Microscopes and magnification

Specification reference

- *2.1.1 (b)*
- *2.1.1 (e)*
- *2.1.1 (f)*

Learning outcomes

After completing the worksheet students should be able to:

- understand the different units of measurement involved in microscopy, and be able to convert from one to another
- perform calculations using a formula to obtain the magnification or the actual size of an object as seen by any type of microscope.

Introduction

The use of microscopes is an essential tool to a biologist. The basic ideas about the types of microscopes and their advantages and disadvantages don't usually pose a problem to students. However, the calculations involved in magnification and scaling issues often prove problematic.

Students can be confronted with three major problems; appreciating the concept of scaling very small objects; using the small units involved and they often cannot convert one unit to another; and finally they have difficulties calculating the magnifications used to make drawings.

The support sheet takes students through these issues one stage at a time.

Teacher notes

- The support sheet assumes that students have been introduced to the use of microscopes and the properties of the different types of microscopes.
- The first step in the support sheet lists the major units involved in microscopy questions. It is an advisable step to ensure that students have a grasp of the names of the different units and the relative size of each unit, before continuing with the sheet.
- The first major mathematical problem is the conversion of one unit to another. In questions students are frequently given values in different units, and are required first to get all values in the same unit. The sheet suggest two basic tips, which can often act as rules to avoid problems. First is the 'rule of thousands'. This allows conversion form one unit to the next in sequence, by either multiplying by 1000 (going from larger unit to smaller) or dividing by 1000 (going from smaller to larger). The second tip is to avoid the use of cm, as these do not fit into the rule of thousands.
- When this idea has been explained there are a few ramped worked examples which you can take the students through. When students feel confident with these examples they could be directed to the first two questions in the task. They could work in pairs or individually. If the students have difficulties with these examples, the teacher could create more examples by using the question format and changing the numbers.
- When students are confident with the units involved and how to convert between the units, they can be reintroduced to the formula to calculate magnifications. The first issue might be problems manipulating the formula. A method is suggested for manipulating the formula, using the triangle idea. Alternatively the students could be given the two formulae and asked to memorize them.

- The sheet suggests a step by step process for dealing with the use of the formulae. This should solve most problems. It could be used in conjunction with the questions (3–6) in the task.
- The exam style questions brings together all of these skills in a typical example. A multiple choice style question and a more demanding calculation is included.

Answers

1 Width of the mitochondrion:

$0.5 \times 1000 = 500$ nm

2 Width of the stomata is:

$$\frac{3.5}{1000} = 0.0035 \text{ mm}$$

3 The formula used was:

$$\text{Magnification} = \frac{\text{image size}}{\text{object size}}$$

palisade cell was:

$$\text{magnification} = \frac{100}{0.2} = \times 500$$

4 The formula used was:

$$\text{Object size} = \frac{\text{image size}}{\text{magnification}}$$

So the artery size was:

$$\text{Object size} = \frac{75}{15} = 5 \text{ mm.}$$

5 Step 1 convert the values to µm

Image of red blood cell was 60 mm

Now follow rule of thousands. $60 \times 1000 = 60\,000$

Now use the formula

$$\text{Magnification} = \frac{\text{image size}}{\text{object size}}$$

$$\text{Magnification} = \frac{60\,000}{7.5} = \times 8000 \text{ magnified.}$$

6 Scale bar length = 20 mm.

Rule of thousands $20 \times 1000 = 20\,000$ µm

Now use the formula:

$$\text{Magnification} = \frac{\text{image size}}{\text{object size}}$$

$$\text{Magnification} = \frac{20\,000}{20} = \times 1000 \text{ magnification}$$

Exam-style questions

1 C (*1 mark*)

2 **a** Scale bar length = 10 mm.

Rule of thousands 10 × 1000 = 10 000 µm (*1 mark*)

Now use the formula:

$$\text{Magnification} = \frac{\text{image size}}{\text{object size}}$$

$$\text{Magnification} = \frac{10\,000}{400} = \times 25 \text{ magnification}$$ (*1 mark*)

b Measure the distance between A and B as 25 mm.

Convert to µm

25 × 1000 = 25 000 µm (*1 mark*)

Now use the formula

$$\text{Object size} = \frac{\text{image size}}{\text{magnification}}$$

$$\text{Object size} = \frac{25\,000}{25} = 1000 \text{ µm}.$$ (*1 mark*)