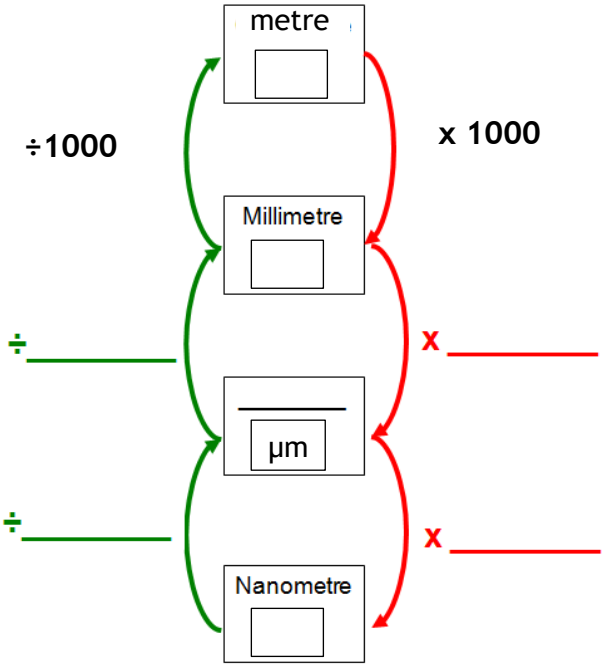
MICROSCOPY WORKBOOK

Units of measurement

1) Complete the diagram below to show: names of the units of measurement, unit symbols, and mathematical operations for converting between units.

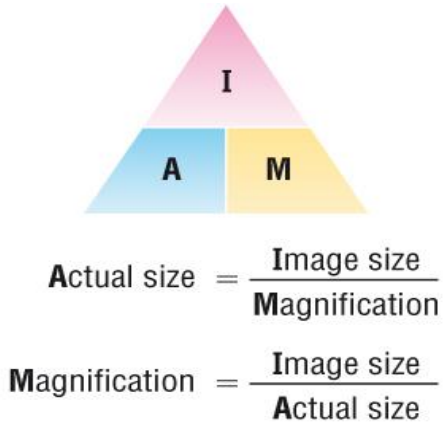
2) Complete the table below to show the corresponding value in nanometres, micrometres and millimetres for the measurements given in each row. The first row has been completed for you. Use standard form where appropriate



Nanometre nm	Micrometre µm	Millimetre mm
1580		
	0.23	
		174
	3	
0.008		
		0.5
18		

Calculating Cell Magnification from images

Reminder:



The photograph shows an electron micrograph of part of a cell.

(a) Name structure P. **(1 mark)**

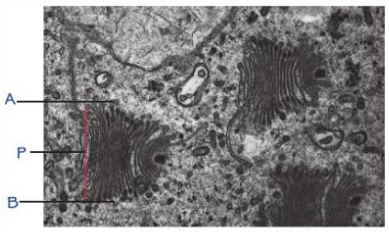
Golgi apparatus

(b) Calculate the width of P at its widest part (between A and B). **(3 marks)**

$16000 = \frac{16}{width}$

Rearrange width $= \frac{16}{16000}$

$= 0.001$ mm



Magnification ×16000

Maths skills

Magnification = size of image / size of real object

As long as you know two of the variables, you can **rearrange the formula** to find the unknown variable.

Image size = **A**ctual size x **M**agnification

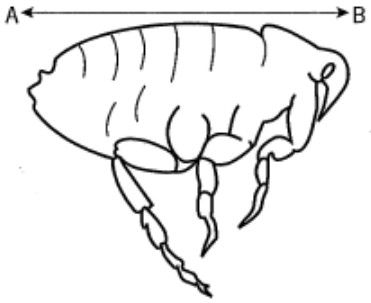
Magnification of images

Calculating magnification of images

Drawings and photographs of biological specimens should always have a magnification factor stated. This indicates how much larger or smaller the image is compared with the real specimen. The magnification is calculated by comparing the sizes of the image and the real specimen.

