B1.8 Microorganisms

Students' learning objective: *I am learning about microorganisms so I can describe how they grow and how the body defends against harmful ones.*

Students have learned about unicellular organisms and microscopes in Unit B1. In this topic they will learn about different microorganisms and how some are harmful while others are helpful. Students will look at gut bacteria and how they are helpful in Unit B3. When teaching this topic, some students may be concerned about infection and the fact that microorganisms are found everywhere. It is important to stress that many microorganisms do not harm us in any way.

Students will also learn about the factors that affect the growth of microorganisms and how the body defends itself against pathogens.

Knowledge check

After working through the *General science quiz*, display the *Knowledge check* slide. The questions are best delivered one by one on mini-whiteboards (MWBs). If students do not know the answer to any of them, you should reteach the relevant concept. Answers are not on the slides because it is best to go over them together as a class.

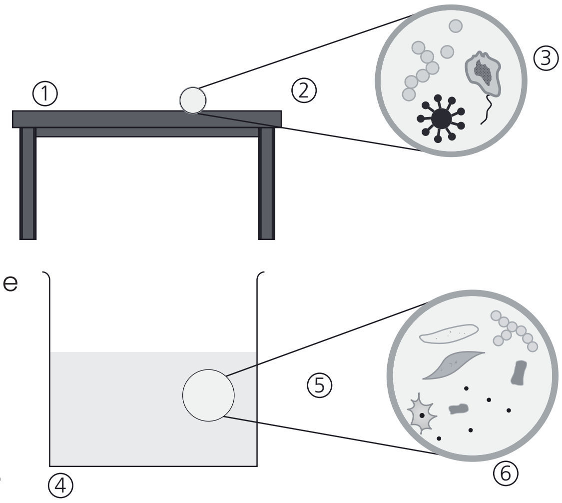
	Question	Answer	Notes
1	What is a unicellular organism?	An organism made of only one cell	This was covered in Topic B1.5.
2	What piece of equipment do we use to view small organisms?	Microscope	This was covered in Topic B1.1.
3	What are four sub-cellular structures found in all cells?	Cell membrane, cytoplasm, genetic material, ribosomes	This was covered in Topic B1.2.
4	What is a factor?	Something that can affect something else	Accept specific examples, such as 'temperature' or 'surface area affecting diffusion', as these were covered in Unit B1.
5	What do organisms need to survive?	Oxygen, nutrients, the right temperature, water	Accept 'food', but help students to see it is the nutrients in the food that are key.
6	Which gas in the air do bacteria need to grow?	Oxygen	

Guided explanation

What are microorganisms?

Students will have heard about microorganisms and have learned about the structures of single-celled organisms such as bacteria and yeast. In this topic, they will focus on the term *microorganisms* and look at how they can be helpful or harmful.

Draw the diagram below and explain as follows:



1. Look at this table surface. It is used as a desk in a school and is cleaned at the end of the day.
2. To look more closely at part of the table, we can use a microscope.
3. We might see various organisms such as bacteria, viruses and fungi. Many of them do not do anything to us. Some are harmful and some helpful.
4. Now look at some pond water in a beaker.
5. We can use a microscope to view the organisms living in the pond water.
6. We might see a different range of organisms here from those on the table surface. Some of these organisms are unicellular, while others are multicellular. What they have in common is that they are very small and we need a microscope to view them. We call these organisms *microorganisms*.

Check for understanding

The Check for understanding (CFU) is best conducted using MWBs. Display the *CFU* slide and ask questions like the ones below. Tailor and adapt your questions to the class in front of you.

- What is a microorganism?
- A scientist is looking at an organism they discovered in seawater. They can see the shape of the organism but need a microscope to view the structures inside it. Is this organism a microorganism?
- What are three examples of microorganisms?

Independent practice review

Students practise independently by answering questions 274–83 from their Practice Books. Full answers can be found on the *IP answers* slide or in the answer documents on Boost.

Q	Notes
282	Accept 'sperm cells do not perform the main functions that organisms do, such as reproduction'.

Core practical

Observing pond water using a microscope

A method is provided on the *Practical worksheet* and *Teacher and technician notes* in Boost – including equipment list and safety notes – if you wish to allow your students to proceed independently. However, for most students it will ordinarily be better to take a *Slow Practical* approach following the guidance below.

