PEARSON

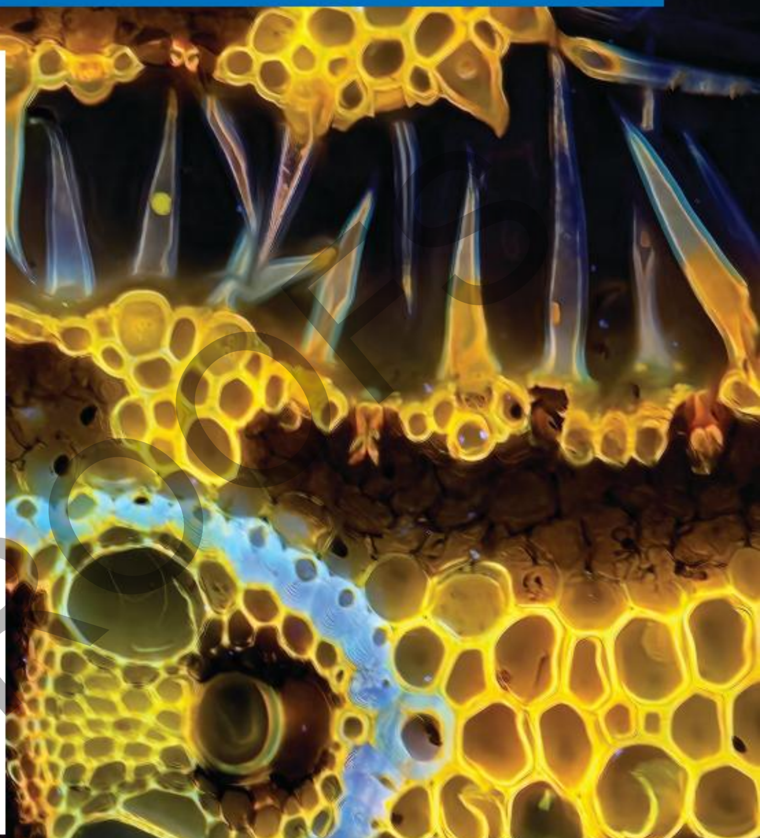
Science

STUDENT BOOK | WESTERN AUSTRALIA

8

TOPIC 1

Cells in plants and animals



For many thousands of years, humans in Australia and around the world have studied the behaviour of living things from the plant and animal kingdoms: how they moved, found food, and protected themselves from the environment.

It is only since the development of the microscope—less than 500 years ago—that scientists were able to see living matter at a scale small enough to make a huge discovery.

Living things—from great white sharks to white ants, from Blue Gum trees in Tasmania to Blue Leschenaultia plants in Western Australia—are all made up of cells. Some living things are made of just one cell, while other living things are made up of trillions of cells.

It is the features and functions of these cells that support the growth and survival of the living things that the cells create.

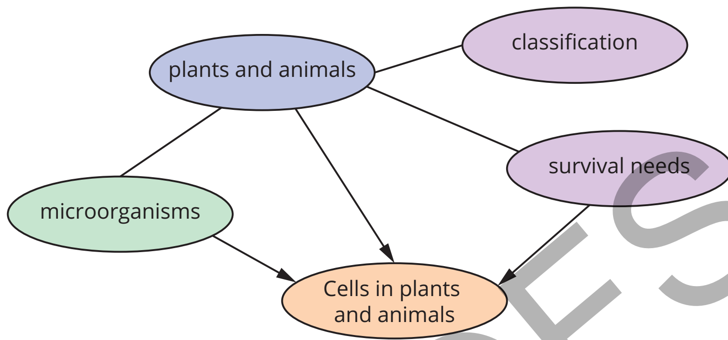
In this topic you will learn about the features and functions of cells.

Learning intentions

- [ ] To understand that cells are the basic unit of living things **xx**
- [ ] To understand the features and function of some cells found in the human body **xx**
- [ ] To understand how the development of technologies has led to improved understanding of cells **xx**
- [ ] To be able to use a microscope to generate data and information **xx**
- [ ] To understand the key role of the nucleus in the function of cells **xx**
- [ ] To be able to use a microscope to observe and record images of plant cells **xx**
- [ ] To understand the roles of the cell wall and cell membrane in the function of cells **xx**
- [ ] To be able to investigate the action of a cell membrane **xx**
- [ ] To understand the role of the cytoplasm in cellular function **xx**
- [ ] To understand the roles of mitochondria and chloroplasts in cellular function **xx**
- [ ] To understand the role of vacuoles in cellular function **xx**
- [ ] To understand the similarities and differences between animal and plant cells **xx**
- [ ] To be able to use microscopes to observe, record and compare unicellular and multicellular organisms **xx**
- [ ] To be able to construct and evaluate representations of cells and cell structures **xx**
- [ ] To be able to explore the ethical and social implications of scientific discoveries such as stem cells **xx**

1 Cells in plants and animals

The key concepts that you will use in this topic:



The following prior knowledge questions will help to support your learning in the topic and can be attempted before the first lesson.

Cells are the basic unit of living things

1 Categorise each of the following as living or non-living.

  a dogs
  b tables
  c people
  d bacteria
  e grass
  f soil
  g insects
  h viruses

2 What are the characteristics of living things?

3 List the different kingdoms of life.

Types of cells

4 Draw a table to show differences and similarities between plants and animals.

5 Name two different body systems and briefly explain their function.

6 Explain the benefits of most plants being green in colour.

Observing cells

7 Which of the following would not be able to be seen by the human eye?

  a a single bacteria
  b a chicken's egg
  c a grain of sand
  d a mouse
  e an atom
  f wings of a fly
  g apple seeds

1.1 Cells as the building blocks of living things

Lesson overview

Mobile phones are often referred to as cell phones. But why? When mobile phones were first introduced (Figure 1.1.1), their networks were divided into small geographic areas, each with its own network tower to boost signal strength. These areas were called cells, and phones that connected to them became known as cell phones. The networks themselves were often referred to as cellular networks.

In a similar way, cells in biology are the small building blocks that form something much larger and more complex. Every living organism, including humans, is made up of biological cells. If life exists beyond Earth, it is likely built from cells as well.

In this lesson you will learn about how cells are the building blocks of life and how they are part of all living systems.

Learning intention

To understand that cells are the basic unit of living things

Success criteria

SC 1: I can describe cells as microscopic units of living things.

SC 2: I can explain the difference between unicellular and multicellular organisms.

SC 1 I can describe cells as microscopic units of living things

All living things are made up of **cells**. Cells are the smallest living unit and can be thought of as tiny factories that carry out the functions needed for a living thing, or **organism**, to survive. These functions include releasing energy from food, removing waste products and making copies of themselves so that the organism can grow. Figure 1.1.2 shows a photo of some stem cells magnified to look much larger than they really are.

KEY TERMS

cell the building blocks of all living things

organism a living thing that functions as an individual

cell theory the idea that all living things are made up of one or more cells that come from pre-existing cells

Cell theory

Key ideas about cells were proposed in the mid-nineteenth century, and in 1855 these ideas were brought together to produce what is described as **cell theory**.

- All living things are made up of one or more cells.
- Cells are the basic building blocks of all living things.
- New cells are produced from existing cells.

FIGURE 1.1.1 An old style 'brick' cell phone from the 1990s … not very comfortable to put in your back pocket!

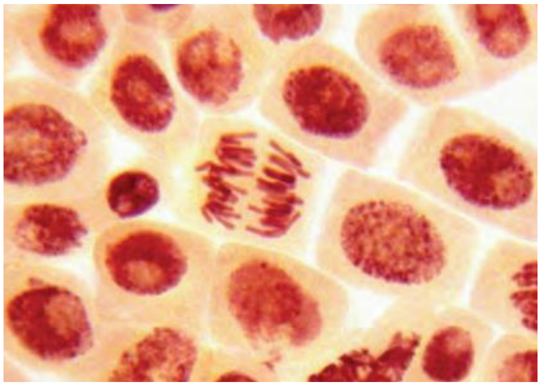


FIGURE 1.1.2 These cells can grow into different types of cells depending on the conditions in the organism; the cell in the middle is in the process of splitting into two cells.

KEY TERMS

microscope an instrument used to make very small things look bigger

multicellular an organism that is made up of many cells

body system a group of interconnected organs and tissues that perform functions in the body

organ a structure that contains at least two different types of tissues that work together to complete a function

tissue a group of cells of the same type that carry out the same function in the body

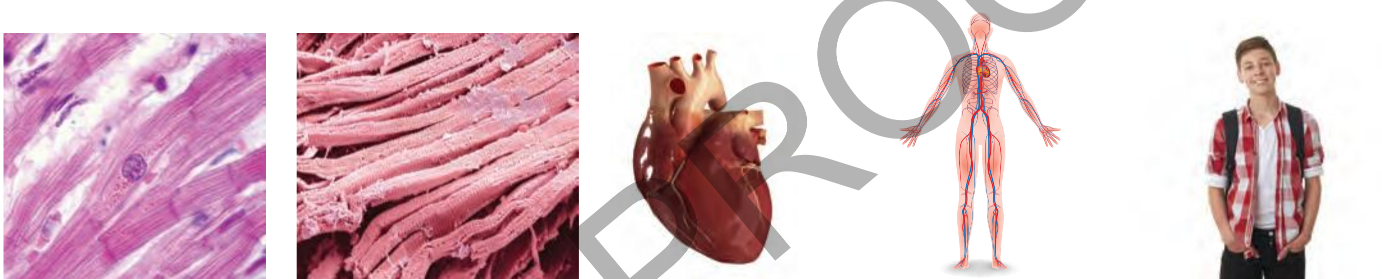
Like most scientific theories, cell theory has evolved as new discoveries have been made. Over time, it has expanded to include additional functions and structures of cells that were unknown a century ago. Modern cell theory now provides greater detail on inheritance, cell composition, and energy transfer within cells. Many of these advancements were made possible by improvements in **microscopes**, allowing scientists to observe cellular features with greater precision.

Most organisms are **multicellular**, meaning they are made up of many cells.

Multicellular organisms, such as humans, are highly complex, consisting of interconnected **body systems**. For example, the circulatory system transports essential substances through the blood.

Body systems are composed of **organs**, such as the heart, which in turn are made up of **tissues**, such as muscle. Each tissue is formed by specialised cells suited to its function—for example, muscle tissue consists of muscle cells. This hierarchical organisation of life is shown in Figure 1.1.3.

cells → **tissues** → **organs** → **systems** → **multicellular organisms**



A muscle cell.

Muscle tissue that is made of many muscle cells.

A heart is an organ that contains several tissue types, including muscle, nervous and connective tissues. The tissues work together to do the task of pumping blood.

The circulatory system is a body system that uses the heart, blood, veins and arteries to carry oxygen, nutrients and wastes to and from other body parts.

A human (multicellular organism) that is made up of many different body systems.

FIGURE 1.1.3 The organisation of multicellular organisms

KEY TERM

organelle the smaller parts of a cell; found in the cytoplasm and have a variety of important functions

What is inside cells?

The shapes you can see inside cells under a microscope are called **organelles**. These are parts of the cell that perform certain roles, such as providing energy and containing the genetic information (DNA) for the organism. You will learn more about organelles later in this topic.

SC 1 CHECK YOUR UNDERSTANDING

List the three components of the cell theory.

SC 2 I can explain the difference between unicellular and multicellular organisms

Number of cells in the human body

Some living things, such as bacteria, are made up of only one cell and are called unicellular organisms. If a living thing is made up of two or more cells, it is called multicellular.

Humans are multicellular organisms made up of approximately 30 trillion (30 000 000 000 000) cells.

What cells do

In multicellular organisms, different functions are carried out by different types of cells, or groups of cells working together, in a variety of systems. You can see some examples of these different cell types in Table 1.1.1.

TABLE 1.1.1 Cell types and functions in humans

Cell type	Functions in humans
red blood cells	carry oxygen around the body
muscle cells	provide support and allow movement
egg cells	involved in reproduction
nerve cells (neurons)	carry messages around the body
fat cells	store fat that can be used as energy when the body needs it
stem cells	have the ability to develop into many different cell types

Skin, which is an organ, contains some of these types of cells. Figure 1.1.4 shows the different types of cells found in human skin.

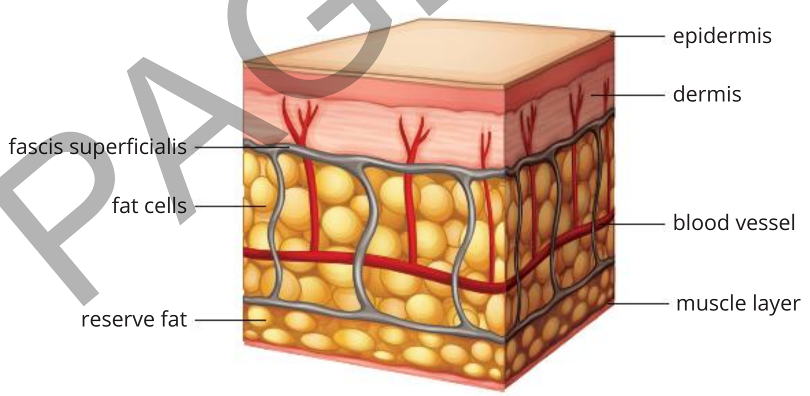


FIGURE 1.1.4 Tissue types found in human skin

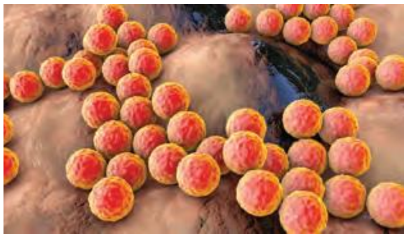


FIGURE 1.1.5 The red spheres are a representation of *Staphylococcus aureus* bacteria, which is a unicellular organism

Unicellular organisms

In unicellular organisms, a single cell carries out all essential functions, including food intake, waste removal, energy production, environmental response, and reproduction. Bacteria are an example of unicellular organisms. Unlike plants or animals, bacteria belong to the Monera kingdom, which consists of single-celled organisms without a distinct nucleus. They reproduce by creating identical copies of themselves, known as clones.

Some bacteria can cause disease, such as *Staphylococcus aureus* (Figure 1.1.5), which may lead to skin infections and, in rare cases, serious conditions like septicaemia (blood poisoning). These bacteria are commonly known as golden staph.

However, not all bacteria are harmful—many play beneficial roles in human health and the environment.

Scifile

Good bacteria

Probiotic yoghurt is an example of a food that is produced with live bacteria. These bacteria can help your body digest food, reduce the number of disease-causing bacteria, help to create vitamins and help the body to absorb medications.

SC 2 CHECK YOUR UNDERSTANDING

Name the term that is used to describe organisms that are made up of only one cell and the term for organisms that are made up of many cells.

Lesson review

Use these questions to check whether you have met the learning intention for this lesson.

1 List the following terms in order from of their biological hierarchy (from least to most complex): human, muscle cells, muscle tissue, circulatory system, heart.

2 Define an 'organ system'.

3 A group of different types of cells was examined under a microscope. They all appeared to be working together. What is the name of the term used to describe what was observed?

4 Classify each of the following as unicellular or multicellular.

- a birds
- b bacteria
- c tree
- d mammals

5 Ralph took a sample of water from a local creek, and he then observed the water under a microscope. He noticed that there were many small simple organisms vibrating around. Is it more likely that Ralph observed multicellular or unicellular organisms? Explain your choice.

1.2 Cells in humans

Lesson overview

All humans start from an egg cell that has been fertilised by a sperm cell.

A fertilised cell contains the genetic information required to create the more than 30 trillion (30 000 000 000 000) cells that make up an average human.

Most of these cells have specific functions in the body. These include protection from disease, transporting oxygen to muscles or making up muscles used for to movement and support.

In this lesson you will learn about the different types of cells in your body, their relative sizes and what some of these cells have in common.

Learning intention

To understand the features and function of some cells found in the human body

Success criteria

SC 1: I can state the function of different types of cells in humans.

SC 2: I can compare the scale of different types of cells in humans.

SC 3: I can describe some features that are common to most types of cells.

