**Microscope Calculations**

**Introduction:**

Any object observed under a microscope is very small and must be accurately measured. A millimetre, 1/1,000 of a metre, is far too large a unit for microscopic objects. Rather, scientists use the unit of a micrometre (μm), 1,000 times smaller than the millimetre. The Greek letter μ is used to symbolise micro, 1/1,000,000 of a metre.

1 mm = 1000 μm

When looking into a microscope, the **field of view** is the visible circular area. By knowing the size of the field of view (diameter), you can measure the size of objects in the microscope. **Field diameter** is simply the number of millimetres or micrometres you will see in your whole field of view when looking into the eyepiece lens.

Since the size of the objects in the field of view is different at each magnification, you have to calculate the diameters of the fields of view at each magnification. This process is called "calibrating your microscope".

**Procedure: Calculating Field of View**

1. Using the low power objective, place a clear plastic ruler on the stage and focus on the mm marks.
2. Visually estimate how many mm fit across the diameter of your field of view. Move the ruler so that you are measuring the diameter (width) of the low-power field of view from left to right. Set one of the millimetre divisions at the edge of the field of view.
3. Record this measurement in the table below. Convert the diameter from millimetres to micrometres.
4. Determine the field diameter for medium power.
5. You cannot measure the diameter of the high power (HP) field of view because it is less than 1 mm. However, you can use the following ratio to calculate the field diameter under high power.

\[
\frac{\text{high - power field diameter}}{\text{low - power magnification}} = \frac{\text{low - power field diameter}}{\text{high - power magnification}}
\]

\[
\frac{x}{6.5} = \frac{40}{400} \quad x = 0.65 \text{ mm}
\]

\[
\frac{x}{6.5} = \frac{40}{100} \quad x = 2.6 \text{ mm}
\]

<table>
<thead>
<tr>
<th>Field</th>
<th>Ocular Lens</th>
<th>Objective Lens</th>
<th>Total Magnification</th>
<th>Field Diameter (mm)</th>
<th>Field Diameter (μm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low power</td>
<td>10</td>
<td>4</td>
<td>40</td>
<td>6.5</td>
<td>6500</td>
</tr>
<tr>
<td>Medium power</td>
<td>10</td>
<td>10</td>
<td>100</td>
<td>2.6</td>
<td>2600</td>
</tr>
<tr>
<td>High power</td>
<td>10</td>
<td>40</td>
<td>400</td>
<td>0.65</td>
<td>650</td>
</tr>
</tbody>
</table>

You can use this knowledge to estimate the size of the cells that you view under the microscope by comparing them with the diameter of the field of view. For example, a cell that takes up 1/5 of a field of view that is 500 μm has a size of about 1/5 of 500 μm, or 100 μm.

**Calculating Actual Size of a Specimen**

<table>
<thead>
<tr>
<th>Field of view diameter</th>
<th>LOW power</th>
<th>Medium power</th>
<th>High power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field of view diameter</td>
<td>6500 μm</td>
<td>2600 μm</td>
<td>650 μm</td>
</tr>
</tbody>
</table>

Calculating the actual size of a specimen:

\[
\text{size of object} = \frac{\text{Field of View diameter}}{\text{# of times specimen fits across}}
\]

For example: calculating actual size of a specimen

Field of view = 1.4 mm = 1400 μm

Size of object = 1400 μm = 280 μm

5 objects
Calculate the size of the following organisms based on the field of view given below.

a. Field of Vision = 1400 μm
   Size = 700 μm

b. Field of Vision = 350 μm
   Size = 175 μm

c. Field of Vision = 350 μm
   Size = 140 μm

Rules for Biological Drawings

1. Draw what you see, not what you think should be there.
2. Drawings (or diagrams) should be as simple as possible, with clean-cut lines (do not sketch) showing what has been observed. All drawings should be done on unlined (blank) paper and should be neatly labelled.
3. Drawings should be large enough to show all parts without crowding. The greater the number of parts to be included, the larger the drawings should be. In general, drawings should be about half a page in size.
4. Keep your drawings to the left side of the page. Save the right-hand side of the page for labels.
5. All labels should be in a column to the right of the drawing, and printed. Lines to the labelled parts should be parallel to each other and should not cross one another. The lettering should be horizontal.
6. Use a ruler for label lines.
7. Do not shade in your drawing. If you wish to indicate the darker area, use dots (stipple).
8. Indicate the thickness of certain structures by using two lines.
9. Most plant and animal tissue are made up the individual cells. When one representative cell of such a tissue is to be drawn, make sure you include the cell boundaries of the other cells that border it. This will indicate the general appearance of the tissue without the necessity of drawing every cell.
10. All drawings must be titled. The printed and underlined side appears immediately above the drawing, against the left-hand margin. The magnification of the object drawn follows the title and is in parentheses, e.g. bone cell (300X)

Calculating the Magnification of a Drawing:

drawing magnification = \frac{size \ of \ actual \ pencil \ drawing}{actual \ size}

You must ALWAYS use the same units for drawing size and actual size for this equation to work!