Students should work in groups of no more than three. For each group and for yourself, provide a microscope, pipette, glass slide, pond water, some disinfectant in a tub and paper towels.

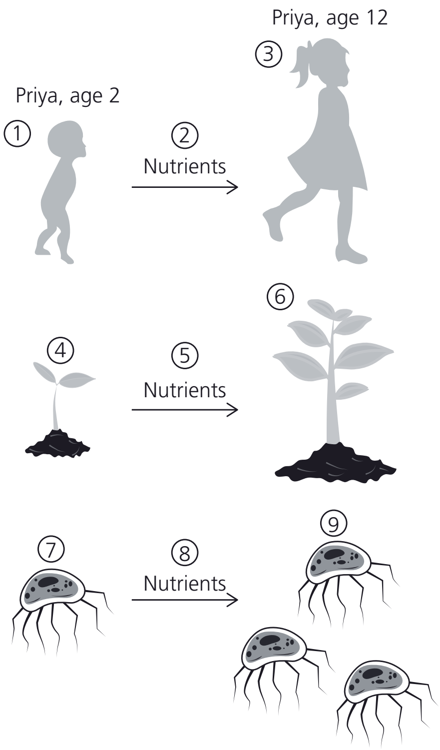
The ideal set-up would be to use a visualiser, if you have one, to make it easier for students to see as you model each step without leaving their workstation.

1. Assign the equipment by getting students to collect apparatus as needed and return to their workstation. Show students how to correctly carry a microscope.
2. Remind students how to place the specimen on the stage and how to focus the image. This would be the perfect time to use questioning to *Cold Call* students on the parts of the microscope and some of its key features. For example:
   - Which part of the microscope do we move to make the field of view smaller?
   - Which objective lens must we always use when first viewing an image using a microscope?
3. When students have accurately observed the sample under the microscope, they can record their observations by drawing a simple diagram on the *Practical worksheet*.

Guided explanation

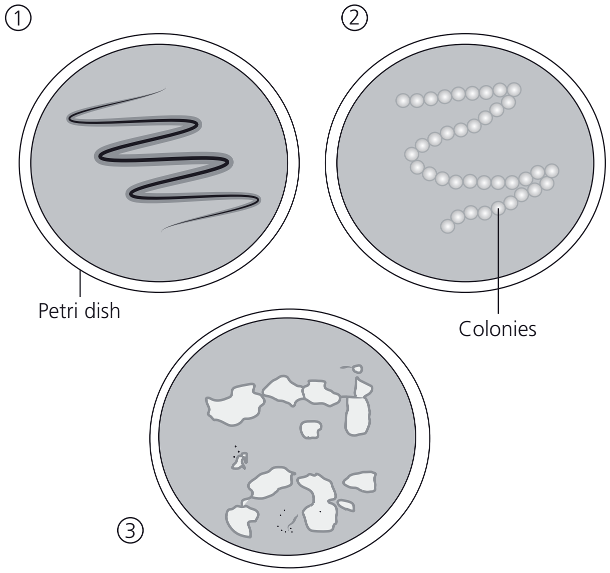
How do microorganisms grow?

Draw the diagram below and explain as follows:



1. This is Priya. She is 2 years old. In order to grow, she needs to eat well and drink lots of water.
2. If she gets lots of nutrients, over time Priya will grow.
3. Priya is now 12 years old and has grown taller.
4. Plants are similar. This is a sapling. It has only a few leaves and a shallow root system.
5. When we give it minerals and water, the sapling can make a lot of its own nutrients.
6. Over time, it will grow into a tree with many leaves and a deeper root system.
7. Microorganisms also need to grow, but they do so in a different way.
8. They still require nutrients to grow.
9. But instead of one microorganism becoming bigger, they grow in number. This is because most microorganisms are unicellular. The availability of nutrients is one factor that can affect the growth of microorganisms.

Now draw the diagram below and explain as follows:



1 We can grow microorganisms in a small, shallow dish called a *Petri dish*. The Petri dish has a nutrient agar on the bottom. This is a gel-like substance that provides the necessary nutrients for the microorganisms to grow. We can add a microorganism solution by swiping it across the top of the nutrient agar.
2 After a day, we might see small groups of microorganisms growing in the Petri dish as they use the nutrients in the agar. We call these small groups *colonies*.
3 After another day, the colonies would grow even larger. This is because there are many microorganisms on the dish.