SC 1 I can state the function of different types of cells in humans

The human body contains a wide variety of **specialised cells**, each with a unique structure that enables it to perform a specific function. These cells work together within tissues and body systems to sustain life.

Some essential processes, such as **cellular respiration**, occur within individual cells, while others involve interactions between cells. For example, in the nervous system—which transmits and processes signals to coordinate movement and sensory information—messages travel from one cell to another. Other functions involve the movement of materials, such as red blood cells transporting oxygen throughout the body.

Despite their differences in structure and function, all cells contain the same genetic material (**DNA**), which is unique to each individual. Examples of specialized cells can be seen in Figure and Table 1.2.1.

KEY TERMS

specialised cell cell that has specific structures to allow it to perform specific functions

cellular respiration a set of processes in the cells that converts chemical energy from nutrients into energy (ATP) that can be used by cells

DNA deoxyribonucleic acid, the molecule that contains genetic information for an organism

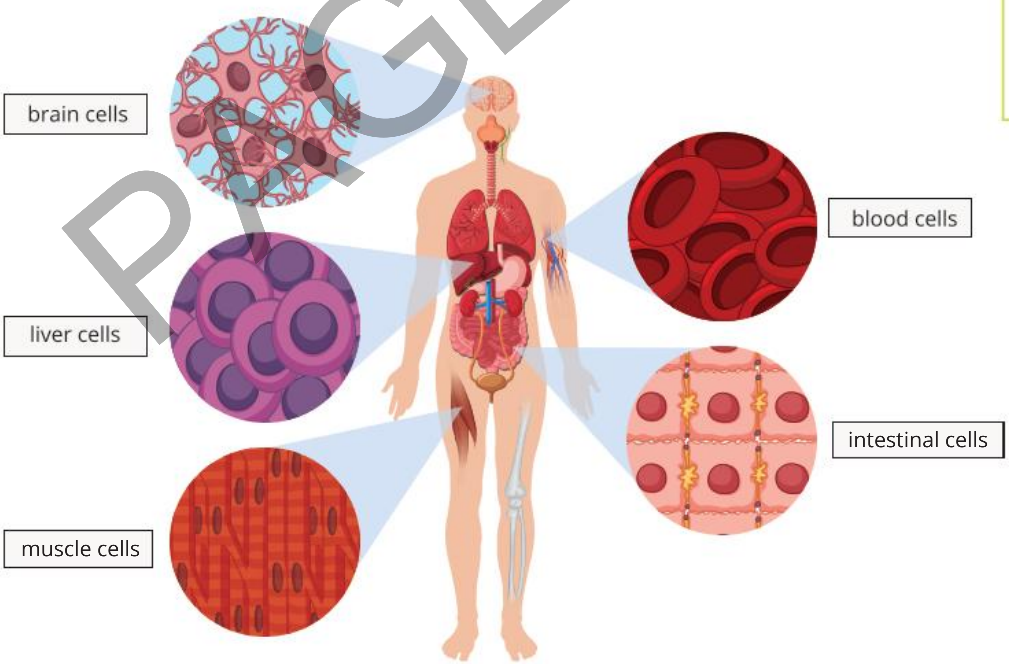
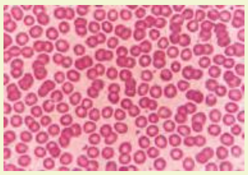


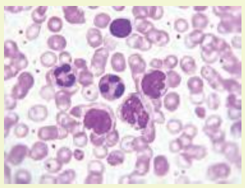
FIGURE 1.2.1 A human has many different types of cells that have different features and functions

TABLE 1.2.1 Examples of specialised cells in the body viewed under a microscope

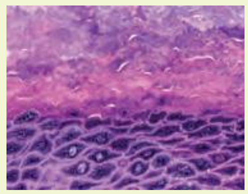
Red blood cells are small flexible cells that transport oxygen around the body.



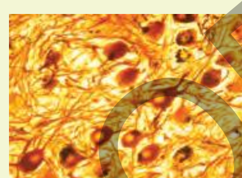
White blood cells stop foreign organisms such as bacteria and viruses from causing infections in the body. The picture below shows six white blood cells (larger cells) amongst red blood cells.



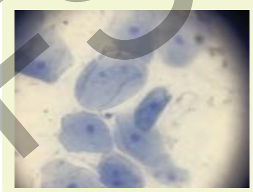
Skin cells create a tight barrier against microorganisms and environmental factors such as bacteria, viruses, UV light, heat and cold. The picture below shows the cross-section of skin cells (stained purple).



Nerve cells have long extensions to relay information and send commands to other cells, muscles and organs.



Cheek cells produce mucous to help to start the digestion process and protect from bacterial infection. The picture below shows the stained cheek cells.



When cells do not function properly

Many common diseases are caused by lack of healthy cells that can carry out their functions properly. Table 1.2.2 summarises some medical conditions related to poor cell health. Some of these diseases are potentially fatal (cause death).

TABLE 1.2.2 Some common cell health issues and the diseases they can cause

Cell health issue	Disease	Effects
lack of healthy red blood cells	anaemia	fatigue, pale skin, shortness of breath
body's immune system cannot tell the difference between the cells of the body and foreign cells	autoimmune diseases	many different types of disease, including arthritis that causes joint pain
cells that reproduce uncontrollably	cancer	range of cancers depending on part of body and cells affected
low white blood cell count	leukopenia	a range of infections, including tuberculosis and HIV

SC 1 CHECK YOUR UNDERSTANDING

Specialised cells can carry out specific functions. List two types of specialised cells and explain their function in the body.

SC 2 I can compare the scale of different types of cells in humans

Size of cells in the human body

The human eye can only see objects that are bigger than approximately 0.1 mm without any magnification. To see objects that are smaller than this, you will need a magnifying instrument such as a microscope. Objects that can be seen without microscopes can be described as **macroscopic**. Objects that can only be seen using a microscope are described as **microscopic**.

Because cells are so small, their size is measured using a unit called a **micrometre** (μm). A micrometre is one-thousandth of a millimetre. A comparison of units of length is shown in Table 1.2.3.

TABLE 1.2.3 Micrometres compared to larger units

Unit	Number of micrometres (μm)
1 metre (m)	1 000 000
1 centimetre (cm)	10 000
1 millimetre (mm)	1000

Most human cells are between 8 and 60 μm, but some cells in the body are a lot longer than this, depending on their function.

Human cells are a lot bigger than most bacteria, which are between 0.1 and 1.5 μm. Table 1.2.4 gives the sizes of some cells in the human body, and Figure 1.2.2 compares the sizes of some human cells with some other organisms.

TABLE 1.2.4 Approximate sizes of cells in the human body

Type of cell	Approximate size of cells
red blood cells	5–8 μm
white blood cells	6–14 μm
egg	100 μm
cheek cells	50–100 μm
sperm	length 4.5 μm, width 2.8 μm
cardiac muscle cells (in the heart)	length 100 μm, width 20 μm
skeletal muscle cells (connected to bones)	length up to 5 cm, width 100 μm
nerve cells	length 100 μm up to 1 m

KEY TERMS

macroscopic able to be seen without the help of a microscope

microscopic describes objects that can be seen only by using a microscope

micrometre one-thousandth of a millimetre, or one-millionth of a metre; the standard unit for micrometre is μm

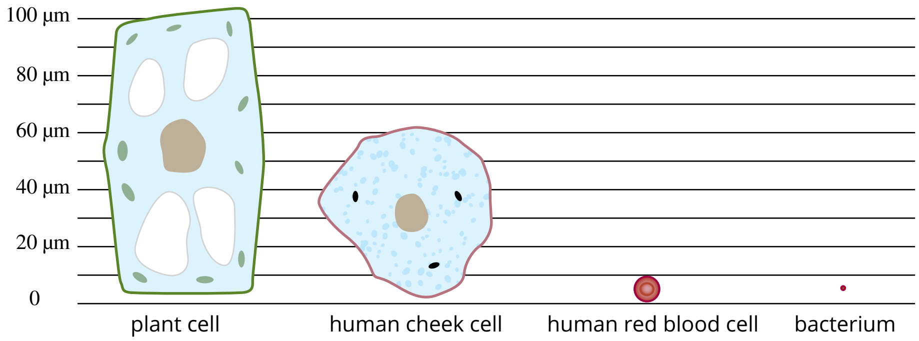


FIGURE 1.2.2 The relative sizes of some human cells (cheek and red blood cell) compared to a plant cell (larger) and a bacterium (smaller)

SCIENCE IN SOCIETY

The evolution of microscopes

Dutch spectacle maker Zacharias Janssen is credited with creating one of the first simple microscopes in the 1600s. However, it was Antonie van Leeuwenhoek in the 1660s who first examined plant and animal cells, leading to new insights into their structure.

In the years that followed, microscopes became increasingly sophisticated, enabling scientists to observe even the smallest cells and uncover their internal components.

GO TO
SkillBuilder: Converting between micrometres, millimetres and centimetres in your Skills Toolkit, page XX.

SC 2 CHECK YOUR UNDERSTANDING

Micrometres are very small, and some objects are invisible to the naked eye.

a What must be used to view objects that are less than 100 µm in size?

b State the term used for objects that are larger than 1000 µm in size.

SC 3 I can describe some features that are common to most types of cells

Although humans are made up of many different types of cells, most human cells have the same features and organelles (specialised structures).

- Cell membrane: the 'skin' around the cell that holds the cell together and controls what goes in and out of the cell.
- **Ribosome**: an organelle that makes proteins that are used by the cell for growth and repair.
- **Nucleus**: the organelle that contains the genetic instructions (DNA) for the cell's functions.
- Mitochondrion: the organelle where most of the energy needed to power the cell's chemical reactions is generated by a process called cellular respiration.
- Cytoplasm: a jelly-like fluid where all cell components, except the nucleus, are found.

You can see these features of a cell in Figure 1.2.3.

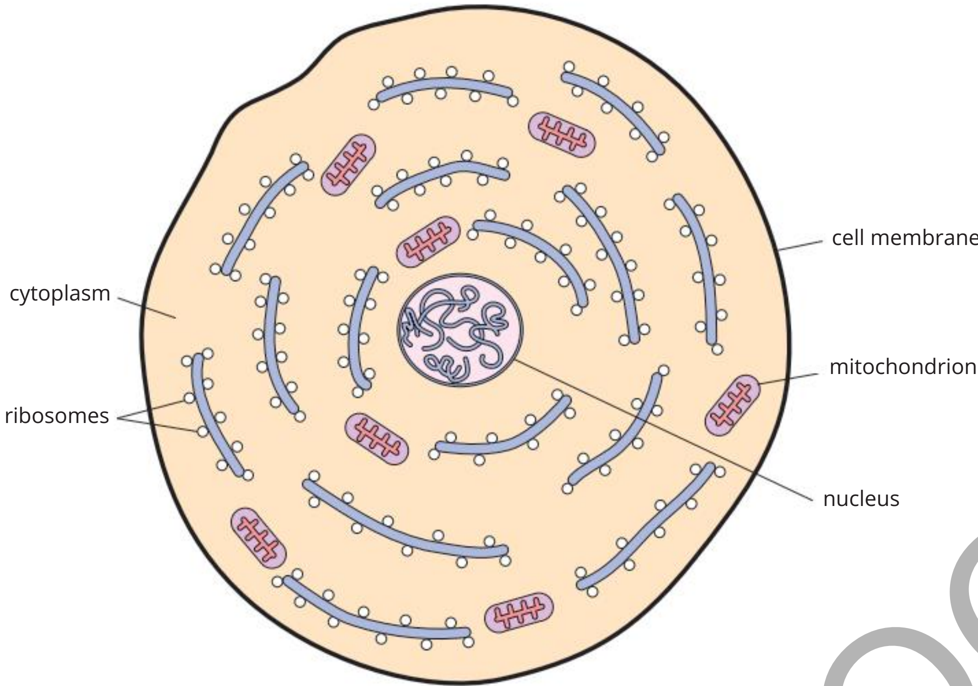


FIGURE 1.2.3 Cross-section diagram showing the basic features of a typical animal cell

SC 3 CHECK YOUR UNDERSTANDING

The nucleus is often described as the 'control centre' of the cell. Explain why people might refer to it as this.

Scifile

Hidden complexity

Since the invention of the microscope, scientists have continuously uncovered new and intricate features within cells. Early microscopes revealed only the basic outline of a cell, but modern electron microscopes now provide detailed views of internal structures, including those within mitochondria.

Recent research suggests that cells contain more than 30 distinct organelles, known as biomolecular condensates, each with specialised functions. Ongoing studies will further clarify their roles, deepening the understanding of cellular complexity.

Lesson review

Use these questions to check whether you have met the learning intention for this lesson.

1 All cells contain common features. List the features that are common to most types of cells in your body.

2 Different cells have different functions. Name the type of cell that is responsible for:

a transporting oxygen around the body

b sending messages around the body that allow it to move

c protecting the body against infection.

3 Explain what the cell membrane is useful for.

4 Muscle cells contain many mitochondria, a lot more than some other types of cells. How would this be useful to the body?

5 List the following measurements in order from smallest to largest:

1.8 cm, 25 mm, 30 000 µm, 1 cm, 80 mm, 20 µm

6 A student examined eight cells lined up in a row under a microscope. The total length was 480 µm. State the type of cell would this most likely be and explain your choice.

1.3 The development of microscopes

Learning intention

To understand how the development of technologies has led to improved understanding of cells

Success criteria

SC 1: I can outline the key developments in microscope technology from the first microscope to present day.

SC 2: I can outline the key discoveries about cells from Hooke's first description of cells to present day.

SC 3: I can describe how specific improvements in microscope technologies lead to new discoveries about the structure and function of cells.

KEY TERM

lens a piece of glass or other transparent material with curved sides used in optical equipment test

Lesson overview

Zacharias Janssen (Figure 1.3.1), the son of a Dutch spectacle maker, is believed to have invented the first microscope around 1590 by placing two lenses inside a tube. This marked the creation of the world's first true microscope, opening the door to the discovery of previously unseen microscopic life.

FIGURE 1.3.1 Zacharias Janssen and his father in 1870

Since then, scientists have continually improved microscope designs. In modern times, the use of electron beams has allowed for imaging of structures even smaller than what visible light can reveal. Today's electron microscopes can magnify objects up to 1 million times their actual size, providing unprecedented detail.

Advancements in microscope technology have enabled scientists to explore cells with greater clarity and depth, leading to groundbreaking discoveries about their structure and function.

SC 1	I can outline the key developments in microscope technology from the first microscope to present day

The discovery of cells

In 1665, English scientist Robert Hooke used a microscope with a simple **lens**—like the one shown in Figure 1.3.2—to investigate cork. He saw that the thin slices of cork (Figure 1.3.3) resembled honeycomb because of the little boxes, or cells, they were made up of. You can see them in his drawing. Hooke had discovered the building blocks of life: cells.

FIGURE 1.3.2 Robert Hooke's microscope

FIGURE 1.3.3 Hooke's drawing of cork cells; these are dead plant cells with only the cell walls remaining

Microscope development

The timeline in Figure 1.3.4 outlines the key developments in microscope technology and the scientists who were involved in these developments.

1609 — Galileo Galilei

Galileo Galilei developed a compound microscope with a **convex lens** and a concave lens that gave a magnification of up to 30 times. The word 'microscope' was first used around 15 years later.

1676 — Antonie van Leeuwenhoek

Antonie van Leeuwenhoek developed a different type of microscope that had only one lens but used improved lens technology. This microscope had a magnification of 270 times, which allowed him to see living cells in unicellular organisms, including bacteria.

1830 — Joseph Jackson Lister

Joseph Jackson Lister combined lenses in a way that produced sharper, more focused images. This allowed him to discover the true structure of red blood cells.

1931 — Ernst Ruska and Max Knoll

Ernst Ruska and Max Knoll built the first transmission electron microscope (TEM). TEMs pass a beam of electrons through the specimen, creating highly detailed cross-sectional images.

1942 — Dennis McMullan and C.W. Oakley

Dennis McMullan and C.W. Oakley developed the first scanning electron microscope (SEM). Using a SEM, it is possible to obtain incredibly detailed images of the surface of objects, as well as 3D images that can reveal the structures of organisms and cells.

