Chapter 9

Cells

CONTEXT AREA

- When you have a drink of water, the water does not slosh around in your arms or legs. The water goes into and around all the small units in your body called cells. Your body contains about one billion cells. Some living things are made of only one cell.
- We need to study cells to understand how plants and animals work. Studying human cells is important for understanding reproduction, nutrition and diseases. Cancer, for instance, is when cells grow out of control.
- This chapter is about cells and how we study them, what cells are like inside. You will see how to use a microscope to see cells and other small objects.

PRESCRIBED FOCUS AREAS

4.1 identifies some key historical scientific breakthroughs

4.2 identifies areas of everyday life that have been affected by scientific developments

4.5 describes areas of current scientific research

DOMAINS

KNOWLEDGE AND UNDERSTANDING

4.8.1 **a** identify that living things are made of cells
b identify and describe the functions of: the nucleus, cytoplasm, cell membrane, cell wall, chloroplast
c identify that substances move into and out of cells
d distinguish between unicellular and multicellular organisms

4.8.3 **a** identify the beneficial and harmful effects that micro-organisms can have on living things and the environment
b explain that reproduction in unicellular organisms takes place by cell division

4.8.4 **b** identify that tissues, organs and organ systems in multi-cellular organisms consist of different types of cells

4.12 **a** identify that technologies make tasks easier or more convenient

SKILLS

4.19 draws conclusions based on information available

4.20 uses an identified strategy to solve problems

4.22 completes a variety of individual and team tasks with guidance

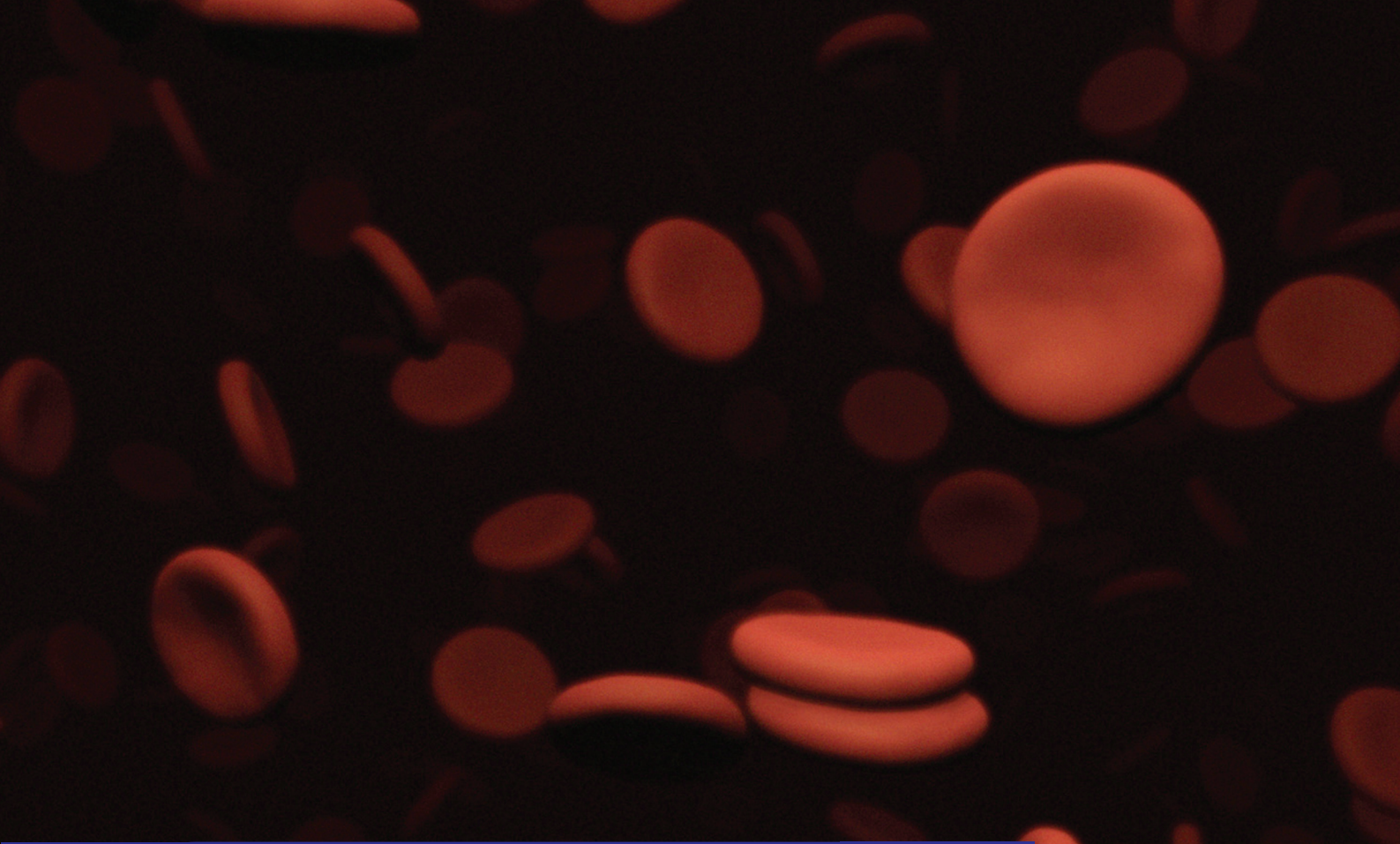
VALUES AND ATTITUDES

4.23 demonstrates a confidence and a willingness to make decisions and take responsible actions

4.24 respects different viewpoints and is honest, fair and ethical

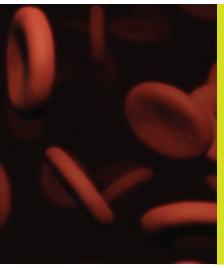
4.25 recognises the relevance and importance of lifelong learning and acknowledges the continued impact of science in many aspects of everyday life

4.26 recognises the role of science in providing information about issues being considered and in increasing an understanding of the world around them



CONCEPTS

What are cells?	Discovery of cells and microscopy
	Cell theory
	Cells in organisms
Spontaneous generation	Experiments to disprove spontaneous generation
Microscopes	Types and terms
	Care of microscopes
Using the compound microscope	Preparing specimens
	Viewing and drawing cells
	Use of stains
Looking into cells	Organelles and functions
	Plant and animal cells
	Drawing cells
Single celled organisms	Protists, bacteria, viruses, features
	Amoeba as typical protist
Cancer	Cell growth and tumours
	Risk factors

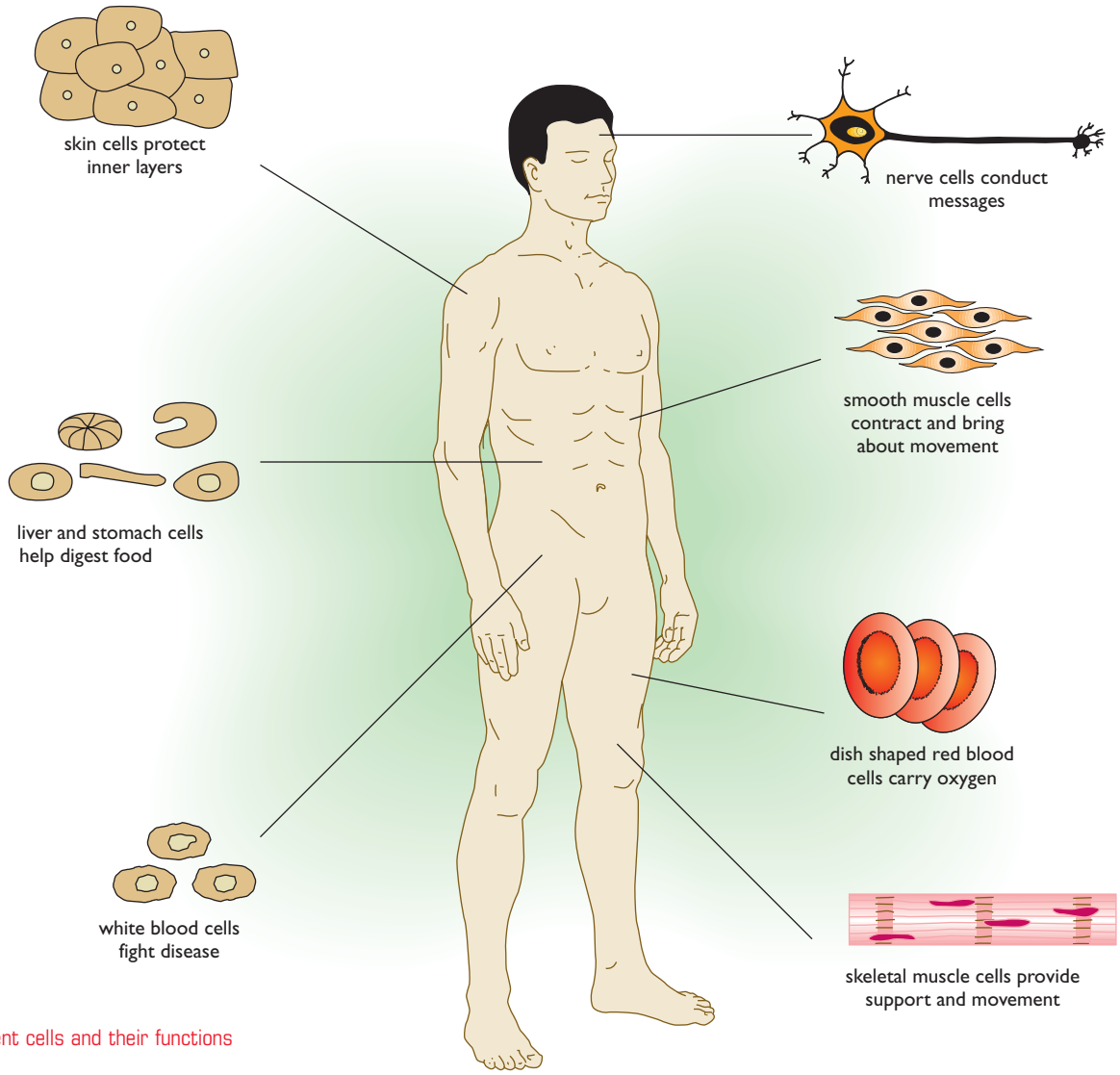


9.1 What are cells?

Cells are the smallest living part of a plant or animal. Plants and animals are made of cells, in the same way that buildings are made of bricks and cities are made of buildings. Until the 17th century, people did not know about cells because they could not see them. The discovery of cells had to wait until the invention of the microscope.