Check for understanding

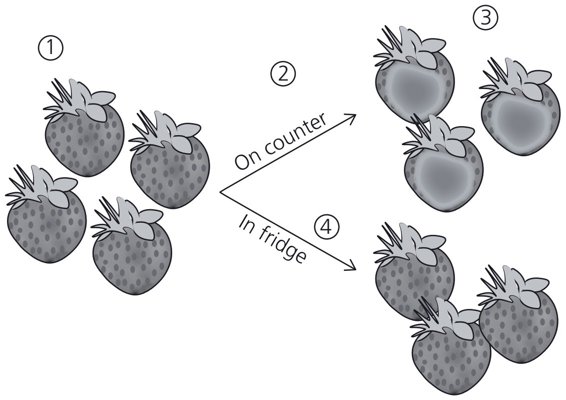
Display the *CFU* slide and, using MWBs, ask questions like the ones below.

- Why do microorganisms need nutrients?
- A student says bacteria grow larger when you give them nutrients. Why are they wrong?
- How do microorganisms grow differently from organisms?
- What do microorganisms need to grow?
- In terms of microorganisms, what is a colony?

Guided explanation

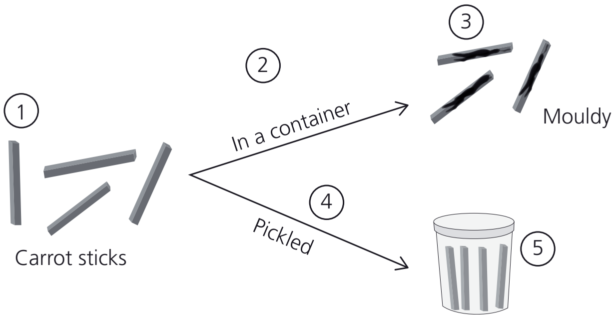
What effect do different conditions have on the growth of microorganisms?

Draw the diagram below and explain as follows:



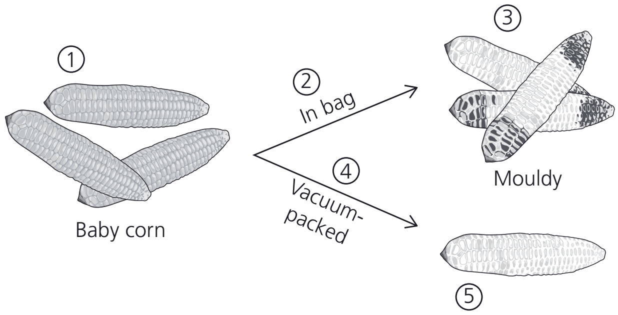
1 If I have some strawberries, I could do two things if I do not want to eat them right away.
2 I could leave them on the kitchen counter.
3 After a while, and especially if it is hot, the strawberries start to rot. I can see microorganisms growing on them. This is because the strawberries contain lots of nutrients and the warm temperature helps the microorganisms to grow.
4 The other option is to put the strawberries in the fridge.
5 The strawberries will last longer now because it is too cold for the microorganisms to grow, even though there are many nutrients in the strawberries. Temperature is a factor that can affect the growth of microorganisms. If the temperature is not the optimum (best) for the microorganisms to grow, they do not grow as quickly. If the temperature is much higher than the optimum, then the microorganisms can be killed. This is why cooking helps food last longer.

Next draw the diagram below and explain as follows:



1 If I have some carrot sticks, I could do two things if I do not want to eat them right away.
2 I could put them in a container in the fridge.
3 After a while, they will get mouldy and I will have to throw them away.
4 Instead, I could buy pickled carrots. These carrots are stored in a liquid that is acidic (something that is sour like vinegar). We say that the carrots are stored in a low pH.
5 This will stop microorganisms from growing in large numbers on the carrots and I can store them for longer. Another factor that can affect the growth of microorganisms is the pH. If the pH is the optimum, then microorganisms can thrive. If the pH differs a lot from the optimum, then the microorganisms will struggle to grow quickly.

