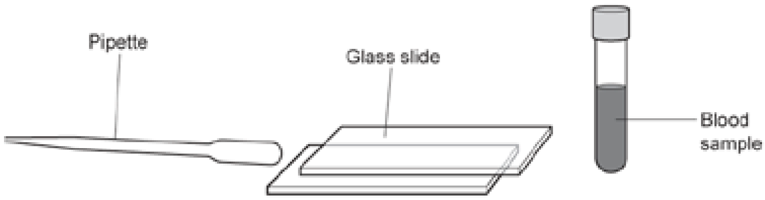
1(a). This is some equipment that could be used when preparing a blood smear.



Describe how to use the equipment to prepare a blood smear that could then be stained and viewed under a microscope.

____

____

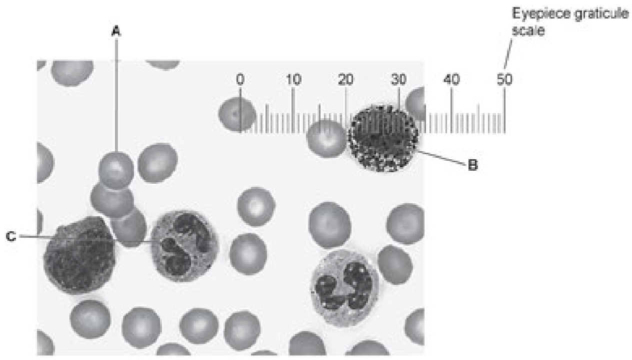
____

____

____

____ **[3]**

(b). This is a light micrograph of a human blood smear.



i. The cell labelled **A** is sometimes known as a red blood cell.

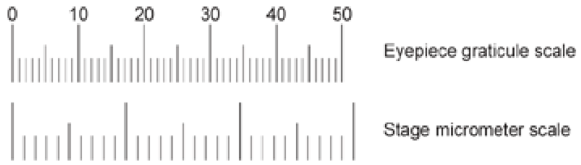
Name cell **A**.

____ **[1]**

ii. In the space below, draw a labelled diagram of cell **C**.

[4]

iii. The image was taken using a × 40 objective lens. The eyepiece graticule scale for the × 40 objective lens was calibrated using the stage micrometer shown below.



Each of the three large divisions on the stage micrometer scale measured exactly 0.01 mm.

Calculate the diameter of cell **B**.

Give your answer in μm to **2** significant figures.

Diameter = ... μm [3]

2. Microscopes vary in terms of magnification and resolution.

Which option describes the terms magnification and resolution?

A Magnification is the size of an image under a microscope and resolution is the sharpness of that image.

B Magnification is the size of the image compared to the actual size and resolution is the ability to distinguish two objects from one another.

C Resolution is the ability to make small objects appear larger and magnification is the ability to distinguish two objects from one another.

D Resolution is the size of an image under a microscope and magnification is the sharpness of that image.

Your answer ☐ **[1]**

3(a).

i. Some students collect a sample of pond water to observe under a light microscope.

They pour some of the pond water onto a microscope slide.

Describe how they could improve their technique in preparing the microscope slide for examination under a light microscope.

[2]

ii. Explain how the students would use the different objective lenses of a light microscope to focus and observe the pond water sample at high power magnification.

____

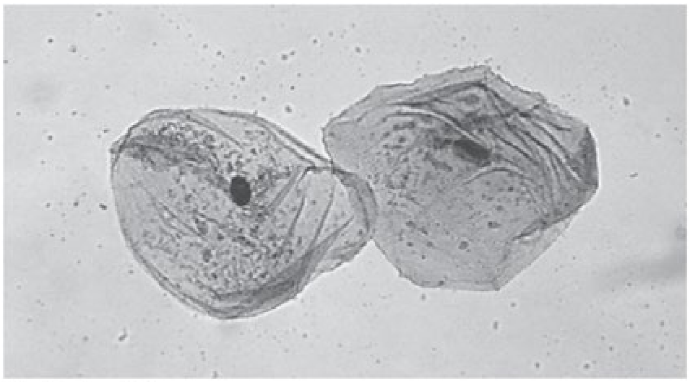
____

____

____

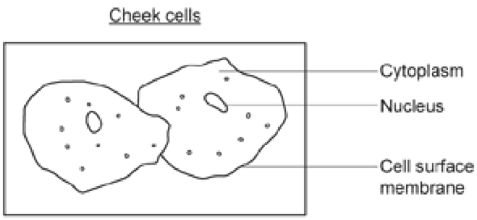
____ **[2]**

(b). The figure shows a photomicrograph of human cheek cells observed by the students under a light microscope.



