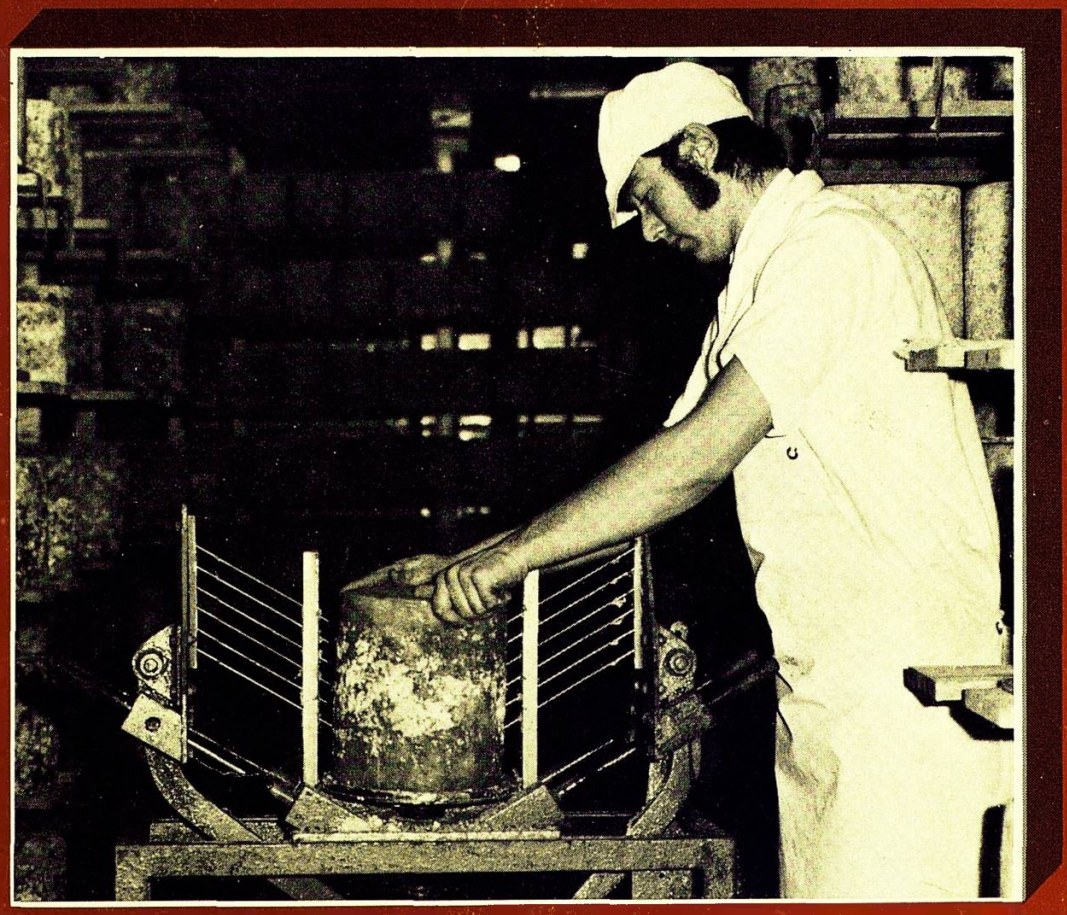
SCIENCE AT WORK



Food and Microbes

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Contents

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ABCDEF 79

1 The microscope

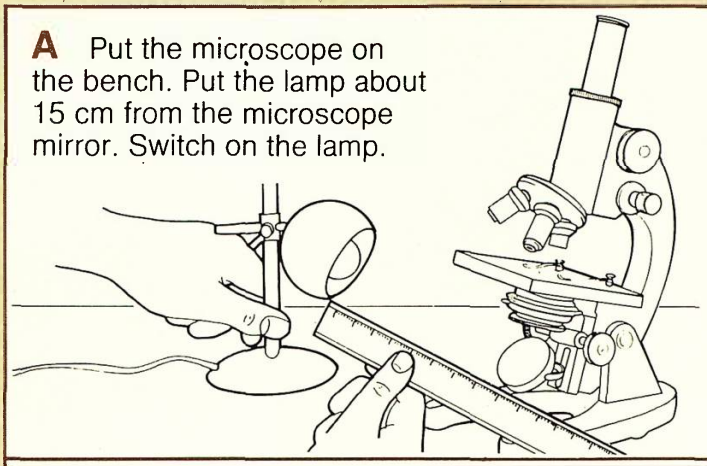
Using a microscope

Apparatus

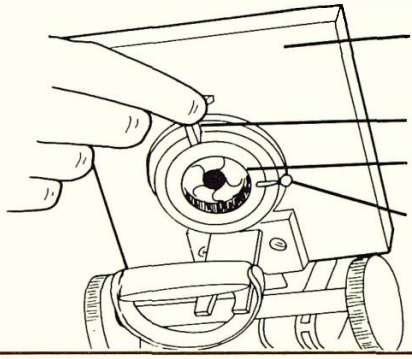
★ microscope ★ lamp ★ ruler ★ prepared slides

You are going to find out how to set up a microscope. A low power (small objective) lens is used for setting up. (Look at the drawing on page 3 for the names of the parts of a microscope.)

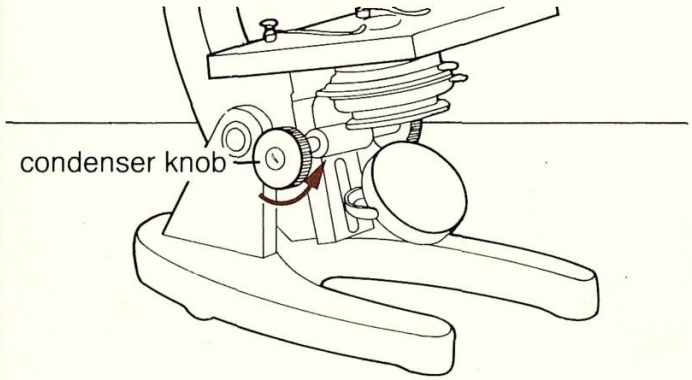
A Put the microscope on the bench. Put the lamp about 15 cm from the microscope mirror. Switch on the lamp.



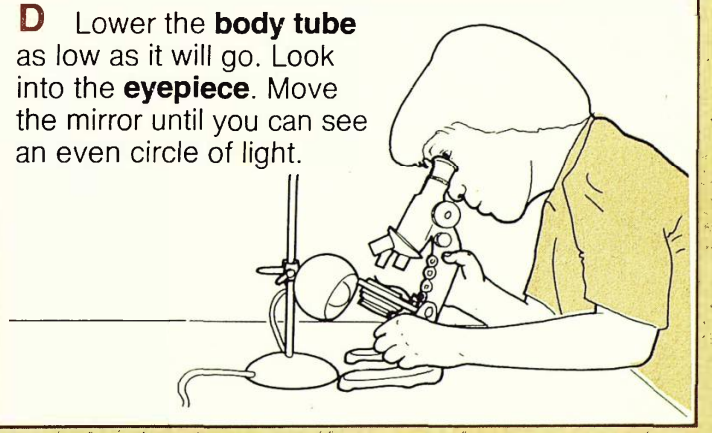
B Move the **iris lever** (underneath the **stage**) so that the iris is half open.



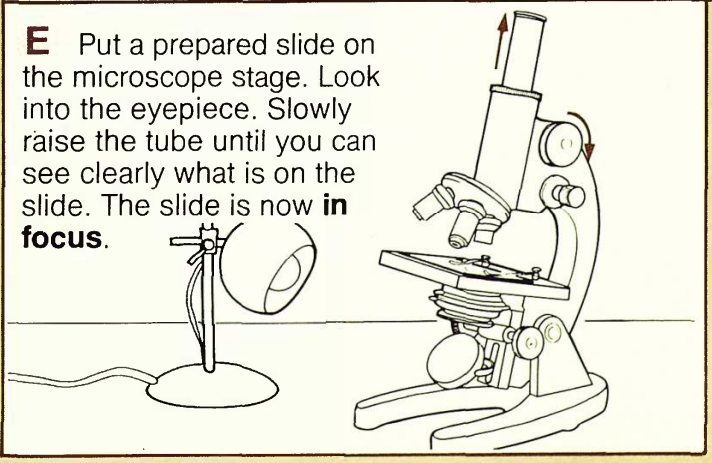
C Raise the **condenser** as high as it will go.



D Lower the **body tube** as low as it will go. Look into the **eyepiece**. Move the mirror until you can see an even circle of light.



E Put a prepared slide on the microscope stage. Look into the eyepiece. Slowly raise the tube until you can see clearly what is on the slide. The slide is now **in focus**.



Q1 Why do you move the mirror when setting up the microscope?

Q2 Describe how you bring an object into focus (as you did in step E).

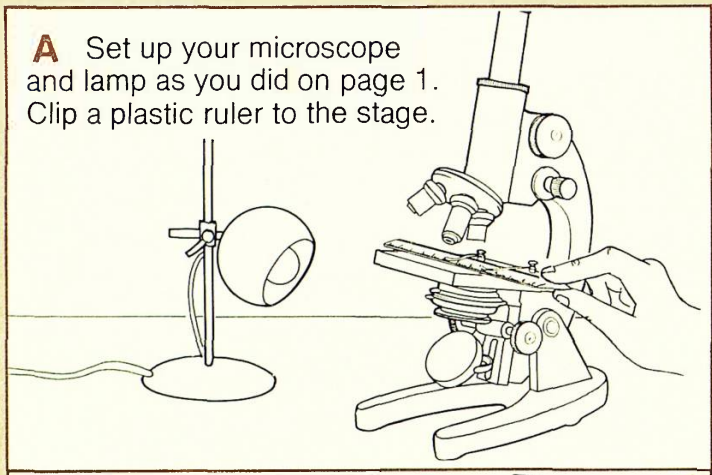
Making things look bigger

Apparatus

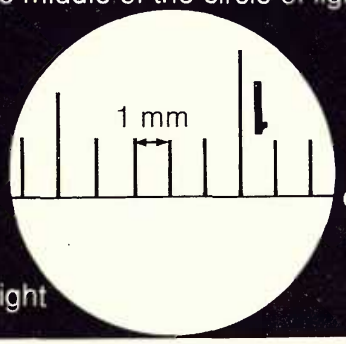
★ microscope ★ lamp ★ prepared slides of diatoms or pollen grains
★ clear plastic ruler

You are going to find out how to measure things with a microscope.

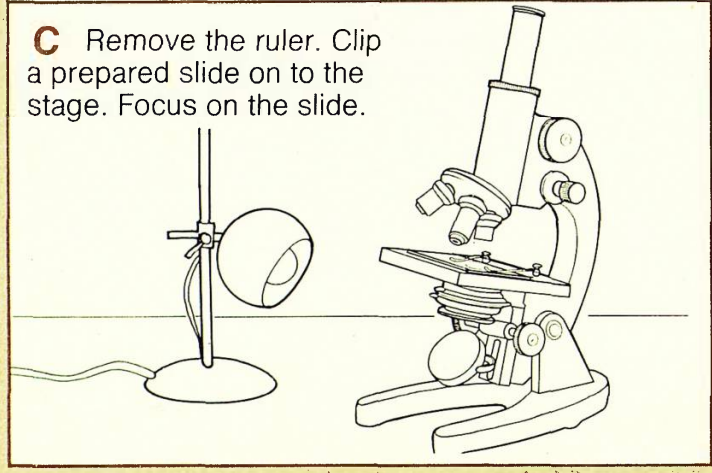
A Set up your microscope and lamp as you did on page 1. Clip a plastic ruler to the stage.



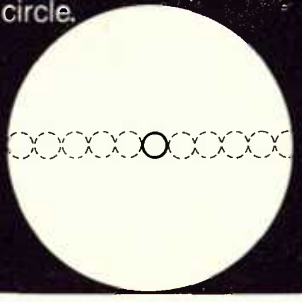
B Focus on the ruler. It should look something like this drawing. Measure (in mm) the distance across the middle of the circle of light.



C Remove the ruler. Clip a prepared slide on to the stage. Focus on the slide.



D Find one object on the slide that you can see clearly. Imagine that several such objects were put side by side across the middle of the circle of light. Try to work out how many objects would fit across the circle.



Q3 What was the distance (mm) across the middle of the circle of light?

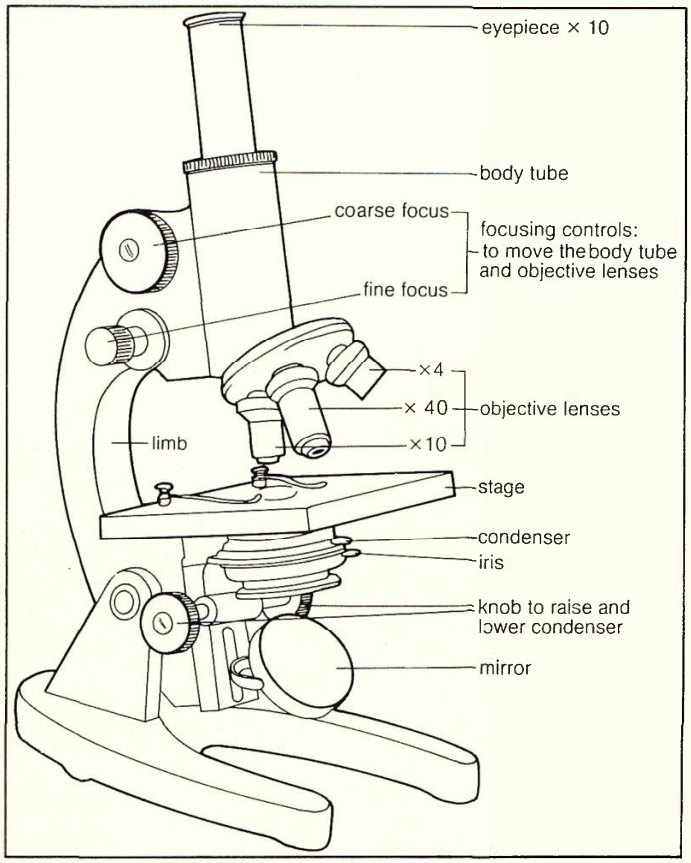
Q4 How many objects on your slide could be put side by side across the middle of the circle?

Q5 Suppose the distance across the circle of light is 5 mm and 10 objects could fit across it. This means that:

1 object measures $\frac{5}{10}$ mm
or
1 object measures 0.5 mm

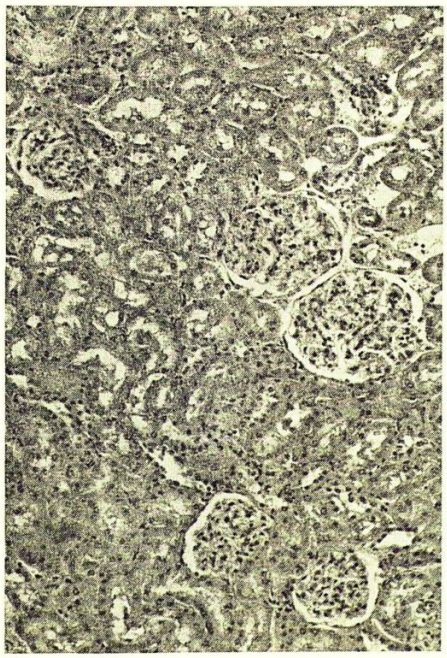
How big is one of your objects?

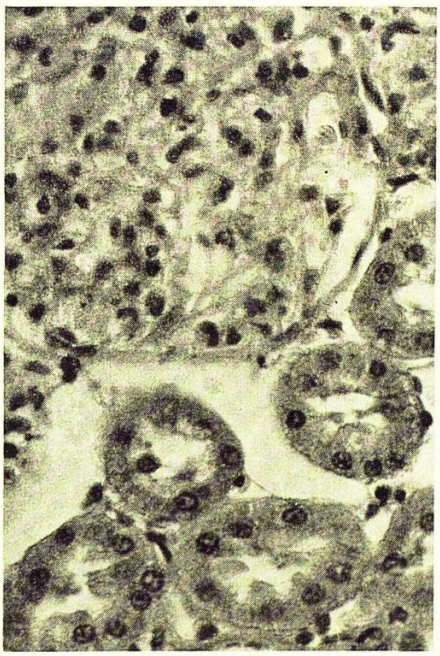
Information: Magnifying things



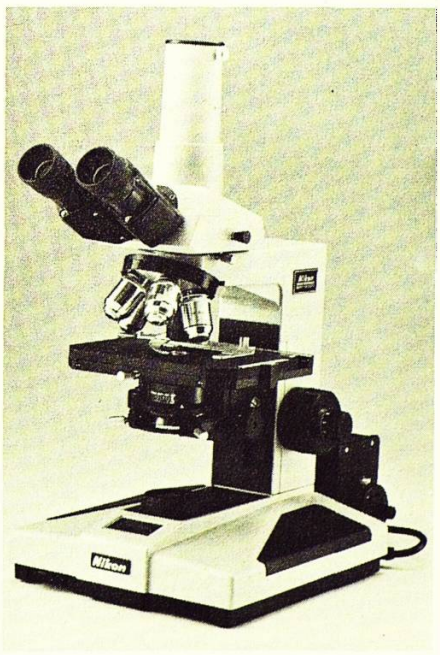
Glass lenses make things look bigger, or **magnify** them. A microscope has several lenses fixed into a tube. To find out how many times a microscope magnifies, the number on the **eye-piece** and the number on the **objective lens** are multiplied together. The result is its **magnification.**

The microscope in the drawing can magnify objects 100 times. They appear 100 times bigger than they really are.





A microscope makes the fine details of objects look bigger. These photos both show part of a rat's kidney. The one on the left is ×100, the one on the right is ×400.



Some microscopes are very complex. This one is used in a medical laboratory. All microscopes must be protected from grease and dust on hands, and from liquids on slides.

The microscope

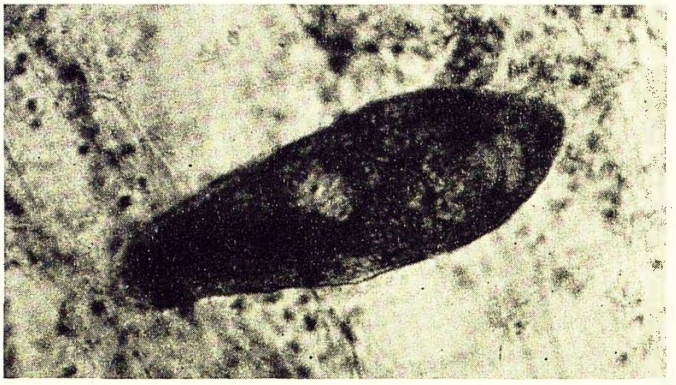
Q6 If a photograph of a specimen carries the mark ×420, what does this mean?

Q7 What substances might damage a microscope?

Information: Types of microbes

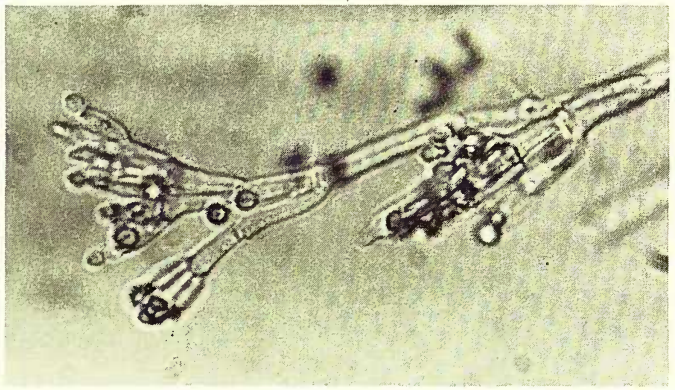
Microbes are very small living things that cannot usually be seen without a microscope. Some microbes are so small that even the most powerful microscope cannot magnify them enough for us to see them. There are four kinds of microbe: **protozoa**, **fungi**, **bacteria** and **viruses**. Most of them cannot make their own food.

