Cells

2

HAVE YOU EVER WONDERED…

- what your skin and hair would look like if they were magnified?
- why plants are green but humans are not?
- why animals need a skeleton but plants do not?

After completing this chapter students should be able to:

- recall that cells are the basic units of living things
- use a light microscope to examine a variety of cells
- distinguish plant cells from animal or fungal cells
- identify structures within cells and describe their functions
- recall that some organisms consist of a single cell
- describe the specialised cells and tissues involved in structure and function of particular organs
- explain that mitosis is the type of cell division used for growth and repair.

2.1 Making things bigger

Sometimes people wear glasses to help them to see clearly. Even if you have very good eyesight, some things in our world are so small or so far away that you will need help to see them. Astronomers use telescopes to observe distant stars or details of the surface of the Moon and planets. Binoculars help bird watchers identify birds high in a tree. Using microscopes, scientists can see things that are invisible to the naked eye.

INQUIRY science 4 fun

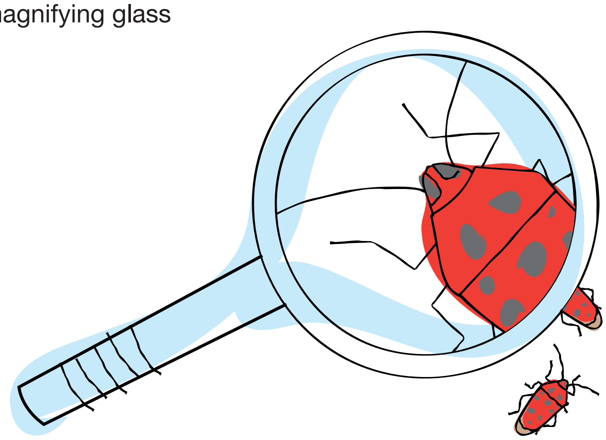
It looks different!

What can you see using a magnifying glass that you could not see before?

Yes

Collect this ...

- magnifying glass



Do this ...

Use the magnifying glass to look at familiar things around you. Some suggestions are your fingerprint, the hairs on the back of your hand or arm, soft leaves, soil, an ant and pictures from a newspaper.

Record this ...

Describe what you could see with the magnifying glass that you could not see with your naked eye.

Explain why you were able to see things differently.

Microscopes

Small things need to be **magnified** or made bigger so that they become visible to us. Scientists use **microscopes** to do this. Objects that can only be seen using a microscope are described as **microscopic**. Microscopes allowed scientists to see the tiny building blocks that make up living things and to see for the first time microscopic living things such as bacteria. Figure 2.1.1 compares the detail you can see with and without a microscope.