The discovery of cells

Anton van Leeuwenhoek (pronounced 'Lay-you-van-hook') was a draper who lived in the Dutch town of Delft. He sold cloth and other fabrics. Near his home was a lake. The water in the lake was clear in the winter, but in summer it became green and murky, and then became very smelly. No one knew why.



Different cells and their functions

Leeuwenhoek had made a microscope with a bead of glass as a lens. In the summer of 1674 he took home a bottle of murky lake water and viewed it with the microscope he invented. What he saw astonished him. There were green globules, some bunched up and some coiled into spirals. There were also many pale things that darted between the globules. They had many different pale colours and shapes, but they all moved quickly in the water. The globules were tiny plants, and the darting things were tiny animals.

Leeuwenhoek had used his microscope to solve a mystery. But he had also discovered an entirely new world of living things too small to see without a microscope. Leeuwenhoek had discovered plants and animals made of one cell. He had also begun the study of microbiology.

In 1663 Robert Hooke was the Curator of Experiments at the Royal Society of London. This was the meeting place for all the top scientists in England. One day Robert Hooke had to show an experiment or idea to the scientists. He decided to demonstrate a microscope that he had built. He looked at a sample of cork. Hooke found that he had to cut it very thin so that the light would pass through it. Hooke saw lines of little boxes which he called cells. They reminded him of the rows of small rooms in gaols called cells. These cells had been a living part of a tree. Plants and animals are made of many cells.

Before long, many people were making and using microscopes. They examined everything they could think of, and worked out new ways to prepare specimens. The branch of science called microscopy developed.

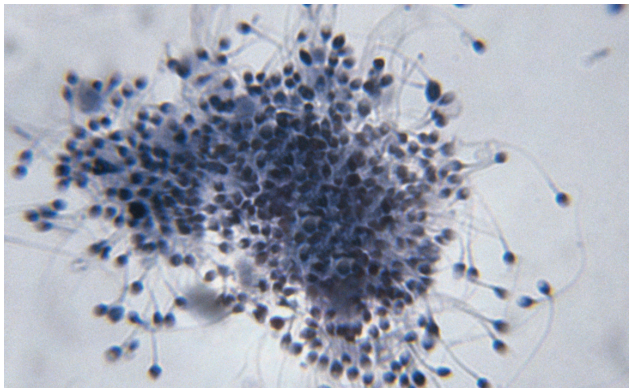
Microscopists discovered that all living things were made of cells. This is now called the cell theory. Living things breed to make new living things. So this idea was expanded to include the idea that 'all cells come from cells'. This means that living things, which are always made of cells, have been formed by other living things made of cells.

The modern cell theory states that 'all living things are made of cells, which are derived from other cells'.

How are cells arranged to make living things?

A human body is made of about one billion cells. We all started as one cell, called an ovum or egg, which was fertilised by a sperm. This produced a fertilised egg. This cell divided to make two cells, then four cells, then eight cells. This process is called cell division.

Organisms which are made of many cells are called multicellular organisms. The different cells in a multicellular organism all work together.



Microscopic image of human sperm

CHECKPOINT:

COPY AND COMPLETE

Cells are the _____ _____ _____ of a plant or animal. Plants and animals are made of _____, in the same way that _____ are made of _____. The modern cell theory states that '___ _____ things are made of _____, which are _____ _____ _____ _____'.

A human body is made of about ___ _____ _____. We all started as one _____. This cell _____ to make ___ cells, then _____ cells, then _____ cells. This _____ is called cell _____.

QUESTIONS

1 Who discovered cells, and why did he call them that?

2 Rank these from smallest to largest: organ, tissue, organism, cell, organ system.

3 What is the difference between cell division and cell specialisation?

4 Name and draw some specialised cells.

5 What is the difference between a microscopist and microscopy?

9.2 Spontaneous generation

Spontaneous generation means making living plants and animals from non-living objects. This idea seems silly to us now, but for thousands of years people believed that it was possible.

If you had gone to school in the 1600s, you would have read this recipe from the famous biologist and doctor Jean-Baptiste van Helmont:

> 'Wrap some wheat seeds in a smelly shirt, and put it in the corner of your house. Wait for a week and you will find mice in the shirt.'

It was also believed that maggots grew from rotting meat, that earthworms were made from soil in heavy rain, and that crocodiles grew out of mud. Food such as soup or broth went bad when it turned into maggots and mould.

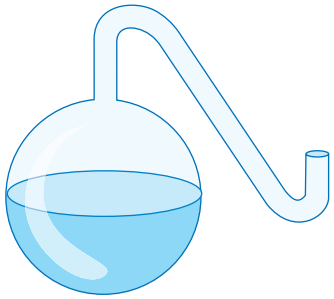
To understand van Helmont's mice recipe, we need to consider the times in which he lived. Most houses were single-room shacks without water or a toilet, and there was no electricity. The streets were narrow and crowded. The few clothes people owned were not washed often, sewage ran into the streets, and rats and mice were common. Only rich people could afford houses with more than one room.

One of the first people to try to show that spontaneous generation was wrong was the Italian doctor and poet Francesco Redi. He did this experiment in 1668. He placed some meat in three jars. One jar was left open to the air, and the other two jars were covered with types of cloth. Redi watched flies walking on the meat in the open jar, and later maggots developed. In the other jars there had been no flies and no maggots grew. But the meat in the covered jars went bad, and the people who believed in spontaneous generation said that his experiment was a failure.

In 1767 the Italian scientist Lazzaro Spallanzani discovered that if he boiled meat broth (soup) in a flask and then sealed it, the broth did not go bad. However, if the neck on the flask was broken, the broth went bad very quickly. Spallanzani said that the life could not have come from the broth but from outside. The supporters of spontaneous generation argued that sealing the flask stopped the 'vital force of life' from entering the flask. This stopped the living organisms from developing.

In 1862 the French chemist Louis Pasteur started the experiments which finally disproved spontaneous generation. Pasteur set up several flasks of meat broth. He boiled them until they were sterile. One flask had its top drawn out into an S shape. Although this flask was open to the

A street in Shropshire, England, in the 1600s



Pasteur's flask

EXPERIMENT

AIM: To repeat Pasteur's experiment

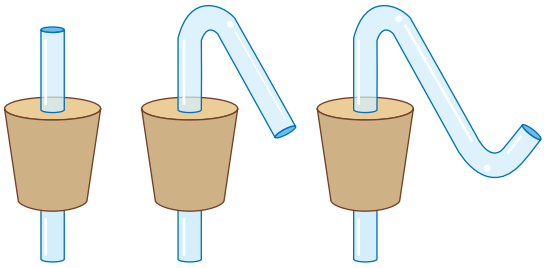
Pasteur's experiment of 1864 finally disproved the idea of spontaneous generation. His experiment can be done again in your school laboratory.

Make up about 200 mL of broth, using sugar, a pinch of salt and a piece of stock cube. Dissolve these in water, and heat them. The solution will be pale brown but transparent (see-through).

Pour equal amounts of this broth into three flasks (any shape will do), and boil them as Spallanzani did. Add water to make the volumes equal. Heating will kill any microscopic living things in the flask.

Prepare three corks or bungs fitted with glass tubes of different shapes, shown in the diagram.

After you have finished boiling the broth, remove the Bunsen burner and seal each flask with a cork fitted with glass tubing. (Before putting the cork in the top of the flask, heat the bottom of the cork in the flame of the Bunsen burner for about two seconds, to kill any microscopic life which might fall into the broth. This is called 'flaming'.) Be careful not to force the cork in too hard, because you might break the flask.



Three corks and tubes

Put your name on each flask and put them in a warm place for next lesson. Caution: if the broth goes cloudy then the heat did not kill all the microbes. Do not take the cork off because the microbes inside might make you sick. Your teacher can kill the microbes by heating (sterilising) or adding disinfectant or bleach.

Write a report of this experiment. Explain your results in terms of microscopic life from the air entering the flasks. Do your results support the idea of spontaneous generation?

air so that the 'vital force' could get into it, the broth in it did not go bad. (Look at the tops of the flasks in the experiment at the end of this Activity.)

This experiment, completed on 22 June 1864, finally disproved the idea of spontaneous generation. Pasteur had shown that something more than broth and air was necessary to make the living things which grew in the flasks. These living things are microscopic life made of only one cell. Pasteur had shown that we are surrounded by microscopic life. Most people call them microbes. They are in the air, in water, and in the flasks in your laboratory.

Some of Pasteur's broth has been saved, and it is kept in the Pasteur Institute in Paris. The broth is still sterile to this day. (The opening has been closed to prevent evaporation of the water.)

CHECKPOINT:

QUESTIONS

1 Explain what is meant by spontaneous generation. How is it different to cell theory?

2 Explain why maggots (the larvae of flies) appear in rotting meat, according to:
a spontaneous generation
b cell theory.