FIGURE 1.3.4 Key developments in microscope technology from the first microscope to present day

SC 1 CHECK YOUR UNDERSTANDING

Describe the first type of microscopes that were used to magnify objects.

SC 2 I can outline the key discoveries about cells from Hooke's first description of cells to present day

This timeline (Figure 1.3.5) is a summary of the key discoveries about cells from Hooke's first description of cells to the present day.

The timeline is a summary, and in many cases other scientists were involved in the various discoveries. The discovery dates are also approximate, because when a scientific discovery is made, it needs to be accepted by a wider scientific community before being accepted. This process could take an especially long time in the nineteenth century when communication between scientists was more difficult than it is today. Even now, with today's communication technologies and global networks of scientists, it takes time to have a scientific discovery accepted.

KEY TERM

convex lens a lens that has at least one surface curving outward

1665, England	**Cells and cell walls**	Robert Hooke observes cells and cell walls. He uses the word 'cell' to describe microscopic honeycomb cavities in cork.
1670s, The Netherlands	**Single celled organisms**	Antonie van Leeuwenhoek observes single-celled organisms, such as protozoa, whilst using a microscope to examine pond water.
1833, Scotland, England	**Nucleus**	Robert Brown becomes the first person to name and describe the cell nucleus in detail.
1855, Switzerland and Germany	**Cell membrane**	Carl von Naegeli and Karl Cramer discover the cell membrane.
1863, Switzerland	**Cytoplasm**	Rudolf Albert von Kolliker gives the name 'cytoplasm' to all the material within a cell.
1890, Germany	**Mitochondria**	Richard Altmann describes mitochondria as elementary living units.
1952, Romania and the United States	**Mitochondria (finer detail)**	George Palade publishes a study on the fine structure of mitochondria.
1955, Romania and the United States	**Ribosome**	George Palade discovers ribosomes using an electron microscope.

FIGURE 1.3.5 Timeline of key discoveries about cells

SC 2 CHECK YOUR UNDERSTANDING

Describe the types of cells that Antonie van Leeuwenhoek observed in pond water.

SC 3 I can describe how specific improvements in microscope technologies lead to new discoveries about the structure and function of cells

Light microscope

Light microscopes (sometimes called optical microscopes) use a combination of lenses to produce a magnified image of a specimen (the object being observed).

Compound microscope

Microscopes that have more than one lens are called compound microscopes. The specimen is lit from below using a lamp or a mirror, so the specimen must be very thin to allow the light to pass through to the observer, as shown in Figure 1.3.6.

Stereo microscope

A **stereo microscope** has two eyepieces and two objective lenses. This means the image is viewed through two combinations of lenses that focus on the same point but from different angles, which produces a three-dimensional image. The specimen in a stereo microscope is lit from above (or the side). Because light does not have to pass through the specimen, the specimen can be almost anything, unlike for a light microscope. Stereo microscopes are used to examine and dissect animal and plant specimens, as shown in Figure 1.3.7.

FIGURE 1.3.6 A monocular light microscope

FIGURE 1.3.7 A researcher using a stereo microscope to help dissect a plant

Electron microscope

Electron microscopes use beams of tiny particles called electrons to create an image of the specimen. They can magnify up to a million times. Electron microscopes produce black-and-white images, but these are often coloured later to highlight important features. There are many types of electron microscopes, including transmission electron microscopes (TEMs), like the one in Figure 1.3.8.

Transmission electron microscope (TEM)

In TEMs, electrons pass through the specimen, so the specimen needs to be sliced into incredibly thin sections. TEMs make it possible to view the structures of cells. Figure 1.3.9 shows some structures inside a cell. The colours have been added to help each part stand out.

FIGURE 1.3.8 A transmission electron microscope (TEM) and the technology required to view the images

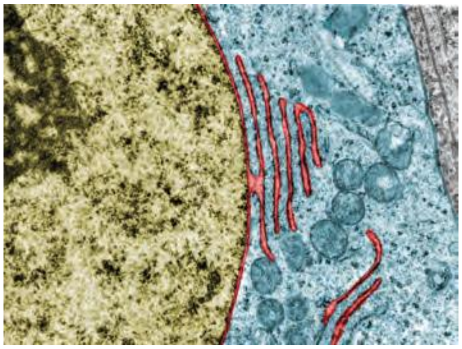


FIGURE 1.3.9 TEM micrograph showing the boundary between the nucleus on the left (coloured gold) and the cytoplasm (coloured blue)

FIGURE 1.3.10 SEM micrograph showing unicellular rod-shaped E. coli bacteria (in blue)

Scanning electron microscope (SEM)

In SEMs, the image is formed by electrons reflecting off the surface of the specimen. SEMs are used to provide three-dimensional images like the one in Figure 1.3.10.

Scanning tunnelling microscope (STM)

Scanning tunnelling microscopes (STMs) were first used in the 1980s and are incredibly powerful. They can create images of individual atoms and molecules. STMs are used for investigating non-living materials such as the surface of metals and crystals.

Photomicrography

Photomicrography involves taking a photograph through a microscope to capture the image of the specimen. Photomicrography can be used in both optical and electron microscopes and is used in a range of fields of science including medicine, geology, forensics and cell biology. It is also an artform that can be used to engage people in the microscopic world. The term **micrograph** is commonly used to describe these pictures taken.

KEY TERM

micrograph photograph of an image from a microscope

SC 3 CHECK YOUR UNDERSTANDING

Describe what type of image is observed with a stereo microscope.

Lesson review

Use these questions to check whether you have met the learning intention for this lesson.

1 State the name given to a photograph that is produced from an object observed under a microscope.

2 Name the microscope that can be used to see fine structures found within the mitochondria.

3 Name the microscope that would be most appropriate to use in a classroom for viewing cells found in pond water. Explain your choice.

4 Describe how photomicrography would be useful to scientists conducting research.

5 If Galileo Galilei used his microscope to examine some 0.1 mm long plant cells, how big would they appear?

1.4 Using a microscope

Introduction

Microscopes have been essential in the discovery of cells, the development of cell theory, and the advancement of cellular biology. While there are many types of microscopes, they all serve the same fundamental purpose: allowing scientists to observe details beyond the limits of the naked eye.

Even the simple microscopes used in school laboratories provide valuable insights, such as revealing cell structures that would otherwise remain unseen.

In this practical investigation, you will learn how to use a light microscope and how to calculate the magnification of a microscope when viewing specimens.

Background

The type of microscope used in schools and many science laboratories is a light microscope. You will probably use a microscope like the one shown here. A light microscope with one **eyepiece** (or ocular lens) is called a monocular microscope, and one with two eyepieces is called a binocular microscope. The parts of a light microscope can be seen in Figure 1.4.1.

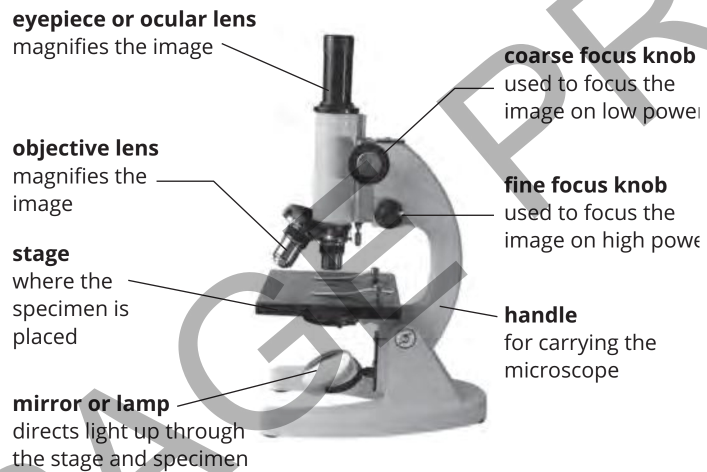


FIGURE 1.4.1 The key parts of a compound microscope and their functions

Microscope magnification

The light microscope uses light and a system of lenses to magnify the image. One lens is called the eyepiece (or ocular lens). This is the lens closest to your eye. The other lens is the **objective lens**. It is closer to the specimen. Microscopes that have two lenses are called compound microscopes.

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 **field of view** refers to how much of a specimen is visible when looking through a microscope. As magnification increases, a smaller portion of the specimen is seen, reducing the overall field of view. This means that zooming in on a specific area provides more detail but reveals less of the whole object.

Learning intention

To be able to use a microscope to generate data and information

Success criteria

SC 1: I can identify key parts of a light microscope and describe their functions.

SC 2: I can calculate the total magnification of a light microscope.

SC 3: I can safely use a microscope to observe and record observations of specimens at a range of magnifications.

KEY TERMS

eyepiece the lens, or combination of lenses, at the viewing end of a microscope or telescope
objective lens the lens in a microscope or telescope that is nearest to the object being viewed
magnification the ratio of the size of an image compared to the size of the object
field of view the amount of the specimen seen through a microscope

The maximum magnification of a light compound microscope is about 1000 times bigger than the specimen when seen with the naked eye. At this magnification, some of the largest bacteria are just visible. The maximum magnification of stereo microscopes is about 100×.

SkillBuilder

Calculating the magnification of a microscope

Most microscopes used in school have two lenses: the eyepiece (or ocular lens) and the objective lens. Both lenses magnify the specimen. The total magnification of the microscope is the combined effect of the two lenses.

To calculate the total magnification, you multiply the magnification of the eyepiece by the magnification of the objective lens.

total magnification = eyepiece magnification × objective lens magnification

Important information

The eyepiece and the objective lenses are labelled with their magnification.

The eyepiece magnification on a microscope is fixed, but there are different objective lenses that range from 4× to 100× that can be changed by rotating the nose piece.

Example

Stephanie was using a microscope with an eyepiece with a magnification of 10×, and an objective lens of 4× was in place. To calculate the total magnification, she multiplied the magnification of the eyepiece by the magnification of the objective lens.

total magnification = eyepiece magnification × objective lens magnification

total magnification = $10 \times 4 = 40$

The correct way to write the magnification is with a multiplication symbol after the number, so Stephanie's microscope had a magnification of 40×.

Aim

To become familiar with the workings of a microscope by observing common objects at various magnifications

Materials

- small samples suitable for viewing under a microscope, such as sugar crystal (both plain and caster), salt, copper sulfate crystal, strand of hair, clothing fibres, small section of a leaf, writing sample, small newsprint
- light microscope
- microscope lamp (if the microscope does not have an inbuilt light source)
- glass microscope slides
- tweezers

SAFETY NOTE

- Ensure that you follow the correct way to focus the microscope so that you do not damage the specimen or the objective lens.

Assessment of risk

Ensure you are aware of the risks of this practical investigation and have considered how safety can be improved before carrying out this activity.

Method

1. Place the sample carefully in the middle of a microscope slide. Place the microscope slide on the stage, holding it in position using the clips.
2. Adjust the mirror and/or light source 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 without touching.
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. If you miss the point of focus, go back to step 4 and start again.
8. Use this procedure to observe each specimen using the microscope.

Results

Draw a table in your notebook, like the one below. In the table, sketch a diagram of your observations for each specimen. Record the magnification used to obtain the clearest image of the object and describe any observations that would not have been possible without the microscope.

Specimen		**Sketch**
Magnification		
Microscopic observations		

Evaluation

1. List three parts of the light microscope and briefly explain their function.
2. Outline how the magnification of a lens affects the field of view in a light microscope.
3. Explain why it is important to know the total magnification when using a microscope.
4. What is multiplied when calculating the magnification of a specimen viewed under a light microscope?
5. Compare the total magnification when using a 10× eyepiece with a 4× objective lens versus a 40× objective lens.
6. Outline how you would record your observations when viewing a specimen under different magnifications.

1.5 The functions of the nucleus in cells

Learning intention

To understand the key role of the nucleus in the function of cells

Success criteria

SC 1: I can identify the nucleus from a visual representation of a cell.

SC 2: I can explain the function of the nucleus of a cell.

FIGURE 1.5.1 An illustration of an animal cell; the nucleus is shown in pink

KEY TERMS

eukaryotic cell a cell that contains a nucleus
nucleolus organelle within a cell nucleus that produces ribosomes
prokaryotic cell a cell that does not have a nucleus
cytoplasm everything contained within a cell membrane except the nucleus

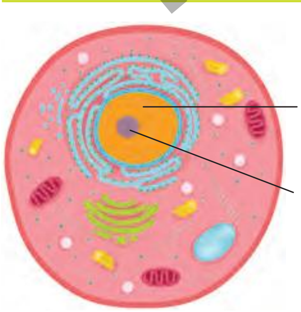


FIGURE 1.5.3 A diagram of an animal cell containing a nucleus

Lesson overview

The nucleus of a cell can be described as the information centre for the cell. The nucleus contains all the genetic information required for that cell, and almost every other cell in the organism contains this same genetic information. This genetic information is vital for the survival of the cell and the organism that the cell belongs to.

Figure 1.5.1 shows the nucleus (pink) of an animal cell surrounded by the other components of the cell.

In this lesson you will learn how to identify the nucleus of a cell and what its key functions are.

SC 1 I can identify the nucleus from a visual representation of a cell

The first organelle to be identified within a cell was the nucleus. Both plant and animal cells contain a nucleus, like the ones in Figure 1.5.2 where the nuclei (the plural of nucleus) look like dots in the middle of the cells.

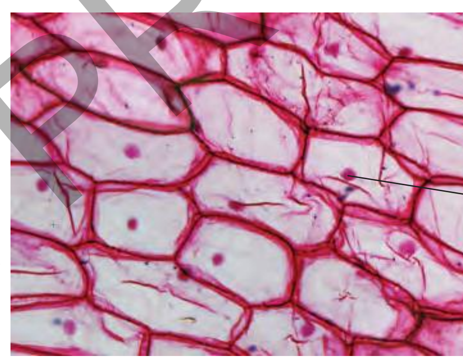


FIGURE 1.5.2 Stained cells showing the nucleus in the central location

Cells that contain a nucleus are called **eukaryotic cells** (Figure 1.5.3).

The nucleus is normally drawn as a circular or oval shape in the centre of a cell diagram. Sometimes a smaller circle can be seen within the nucleus. This structure is called the **nucleolus**.

Ribosomes, which are involved in the production of proteins, are produced in the nucleolus of eukaryotic cells.

Some cells in unicellular organisms, such as bacteria, do not a contain a nucleus. These are called **prokaryotic cells**. However, they still contain DNA, which is spread out in the **cytoplasm** of the cell.

SC 1 CHECK YOUR UNDERSTANDING

Describe the location of the nucleus in a eukaryotic cell.

SC 2 I can explain the function of the nucleus of a cell

The nucleus can be considered the control centre of the cell. It is called this because it contains DNA, which provides the instructions for the cell, including for the chemical reactions in the cell, how the cell develops and how it reproduces.

Every nucleus in every cell of an organism, whatever the function of the cell, contains the same DNA. The nucleus is surrounded by a membrane that protects the nucleus and the DNA inside it. The DNA of animal and plant cells is so long that it needs to be tightly packaged into chromosomes so that it fits inside the nucleus (Figure 1.5.4). DNA is made up of small sections called genes.

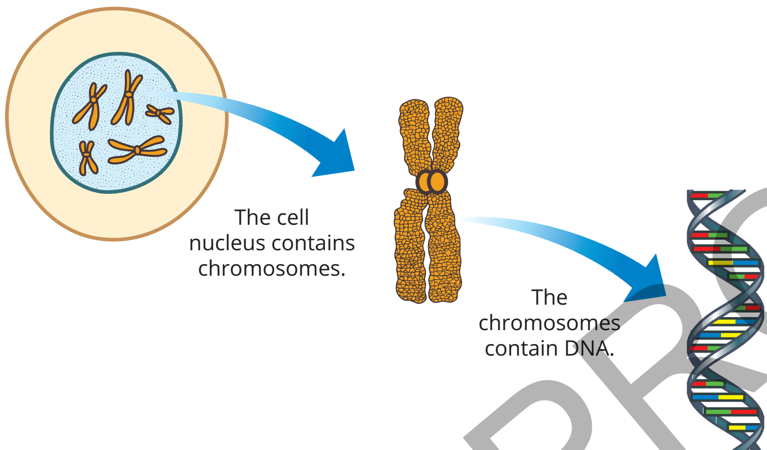


FIGURE 1.5.4 The nucleus of the cell contains chromosomes, which contain tightly packed DNA

Not all cells have a nucleus

Not all cells have a nucleus. For example, the DNA of bacteria is not packaged in a nucleus – it floats freely in the cell.

