

2 Micro-organisms and disease

Science *in context!*

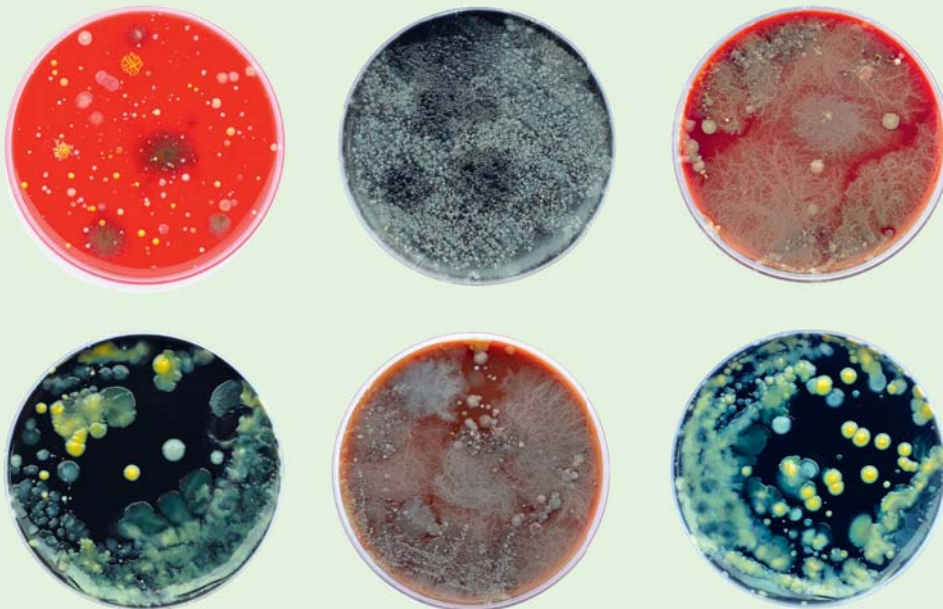
Medicines for the future

Scientists have to look for chemicals that kill bacteria, viruses or fungi but which don't hurt people. That isn't easy and they have to look in all sorts of different places.

Scientists have to make careful **observations** and ask the right questions. They do experiments to see if they are right and collect **evidence** they can show to other scientists. They have to be able to develop **explanations** that convince other people about their ideas.

Here are some examples of the way scientists are looking for new chemicals to kill bacteria:

- Many of the antibiotics, such as penicillin, that we use are made by mould fungi. Many mould fungi are found in the soil. Some scientists wonder if there are moulds in the soil which would make new chemicals to kill bacteria. They are investigating moulds from soils all over the world.
- Some scientists ask questions about what disease-causing bacteria need to live and grow. Then they use computers to try and design new chemicals that will stop the bacteria growing or kill them.
- The slime that fish make to cover their bodies seems to protect them from infections. If they lose their slime, their scales get infected very quickly. Some scientists observed this. Now they are investigating different chemicals from fish slime to see if they can find one that kills bacteria.
- People in Ancient Egypt used honey to help heal wounds. Modern scientists asked if this could really work. They have found there are chemicals in honey which seem to stop infections caused by bacteria. Some honey-based medicines are now used in hospitals. Scientists hope to make more and better medicines from honey.



A set of Petri dishes with different culture media and micro-organisms growing. They show the diversity in micro-organisms

- Crocodiles live in filthy water. They often fight and bite each other. Although their teeth are dirty, the bites don't get infected. Scientists looked at crocodile blood and found a chemical that kills a wide range of bacteria. They are working hard to see if this can be made into an antibiotic medicine to cure people with bacterial infections.



In this chapter you will explore the link between micro-organisms and disease, including the work of the famous French scientist Louis Pasteur. You will also be looking at the importance of micro-organisms in food production and in the natural decay process.