WORKED EXAMPLE

The image shows a flea which is 1.3 mm long as measured using an eyepiece graticule (see page 34). To calculate the magnification of the image measure the image (or the scale bar if given) on the paper, in this example the body length as indicated by the line A – B.



$$\text{Magnification} = \frac{\text{length of image}}{\text{length of real specimen}}$$

For this image the length of the image is 42 mm and the length of the real specimen is 1.3 mm.

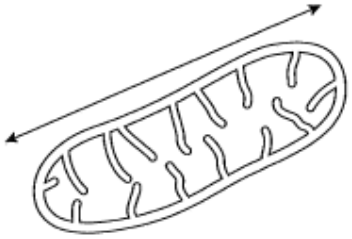
The magnification is therefore 42 ÷ 1.3 = 32.31

The magnification factor should therefore be written as ×32.31

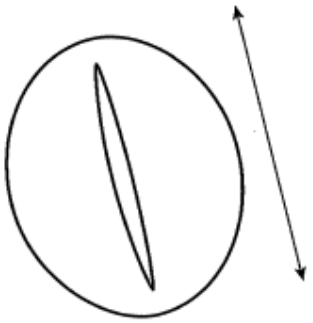
SUMMARY QUESTION

1 For each of the images shown, calculate a suitable magnification factor.

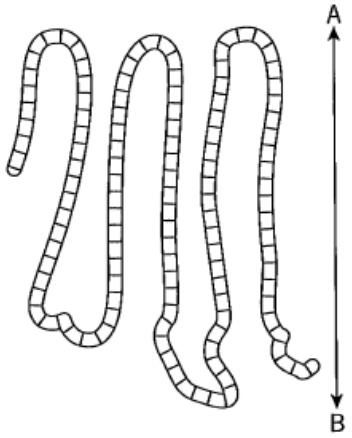
a A mitochondrion that is 1.5 μm long.



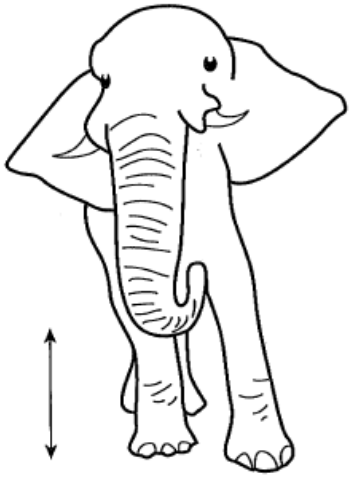
b A pollen grain that is 50 μm wide.



c Villi in the small intestine that are 1.2 mm long from A to B.



d An African elephant (the scale bar is 1.0 m).



REMEMBER:

Use the same units

A common error is to mix units when performing these calculations. Begin each time by converting measurements to the same units for both the real specimen and the image.

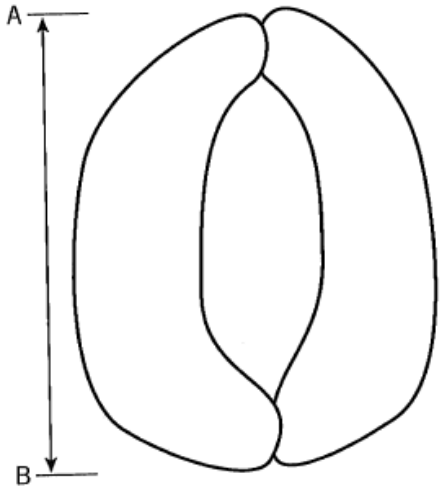
Magnification factors and real dimensions

Using magnification factors to find real dimensions

Magnification factors on images can be used to calculate the actual size of features shown on drawings and photographs of biological specimens. For example, in a photomicrograph of a cell individual features can be measured if the magnification is stated.

WORKED EXAMPLE

The magnification factor for the image of the open stoma is ×5000. This can be used to find out the actual size of any part of the cell. For example, how long is one guard cell from A to B?



First measure the length of the guard cell as precisely as possible. In this example the image of the guard cell is 52 mm long.

Next convert this measurement to units appropriate to the image, in this case you should use μm because it is a cell.