Now draw the diagram below and explain as follows:



1 If I have some baby corn, I could do two things if I do not want to eat them right away.
2 I could put them in a bag in the fridge.
3 After a while, they can get mouldy, as microorganisms grow on them.
4 Instead, I could buy vacuum-packed baby corn. This means that all the air, including oxygen, has been taken out of the packaging.
5 The baby corn will last longer when it is vacuum-packed. This is because microorganisms need oxygen to survive.

Display the slide and explain as follows. In summary, there are four factors that can affect the growth of microorganisms:

- availability of nutrients
- optimum temperature
- optimum pH
- availability of oxygen.

If any of these factors are not optimum or not present, then microorganisms either grow slowly or not at all.

Check for understanding

Display the *CFU* slide and, using MWBs, ask questions like the ones below.

- Name the four factors that affect the growth of microorganisms.
- Why does fruit last longer when kept in the fridge?
- How does pH affect the growth of microorganisms?
- What happens to bacteria if there is not enough oxygen?
- What happens to microorganisms when the temperature is much higher than the optimum?

Independent practice review

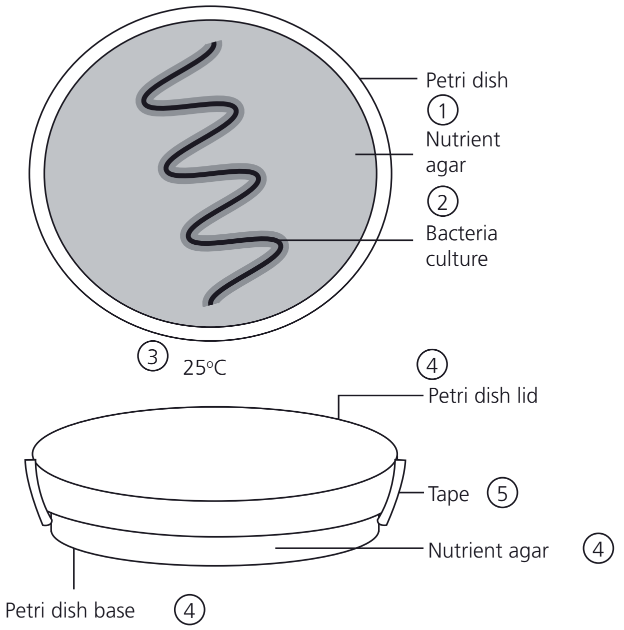
Student Practice Book questions 284–97.

Q	Notes
286a	Students are required to know only that colonies are groups of microorganisms.
287	Students need to remember that vinegar and lemon juice are acidic.
292	The chef has placed the rice on the counter instead of putting it in the fridge.
296	Students are required to know only that vinegar lowers the pH.

Guided explanation

How do we grow microorganisms?

Draw the diagram below and explain as follows:



1 We can grow microorganisms in a Petri dish that has a solid nutrient agar at the bottom. This nutrient agar has all the nutrients needed for microorganisms to grow well. It also provides a solid structure for them to grow on and form colonies. We use a Petri dish so we can easily grow microorganisms in a controlled, sterile environment. *Sterile* means that no other microorganisms are growing inside the dish. We can also observe the growth of microorganisms better when they grow in a Petri dish.

2 We add the microorganisms by carefully spreading them onto the surface of the nutrient agar using a swab.

3 We need to grow microorganisms at a constant temperature or else they will not grow properly. To do this, we place the Petri dish in an *incubator*. This is a machine that stores the Petri dish at a constant temperature. The temperature we use in schools is 25°C. We cannot incubate at higher temperatures, as this could encourage harmful microorganisms to grow.

4 Look at the Petri dish from the side. We can see the lid, base and nutrient agar.

5 To secure the lid onto the Petri dish, we use two pieces of tape, one on either side. The tape needs to be slightly loose. This allows air, which contains oxygen, to enter the Petri dish.

Check for understanding

Display the *CFU* slide and, using MWBs, ask questions like the ones below.