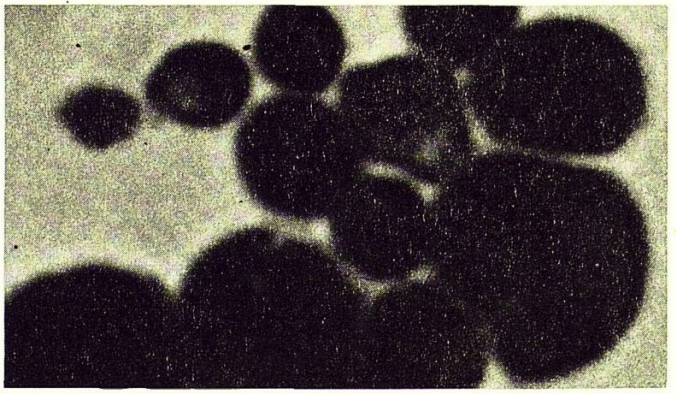
Protozoa



There are about 30 000 kinds of protozoa. They are small living things and each is just a single **cell**. Some protozoa live in water, some in soil and some in the bodies of other animals. The left-hand photo shows *Entamoeba* (×1600). This protozoan can be found in the human gut and causes **dysentry.** The photo on the right shows *Paramecium* (×400) which lives in pond water.

Fungi



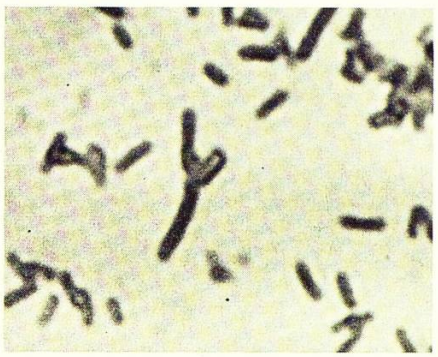


Fungi are plants that do not have the green substance, **chlorophyll**, in their cells. Some fungi, such as **toadstools, mushrooms** and **moulds** can be seen without a microscope. Others, such as **yeasts**, can only be seen when magnified by a mcroscope. The photos show examples of fungi: *Penicillium* (×400) on the left and yeast (×1000) on the right.

Bacteria

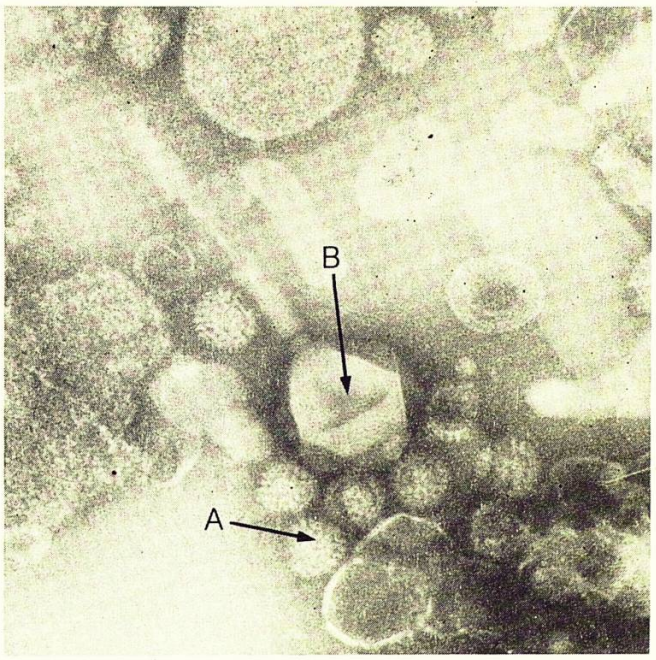
Bacteria are very small cells that can only be seen with a microscope that magnifies at least 400 times. The photo shows one of the largest bacteria. It is *Bacillus megaterium* (×1000).

This photograph shows part of a dead cell taken from a human cheek. It is surrounded by bacteria (×1600).



Bacteria have many different shapes. Some have a **spiral** shape. Some are round. Others have **threads** on their body to help them move. The picture shows **rod** bacteria (×1600).

Viruses



Viruses are so small that they can only be seen with the help of a special microscope, known as an electron microscope. Viruses can only live inside the cells of living animals, plants and bacteria. Some viruses look like crystals. The photo shows two types of virus, a round one (A) and a larger one (B) with a head and tail (×20000).

Q8 How many kinds of microbe are there?

Q9 How many kinds of protozoa are there?

Q10 Where might you find protozoa?

Q11 What is a fungus?

Q12 How could you classify (or group) bacteria?

Q13 Where do viruses live?

2 Fungi

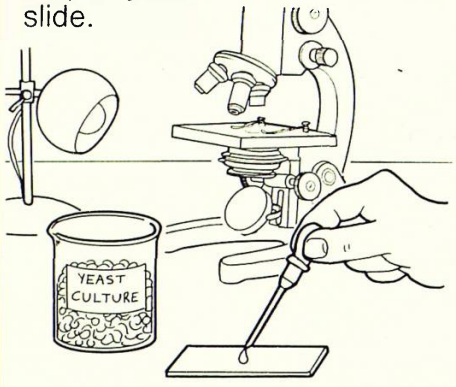
Looking at yeasts and moulds

Apparatus

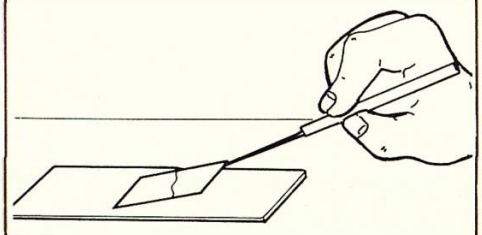
★ microscope ★ lamp ★ 2 droppers ★ tweezers ★ mounted needle
★ 2 slides ★ 2 cover slips ★ yeast culture ★ bread mould culture
★ stop clock

You are going to look at two kinds of fungus with a microscope.

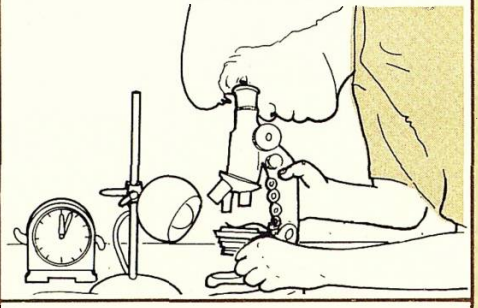
A Set up a microscope and a lamp on the bench. Put one drop of yeast culture on to a slide.



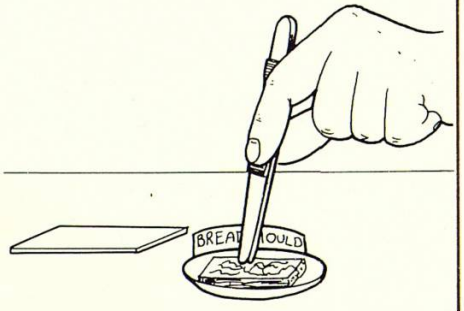
B Carefully, put a cover slip over the drop of culture. Try not to trap any air bubbles.



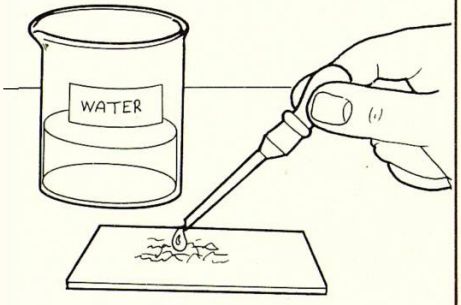
C Look through the eye-piece at the culture under the microscope. Watch the cells for 5 minutes. Note any changes that happen to the cells. Then remove the slide.



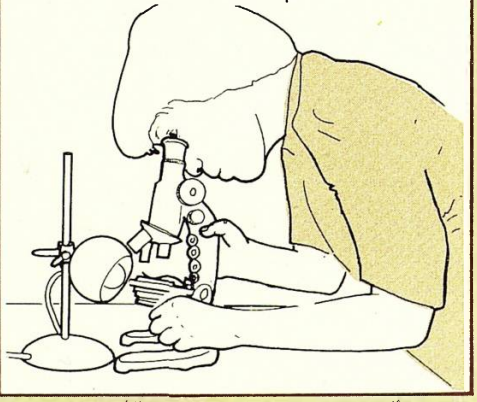
D Using tweezers, pick up a few pieces of mould from some bread mould culture. Put them on to a slide.



E Using a clean dropper, add one drop of water to the culture on the slide. Put a cover slip over the drop of culture.



F Look through the eye-piece at the bread mould under the microscope.



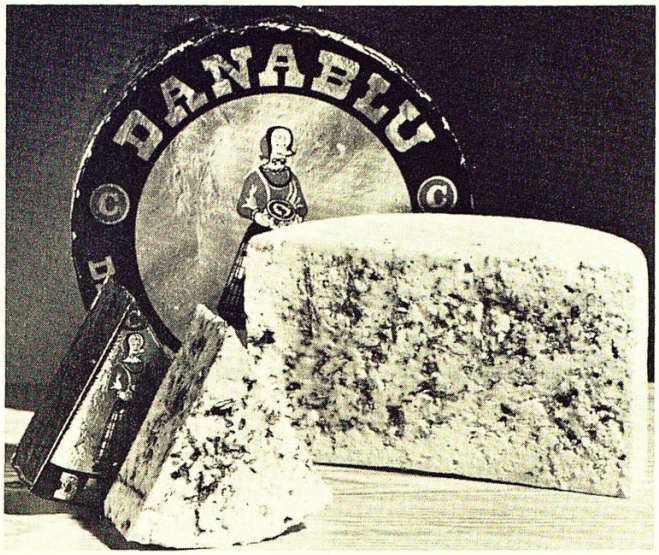
Q1 How would you describe the yeast cells: round, square or oval?

Q2 Did the yeast cells change at all as you watched them?

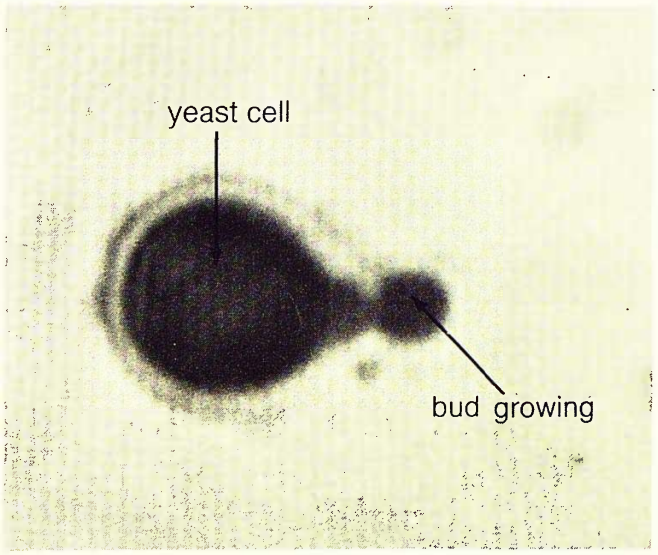
Q3 What does the bread mould fungus look like?

Q4 Make a drawing of the bread mould as it appears under the microscope.

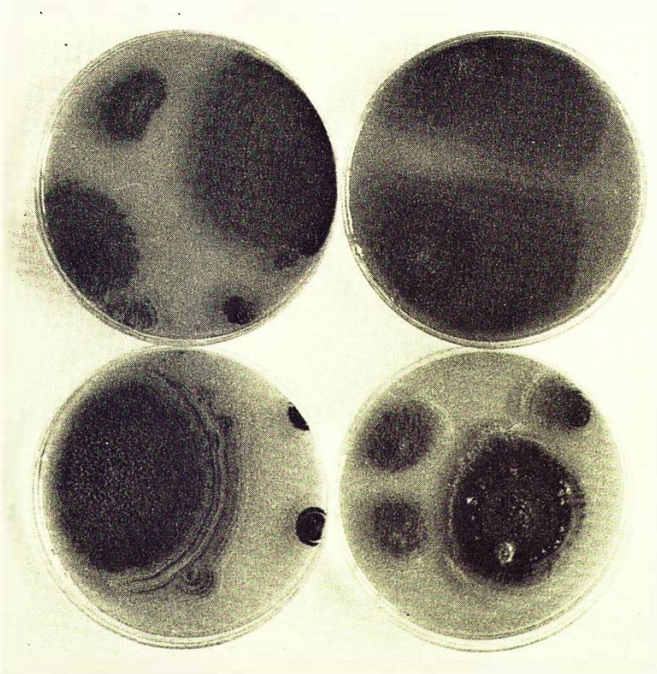
Information: Moulds and yeasts



Moulds can grow on many foods. Sometimes, we want mould to grow on food. The blue **veins** in cheeses are caused by the *Penicillium* mould.



Yeast cells grow when they have enough food. When the cell reaches a certain size, the cell splits into two. This is how the number of yeast cells in a culture increases. The photo shows a yeast cell dividing (×1600).



Fungi, such as moulds and yeast, feed on bread and fruit. The fungi pass chemicals on to the food. These chemicals help to dissolve the food and change it so the fungi can absorb it. The photo shows mould colonies.
Some moulds are very important in medicine because they can be used to make **antibiotics.** Antibiotics are chemicals which can kill some of the bacteria that cause diseases. The mould *Penicillium* is used to make an antibiotic called **penicillin.** Two other antibiotics are **streptomycin** and **aureomycin.**

Q5 How do we make use of moulds in food?

Q6 What happens to yeast cells when they have enough food?

Q7 How do fungi damage food such as fruit and bread?

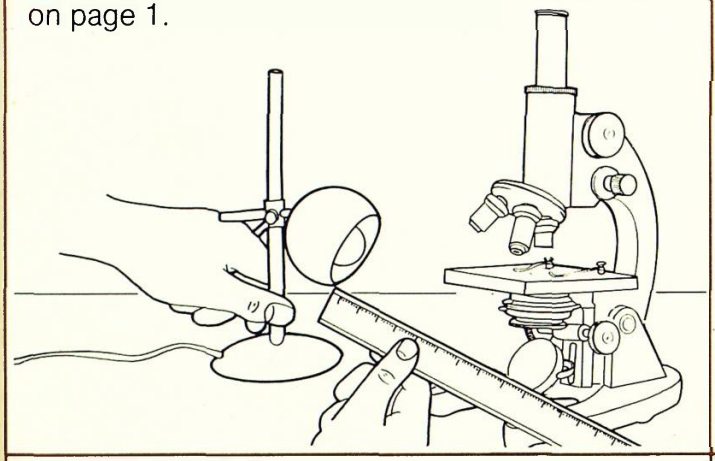
Identifying moulds

Apparatus

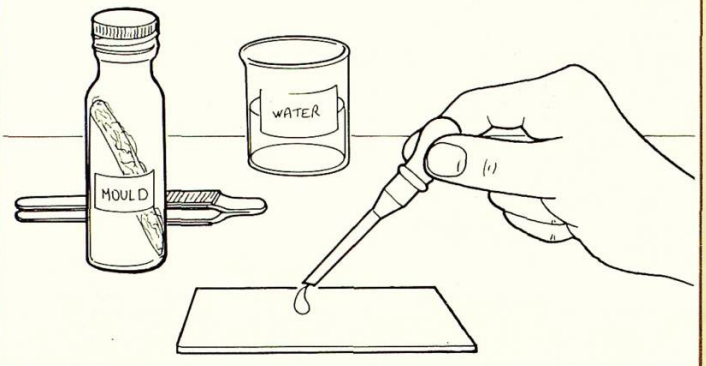
★ microscope ★ lamp ★ microscope slides ★ cover slips ★ dropper
★ mounted needle ★ mould cultures ★ beaker of water ★ tweezers

You are going to look at moulds with a microscope and try to identify them.

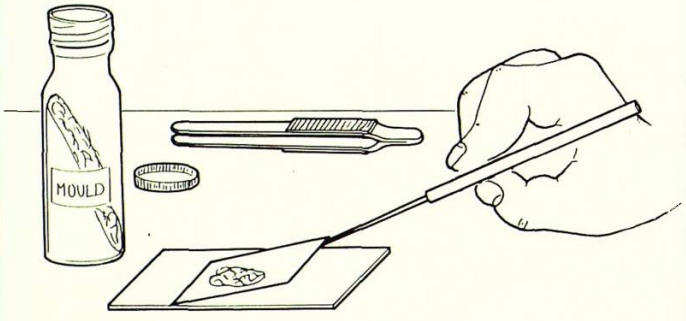
A Set up a microscope and a lamp as you did on page 1.



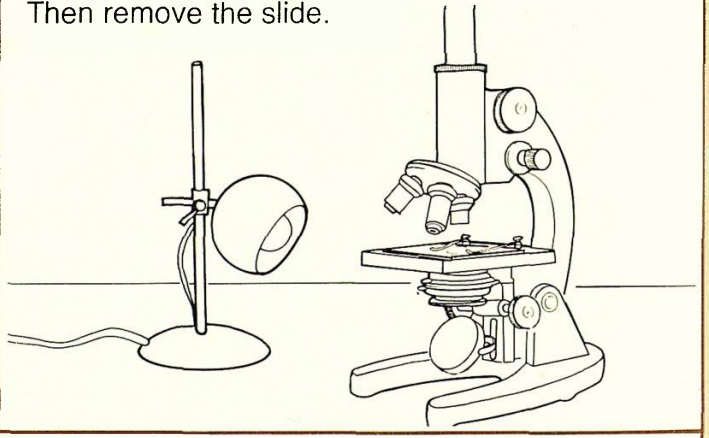
B Put one drop of water on to a microscope slide. Use tweezers to put some bits of mould into the drop.



C Using a mounted needle, carefully lower a cover slip on to the drop on the slide. Try not to trap air bubbles.



D Clip the slide on to the microscope stage. Look through the eyepiece at the mould culture. Use the table on page 9 to identify the mould. Then remove the slide.



E Repeat steps B to D with as many moulds as you have time for.

Q8 Why must the microscope be kept upright when you look at the culture?

Q9 Why is a cover slip put on top of the culture?

Q10 Use the table on page 9. Write down the names of any moulds you see.

Information: Identifying moulds

Moulds are very simple plants. Most moulds feed on decaying organic matter. Some moulds feed on simple animals, such as small worms. Humans eat some moulds, such as those in blue cheese. Other moulds spoil foods and can cause diseases in humans, such as ringworm. Use this table to help you identify moulds.

START HERE → Moulds

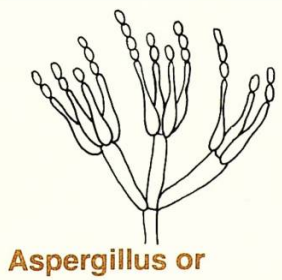
Do the threads that form the mould have cross-walls?

Yes

Are the threads clear and colourless or brightly coloured?

Do spores look like brush-heads?