Magnification ×400

The figure shows a drawing made by a student of the cells from this photomicrograph.



Magnification ×400

A student said the figure of the drawn cheek cells was a correct biological drawing.

Identify **two** pieces of evidence from both figures that support the student's comment.

1 ____

____

____

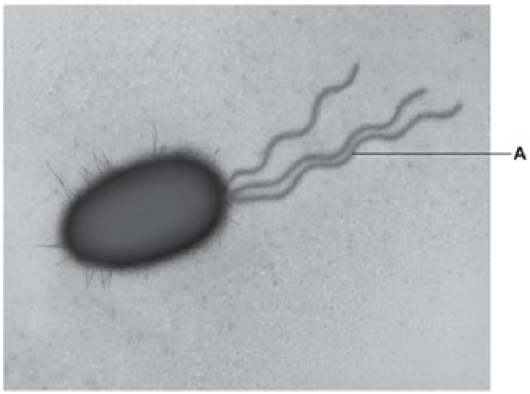
2 ____

____

____ **[2]**

4. *Escherichia coli* is a bacterium that is used widely in scientific experiments and in biotechnology.

This is a transmission electron micrograph of *E. coli*.



i. Name the structure labelled **A**.

A .... **[1]**

ii. Based on your knowledge, **estimate** the diameter of the *E. coli* cell.

Give your answer in μm.

Diameter = ... μm **[1]**

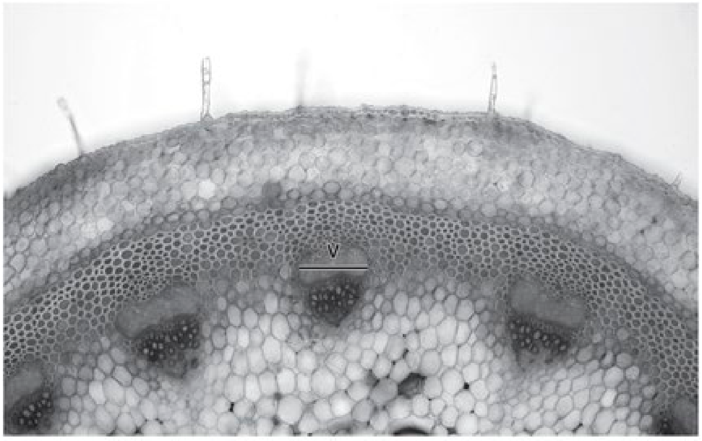
5. Xylem vessels maintain the transpiration stream by transporting water up plant stems.

A pair of students dissect the vascular tissue of the primrose plant, *Primula vulgaris.*

i. State **and** explain **one** safety precaution that the students should take when dissecting the vascular tissue.

.... **[2]**

ii. This is a light micrograph of a transverse section through the stem of *P. vulgaris.*



× 90

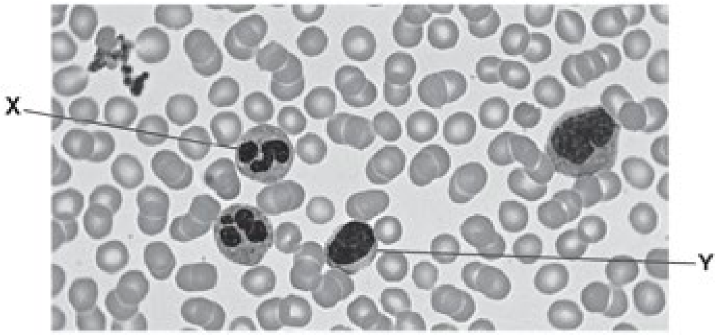
The diameter of one of the vascular bundles is shown by the line labelled **V**.

Calculate the actual diameter of the vascular bundle labelled **V**.

Give your answer in mm and to **2** significant figures.

Diameter of the vascular bundle **V** = ... mm **[2]**

6. The image shows a photomicrograph of a blood smear.



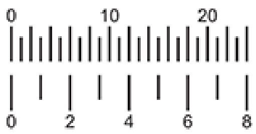
Which row in the table below correctly identifies cell **X** and cell **Y**?

	X	Y
A	neutrophil	erythrocyte
B	neutrophil	lymphocyte
C	lymphocyte	neutrophil
D	platelet	neutrophil

Your answer [1]

7. A student observes xylem tissue under a microscope. The student uses an eyepiece graticule and a stage micrometer to measure the diameter of a xylem vessel.