Another example is red blood cells, which carry oxygen around the body. Not having a nucleus allows red blood cells to carry more oxygen. They start off with a nucleus but lose it as they mature. This means that red blood cells cannot grow or reproduce; they survive for only 100–120 days.

SC 2 CHECK YOUR UNDERSTANDING

Outline the main function of the nucleus.

Scifile

DNA storage

Inside the nucleus, DNA is neatly packaged into structures called chromosomes. If you stretched out all the DNA in a single human cell, it would be about 2 m long!

Lesson review

Use these questions to check whether you have met the learning intention for this lesson.

1 Describe what the nucleus looks like in a typical cell diagram.

2 List the key cell functions that the nucleus controls.

3 Explain the key difference between how DNA is stored in eukaryotic cells and prokaryotic cells.

4 Explain the benefit of red blood cells lacking a nucleus.

1.6 Observing cells

Learning intention

To be able to use a microscope to observe and record images of plant cells

Success criteria

SC 1: I can use a microscope at a range of magnifications to observe and record features of plant cells.

SC 2: I can use microscopic observations to describe and compare plant cells.

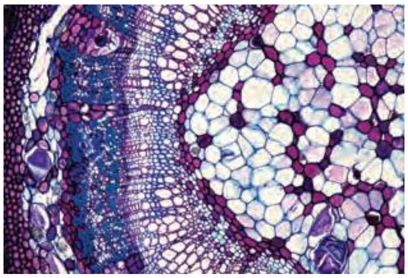


FIGURE 1.6.1 This light microscope image of a cross-section of a plant stem shows different types of cells

SAFETY NOTE

- Iodine is harmful and also causes stains. Wear safety glasses and avoid contact with skin and clothes.

HINT

Check in with your teacher to make sure you have correctly prepared your slides and set up the microscope. You can also use Figure 1.4.1 to help you remember the names of the parts and their functions.

Introduction

Light microscopes continue to be used by scientists to study cells and their components, such as the image in Figure 1.6.1. Magnifications of up to 400 times can easily be obtained with a light microscope, and this is often enough to reveal not just the shape of cells but their internal structures as well.

In this practical investigation, you will use your microscopy skills to examine a range of cells and organisms.

Background

Earlier in the topic you should have learned how to use a light microscope. In this lesson, you will be using a microscope to observe some plant cells from onions and rhubarb. If you are careful, you should be able to observe and draw some basic parts of the cells.

Aim

To test your microscopy skills and observe and compare plant cells

Materials

- slices of onion and rhubarb leaf stalk
- a few drops of iodine
- a few drops of water
- microscope and lamp
- filter paper
- 2 microscope slides and cover slips
- eye-dropper and forceps
- safety glasses

Assessment of risk

Ensure you are aware of the risks of this practical investigation and have considered how safety can be improved before carrying out this activity.

Method

1 Carefully peel a thin (one-cell thick) layer of onion skin from an onion.

2 Use tweezers to place a small sample of the onion skin onto a glass microscope slide. Make sure the skin is lying flat, rather than folded.

3 Place a drop of water and a drop of iodine on the onion skin sample and carefully cover with a cover slip. The iodine stains the cells and makes them easier to see.
See Hint.

4 Use the microscope to observe the cells at two different magnifications.

5 Carefully peel a thin layer of skin from the outside of the rhubarb leaf stalk. Repeat the procedure that you used for preparing the onion skin sample, but do not use the iodine stain.

SkillBuilder

Increasing magnification

When you want to change the magnification of a microscope from a lower magnification to a higher magnification, follow these steps.

1. Make sure that the specimen, or the part of the specimen that you want to look at, is in the centre of the field of view.
2. Focus the specimen on low power.
3. Without moving anything else, carefully turn the objective lenses around so that the one with the higher magnification is above the slide.
4. Look through the eyepiece. If the specimen is not in focus, use the (fine) focus to sharpen the image.

Example

Pari focused in on a sliver of onion using the 4× objective lens. Combined with a standard 10× eyepiece lens this gave a total magnification of 40×. She then turned the objective lens so that the 10× lens was above the specimen. Using the fine focus knob, she was able to obtain a sharply focused image with a magnification of 100×.

An important skill when using a microscope is to be able to represent what is observed through the microscope.

SkillBuilder

Drawing from the microscope

Scientific drawings of cells

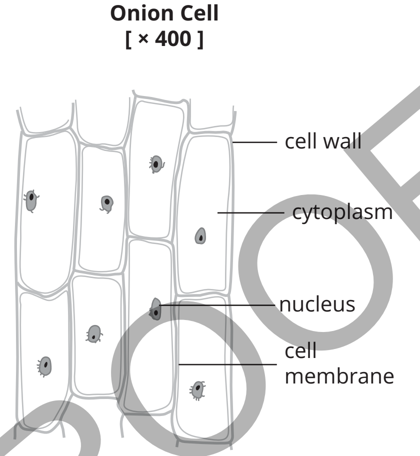
Scientific drawings and diagrams are an important way to record and communicate information, such as your observations of cells when looking through a microscope. When drawing specimens, you should:

- use white, unlined paper
- draw in lead pencil only
- draw simple and clear lines
- make your drawing large enough to see detail (10 cm × 10 cm) if possible
- draw two-dimensional shapes (not in 3D)
- use small dots (called stippling) rather than shading to show depth
- draw one or a few cells to represent the whole sample; there is no need to draw every cell in the field of view
- draw only what you can see, not what you think you should see (e.g. organelles that are too small to see through a light microscope)

- write clear labels for the features you want to highlight; place labels on either side of the drawing
- rule a straight line between each label and its feature; make sure the label lines do not cross over each other
- write the name of the specimen and the magnification at which it was observed above the drawing.

Example

Lucas observed onion cells through a microscope and created the following scientific drawing.



HINT

To calculate total magnification, multiply the magnification of the eyepiece (ocular lens) by the magnification of the objective lens.

Results

In your notebook, draw a few cells at the higher magnification. On your diagram, record the type of cell you have drawn and the magnification used.

Conclusion

Write your conclusion to the experiment by answering the following questions in your notebook.

1. List the parts of the cell you were able to see clearly in the onion skin cell and in the rhubarb skin cell.
2. Explain why there may be parts of the cell that you were not able to observe.
3. Compare and contrast the appearance of the onion cells and rhubarb cells.
4. Propose a reason why iodine was used to stain the onion cells but not the rhubarb cells.

1.7 The roles of the cell wall and cell membrane

Lesson overview

Imagine collecting the shopping in a paper bag. The bag helps keep everything together. Without it the shopping will just fall out onto the floor. A cell membrane is a bit like a paper shopping bag. It keeps things together, but there are some things, like water, that can pass through the bag from the inside out, or from the outside in.

If you wanted to stack a lot of shopping, it might be better to put the bags inside a cardboard box. The box provides strength, and it is much easier to stack boxes on top of each other than it is to stack bags. The box is a bit like a cell wall. It gives the cell a fixed shape and protects the materials inside the cell, including the membrane.

In this lesson, you will learn about the functions of the cell membrane and the cell wall. You will also discover why plants cells need cell walls but animal cells do not.

Learning intention

To understand the roles of the cell wall and cell membrane in the function of cells

Success criteria

SC 1: I can identify the cell membrane and cell wall of a cell from a photomicrograph, model or other visual representation.

SC 2: I can describe the functions of cell membranes and cell walls.

SC 3: I can compare the functions of cell membranes and cell walls.

SC 1	I can identify the cell membrane and cell wall of a cell from a photomicrograph, model or other visual representation

Cells in animals

Cells in animals do not have a **cell wall**. This allows the cell to be flexible. Think of red blood cells, which need to squeeze through different places in the body to deliver oxygen. Many animals that need to have support will have some form of skeleton or shell that can provide that structure. The **cell membrane** can be seen in diagrams (Figure 1.7.1) and micrographs (Figure 1.7.2) as the edge or border of the cell.

FIGURE 1.7.1 A representation of a typical animal cell

KEY TERMS

cell wall a rigid layer on the outside of a plant cell or prokaryotic cell; provides the skeleton of a plant

cell membrane thin layer that separates the cell from its surroundings and controls what can move in and out of the cell

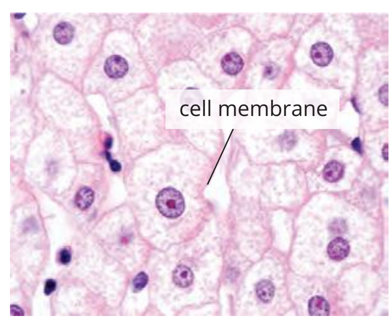


FIGURE 1.7.2 A micrograph showing stained human liver cells; the cell membrane is the structure surrounding each cell

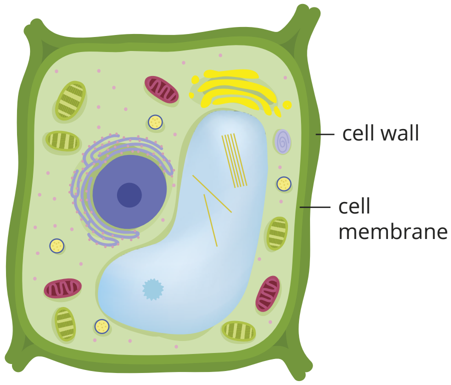


FIGURE 1.7.3 A diagram showing the cell wall and cell membrane of a plant cell

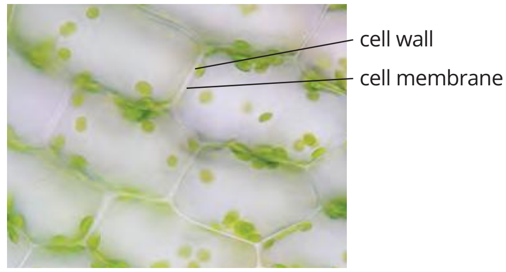


FIGURE 1.7.4 A micrograph of leaf cells under a light microscope; the cell wall is the thicker structure surrounding the cell, and the cell membrane is inside the cell wall

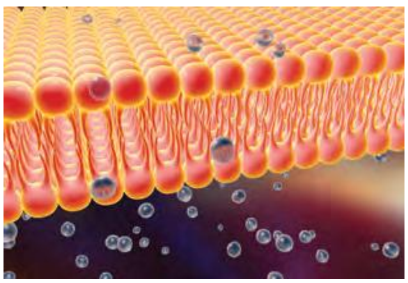


FIGURE 1.7.5 A close-up cross-section of a cell membrane; some substances are moving into and out of the cell through the cell membrane

KEY TERMS

semi-permeable membrane a thin layer of material that only certain particles can pass through

osmosis process by which particles of water pass through a semi-permeable membrane from a less concentrated solution into a more concentrated one

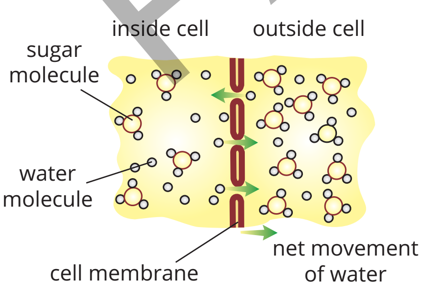


FIGURE 1.7.6 Representation of osmosis; the smaller water molecules can pass through the membrane, while the larger sugar molecules cannot

Cells in plants

Plant cells have a cell wall and a cell membrane. In plant cells, it can be difficult to see the cell membrane as separate from the cell wall. The cell wall is the thicker structure surrounding the plant cell, and the cell membrane is inside the cell wall, as shown in the diagram (Figure 1.7.3) and photo (Figure 1.7.4).

SC 1 CHECK YOUR UNDERSTANDING

Describe the position of the cell wall and cell membrane in a plant cell.

SC 2 I can describe the functions of cell membranes and cell walls

Cell membrane

Every cell is enclosed by a 'skin' that keeps it separate from the environment around it. This is the cell membrane (Figure 1.7.5). The cell membrane holds the cell together and controls what comes into and goes out of the cell. It is a **semi-permeable membrane** because only some substances can pass through the membrane, and some cannot.

Controlling what moves into and out of a cell

The cell membrane controls what can go in and out of the cell, which is why it is also known as a semi-permeable membrane. It acts like a fence surrounding a block of land with gate doors that allow only some things to move in or out. In the diagram you can see water molecules are able to pass in and out of the cell, but glucose molecules cannot. The movement of water molecules in and out of the cell is known as **osmosis** (Figure 1.7.6).

Cell wall

All cells have a cell membrane, but plant cells and fungal cells also have a cell wall that surrounds the cell membrane. The cell wall helps support the plant or fungus and gives it shape (Figure 1.7.7).

Plants and fungi need this extra support to protect them from external environmental exposure or physical damage. This rigid (or stiff) structure means that the cells are not very flexible and cannot easily change shape.

Cell walls need to be semi-permeable to allow for transport of substances, but they do not control what goes in and out of the cell in the way that cell membranes do.

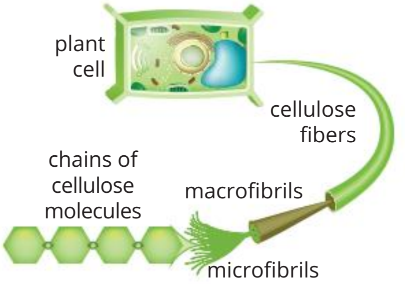


FIGURE 1.7.7 Plant cell walls have a more rigid structure and are made up of a sugar molecule known as cellulose

SC 2 CHECK YOUR UNDERSTANDING

Define the term semi-permeable membrane.

SC 3 I can compare the functions of cell membranes and cell walls

Cell membranes

Cell membranes are extremely thin. Even when viewed through a microscope, unless a stain is used, they are often impossible to see. They are semi-permeable, which means they have spaces in them that allow some particles (molecules) to pass through. In this way, they can be thought of as filters. However, they also contain pathways that act as gatekeepers, controlling which substances can pass into and out of the cell.

Cell walls

Cell walls in plants are mostly made of cellulose. It can be very strong, especially when combined with other materials. It is not surprising then that cell walls provide strength and shape for the cell.

SC 3 CHECK YOUR UNDERSTANDING

Explain the difference between how the cell membrane and the cell wall let substances in and out of the cell.

Lesson review

Use these questions to check whether you have met the learning intention for this lesson.

1. Describe the purpose of the cell wall in plant cells.
2. Name the term used to describe the movement of water in and out of the cell.
3. Explain the differences in appearance and location between the cell membrane and the cell wall.
4. Outline how the cell membrane and cell wall work together in plant cells.
5. If a cell contained a large amount (high concentration) of water and was put into a beaker of sugary water solution, is water more likely to move in or move out of the cell membrane? Explain your answer.

1.8 Investigating the action of a cell membrane

Learning intention

To be able to investigate the action of a cell membrane

Success criteria

SC 1: I can develop a prediction around the movement of water through a membrane.

SC 2: I can measure and record masses and volumes with a high level of precision.

SC 3: I can use knowledge of cell membranes to explain experimental results.

Introduction

Cell membranes are a vital part of all plant and animal cells. They control what goes in, what stays in and what leaves the cell. The cell membrane can be thought of as the 'skin' of the cell.

The process of water moving into and out of a cell is called osmosis (Figure 1.8.1). Chemicals dissolved in water (e.g. salt) affect how the water passes into and out of the cell. This process is vital for the balance of chemicals inside the cell.

In this practical investigation, you will investigate how adding salt to water affects the flow of water into and out of a cell through a membrane.