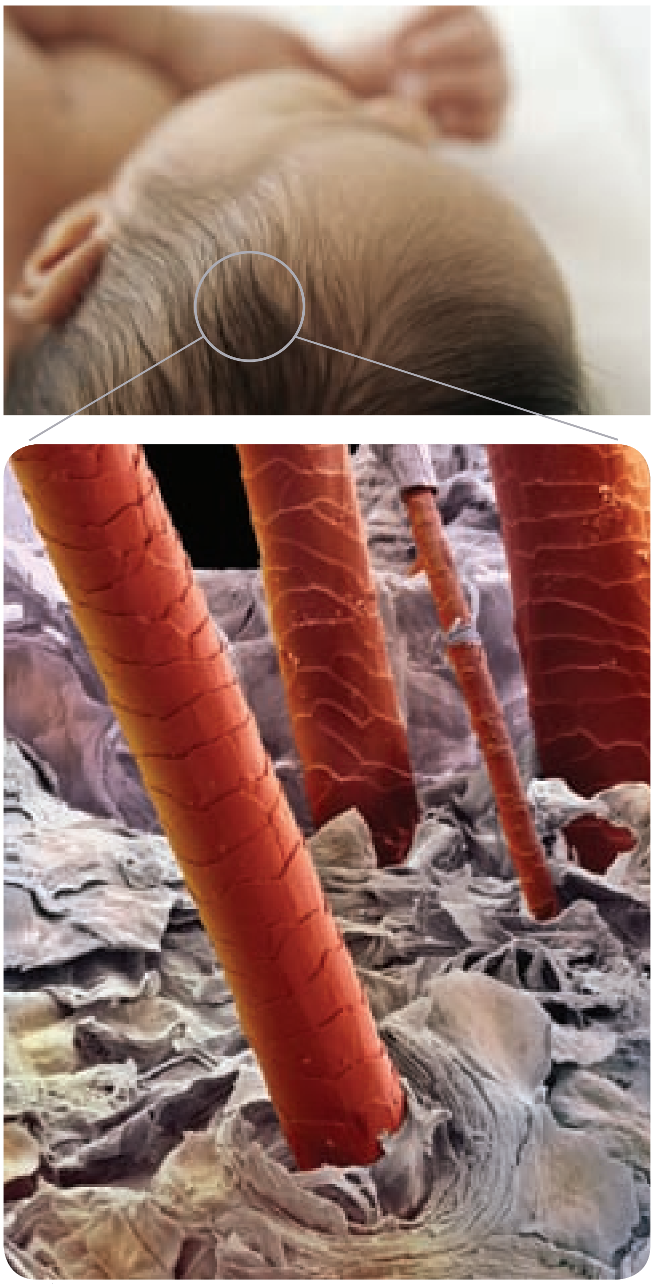


Figure 2.1.1 In the picture on the top, you can see the baby's hair and scalp, but a microscope can show so much more than your naked eye can. Using a very powerful microscope, you can see single hairs surrounded by skin cells of the scalp.

The type of microscope used in schools and many laboratories is a **light microscope**. Light from a mirror or a lamp passes through a **specimen** or object. The specimen being looked at must be very thin so that the light can pass through it easily. The light then passes through a series of lenses that cause the specimen to appear bigger. What you see through the microscope is called the **image**. You will probably use a microscope like the one shown in Figure 2.1.2. This is a monocular light microscope (**monocular microscope**) because it has only one eyepiece or ocular lens. Many light microscopes have two eyepieces or ocular lenses. They are **binocular microscopes**.

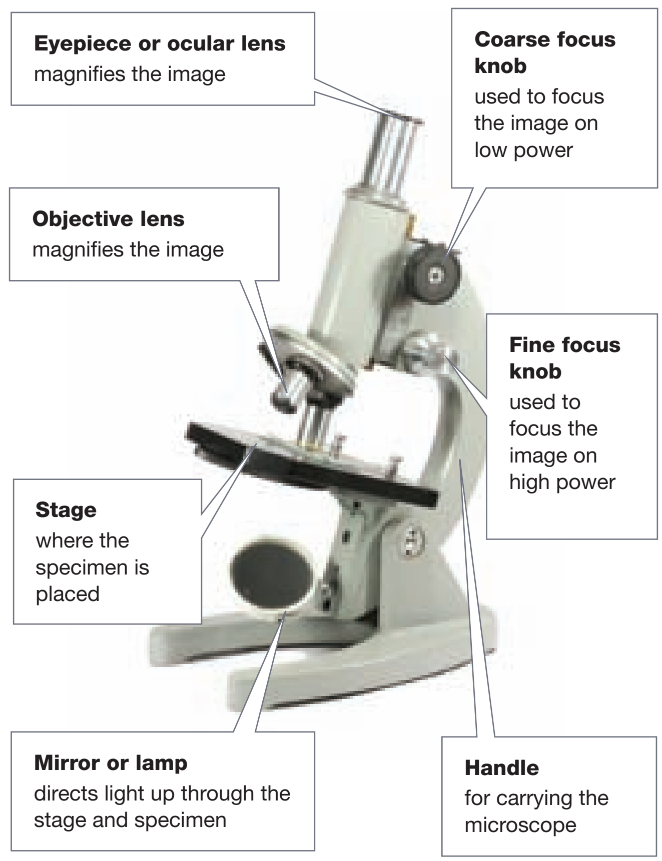


Figure 2.1.2 This photograph shows how the parts of a microscope are organised.