Key points

- Remember that the seven characteristics of living organisms are nutrition, respiration, reproduction, excretion, movement, sensitivity and growth.
- Micro-organisms are very small living organisms, which often can only be seen using a microscope.
- Bacteria are one of the most common types of micro-organisms. They are made up of single cells, which have a cell wall, genetic material, plasmid, cytoplasm, slime capsule and flagellum. Bacteria carry out all the common activities of living things.
- Some bacteria are very useful to people, some have no effect and some are harmful and cause diseases in people, other animals and plants.
- Fungi are micro-organisms but they can be very large. They carry out all the characteristic activities of living things.
- Yeasts are single-celled fungi. They reproduce by budding. Moulds are fungi made up of tiny thread-like structures called hyphae. Fungi reproduce by making spores.
- People use fungi for food and to make bread but they can also cause diseases in people, other animals and plants.
- Viruses are incredibly small micro-organisms which are made up of a protein coat and genetic material. They are parasites – they can only reproduce by taking over the cell of another living organism and using it to make new viruses. All viruses cause disease.
- Micro-organisms such as bacteria and yeasts are involved in the process of decay.
- Bacteria, viruses and fungi all cause diseases in animals (including people) and plants.
- One of the first people to make discoveries about micro-organisms was the French scientist Louis Pasteur.

Learning outcomes

After this topic you should be able to:

- label a diagram of a bacterium
- explain that bacteria are living organisms
- list some of the ways bacteria affect people.

When you look around you can see your classmates. You may see plants and animals. But there are millions of tiny living organisms you cannot see. These are **micro-organisms**. They are on your desk, on your skin and even in the air you breathe. One of the most common types of micro-organisms are **bacteria**. Micro-organisms are sometimes called microbes for short.

What are bacteria?

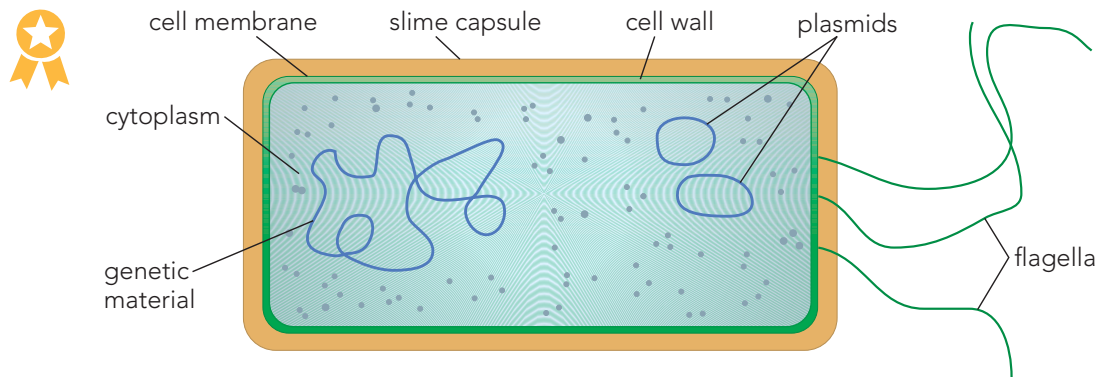
Bacteria are some of the smallest of all living organisms and come in lots of shapes and sizes. About 100 of the largest bacteria lined up would just about stretch across this full stop. You cannot see individual bacteria without using a microscope. Each bacterium is a single cell.

Practical activity Plant and animal cells

What do plant and animal cells look like when you look down a microscope?

- Work in a small group and make a quick labelled drawing of an animal cell and a plant cell to remind yourselves of what they look like.

Now look at a typical bacterial cell in the diagram below.



A bacterial cell ($\times 74\,000$)

Bacterial cells look rather different to plant and animals cells. They don't have a proper nucleus. They have a loop in the cytoplasm that carries all the information about how to make a new cell (the genetic information). Bacteria often have other small pieces of genetic information called plasmids.

Bacteria are living organisms. What do all living things do? Bacteria take in food and respire. They excrete carbon dioxide and other waste products. They can grow and they reproduce by simply splitting in half. If they have all the things they need, some bacteria can split in half every 20 minutes. Some bacteria have flagella to move themselves about.