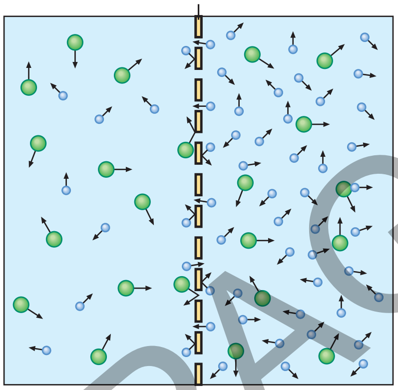


FIGURE 1.8.1 Particles involved in osmosis through a membrane

Background

Hens' eggs contain only one cell. This cell is surrounded by the yellow yolk of the egg, which is a collection of nutrients, including fat, proteins and carbohydrates. The egg white is 90% water, with proteins and other chemicals dissolved in the water.

When you break an egg, you can sometimes see a very thin skin just under the shell (Figure 1.8.2). This is not a cell membrane; it is the membrane of the egg. Nevertheless, an egg's membrane behaves in a similar way to a cell membrane. In this experiment, these similarities are taken advantage of to investigate the action of a cell membrane using an egg.

Osmosis

Membranes like the one that surrounds an egg allow only very small particles, like water, to pass through the membrane. These membranes are called semi-permeable membranes because they allow some substances to cross but not others. The process of water passing through a membrane is called osmosis. The overall direction of the flow of water through the membrane is from the side with a lower concentration of solute to the side with a higher concentration of other chemicals, as shown in the Figure 1.8.3. As water passes through the membrane to the side with a higher concentration of chemicals, that concentration will be reduced.

Aim

To investigate the movement of water through a cell membrane

Prediction

Read the method and write a prediction for what will happen to the mass of the eggs (one in salt water and one in distilled water) and the volumes of water in this experiment.

FIGURE 1.8.2 The membrane of the egg is just under the shell

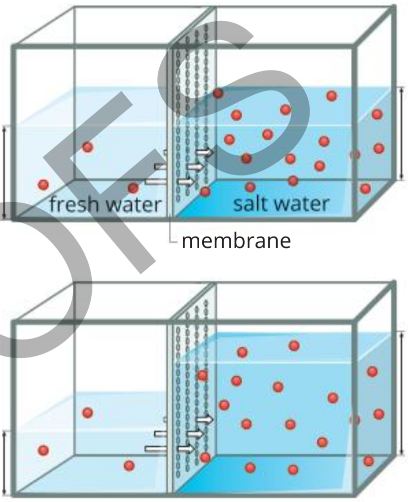


FIGURE 1.8.3 Water moves through a membrane to the area where there is a higher concentration of other chemicals (shown by the red dots)

Materials

- 2 eggs
- 500 mL white vinegar
- 1 tablespoon salt
- 500 mL distilled water (pure water with no chemicals dissolved in it)
- electronic balance
- 200 mL measuring cylinder
- container large enough to hold two eggs immersed in vinegar
- 2 × 500 mL beakers
- plastic wrap

Assessment of risk

Ensure you are aware of the risks of this practical investigation and have considered how safety can be improved before carrying out this activity.

SAFETY NOTES

- Wear eye protection when using the vinegar in the first part of the experiment.
- Students should ensure that they let their teacher know if they have food allergies and a different experiment can be conducted.

Method

1. In your notebook, copy Tables 1.8.1 and 1.8.2 and their titles from the Results section.
2. Place the two eggs in a container of vinegar so that both eggs are completely covered.
3. Leave the eggs undisturbed for two days. By this time the vinegar should have dissolved the eggshell. The membrane inside the shell becomes the outer layer of the egg.
4. Carefully remove the eggs from the vinegar and rinse them. Pat them dry with paper towel.
5. Label the two glass beakers ‘salt water’ and ‘distilled water’.
6. Make a concentrated salt solution by adding a tablespoon of salt to 250 mL of distilled water.
7. Measure out 200 mL of the salt water and pour it into the beaker labelled ‘salt water’.
8. Measure out 200 mL of the distilled water and pour it into the beaker labelled ‘distilled water’.

9 Use a balance to find the mass of each egg. Record each mass in the Day 0 column of Table 1.8.1.

10 Place one egg in each beaker of water and cover with plastic wrap.

11 Each day, for the next three days, measure and record the mass of the eggs.

12 On Day 3, measure and record the volume of water remaining in each of the beakers. Record this in the Day 3 column of Table 1.8.2.

Results

Record your results in your notebook/in the tables below.

TABLE 1.8.1 Changes in the mass of eggs in salt water and distilled water

Treatment	Mass of egg (g)				
	Day 0	Day 1	Day 2	Day 3	Total change in mass (g)
distilled water					
salt water					

HINT

When you measure the mass of the eggs, take only one egg at a time from the solutions. This will ensure that each egg is returned to the correct solution.

TABLE 1.8.2 Changes in the volume of salt water and distilled water

Treatment	Volume of water (mL)		
	Day 0	Day 3	Total change in volume (g)
distilled water	200		
salt water	200		

Conclusion

Answer the following questions in your notebook to construct a conclusion to the experiment.

1 Describe any changes that took place in the two eggs.

2 Describe any change in the volume of the water in the two beakers.

3 Compare the actual results with your prediction.

4 Consider the process of osmosis and explain what you think was happening to the eggs and the role the membrane played.

Evaluation

Evaluate your investigation and the quality of the data with reference to readability, validity and accuracy.

1.9 The functions of the cytoplasm in cells

Lesson overview

In this topic you should be starting to put together your knowledge and understanding of the various parts of animal and plant cells.

Cells are mini systems in which each component works together. To do this, the components have to 'live' together, and the place where they do this is called the cytoplasm of the cell. Cytoplasm was discovered around 1865 when microscopes were able to create sufficiently detailed images.

The word 'cytoplasm' comes from 'cyto-', for cell, and '-plasm', for being formed into a shape.

In this lesson, you will learn about the location, contents and functions of the cytoplasm (Figure 1.9.1).

SC 1 I can identify the cytoplasm of a cell from a photomicrograph, model or other visual representation

Cells are filled with a jelly-like mixture of fluid and organelles called the cytoplasm. The cytoplasm includes everything inside the cell membrane except the nucleus (Figure 1.9.2). The liquid part of the cytoplasm is called the **cytosol**.

Finding the cytoplasm

In diagrams of cells, the cytoplasm is often shown as the background colour of the cell, as you can see in the micrograph of the moss cells (Figure 1.9.2). Although in diagrams the cytoplasm may appear to be the background of the cell, it is important to remember that the cytoplasm is everything inside the cell membrane, including the fluid (cytosol) and all the organelles except the nucleus.

SC 1 CHECK YOUR UNDERSTANDING

What structures are included in the cytoplasm when observing cells?

SC 2 I can describe the components that are contained in the cytoplasm of a cell

The cytoplasm is mostly made up of water, salts, proteins and organelles. The organelles contained in the cytoplasm are:

- ribosomes, where proteins are made
- mitochondria, where chemical energy from food is transformed into energy for the cell, and
- chloroplasts, where sunlight is used to create nutrients through **photosynthesis**.

Learning intention

To understand the role of the cytoplasm in cellular function

Success criteria

SC 1: I can identify the cytoplasm of a cell from a photomicrograph, model or other visual representation.

SC 2: I can describe the components that are contained in the cytoplasm of a cell.

SC 3: I can describe the functions of the cytoplasm of a cell.

FIGURE 1.9.1 The cytoplasm is enclosed by the membrane of the cell

KEY TERMS

cytosol fluid found in the cytoplasm of a cell

photosynthesis the chemical reaction in plants that converts carbon dioxide and water into oxygen and glucose using energy from sunlight

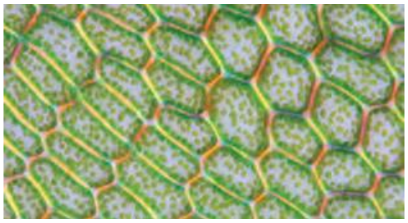


FIGURE 1.9.2 Moss plant cells seen through a light microscope; the cytoplasm is everything inside the cell membrane except the nucleus

KEY TERM

cytoskeleton a network of proteins in the cytoplasm

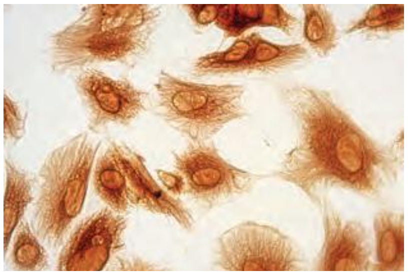


FIGURE 1.9.3 A light microscope image of stromal cells, which connect tissue in organs. The brown stain helps to show the protein cytoskeleton in the cells

Scifile

Fake limbs

The *Amoeba proteus* can use its cytoskeleton to create fake limbs known as pseudopods. The pseudopods allow the amoeba to move around and bring it closer to nutrient sources.

Supporting the cell

The cytoplasm fills out a cell and gives it shape and support. A network of proteins in the cytoplasm acts like a cellular 'skeleton', providing structure and holding organelles in place. This network of proteins in the cytoplasm is known as the **cytoskeleton** which can be seen in the cells in Figure 1.9.3.

SC 2 CHECK YOUR UNDERSTANDING

List the organelles that are found within the cytoplasm of the cell and briefly outline their function.

SC 3 I can describe the functions of the cytoplasm of a cell

Many important cellular processes occur in the organelles contained in the cytoplasm, some of which include chemical reactions and processes involved in cell growth.

The cytoplasm also allows materials to move around the cell – material taken in from outside the cell travels through the cytoplasm to reach the organelles, and products created by the organelles travel through the cytoplasm to exit the cell through the cell membrane.

How does the cytoplasm move things?

Parts of the cytoplasm can move around to change the position of organelles. An example is in plant cells where chloroplasts, which use sunlight to create nutrients, use the cytoskeleton to move to the areas of the cell that are exposed to the most sunlight.

Some unicellular organisms can use their cytoplasm for movement as the cells respond to the environment around them. For the whole cell to travel, the cytoplasm can be extended to move in one direction.

SC 3 CHECK YOUR UNDERSTANDING

Explain one key function of the cytoplasm in the cell.

Lesson review

Use these questions to check whether you have met the learning intention for this lesson.

1 Define the term 'cytoplasm'.

2 Name one component found in the cytoplasm.

3 Describe what the cytoplasm looks like when viewing cells under a light microscope.

4 The cytoplasm is made up of different parts. Identify the key features of:

   a the cytosol

   b the cytoskeleton.

5 The cytoplasm contains a range of different substances. Explain the importance of the cytoplasm having this feature.

1.10 The functions of mitochondria and chloroplasts in cells

Lesson overview

Humans, like all animals, survive by eating plants, or eating animals that have eaten plants, or eating animals that have eaten animals that have eaten plants. Only plants can create food from carbon dioxide and water, with help from sunlight.

Within their cells both plants and animals have specialised organelles known as mitochondria to help make energy for their cells from glucose. Plants have organelles called chloroplasts to assist in creating food (glucose) from the Sun's light energy.

It could be said that without chloroplasts, there would be no mitochondria. Without plants, there would be no animals.

In this lesson, you will learn about how chloroplasts and mitochondria carry out their roles in cells and how they have more things in common than you might think.

SC 1 I can identify the mitochondria and chloroplasts of a cell from a photomicrograph, model or other visual representation

Mitochondria are only 0.5–3 µm long, so you need an electron microscope to see them in detail. Cells that require a lot of energy contain more than 1000 mitochondria.

Mitochondria are made up of an outer membrane and an inner membrane that has many folds. In diagrams, mitochondria often have an oval shape with folds in the middle (Figure 1.10.1). In real cells, the inner membrane folds can be seen at high magnification using an electron microscope (Figure 1.10.2).

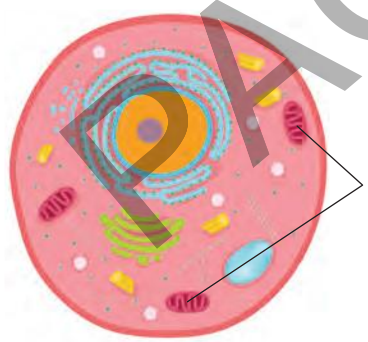


FIGURE 1.10.1 A diagram of an animal cell showing the mitochondria

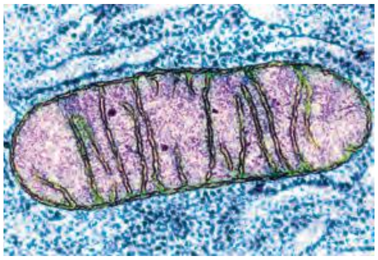


FIGURE 1.10.2 A micrograph of a mitochondrion seen through a transmission electron microscope; the membranes of the mitochondrion are coloured green (long 'tubular' shapes)

Learning intention

To understand the roles of mitochondria and chloroplasts in cellular function

Success criteria

SC 1: I can identify the mitochondria and chloroplasts of a cell from a photomicrograph, model or other visual representation.

SC 2: I can describe the functions of the mitochondria and chloroplasts of a cell.

SC 3: I can compare and contrast the presence and functions of the mitochondria and chloroplasts in cells.

KEY TERMS

mitochondria organelles where energy is released from food through the process of cellular respiration

chloroplast an organelle within the cell where photosynthesis takes place

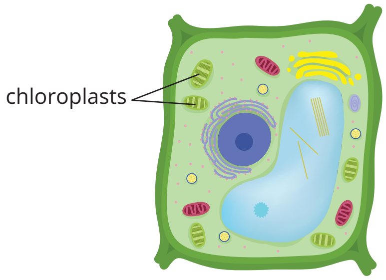


FIGURE 1.10.3 A diagram of a plant cell showing the chloroplasts scattered throughout the cytoplasm

Finding chloroplasts

Chloroplasts are approximately 5–7 µm long. They are slightly larger than mitochondria and can be seen through a light microscope.

In diagrams (Figure 1.10.3), chloroplasts are represented as green oval shapes with lines across the middle, which represent the stacked compartments inside the chloroplasts.

Chloroplasts appear green because of the large amounts of **chlorophyll** they contain. Because chloroplasts are green, they can be seen through a light microscope without staining (Figure 1.10.4).

KEY TERM

chlorophyll the substance found in plant leaves that make leaves green and collects energy from the Sun for photosynthesis

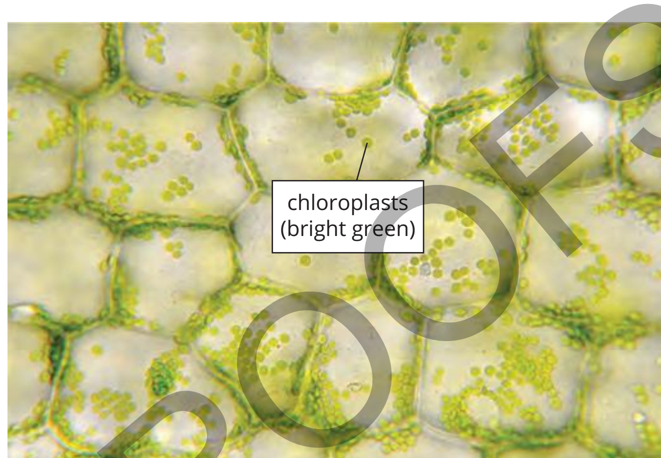


FIGURE 1.10.4 Image of cells in a leaf seen under a light microscope; each cell contains many green chloroplasts

Chloroplasts are surrounded by an outer membrane and contain compartments that are made from folded membranes. These stacked compartments can be seen in cross-section images of chloroplasts (Figure 1.10.5).

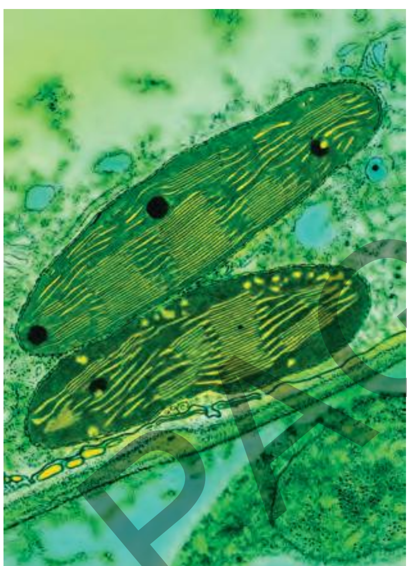


FIGURE 1.10.5 Two chloroplasts in the leaf cell of a pea plant seen through a transmission electron microscope; the image has been coloured, and the membranes that make up the inner compartments are shown in yellow (long, thin 'stacked' lines)

SC 1 CHECK YOUR UNDERSTANDING

Explain why chloroplast are easier to view within the cell in comparison to mitochondria.