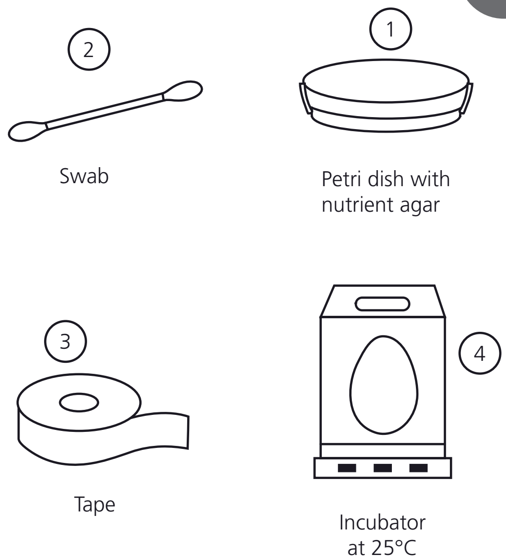
- Name the piece of equipment in which we grow microorganisms.
- How does the nutrient agar help microorganisms grow?
- At what temperature do we grow microorganisms in schools?
- Why should the tape securing the lid on a Petri dish be loose?

Guided explanation

Growing microorganisms in a Petri dish

Draw the diagram below and explain as follows:

1. When we grow microorganisms, we need a Petri dish that has solid nutrient agar in it. This has already been *sterilised*, which means that any bacteria already in or on the dish have been killed.
2. As a source of microorganisms we can use what we find on our hands. Use a swab to take a sample of these microorganisms.
3. Secure the lid onto the Petri dish using tape and ensure that the tape is loose so that air (oxygen) can still enter the dish.
4. This apparatus is an incubator. The temperature inside it is controlled, so that it stays the same or constant when switched on. We grow microorganisms at 25°C, so that no harmful ones can grow.



Check for understanding

Display the *CFU* slide and, using MWBs, ask questions like the ones below.

- What is the purpose of an incubator?
- What is the piece of equipment we use to grow microorganisms at a constant temperature?

Independent practice review

Student Practice Book questions 298–308.

Q	Notes
301	Students should explain that 25°C is important both to help microorganisms grow well and also to prevent harmful microorganisms from growing.
304	Accept 'to prevent contamination by other microorganisms'.
307	Accept answers that suggest the other food source may contain more nutrients for bacteria to grow even faster.

Core practical

Growing microorganisms in a Petri dish

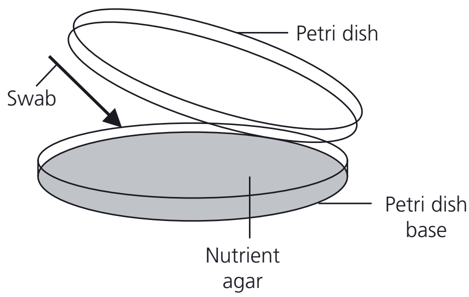
This practical can be undertaken only if your school has an autoclave to sterilise all equipment used.

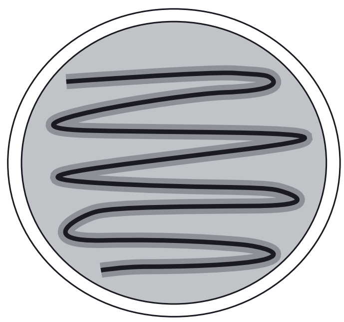
A method is provided on the *Practical worksheet* and *Teacher and technician notes* in Boost – including equipment list and safety notes – if you wish to allow your students to proceed independently. However, for most students it will ordinarily be better to take a *Slow Practical* approach following the guidance below.

Students should work in groups of no more than three. For each group and for yourself, you will require access to an incubator set to 25°C, two sterile Petri dishes containing solidified nutrient agar, sterile swabs, beaker with disinfectant (such as Milton), paper towels, access to running water and a sink, hand soap, stopwatch, tape and marker pen.

The ideal set-up would be to use a visualiser, if you have one, to make it easier for students to see as you model each step.

1. Assign the equipment by getting students to collect apparatus as needed and return to their workstations. Emphasise that the Petri dishes are sterile, so the lid should not be opened until needed.
2. Ask one student from each group to wash their hands with hand soap under running water for 60 seconds.
3. Another student from each group should use a sterile swab to take a sample from the student who has washed their hands by swabbing the palm, between fingers and on fingertips.
4. While lifting the Petri dish lid with one hand at an angle, as shown in the diagram, gently swipe the swab onto the nutrient agar in a zigzag pattern.
5. Replace the lid and discard the swab in the beaker containing disinfectant.
6. Take two small pieces of tape and loosely secure the lid at opposite points of the dish.
7. Turn the Petri dish upside down and label the base with your initials. Explain that we store the Petri dish upside down to prevent condensation from collecting on the bacteria as they grow inside the incubator.
8. Place the Petri dish in the incubator set to 25°C for at least 36 hours.
9. After 36 hours, ask students to make observations of any growth in the Petri dish.