Key terms

- **bacteria**
- **colony**
- **culture**
- **micro-organisms**

Useful and harmful bacteria

Some bacteria cause diseases in humans and other in organisms such as animals and plants, for example:

- *Salmonella* bacteria cause stomach upsets.
- Bean blight is caused by bacteria.

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Many bacteria are harmless and some are very useful to us. For example:

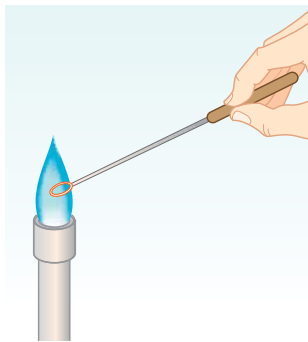
- Bacteria help to decay the bodies of dead plants and animals.
- Bacteria in our guts and on our skin help to keep us healthy.
- We use bacteria to make cheese, yoghurt, wine and vinegar as well as for treating human sewage.

Growing bacteria

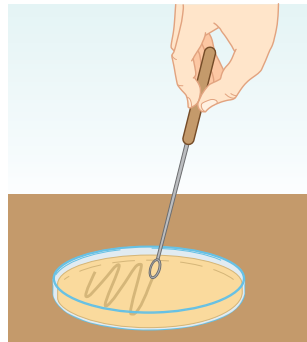
If you grow bacteria on special jelly that contains all the nutrients (food) they need, they form **colonies**. These colonies are big enough to be seen without a light microscope. This makes it easy for scientists to see if a chemical will kill disease-causing bacteria. But take great care when you **culture** bacteria and follow these instructions carefully to avoid any risk from harmful bacteria:



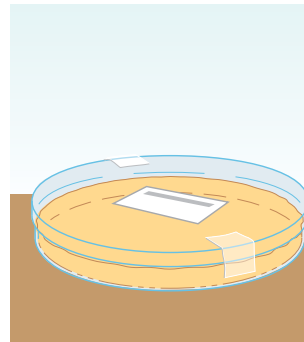
Growing bacteria in the laboratory



Sterilise the inoculating loop used to transfer micro-organisms to the agar by heating it until it is red hot in the flame of a Bunsen and then letting it cool. Do not put the loop down or blow on it as it cools.



Dip the sterilised loop in a suspension of the bacteria you want to grow and use it to make zigzag streaks across the surface of the agar. Replace the lid on the dish as quickly as possible to avoid contamination.



Seal the lid of the Petri dish with adhesive tape to prevent micro-organisms from the air contaminating the culture – or micro-organisms from the culture escaping. Do not seal all the way around the edge so oxygen can still get into the dish. This is so that harmful bacteria that do not need oxygen are not able to grow.

Expert tips

We will use the word nutrient in slightly different ways. Here it means all the food substances that the bacteria require, such as simple sugars and mineral salts.

Summary questions

- 1 Make a table to compare a bacterial cell with a plant cell and an animal cell. You will need four columns – one for each type of cell and one for the features you are comparing.
- 2 Bacteria grow fast when they have just the right conditions. Write a plan to investigate the best temperature for bacteria to grow as fast as possible. You could present your plan as a series of drawings or as a flow chart.
- 3 The diagram of the bacterial cell on the opposite page is 74 000 times its actual length. Calculate its actual length and show your working.

Learning outcomes

After this topic you should be able to:

- explain that yeast and moulds are types of fungi
- describe yeasts and moulds.

We do not need a microscope to see all micro-organisms. **Fungi** are called micro-organisms but they can grow very big indeed!



This puffball is a very large micro-organism. The apple gives you an idea how large it is



Fungi destroy millions of tonnes of food around the world every year

Expert tips

You can see that green mould is growing on these oranges. Spores from the air grew hyphae, which entered the fruits through breaks in the surface. At first the mould looks white, then it makes spores that make it look green. Let some oranges go mouldy and then look at some of the fungus under a microscope to see the hyphae and spores.