SC 2 I can describe the functions of the mitochondria and chloroplasts of a cell

Mitochondria (singular, mitochondrion) are organelles that can convert glucose from food into energy that the cell can use. Mitochondria release energy using a series of chemical reactions called cellular respiration. The type of cellular respiration that takes place in the mitochondria is called aerobic respiration because it involves oxygen.

Mitochondria are found in both plant and animal cells. The number of mitochondria in a cell is related to how much energy the cell needs. Very active cells, such as heart muscle cells and neurons in the brain, have thousands of mitochondria. The structure of mitochondria is complex with an inner and outer membrane that act together to control the movement of chemicals within the mitochondria (Figure 1.10.6).

The function of chloroplasts

Chloroplasts trap energy from sunlight and use it to make food for the plant. This process is called photosynthesis (Figure 1.10.7).

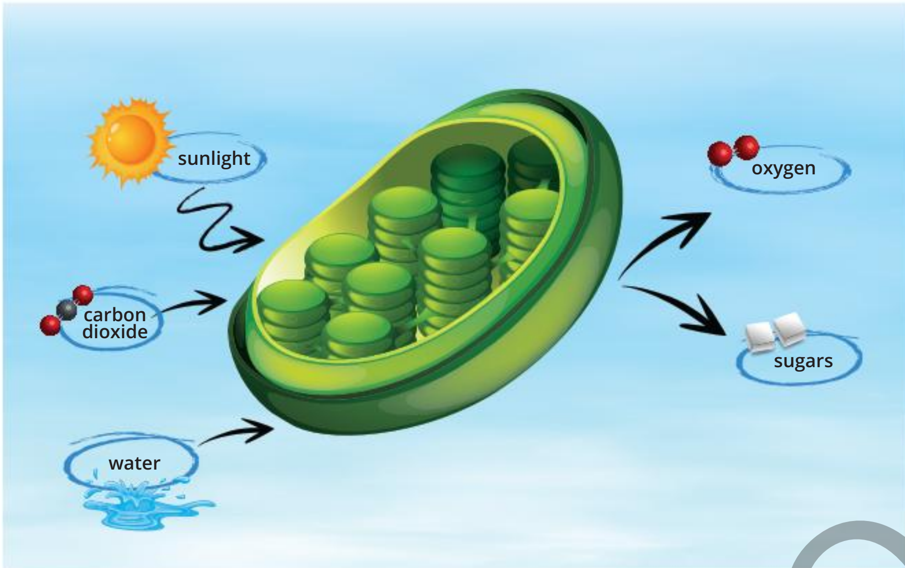


FIGURE 1.10.7 The process of photosynthesis; the inputs for photosynthesis are water and carbon dioxide. The outputs are food in the form of sugars (nutrients for the plant) and oxygen

FIGURE 1.10.6 Cutaway representation of a mitochondrion showing the inner (bright-yellow wavy structure) and outer (beige) membranes

Chloroplasts are typically located in the cells of plant leaves and stems. The green colour of plants is from a pigment inside chloroplasts called chlorophyll. Chloroplasts are found in plants and many protists (single celled eukaryotic organisms) but not in animals or fungi.

SC 3 CHECK YOUR UNDERSTANDING

Describe the function of chloroplasts within plant cells.

SC 3	I can compare and contrast the presence and functions of the mitochondria and chloroplasts in cells

Similarities between mitochondria and chloroplasts

Look at Figure 1.10.8. You will see that mitochondria and chloroplasts both have an inner and outer membrane and have structures inside the inner membrane. Chemical processes occur within these structures, so both mitochondria and chloroplasts act like mini factories, with inputs (energy and/or substances going in) and outputs (energy and/or substances going out).

Differences between mitochondria and chloroplasts

The main difference between mitochondria and chloroplasts is the processes occurring inside them. Chloroplasts use carbon dioxide (CO_2) and water

Scifile

The origins of mitochondria and chloroplasts

Scientists have long proposed that mitochondria and chloroplasts originated as unicellular prokaryotic organisms that were engulfed by a larger cell. Both organelles contain their own DNA, have cell membranes, and reproduce in a way similar to prokaryotic organisms, supporting this theory.

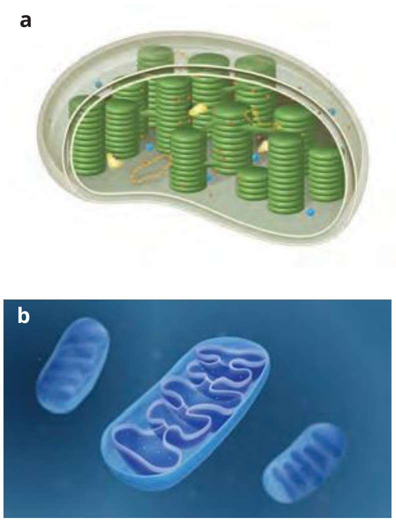


FIGURE 1.10.8 (a) Cross-section illustration of a mitochondrion showing its internal 'wavy' structure; (b) Cross-section illustration of a chloroplast showing its internal stacked structures

(H_2O) to make glucose ($C_6H_{12}O_6$) as 'food' for the cell. This process is called photosynthesis. Photosynthesis requires sunlight and produces oxygen (O_2) as a by-product.

Mitochondria convert glucose and oxygen back to carbon dioxide and water, releasing chemical energy in the process in the form of a chemical called ATP (adenosine triphosphate), which can be used by the organism. This process is called cellular respiration.

From this, it should be clear that the chemical action of mitochondria and the chemical action of chloroplasts are opposite to each other (Figure 1.10.9).

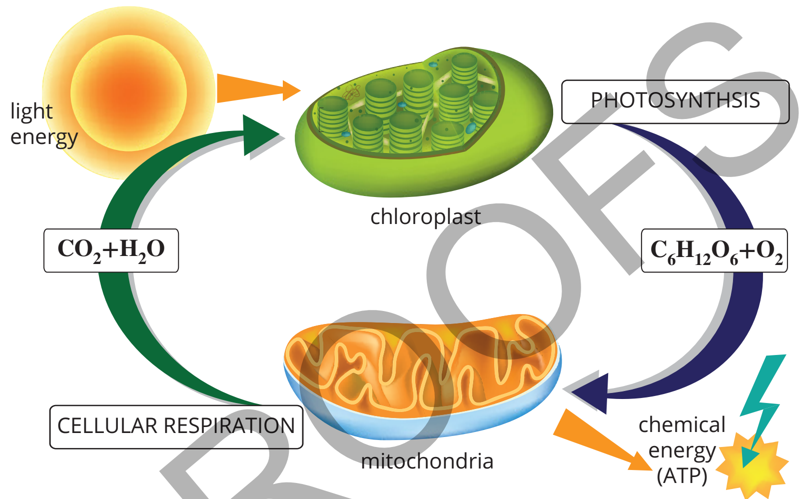


FIGURE 1.10.9 The relationship between the chemical processes occurring in mitochondria and chloroplasts

SC 3 CHECK YOUR UNDERSTANDING

Describe the chemical relationship between mitochondria and chloroplasts within plant cells.

Lesson review

Use these questions to check whether you have met the learning intention for this lesson.

1 Identify the types of microscopes required to view mitochondria and chloroplast.

2 What colour would chloroplasts be when viewing untreated plant cells under a simple microscope?

3 Identify the cell types that contain chloroplasts.

4 Identify and briefly explain the two different processes that occur in mitochondria and chloroplasts.

5 Emad was viewing different types of body cells under the microscope. He recorded the approximate number of organelles that he saw in each type of cell viewed. He noted that the skin cells and nerve cells (also known as neurons) had very different numbers of mitochondria. Predict which cells that Emad viewed had more mitochondria and explain why this would be the case.

1.11 The functions of vacuoles in cells

Lesson overview

Most systems require some storage facility. Bedrooms have wardrobes, kitchens have fridges, and houses have water tanks and rubbish bins. Cells are just the same. There are many substances going in and out of cells, and there are new materials being created all the time. Vacuoles are the way that cells solve their storage issues.

In this lesson, you will learn about how vacuoles are a necessary part of plant and animal cells, how they act as storage for a range of materials and how they can also provide much needed support and protection for the cell.

Learning intention

To understand the role of vacuoles in cellular function

Success criteria

SC 1: I can identify the vacuoles of a cell from a photomicrograph, model or other visual representation.

SC 2: I can describe the functions of vacuoles in plant and animal cells.

SC 1 I can identify the vacuoles of a cell from a photomicrograph, model or other visual representation

Vacuoles are found in most cells, but the number and size of vacuoles is different in plant and animal cells. Plant cells have a single large vacuole that can take up most of the space inside the cell (Figure 1.11.1), while animal cells can have many smaller vacuoles that can appear and disappear depending on the needs of the cell (Figure 1.11.2).

It can be difficult to tell the difference between a vacuole and the cytoplasm when viewing a cell through a light microscope. This is because if the vacuole is filled with fluid, it is transparent and varies in shape and size between cells. In plant cells, the vacuole can usually be identified as a large space in the middle of the cell, with other organelles pushed to the side of it (Figure 1.11.3).

KEY TERM

vacuole a small structure in animal cells that may contain wastes or chemicals, or a large sap-filled structure in plant cells that stores water, wastes and nutrients

FIGURE 1.11.1 The vacuole of this plant cell (coloured blue in this micrograph) fills almost all the cell

FIGURE 1.11.2 This unicellular organism (a protozoan) contains several vacuoles

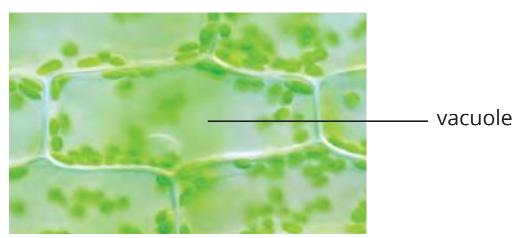


FIGURE 1.11.3 Plant cells seen through a light microscope; the vacuole is the large space in the middle of the cell pushing the green chloroplasts towards the edge of the cell

SC 1 CHECK YOUR UNDERSTANDING

Identify how scientists can distinguish the vacuole from the cytoplasm when viewing plant cells under a microscope.

SC 2 I can describe the functions of vacuoles in plant and animal cells

Vacuoles are organelles that are involved in storage, but they have many functions in plant and animal cells.

Vacuoles in plant cells

In plant cells, vacuoles contain a solution called sap. The vacuole is separated from the rest of the cytoplasm by a semi-permeable membrane, and this controls the contents of the sap, which include waste materials, pigments that give the plant colour, nutrients for growth and even toxins to help protect the plant from being eaten by insects or other animals.

The vacuole of plant cells also provides structure. When it is full, the vacuole presses against the plant cell wall and helps to keep the plant rigid. This pressure is called turgor pressure. This effect can be seen when a plant has plenty of water and the turgor pressure is high. When the plant is lacking in water, the cells will lose this support, and the plant will wilt (Figure 1.11.4).

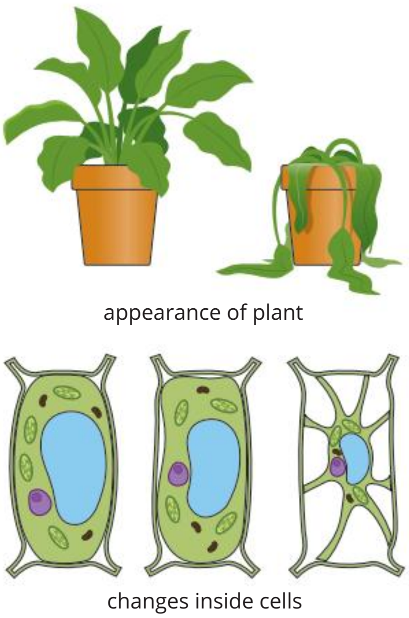


FIGURE 1.11.4 As the vacuoles in a plant's cells lose water, turgor pressure is reduced, which causes the stems of the plant to lose strength and the plant to wilt

Vacuoles in animal cells

Not all animal cells contain vacuoles. In those that do, the vacuoles are much smaller than those in plants, and the cell can also contain many vacuoles. These vacuoles store materials depending on the needs of the cell. For example, the vacuoles in fat cells may contain lipids, which are the chemicals used to make fat.

Contractile vacuoles are often seen in unicellular organisms. These control the amount of water in the cell by increasing and decreasing size (Figure 1.11.5).

FIGURE 1.11.5 Two contractile vacuoles in a paramecium cell seen under a light microscope

Some materials do not easily pass in and out of the cell through the cell membrane. The vacuoles also help these materials, such as nutrients, move into the cell and other materials, such as toxins, to move out of the cell. The vacuole acts like an exit 'waiting room' or an entry 'reception room' for the material. While they are in the vacuole, the material may be broken down into smaller particles.

SC 2 CHECK YOUR UNDERSTANDING

Describe what occurs when plant cell vacuoles are full.

Lesson review

Use these questions to check whether you have met the learning intention for this lesson.

1 Identify the substances that plant vacuoles contain.
2 State key the difference between the structure of the vacuole in plant cell and animal cells.
3 Explain the role of vacuoles in maintaining the functions of the cell.
4 During dry summer months, some plants can start to become wilted if they are not watered often. Explain why this may occur.

1.12 Comparing plant and animal cells

Lesson overview

Animals and plants, such as the bees and flowering plants in this rainforest (Figure 1.12.1), have different survival needs.

Cells are the building blocks of all living things. Because animals and plants survive and grow in different ways, the cells in plants and animals must have different functions. You have learned about many of these functions when investigating the functions of the various organelles in plant and animal cells in this topic.

In this lesson, you will bring together some of your knowledge and understanding of plant and animal cells to describe and explain their similarities and differences.

SC 1	I can distinguish animal and plant cells in a photomicrograph, model or other visual representation based on their appearance and organelles present

Learning intention

To understand the similarities and differences between animal and plant cells

Success criteria

SC 1: I can distinguish animal and plant cells in a photomicrograph, model or other visual representation based on their appearance and organelles present.

SC 2: I can compare and contrast animal and plant cells based on the functions of their organelles.

FIGURE 1.12.1 Bees collecting flower nectar

Viewing animal cell organelles

Organelles are only visible using a microscope. Some larger organelles, such as the nucleus, can be seen through a light microscope, but other organelles, such as mitochondria, are so small that they can only be seen with higher magnification through an electron microscope. Figure 1.12.2 shows a typical animal cell that would be seen using a light microscope, with some organelles visible.

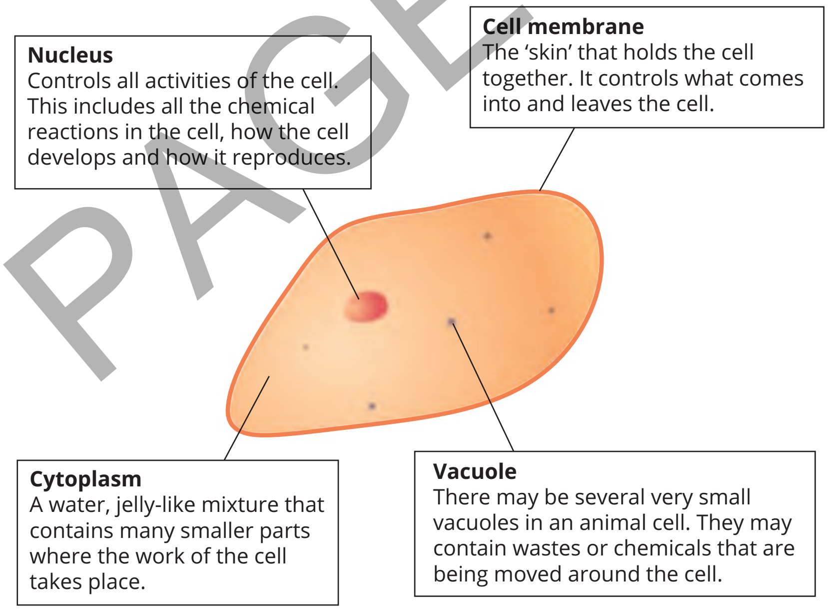


FIGURE 1.12.2 A diagram of an animal cell; the cell also contains smaller organelles that cannot be seen through a light microscope

Viewing plant cell organelles

Plant cells are like animal cells, but because they function differently, they have some different structures, such as cell walls, chloroplasts and a single large vacuole. Plant cells are also larger than most animal cells. Remember that the first cells to be discovered were plant cells. Figure 1.12.3 shows the structure of a typical plant cell.