Then it may be:

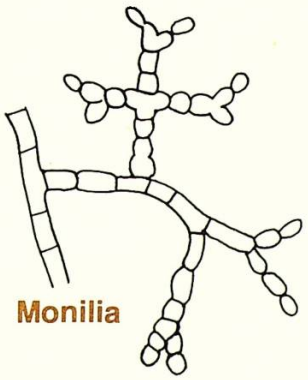


Aspergillus or

Penicillium

Do spores form chains and branches?

Then it may be:



Monilia

Are the threads dark coloured and cloudy?

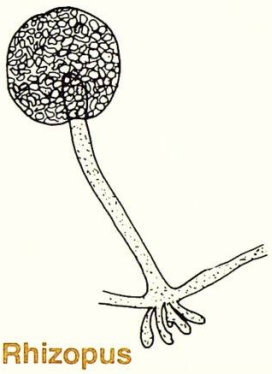
Then it may be:

Cladosporium

No

Do spore-bearing threads have a clump of roots at the bottom?

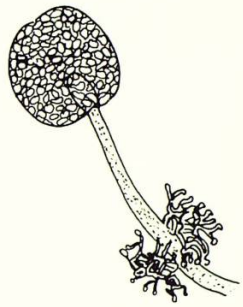
Then it may be:



Rhizopus

Do spore-bearing threads have a tangle of smaller spores at the bottom?

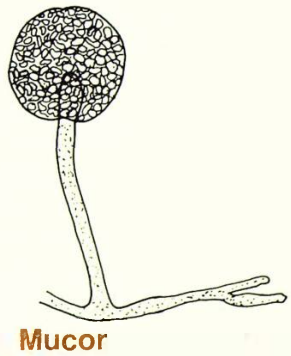
Then it may be:



Thamnidium

Is there no other growth at the bottom of the spore-bearing threads?

Then it may be: →



Mucor

You may see moulds in your experiment on page 8 that are different from those shown here. If so, ask your teacher to help you.

Q11 In what way can moulds harm humans?

Q12 In what way can moulds help humans?

3 Bacteria

Looking at bacteria

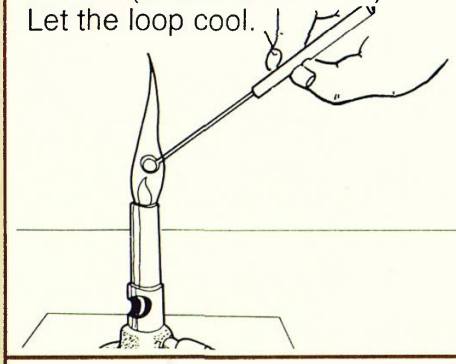
Apparatus

★ microscope ★ lamp ★ grease-free slide ★ dropper ★ wire loop
★ bench swabs ★ mounted needle ★ Bunsen burner ★ heatproof mat
★ bacteria culture ★ safranine dye ★ distilled water

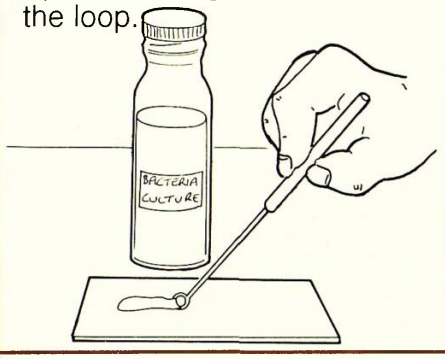
You are going to look at bacteria with a microscope. Bacteria are **transparent**, so they have to be dyed or **stained** before you can see them.

Wash your hands and swab the bench before and after the experiment.

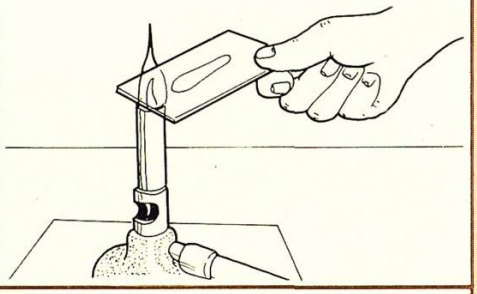
A Hold a wire loop in a Bunsen flame until the loop is red hot (about 10 seconds). Let the loop cool.



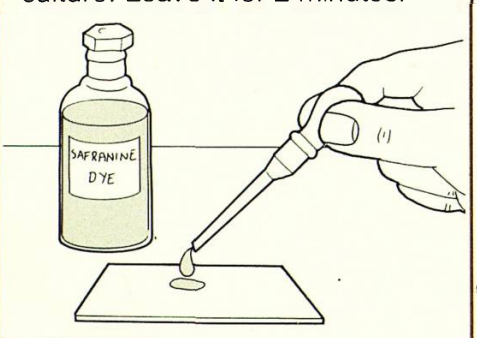
B Put 2 or 3 wire loopfuls of bacteria culture on a slide. Spread it along the slide with the loop.



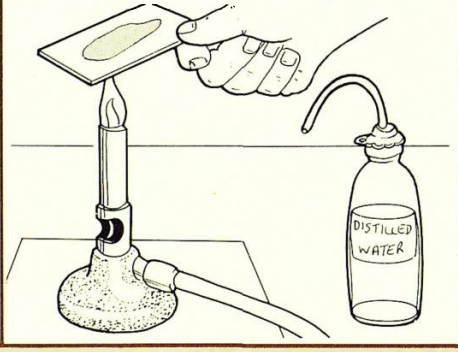
C Pass the slide once through the Bunsen flame. Then hold it over the flame for a few seconds to make the culture stick to the slide.



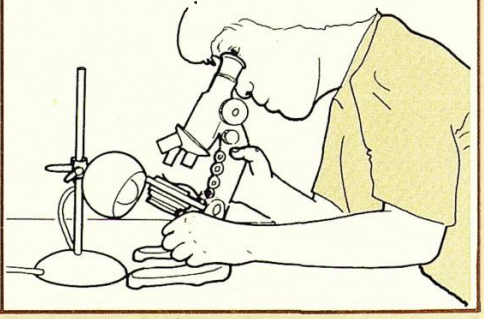
D Using a clean dropper put 2 or 3 drops of stain on the culture. Leave it for 2 minutes.



E Rinse the slide with distilled water. Hold it over the Bunsen flame to dry.



F Look at the slide under the microscope. You will need to magnify it about 400 times. Then wash your hands.



Q1 Make a drawing of the bacteria as they appear under the microscope.

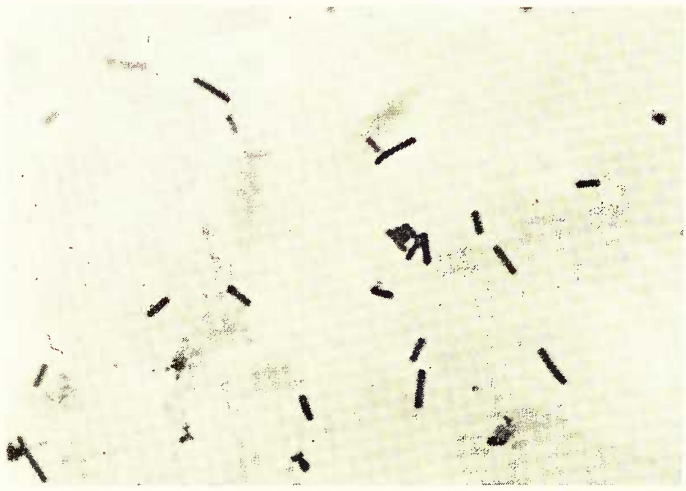
Q2 Why are the drops of culture spread along the slide?

Q3 Why do you have to stain the bacteria?

Q4 How do you make the bacteria stick to the slide?

Q5 What shape are the bacteria?

Information: More and more bacteria



When bacteria are warm and have a good food supply, they grow. So the numbers of bacteria increase. One bacterium can produce 1 000 000 (1 million) more bacteria in 15 hours.

The photo shows bacteria (×1600) that spoil food. As the bacteria multiply, they stick together to form **strings.**

If it gets cold, or there is no food, some bacteria develop a tough coat. The bacteria are then called **spores**. They can remain alive a long time without food or warmth.

There are some conditions in which bacteria do not grow well. Most bacteria do not grow in acids, such as ethanoic acid (**vinegar**).

Bacteria do not grow in very cold places (below −20 °C), such as in a freezer.

Q6 What happens to bacteria when they are warm and have plenty of food?

Q7 How many bacteria can one bacterium produce in 15 hours?

Q8 What happens to bacteria in freezing conditions?

Q9 How could you treat onions to make sure bacteria would not grow on them?

4 Using microbes

Using yeast to make bread

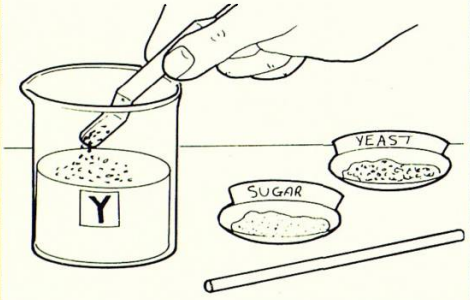
Apparatus

★ two 100 cm^3 beakers, labelled X and Y ★ measuring cylinder ★ glass rod
★ spatula ★ 2 mixing bowls, labelled X and Y ★ tablespoon ★ baking tray
★ oven ★ stop clock ★ salt ★ yeast ★ sugar ★ flour
★ 2 pieces of lard (5 g each)

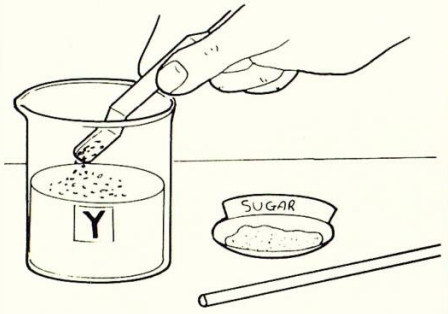
You are going to find out why yeast is used to bake bread.

Wash your hands before you start the experiment.

A Put 50 cm^3 warm water in beaker Y. Add 2 spatulas of yeast. Add 2 spatulas of sugar. Stir gently. Leave the mixture for 10 minutes until bubbles appear.

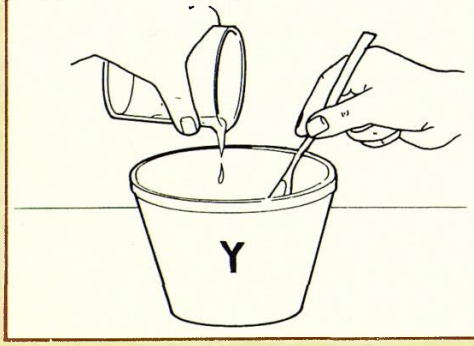


B Put 50 cm^3 warm water in beaker X. Add 2 spatulas of sugar. Stir gently. Put the mixture to one side and go on to step C.

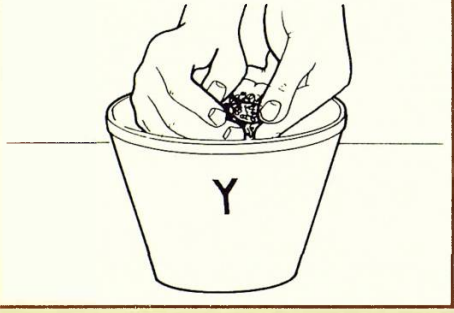


C Put 2 heaped spoonfuls of flour in mixing bowl Y. Add a pinch of salt. Mix together. Rub in 5 g of lard.

D When the mixture in beaker Y is ready add a little of it to bowl Y. Stir. Repeat this step until you have a firm dough.



E Knead the dough until it feels smooth and elastic. Leave the bowl of dough on a radiator for 20 minutes. Repeat steps C to E using beaker X and bowl X.



F Put the dough (with yeast) on a tray. Mark the top with a Y. Put the other dough on the tray. Bake in a very hot oven for 20 minutes.

Q1 Which loaf is largest after baking?

Q2 Which loaf feels heaviest after baking?

Q3 Why do you think yeast is used to bake bread?

Using yeast to make wine

Apparatus

★ 4 boiling tubes ★ 2 test tube racks ★ wax pencil ★ 4 cotton wool balls
★ 2 spatulas ★ dried yeast ★ sugar ★ beaker of apple juice ★ fridge

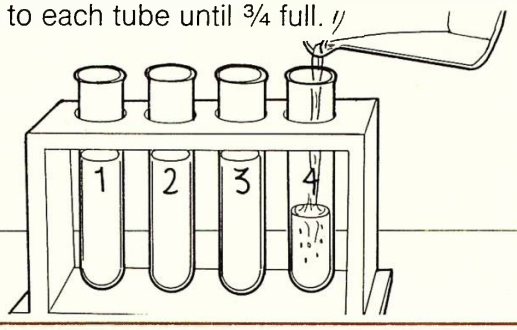
You are going to make some wine by **fermenting** apple juice and yeast.

Never taste anything in the laboratory unless your teacher has told you to do so.

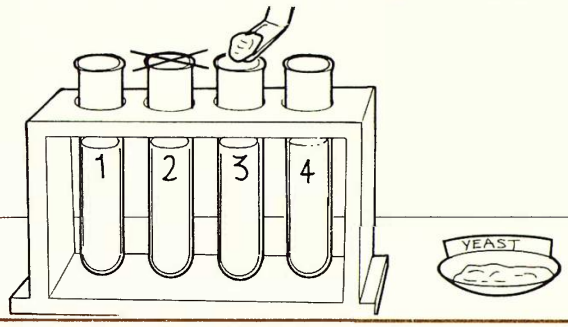
Q4 Copy this table.

Tube number	Contents of tube	Appearance of tube contents after one week	Smell of tube contents after one week	Taste of tube contents after one week

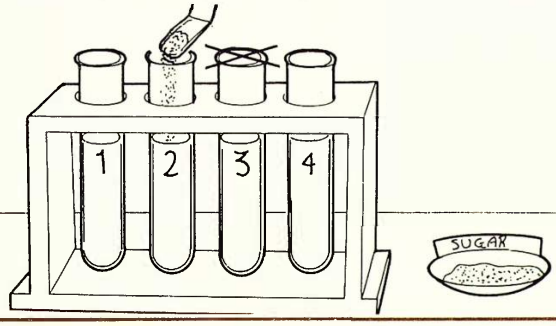
A Label 4 boiling tubes 1, 2, 3 and 4. Add apple juice to each tube until ¾ full.



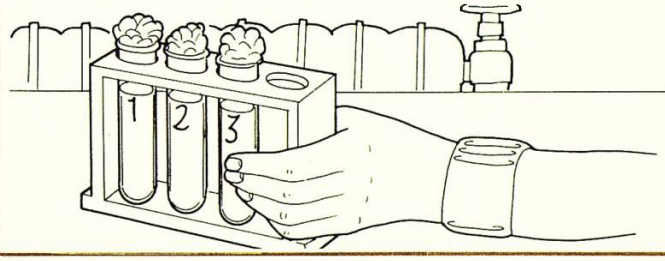
B Add 1 spatula-tip of yeast to tubes 1, 3 and 4.



C Add 1 spatula-tip of sugar to tubes 1, 2 and 4.



D Put cotton wool in the top of each tube. Then put tubes 1, 2 and 3 on or near a radiator. Put tube 4 in a fridge. Leave for one week.



E After one week look at all the tubes. Smell their contents. Try tasting their contents. Complete the table.

Q5 After one week, was there any difference between tubes 1 and 4?

Q6 What reasons can you give for your answer to Q5?

Q7 After one week, was there any difference between tube 1 and 2 or 3?

Q8 What reason can you give for your answer to Q7?

Q9 What kind of microbe is yeast?

Making cheese and yogurt

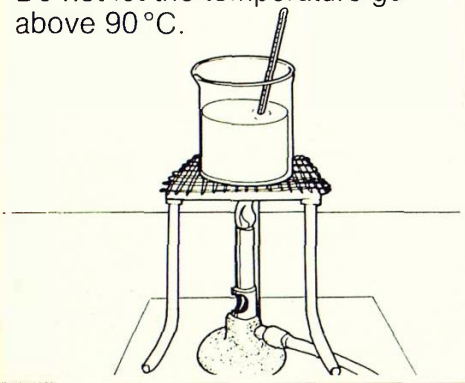
Apparatus

★ 250 cm^3 beaker ★ heatproof mat ★ tripod ★ gauze ★ glass rod
★ Bunsen burner ★ spatula ★ sieve ★ bowl ★ 2 pieces of muslin
★ thermometer ★ plastic pot ★ fresh milk ★ yogurt bacteria

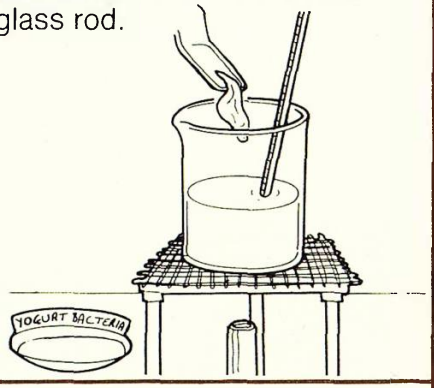
You are going to make yogurt and cream cheese by adding bacteria to fresh milk.


All apparatus must be clean.

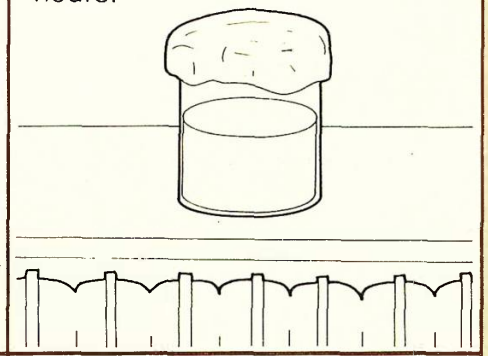
A Half fill a 250 cm^3 beaker with fresh milk. Heat **gently**. Do not let the temperature go above 90 °C.



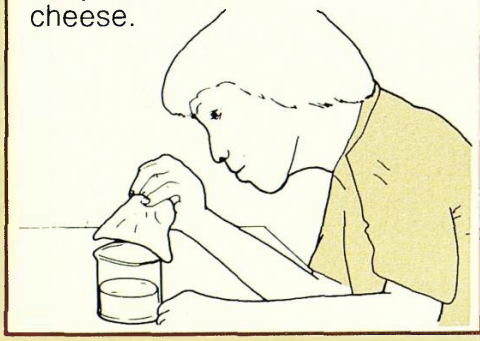
B Turn off the Bunsen burner. Add 5 spatulas of yogurt bacteria to the warm milk. Stir with a glass rod.



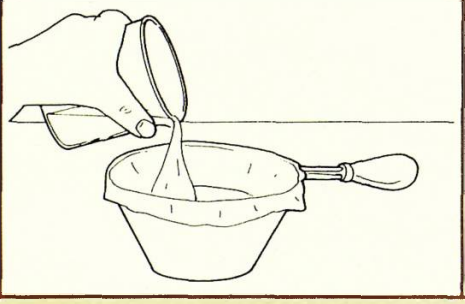
C Cover the beaker with muslin. Leave in a warm place (on or near a radiator) for 24 hours.



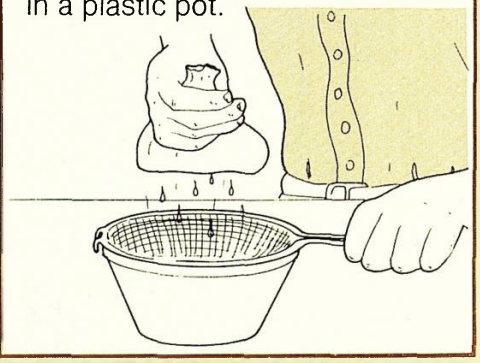
D **Next day:** Look at the yogurt you have made. In steps E and F you can use the yogurt to make cream cheese.