Zig-zag pattern

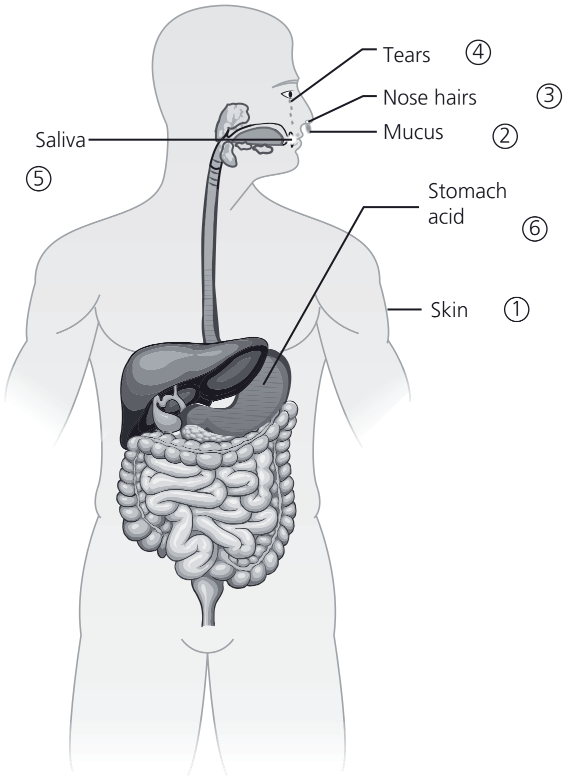
Ask questions such as:

- What do we call the clumps of microorganisms that have grown on the Petri dish?
- Why did we grow the microorganisms at 25°C?
- Why did we place the Petri dish upside down in the incubator?
- Why did we use an incubator instead of leaving the Petri dish on the bench for 36 hours?

Guided explanation

What is the body's first line of defence?

Draw the diagram below and explain as follows:



1 Some microorganisms are helpful to humans, but some can be harmful. Microorganisms that can cause disease are called *pathogens*. Our skin forms a physical barrier against these pathogens and is one of the most important defences against pathogens entering our body and making us ill.

2 As we breathe in, pathogens can enter through our nose. We have two defences here to stop them from reaching our lungs: the first is *mucus* in our nostrils, which traps pathogens that enter the nose. We then sneeze this mucus out.

3 The second defence is *nose hairs*, which trap dust, dirt and some microorganisms and therefore stop them from going any further. They sweep out the mucus that has microorganisms trapped within it. Together, the skin, nose hairs and mucus form the body's *physical* defences against pathogens.

4 If pathogens try to enter our eyes, our tear ducts produce a film of tears on the eyes' surface. These ducts also produce substances called *enzymes*, which kill pathogens that could enter through the eye. Enzymes do this by breaking down microorganisms' cell walls.

5 Pathogens can sometimes enter our bodies through the food or drink we consume. The saliva in our mouths contains enzymes that can kill microorganisms.

6 If pathogens pass through the mouth, they are killed by the strong hydrochloric acid in our stomachs. Together, tears, saliva and stomach acid form the body's *chemical* defences against pathogens.

Check for understanding

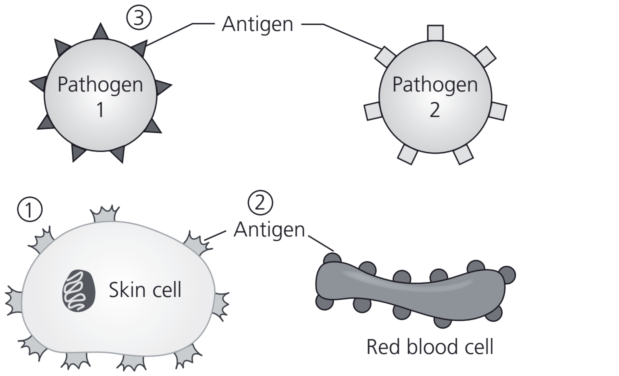
Display the *CFU* slide and, using MWBs, ask questions like the ones below.