Eyepiece graticule scale



Stage micrometer scale: 1 division = 10 μm

The xylem vessel has a diameter of 21 units on the eyepiece graticule scale.

What is the actual diameter of the xylem vessel in micrometres?

A 7
B 65
C 70
D 210

Your answer [1]

8. A student was observing and measuring cells using a light microscope.

Which option describes a method that would enable the student to accurately measure the length of a cell?

A View the cells using a calibrated eyepiece graticule and note the magnification of the eyepiece lens.
B View the cells using a calibrated eyepiece graticule and note the magnification of the objective lens.
C View the cells using a stage micrometer and note the magnification of the eyepiece lens.
D View the cells using a stage micrometer and note the magnification of the objective lens.

Your answer [1]

9. Which of the following describes, from lowest to highest, the resolution of images than can be achieved by different types of microscope?

A Light microscope → scanning electron microscope → transmission electron microscope
B Light microscope → transmission electron microscope → laser scanning confocal microscope
C Light microscope → transmission electron microscope → scanning electron microscope
D Scanning electron microscope → transmission electron microscope → light microscope

Your answer [1]

10. Some students investigated the effect of time on the growth of bacterial populations.

The students prepared a large flask of bacterial culture.

They divided this large culture into a number of smaller flasks each containing 50 cm^3 of bacterial culture.

They then incubated the smaller flasks at 20 °C for up to 48 h.

Every 4 h the students removed one of the flasks and counted the bacteria.

The students recorded the total number of bacteria and the number of viable bacteria in each flask.

When counting the number of bacteria, the students performed serial dilutions on samples removed from each small flask. In each serial dilution, the students removed 0.1 cm^3 and added it to 9.9 cm^3 of water.

To estimate the total number of bacteria, the students used a light microscope to count the number of bacterial cells in a 0.01 cm^3 sample of the final serial dilution.

To estimate the number of viable bacteria, the students spread 0.1 cm3 of the final serial dilution on an agar plate and counted the number of colonies that had grown after 24 h.

i. The students shook each flask before they removed the samples for counting.

Suggest why the students shook the flasks.

____ [1]

ii. It can be more difficult to count bacterial cells using a light microscope than it is to count human cells.

Suggest **one** reason why bacterial cells are difficult to count using a light microscope.

[1]

iii. In one 0.01 cm3 sample the students counted 52 bacterial cells under the microscope.

Describe the calculation steps the students would then need to make to estimate the total number of bacteria in the small flask.

[3]

11(a). Fig. 2.1 shows a light micrograph of a blood smear.

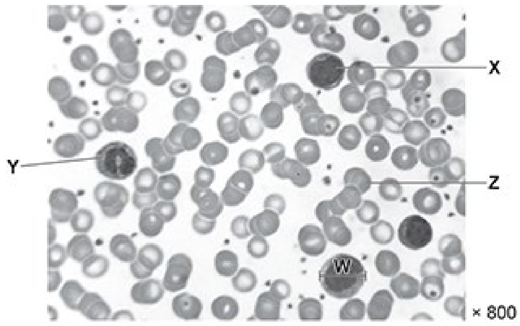


Fig. 2.1

i. The cells labelled **X** and **Y** in **Fig. 2.1** are two different types of white blood cell.

Identify the types of white blood cell labelled **X** and **Y**.

X

Y

[2]

ii. The blood cell labelled **Z** in **Fig. 2.1** contains a high concentration of haemoglobin.

Outline **two** other ways in which the blood cell labelled **Z** is adapted for its function.

[2]

iii. The diameter of another blood cell is represented by the line **W** in **Fig. 2.1**.

The magnification used to produce **Fig. 2.1** was × 800.

Calculate the actual diameter, **W**, of the blood cell.

Give your answer in μm.

Diameter = ... μm **[2]**

(b). Some white blood cells have a high concentration of lysosomes.

i. State the role of lysosomes in white blood cells.

[1]

ii. A scientist calculated two values for the lysosomes in a white blood cell:

- mean volume of a lysosome = 6.5×10^{-14} cm^3
- mean number of H^+ ions per lysosome = 1.3×10^{-21} mol

Use these values to calculate the mean H^+ ion concentration per lysosome in this white blood cell.

Give your answer in mol dm^{-3}.

Mean H^+ ion concentration = ... mol dm^{-3} **[2]**

iii. The formula used to calculate pH is

$pH = -\log [H^+]$
where $[H^+]$ is H^+ ion concentration in mol dm^{-3}.

Use your answer from **part (ii)** to calculate the mean pH of the lysosomes in this white blood cell.