E Put a sieve over a bowl. Line the sieve with clean muslin. Pour the yogurt into the muslin. Leave for 24 hours.



F **Next day:** Squeeze the liquid from the solid cheese in the muslin. Put the cheese in a plastic pot.



Q10 Why is the milk and yogurt bacteria mixture left in a warm place?

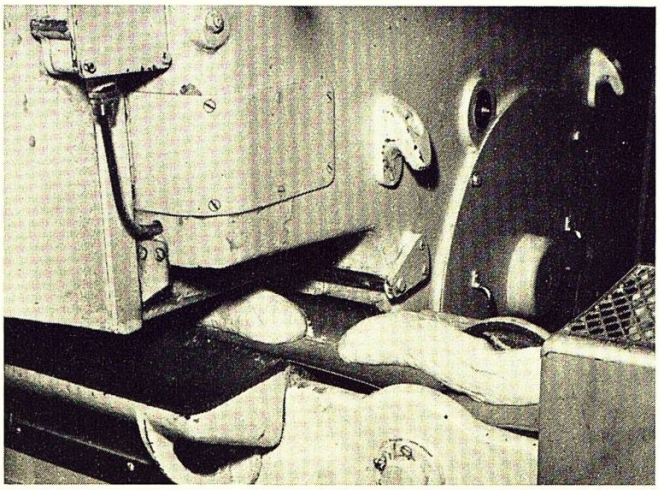
Q11 What does the yogurt look like?

Q12 Why is the cheese squeezed in the muslin?

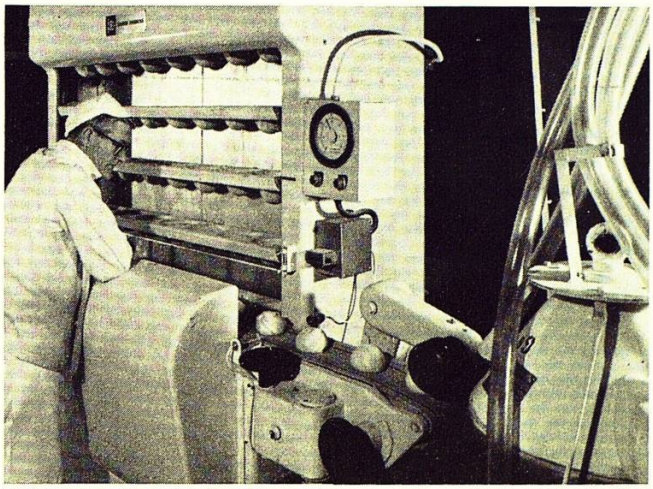
Q13 What does the cream cheese look like?

Information: Bread making in a bakery

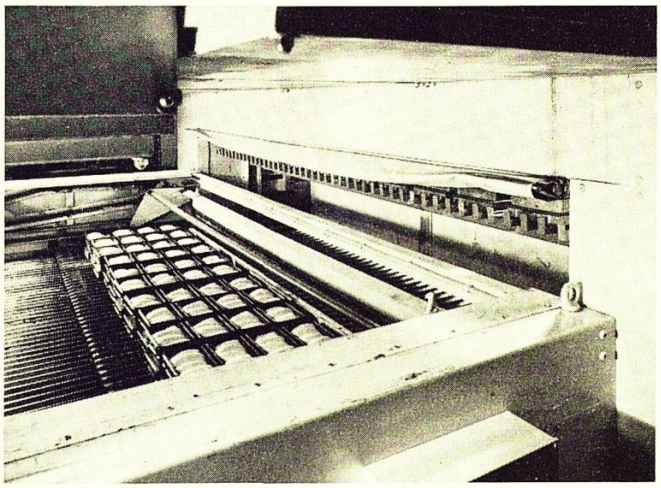
A lot of the bread eaten today is made in factories called **plant bakeries.**



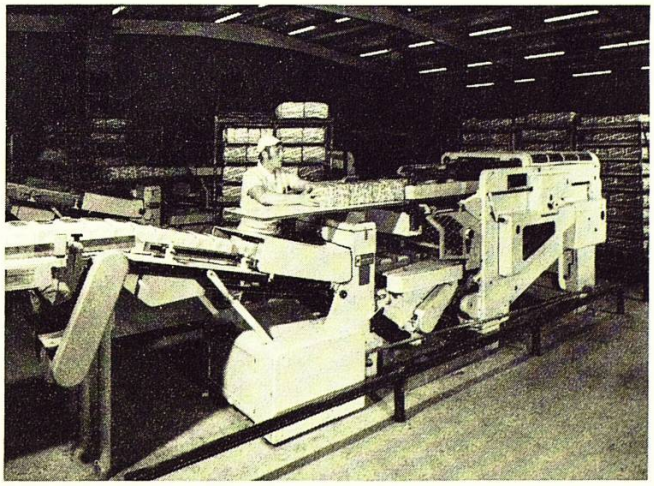
The flour arrives at the bakery by road tanker. It is stored in tanks until it is needed to make dough. The dough is made by machine. Large mixers can hold 150 kg of flour and 100 kg of water, as well as yeast, fat and salt. The photo shows dough coming out of the mixer.



The dough is moulded into balls. These are put into a **prover** (shown on the left of the photo) to prove (rise). Then the dough is **kneaded** before being put back into the prover to rise a second time.



The dough is then shaped into loaves which are cooked in a large, hot oven. The floor of the oven is a **conveyor belt** which moves the bread very slowly through the oven.



When the loaves have been baked, they are left to cool. They can then be sliced and wrapped by machine. The bread is not handled at all until this is done.

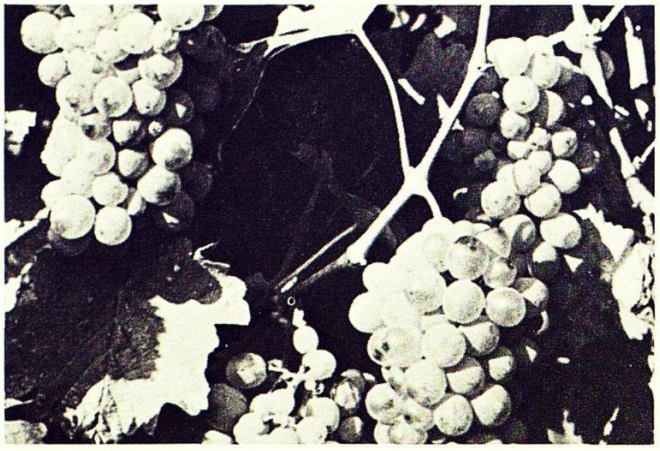
Q14 What makes the bread rise during proving?

Q15 What happens to the live yeast in the hot oven?

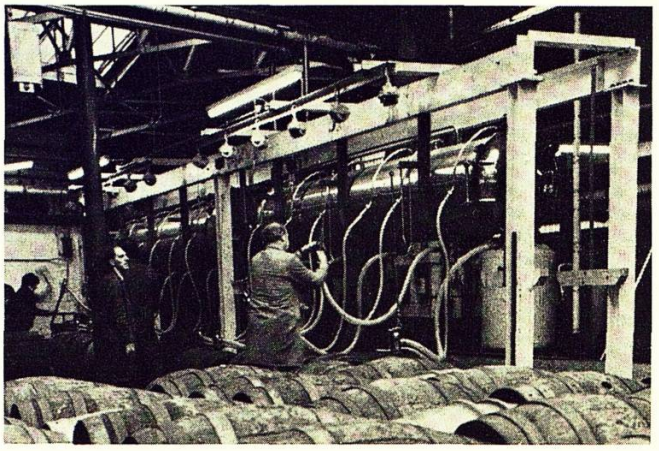
Q16 How is bread moved through bakery ovens?

Q17 Why is the bread not handled until it has been wrapped?

Information: Making wine and beer

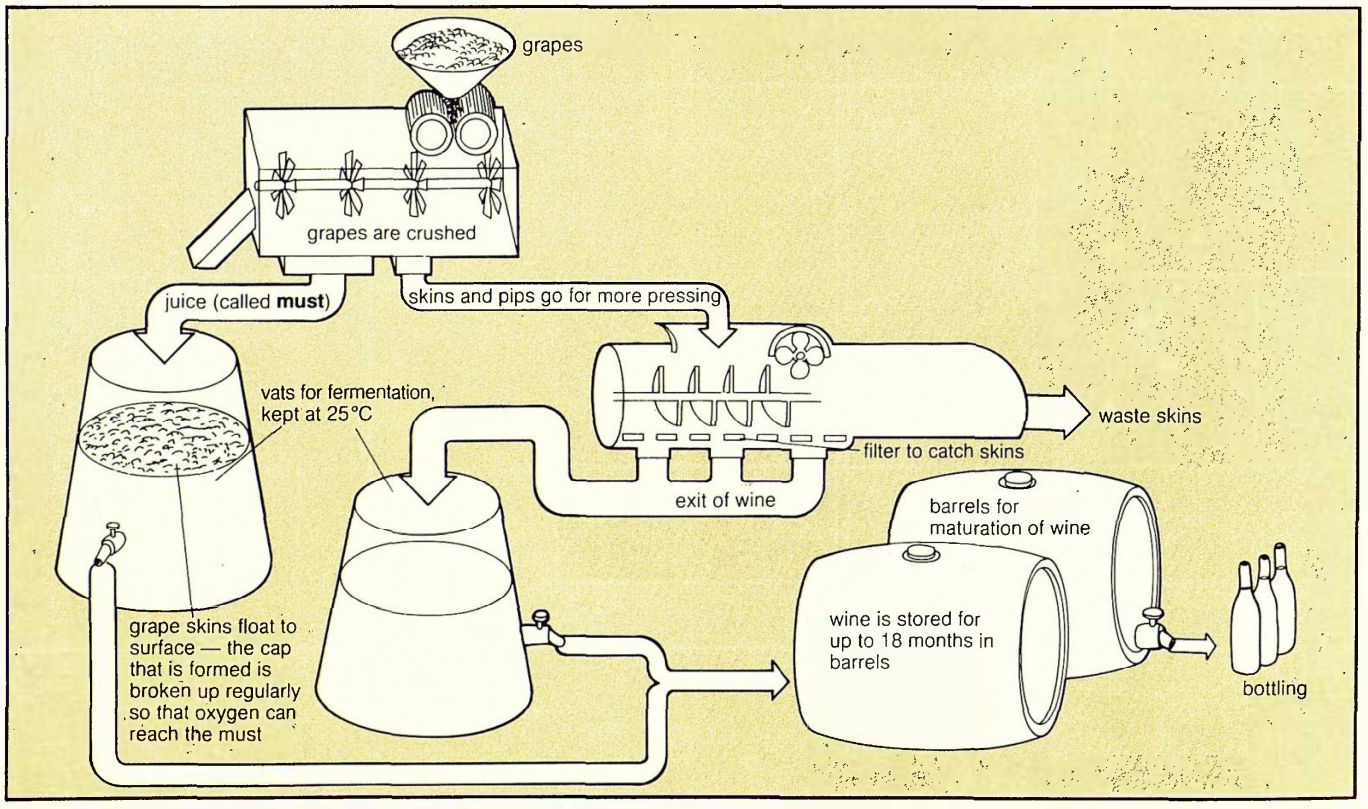


Wine is the **fermented** juice of fruit. Most wine is made from grapes which have yeasts on their skins. **Fermentation** happens when yeast turns sugar into **alcohol** and carbon dioxide gas is given off. After a time, the fermentation stops. The wine is then left to **mature** for several months before it is ready for drinking.



Just as wine may be made from any fruit, beer can be made by fermenting any **cereal** in water. Barley is the most widely used cereal. **Hops** are added to beer to give the drink its bitter flavour. There are many different types of yeast used to give beers and wines different flavours.

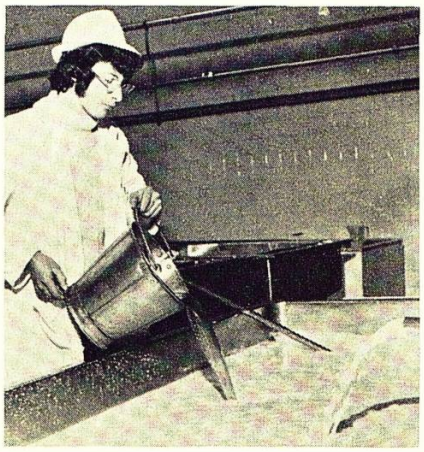
The stages in wine-making



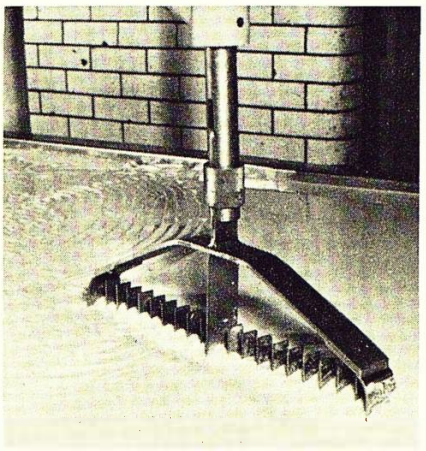
Q18 What is fermentation?

Q19 Why is it important to keep grape skins in fermenting vats?

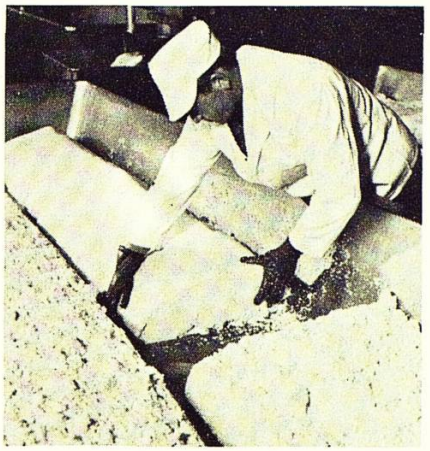
Information: Making cheese



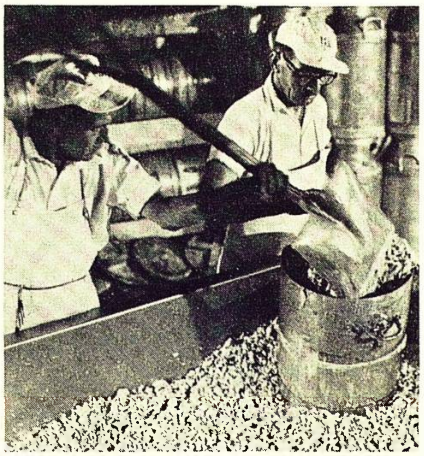
To make Cheddar cheese, milk is heated to 73 °C, then cooled to 29 °C. While the milk is cooling, bacteria are added. After 35 minutes **rennet** is added (as shown in the photo).



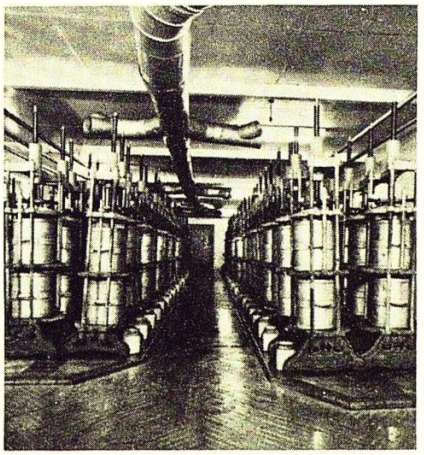
The rennet is stirred into the milk. It makes the milk separate into soft, white lumps called **curds**, and a watery liquid, called **whey**.



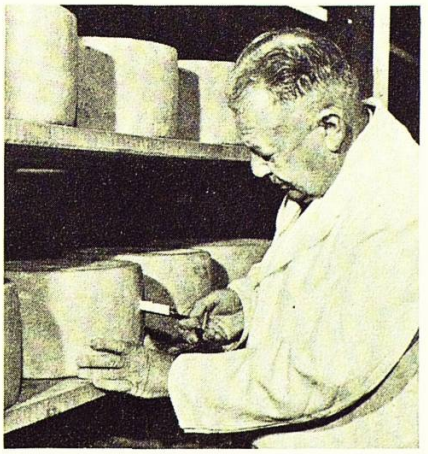
The whey is drained off, leaving the solid curd. This is cut into blocks ready for milling.



The curds are put through a mill which cuts them into small pieces. Salt is added, then the cheese is put into moulds (as shown in the photo).



The cheese moulds are put into presses to get rid of moisture. The cheese forms a firm coat **(rind)**.



After 2 days, the cheeses are taken out of the moulds. They are put into a store to ripen. They are then graded for quality.

Q20 What are curds?

Q21 What happens to cheese after it is put into a mould or press?

Q22 Why do you think salt is added to the cheese?

Q23 Can you think of any other ways we use microbes? What are they?

5 Damage to our food

Changes in food when it goes bad

Apparatus

★ samples of fresh and bad foods on labelled dishes ★ metal tweezers
★ 4 agar plates ★ clear tape ★ Bunsen burner ★ heatproof mat
★ hand lens ★ wax pencil ★ bench swabs

You are going to find out how food changes when it goes bad. You are going to grow some of the microbes that turn food bad.

Wash your hands and swab the bench before and after the experiment.

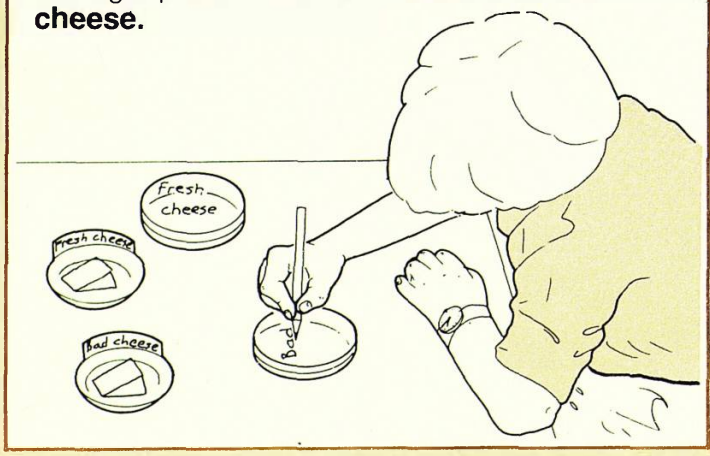
Q1 Copy this table.

Name of food	Appearance of fresh food	Appearance of bad food

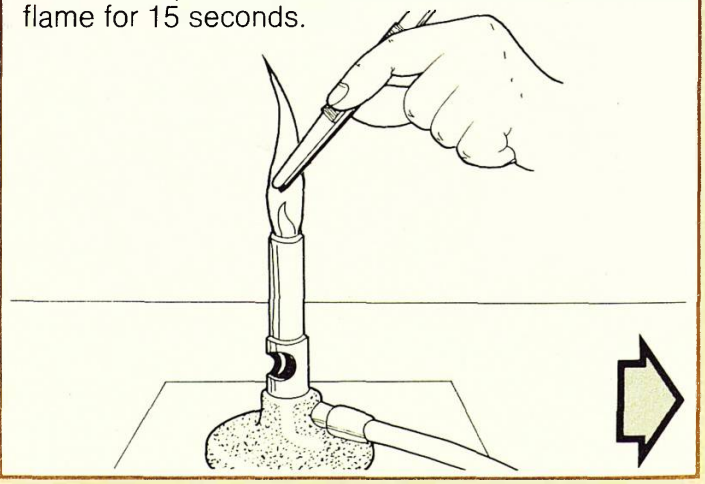
A Look at the fresh and bad foods. Fill in the table.