- What is a *pathogen*?
- Is yeast that we use to bake bread a pathogen?
- Why are the bacteria in some yoghurts not pathogens?
- How does the skin protect us against pathogens?
- How do tears protect us from pathogens?
- How does the body protect us from pathogens in our food?

Guided explanation

What is the body's second line of defence?

Draw the diagram below and explain as follows:

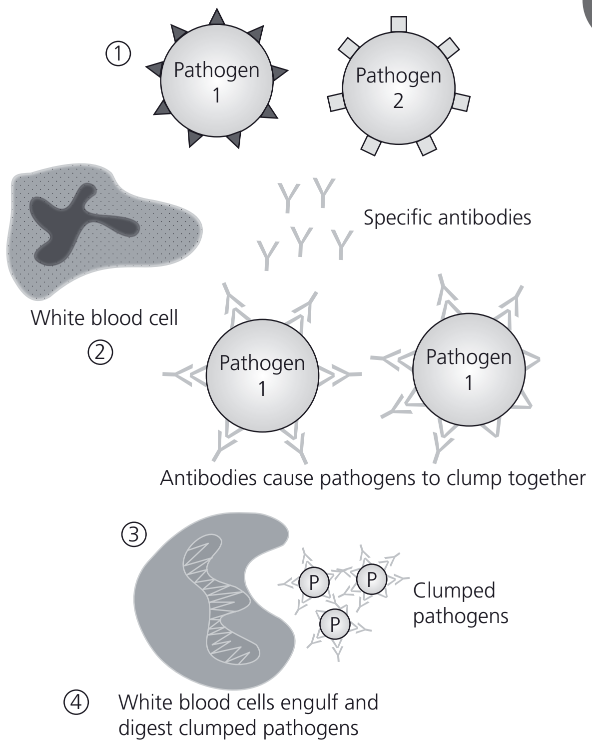


1 This is a skin cell. It has some proteins on its surface that help other cells to recognise it as a skin cell. These proteins are called *antigens*.

2 Now look at a red blood cell. It has different antigens on its surface that identify it as a red blood cell.

3 Pathogens also have antigens. Each type of pathogen has different antigens on its surface. This helps the body to identify a pathogen as being different. For example, pathogen 1 might be the virus that causes the common cold, while pathogen 2 might be bacteria that give us food poisoning.

Now draw the diagram below and explain as follows:



1 If pathogens enter our body and somehow get past the physical and chemical defences, our body needs another way to stop them from making us ill.

2 The body does this by using *white blood cells*. These are cells in our blood that do two important jobs to get rid of pathogens. The first is to produce proteins called *antibodies*.

3 These antibodies attach to the antigens on the surface of the pathogens. This causes the pathogens to clump together.

4 Another white blood cell can then engulf (surround) the clumped pathogens and digest them. This is how white blood cells get rid of pathogens that enter the body.

Check for understanding

Display the *CFU* slide and, using MWBs, ask questions like the ones below.

- What is an *antigen*?
- What is the difference between an antigen and an antibody?
- How are pathogens killed when antibodies attach to them?
- Why can't antibodies for one pathogen attach to another pathogen?
- Do only pathogens have antigens?

Independent practice review

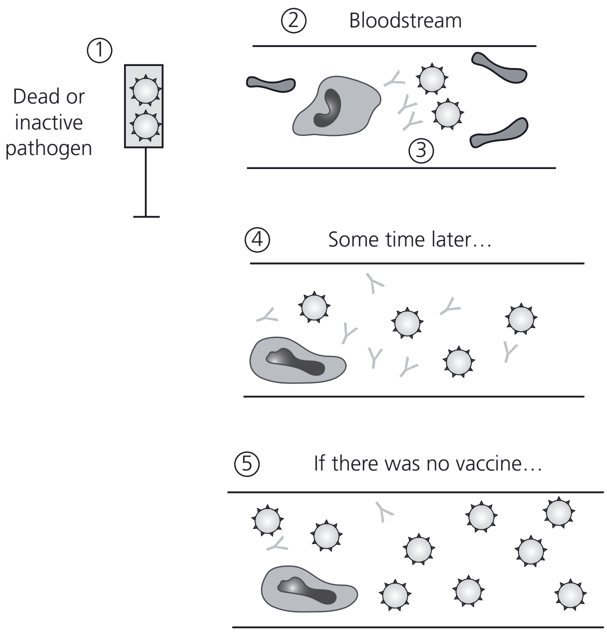
Student Practice Book questions 309–20.