3 Van Helmont's mice recipe worked well in the 1600s, but it would not work today. Explain why.

4 Put these people in order according to the date they made their discovery, then copy the table into your note book. Complete the table.

- Louis Pasteur
- Robert Hooke
- Lazzaro Spallanzani
- Francesco Redi
- Antony van Leeuwenhoek
- Jean-Baptiste van Helmont.

Date	*Person*	*Discovery or event*
.....	.....	.....
.....	.....	.....
.....	.....	.....

9.3 Microscopes

A microscope is an instrument which enables us to see very small objects. The first microscopes were made of only one magnifying glass (called a lens) in a tube. This is called a simple microscope. Later, compound microscopes were invented. They have two lenses. Each lens is at the end of a tube that can be moved up and down. The lens at the top of the tube, where you put your eye, is called the eyepiece. The lens at the bottom of the tube is called the objective.

Types of microscopes

The microscopes used in schools are compound microscopes, and they use light to magnify the object. The image can be seen by looking into the eyepiece of the microscope. There are two types of light microscopes.

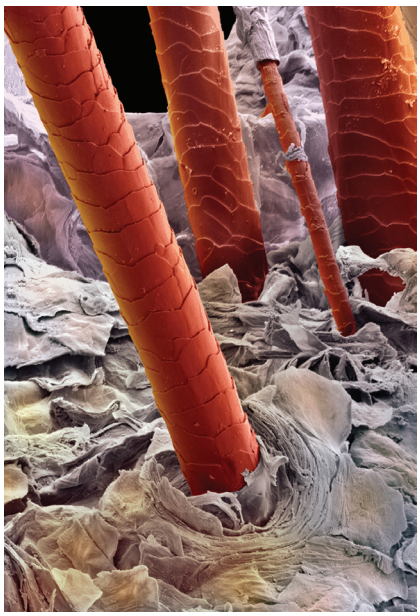
The first type has only one objective lens, but it can have either one or two eyepieces. Light is passed through the object from below, using a mirror or a lamp built into the microscopes. The object being looked at is usually very thin so that the light can pass through it, and it is placed on a rectangle of glass called a slide. There is no special name for this sort of microscope. It is just called a compound microscope. It can magnify objects from about 40 to 1000 times, depending on the lenses you use.

The second type of compound microscope is called a dissecting microscope or dissector, because it is sometimes used to help dissect (cut up) small objects. A dissector has a separate set of lenses for each eye, so you can see the object in three dimensions (3D). This allows you to judge depth or distance, which you cannot do with only one eye open. A light shines onto the object instead of through it. Objects don't have to be specially prepared to be looked at under a dissector. Typical magnifications of dissecting microscopes are 4 to 100 times. Special light microscopes have been developed. Confocal microscopes use laser light to view successively deeper layers. Some microscopes are used in combination with computers and cameras.

There is another type of microscope. It is called an electron microscope. Instead of using light to produce the image, an electron microscope uses a beam of electrons. The image is viewed on a television screen or computer monitor. Electron microscopes can magnify up to 500 000 times, but they are very large and expensive. Types of electron microscopes are called the scanning electron microscope and the tunnelling electron microscope. A false colour image is formed when a computer converts the image into colour instead of black and white. Electron microscope images are black and white, but colour can be added. This is called a false colour image. The colours are chosen by the operator according to what features are important.

There are other types of microscope. One type is a petrological microscope, which is used for viewing thin sections of rocks.

A compound microscope



A scanning electron microscope image of human hair

Microscopes are used because they increase our ability to see tiny objects. Through their magnification they increase our resolution, or resolving power.

magnification This is how many times larger the object looks, compared with its size in real life. The lenses on a microscope have the magnifications written on them. 10× means ten times magnification. Common magnifications are 4×, 5×, 10×, 20× and 40×. To find the magnification of two lenses together, multiply the two numbers. A 10× and a 40× lens produce a magnification of 400×.

resolution This is the amount of detail you can see. By themselves, our eyes cannot tell two objects apart if they are closer than 0.25 mm. Using a microscope increases the resolution, so that closer objects can be separated.

Caring for a microscope

Microscopes are delicate instruments and must be looked after carefully. Here are a few hints.

- Carry the microscope with two hands: one hand under it and one hand holding it.
- Do not tip the microscope. The eyepiece lens and stage clips might fall out.
- Store the microscope in its box or under a dustproof cover when not in use.
- Do not try to clean the microscope. You might damage the controls or scratch the lenses.

A scanning electron microscope

- Check that the microscope is working and has all its pieces (such as mirrors) attached. Check when you start using it, and when you return it at the end of the lesson.

CHECKPOINT:

COPY AND COMPLETE

A microscope is an _____ which enables us to see _____ _____ objects. A compound microscope has two _____. It can _____ objects from about __ to ___ times. A _____ microscope has a separate set of lenses for each eye.

Instead of using light to produce the _____, an electron microscope uses a _____ of _____. The image is viewed on a _____ screen.

QUESTIONS

1 What is the difference between a light microscope and an electron microscope? Which type do you have at school?

2 What is the difference between a compound microscope and a dissecting microscope?

3 What are the meanings of these microscope words: convex, specimen, magnification, microscope slide, resolution?

4 What does 10× mean on the side of a lens? If a microscope has two lenses marked 10× and 10×, what is the total magnification?

5 What are the rules for caring for a microscope?

9.4 Using a compound microscope

Here are some notes about how to set up and use the microscope.

Place the microscope on a flat surface. Adjust the mirror so that the light is reflected up into the tube of the microscope. Do not let direct sunlight strike the mirror. It will damage your eyes if you look at it. Use the iris diaphragm and condenser (if fitted) to obtain an even amount of light.

The object you wish to look at is called the specimen. To look at a specimen under the microscope you need a small flat piece of glass called a microscope slide. A microscope slide with a specimen on it is called a prepared slide. Sometimes a very thin piece of glass called a coverslip is used to protect the specimen.

Place the microscope slide over the hole in the stage. Use the stage clips or spring arm to hold it in place.

Start with the lowest magnification objective lens. Look at the side of the microscope, and wind the body tube down using the coarse focus knob. Stop just before the objective lens touches the slide. Then look into the microscope and wind upwards until the image comes into focus.

Adjust the image with the fine focus knob and condenser and iris if needed. Remember to always focus upwards.

It is important to make a good prepared slide, but it is equally important to be able to draw what you see. When drawing, remember to show only the main parts. Always draw in pencil. Add labels to highlight the important features. An experienced microscopist works with both eyes open. This stops them from becoming tired and getting a headache.

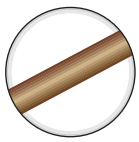
Caution: Do not use 'live' biological samples. Do not use blood, spit or cheek cells, because of the risk of infection by diseases such as hepatitis.

EXPERIMENT

AIM: To make and view slides

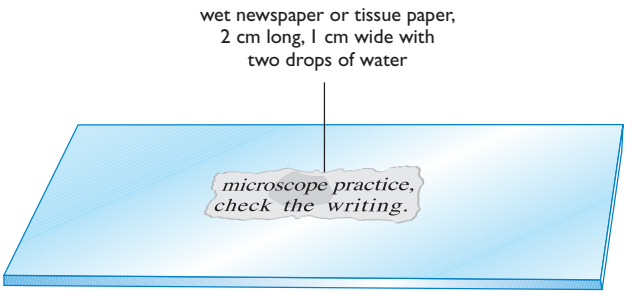
1 Temporary slides. These prepared slides are not made to last a long time. Two ideas are wet newspaper and a piece of hair taped on to a microscope slide. Make these slides and view them with the compound microscope. In your note book, draw a view of what you see. Check the newspaper to see if the image you see is the right way up, or upside-down or back-to-front.

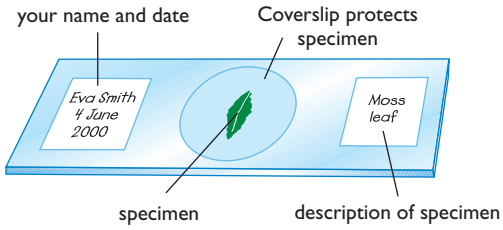
letter from newspaper x 40



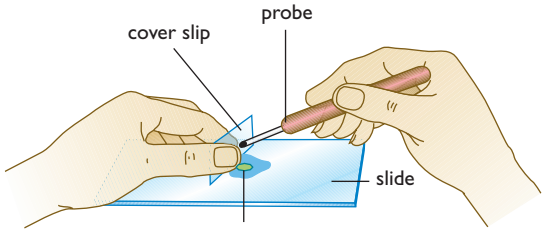
brown hair x 100

2 Permanent slides. On these slides, the specimen is protected with a tiny piece of glass called a coverslip. Sometimes the coverslip is glued down, but usually it is held with water. You must lower the coverslip carefully as shown so that there are no air bubbles caught under it.





A prepared microscope slide

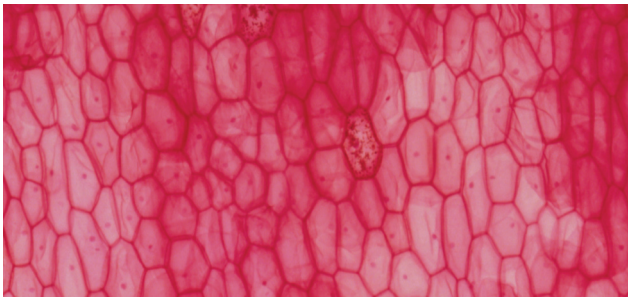


Lowering a cover slip

Make the following prepared slides. Draw what you see for each of them. Show each slide you make to your teacher. Your teacher will tell you which of these slides will be used for assessment.

a Onion skin cells

Between the fleshy layers of an onion are some thin, transparent layers. These layers are one cell thick. Peel off a layer of this skin and put it onto a microscope slide. Add one drop of water and then lower the coverslip so that no air bubbles are trapped. Draw what you see.