B Choose one food, e.g. apple. Label one agar plate **Fresh apple** and another **Bad apple.**

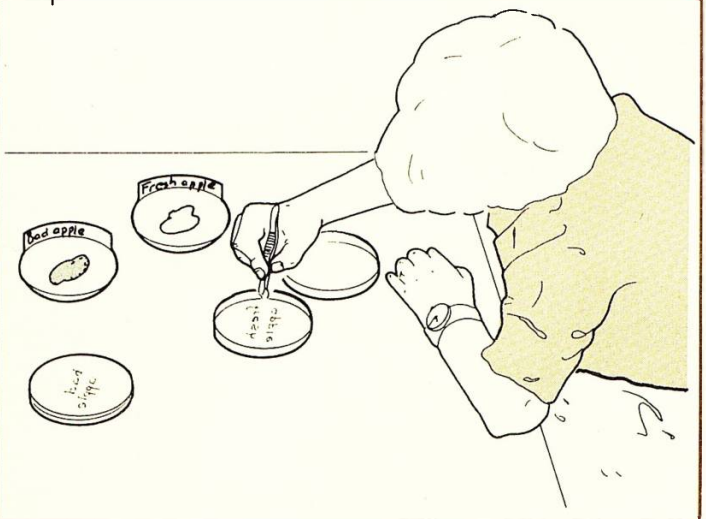
C Choose a second food, e.g. cheese. Label one agar plate **Fresh cheese** and another **Bad cheese.**



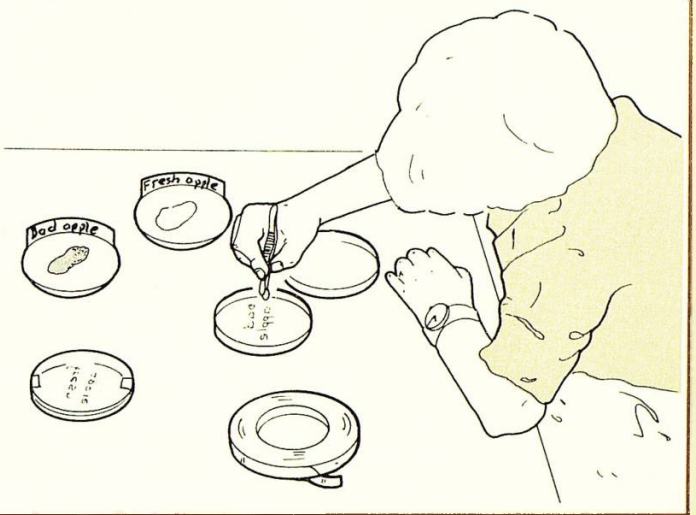
D Heat a pair of tweezers in a normal Bunsen flame for 15 seconds.



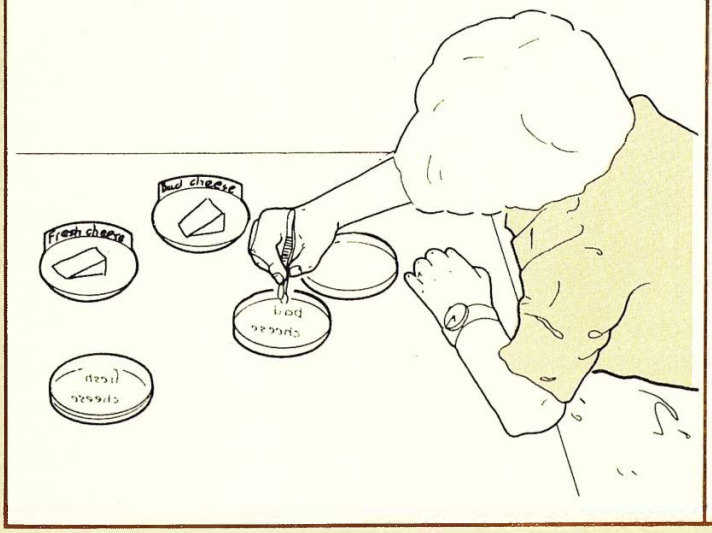
E Open the agar plate labelled with the first fresh food. Using tweezers, put a piece of the fresh food in the agar plate. Seal the plate with tape.



F Heat the tweezers in the Bunsen flame as you did in step D. Using tweezers, put a piece of the bad food in the correct agar plate. Seal the plate with tape.



G Repeat steps D to F with the other food you have chosen. Leave the plates in a warm place for 2 days.



H **After two days,** look at the contents of the agar plates. Use a hand lens. **Do not open the plates.** Then wash your hands.

Q2 Why were the tweezers held in a Bunsen flame?

Q3 Why were the agar plates kept in a warm place for 2 days?

Q4 On which plates were most microbes growing after 2 days?

Q5 Did the fresh or bad foods have the most microbes growing on them?

Q6 Did all the microbes growing on the agar plate appear to be the same type?

How microbes reach food

Apparatus

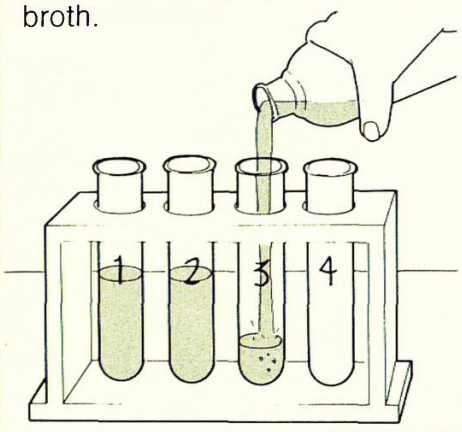
★ nutrient broth ★ 4 boiling tubes ★ test tube rack ★ cooking foil
★ cotton wool ★ short, straight glass tube ★ short s-shaped glass tube
★ pressure cooker ★ stop clock ★ wax pencil ★ gas ring

You are going to find out where the microbes that damage our food come from.

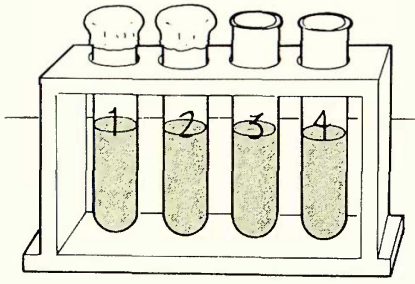
Q7 Copy this table.

Tube number	Treatment of tube	Appearance of tube contents: when removed from pressure cooker	Appearance of tube contents: after one week

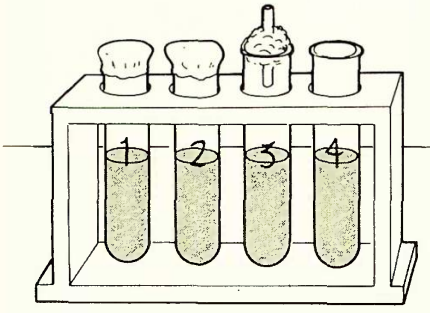
A Label 4 boiling tubes 1 to 4. Half fill each tube with nutrient broth.



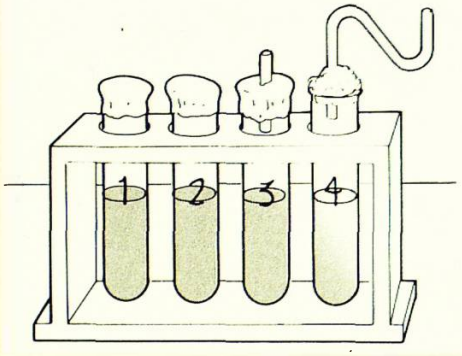
B Cover the tops of tubes 1 and 2 tightly with cooking foil.



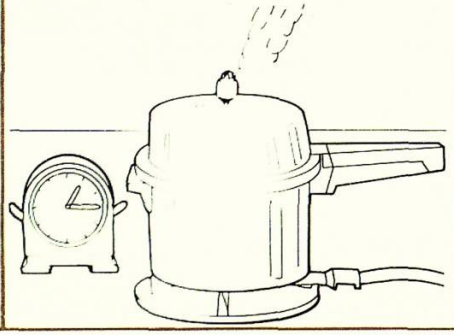
C Put a straight glass tube, surrounded by cotton wool, into tube 3. Cover with foil, leaving a hole for the tube to poke out.



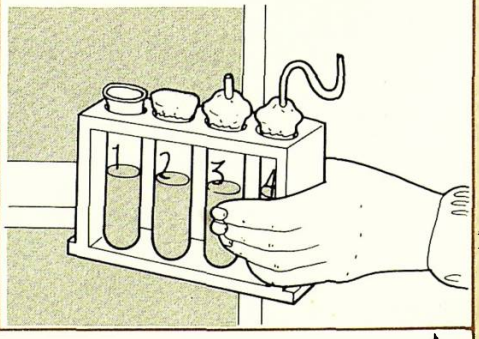
D Put an s-tube, surrounded by cotton wool, into tube 4. Cover with foil, leaving a hole for the tube to poke out.



E Ask your teacher to put the tubes in a pressure cooker for 15 minutes. When they have been taken out, remove the foil from tubes 1, 3 and 4.



F Record in your table the treatment of each tube and the appearance of its contents. Then store the tubes in a warm dark place for one week.



G After one week, record in your table the appearance of the tubes' contents.

Q8 What happens to any microbes present when the broth is cooked in the pressure cooker?

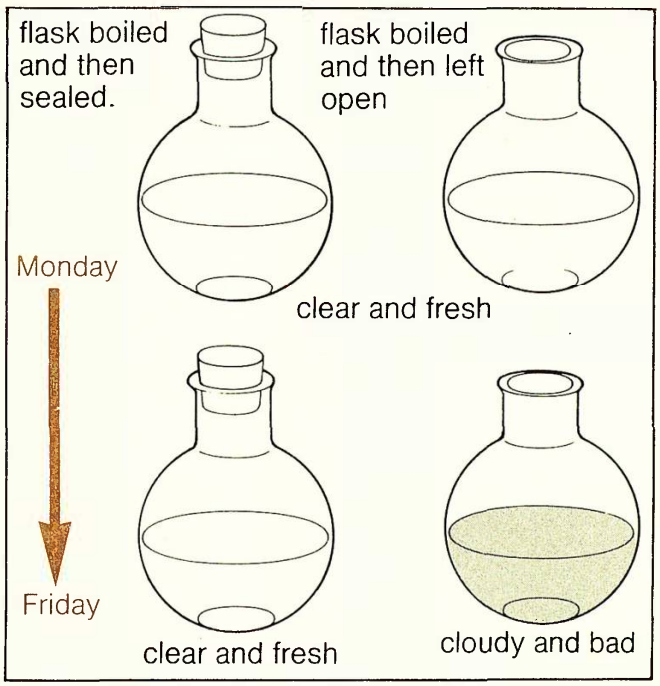
Q9 In which tubes did the broth go bad after 1 week?

Q10 In which tubes did the broth not go bad after 1 week?

Q11 If the broth went bad in some tubes, but not all, say why you think this happened.

Q12 Microbes make food go bad. Where must the microbes have come from to make your broth go bad?

Information: Discovering microbes



Before the last century, people thought that microbes would grow as if by magic inside a broth or soup. A French scientist called Pouchet carried out the experiment shown in the diagram. He thought microbes were made when oxygen in the air reached the broth.

Louis Pasteur, another French scientist, thought Pouchet was wrong. Pasteur thought that microbes were already present in the air. He made flasks with curved necks. These let air into the broth but microbes were trapped in the s-bend. His broth stayed fresh and clear. The photo shows Louis Pasteur.

Q13 Why did the broth in Pouchet's open flask go cloudy and bad?

Q14 Why were the microbes trapped in the s-bend of Pasteur's flask?

Q15 Which of the tubes in your experiment was a copy of Pasteur's flask?

Q16 Did you get the same results as Pasteur with your tube?

6 Stopping food damage

How we can stop microbes growing on food

Apparatus

★ 8 sealed tubes of broth containing microbes ★ 1 sealed tube of broth
★ distilled water ★ weak salt solution ★ strong salt solution ★ wax pencil
★ weak sugar solution ★ strong sugar solution ★ ethanoic acid (vinegar)
★ sodium nitrite solution ★ test tube rack ★ 7 droppers ★ 9 elastic bands
★ bench swabs

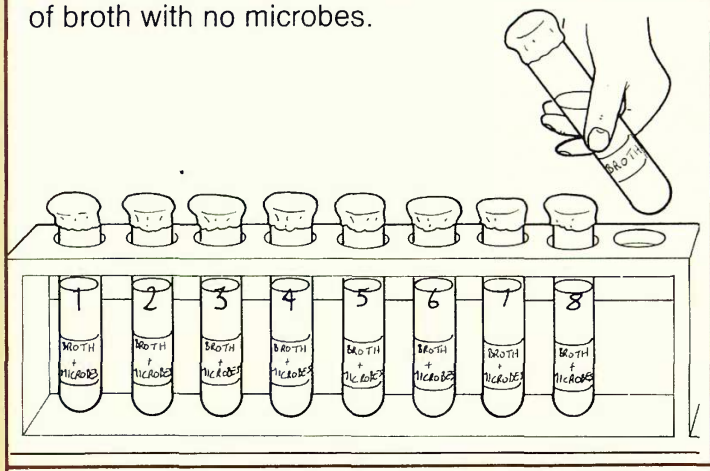
You are going to find some ways of stopping microbes growing in broth.

Swab the bench before and after the experiment.

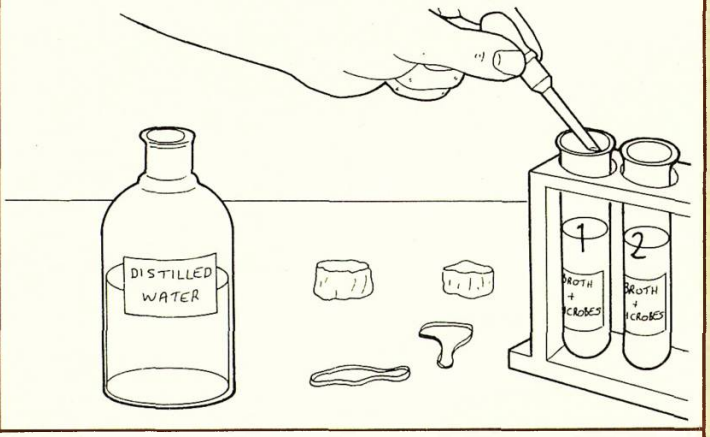
Q1 Copy this table.

Tube number	Treatment given to tube	Appearance of tube after 2 days

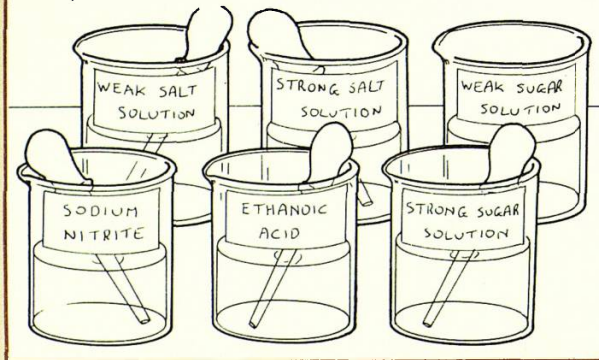
A Take 8 tubes of broth containing microbes. Number them 1 to 8. Write number 9 on the tube of broth with no microbes.

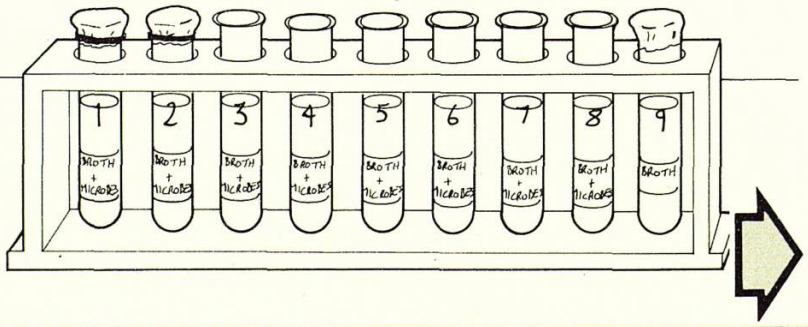


B Remove the foil from tubes 1 and 2. Add 5 drops of distilled water to tubes 1 and 2. Put back the foil caps. Seal the tubes with elastic bands.

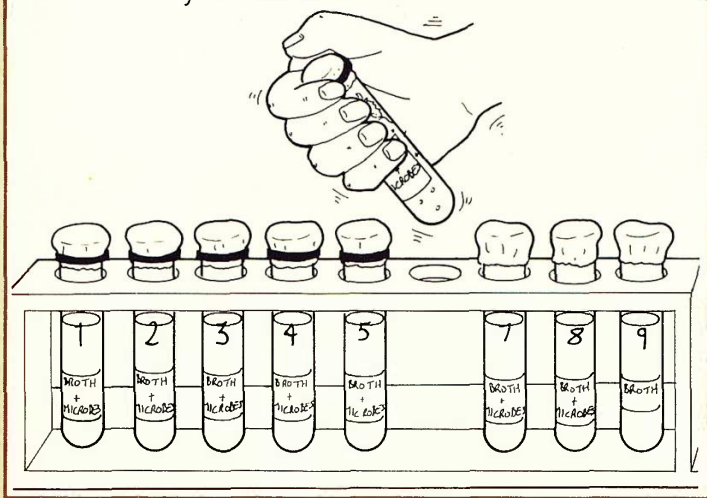


C Remove the foil caps from tubes 3 to 8. Use a clean dropper for each solution. Add 5 drops of weak salt solution to tube 3; 5 drops of strong salt solution to tube 4; 5 drops of weak sugar solution to tube 5; 5 drops of strong sugar solution to tube 6; 5 drops of ethanoic acid to tube 7 and 5 drops of sodium nitrite to tube 8.

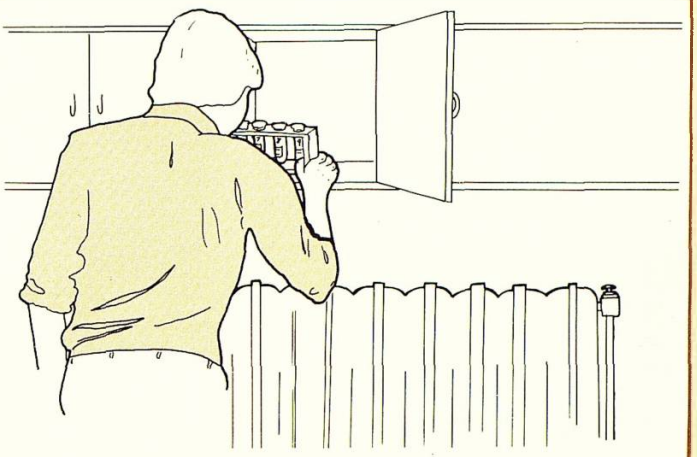




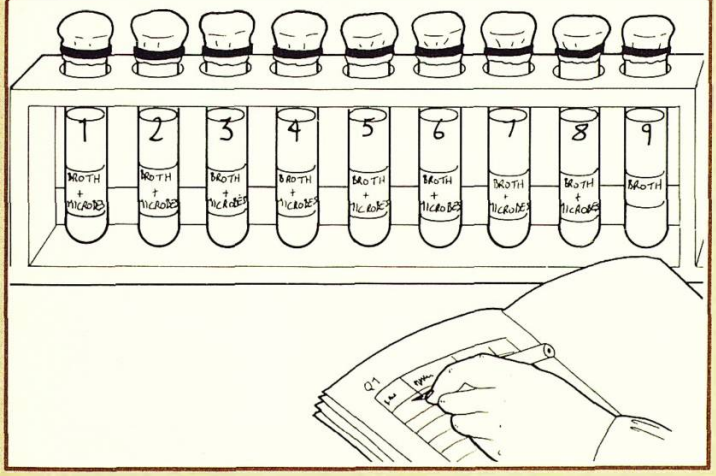
D Replace the foil caps. Seal all the tubes with elastic bands. Shake the tubes. Fill in the first 2 columns of your table.



