# M1.8 Make order of magnitude calculations

## Teacher answers

### Quiz

1 This is an electron micrograph of a mitochondrion. Its actual length is 5μm. Calculate the magnification of the image.

B0000119 Credit Prof. R. Bellairs, Wellcome Images 
TEM of a mitochondrion
A transmission electron micrograph of a mitochondrion in a chick embryo cell.
Collection: Wellcome Images 
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**B0000119** **Credit** [Prof. R. Bellairs](https://wellcomeimages.org/indexplus/result.html?wi_credit_line%3atext=%22Prof.%20R.%20Bellairs%22&%24%3dsort=sort%20sortexpr%20image_sort&%2asform=wellcome-images&_IXACTION_=query&_IXFIRST_=1&_IXSPFX_=templates%2fb&_IXFPFX_=templates%2ft&%24%20with%20image_sort=.), Wellcome Images   
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**Collection:** [Wellcome Images](https://wellcomeimages.org/indexplus/result.html?wi_library_dept%3atext=%22Wellcome%20Images%22&%24%3dsort=sort%20sortexpr%20image_sort&%2asform=wellcome-images&_IXACTION_=query&_IXFIRST_=1&_IXSPFX_=templates%2fb&_IXFPFX_=templates%2ft&%24%20with%20image_sort=.)   
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Magnification = size of image / size of the real object

Size of image = 80 mm = 800000 μm

Size of object = 5 μm

Magnification = 80000 / 5 = x16000

2 This botanical illustration from about 250 years ago shows a banana plant. The image has a scale line where each division represents 30cm. What is the magnification?

**V0043033 Credit: Wellcome Library, London
Banana plant (Musa species): flowering and fruiting plant with stolons and separate floral segments and sectioned fruit, also a description of the plant's growth, anatomical labels and a scale bar. Etching by G. D. Ehret, c. 1742, after himself.
By: Georg Dionysius Ehret 
Size: platemark 63.2 x 46.5 cm. 
Collection: Iconographic Collections 
Library reference no.: ICV No 43624 
Full Bibliographic Record Link to Wellcome Library Catalogue 
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**V0043033** **Credit:** Wellcome Library, London

Banana plant (Musa species): flowering and fruiting plant with stolons and separate floral segments and sectioned fruit, also a description of the plant's growth, anatomical labels and a scale bar. Etching by G. D. Ehret, c. 1742, after himself.

**By:** [Georg Dionysius Ehret](https://wellcomeimages.org/indexplus/result.html?create_creator_name_name%3atext=%22Georg%20Dionysius%20Ehret%22&%24%3dsort=sort%20sortexpr%20image_sort&%2asform=wellcome-images&_IXACTION_=query&_IXFIRST_=1&_IXSPFX_=templates%2fb&_IXFPFX_=templates%2ft&%24%20with%20image_sort=.)   
**Size:** platemark 63.2 x 46.5 cm.   
**Collection:** [Iconographic Collections](https://wellcomeimages.org/indexplus/result.html?wi_library_dept%3atext=%22Iconographic%20Collections%22&%24%3dsort=sort%20sortexpr%20image_sort&%2asform=wellcome-images&_IXACTION_=query&_IXFIRST_=1&_IXSPFX_=templates%2fb&_IXFPFX_=templates%2ft&%24%20with%20image_sort=.)   
**Library reference no.:** ICV No 43624   
**Full Bibliographic Record** [Link to Wellcome Library Catalogue](http://catalogue.wellcomelibrary.org/record=b1176510)   
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The magnification is calculated using the scale where 30 cm is represented by major divisions which are actually 6.5 mm apart

Magnification = size of image/ size of the real object

Size of image = 6.5 mm

Size of object = 30 cm = 300 mm

Magnification = 6.5 / 300 = x 0.022 or approximately 1 / 50

3 A false-colour transmission EM image of a white blood cell has a magnification of x2000. What is the diameter of the white blood cell?

B0004162 Credit University of Edinburgh, Wellcome Images 
Monocyte and two red blood cells
Colour-enhanced image of a monocyte and two red blood cells. Monocytes are white blood cells that develop into macrophages, cells that ingest and destroy dead cells and micro-organisms.
Transmission electron micrograph 1980 - 2000 
Collection: Wellcome Images 
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**B0004162** **Credit** [University of Edinburgh](https://wellcomeimages.org/indexplus/result.html?wi_credit_line%3atext=%22University%20of%20Edinburgh%22&%24%3dsort=sort%20sortexpr%20image_sort&%2asform=wellcome-images&_IXACTION_=query&_IXFIRST_=1&_IXSPFX_=templates%2fb&_IXFPFX_=templates%2ft&%24%20with%20image_sort=.), Wellcome Images   
Monocyte and two red blood cells

Colour-enhanced image of a monocyte and two red blood cells. Monocytes are white blood cells that develop into macrophages, cells that ingest and destroy dead cells and micro-organisms.

[Transmission electron micrograph](https://wellcomeimages.org/indexplus/result.html?wi_technique%3atext=%22Transmission%20electron%20micrograph%22&%24%3dsort=sort%20sortexpr%20image_sort&%2asform=wellcome-images&_IXACTION_=query&_IXFIRST_=1&_IXSPFX_=templates%2fb&_IXFPFX_=templates%2ft&%24%20with%20image_sort=.) 1980 - 2000   
**Collection:** [Wellcome Images](https://wellcomeimages.org/indexplus/result.html?wi_library_dept%3atext=%22Wellcome%20Images%22&%24%3dsort=sort%20sortexpr%20image_sort&%2asform=wellcome-images&_IXACTION_=query&_IXFIRST_=1&_IXSPFX_=templates%2fb&_IXFPFX_=templates%2ft&%24%20with%20image_sort=.)   
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Size of object = size of image/magnification

Size of image = 40 mm = 40000 μm

Magnification = 2000

Size of object = 40000 / 2000 = 20 μm

(note: clearly the cell is not spherical – answers within a sensible range (or even better reporting an interval for the diameter) should be credited)