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Stereo microscopes

When you hear music in stereo or see an image in stereo, it means that the information is coming from two different directions. Using a **stereo microscope** is like having two monocular microscopes joined together, with each one focusing on the same point but from different angles. The image you see is therefore in three dimensions.

Figure 2.1.3 Stereo microscopes give a realistic 3D view of the specimen. The distance between the specimen and the objective lens also leaves room for scientists to work on the specimen.

The light source for stereo microscopes may be lamps or reflected light from the Sun. Light shining onto the specimen is reflected back up through the lenses to create the image. Light does not pass through the specimen, and therefore the specimen does not have to be thinly sliced or prepared in any other way. This means that anything can be placed under a stereo microscope.

The distance between the objective lens and the specimen is much greater than in a monocular or binocular microscope. This means that you can work on the specimen as you are viewing it. This gives the stereo microscope its other name of dissecting microscope. A **dissection** is when a scientist cuts apart a dead plant or animal to study it. Scientists can carry out dissections while they are looking through the microscope: the scientist in Figure 2.1.3 is dissecting a plant.

When you move a specimen under a stereo microscope the image moves in the same way. That is, you move the specimen to the right and the image also moves to the right.

Table 2.1.1 compares monocular or binocular microscopes with stereo microscopes.

Table 2.1.1 Comparison of types of light microscope

Monocular or binocular microscope	Stereo microscope
Provides a two-dimensional image of the specimen.	Provides a three-dimensional image of the specimen.
Maximum magnification about ×1000.	Maximum magnification about ×100.
When viewed through the microscope, the image appears to move in the opposite direction to the actual movement.	When viewed through the microscope, the image appears to move in the same direction as the actual movement.
Light passes through the specimen.	Light reflects off the specimen.
Specimen is placed on a slide. May be complete objects such as microscopic organisms or fibres. However, specimens are frequently a very thin slice.	Specimen can be anything—no preparation is required.
When the specimen is sliced, it provides a view of the inner structure of the specimen.	Provides a view of the surface of the specimen.
Shows colour of the original specimen; however, stains or dyes can be used to increase the contrast between parts.	Shows colour of the original specimen

Magnification

The **magnification** of the microscope tells you how much bigger the image is than the real object. If the microscope has a magnification of ×10, then the image is ten times bigger than the actual object. (The symbol × stands for *magnified by*.)

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Calculating magnification

The microscope in Figure 2.1.2 on page 41 has two lenses—the eyepiece or ocular lens, and the objective lens. Both lenses magnify the specimen. To calculate the total magnification, you multiply the magnification of the ocular lens by the magnification of the objective lens. Some examples are shown in Table 2.1.2.

Table 2.1.2 Calculation of common magnifications

Ocular lens magnification	Objective lens magnification	Calculation and total magnification
× 10	× 4	× 10 × 4 = × 40
× 10	× 10	× 10 × 10 = × 100
× 10	× 40	× 10 × 40 = × 400

As the magnification increases, then the amount of the specimen you can see (the **field of view**) gets smaller.

The maximum magnification achieved by light microscopes is about ×1000. At this magnification some of the largest bacteria are just visible.

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The magnification of stereo microscopes is lower than in monocular or binocular microscopes, with ×100 the usual maximum magnification.

Very small measurements

Units like metres (m) or centimetres (cm) are normally used to describe your height, and centimetres or millimetres (mm) to describe the diameter of a coin or the length of a pin. However, it is difficult to measure the diameter of the full stop at the end of a sentence because a full stop is less than one millimetre in diameter. You will either have to estimate the size of the full stop as a fraction of a millimetre, or use a smaller unit. Many of the objects observed using a microscope are smaller than the full stop and so must be measured in units smaller than a millimetre.