Q	Notes
315	Students should answer in terms of pathogens.
319	Students should mention both saliva and stomach acid.

Guided explanation

How do vaccines work?

Draw the diagram below and explain as follows:



1 A *vaccine* is a substance that contains a small amount of dead or inactive forms of a pathogen. This pathogen still has antigens on its surface but it does not make us ill because it cannot function.

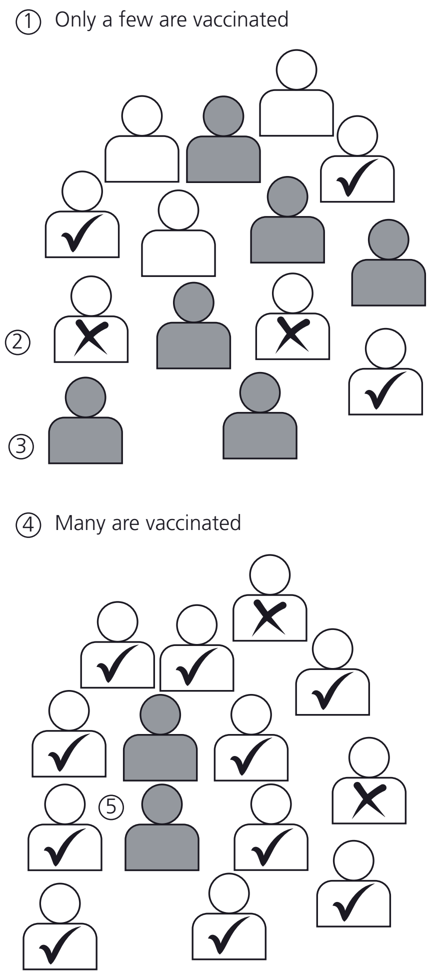
2 When the vaccine is injected into our bloodstream, our white blood cells identify the antigens as being different from those of our normal cells.

3 They then slowly produce a small amount of antibodies that are specific to the antigens on the dead or inactive pathogens. Some of these white blood cells become memory cells. The dead pathogens are cleared by being engulfed and digested by other white blood cells.

4 After some time, which may be months or years, when the vaccinated person is exposed to the real pathogen, there are more pathogens in the bloodstream. But the memory cells recognise the antigens on the pathogens faster than before, so they can produce more antibodies quickly. These antibodies can last longer in the bloodstream as well. The person does not become sick, as the pathogens do not have a chance to grow and make them ill.

5 If the person had not had a vaccine, then the pathogens could have reproduced and grown in number, and the white blood cells would not be able to produce antibodies as quickly. This would make the person ill.

Now draw the diagram below and explain as follows:



1 There is a population of people living in an area. Only a few people in this population are vaccinated against a pathogen.
2 There are a few people in this population who cannot be vaccinated. This is because they are too young or too old or they have an illness that means they cannot be given the vaccine.
3 When some people in this population are infected with the pathogen, they start to spread it. The few people who are vaccinated do not fall ill, but because many people have not been vaccinated, more people become ill, as the pathogen can spread easily and quickly.
4 Look again at the same population, but this time more people are vaccinated against the pathogen. There are still people who cannot be given the vaccine.
5 When someone in this more vaccinated population falls ill, they spread it to people who have not had the vaccine. However, as many people have had the vaccine, most of the population are protected and it becomes difficult for the pathogen to spread among this group. When a high percentage of the population has been vaccinated against a disease, the protection provided against spread of the disease is called *herd immunity*.

Check for understanding

Display the *CFU* slide and, using MWBs, ask questions like the ones below.

- What is in a vaccine?
- What do white blood cells do when they identify antigens in a vaccine?
- What happens to the dead pathogens in the body after antibodies are produced?
- Why can some people not be vaccinated?
- What is *herd immunity*?

Independent practice review

Student Practice Book questions 321–33.

Q	Notes
329	There are more reasons why a pathogen may not completely disappear, but, at this level, a response suggesting that not all people can be vaccinated is sufficient.