IB · DP · Biology

🕐 2 hours   ❓ 15 questions

Structured Questions: Paper 2

1.1 Cells: Theory

1.1.1 Cell Theory / 1.1.2 Functions of Life / 1.1.3 Surface Area to Volume Ratio / 1.1.4 Cell Specialisation / 1.1.5 Stem Cells / 1.1.6 Skills: Cell Theory

Easy (5 questions)	/34
Medium (5 questions)	/41
Hard (5 questions)	/43
Total Marks	**/118**

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Easy Questions

1 (a) In order to be considered living, organisms carry out the functions of life.

Define the following:

i. Homeostasis

ii. Excretion

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(2 marks)

(b) The unicellular group, dinoflagellates, can be found in fresh water, preying upon other protozoa.

Dinoflagellates contain eyespots and two flagella enabling them to find and move towards prey. Every day they undergo mitosis and in some cases this forms 'red tides'.

State which functions of life have been described in this passage on dinoflagellates.

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(4 marks)

2 (a) *Amoeba proteus* is a unicellular organism that inhabits freshwater ponds and streams.

At its largest size, *Amoeba proteus* can be visible to the naked eye.

State how the surface area to volume ratio changes as the *Amoeba proteus* grows.

(1 mark)

(b) Gaseous exchange allows the *Amoeba* to undergo respiration.

State which aspect of the surface area to volume ratio has the greater effect on the rate of gaseous exchange.

(1 mark)

(c) The contractile vacuole of the *Amoeba* helps maintain its osmotic equilibrium by excreting excess water from the cell.

State which aspect of the surface area to volume ratio would depend on this organelle.

(1 mark)

3 (a) Glia and skeletal muscle cells are two examples of specialised cells. However, they were once stem cells.

Define the term stem cell.

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(2 marks)

(b) The specialised cells mentioned in part (a) will differentiate when certain genes are expressed, as all cells contain the same genes.

State the term used to describe an organism's entire set of genes.

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(1 mark)

(c) It is hoped that our knowledge of stem cells can allow doctors to use them for therapeutic uses.

Describe how stem cells are being used to treat Stargardt's macular dystrophy.

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(2 marks)

4 (a) The diagram below is of an *Amoeba*. The actual size, measured between points **A** and **B**, is 320 µm.

When a student measured the same distance using an image from a microscope they determined the size to be 128 000 µm.
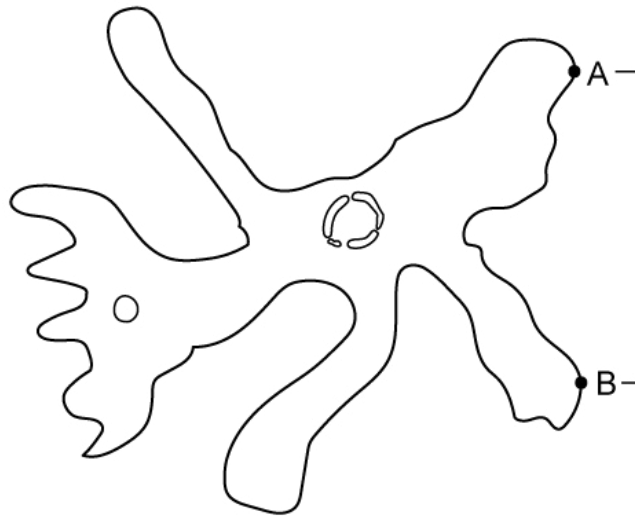
Calculate the magnification of this *Amoeba*. Show your working.

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(2 marks)

(b) Whilst examining the *Amoeba,* the student also measured the length of the organelles present, including the nucleus. The length of the nucleus on the microscope image was 28 000 µm.

If the student was examining the nucleus using the same magnification as part (a), in millimetres (mm), calculate the actual size of the nucleus.

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(2 marks)

(c) The freshwater habitats of *Amoeba proteus* may contain organisms that have more complex structures eg. freshwater snails. The snails have primitive gills enabling them to breathe under water and mucus-producing glands that allow them to hibernate when the water freezes.

Independently these structures have different properties but when combined they provide the snails with survival properties in the aquatic environment.