A **micrometre** (μm) is one-thousandth of a millimetre, or one-millionth of a metre. It is the unit most often used by scientists to measure microscopic objects.

Electron microscopes

Electron microscopes are much more powerful than light microscopes. You can see this in Figure 2.1.4. Electron microscopes use beams of tiny particles called electrons instead of light, and they are able to magnify up to a million times. There are two types of electron microscopes: transmission electron microscopes (TEM) and scanning electron microscopes (SEM). Table 2.1.3 compares these two types of microscopes.

SciFile

Discovering bacteria

The 17th century Dutch scientist Antonie van Leeuwenhoek discovered bacteria by observing the plaque from between his own teeth under a microscope.

Table 2.1.3 Comparison of TEM and SEM

TEM	SEM
Specimen is a very thin slice.	Specimen can be anything. No need to slice.
Electrons pass through the specimen.	Electrons reflect off the surface of the specimen.
Provides a view of the inner structure of the specimen (e.g. a cell).	Gives greatly magnified views of objects (e.g. insects, leaf surface, bacteria).
Image is black and white but can be coloured to increase contrast.	Image is black and white but can be given false colour using computers.

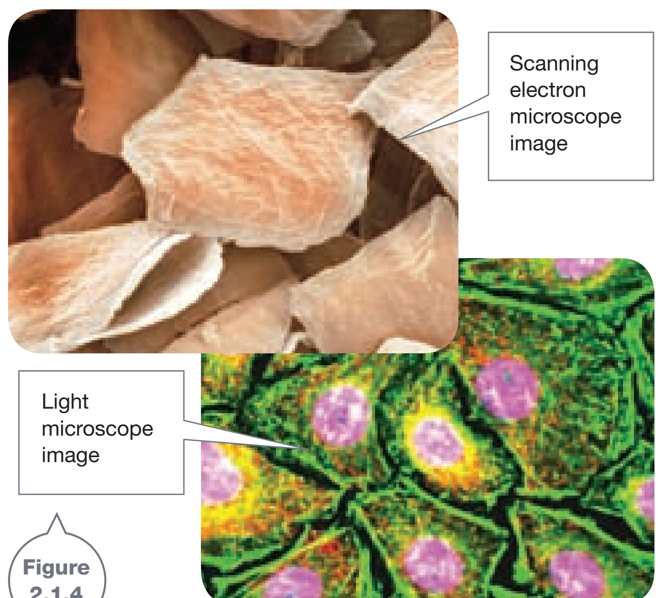


Figure 2.1.4 Light microscopes and scanning electron microscopes provide very different images of the same cells.

SKILL BUILDER

Converting units of length

Scientists use many units of length and often have to convert one to the other. In the metric system, these conversions are carried out by multiplying or dividing by a factor of ten such as 10, 100 or 1000. Table 2.1.4 shows you how to make some conversions.

Table 2.1.4 Converting units of length

Unit of length	Convert by	To
Kilometres (km)	× 1000	Metres (m)
Metres (m)	× 100	Centimetres (cm)
Centimetres (cm)	× 10	Millimetres (mm)
Millimetres (mm)	× 1000	Micrometres (μm)
Metres (m)	÷ 1000	Kilometres (km)
Centimetres (cm)	÷ 100	Metres (m)
Millimetres (mm)	÷ 10	Centimetres (cm)
Micrometres (μm)	÷ 1000	Millimetres (mm)

2.1 Unit review

Remembering

1 **Name** the lenses found in a light microscope.

2 **Recall** the units used to measure microscopic objects.

3 **Recall** what happens to the field of view as the magnification used increases.

4 **Name** two different types of:
- a light microscope
- b electron microscope.

Understanding

5 **Explain** why people examining a crime scene might use a magnifying glass as they search for clues.