So the magnified image is $52 \times 1000 = 52\,000$ μm

Remember size of image ÷ real size = magnification. Rearrange this equation to get:

Size of image ÷ magnification = real size

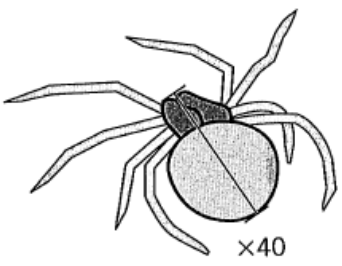
So the real length of the guard cell is now found by dividing:

$52\,000 \div 5000 = 10.4$ μm

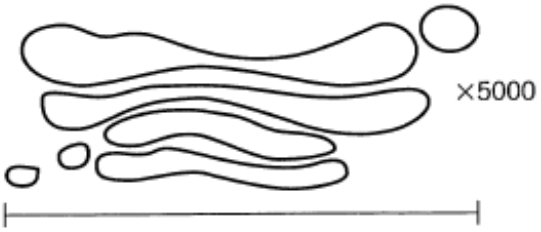
SUMMARY QUESTION

1 For each of the images shown, use the magnification factor to determine the actual size of the object indicated.

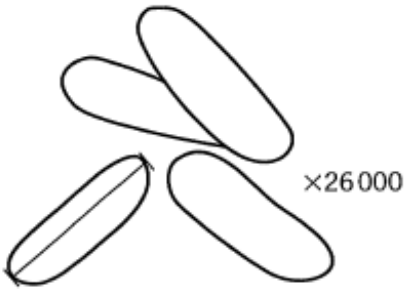
a The length of the head and body of a spider



b The width of a Golgi apparatus

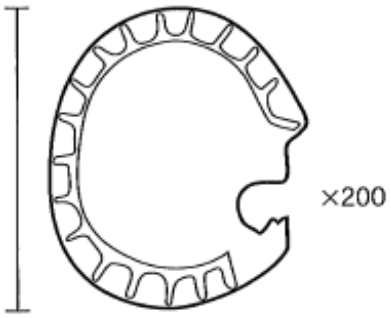


c The length of a bacterial cell



d The length of the antenna of a butterfly

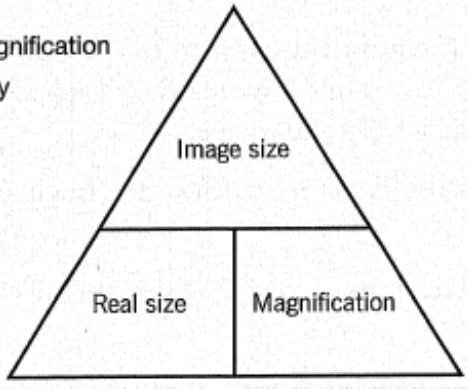
e The length of a fern sporangium



REMEMBER:
size of an image ÷ real size = magnification

Rearrange this equation to find any of the three values.

Use an equation triangle to help:



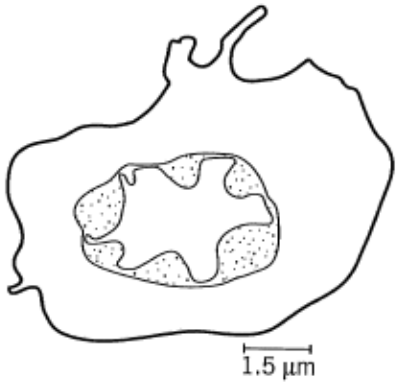
Scale bars

Using scale bars to find real dimensions

Scale bars can be used to calculate the actual size of features shown on drawings and photographs of biological specimens. For example, in a photomicrograph of a cell individual features can be measured by using the scale bar.

WORKED EXAMPLE

In the image of a frog leucocyte, the scale bar at the bottom represents 1.5 μm. This can be used to find out the actual size of any part of the cell.



For example, what is the maximum diameter of the nucleus?

Step 1: measure the scale bar, which in this example is 8 mm long.

Step 2: if the scale bar is not already in whole units then work out the equivalent of 1 μm on the image.

- If 1.5 μm is equivalent to 8 mm then 1 μm is equivalent to $8 \div 1.5 = 5.33$ mm
- Thus every 5.33 mm on the image is equivalent to 1 μm in the real specimen. All you need to do now is work out how many times 5.33 mm divides into the dimension of the nucleus in the image.