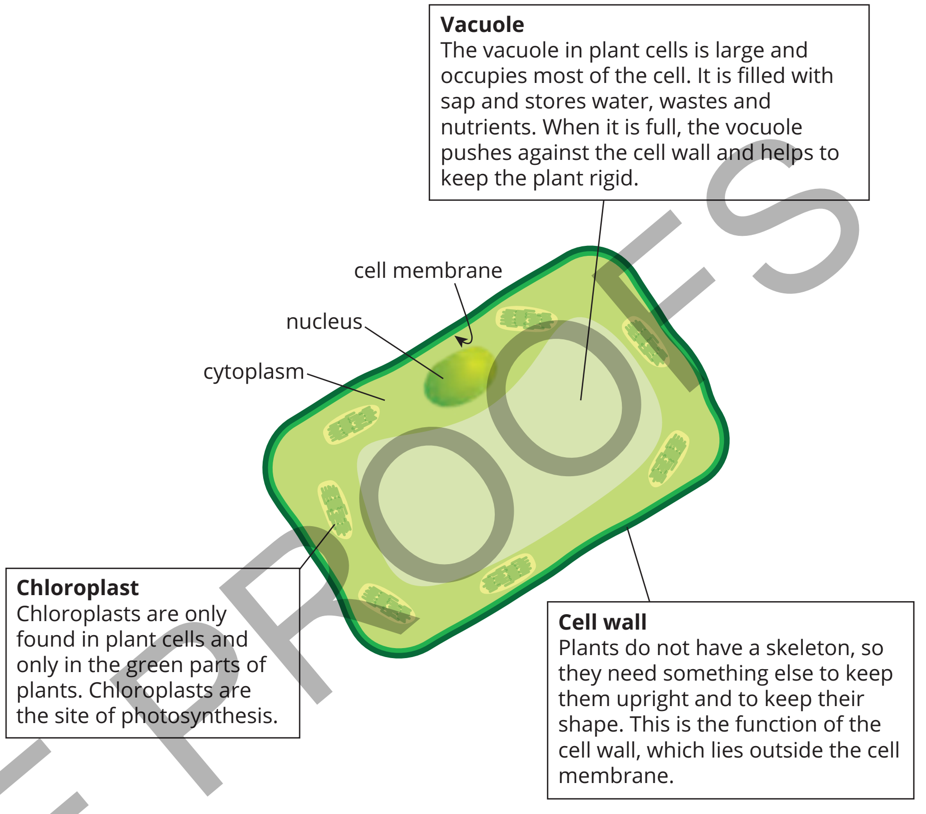


FIGURE 1.12.3 A diagram of the structures seen in a plant cell through a light microscope

SC 1 CHECK YOUR UNDERSTANDING

List the visible features of plant cells that distinguish them from animal cells.

SC 2 I can compare and contrast animal and plant cells based on the functions of their organelles

Organelles common to all eukaryotic cells

Each organelle has a special job or function. Some organelles are found in both plant and animal cells, including:

- cell membrane
- cytoplasm
- nucleus
- mitochondria.

Animal cell organelles

Some organelles are found only in animal cells. These are:

- **lysosomes** – 'garbage disposal' units that get rid of waste from the cell
- **centrioles** – tiny tubes that help a cell split into two during cell division.

KEY TERMS

lysosome organelles that get rid of wastes from animal cells

centriole barrel-shaped structure made from microtubes that is part of the cytoskeleton in animal cells

Plant cell organelles

Like animal cells, plants cells have a cell membrane, cytoplasm, nucleus and mitochondria. They also have the following organelles that are unique to plant cells.

- Cell wall – plant cells have a cell wall outside the cell membrane. The cell wall helps support the plant and gives it shape.
- Large vacuoles – both plant and animal cells have vacuoles, but the vacuole in a plant cell is much larger than in an animal cell.
- Chloroplasts – chloroplasts carry out photosynthesis and can be found in cells in the leaves of plants (Figure 1.12.4).

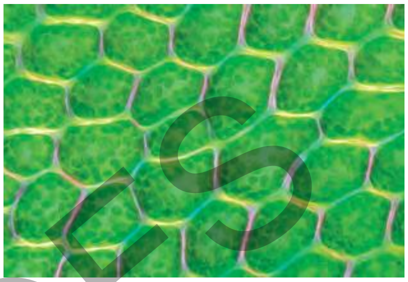


FIGURE 1.12.4 Chloroplast and thick cell walls present in a micrograph of moss cells viewed under a light microscope

Comparing plant and animal cells

Animal and plant cells are very similar. However, there are several differences between plant and animal cells. The main differences between the functions of the organelles in plant and animal cells are summarised in Table 1.12.1 below and illustrated in Figure 1.12.5.

TABLE 1.12.1 Summary of the functions of organelles in animal and plant cells

Function	Organelle	Present in animal cells	Present in plant cells
Making and processing proteins	nucleus	✓	✓
	ribosomes	✓	✓
Energy and food production	mitochondria	✓	✓
	chloroplasts	✗	✓
Storage and structure	vacuole	✓ small	✓ large
	cell wall	✗	✓
	cell membrane	✓	✓

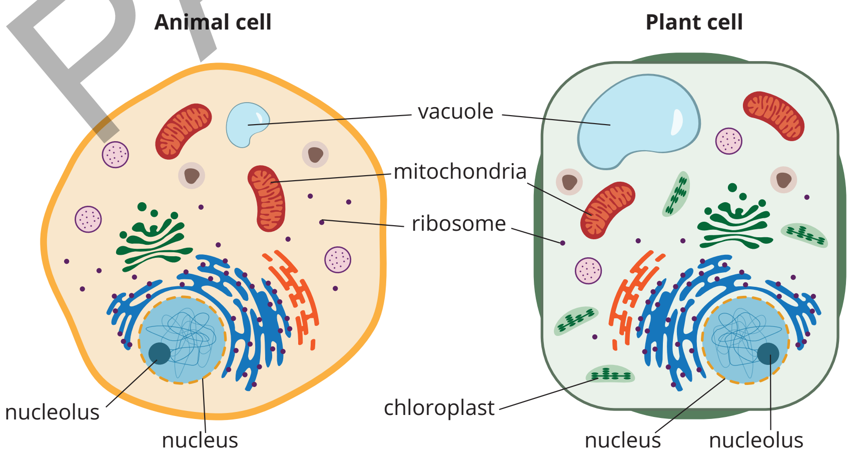


FIGURE 1.12.5 A diagram of an animal cell and a plant cell, showing their organelles

SCIENCE IN SOCIETY

Australian plants adapting to harsh conditions

When you observe plant cells under a microscope, you can see that they share many common features, but there are also differences depending on the type of plant and the cell's function. For example, leaf cells are packed with chloroplasts because they are the primary site of photosynthesis.

Root cells, on the other hand, lack chloroplasts because they are located underground where there is no light. Instead, root cells have many mitochondria, the organelles responsible for producing energy. This allows the roots to absorb water and nutrients efficiently.

In Australia, researchers study the cells of various native plants to understand how they adapt to different environments. For example, the cells of desert plants like the spinifex grass have thick cell walls and large vacuoles to store water, helping them survive in arid (dry) conditions (Figure 1.12.6).

FIGURE 1.12.6 A ring of spinifex grass

By comparing different types of plant cells, scientists can learn how plants have evolved to thrive in various habitats. This knowledge is crucial for agriculture, conservation, and understanding the impacts of climate change.

SC 2 CHECK YOUR UNDERSTANDING

List four features that are common to both plant and animal cells.

Lesson review

Use these questions to check whether you have met the learning intention for this lesson.

1 Identify the differences in the structure and vacuole storage in plant and animal cells.

2 Explain why both plant and animal cells require mitochondria.

3 Compare how plant and animal cells remove waste products.

4 Draw a Venn diagram with the headings 'animal only', 'plant only', 'both plant and animal' to compare and contrast the features of plant and animal cells.

5 Ebony was viewing cells under a light microscope, she noticed that the cells were rigid in shape and had many visible oval shaped organelles that were pushed to the exterior parts of the cell. What type of cells was Ebony most likely viewing? Explain your answer.

1.13 Organisms under the microscope

Introduction

Light microscopes continue to be used by scientists to study cells and unicellular organisms. Pond water contains a range of simple organisms, and at high magnification, cells, cell structures and organelles can be identified.

FIGURE 1.13.1 A *Cyclops* is an example of a multicellular animal that lives in pond water and is difficult to see without a microscope

In this practical investigation, you will use your microscopy skills to examine a range of unicellular and simple multicellular organisms found in pond water, like the one in Figure 1.13.1. You will have the opportunity to practise preparing a wet mount, obtaining high-quality observations at a range of magnifications and recording your observations using scientific drawing.

Learning intention

To be able to use microscopes to observe, record and compare unicellular and multicellular organisms

Success criteria

SC 1: I can use a microscope, with the appropriate magnification, to observe a variety of unicellular and multicellular organisms.

SC 2: I can record observations, including the magnification used, of unicellular and multicellular organisms using a microscope.

SC 3: I can evaluate the experimental method used to observe cells and organisms at the microscopic scale.

Background

Microscopes can be used to view tiny structures in pond water that are not visible to the naked eye, such as unicellular organisms and the organelles inside cells. The common pond water species *Euglena*, *Paramecium*, *Amoeba* and *Spirogyra* are useful organisms to view under the microscope because of their interesting and easy-to-view structures. *Euglena*, *Paramecium* and *Amoeba* are freshwater protists (a single-celled organism with a distinct nucleus), and *Spirogyra* is a type of green algae.

Organisms that might be observed in the pond water are shown here in Figure 1.13.2. You can use this diagram to help identify the organisms you observe.

FIGURE 1.13.2 Various microscopic organisms found in pond water

Aim

To view unicellular and multicellular organisms under a light microscope and identify cell structures and organelles

Materials

- sample of pond water, or separate samples of microorganisms such as *Euglena*, *Paramecium* and *Spirogyra*
- glass microscope slides
- glass coverslips
- plastic Pasteur pipettes
- forceps
- toothpicks
- cotton wool
- light microscope

SAFETY NOTES

- Handle glass slides and coverslips with care. If they break, inform your teacher and they will direct you on the correct method of disposal.
- Do not taste the pond water.

Assessment of risk

Ensure you are aware of the risks of this practical investigation and have considered how safety can be improved before carrying out this activity.

SkillBuilder

Preparing a wet mount

To prepare a wet mount, follow the steps below.

1. Place a drop of water onto the specimen on the microscope slide. If a stain is being used, it can be added to the drop of water at this stage.
2. Place one edge of the coverslip on the slide and lower it carefully using a toothpick, tweezers or your finger to avoid trapping air bubbles, as seen in Figure 1.13.3.

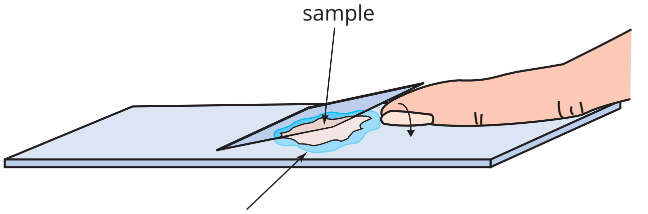


FIGURE 1.13.3 Lowering the coverslip onto the specimen

3. Soak up any excess water or stain with a piece of filter paper or tissue.
4. The specimen is now ready to be observed using the microscope.

Example

Pearl was preparing a wet mount to view under a light microscope (Figure 1.13.4). First, she placed her specimen on a microscope slide and added a drop of water on top of the specimen. She didn't need a stain for her specimen, but if she did, she would have added that at this stage. Next, she placed one edge of the coverslip on the slide and slowly lowered it with her finger. She was careful not to move too quickly, which can introduce air bubbles. Some liquid came out the sides of the coverslip, so she soaked up that excess liquid with a piece of tissue. Her wet mount was now ready to view under the microscope.

FIGURE 1.13.4 Using wet mounts for viewing specimens improves the quality of the image and protects the specimen from damage or dust from the environment

Method

1 Place your sample in the centre of a slide. For the pond water, *Euglena* and Paramecium, use the plastic Pasteur pipette to place a drop of the sample onto the slide. For *Spirogyra*, use the forceps to place a segment of leaf onto the slide.

2 For specimens in water, tease out a few fibres of cotton wool and place them on the slide. The fibres will slow the movement of the organisms to help with observations.

3 Prepare the wet mount as described in the SkillBuilder: Preparing a wet mount.

HINT

Check with your teacher to make sure you have correctly prepared your slides and correctly set up the microscope.

4 Place the slide on the microscope stage. Make sure the light of your microscope is turned on.

5 Rotate the 4× objective lens over the stage. Adjust the coarse focus and then the fine focus until the sample can be seen clearly through the eyepiece.

6 Rotate the next-highest objective lens (10×) over the sample and adjust the focus.

7 Rotate the 40× objective lens over the sample and adjust the focus. Make some observations about what you see.

Results

Copy the table below in your notebook for each organism. In the table, record your observations. Include a sketch of the organism under observations, including any information about the structure and movement of the organism or any cell structures or organelles that you observed.

Organism name		Observations
Unicellular or multicellular		
Magnification		

HINT

To calculate total magnification, multiply the magnification of the eyepiece (ocular lens) by the magnification of the objective lens.

Conclusion

Write your conclusion to the experiment by answering the following questions in your notebook.

1 Explain why some organisms, such as *Euglena* and *Spirogyra*, are green.

2 Compare the movement of unicellular organisms in your samples.

3 You might have seen spaces called vacuoles inside cells in your specimens. What is the function of vacuoles?

Evaluation

Evaluate your practical investigation by considering the following questions:

1 Describe any difficulties you had observing the organisms.

2 How did you overcome these difficulties?

3 Suggest other improvements that could be made to the experiment.

1.14 Modelling cells

Introduction

Most people, including scientists, use drawings or models to represent things, explain ideas, give instructions, send warnings and display emotions. Communication of science ideas can be greatly improved by using clear, accurate and engaging models, including diagrams. The ability to draw diagrams that can describe knowledge or explain understanding is an important part of science inquiry.

In this inquiry activity, you will explore how 2D or 3D models can be used to describe, explain and compare the structure and function of cells, like the teacher is demonstrating in Figure 1.14.1.

Learning intention

To be able to construct and evaluate representations of cells and cell structures

Success criteria

SC 1: I can create and evaluate two-dimensional diagrams to compare plant and animal cells.

SC 2: I can create a three-dimensional model of a plant or animal cell with the organelles accurately represented and labelled.

SC 3: I can evaluate the quality of a three-dimensional model of a cell.

FIGURE 1.14.1 A teacher using a model of a cell to explain parts of a cell

Part A: Drawing cells

Background

An essential skill in science is the ability to effectively communicate observations. While photographic images and videos of cells provide realistic representations, they may not always convey key details without additional information. For example, an image alone may not indicate:

- the actual size of the cell
- its true shape
- internal structures
- whether the cell or its parts are moving.

Providing context and explanations alongside images ensures that observations are accurately understood.

Aims

To draw an accurate and helpful scientific diagram of an animal cell and a plant cell from a micrograph

To provide a written explanation and to use the representations to describe and compare aspects of plant and animal cells

Plan

Use the following image and description to create a representation of a plant cell and an animal cell.

Your diagrams should include:

- labels of visible cell organelles and structures
- a scale bar
- the magnification
- the use of colours where appropriate.

