ESSENTIAL SCIENCE STAGE 7 FOR CAMBRIDGE SECONDARY 1

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Oxford excellence for Cambridge Secondary 1
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.
• 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.
2.1 Bacteria

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.

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.

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.
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:

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.

Summary questions

Expert tips

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.

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

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.
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.

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.

**Summary questions**

1. **a)** Explain the ways in which we can tell that fungi are living organisms.
   **b)** Draw a table to compare yeasts and moulds.

2. Moulds can make food go bad. Suggest ways to investigate the conditions moulds need to grow.

3. Describe a method to make a slide so that you could study some yeast or mould under the microscope.

4. What is the actual diameter of the yeast cells shown in the photo above? Explain the way you arrived at your answer.

**Key terms**

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

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.

Viruses look like something from outer space

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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.
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.
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 respires, 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.

**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.
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.

Summary questions

1 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.

Key terms

• yoghurt