State the type of property that multicellular organisms, like the freshwater snail, have.

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(1 mark)

5 (a) *One mark is available for clarity of communication throughout this question.*

Draw a biological diagram of the *Euglena* sp. below.

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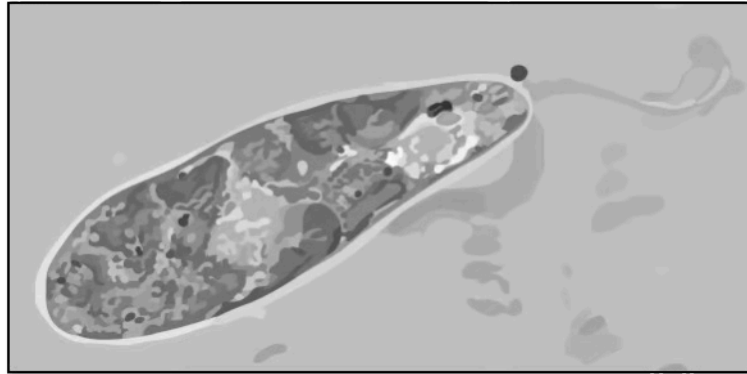
(4 marks)

(b) Although almost all organisms conform to the cell theory, there are exceptions.

List **three** examples and state why they are an exception to the theory.

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(6 marks)

(c) Explain why cells differentiate, using examples within your answer.

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(5 marks)

Medium Questions

1 (a) A patient with a spinal cord injury was healed using stem cell therapy by the following process:

   1. Stem cells collected from the patient's own tissues.
   2. Stem cells cultured in laboratory for one month to increase their numbers.
   3. Stem cells injected into injury site of patient.
   4. Stem cells develop into nerve cells and replace damaged nerve tissue.

Suggest **two** properties of the stem cells that made this therapy possible.

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(2 marks)

(b) Explain why the stem cells used in part (a) were taken from the patient and not from a stem cell donor.

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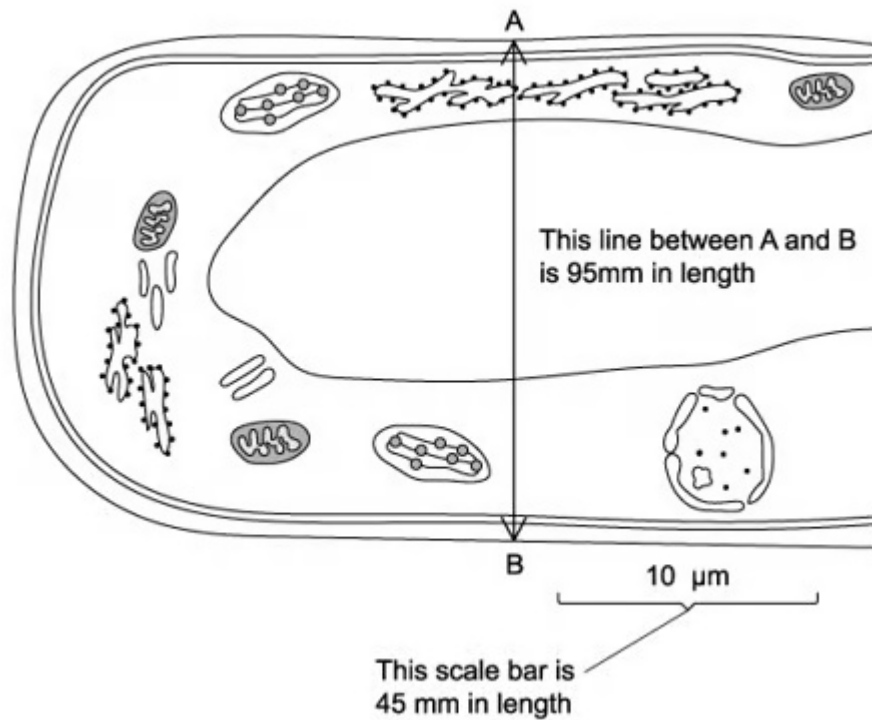
(2 marks)

(c) Although it would also be possible to use embryonic stem cells from embryos created by IVF to treat the patient in part (a), this is a controversial method. Explain why.