SkillBuilder

Adding scales to diagrams

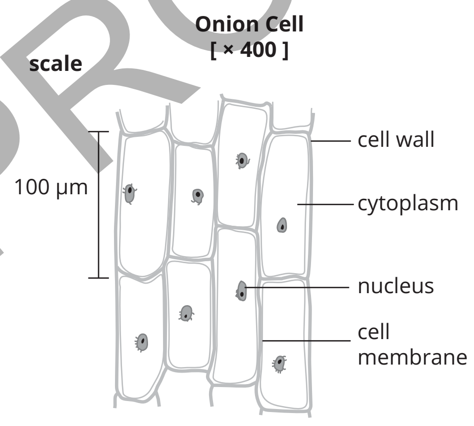
You need to know the magnification of the image to add a scale bar. Scale bars are usually 1 cm long, and the label on the scale bar indicates what distance the 1 cm scale bar represents in terms of the image.

You can divide the distance on the image by the magnification of the image to find out what a scale bar represents.

Example

Paula wanted to calculate what her 1 cm scale bar would represent on an image at a magnification of 40×. She divided 1 cm by 40, which equals 0.025 cm. This is equal to 250 μm. This means that the 1 cm scale bar on Paula's image represents 250 μm in the actual specimen.

Paula then observed some onion cells through a microscope and created the following scientific drawing with a scale bar as shown in the figure. To calculate what the scale bar represents, she divided the distance on the image 1 cm by the magnification (100×), which is 1 ÷ 100 = 0.01 cm, or 100 μm. By using the scale bar, you can see that the length of the onion cells in the actual specimen is approximately 150–200 μm.



Conduct

1 Consider the micrograph of *Elodea* cells (Figure 1.14.2). In your notebook, draw a labelled diagram approximately 6 cm tall that shows the key observable features of this plant cell. Include a scale bar.

FIGURE 1.14.2 Canadian pondweed, *Elodea canadensis* (darkfield and polarised light micrograph)

HINT

If drawn at a height of 6 cm, the magnification is 3000×.

2 Read the following description of a cell and use your knowledge of cells to create a diagram in your notebook that would communicate the information to a Year 8 student who is also studying this topic.
The animal cell is spherical in shape and contains a nucleus with a clearly visible nucleolus. There are several vacuoles, some close to the edge of the cell where food material is being broken down. Five organelles responsible for producing energy in the cell are visible, and ribosomes can be seen arranged along the internal structure of the cell.

Evaluate

Evaluate your drawing in your notebook by considering the following questions.

1. How was the light micrograph enhanced to communicate more information about the cell?
2. How did your diagram communicate more information than the micrograph?
3. How does your diagram communicate information more effectively than the written description that was given to you?
4. How well do the diagrams differentiate between plant and animal cells?

Part B: Modelling cells

Aims

To create a 3D scientific model of an animal cell or a plant cell from a 2D source

To evaluate how well the model can be used to describe and explain the structure and function of the cell

Plan and design

This activity can be completed as an individual task or as a group activity.

Choose a 2D representation as your source material for your model of a cell. This can be one of the diagrams that you created in Part A of this lesson.

You will be given a range of materials to create the model. The model must meet the following criteria.

- The texture, strength and colour of the materials chosen should best present the cell structures that they represent.
- The model should be made to scale, and the scale should be communicated on the model.
- Structures and organelles should be correctly labelled.
- Where possible, dynamic features or functions of the cell should be represented within the model.
- The model should allow for comparison of the cell represented with other animal or plant cells.

Evaluate

Evaluate your model in your notebook by considering the following questions.

1. How well were you able to select appropriate materials?
2. What was the most challenging aspect of the model to create at the correct scale?
3. What strategies did you use to represent dynamic features of cell function?
4. What additional information about the cell would help you to model the cell more accurately?

1.15 Implications of stem cell research

Learning intention

To be able to explore the ethical and social implications of scientific discoveries such as stem cells

Success criteria

SC 1: I can explain what stem cells are and how they function.

SC 2: I can describe the ethical implications of stem cell research.

SC 3: I can describe the social implications of stem cell research.

KEY TERM

embryonic stem cell special cell found in the developing embryo (product of a fertilised egg) that can develop into many different types of cells

Introduction

Stem cell research is a field of science that focuses on the study of stem cells and their potential use in medical treatments. Stem cells are special cells in the body that can develop into many different types of cells, such as muscle cells, nerve cells or blood cells. This ability to develop into different types of cells makes stem cells a promising tool for treating a variety of medical conditions, from injury or disease of tissues, to diseases that involve the loss or malfunction of cells, such as cancer, heart disease and neurological disorders.

Stem cell research is a rapidly evolving field that has the potential to revolutionise medicine, but it also raises several social and ethical concerns.

In this inquiry, you will explore the social and ethical implications of stem cell research.

Background

Stem cell research is a rapidly evolving field that has the potential to revolutionise medicine. However, it also raises several social and ethical concerns.

- Social concerns relate to an issue that affects a group of people in society.
- Ethical concerns arise from a person's beliefs about an issue being right or wrong.

Some of the most prominent issues are explained here.

Embryonic stem cell research

The use of **embryonic stem cells** in research raises ethical questions about the destruction of human embryos.

Some people believe that embryos have moral status and should not be used for research purposes, while others believe that the potential benefits of stem cell research outweigh any moral concerns. 'Moral status' is a term used in ethics to refer to the degree of importance given to something or someone – that is, how important it is to treat them well and make sure no harm is done to them. So, when people say embryos have moral status, they mean that they think embryos are important beings that should be treated with care and respect.

Religious objections

Some religious groups have moral objections to stem cell research. They think it is wrong to conduct stem cell research, particularly when it involves the use of embryonic stem cells. For example, the Roman Catholic Church has stated that the use of embryonic stem cells is morally unacceptable because it involves the destruction of human life.

Access and distribution of treatments

There are concerns about who will have access to stem cell treatments once they become available and who will bear the costs. There are also concerns about how stem cell treatments will be distributed fairly and equitably, especially in developing countries.

Human enhancement

Stem cell research may make it possible to use the technology for purposes beyond therapeutic treatment (use for a disease or illness), such as for human enhancement. This raises ethical questions about what constitutes acceptable uses of the technology and the potential risks and benefits of using it for non-medical purposes.

Privacy and informed consent

The privacy and informed consent of patients who participate in stem cell research, particularly when it comes to the use of their tissue and personal information, is also a source of concern.

Overall, stem cell research is an area of science that requires careful consideration of its social and ethical implications.

Aim

To create an infographic about the scientific discovery of stem cells and the social and ethical implications of stem cell research

Plan

Read the following information on stem cells.

Stem cells

Multicellular organisms, like humans are complex beings that are made up of wide variety of cells. Every cell in the body is uniquely structured to carry out a specific function, and this keeps the body working. But how do these cells become so complex and so well suited to each job they perform? The answer comes down to specific stages of development that take place after an egg is fertilised by a sperm and embryonic development begins. During the development of an embryo, clusters of cells, known as embryonic stem cells, start to develop specific characteristics. These stem cells are like a blank canvas that can develop into any type of cell found in the body. The stem cell undergoes differentiation and specialisation, where the cell develops specific characteristics that allow the cell to perform its intended function. A gastric chief cell is one example of a specialised cell that is found in the lining of your stomach. It has an unusual shape with finger like projections coming from the top known as microvilli, a nucleus that is found at the bottom, many mitochondria, and complex structures known as endoplasmic reticulum that allow stomach enzymes to be produced. These stomach enzymes help break down food.

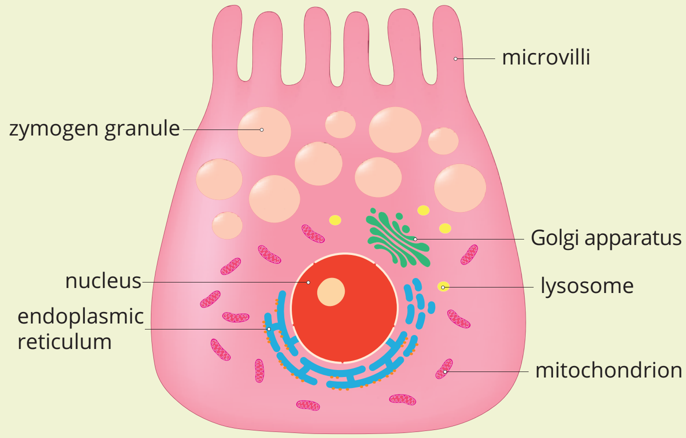


FIGURE 1.15.1 Gastric chief cell structure

The same type of stem cell that produced this gastric chief cell, could have instead developed into a goblet cell that is found in the lung and responsible for secreting mucus to trap any dust particles that are inhaled.

Embryonic stem cells are truly amazing in their ability to make any type of cell, which is why scientists find them so interesting with their potential possibilities in modern medicine to cure disease and illness. But, with this great potential to repair damaged organs, make new brain cells, re-grow limbs comes great responsibility and debate. Embryonic cells must come from an embryo and how scientists obtain that embryo raises many ethical and social implications.

Another type of stem cell is an adult stem cell that are found in different parts of the body including bone marrow. These stem cells are already being used in more mainstream medical applications and scientific research. Adult stem cells can develop into a range of cells, but, not every cell type, which makes them more limited in their capacity.

1 Make summary notes explaining what stem cells are and how they function.
2 Research the positive and negative social implications of stem cell research. Record these notes in a table.
3 Research the positive and negative ethical implications of stem cell research. Record these notes using a graphic organiser such as a PNI (Positives/Negatives/Interesting) chart or a Venn diagram.

Design

1 Consider what makes an infographic informative and engaging. Take notes about the elements you will use to design your infographic and draft your layout.
2 Using the information gathered in the planning stage of this inquiry activity, consider what information to include in your infographic. Choose your key headings.

Conduct

Using all the information you gathered about stem cell research and infographics, create your infographic. Use the key information you gathered during the Plan stage and the elements and headings that you identified in the Design stage.

Improve

1 State what you are proud of in your infographic.
2 Describe how you can improve the look and feel of your infographic to make it more engaging.
3 Explain how you might change the information to make it more informative.
4 Discuss whether you would you do anything differently from the Plan stage next time.

Evaluate

1 What aspect of stem cell research were you investigating in this inquiry activity?
2 In this activity, you planned and conducted an inquiry into stem cell research and the social and ethical implications of this research. What skills did you use during this activity?

1 Cells in plants and animals

Topic summary

The key concepts included in this topic are:

- Cells are the basic unit of all living things and arise from pre-existing cells.
- The evolution of microscopes has allowed people to see cells at a microscopic level and understand more about their specific structure.
- Unicellular organisms can survive as a single cell that undergoes all necessary functions to live independently.
- Multicellular organisms are made up of many different types of cells that work together to allow the organisms to survive.
- All cells share similar features including cell membranes, genetic material, ribosomes and cytoplasm.
- Plant and animal cells both contain a nucleus and specialised organelles that allow them to survive.
- Plant cells have a cell wall, chloroplast and large vacuole.
- Humans are made up of many different types of specialised cells that are organised into tissues, organs and systems.
- Stem cells are cells that are yet to be specialised and are a topic of ethical consideration in society.

Review questions

The following questions will assess your success in achieving the learning intentions for this topic.

Remember

1 Describe what a cell is.

2 Identity the cell structures that were the first to be seen using a microscope.

3 State a type of cell does not contain a nucleus.

4 Describe the function of the cell membrane.

5 List the key features that a plant cell has than an animal cell does not and briefly describe the function of each feature.

Understand

6 Compare the size of a typical eukaryotic cell (such as plant and animal cells) to prokaryotic cells (such as bacteria).

7 Explain how multicellular organisms differ from unicellular organisms.

8 There are many different types of specialised cells in the respiratory system. What functions would these cells need to carry out?

9 What are scientists able to observe using an electron microscope that they cannot see using a stereo microscope?

10 Why do both plant and animal cells need a nucleus and mitochondria to survive?

Apply

11 How can the cytoplasm be identified in a cell diagram?

12 Calculate the total magnification of a light microscope if the eyepiece magnification is 10× and the objective lens magnification is 40×.

13 Ben is teaching another student how to use the light microscope to identify different parts of onion cells. How could Ben explain to the student how to tell the difference between the cell wall and the cell membrane?

Analyse

14 In an environment where the conditions change quickly, how would the survival of a unicellular organism compare with a multicellular organism?

15 Compare the functions of vacuoles in plant cells and animal cells.

Extension

16 An average cheek cell is approximately 60 µm in diameter. Draw a diagram of a cheek cell in your notebook that:

- **a** is one thousand times as large
- **b** includes labelled cell features.

17 Research two ways Australian scientists are using stem cells.

- **a** Provide a summary of each of these innovations.
- **b** Outline some ethical and social implications that the scientists would need to consider when conducting their research.

Topic reflection

The learning intentions for this topic are given in each lesson and at the beginning of the topic. Consider how well you have achieved them. Note down any particular areas that you are confident in, and others where you are not so sure.

1 Glossary

body system a group of interconnected organs and tissues that perform functions in the body

cell the building blocks of all living things

cell membrane thin layer that separates the cell from its surroundings and controls what can move in and out of the cell

cell theory the idea that all living things are made up of one or more cells that come from existing cells

cell wall a rigid layer on the outside of a plant cell or prokaryotic cell; provides the skeleton of a plant

cellular respiration a set of processes in the cells that converts chemical energy from nutrients into energy (ATP) that can be used by cells

centriole barrel-shaped structure made from microtubes that is part of the cytoskeleton in animal cells

chlorophyll the substance found in plant leaves that make leaves green and collects energy from the Sun for photosynthesis

chloroplast an organelle within the cell where photosynthesis takes place

cytoplasm everything contained within a cell membrane except the nucleus

cytoskeleton a network of proteins in the cytoplasm

cytosol fluid found in the cytoplasm of a cell

DNA deoxyribonucleic acid, the molecule that contains genetic information for an organism

electron microscope a type of microscope that uses beams of electrons to magnify up to a million times. There are two types of electron microscopes: transmission electron microscopes (TEM) and scanning electron microscopes (SEM)

embryonic stem cell special cell found in the developing embryo (product of a fertilised egg) that can develop into many different types of cells

eukaryotic cell cell that contains a nucleus

eyepiece the lens, or combination of lenses, at the viewing end of a microscope or telescope

field of view the amount of the specimen seen through a microscope

lens a piece of glass or other transparent material with curved sides used in optical equipment test

light microscope a microscope that uses light to view specimens

lysosome organelles that get rid of wastes from animal cells

macroscopic able to be seen without the help of a microscope

magnification the ratio of the size of an image compared to the size of the object

micrograph photograph of an image from a microscope; also known as a photomicrograph

micrometre one-thousandth of a millimetre, or one-millionth of a metre

microscope an instrument used to make very small things look bigger

microscopic describes objects that can be seen only by using a microscope

mitochondria organelles where energy is released from food through the process of cellular respiration

multicellular an organism that is made up of many cells

nucleolus organelle within a cell nucleus that produces ribosomes

nucleus organelle that contains the genetic information for the cell (plural nuclei)

objective lens the lens in a microscope or telescope that is nearest to the object being viewed

organ a structure that contains at least two different types of tissues that work together to complete a function

organelle the smaller parts of a cell; found in the cytoplasm and have a variety of important functions

organism a living thing that functions as an individual

osmosis process by which particles of water pass through a semi-permeable membrane from a less concentrated solution into a more concentrated one

photosynthesis the chemical reaction in plants that converts carbon dioxide and water into oxygen and glucose using energy from sunlight

prokaryotic cell a cell that does not have a nucleus

ribosome an organelle that produces proteins from amino acids; proteins are required for many functions including growth, repair and controlling chemical reactions

semi-permeable membrane a thin layer of material that only certain particles can pass through

specialised cell cell that has specific structures to allow it to perform specific functions

stereo microscope a binocular microscope that creates a three-dimensional image

tissue a group of cells of the same type that carry out the same function in the body

unicellular organism living thing made up of only one cell

vacuole a small structure in animal cells that may contain wastes or chemicals, or a large sap-filled structure in plant cells that stores water, wastes and nutrients

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