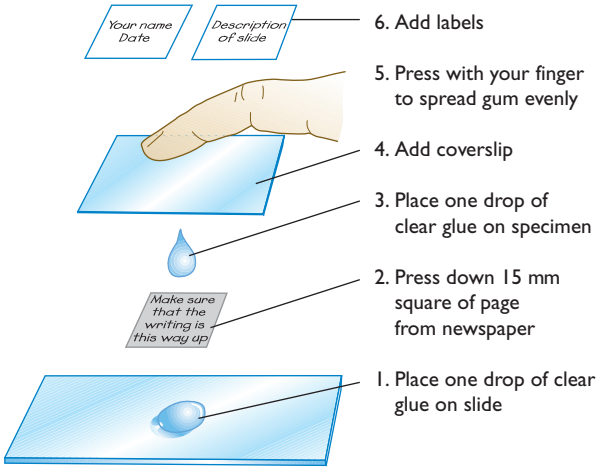
Onion skin cells

b Using stain

Again use onion skin, but this time add a drop of methylene blue stain. How does it change the onion cells? Be careful not to get stain on your skin or clothes, because it is very hard to remove.

c Newspaper

If you use clear glue (clear gum for gluing paper is best) instead of water, you can make a permanent slide. Find some small print in a newspaper and place it on the slide right way up. Make the slide as shown.



Making a permanent slide

This method can be extended to prepare slides of postage stamps, hair, and different kinds of paper. If they are made correctly, these slides will last for many years. More suggestions for specimens to prepare and view are discussed in Activity 9.8.

3 Prepared slides. These are microscope slides that schools purchase already prepared. They are parts of plants and animals. They have been made by hand by experienced people, and can be quite expensive. Your teacher may have some for you to look at.

4 Minigrid slides. These slides have a grid etched onto their surface. The grid lines are 1 mm and 0.1 mm apart. The grid lines allow you to measure the size of small objects.

CHECKPOINT:

COPY AND COMPLETE

To look at a _____ under the _____ you need a small flat piece of _____ called a microscope _____. A microscope slide with a _____ on it is called a _____ slide. Sometimes a very thin piece of _____ called a _____ is used to protect the _____.

When _____, remember to show only the ____ parts. Always draw in _____. Add _____ to highlight the _____ features. An experienced _____ works with both ____ open.

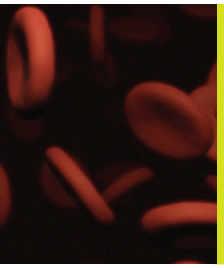
QUESTIONS

1 Why is it unwise to use your blood or spit when making microscope slides?

2 What is the difference between a specimen and a slide?

3 What is the benefit of using a stain when viewing some specimens?

4 Write a set of instructions for using a microscope, which could be glued on the door of the microscope storage cupboard. They must be short but thorough.



9.5 Looking into cells

The microscope photographs below show cells from an animal (human cheek cells) and a plant (cell of a green pond weed). They have been viewed with a light microscope. The cells were stained before they were photographed, to make them easier to see. Microscope photographs are sometimes called micrographs. The cells are drawn in the illustration.

Animal and plant cells are similar in that they are both the basic units (smallest parts) of animals and plants. They contain many common features, such as a nucleus, membrane, protoplasm, cytoplasm, and vacuoles. The parts inside a cell which allow it to function are called organelles.

The outside of a cell is called the membrane. The membrane around a cell is like the fence and gates around a paddock. It controls the substances which enter and leave the cell. Food and oxygen enter the cell, and waste products move out of cells. One waste product is carbon dioxide.

The contents of a cell are called protoplasm. The protoplasm consists of the nucleus and the jelly-like cytoplasm. The nucleus contains all the information needed to make the cell operate as it should. It is like the control centre or manager of the cell.

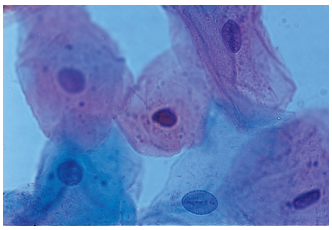
There are a few differences between plant and animal cells. Plant cells have a cell wall. This supports the cell and gives it shape. Every plant cell has a set shape. Animal cells do not have a cell wall, and cannot support themselves. Most animal cells have no set shape. Animals have special cells which make shells and bones.

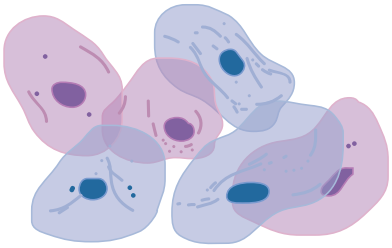
Plant cells contain chloroplasts, where food is made. Animal cells do not contain chloroplasts.

The other important difference between plant and animal cells is the size of the vacuoles. Vacuoles contain food and other chemicals in a water solution. In plants they are large, but in animal cells the vacuoles are small, or there might be none at all.

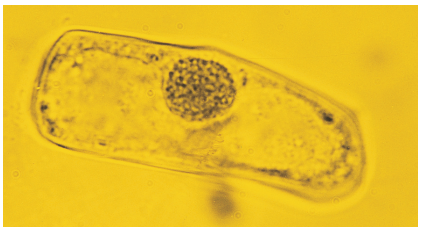
Remember that all cells need food and oxygen to obtain the energy they need to stay alive. They produce wastes which are removed from the cell. These materials enter and leave through the membrane.

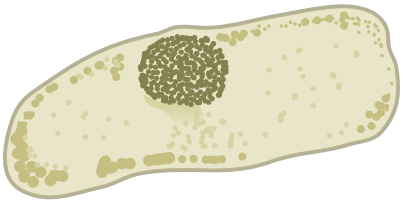
Also shown in a photograph below is a paramecium. A paramecium is a one-celled organism. It belongs to the kingdom called protista (see page 124). In its one cell a paramecium has to obtain food, convert it into energy, grow and reproduce. Paramecium move by tiny hairs called cilia. Even though a paramecium is made of one cell, this cell is very complex and able to perform all the life functions needed by living things.



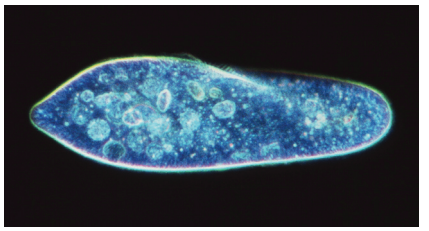


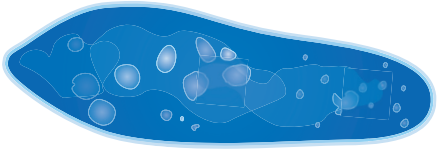
Micrograph of a human cheek cell





Micrograph of a pond weed cell



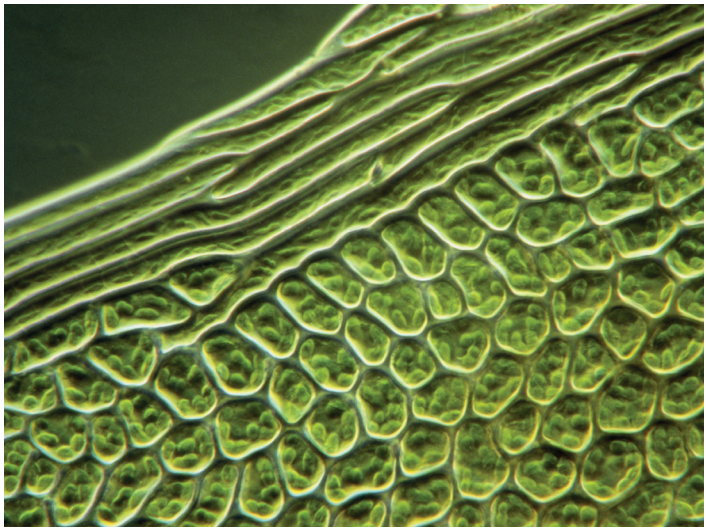


Micrograph of a paramecium

One reason for the difference between plant and animal cells is their requirements (the things they need). Plants make their own food. Plant cells need water and carbon dioxide and minerals from the soil, and sunlight to provide the energy. Food making takes place in the chloroplasts. The vacuoles contain minerals and food products that are ready to be used by the cell.

Animals eat ready-made food. Their cells convert the food into energy. This happens in the parts of cells called mitochondria. Animal cells need a steady supply of food and oxygen.

Plant cells cannot use the energy in solar energy to keep them alive, but obtain their energy from the food they make. Plant cells and animal cells both contain mitochondria in their cells to convert food into energy.



Cells in a moss leaf

CHECKPOINT:

COPY AND COMPLETE

Animal and plant cells are _____ in that they are both the basic units of _____ and _____. They both contain many _____ features, such as a _____, membrane, _____, cytoplasm and _____. The parts _____ a cell which allow it to _____ are called _____.
One reason for the _____ between plant and animal cells is their _____. Plants ____ their own ____. Plant cells need _____ and _____ _____ and _____ from the soil, and _____ to provide the _____. Animals ___ ready-made ____. Their cells convert the ____ into _____. Animal cells need a steady supply of ____ and _____.

QUESTIONS

1 Why are cells important?

2 What is a micrograph? Which two words have been shortened and joined together to make the word micrograph?

3 Use the notes to complete this table of organelles.

Organelle	*Function or description of organelle*
nucleus	*controls everything which happens in the cell*
protoplasm	.....
cytoplasm	.....
membrane	.....
cell wall	.....
vacuole	.....
chloroplast	.....
mitochondria	.....