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(2 marks)

2 (a) The drawing below shows part of a plant cell as seen with an electron microscope. The scale bar (measuring 45 mm in length) on this drawing represents a length of 10 μm.

A

This line between A and B is 95mm in length

B

10 μm

This scale bar is 45 mm in length

Calculate the magnification of the drawing. Show your working.

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(2 marks)

(b) Calculate the actual width of the cell in part (a) from A to B. Give your answer in micrometres (μm) and show your working.

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(2 marks)

(c) Identify **two** ways in which striated muscle fibres (fused muscle cells) differ from the cell shown in part (a).

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3 (a) Calculate the surface area to volume ratio of a cube with each edge measuring 2 cm. Show your working.

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(2 marks)

(b) When first hatched, the young tadpoles of some frog species are less than 1.5 mm long and have not yet developed gills.

Explain how these young tadpoles are able to get enough oxygen to their cells without developed gills.

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(2 marks)

(c) A researcher calculated the surface area of a large number of frog eggs. She calculated the mean surface area to be 10.12 mm^2. Frog eggs are generally spherical. She calculated the surface area using the following equation: $4\pi r^2$.

(i)   Rearrange this equation to find r^2 and use it to calculate the mean r^2 of these frog

(ii)   Calculate the mean diameter of these frog eggs. Give your answer to 3.s.f.

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(3 marks)

4 (a) The diagram below is of a mitochondrion at a magnification of ×20 000. The distance between points **A** and **B** in the diagram is 6.4 cm.
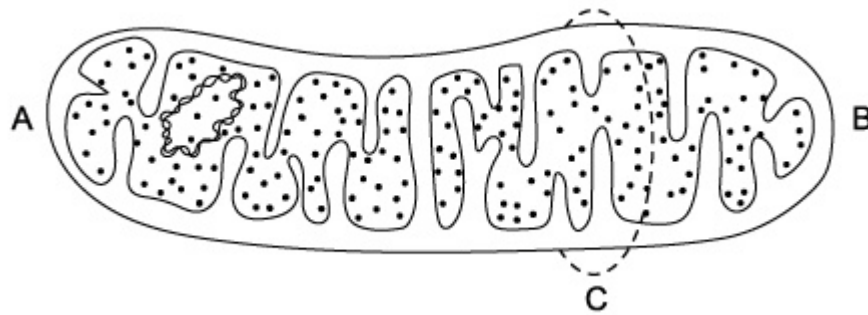
Calculate the actual length of this mitochondrion in micrometres (μm). Show your working.

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(2 marks)

(b) The circumference of a mitochondrion, labelled **C** in the diagram in part (a), is 1.5 μm. A student is making an accurate scale model of a mitochondrion for a school science project and wants to magnify a mitochondrion 50,000 times.

In centimetres (cm), what will be in the circumference of the student's model?

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(2 marks)

(c) The mitochondrion in part (a) is responsible for the process of cell respiration to release energy. Which 'function of life' is this set of chemical reactions a part of?

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(1 mark)

(d) Briefly outline the key ideas that make up cell theory.

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5 (a) *One mark is available for clarity of communication throughout this question.*

Discuss the advantages of the use of adult stem cells.

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(3 marks)

(b) You are given a sample of plant tissue. Describe how you would prepare and view a sample of cells from this tissue using a light microscope.

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(5 marks)

(c) Explain why surface area to volume ratio is an important factor in limiting cell size.