Give your answer to **2** significant figures.

pH = ... **[1]**

iv. The scientist stained the lysosomes in a sample of living white blood cells.

The table shows the properties of five stains, **A** to **E**.

Stain	Properties
A	Suitable to stain alkaline components.Taken up by active cells.
B	Suitable to stain acidic components. Taken up by active cells.
C	Suitable to stain neutral components. Taken up by active cells.
D	Suitable to stain alkaline components. Can be used to stain fixed sections of tissue.
E	Suitable to stain acidic components. Can be used to stain fixed sections of tissue.

Select the most appropriate stain for the scientist to use, based on your answer from **part (iii)**.

---**[1]**

(c). Differential staining can be used to distinguish between bacteria with thick cell walls and bacteria with thin cell walls.

Four substances are used when differentially staining bacteria:

- Crystal violet, which stains bacteria purple.
- Safranin, which stains bacteria pink but is not visible in the presence of crystal violet.
- Alcohol, which removes fixed stains from bacteria with thin cell walls.
- Iodide solution, which fixes crystal violet to bacterial cells.

Suggest a practical procedure for staining a slide that would allow thin-walled bacteria to be differentiated from thick-walled bacteria.

[2]

12. A group of students were investigating mitosis. They examined cells from onion root tip squashes that had been prepared using acetic orcein stain. Chromosomes appear a purple red colour when this stain is used.

Fig. 2.4 shows a light micrograph of one of these cells. A student stated that this cell was at metaphase.

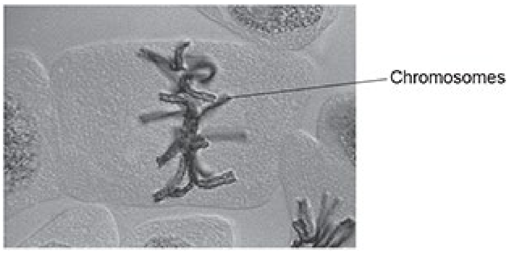


Fig. 2.4

i. Describe how **Fig. 2.4** shows the importance of differential staining for observing cells undergoing mitosis.

[1]

ii. Identify one piece of evidence that would have led the students to conclude that the cell in **Fig. 2.4** is at metaphase.

[1]

iii. Three students were studying onion root tip squashes under the microscope. They recorded the number of cells at each stage of mitosis. A record of their observations is shown below.

Student 1:	Metaphase 1 cell
	Anaphase 3 cells
	Prophase 3 cells
Student 2:	Anaphase 4 cells
	Prophase 5 cells
	Telophase 1 cell
Student 3:	Telophase 3 cells
	Metaphase 5 cells
	Prophase 2 cells

In the space below draw an appropriate table to present the students' observations.

Include the headings for the columns. You are **not** required to enter any of the results into your table.

[2]

13. Fig. 4.1 shows a light micrograph of cells in the blood.

Cell **X** plays a role in the immune response.

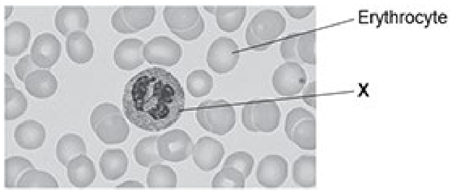


Fig. 4.1

i. Name cell **X**.

[1]

ii. The magnification of the microscope used to observe the cells in **Fig. 4.1** was ×950.

Calculate the diameter of cell **X** in **Fig. 4.1**.

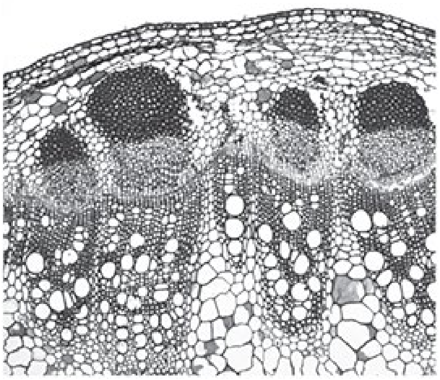
Give your answer in micrometres.

Diameter = ... µm **[2]**

iii. Using **Fig. 4.1**, explain why blood is described as a tissue and not an organ.

[1]

14. The photomicrograph is of a transverse section of a stem of a sunflower, *Helianthus annuus*.



i. **On the photomicrograph**, label the location of meristem tissue.

[2]

ii. Name the type of microscope used to produce the photomicrograph **and** explain the reasons for your choice.

Name of microscope ______________________________

Reasons for your choice ______________________________

____

____

______________________________ **[3]**

END OF QUESTION PAPER