Step 3: measure the desired feature, in this case the width of the nucleus. The width of the nucleus is 31 mm.

Step 4: the real dimension of the nucleus is now found by dividing using the sum:

length of the feature on the image ÷ length of 1 μm on the image

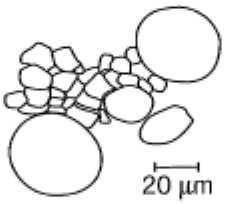
$31 \div 5.33 = 5.8$ μm

SUMMARY QUESTION

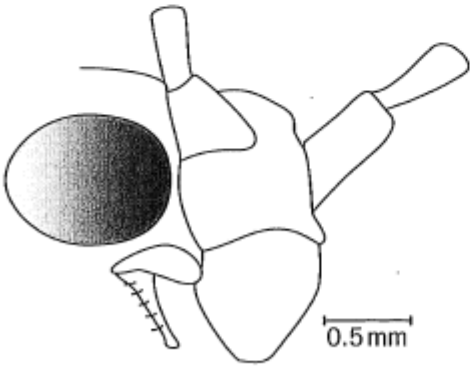
1 For each of the images shown, use the scale bar to determine the actual size of the object indicated.

a Length of the *Euglena*

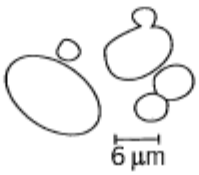
b Width of the widest xylem cell



c Width of the insect's compound eye

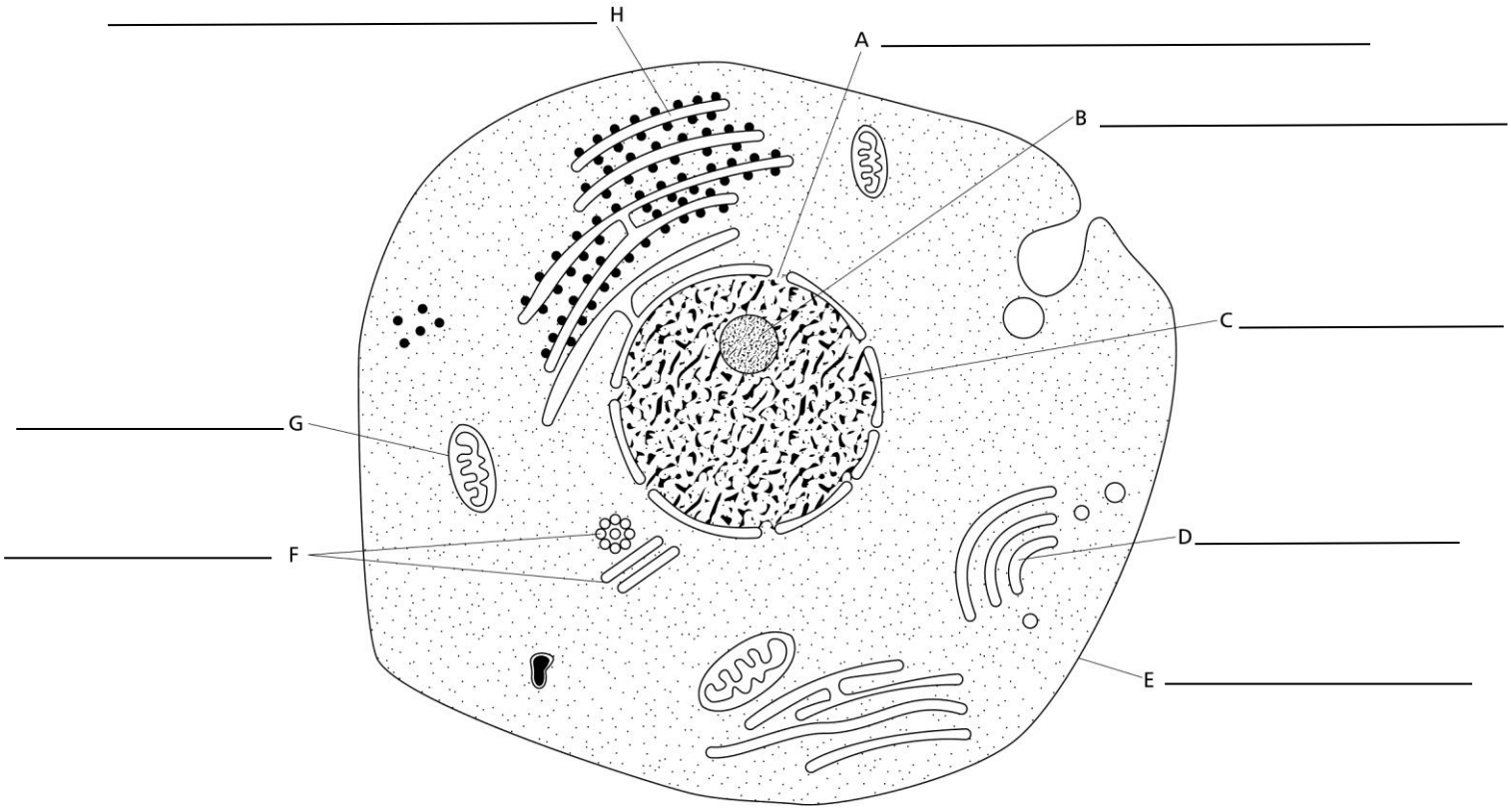


d Mean length of the yeast cells



REMEMBER: Take care when measuring the scale bar and don't round up numbers until the end of the calculation.

The diagram below shows the general structure of an animal cell as seen under an electron microscope. Label structures A-H



Show your working for all questions:

1) Calculate the magnification factor of the diagram

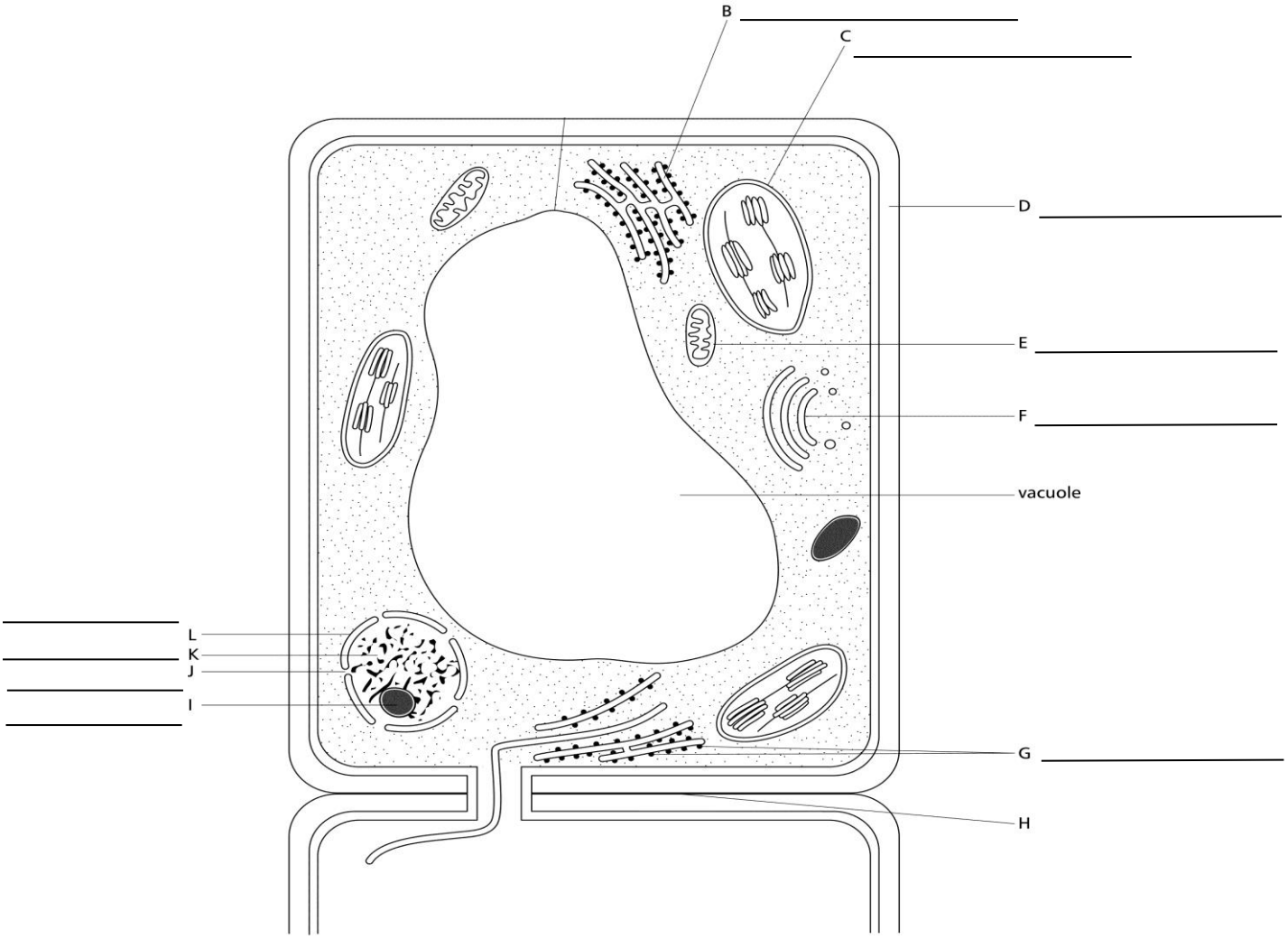
2) Calculate the length of structure G

3) Calculate the diameter of the nucleolus (structure B)

4) Calculate the diameter of the nucleus

5) Calculate the diameter of the cell at its widest point

The diagram below shows the general structure of a plant cell when viewed under an electron microscope. Label structures B-L



1) Calculate the magnification factor of the diagram

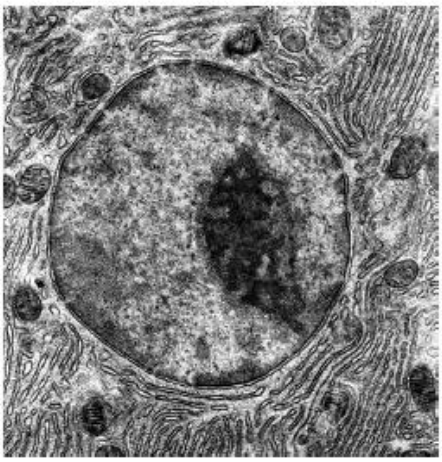
2) Calculate the thickness of the cellulose cell wall (D).