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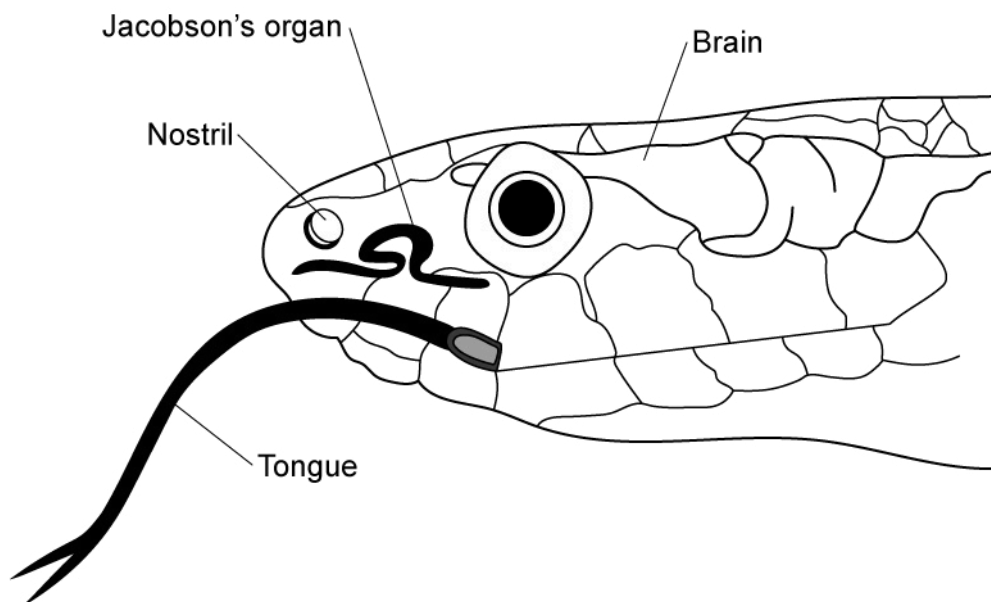**(7 marks)**

Hard Questions

1 (a) *Pseudonaja textilis* (Eastern Brown Snake) has a group of specialised chemoreceptors located in the Jacobson's organ, which is on the roof of the snake's mouth. It also has venom glands that produce a neurotoxin.

These are essential in allowing the snake to detect and paralyse its prey.

Explain the property described in this passage that allows multicellular organisms to function efficiently.

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(2 marks)

(b) The Jacobson's organ in *Pseudonaja textilis* (Eastern Brown Snake) is a pair of crescent-shaped chambers where odour molecules are deposited by the forked tongue when it retracts back into the mouth.

Suggest why Jacobson's organ is crescent-shaped.

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(c) Scientists studying the expression of olfactory receptor (OR) genes in four snake species found that fewer than 3% were non-functional genes compared to humans who have up to 67% non-functioning OR genes. These genes code for olfactory receptor proteins located in the cilia of the nostrils.

Deduce why the expression of certain genes, like the OR gene in nostrils, is beneficial to multicellular organisms.

(2 marks)

2 (a) Creutzfeldt-Jakob disease is a rare neurodegenerative disease caused by abnormally-folded proteins found in the brain. Proteins that trigger abnormal folding are called prions.

Suggest why scientists have not classified prions as living.

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(2 marks)

(b) Viruses and viroids are two other particles that are not considered to be living entities. These are considered exceptions to the cell theory.

Discuss two other discrepancies to cell theory that scientists have discovered.

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(2 marks)

(c) *Euglena gracilis* is a unicellular eukaryotic organism that inhabits moist soils and stagnant fresh water, often forming green scum on the surface of ponds and lakes.

E. gracilis are heterotrophic and autotrophic, and propel themselves using a flagellum. They have an eyespot which allows them to respond to sunlight and contractile vacuoles that regulate the composition of the cytoplasm.

Compare the functions of life of *E.gracilis* and a *Paramecium* species.

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(3 marks)

3 (a) A plant palisade mesophyll cell is 4 μm in width and depth, and 25 μm in length.

Its shape is approximately cuboid.

Calculate the surface area to volume ratio of this cell. Show your working.

(3 marks)

(b) If the palisade cell in part (a) has a large central vacuole, so that the cytoplasm (not including the vacuole) extends inward 500 nm from the plasma membrane of the cell.