6 **Define** the following terms.
- a microscopic
- b specimen
- c image

7 **Describe** what happens to the image seen in a monocular microscope when the slide is moved:
- a to the left
- b to the right
- c downwards.

8 **Explain** why the specimen prepared for a monocular microscope must be very thin.

9 **Describe** how to calculate the magnification of a microscope.

10 **Explain** why there is more detail in an image produced using a TEM than in the image from a light microscope.

Applying

11 **Calculate** the numbers missing from the following unit conversions.
- a 5 cm = ____ mm
- b 8000 μm = ____ mm
- c 1 m = ____ μm

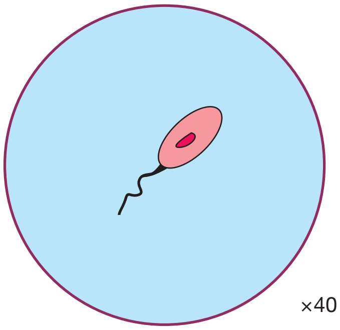
12 **Calculate** how many micrometres are in 3 millimetres.

13 **Calculate** the total magnification in the following examples.

	Ocular lens	Objective lens
a	×4	×10
b	×10	×100
c	×4	×40

14 The image of the specimen shown in Figure 2.1.5 was obtained using a magnification of ×40. **Apply** your knowledge of magnification to draw a picture of the image magnified ×80.

Figure 2.1.5



Analysing

15 Use the information in Figure 2.1.6 to **compare** the size of a human cheek cell, a fat cell, a red blood cell and a white blood cell.

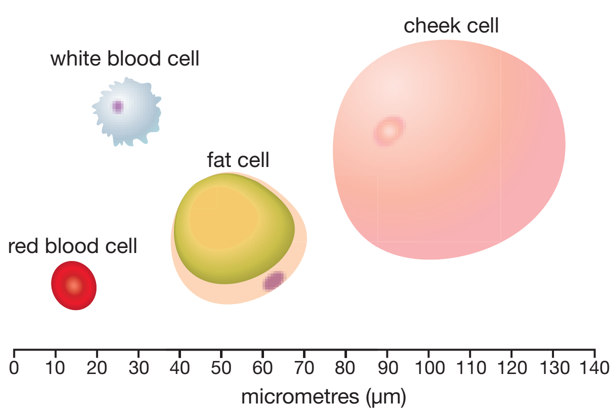


Figure 2.1.6

16 **Compare** the way the electrons move to produce the images in a SEM and a TEM.

17 **Compare** the way that specimens are prepared for a stereo microscope and a monocular microscope.

18 **Compare** the image seen using a stereo microscope with the image created with a SEM.

Evaluating

19 a **Identify** the type of microscope that most likely produced the image shown in Figure 2.1.7.

b **Justify** your answer.

Creating

20 **Construct** a table that lists the parts of the microscope and summarises the functions of each part.

Inquiring

1 Research microscopes and state the maximum magnification that can be achieved by different types.

2 Research electron microscopes and state when the first one was built and who built it.

3 Investigate ways that electron microscopes are used in a variety of workplaces.

4 Use available resources to research and describe an electron.

Figure 2.1.7

2.1 Practical activities

Preparing a wet mount

SKILL BUILDER

1 Place a drop of water onto the specimen on the microscope slide. If a stain is being used, then it can be added to the drop of water at this stage.

2 Gently lower a thin glass cover slip onto it as shown in Figure 2.1.8.

3 Soak up any excess water or stain with a piece of filter paper or tissue.

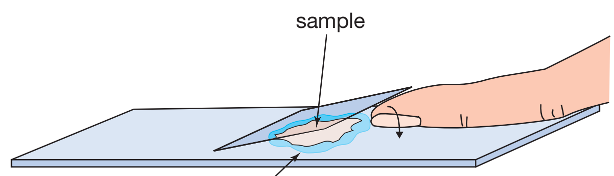


Figure 2.1.8

1 Getting to know the microscope

Before starting this activity, make sure that you have read and understood the Skill Builders 'Preparing a wet mount' and 'Using a microscope' at the top of these pages.