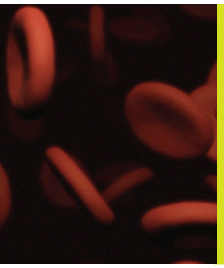
4 Use the information in the text to complete this table showing the differences between plant and animal cells.

Organelle	*Animal cells*	*Plant cells*
cell wall	.....	.....
chloroplast	.....	.....
vacuole	.....	.....

5 Complete this table, relating to the requirements (needs) of plants and animals.

Material	*Needs of plant cells*	*Needs of animal cells*
light	*needed*	*not needed*
oxygen	.....	.....
minerals from soil	.....	.....
ready made food	.....	.....

6 Which of these products go into cells and which goes out of them? oxygen, wastes, food.



9.6 Single-celled organisms

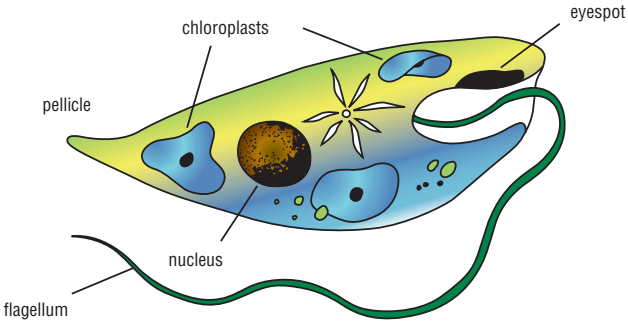
The plants and animals we can see are made of many cells, sometimes many billions, all organised and working together. These are called multicellular organisms.

Some living things are made of only one cell. They are called unicellular organisms. They are classified in the group called protists. Most protists are too small to see without a microscope. They are common in wet places such as the sea, ponds and damp ground.

Each protist cell contains a nucleus and organelles. Protists feed in two ways. Some make their food like plants, by using the energy in sunlight. Some are like animals and catch and eat food. Some can do both: they make food using sunlight and eat other living things for food.

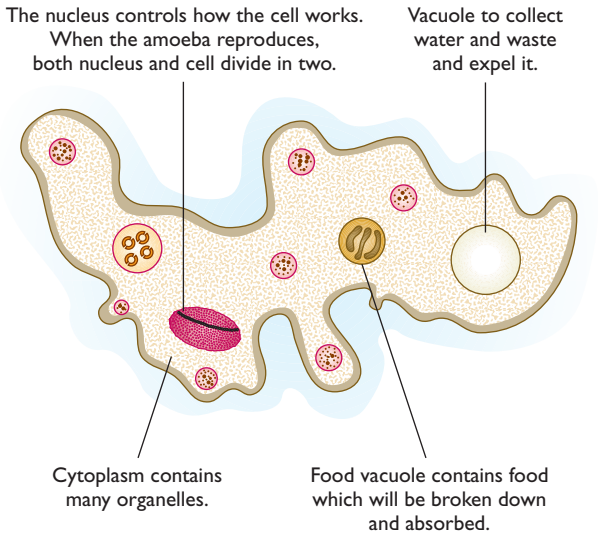
An amoeba ('a-me-ba') is a well-known protist. Amoebas live in water, where they float around. They do not have a fixed shape. Their one cell is like a bag which moves by flowing in any direction. They feed by engulfing their prey. When the food enters the cell it is locked away in vacuoles. The food is later broken down and absorbed into the cytoplasm. Amoebas reproduce mainly by dividing into two parts.

A euglena is a very special protist. It can eat food like animals and make food like plants. Euglena use the energy in solar energy to make food. Its tube-like body is 0.1 mm long, with a long hair like flagellum ('flaj-ell-um') for swimming. Euglena live in fresh water, salt water and in the soil. When the water dries up Euglena forms a thick protective wall around itself and lies dormant until the environment improves. Euglena reproduce by dividing down the middle and making two protists out of one.

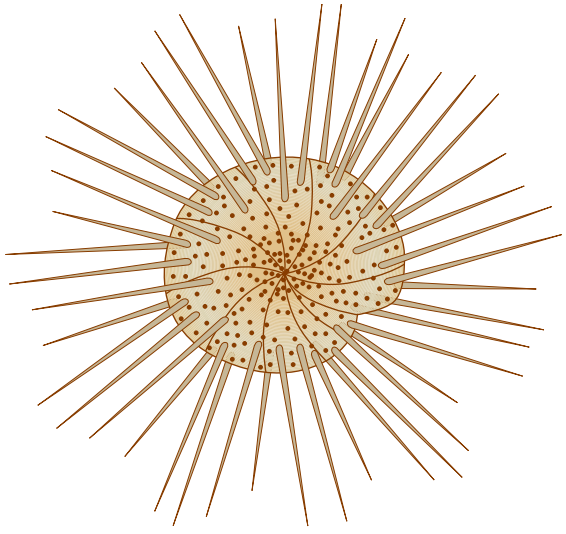


A Euglena

Protists are very common and important. Most protists do not harm people, and some are beneficial. Some live in our intestines and help digest food. Some protists are so abundant that their bodies make rocks. Each protist makes a tiny shell made of chalk or glass, and lives in it. When they die their tiny shells pile up on the sea bed. Eventually their shells will be squashed and cemented together to make a sedimentary rock. The rock called chalk is made from the bodies of protists called foraminiferans.



An amoeba



A foraminiferan

A few protists cause disease. The disease malaria is widespread in the tropics. It is caused by a protist called plasmodium ('plaz-mode-ium').

Bacteria

Bacteria are also one-celled living things. Their cells are about one thousand times smaller than protists. (It is difficult to see bacteria with a light microscope.) Bacteria cells lack many of the internal parts that are found in the cells of protists. This is why bacteria are classified differently to protists.

Bacteria are very common and important in the environment. Most bacteria are beneficial to people. They are used to decompose sewage in water treatment plants. Other bacteria live in the roots of plants called legumes. They convert nitrogen gas in the air into fertiliser which plants can use. Millions of bacteria live in our body and help us digest our food. The presence of bacteria in water is an indication that there is sewage pollution. Bacteria are very important in the environment. Some other bacteria cause disease, and others cause decay. Food poisoning is caused by bacteria that live in the food. Antibiotics are chemicals which destroy bacteria.

Bacteria can live in every environment on or in the Earth. Bacteria have been found in boiling ponds of volcanic mud, at the deepest and darkest depths of the ocean, and even in solid rock. These bacteria obtain their energy not from the sun or from food, but from chemicals in the Earth.

Viruses

Viruses are even smaller than bacteria. They are not made of cells. Instead they consist of the chemicals found in the nucleus of cells. Viruses enter a healthy cell and take over the cell to make more viruses. This causes disease. Viruses infect all types of living things.

EXPERIMENT

AIM: To observe microscopic life in a hay infusion

A hay infusion is the proper name for smelly stagnant water which is home to protists. To make a hay infusion your teacher will have put some dead grass (hay) into water about a week ago. After a few days, microscopic single-celled animals and plants will be living in it. Their spores (like eggs) were on the grass when it was placed in the water (remember cell theory in Activity 9.2). As the grass decays the protists breed. An entire community of plants and animals will be living on the rotting grass.

Make the microscope slide as you did in Activity 9.4. Use one drop of hay infusion water to make the slide. Cover with a coverslip. Carefully move the microscope slide to obtain the best view of protists. Draw some of the protists you find. Happy hunting!

CHECKPOINT:

COPY AND COMPLETE

Some _____ things are made of only one ____. They are called _____ organisms. They are _____ in the group called _____.

Each protist ____ contains a _____ and _____. An amoeba is a well-known _____. _____ live in _____. They feed by _____ their ____. Most _____ do not ____ people and some are _____. A ___ protists cause _____.

Bacteria are also one-_____ _____ things. Their _____ are about one _____ times smaller than _____. Bacteria cells ____ many of the _____ parts that are found in the cells of _____.

Viruses are not made of _____. Instead they consist of the _____ found in the _____ of cells. Viruses enter a _____ cell and ____ ____ the cell to make more _____.

QUESTIONS

1 What is the difference between a unicellular organism and a multicellular organism? Give examples of each.

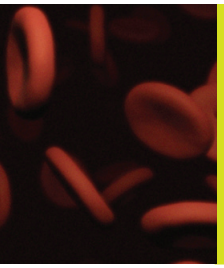
2 What is a protist? What is an example of a protist?

3 How do protists affect people?

4 How do the size of bacteria cells compare to the size of protist cells?

5 How do viruses reproduce themselves?

6 What is the connection between Leeuwenhoek and the hay infusion experiment?



9.7 Cancer

Cancer is a group of diseases which result from uncontrolled cell division. A cancer can form in any part of the body. Cancers are known in all animals and have been found in ancient Egyptian mummies and dinosaur fossils.

Every cell has genes which control cell division. The genes are in the nucleus. Cells reproduce when an organism is growing, and to replace cells which are old or die through injury. When the right number of cells has been made, the genes switch off and cell division stops.

Sometimes genes are damaged or altered. The damage can be caused by radiation, viruses, or chemicals. The genes that cause cancer are called oncogenes. Cancer-causing chemicals are called carcinogens.

The genes can be damaged so that they are permanently turned on. When cell division gets out of control, lots of cells grow. This is called a growth or tumour. The tumour is the cancer. The tumour might split off and spread throughout the body, causing secondary cancers. The secondary cancers can damage or destroy vital organs.