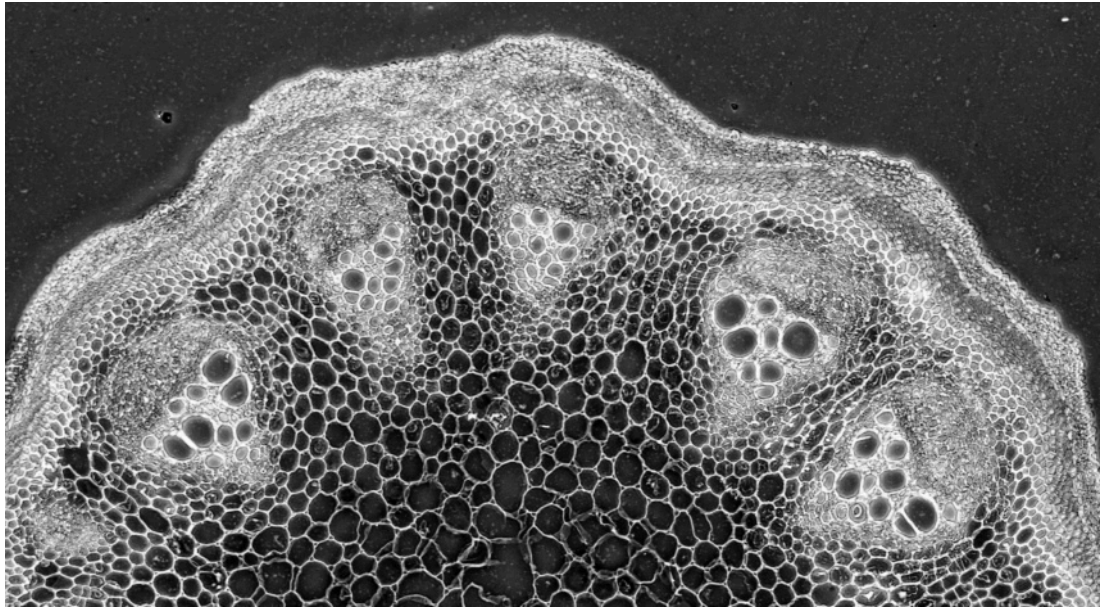Calculate the surface area to cytoplasmic volume ratio. Show your working.

(3 marks)

(c) From part (b) comment on what the function of the plant vacuole is.

(2 marks)

4 (a) The image below is a photomicrograph of a transverse section through part of a stem.

Doc. RNDr. Josef Reischig, CSc., CC BY-SA 3.0 <https://creativecommons.org/licenses/by-sa/3.0>, via Wikimedia Commons

Draw a large tissue plan diagram of this part of the stem.

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(4 marks)

(b) A student used a light microscope to study the plant stem pictured in part (a). The diagram below shows the stage micrometer scale that was used to calibrate an eyepiece graticule.

One division, on either the stage micrometer scale or the eyepiece graticule, is the distance between two adjacent lines.

The length of one division on this stage micrometer is **0.01 mm**.
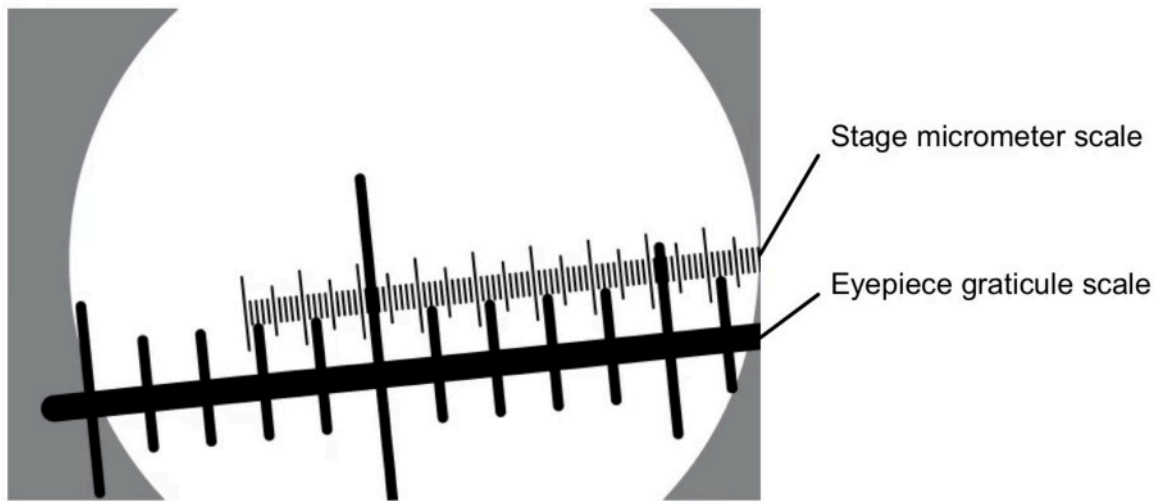
Using this stage micrometer, calculate the actual length of one eyepiece graticule division. Show your work.