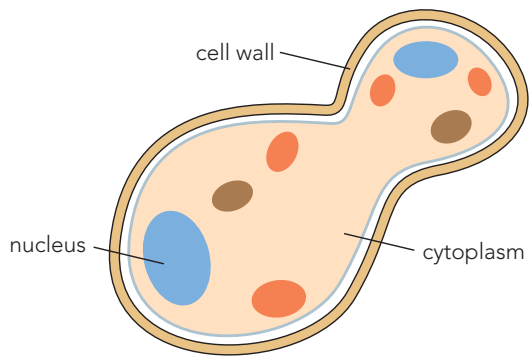
Finding out about fungi

You will probably have seen fungi on market stalls, growing wild or as part of your food. The mushrooms and puffballs you have seen are the parts that the fungus uses for reproduction. Most of the rest of the fungus spreads out in the soil as very thin, thread-like structures called **hyphae**. Many fungi are very useful to people. However, all fungi get their food from dead or other living organisms and so some of them cause a lot of damage. They digest crops and food and make them rot.

There are lots of different types of fungi. They usually need moist conditions to grow. You are going to look at **yeast** and moulds. The cells of these fungi can be seen under the microscope. You will find they look very different both from plant and animal cells and from each other.

Yeasts

Yeasts are single-celled organisms. They are found all around us. They often grow on the skins of fruits, feeding on the sugar in the fruit. They usually respire using oxygen from the air, but they can respire without oxygen if there is none available. Each yeast cell has a nucleus, cytoplasm and a membrane with a cell wall round it. They reproduce by budding, with a small new yeast cell forming from the old one as you can see in the diagram and photo at the top of the opposite page.



Yeast cell

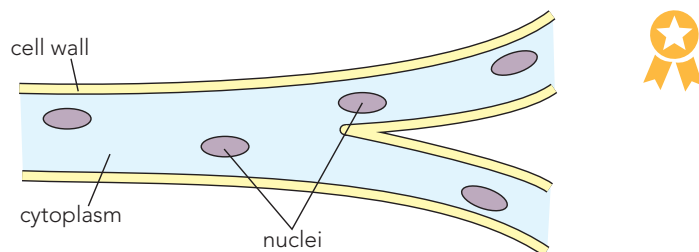


Scanning electron micrograph of yeast cells (× 1500)

There are many different types of yeast. People have used some types of yeast for centuries to make bread and drinks such as beer and wine. But different yeast cells can also cause diseases of the skin, the lungs and the brain.

Moulds

Moulds are very different from yeasts. They are made up of tiny, thread-like structures called hyphae. Hyphae are not made up of individual cells. Have a look at the structure of a mould hypha in the diagram below. See how it differs from the structure of the yeast.



Mould hyphae

Moulds need oxygen to respire. They get their food by digesting it outside their bodies and then taking in all the substances they need. This is why mouldy food goes very soft because it is being digested. Moulds reproduce, but they do not split in two. They make little fruiting bodies that are full of spores. Each spore can grow into a new mould.

You will be finding out more about fungi on pages 32, 39 and 41.

Key terms

- **fungus (plural fungi)**
- **hypha (plural hyphae)**
- **yeast**

Summary questions

- Explain the ways in which we can tell that fungi are living organisms.
 - Draw a table to compare yeasts and moulds.
- Moulds can make food go bad. Suggest ways to investigate the conditions moulds need to grow.
- Describe a method to make a slide so that you could study some yeast or mould under the microscope.
- What is the actual diameter of the yeast cells shown in the photo above? Explain the way you arrived at your answer.