For example: calculating the magnification of a drawing if the actual size was 200 μm.

7cm = 70mm × 1000 μm = 70 000 μm

\frac{70 000 \mu m}{200 \mu m} = 350X

Microscope Calculation Questions:

1. How many micrometres are in 1 millimetre?
2. How many micrometres are in 1 metre?
3. What happens to the field of view when you change from low-power magnification to high-power magnification?
4. How many times is the magnification increased when you change from low-power to high-power magnification?
5. Approximately 500 of a certain type of bacteria can fit across your low-power field of vision. What is the approximate size of 1 bacterium?
6. Approximately 7 of a certain type of protozoa can fit across your high-power field of vision. What is the approximate size of 1 protozoan?
7. If a microscope has a low-power magnification of 100X, a high-power magnification of 600X, and a low-power field diameter of 1800 micrometres, what is the high-power field diameter in micrometres?
8. If 200 objects fit across a low-power field of view whose field diameter is 3000 micrometres, what is the approximate size of each object?
9. A diagram is drawn as 12.3 cm long of a specimen known to be 340 μm long. What is the diagram magnification?
10. A cell is observed under high power to be about half the field diameter. A student draws the cell 25 cm in length. What is the magnification of the drawing?
11. A skin cell was drawn 2500X its actual size. If the drawing is 18.2 cm long what is the size of the actual cell?
12. 40 potato cells are counted across the center of the medium field of view. One cell is 2 cm long. What is the counting magnification?
13. How many times is the diameter of a field decreased when you change from low-power to high-power magnification?
Microscope Calculations - Solutions

1. \(1\, \text{mm} = 1000\, \mu\text{m}\)
2. \(1\, \text{m} = 100\, \text{cm} = 1000\, \text{mm} = 1,000,000\, \mu\text{m}\)
3. Field of view gets smaller
4. LP mag = \(10 \times 4 = 40\times\)
   HP mag = \(10 \times 40 = 400\times\)
   \(\frac{400}{40} = 100\times\) increase
5. LP diameter = 6.5 mm
   size of bacteria = \(\frac{6.5}{500} = 0.013\, \text{mm} = 13\, \mu\text{m}\)
6. HP diameter = 0.05 mm
   size = \(\frac{0.05}{7} = 0.007\, \text{mm} = 7\, \mu\text{m}\)
7. \(\frac{\text{HP diam}}{\text{LP diam}} = \frac{\text{LP mag}}{\text{HP mag}}\)
   \(\frac{\text{HP diam}}{1000\, \mu\text{m}} = \frac{100}{600}\)
   HP diam = \(\frac{100}{(1200)} = 300\, \mu\text{m}\)
8. Size = \(\frac{300\, \mu\text{m}}{30} = 150\, \mu\text{m}\)
9. \(12.3\, \text{cm} = 123\, \text{mm} = 123000\, \mu\text{m}\)
   mag = \(\frac{123000\, \mu\text{m}}{340\, \mu\text{m}} = 3.618\times\)
10. cell = \(\frac{65\, \mu\text{m}}{5} = 13\, \mu\text{m}\)
    \(25\, \text{cm} = 250\, \text{mm} = 250000\, \mu\text{m}\)
    mag = \(\frac{250000\, \mu\text{m}}{325\, \mu\text{m}} = 769.2\times\)
11. Size = \(\frac{\text{drawing}}{\text{mag}} = \frac{18.2\, \text{cm}}{250} = 0.07\, \text{cm} = 7\, \mu\text{m}\)
12. cell size = \(\frac{\text{field diam}}{\text{mag}} = \frac{2600\, \mu\text{m}}{40} = 65\, \mu\text{m}\)
    \(2\, \text{cm} = 20000\, \mu\text{m}\)
    \(\text{mag} = \frac{20000\, \mu\text{m}}{65\, \mu\text{m}} = 307.7\times\)
    \(\frac{6.5\, \text{mm}}{0.65\, \text{mm}} = 10\times\)