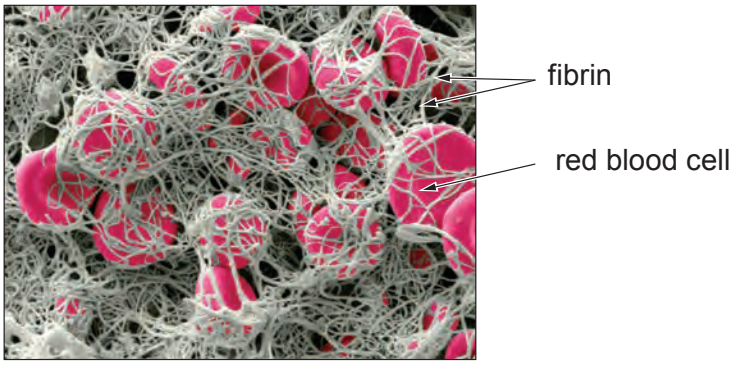
(b) Thrombin is an enzyme which is secreted into blood plasma when tissues are damaged. It catalyses the conversion of fibrinogen, in plasma, into the insoluble, fibrous protein, fibrin. Fibrin seals wounds in tissue. This is shown in **Image 6.2**.

Image 6.2



Fibrin is a fibrous protein, fibrinogen is a globular protein.

Using the information provided, explain how the conversion of fibrinogen to fibrin allows the formation of a blood clot. [3]

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(c) Thrombin catalyses the hydrolysis of an arginine-glycine bond in fibrinogen as shown in **Image 6.3**.

Image 6.3

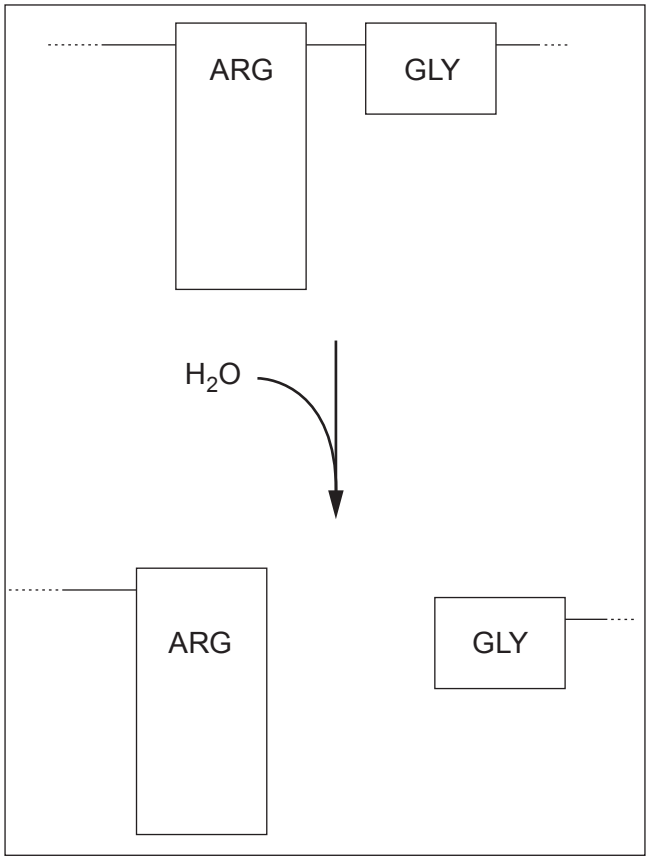
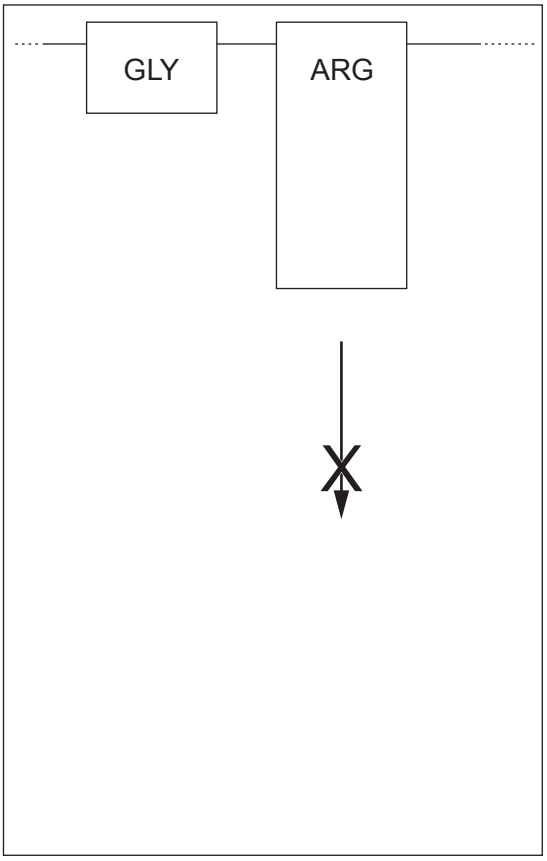


