Magnification and Scale

Cells are extremely small but knowing the sizes of objects viewed under the microscope can be really useful. For example, a plant scientist might want to compare the relative sizes of pollen grains from plants in the same genus to identify different species.

With a compound microscope, the magnification is the product of both lenses, so if microscope has a 10x eyepiece and an 40x objective, the total magnification is 400x.

Magnification is defined as the ratio of the size of the image to the size of the object.

\[
\text{Magnification} = \frac{\text{Size of image}}{\text{Actual size of object}}
\]

The relationship between these three values can be shown using the equation triangle to the right, which offers a quick way of rearranging the values in order to derive related formulas. Ask your teacher to demonstrate how to use it if you are not familiar with it.

Printed images of structures seen with a microscope usually show a scale bar or give the magnification or both, so that the size of an object can be calculated. For example, the magnification of the micrograph shown below is given as 230x.

In the micrograph above, you can see a spherical structure called a glomerulus. In the image, the glomerulus is approximately 35 mm across. You can check this using a ruler. Thus:

\[
\text{Actual size of glomerulus} = \frac{\text{Size of image}}{\text{Magnification}} = \frac{35 \text{ mm}}{230x} = 0.15 \text{ mm}
\]

In most micrographs, most measurements are expressed in micrometers. A micrometer (μm) is 10⁻³ mm, so 1 mm is 1000 μm. So the diameter of the glomerulus = 0.15 x 1000 = 150 μm.
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Because cells are small, they are viewed through lenses and microscopes. Photographs and diagrams often have scale bars to show the degree of magnification of the image. This image shows a red blood cell. The scale bar shows 2 μm, which represents the actual size of the bar. From this, you can calculate both the size of the cell and the magnification of the image.

Magnification of the image

Use a ruler to measure the length of the scale bar in the upper-right corner of the micrograph. This is 9 mm. Convert this number to micrometers. This is equal to 9,000 μm. Thus:

\[
\text{Magnification} = \frac{\text{Size of image (scale bar)}}{\text{Actual size of object (scale bar)}} = \frac{9,000 \, \mu m}{2 \, \mu m} = 4,500x
\]

Size of the cell

Use a ruler to measure the diameter of the red blood cell in the center of the above micrograph. This is 30 mm. Convert this number to micrometers. This is equal to 30,000 μm. We already know the magnification is 4,500x.

Rearrange the magnification equation to find the actual length of the red blood cell.

\[
\text{Actual size of object (cell)} = \frac{\text{Size of image (cell)}}{\text{Magnification}} = \frac{30,000 \, \mu m}{4500x} = 6.7 \, \mu m
\]

Drawing a scale bar

Assume you made a micrograph of a deer tick. You observed the tick under a stereoscope at 20x magnification and know the tick’s actual length is 2.0 mm. You want to draw a scale bar representing an actual distance of 1 mm. How long should the drawing of the scale bar be?

Use the formula:

\[
\text{Size of image (scale bar)} = \text{Magnification} \times \text{Actual size of object (scale bar)} = 20x \times 1 \, mm = 20 \, mm \text{ in length}
\]
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Answer the questions below.

1. Shown to the right is a micrograph of a bacteriophage taken with an electron microscope. Determine at what magnification the image was taken. Show your work. Hint: 1,000,000 nanometers (nm) = 1 millimeter (mm)

2. What is the actual length of the bacteriophage in nanometers (nm). Explain how you determined this.

3. The elephant shown is actually 3.5 m tall. What is the magnification of this picture? Show your work.

4. The image of the dragonfly has been magnified 0.25x. What is the actual length of the insect in centimeters (cm). Show your work.

5. What is the actual length of the arabid pollen grain shown to the right in micrometers (μm). Show your work.