Learning outcomes

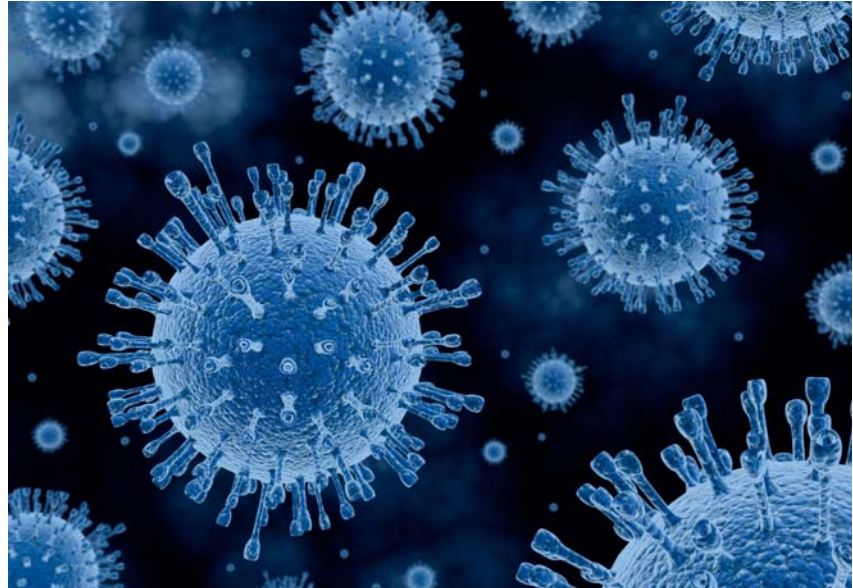
After this topic you should be able to:

- describe the structure of a virus
- explain what is meant by a parasite
- explain why viruses are such effective parasites.

Expert tips

Viruses are so simple, yet they can be so deadly. Unlike bacteria, fungi, animals and plants, they do not have cells. They have genetic material enclosed in a protein coat. Some, like HIV, are also surrounded by a membrane taken from their host cell.

Imagine a micro-organism that doesn't respire, feed, move, excrete or have any sensitivity – but which can reproduce by taking over other organisms. It sounds unbelievable – but this is what viruses do.

What is a virus?

Viruses look like something from outer space

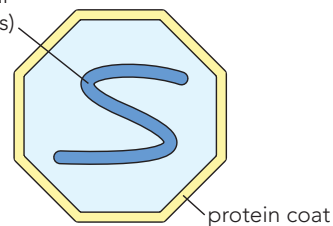
A **virus** is incredibly small, about 0.0001 mm long. Viruses can reproduce, but only inside the cells of another living organism such as an animal or a plant. Viruses don't respire or move themselves, feed or excrete so they are unlike any other living organism. Under very powerful microscopes viruses can be seen as strange shapes, which are made of protein and genetic material.



A single sneeze like this releases millions of viruses into the air for other people to breathe in – and catch your cold!



genetic material
(not in a nucleus)



The structure of a virus

Viruses and disease

All viruses cause diseases in living organisms. Diseases caused by viruses include colds, influenza, chickenpox, measles, polio and HIV/AIDS. Viruses cannot move themselves from one organism to another but they have found ways of spreading around in different ways. For example, the virus that causes the common cold spreads when people cough or sneeze.

Practical activity Make a virus!

Work in a group. Look for different images of viruses on the internet or in books. Choose one virus and find out what it looks like and what disease it causes.

Plan to make a model to show the structure of your virus. If there is time, make your model and present it to the class.

Viruses are parasites

Viruses are **parasites**. Some people say they are the ultimate parasite. But what does this mean? A parasite is an organism that takes what it needs to live from another living organism known as the host. A parasite always hurts its host, and sometimes it will even kill it.

As well as viruses our parasites include:

- animals, such as tapeworms and threadworms
- bacteria, such as *Mycobacterium leprae*, which causes leprosy
- fungi, such as *Candida*, which causes thrush.

Most parasites rely on their host for food, and sometimes protection. Viruses rely on their host for everything. Once viruses get into the body they invade the cells. The protein coat of the virus often stays outside the cell but the genetic material is injected through the cell membrane. The genetic material of the virus then takes control of the nucleus of the host cell. It uses the host to make lots of new viruses. Eventually the cell bursts and releases all of the new viruses. These then spread through the body and infect more cells. They can also leave the body and infect someone else.

We have developed antibiotic medicines which can be used to cure diseases caused by bacteria. However, we do not yet have medicines which can destroy viruses and so we cannot cure viral diseases.

Expert tips

We have used the scientific names for the bacterium that causes leprosy and the fungus that causes thrush. Each species has a name like this. Viruses, however, are named very differently without using words taken from Latin or Ancient Greek.