Purpose

To make a wet mount and view it using a monocular or binocular microscope.

Materials

- monocular microscope
- microscope lamp (if needed)
- a section of newspaper containing small print
- eye-dropper
- glass microscope slide
- cover slip

SAFETY

Cover slips and microscope slides break easily. Treat them with care.

Procedure

1 Cut out a small section (1 cm × 1 cm) of newspaper with small print. Make sure that there is a letter 'e' in the section.

2 Use the newspaper to prepare a wet mount slide by following the procedure described in the Skill Builder above.

3 Set the microscope to the lowest magnification and focus the image of the newsprint. Try to get the letter 'e' into the field of view.

4 Slowly move the slide containing the newsprint to the left, and record which way the image appears to move.

5 Record how the image moves when the slide is moved to the right, away from and towards you.

6 Increase the magnification and then observe the news print again.

Results

For two different magnifications:

1 Sketch what you see in a field of view.

2 Record the magnification used.

3 Count how many letters fit in the field of view.

Discussion

1 **Recall** whether the letter 'e' was the same way up as on the newsprint, or upside down.

2 **Recall** how the letters in the specimen appeared to move by copying the following sentence into your notebook and filling in the blanks as you go.

When I moved the slide to the right, the letters appeared to move to the ____. Moving the slide towards me seemed to make the letters move ____ from me. Then, when I moved the slide away from me, the letters moved ____ me. Every time I moved the slide, the letters seemed to go in the ____ direction.

3 **State** how many letters fitted into the field of view at each magnification.

4 **Explain** the relationship between the field of view and the amount of the specimen that can be seen.

SKILL BUILDER

Using a microscope

1. Place the slide on the stage and secure it using the clips.
2. Adjust the mirror or diaphragm so that the maximum amount of light is passing through the slide.
3. Select the objective lens with the lowest magnification.
4. Looking at the microscope from its side, adjust the coarse focusing knob to bring the stage and objective lens as close as possible to each other.
5. Looking through the eyepiece, turn the coarse focusing knob so that the stage and objective lens move further apart.
6. Keep doing this until the specimen is in focus.
7. Adjust the fine focusing knob to sharpen the focus on the specimen.
8. If you miss the point of focus, go back to step 4 and start again.

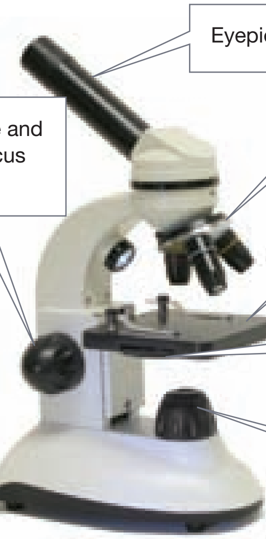


Figure 2.1.9

2 I can see more!

Before starting this activity, make sure that you have read and understood the Skill Builder 'Using a microscope' above.

Purpose

To observe common objects at various magnifications.

Materials

- monocular or binocular microscope
- microscope lamp
- glass microscope slides
- cover slips
- eye-dropper
- small samples suitable for viewing under a microscope, such as a sugar crystal (both plain and caster), salt, copper sulfate, hair, clothing fibres, leaf, insect, writing sample (in ballpoint pen ink), mini grid (optional). Note: These do not need to be viewed as wet mounts.

SAFETY

Cover slips and microscope slides break easily. Treat them with care.

Procedure

1. Observe a small specimen of each item under the microscope.
2. If you do not see an image, try shining the microscope lamp onto the surface of the object. You may notice that this works very well with solid objects.

Results

Sketch what you see in each case and record the magnification used to obtain the clearest image.

Discussion

1. **Describe** in words how each specimen appeared. In your description note observations that were not possible without the microscope.
2. **State** which specimen you found most interesting, and **explain** why.