E Put tube number 1 in a fridge. Put tubes 2 to 9 in a warm, dark place. Leave for 2 days.



F **After 2 days,** take tube 1 out of the fridge. Collect the other tubes. Look at the tubes but do not open them. Fill in the last column of your table.



If any substance stops the growth of microbes, it is called a **preservative.** If microbes have grown in the broth it will look cloudy.

Q2 Why were the tubes kept sealed with foil?

Q3 Why was tube 9 left untreated and containing no microbes?

Q4 Why was distilled water added to tubes 1 and 2?

Q5 Do microbes grow in sweet (sugar) solutions?

Q6 Do microbes grow in salt solutions?

Q7 Do microbes grow in acid solutions?

Q8 Is sodium nitrite a preservative?

Q9 Does a low temperature affect the growth of microbes? (Clue: compare tubes 1 and 2.)

Stopping food damage

Information: Preserving food

Microbes grow and increase in number when they are living in the right temperature and have enough food. To **preserve** food, it is necessary to kill the microbes or make them **inactive.** The table shows the main ways of treating foods to preserve them from damage caused by microbes.

Method of preservation	Effect of preservation on:				
	bacteria	fungi	oxygen	water	acidity
cooking	kills most types	kills most types			
chilling	slows down growth	slows down growth			
vacuum packing	slows down growth	slows down growth	removes and keeps out the gas		
canning and bottling	kills all types	kills most types	removes and keeps out the gas		
freezing	kills up to ¾ of all types	stops them growing		turns solid	
dehydration	stops them growing	stops them growing		removes	
curing	slows down growth	slows down growth			
pickling	makes them inactive	stops them growing			makes it more acid
adding chemicals	stops them growing	stops them growing			may change

Q10 What is the disadvantage of buying food preserved by freezing?

Q11 What might happen if oxygen got into vacuum-packed foods?

Q12 Some foods have "sell by" labels like the one shown. What is the importance of this label?

7 Milk

Testing milk for freshness

Apparatus

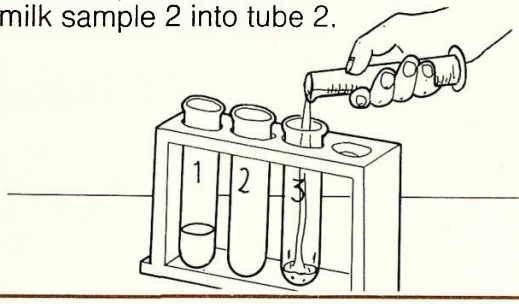
★ 2 milk samples, numbered 1 and 2 ★ methylene blue solution ★ stop clock
★ 3 test tubes ★ test tube rack ★ two 10 cm^3 measuring cylinders
★ dropper ★ wax pencil ★ beaker of warm water

You are going to do a chemical test on milk. Methylene blue is a chemical which changes from blue to colourless as the amount of oxygen in a solution goes down.

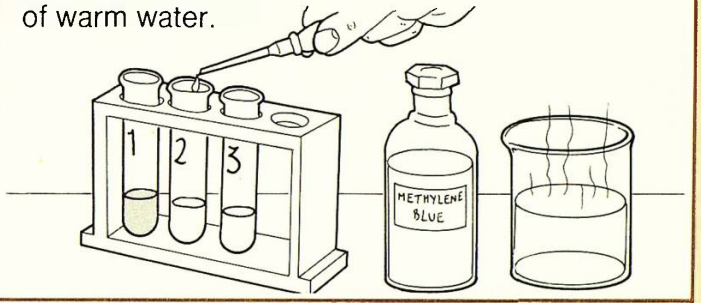
Q1 Copy this table.

Tube number	Treatment of tube	Colour of tube contents: at start	after 15 minutes	after 30 minutes	after 45 minutes

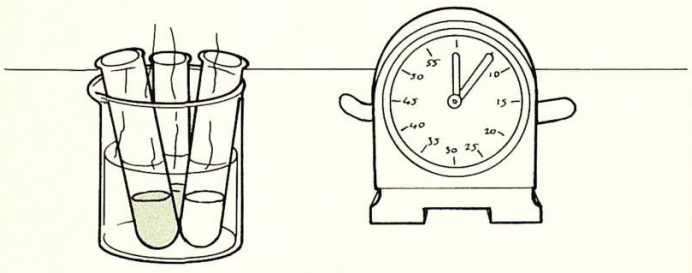
A Label 3 test tubes 1, 2 and 3. Put 10 cm^3 of milk sample 1 into tubes 1 and 3. Put 10 cm^3 of milk sample 2 into tube 2.



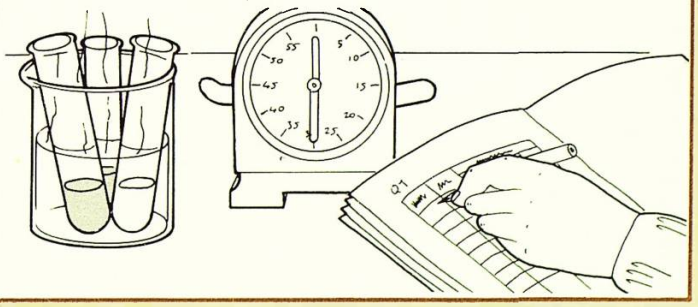
B Add 1 drop of methylene blue to tubes 1 and 2. Shake both the tubes. Stand them in a beaker of warm water.



C Fill in the first 3 columns of your table. Start the stop clock. Watch the tubes.



D Record in your table the colour of the tubes' contents after 15, 30 and 45 minutes.



Q2 Microbes use oxygen to live. If the amount of oxygen in a container goes down fast, what does this tell you about the number of microbes in the container?

Q3 Which milk sample changed the colour of the methylene blue quickest?

Q4 Which milk sample had the most microbes in it?

Q5 Why did you leave tube 3 untreated?

Why milk turns sour

Apparatus

★ labelled samples of fresh and 4-day-old milk ★ 2 sterile petri dishes
★ 2 sterile droppers ★ Bunsen burner ★ heatproof mat ★ wax pencil
★ clear tape ★ bench swabs ★ 2 bottles of milk agar

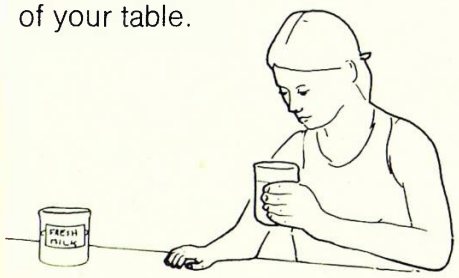
You are going to find out what turns milk sour.

Wash your hands and swab the bench before and after the experiment.

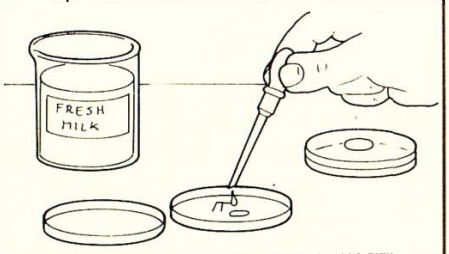
Q6 Copy this table.

Age of milk	Smell of milk	Appearance of milk	Appearance of agar after 2 days

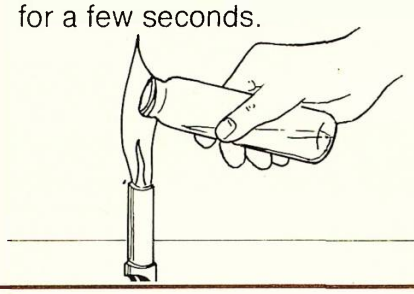
A Look at samples of fresh and 4-day-old milk. Smell them. Fill in the first 3 columns of your table.



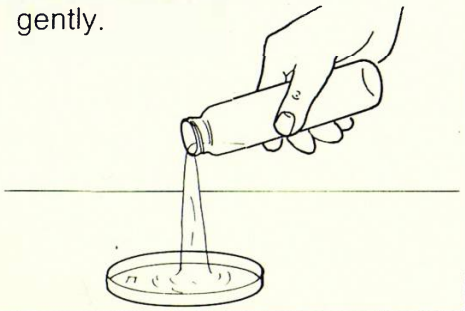
B Label the bottom of a petri dish F (for Fresh). Label another dish O (for Old). Put 2 drops of fresh milk in dish F.



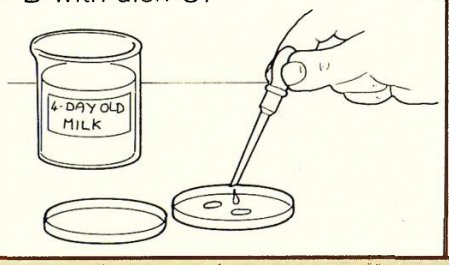
C Remove the top from a bottle of milk agar. Hold the bottle neck in a Bunsen flame for a few seconds.



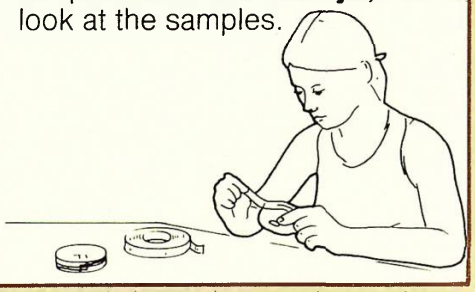
D Pour all the agar into dish F. Put on the lid. Swirl the dish gently.



E Using a clean dropper, put 2 drops of 4-day-old milk in dish O. Repeat steps C and D with dish O.



F Seal both petri dishes with tape. Leave them at room temperature. **After 2 days,** look at the samples.



Q7 Make drawings in your table to show what the milk looked like after 2 days.

Q8 Milk agar provides food for microbes. Which milk sample appeared to have most microbes?

Q9 What makes milk go sour?

Q10 How does milk change when it goes sour?

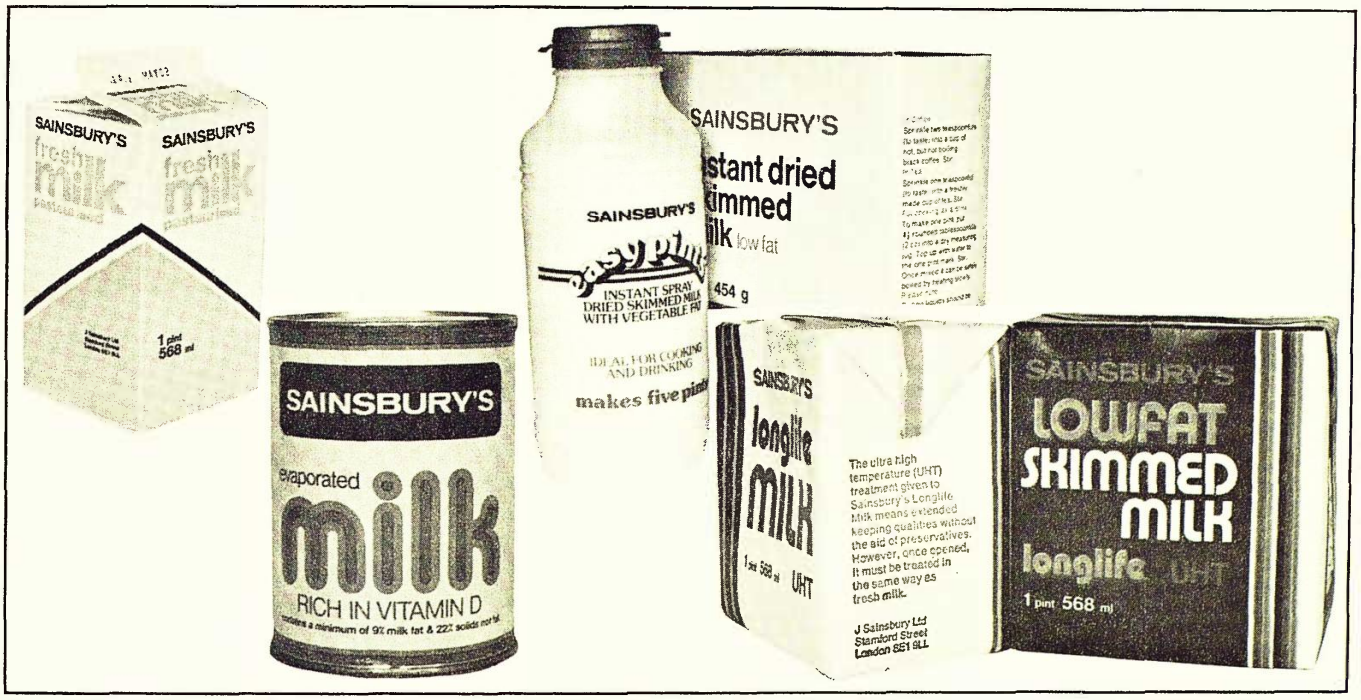
Information: Preserving milk

Milk is a cheap and good food. It can be preserved in different ways.

In **pasteurization**, milk is heated to 71.6 °C and held at this temperature for 15 seconds. The milk is then cooled quickly and bottled. This process does not change the taste of milk. Pasteurization does not kill all bacteria. If the milk is kept in a warm place it will soon turn sour.

When milk is **sterilized**, it is put into bottles which are sealed with metal caps. The bottles are put into containers and heated to 104.5 °C for 15 minutes. This process changes the taste of milk. Sterilization kills all bacteria so the milk keeps until the bottle is opened.

In **Ultra High Temperature** (UHT) treatment, milk is heated to 132 °C for 2 seconds. This method kills all bacteria and only slightly changes the taste of the milk. Once the carton has been opened, it must be used as fresh milk.



Milk from which one-third of the water is removed by **evaporation** at temperatures below 65.5 °C is known as **evaporated** milk. The milk is canned and sterilized. This treatment changes the taste of milk.

Condensed milk is milk from which two-thirds of the water and most of the fat is removed. Sugar is added so that the milk is very sweet.

Dried or **powdered** milk has all the water and often the fat removed. It can be used as powder to add to tea or coffee, or it can be made back into liquid by adding water. This process changes the taste of milk.

Q11 Why does pasteurized milk turn sour in a sealed bottle?

Q12 Why do sterilized milk and UHT milk not turn sour in their containers?

Q13 In what ways is pasteurization different from UHT treatment?

Q14 After whom is the process of pasteurization named?

8 Food preservation

Preserving beetroot

Apparatus

★ ½ kg of whole, fresh beetroot ★ sliced beetroot (brine treated) ★ tripod
★ salt solution ★ spiced vinegar ★ 500 cm^3 beaker ★ 250 cm^3 beaker
★ gauze ★ Bunsen burner ★ heatproof mat ★ cloth ★ elastic band
★ polythene bag ★ screw-topped jar (kilner type) ★ jam jar with lid
★ 3 labels ★ stop clock

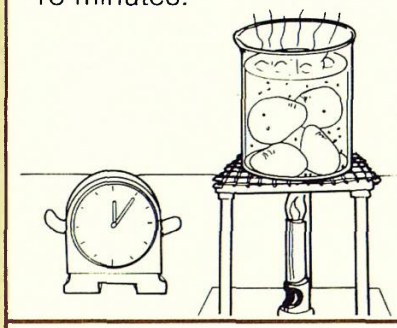
You are going to preserve beetroot in 3 different ways—freezing, bottling and pickling.

All the apparatus must be very clean.

Q1 Copy this table.

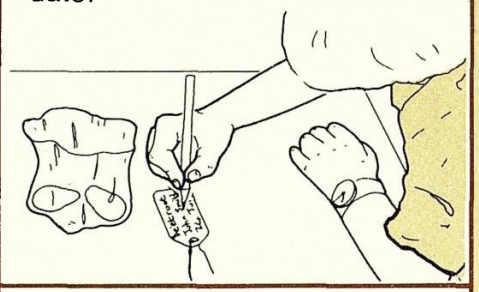
Date at start and 2 weeks later	Appearance of beetroot after treatment:		
	freezing	bottling	pickling
(start) date:			
(end) date:			

A Half fill a 500 cm^3 beaker with water. Add ½ kg of fresh beetroot. Boil the beetroot for 15 minutes.

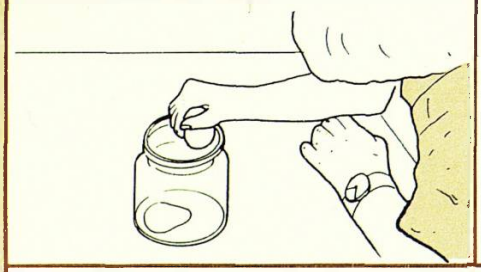


B Let the beetroot cool enough for you to handle it. Then peel the beetroot.

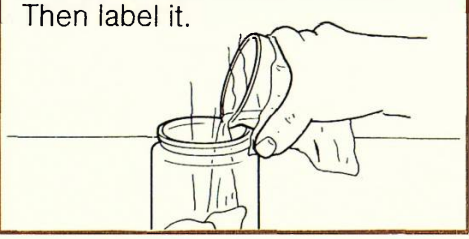
C Put half the cooked beetroot in a polythene bag. Seal it and label it **frozen beetroot.** Add your name and the date.



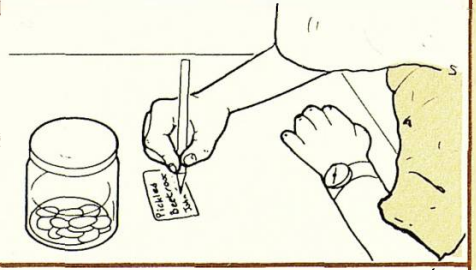
D Give the bag to your teacher for freezing. Then put the rest of the cooked beetroot in a clean jar.



E Boil some salt solution in a clean beaker. Then pour it over the beetroot in the jar. Screw the lid on tightly. Give it to your teacher to sterilize. Then label it.



F Put some sliced beetroot in a jam jar. Cover with spiced vinegar to pickle it. Screw on the lid. Label the jar.



G Record in your table the appearance of all the beetroot samples. Look at the beetroot after 2 weeks and record its appearance again.