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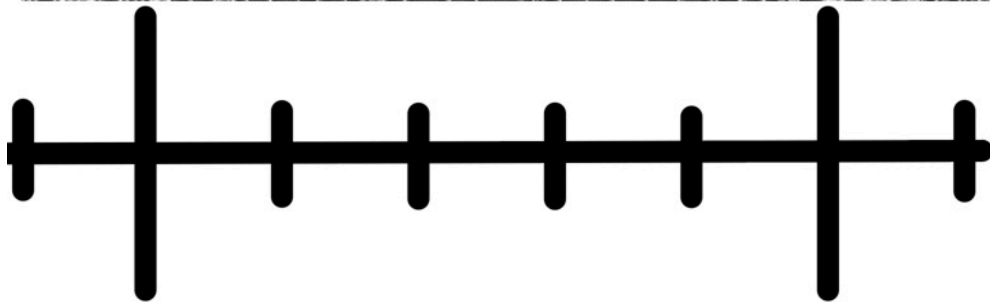
(2 marks)

(c) The photomicrograph below was taken using the same microscope with the same lenses as part (b).

The same eyepiece graticule was also used; a section of that graticule is shown under the image below.
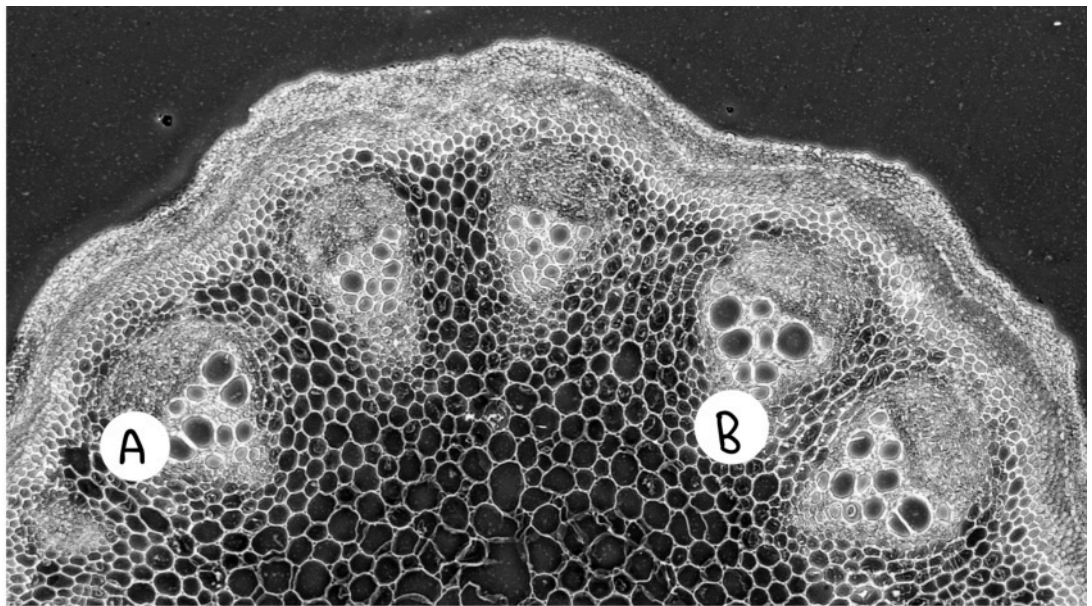
Use the calibration of the eyepiece graticule unit from part (b) and the information in the photomicrograph to estimate the actual length **in μm** of the plant tissue from **A** to **B**.

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(1 mark)

5 (a) *One mark is available for clarity of communication throughout this question.*

Explain the importance of the surface area to volume ratio to a growing bacterial cell.

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(3 marks)

(b) Evaluate **two named** therapeutic uses of stem cells.

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(7 marks)

(c) Compare and contrast the functions of life in a *Paramecium* with a **named** photosynthesising organism.

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(5 marks)