There are two types of tumours. Benign tumours do not spread to other tissue. They are not normally fatal (causing death) unless they grow in a vital organ such as the brain. Malignant tumours grow into surrounding tissue. They can be fatal if their growth is not stopped. Malignant tumours can spread to different parts of the body.

Risk factors

Cancer doesn't have only one cause. Many things that we do can increase the chances of contracting cancer. These are called risk factors. You cannot be certain that you will not get cancer, but you can reduce the chance by avoiding the risk factors.

The known risk factors are described below. Sometimes two risk factors acting together can have a greater effect than each on its own. An example is smoking, where the risk of contracting lung cancer is increased if the smoker also drinks alcohol.

sunlight The ultraviolet light in sunlight causes skin cancer.

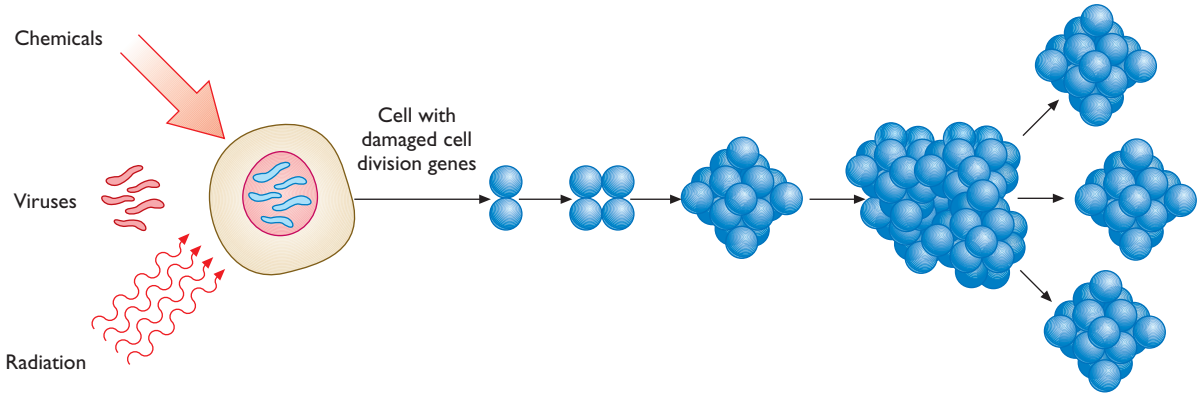
smoking Tobacco tar contains 17 known carcinogens. Cancers can form in the lungs, throat, nose, bladder and pancreas.

fatty diet Fatty foods cause your liver to make bile, which may cause colon cancer.

alcohol Excessive consumption of alcohol can cause cancer of the mouth, throat and stomach.

asbestos Fibres of asbestos, once used as insulation, can be breathed into the lungs. They can cause cancer and other diseases.

chemicals Many chemicals attack the genes in cells and can cause cancer. Examples include coal tars and some solvents and dyes.



How tumours form

radiation Radiation from rocks, the atmosphere, and medical procedures can cause cancers. The more radiation, the greater the risk. Having a medical X-ray is not very risky, and any risk is outweighed many times by the benefits.

sexual activity Cervical cancer can be induced by sperm. Ovarian and breast cancer is more common in women who have babies at an older age, and in women who do not breast feed.

Remember, these only increase the risk. They do not mean that you will or won't contract that type of cancer. There are some warning signs:

- a bad persistent cough or hoarseness
- a change in bowel habits or bleeding from the anus
- a sore that does not heal
- a mole or wart that changes
- unusual bleeding or discharge
- a lump in the breast, neck, armpit or testicles
- unexplained weight loss
- indigestion or difficulty in swallowing

CHECKPOINT:

COPY AND COMPLETE

Cancer is a group of _____ which result from uncontrolled ____ _____. A cancer can form in any ____ of the ____.

When cell _____ gets out of _____, lots of cells ____. This is called a _____ or _____. The tumour is the _____. The tumour might _____ off and _____ throughout the ____ causing _____ _____. The secondary cancers can _____ or _____ vital organs.

There are ___ _____ of tumours. _____ tumours do not _____ to other tissue. _____ tumours ____ into surrounding _____.

Many things that we do can _____ the chances of _____ cancer. These are called ____ _____.

Sometimes two ____ _____ acting together can have a _____ effect than each on their _____.

QUESTIONS

1 What is cancer?

2 What is the meaning of these words: tumour, risk factor, oncogene, carcinogen?

3 What is the difference between a malignant and a benign tumour?

4 The table below shows the four most common cancers in men and women in NSW in 1995. The number shown in each column is the number of new cases for each type of cancer.

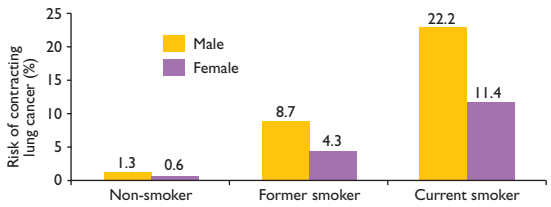
Type of cancer	*Men*	*Women*
prostate	*4150*	—
breast	—	*3448*
lung	*1750*	*825*
skin (melanoma)	*1413*	*967*
colon	*1189*	*1131*

a Rank the four cancers in order of incidence for men and women.

b Which cancer has nearly the same incidence in men and women?

5 The 'Slip, Slop, Slap' campaign is aimed at encouraging people to change their habits to reduce the risk of developing a certain type of cancer. What is the type of cancer and what are the main elements of the campaign?

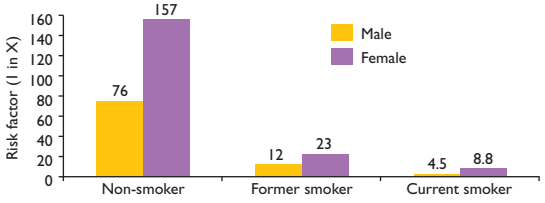
6 This chart shows the risk of contracting lung cancer.



a Are males or females more likely to develop lung cancer?

b Which group of people have the greatest risk of contracting lung cancer?

7 The chart shows the risk factors for contracting lung cancer. 76 means there is a 1 in 76 chance of contracting lung cancer.



a Females have a lower incidence of lung cancer than men, yet on the bar graph the bar is higher. Why is this?

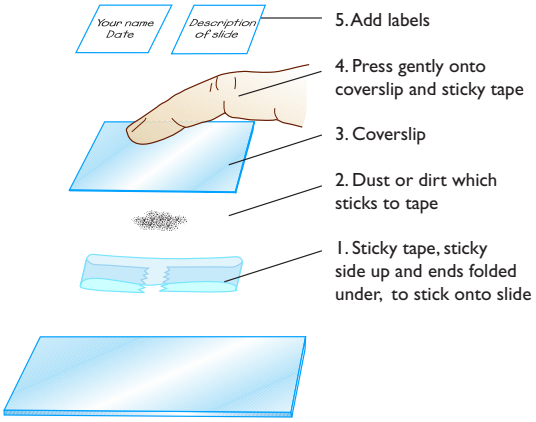
b What is the chance of a man who smokes contracting lung cancer?

9.8 Additional microscope activities

These are some additional microscope activities. Some are difficult and require work at home.

Compound microscopes

What makes up the dust in your house or classroom? Use some sticky tape to collect some dust from a quiet corner of a room, protect it with a coverslip, and write your name and the date on it. Examine the dust under the microscope. What does it consist of, mainly?



Making a slide of household dust

Fibres are the thin strands of material that make up clothes and fabrics. They often fall off clothes and can make up most of the dust in homes. Fibres are also important in police forensic work, because the type of fibre and its colour can link a suspect to the scene of the crime.

Make prepared slides of some fibres or hairs. Use clear gum to secure the coverslip. Keep the slide flat for 24 hours as the gum dries and hardens.

Could you identify an unknown fibre by viewing it under the microscope?

Dissecting microscopes

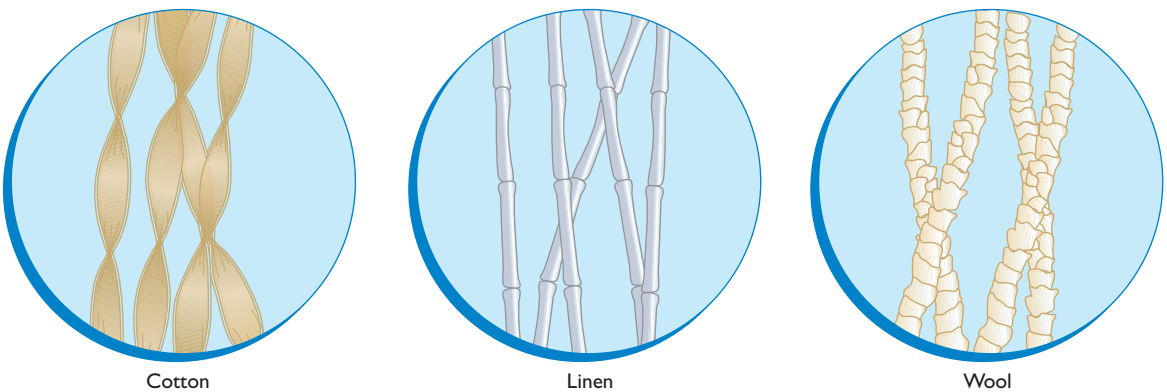
Dissecting microscopes use light which has been reflected off the specimen. A dissecting microscope allows you to examine thick objects, and objects which light does not pass through. Use dissecting microscopes to examine each of the following:

- A coin, such as 5 cents. Check the tiny scratches on its surface.
- The point on a pin or needle. How sharp is it?
- Small invertebrate animals.