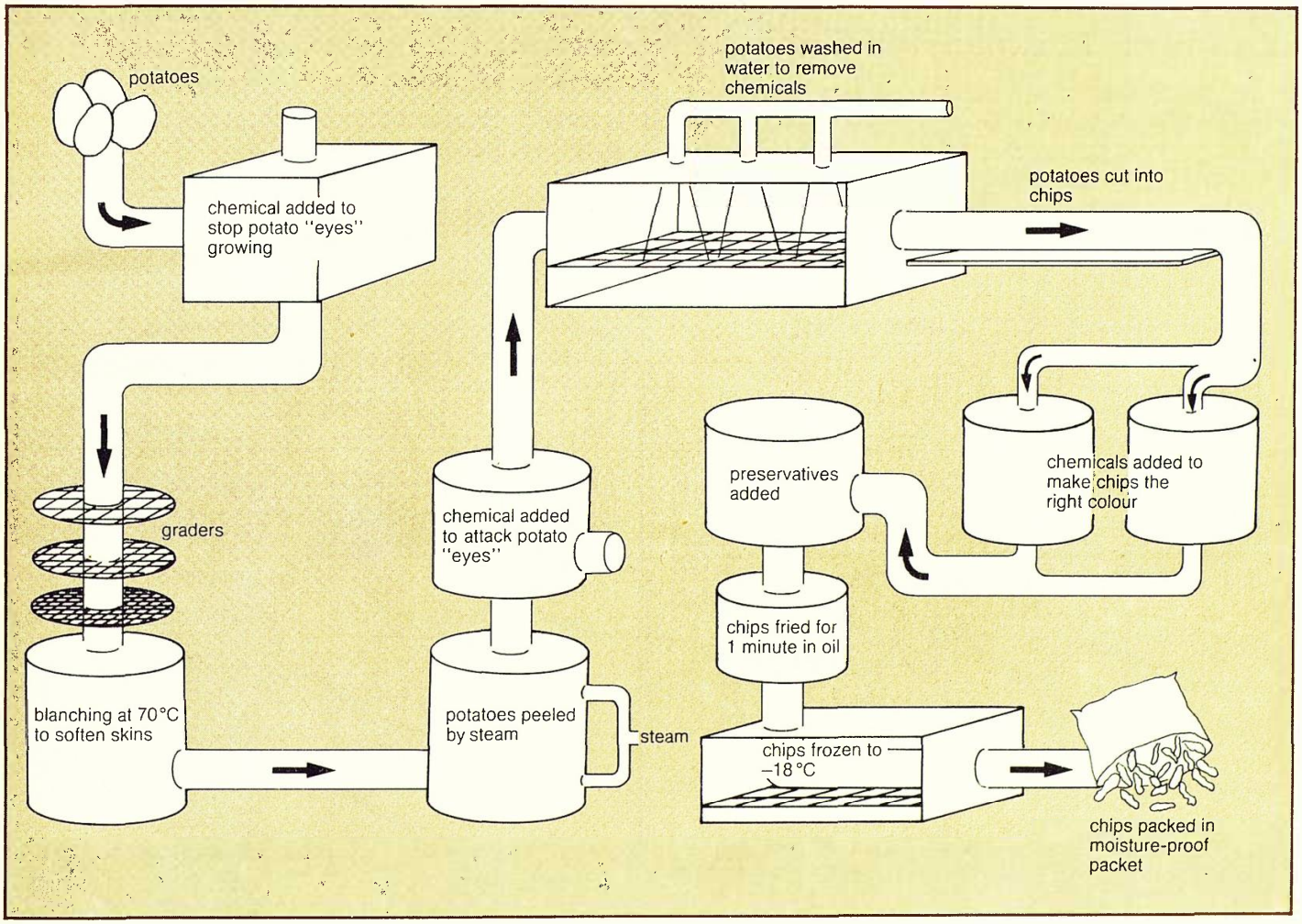
Q2 How does freezing preserve food?

Q3 How does bottling preserve food?

Q4 How does pickling preserve food?

Information: Processing and preserving food

Many foods are **processed** to make them pleasant to eat. Some processed foods are then preserved. The diagram shows how potatoes are processed to make chips, then frozen to preserve them.



Q5 How are potatoes peeled in the processing shown above?

Q6 For how long are the chips fried?

Q7 What are the 2 methods of preserving used in this processing?

Q8 Suggest 2 other ways of preserving potatoes.

9 Microbes in the kitchen

How effective is your washing up?

Apparatus

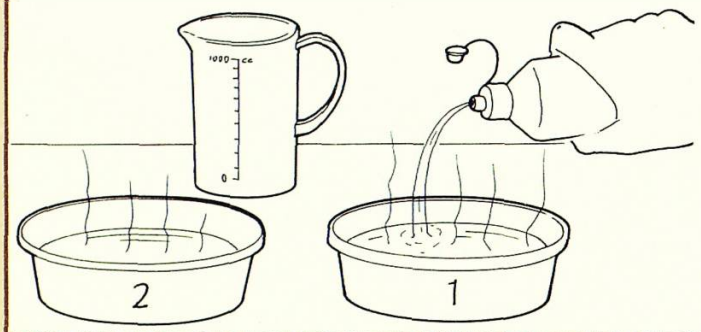
★ 4 bowls numbered 1 to 4 ★ washing up liquid ★ washing up cloth
★ measuring jug ★ hot water ★ 4 dirty plates numbered 1 to 4
★ dusting powder

You are going to find out which method of washing up leaves plates cleanest.

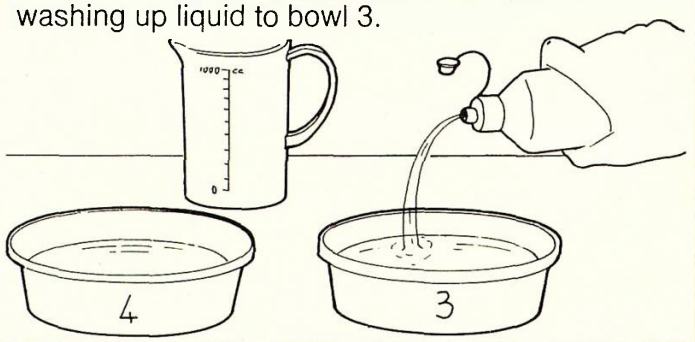
Q1 Copy this table.

Bowl and plate number	Method of washing up	Appearance of plate after dusting

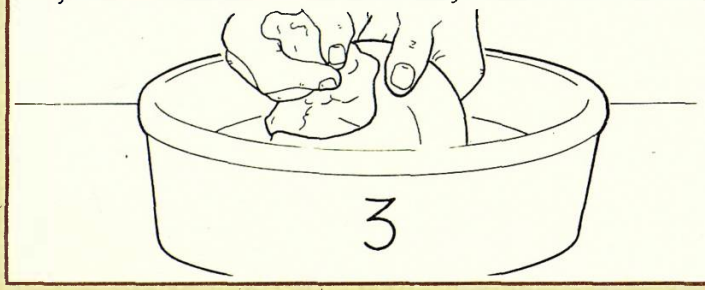
A Put 2 litres of hot water in each of bowls 1 and 2. Add 1 squirt of washing up liquid to bowl 1.



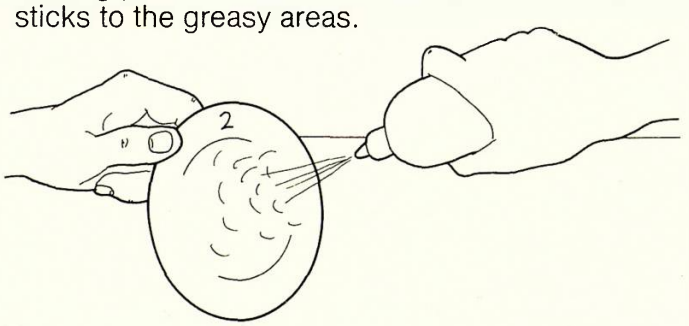
B Put 1 litre of hot water and 1 litre of cold water in bowl 3. Repeat for bowl 4. Add 1 squirt of washing up liquid to bowl 3.



C Put a dirty plate in each bowl. Make sure the numbers match. Wipe over each plate 5 times. Take out the plates and leave them to drain and dry. Fill in the first 2 columns of your table.



D When the plates are dry, brush or puff some dusting powder over each of them. The powder sticks to the greasy areas.



Keep the cleanest plate for the next experiment.

Q2 In your table, make drawings to show what the plates look like after dusting.

Q3 Which method of washing up left most grease on the plate?

Q4 Which method of washing up removed most grease from the plate?

Testing for bacteria on washed containers

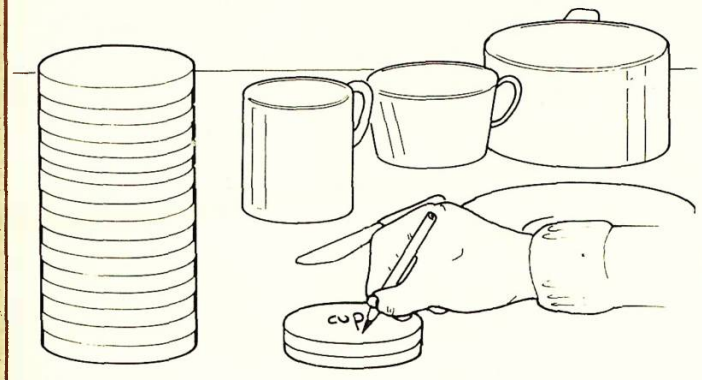
Apparatus

★ washed cups, plates and cutlery for testing ★ several agar plates ★ tape
★ sterile distilled water ★ sterile cotton wool buds ★ wax pencil
★ cleanest plate from previous experiment

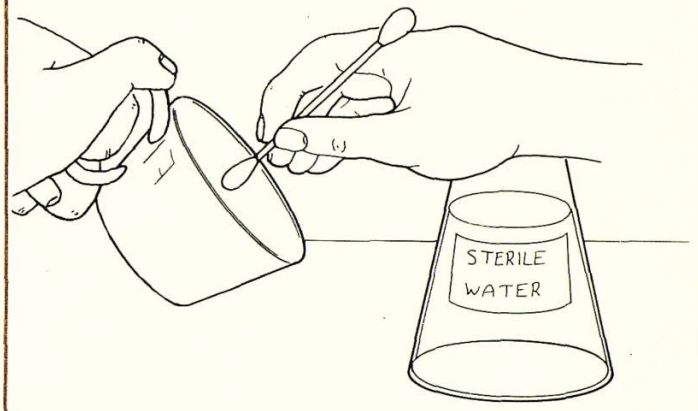
You are going to find out if bacteria are present on items that have been washed up.

Wash your hands and swab the bench before and after the experiment.

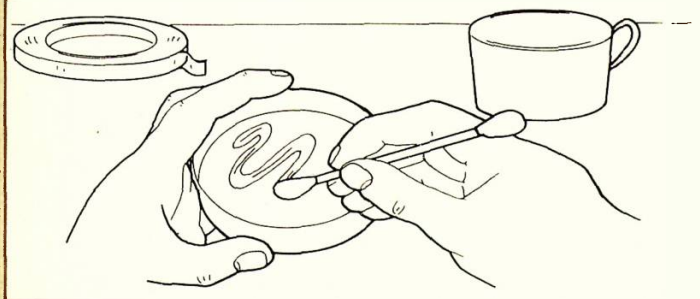
A Label an agar plate with the name of an item for testing. Repeat this until you have only one agar plate left. Leave it unused.



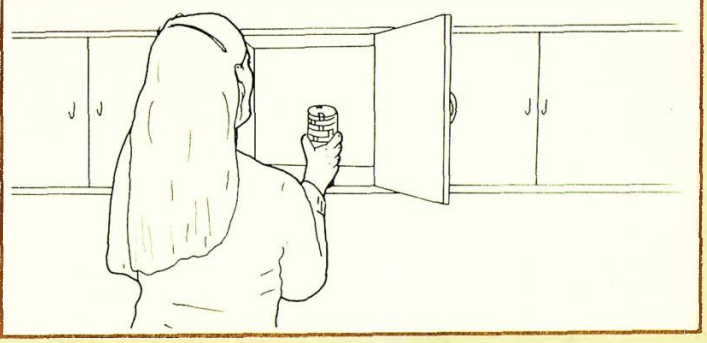
B Dip a clean cotton wool bud into sterile water. Then rub the bud lightly over the first item for testing.



C Open the agar plate labelled with the item you are testing. Gently, wipe the cotton wool bud over the agar. Replace the lid and seal with tape.



D Repeat steps B and C for each item. Then leave all the agar plates (including the one you have not used) at room temperature for 2 days. After 2 days, examine the plates for colonies of bacteria.

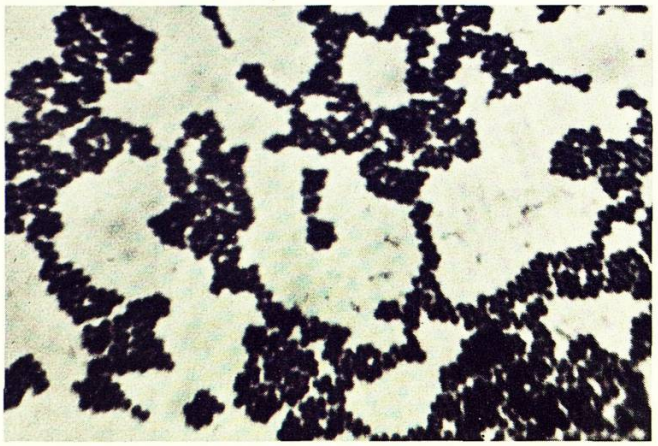


Q5 Why was one agar plate left unused?

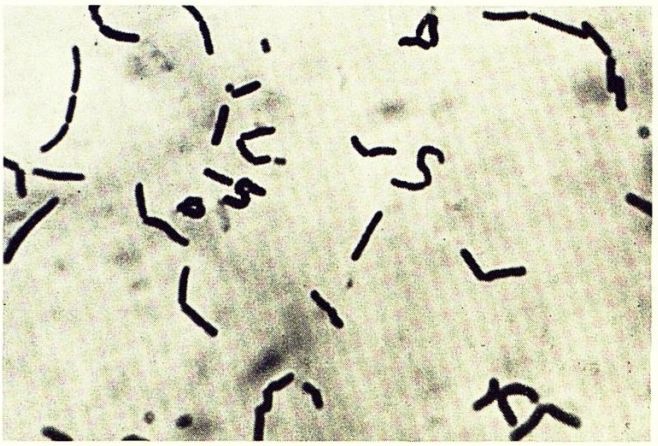
Q6 Did the agar plates have colonies of bacteria on them?

Q7 Does washing up remove bacteria from dishes?

Information: Danger in a kitchen



Bacteria can be found in kitchens. Some bacteria are harmless, but some cause disease. Bacteria that cause disease are **pathogenic**. The bacteria that cause food poisoning include *Salmonellae, Staphylococci* and some *Clostridia*. The photo shows *Staphylococci* (×1600).

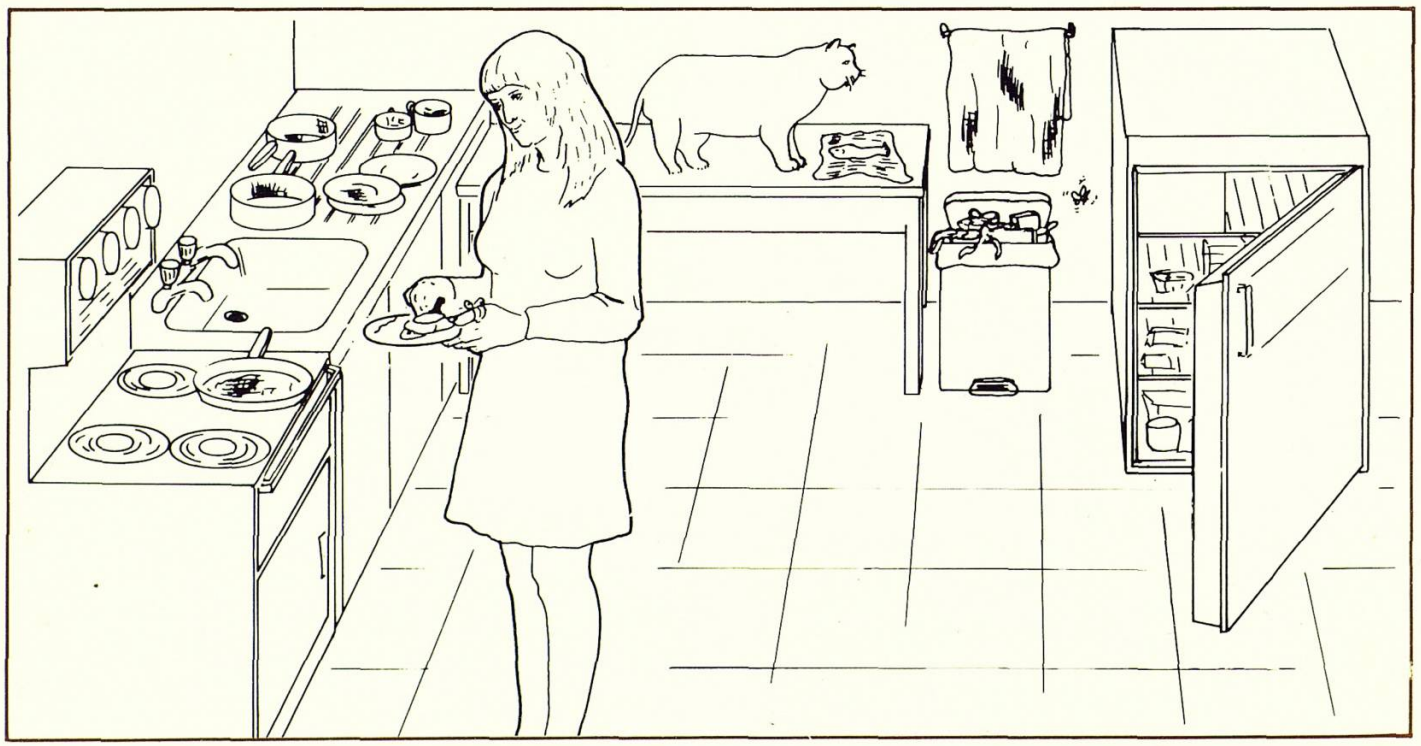


The most dangerous types of food poisoning is caused by a bacterium known as *Clostridium botulinum* (shown above ×1600). This food poisoning is called **botulism.** The **toxin** (poison) made by *Clostridium* is the most poisonous substance known to man. Two or three spoonfuls would be enough to kill 100 million people.

Q8 What is a pathogen?

Q9 What is botulism?

Q10 Study the drawing below. List places where there may be lots of microbes.



Teachers' Guide to Food and Microbes

SCIENCE AT WORK

Introduction

The units

Science at Work is a series of 18 science units for 14-16 year old, less able pupils. Each unit consists of a pupils' book and a teachers' guide. Each provides a complete half-term's course of study. The units are self-contained, and can be taken in any order.

The pupils' books

The pupils' books provide information, practical investigations and questions. Pupils are thus able to work from the books at their own pace; generally, the work becomes more difficult towards the end of each book and the weakest pupils are not expected to finish every unit. The material has been checked by a language specialist, who has ensured that the reading level is as low as possible.

INVESTIGATIONS

Each investigation begins with a list of the apparatus required. The purpose is then stated, and instructions for the investigation given (in words and pictures). Finally, the pupils are asked questions which help them record their results and draw conclusions. (Throughout the books a pupil is expected to make a written response each time a 'Q' appears.)

INFORMATION

Appropriate information from the real world follows most investigations, in most cases from the world of work. Questions are also asked about these information sections.

The teachers' guides

Each unit has a teachers' guide. This contains record sheets and information for the teacher.

RECORD SHEETS

Record sheets in the form of masters are provided in each guide. These sheets will save pupils copying tables, and will help them write answers to questions as complete sentences. One record sheet is provided for each chapter of the pupils' book. Teachers may decide to give record sheets only to those pupils who have difficulty with writing; alternatively, they may be given to all pupils.