3) Calculate the length of the cell.

4) Calculate the length of structure C.

5) Calculate the length of the vacuole.

(b) The photograph shows a nucleus found in an animal cell.



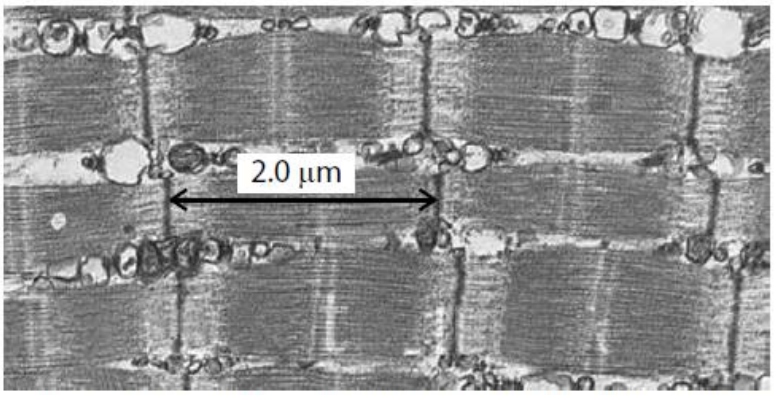
Magnification: x 6 000

(i) Calculate the diameter of this nucleus in µm.

(2)

Answer ..... µm

(b) The electron micrograph shows the arrangement of protein filaments in the contractile units of muscle myofibrils.



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(i) Calculate the magnification of this electron micrograph.

(2)

Answer .....