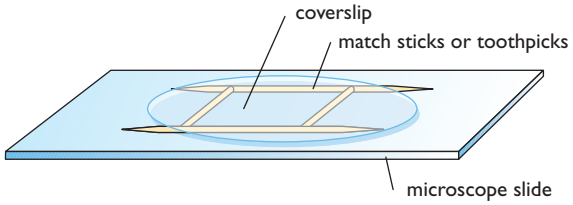
Small animals are best seen using a prison cell. This is a special microscope slide which stops ants and other mobile animals from escaping.

Pick up these tiny creatures with a wet paintbrush, because tweezers or your fingers could crush them. Return the specimens to where you found them.

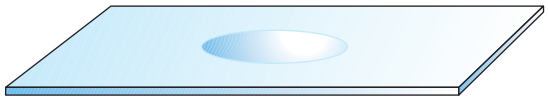
A cavity slide is a microscope slide with a small circular hollow in one side. A drop of water is put into the cavity and a coverslip is placed on top. The cavity becomes a tiny swimming pool for microscopic plants and animals. The coverslip stops the water from evaporating.



Microscopic views of cotton, linen and wool fibres



A prison slide



A cavity slide

Using a compound microscope as a dissecting microscope

Compound microscopes use prepared slides which are very thin and transparent. Objects which are thick or not transparent should be viewed with a dissecting microscope. But with a few modifications, a compound microscope can be used. Remember, the thinner your specimen, the easier it will be to focus and see.

To set up a compound microscope to view specimens using reflected light, follow these steps.

1. Move the mirror so that no light is directed into the microscope tube.
2. Place a piece of cardboard, preferably black, over the stage.
3. Shine a light onto the stage from the side. A bright window, or a microscope lamp, is ideal.
4. Prepare the temporary slides as shown, or use a prison slide for small living things.

Unusual things to look at

1. What do you see when you look at a mirror with a microscope? Use a mirror tile or something small.
2. Ask your teacher to make some hot saturated salt solution. A small amount in a test tube is ideal. Using a dropper, place one drop onto a microscope slide. Can you see the salt crystals growing?
3. Wrigglers and tumblers are the larvae of mosquitoes. Their tiny heart and blood vessels can be seen with a microscope. Be careful collecting them, as adult mosquitoes can carry many viral diseases. As an alternative, use tiny worms grown as food for goldfish, or even tiny fish. Wrap the fish in wet filter paper so they will not dry out and die.
4. Spread out some clear glue or gum over a microscope slide. Onto it sprinkle some of the substances and objects listed.
   - pollen from a flower or pine cone
   - the fluff from thick winter clothes
   - talcum powder

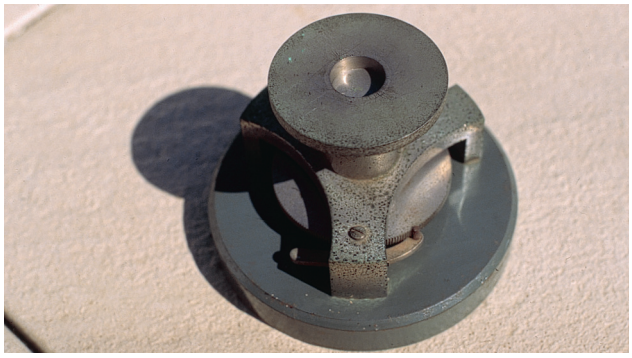
   Cover the glue with a coverslip and view under the low power of a microscope.
5. Pepper tastes like it has tiny prickles on the outside of the grains. Does it? How could you check this out?
6. Leaves look quite smooth to us. Close up they are very different, especially the back of the leaf. Select a range of leaves, grass is ideal, and view it under low power magnification. How are leaves different in different types of plants?
7. Some types of lip gloss are made of tiny sparkly cubes of many colours. Spread a thin film onto a slide to view it.

Thin sections

It is very pleasing to be able to prepare thin sections of specimens. These are done in two ways. The simplest is by cutting a wedge, from an object such as an apple. You will need a sharp knife to make a clean cut. At the thin end of the wedge you cut you will see a rough edge and single cells that have been ripped apart. A drop of stain (iodine or methylene blue) makes the cells stand out.

Microscopists use a microtome (micro-toam) to cut thin sections. A microtome has a section that can be raised or lowered relative to a flat cutting area. Very thin slices can be cut. Microscopists soak the specimen in hot wax, and when solidified they cut slices with special knives.

In class you can cut slices of a freshly picked soft stemmed plant, such as a lily, quite successfully. Your slice must be transparent to be seen with a microscope. These slices can be mounted and preserved with clear gum.



A microtome

Review and Research

Review questions

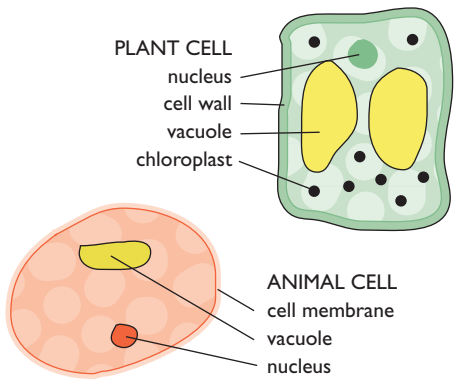
1 Say whether each statement is true or false.
- a Plant cells and animal cells are the same as each other.
- b There are different types of animal cells, such as nerve, muscle and blood cells.
- c The bodies of all living things are made of cells.
- d Nothing is smaller than a cell.
- e Electron microscopes have greater magnification than light microscopes.
- f A group of like cells is called a tissue.
- g Only animal cells have a cell wall.
- h Vacuoles store water and dissolved food in cells.
- i A cell wall gives shape and supports plant cells.
- j Cancer occurs when cell division gets out of control.
- k Chloroplasts help animal cells to obtain energy.

2 Match each word in the list below with the phrase that has the same meaning.
- carcinogen
- dissector
- fission
- membrane
- micrograph
- multicellular
- nucleus
- organelle, specimen
- protoplasm
- stain or dye
- system

a What you prepare and look at under a microscope.
b A group of organs which work together for the survival of the organism.
c The group name of the parts inside a cell.
d Microscope with two objectives, allows the observer to judge depth and distance.
e A colouring agent added to specimens to make the cells easier to see.
f Organelle which controls the activities of the cell.
g A chemical substance which causes a tumour to grow.
h Organism which is made of many cells.
i The thin layer which surrounds plant and animal cells.
j The living contents of a cell.
k Splitting into two parts.
l Photograph taken with the help of a microscope.

3 What is the difference between the following words or phrases?
- a compound and dissector
- b cell and organelle
- c cytoplasm and protoplasm
- d cell specialisation and cell division
- e microscope slide and coverslip
- f cell membrane and cell wall
- g protist and bacteria
- h benign and malignant

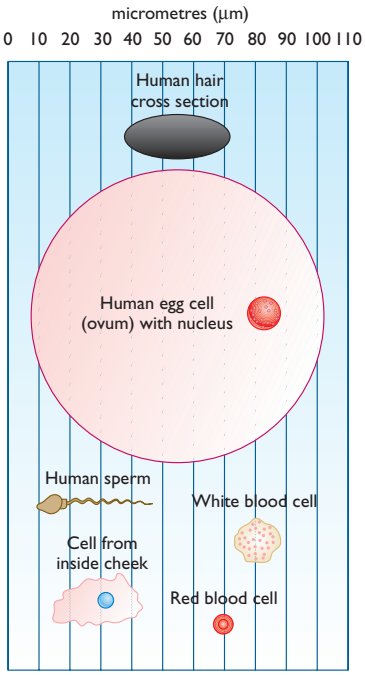
4 The drawings below show simple plant and animal cells. What are the functions (jobs) of the following organelles?
- a cell wall
- b chloroplast
- c cell membrane
- d nucleus
- e vacuole



Plant and animal cells

5 The following diagram shows a piece of human hair. On it are superimposed some human cells. The scale across the top is in micrometres. One micrometre is one millionth of a metre, written as µm. The µ (= mu in the ancient Greek alphabet) means micro, and m means metres.
- a What is the width of a human hair?
- b What is the width of the nucleus of a human egg cell?

c What is the width of these cells?
- A human egg cell
- A human sperm cell
- A white blood cell
- A red blood cell
- A skin cell from inside a cheek.



Comparison of cell sizes

6 Design a poster to show that an active lifestyle with the right food can reduce the chances of getting cancer.

Extension experiment

AIM: To make a model cell

Your model cell will have to be three-dimensional, because real cells are three-dimensional. Lollies and other confectionery are best to use as the organelles.

You can form the cell in a small plastic bag or margarine container. Make the cytoplasm from jelly. Use a big lolly as the nucleus, small green lollies (such as spearmint leaves) as chloroplasts, white lollies (such as Minties) as vacuoles, and small coloured lollies as mitochondria. There are many other organelles in cells which we have not mentioned in this chapter. You can read about them in biology textbooks, and put them into your model cell.

This is an experiment which you can eat, but wait until the jelly has set!

Thinking questions

1 Bacteria reproduce mainly by dividing into two. With good conditions, such as warmth, water and food, they can divide every 20 minutes. If you start with one bacterium, how many will you have after 20 minutes, 40 minutes, one hour, three hours, and one day? Why hasn't the Earth been over-run with bacteria?

2 How many cells are there in a worm? To calculate this we have to make a lot of assumptions. For example: all cells are the same size, there is no body cavity (or hole or stomach) in the worm, and all the cells pack together evenly.

Assume that each cell is 33 µm across. This means that there are 300 cells side-by-side in a length of one millimetre. For the calculation, assume our worm is box-shaped, 4 mm wide, 4 mm thick and 80 mm long.

How good is your estimate? How can you improve it? Can you make a better estimate?