Key terms

- **parasite**
- **virus**

Summary questions

- 1 Why do some people think that viruses are not living organisms?
- 2 You may need to do some research to answer this question. State the range of lengths in millimetres of the following:
virus, bacterium, animal cell, plant cell
- 3 Make a diagram, chart or some models to compare the sizes of the different cells in question 2.
- 4 Why are drawings and photos of micro-organisms always magnified? What is the magnification of the viruses shown in the illustrations on these pages? Show your working.

Learning outcomes

After this topic you should be able to:

- explain how yeast is used in the production of bread
- explain the way bacteria are used to make yoghurt and cheese
- make conclusions from data collected in an investigation.

Every time you eat cheese, yoghurt or bread you are eating foods made using micro-organisms.

Bread making with yeast

If yeast cells have air, warmth and plenty of sugar, they will respire and grow very quickly, making lots of carbon dioxide as a waste product. For thousands of years people have used this to help them make bread that is light and airy. Flour, sugar, yeast and some water or milk are mixed together to make dough. The dough is kept somewhere warm to rise. As the yeast respire, the carbon dioxide bubbles make the dough get bigger. Its texture gets lighter. When the bread is cooked, the bubbles of gas get bigger and the dough rises even more.



The yeast in this naan bread made it rise when it was cooking

Yoghurt making using bacteria

Yoghurt is a creamy solid made by mixing bacteria with warm milk. The bacteria feed on the sugar in the milk and make a chemical called lactic acid. This gives the yoghurt its sharp, tangy taste. The lactic acid causes the milk to clot and solidify into yoghurt, and the action of the bacteria also helps to give it a smooth, thick texture. Once the yoghurt-forming bacteria have worked on the milk, they also help to stop other bacteria growing, which might turn the milk bad.



Many different animals including camels are used for milking. If the right bacteria are added, the milk soon turns into yoghurt

Practical activity Keeping milk good

Ordinary milk goes bad in just a few days – less than that if it gets really warm. Yoghurt lasts much longer.

Set up a simple investigation to show how the yoghurt-forming bacteria help keep the milk good for a long time.

- Measure out 10 cm³ of milk into each of two small containers or test tubes. Label the tubes 'Milk – room temperature' and 'Milk – cool'.
- Put 10 cm³ of yoghurt into each of two small containers or test tubes. Label the tubes 'Yoghurt – room temperature' and 'Yoghurt – cool'.
- Place one milk and one yoghurt container at room temperature on the side of your classroom
- Place one milk and one yoghurt container somewhere cool, such as a fridge.
- Observe all the containers every day and record the appearance and the smell of the contents. Once they have gone off, throw them away!
- Display your results and make your conclusions.



Make sure you do not taste the milk and yoghurt used in your experiment!

Using bacteria to make cheese

Cheese is made by the reaction of certain bacteria with milk, changing the texture and taste and also preserving it. Some cheeses can survive for years without going bad.

The bacteria used in cheese making produce a lot of lactic acid. This makes the milk separate into a very solid part (curds) and a liquid part (whey). Sometimes juices from the stomachs of young animals such as calves are added to make the milk separate even more.

The curds can be used fresh, often with herbs and seasoning added. They can also be mixed with salt and other bacteria, or even moulds, and then pressed and left to dry out. These hard cheeses can last a very long time.

Sometimes moulds are added to cheeses, or the cheeses are wrapped in the leaves of different plants. Both the moulds and the leaves give the cheese extra flavour.



In cheese making, solid curds are made by the action of bacteria on milk. The curds can be eaten fresh or turned into hard cheeses using more bacteria and salt

Key terms

- yoghurt

Summary questions

- a) Explain why bread dough put in the fridge or when cooked immediately after it is made does not rise.
 - b) Describe an investigation to find the effect of temperature on the bacteria that are used to make bread.
- 2 Work together in a group and find out about the making of a local cheese **or** yoghurt. Make a poster to explain the process. You could use your poster to contrast home production with industrial production using information from websites.