Image 6.4



Name the type of bond broken in **Image 6.3** and explain why thrombin can catalyse this reaction, but it would not catalyse the breaking of a glycine-arginine bond as shown in **Image 6.4**. [2]

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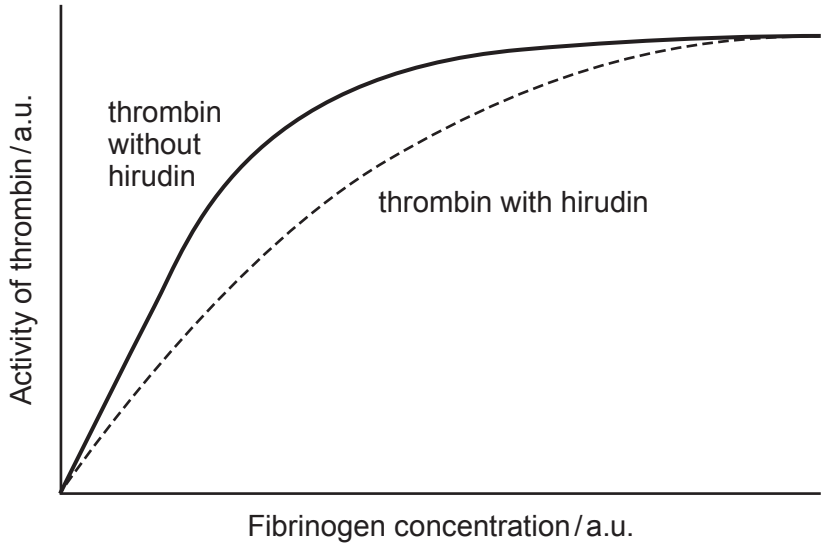
(d) Leeches are organisms which feed by sucking blood. Their saliva contains many components, including a protein called hirudin.

Graph 6.5 shows the inhibitory effect of hirudin on the activity of thrombin.

Graph 6.5



(i) Using your knowledge of enzymes, identify and explain the type of inhibition shown by hirudin and suggest how hirudin enables the leech to feed effectively. [4]

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(ii) Leeches for medical use are farmed in South Wales as a source of hirudin. Suggest a use for hirudin in medicine. [1]

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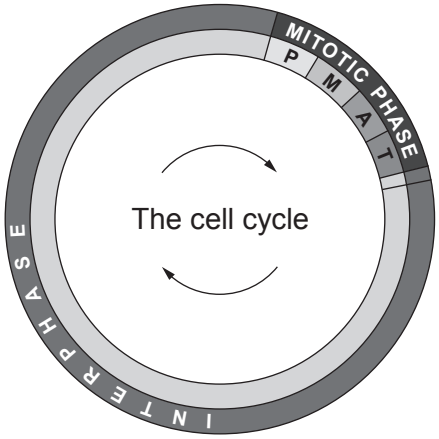
7. A eukaryotic cell cycle is represented in the **Image 7.1**.

Image 7.1



When looking at a group of cells under the microscope, cells undergoing mitosis can be seen as they will have visible chromosomes. The mitotic index, which represents the proportion of cells undergoing mitosis within a group of cells, can be calculated as follows:

$$\text{Mitotic index} = \frac{\text{cells in mitosis}}{\text{total number of cells in field of view}}$$

Cyclins are a family of regulatory proteins that control the progression of the cell cycle. The concentration of cyclin B peaks at the start of mitosis before dropping rapidly as the cells exit mitosis. Some mutations result in abnormally high concentrations of cyclin B.

Describe the events occurring during interphase that are necessary before mitosis can occur.

Using examples, explain why some tissues in humans naturally have a higher mitotic index than others.

Suggest and explain the possible effects of abnormally high concentrations of cyclin B.

[9 QER]

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