Research questions

1 Many protists grow beautiful shells around their cell. When they die their shells pile up and can make sedimentary rocks. The main types of these protists are foraminiferans, radiolarians and diatoms. Find some of the shapes of these protists, the composition of the shell, and the name of the rock which they make.

2 There are many forms of cancer. Research one form of cancer, and describe how it forms and how it is treated.

Word check

amoeba
bacteria
benign
carcinogen
chloroplast
compound
coverslip
cytoplasm
dissector
dye
fission
infusion
magnification
malignant
membrane
micrograph
microscopy
mitochondria
multicellular
nucleus
oncogene
organelle
organism
protist
protoplasm
radiation
risk factors
specimen
spontaneous
temporary
vacuole

Concept map

Draw a concept map of the important ideas in this chapter.

Leukaemia

Michael is a boy in your class. He has been away from school for a long time. Today the Year Advisor, Mr Davison, came into your class and told everyone that Michael has had treatment for leukaemia. Michael will be back at school next week.

How will this affect you? Will you catch leukaemia? Will Michael have any hair? Will he be able to join in school activities?

Leukaemia is a type of cancer that affects the blood. It has many symptoms (signs or indicators). Diagnosis (identification of the disease) is confirmed with some tests. One is a blood test. Another is a bone marrow biopsy, where a small sample of bone marrow is removed and examined with a microscope. Nobody knows what causes leukaemia. This disease probably has many causes. It affects more young people than older people, and more boys than girls.

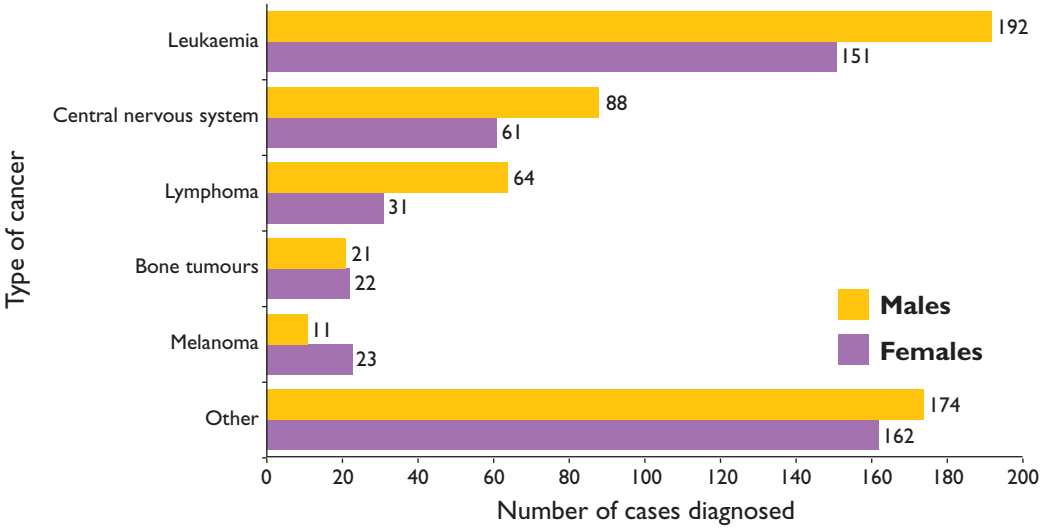
Leukaemia is a disease in which too many of one type of blood cell are made. The developing blood cells take over the bone marrow, where all blood cells are made. Not enough of the other types of blood cells are made. The cells in the blood are out of balance and the person gets sick.

Michael has had his leukaemia treated with chemotherapy. This is where chemicals (drugs) are used in the treatment (therapy) of the illness. Chemotherapy kills all rapidly growing cells. Cancer cells and some non-cancer cells are killed. This causes some side effects. Side effects are unwanted changes that happen because of the treatment, and can include, for example, the loss of appetite, feeling tired and sick, a dry mouth, and skin problems. These side effects happen because the chemotherapy kills all rapidly growing cells, not just the cancer cells.

Michael is now in remission. This means that the symptoms of the disease are beginning to disappear. His cancer cells are being killed and his body is getting back to normal.

Back in your class, Michael will be like anyone else. You cannot catch leukaemia from him. The only side effect you might notice is that he has lost some hair. But it is important that Michael has the support of his friends and the class. Help him to settle into the school routine, because he might get more tired than you. Treat him with the care and respect that you would show to anyone in your class.

Types of cancer diagnosed in NSW 1998–2002, in children aged 0–14 years



QUESTIONS

1 Look up the meaning of these words from the passage: symptoms, diagnosis, biopsy, bone marrow, therapy, chemotherapy, side effects, remission, leukaemia.

2 Place these words in order: therapy, remission, biopsy, symptoms.

3 In a bone marrow biopsy, some developing blood cells are removed from the bone marrow and examined with a microscope. What would the pathologist look for?

4 Describe the steps, in point form, from feeling sick to remission in the case of a person diagnosed with leukaemia.

Use the graph above to answer the questions that follow.

5 How many cases of leukaemia were diagnosed by doctors in the period 1998–2002?

6 Is it true that leukaemia is the most common childhood cancer? Does leukaemia affect more boys than girls? Is this true for all childhood cancers?

7 Which parts of the body are affected by the cancers shown in the graph?

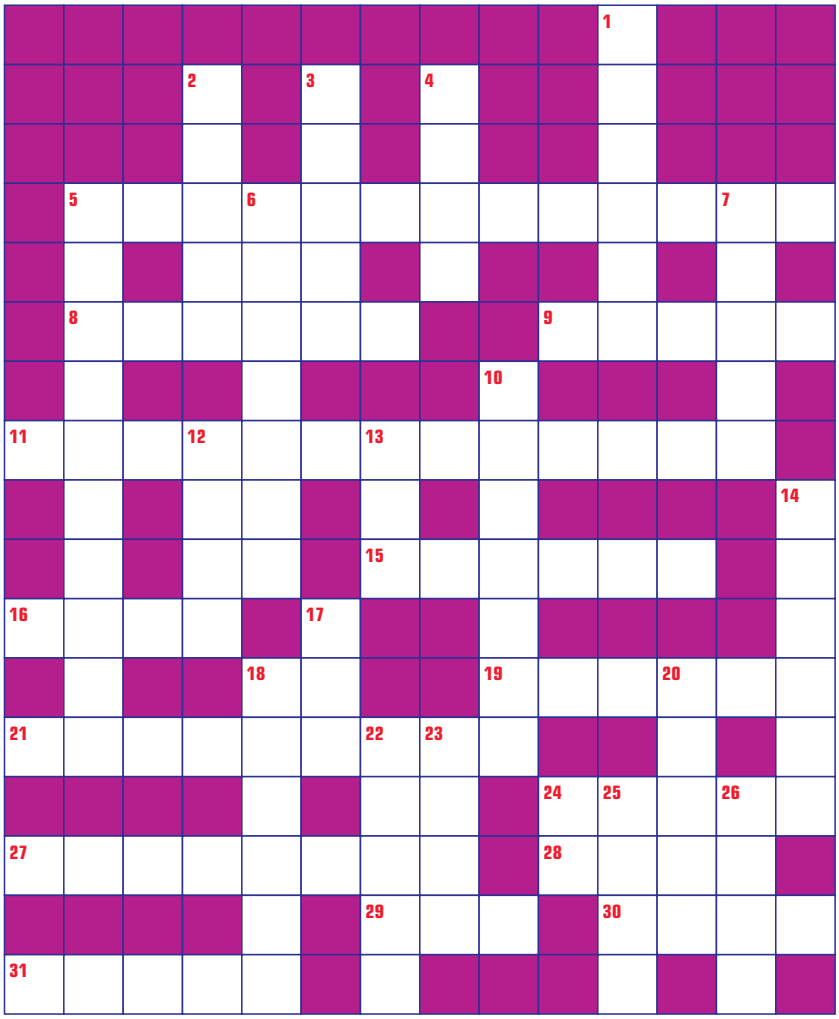
Cells crossword

Across

5 How many times larger an image is seen compared with its real size (13 letters)
8 Disease when cells form a tumour (6)
9 What you see when you look into a microscope (5)
11 Something you need when you are studying hard (13)
15 The top lens on a microscope (6)
16 We eat this so our cells can obtain the energy to stay alive (4)
19 Microscopes use these to magnify images (6)
21 Letting substances pass through it or into it (9)
24 Common name given to slippery green algae (5)
27 What you prepare and look at with the microscope (8)
28 Scientist who tried to disprove the idea of spontaneous generation (4)
29 If in doubt, you should do this (3)
30 The top of Pasteur's flask. Also the part of your body which joins your head and chest (4)
31 This, and dye, makes cells easier to see (5)

Down

1 Group of similar organs which function together to make an organism (6)
2 Group of tissues which form a part of the body (5)
3 Glass used to support the specimen when viewing with the microscope (5)
4 Black, brunette or blonde fibres, can be viewed with a microscope (4)
5 One of these allows us to view very small objects, such as cells (10)
6 Control centre of a cell (7)
7 The organisation of cells is cells, tissue, _____, organ system, organism (5)
10 Part of cell that is large in plant cells and often missing in animal cells (7)
12 Opposite of hot (4)
13 A dissecting microscope is really this number of microscopes side-by-side (3)
14 A group of similar cells (6)
17 Chromosomes and genes are made of this chemical (3)
18 Type of tumour which does not spread to other parts of the body (6)
20 Piece of glass which the coverslip sits on (5)
22 If you drop a glass microscope slide it may do this (5)
23 The ocular is one of these at the top of the microscope (4)
25 A magnifying glass is also called a convex ___ (4)
26 The biologist van Helmont published a recipe to make these living things (4)



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