OTHER RESOURCES FOR THE TEACHER

Each teachers' guide contains:
course and unit objectives
hints on introducing and teaching the unit
an apparatus list (for technicians)
safety procedures
new scientific words (which pupils may have difficulty reading)
answers to questions in the pupils' book
a resource list.
Specimen questions for a post-unit test are also included.

Examining the course

Science at Work is derived from a successful and well-proven modular scheme developed by teachers in Manchester LEA. Most of the pupils following the course in Manchester gain a CSE Mode III certificate in science. Model CSE papers for most of the regional examination boards are available on request from Addison-Wesley.

Aims of the course

1. To provide a flexible science course based on non-sequential study units. Though developed predominantly for less able pupils, the course can cater for pupils capable of CSE grade I by the addition of suitable extension work.
2. To develop pupils' thinking in scientific methodology and the approach to problem solving.
3. To give knowledge and understanding of science relevant to pupils' interests, environment, and future work and leisure needs.
4. To develop pupils' interest in science and enjoyment of science.
5. To provide a wide range of practical experiences and develop practical skills.
6. To develop the ability to work both independently and as a member of a team.

General objectives of the course

1. To develop the ability to carry out experimental procedures and written work according to instructions.
2. To develop manipulative skill in handling equipment and an awareness of safe practice.
3. To develop powers of accurate observation.
4. To develop the ability to check statements and assertions against tests of observation and experiment.
5. To develop skill in handling the interpretation of data.
6. To develop the ability to look for and make generalisations (this objective is likely to be achieved by only the ablest pupils).
7. To be able to understand and recall the factual content of the material.
8. To develop communication skills—verbal, written, and mathematical.
9. To develop the ability to apply knowledge gained.
10. To encourage pride in neatly and accurately produced work.
11. To develop awareness of the responsible use of science and technology.

Objectives of the Food and Microbes unit

When they have completed the unit, the pupils will have practised the following skills:

the use of a microscope, hand lens, sterile techniques and a thermometer
the pouring of agar plates
the timing of events or processes
the measurement of objects using a microscope
the calculation of magnifications
the observation of objects through a microscope and the drawing of those objects
the observation of changes in liquid and solid media
the recording of observations in table form
the making of bacterial smears
the staining of bacterials smears
the making of temporary preparations of moulds

In their work on *Food and Microbes* pupils will

learn the parts of a microscope and their use in magnifying specimens
measure specimens in a field of vision and calculate magnification
learn that microbes can be classified into 4 groups: viruses, protozoa, bacteria, fungi
learn how to make temporary preparations of yeasts and moulds
observe fungal cells and hyphae
identify fungi using a simple key
learn that fungi can be harmful and beneficial
prepare stained bacterial smears
learn that microbes grow and multiply rapidly in favourable conditions
use microbes to make bread, yogurt, cheese and wine
realise the importance of safety regulations and sterile techniques
discover that the colour of methylene blue is dependent on the oxygen concentration in the solution
prepare agar plates and inoculate these
discover that microbes can make food go bad and such decay causes changes in the food
discover that certain conditions are necessary for the rapid growth of microbes
discover that microbes are present in air and that the particles are heavier than air
discover that chemicals can prevent the growth and multiplication of bacteria
learn that food can be preserved in many ways, but that all involve methods of killing or preventing the growth of microbes
discover that the age and condition of milk can be tested by chemical means
discover that bacteria make milk sour
learn that milk can be preserved in six ways
discover that preservation techniques may change the appearance and texture of food
discover that washing up does not remove all bacteria from crockery and cutlery
learn that some of the bacteria in food can cause food poisoning

Teaching the Food and Microbes unit

Introducing the unit

The unit may be introduced in several ways.

1. Mounting a display of material obtained from food processors (addresses below), together with a collection of empty, cleaned food packages so that our dependence on processed and preserved foods be emphasised.
2. Encourage the collection, collation and display of newspaper cuttings related to food shortages, food 'mountains' and food poisoning e.g. the outbreak of botulism in Birmingham in 1978.
3. Showing a film e.g. 'Food Preservation' or 'A Tale of Two Microbes'—available on loan from Unilever Film Library.

The following supply materials relevant to the course.

Metal Box Ltd., Queen's House, Forbury Road, Reading RG1 3JH
Milk Marketing Board, Thames Ditton, Surrey
Birds Eye Foods, Station Avenue, Walton-on-Thames, Surrey

Teaching the unit

Teachers are reminded of the potential danger of practical microbiology in schools. Teachers and technicians must be aware of the necessary precautions which are fully explained in the references given on the last page of this guide.

Teachers should discuss the possible hazards with their pupils before practical work is begun and establish a sensible code of practice from the outset.

Great care must be taken when culturing any micro-organisms as pathogens may contaminate the culture. All petri dishes must be sealed with adhesive tape after inoculation and must not be reopened by pupils. All bacterial and fungal cultures must be destroyed before disposal. Plastic disposable petri dishes must be incinerated unopened. All glassware should be placed in hypochlorite solution and then opened and soaked for several hours. Starch-iodide paper should be used to check that free chlorine is being produced.

Biological suppliers will provide fungal cultures in small screw-topped glass bottles on agar slopes. These cultures can be kept for some time, if the growth rate is slowed down by storage in the refrigerator. A stock culture could be prepared by sub-culturing the one delivered on the appropriate liquid or agar medium.

Details of plate pouring techniques can be found in:

C. H. Collins. *Microbial Methods*, Butterworth, 1967

J. Humphries. *Bacteriology*, Murray, 1974

Different agars can be bought as granules or tablets. Instructions for making up agar media are on the jar labels. A useful reference is *The Oxoid Manual*, published by Oxoid Ltd.

The pupils' book contains 9 chapters. All chapters have practical and information sections. There are sequential questions within each chapter: these indicate when a student has to write in a notebook. For slow readers and writers, there are record sheets to each chapter. The record sheets are copyright free and are contained within this teachers' guide (pages 7-15).

Samples of the type of questions that may be used for assessment when pupils have completed the unit are on page 16.

In the pages which follow, each chapter is discussed with reference to: apparatus per working group; new scientific words; safety and teaching hints; answers to practical questions (where necessary); resources.

Detailed teaching notes

1 THE MICROSCOPE

USING A MICROSCOPE *(pupils' book page 1)*

Apparatus: microscope; lamp; prepared slides; ruler

New Words: microscope, focus, condenser

The prepared slides should be specimens that are easily seen, such as whole mounts of insect legs and mouthparts. Teachers may have to modify the instructions depending on the model of microscope available. Some teachers may also want to teach students how to focus the condenser.

Q1 To make sure the illumination of the specimen is adequate and even.

MAKING THINGS LOOK BIGGER *(pupils' book page 2)*

Apparatus: microscope; lamp; prepared slides of diatoms or pollen grains; clear plastic ruler

New Words: magnify, protozoa, fungi, bacteria, virus, cell, dysentery, chlorophyll, mould

Pieces of clear plastic ruler will be more convenient to use than intact rulers.

Q3-Q5 Depend on observation.

2 FUNGI

LOOKING AT YEASTS AND MOULDS (pupils' book page 6)

Apparatus: microscope; lamp; 2 droppers; tweezers; mounted needle; 2 slides; 2 cover slips; yeast culture; bread mould culture; stop clock

Supplies of dried yeast can be purchased from chemists, wine-making or health food shops. The culture is made by putting 1 spatula of yeast in 10 cm^3 of 10% glucose solution, and should be kept in a warm place. The pin-mould (*Mucor* sp) can be purchased as a pure culture from biological suppliers, or dampened bread kept in a sealed container for one week should develop a growth of whitish threads whose uprights carry black tips. These could be sub-cultured on to malt or potato-dextrose agar.

Q1-Q4 Depend on observation.

IDENTIFYING MOULDS
(pupils' book page 8)

Apparatus: microscope; lamp; slides; cover slips; dropper; mounted needle; mould cultures; beaker of water; tweezers

The collection of mould fungi from natural sources is interesting but it is difficult to isolate pure cultures or to type them. In general it is best to obtain pure cultures from suppliers. Many foods (particularly cakes and bread) contain fungistats and so frequently do not develop the sort of growth expected. The three species below are easy to culture.
Aspergillus niger (Black-mould) can be cultured on complete agar medium.
Mucor mucedo (Pin-mould) can be cultured on malt or potato-dextrose agar.
Rhizopus stolonifer (Bread-mould) can be cultured on malt or potato-dextrose agar.

Q8 So that the preparation does not slip off the slide.

Q9 So that (a) liquid from the preparation does not get into the lens; (b) the specimen can be focused.

Q10 Useful references for identification: G. C. Ainsworth and G. R. Bisby. *A Dictionary of the Fungi*, Commonwealth Mycological Institute, 1971.
C. T. Ingold. *The Biology of Fungi*, 3rd edn., Hutchinson Educational, 1973.
Penguin Native Guides. *Fungi of Northern Europe*, Penguin, 1978.

3 BACTERIA

LOOKING AT BACTERIA
(pupils' book page 10)

Apparatus: microscope; lamp; grease-free slide; dropper; wire loop; bench swabs; mounted needle; Bunsen burner; heat-proof mat; bacteria culture; safranine dye; distilled water
New Words: stain, spores

Bacillus subtilis is the culture to use. A pure culture can be purchased from Philip Harris Limited or one can be made from a boiled hay infusion as described in: J. Humphries. *Bacteriology*, Murray, 1974.
Slides must be dipped in alcohol to make them grease free.
Teachers may prefer to demonstrate the technique before students attempt it. Extra tuition may be needed on the use of the high power objective.

Q1 Depends on observations.

Q2 To make sure they are spread evenly and thinly.

Q3 So they can be seen.

Q4 By heating the preparation in a Bunsen flame, the bacteria stick to the slide.

Q5 Rod shaped.

4 USING MICROBES

USING YEAST TO MAKE BREAD (pupils' book page 12)

Apparatus: two 100 cm^3 beakers labelled X and Y; measuring cylinder; glass rod; spatula; 2 mixing bowls labelled X and Y; tablespoon; baking tray; oven; stop clock; salt; yeast; sugar; flour; 2 pieces of lard (5 g each)

Some teachers may have to arrange access to ovens for cooking the bread. Whilst the bread is baking, pupils could set up experiments on wine and yogurt.

Q1-Q2 Depend on observations. Some teachers may prefer pupils to weigh the bread for Q2.

Q3 To make the bread rise.

USING YEAST TO MAKE WINE (pupils' book page 13)

Apparatus: 4 boiling tubes; 2 test tube racks; wax pencil; 4 cotton wool balls; 2 spatulas; dried yeast; sugar; beaker of apple juice; fridge
New Word: fermenting

The apple juice should be a clear solution. Schloer works well. If the pupils are to taste the products, all apparatus must be thoroughly washed.

Q5 Tube 1 should be cloudier than 4. It may smell and taste differently too.

Q6 Temperature. Q7 1 cloudy, 2 clear, 3 cloudy (but less than 1).

Q8 Only 1 had yeast, sugar and apple juice; 2 had no yeast and 3 had apple juice (which could provide food for yeast) but no sugar.

Q9 A fungus.

MAKING CHEESE AND YOGURT
(pupils' book page 14)

Apparatus: 250 cm^3 beaker; heatproof mat; tripod; gauze; glass rod; Bunsen burner; spatula; sieve; bowl; 2 pieces of muslin; thermometer; plastic pot; fresh milk; yogurt bacteria
New Words: plant bakeries, kneaded, conveyor belt, alcohol, mature, cereal, whey, rind

For yogurt bacteria, use any retail brand of live or natural yogurt except 'Dessert Farm' brand (This has been pasteurised, so the bacteria are inactivated). The plastic pot can be a used, washed yogurt or cream cheese pot.
Q10 So that the conditions are ideal for bacteria to grow and multiply.
Q11 A thick cream.
Q12 To separate the liquid (whey) from the solids (curds).
Q13 A creamy solid.

5 DAMAGE TO OUR FOOD

CHANGES IN FOOD WHEN IT GOES BAD (pupils' book page 18)

Apparatus: samples of fresh and bad foods on labelled dishes; metal tweezers; 4 agar plates; clear tape; Bunsen burner; heatproof mat; hand lens; wax pencil; bench swabs

One week before this lesson, sample pieces of bread, cheese and apple should be put in small sealed jars and kept in a warm dark place. This will encourage mould growth. The agar should be nutrient agar and the jelly made according to manufacturers' instructions. There is no need to incubate plates in an oven. If they are kept at room temperature for 3-4 days, mould growth on the 'bad' food plates should be well established. Observe D.E.S. recommendations for the preparation, use and disposal of plates.
Q2 To sterilise them.
Q3 To provide the best conditions for the growth of microbes.
Q4-Q6 Depend on observations.

HOW MICROBES REACH FOOD
(pupils' book page 20)

Apparatus: nutrient broth; 4 boiling tubes; test tube rack; cooking foil; cotton wool; short, straight glass tube; short, s-shaped glass tube; pressure cooker; stop clock; wax pencil; gas ring

The nutrient broth should be made from Oxoid Nutrient broth tablets according to manufacturers' instructions.
Teachers should sterilise the tubes in a pressure cooker or an autoclave.
The experimental tubes should be kept in a dark place. The experiment shows that microbes are heavier than air.
Q8 They are killed.
Q9 Tube 1, and, to a lesser extent, tube 3.
Q10 Tubes 2 and 4.
Q11 The broth goes bad in the tubes where the microbes can enter.
Q12 The air.

6 STOPPING FOOD DAMAGE

HOW WE CAN STOP MICROBES GROWING ON FOOD
(pupils' book page 22)

Apparatus: 8 sealed tubes of broth containing microbes; 1 sealed tube of broth; distilled water; weak (1%) salt solution; strong (20%) sugar solution; ethanoic acid (white distilled malt vinegar); 20% sodium nitrite solution; wax pencil; test tube rack; 7 droppers; 9 elastic bands; bench swabs
New Words: preservative, inactive, vacuum-packed, dehydration, curing, pickling

The nutrient broth should be made from Oxoid Nutrient broth tablets according to manufacturer's instructions. Some broth should be inoculated with 2-3 loopfuls of *E. coli* culture obtainable from biological suppliers such as Philip Harris Ltd.
Sodium nitrite is the major preservative used by food manufacturers today. Smoking is a method not included in the experiment as this technique accounts for a tiny fraction of all food preserved. Teachers could encourage children to devise an investigation on the effectiveness of smoke as a preservative.
Q2 To prevent entry of microbes from the air.
Q3 As a control to make comparison of tube cloudiness easy.
Q4 Partly as a control and to show water is not a preservative.
Q5-Q9 Depends on observations.

7 MILK

TESTING MILK FOR FRESHNESS (pupils' book page 25)

Apparatus: 2 milk samples, numbered 1 and 2; methylene blue solution; stop clock; 3 test tubes; test tube rack; two 10 cm^3 measuring cylinders; dropper; wax pencil; beaker of warm water

Use homogenised milk as it does not separate when it sours. Sample 1 is fresh. Sample 2 is 4-5 days old. A thermostatically-controlled water bath set at 40°C could be used instead of a beaker of hot water. If the temperature of the water is lower than 40°C, the colour change may not occur in 45 minutes.

Q2 There are many microbes in the container, or they are very active.
Q3 Sample 2. Q4 Sample 2.
Q5 Tube 3 is untreated as a check to ensure that the blue colour in 1 or 2 is completely discharged.

WHY MILK TURNS SOUR (pupils' book page 26)

Apparatus: labelled samples of fresh and 4-day-old milk; 2 sterile petri dishes; 2 sterile droppers; Bunsen burner; heat-proof mat; wax pencil; clear tape; bench swabs; 2 bottles of milk agar
New Words: pasteurisation, evaporation, condensed

Use pasteurised milk as the appearance of fresh and sour pasteurised milk is very different. Make milk agar according to manufacturers' instructions. Nutrient agar is an alternative. The agar, in McCartney bottles, must be kept warm until pupils are ready to pour—otherwise it will solidify. Teachers may want to demonstrate plate pouring and have pupils practice the technique with water and clean glass petri dishes beforehand. Observe D.E.S. recommendations for the preparation, use and disposal of plates.

Q7 Depends on observations. Q8 The 4-day-old milk.
Q9 Microbes. Q10 Depends on observations.

8 FOOD PRESERVATION

PRESERVING BEETROOT (pupils' book page 28)

Apparatus: $\frac{1}{2}$ kg of brine-treated, fresh beetroot; tripod; 20% salt solution; spiced vinegar; 500 cm^3 and 250 cm^3 beakers; kilner jar; jam jar with lid; 3 labels; stop clock; gauze; Bunsen burner; heatproof mat; cloth; elastic band; polythene bag
New Word: processed

If fresh beetroot are not available, fresh red cabbage could be substituted. Whole beetroot can be 'brine-treated' by covering it with salt and leaving overnight. It will be best to preserve small quantities of food. Spiced vinegar —boil and cool malt vinegar with $\frac{1}{2}$ teaspoon of pickling spice.

Q2-Q4 The conditions in which the foods are kept prevent the growth of microbes.

9 MICROBES IN THE KITCHEN

HOW EFFECTIVE IS YOUR WASHING UP? (pupils' book page 30)

Apparatus: 4 bowls numbered 1 to 4; washing up liquid; washing up cloth; measuring jug; hot water; 4 dirty plates numbered 1 to 4; dusting powder

The plates should be artificially soiled with a mixture of warm lard, egg and tomato and allowed to dry before the experiment. The dusting powder should be carbon black in a 'pepper pot' or talcum powder puffer.

Q2-Q4 Depends on observations.

TESTING FOR BACTERIA ON WASHED CONTAINERS (pupils' book page 31)

Apparatus: washed cups, plates and cutlery for testing; several agar plates; tape; sterile distilled water; sterile cotton wool buds; wax pencil; cleanest plate from previous experiment
New Words: pathogenic, toxin, botulism

A collection of old crockery and cutlery could be used for the investigation. Agar is nutrient agar made according to manufacturer's instructions. Observe D.E.S. recommendations on the preparation, use and disposal of agar plates.

Q5 As a control.
Q6-Q7 Depend on observations.

1 The microscope

USING A MICROSCOPE (page 1)

Q1 I moved the mirror when setting up the microscope so that .....

.....

Q2 To bring an object into focus I did the following: .....

.....

MAKING THINGS LOOK BIGGER (page 2)

Q3 The distance across the middle of the circle of light was ..... mm.

Q4 I could put ..... objects side by side across the middle of the circle.

Q5 One of my objects measured ..... mm.

INFORMATION: MAGNIFYING THINGS (page 3)

Q6 If a photograph of a specimen carries the mark X420, this means .....

.....

Q7 A substance that might damage a microscope is .....

INFORMATION: TYPES OF MICROBES (page 4)

Q8 There are ..... kinds of microbe.

Q9 There are ..... kinds of protozoa.

Q10 Protozoa might be found in .....

Q11 A fungus is .....

.....

Q12 I could put bacteria into groups (classify them) according to .....

.....

Q13 Viruses live in .....

2 Fungi

LOOKING AT YEASTS AND MOULDS (page 6)

Q1 The shape of yeast cells is .....

Q2 The yeast cells *did/did not* change as I was watching them.

Q3 The bread mould fungus looks like .....

Q4 On the back of this sheet of paper, draw the bread mould as it appeared under the microscope.

2 Fungi (continued)

INFORMATION: MOULDS AND YEAST (page 7)

Q5 One way of using mould in food is .....

Q6 When yeast cells have enough food they .....

Q7 Fungi damage bread by .....

IDENTIFYING MOULDS (page 8)

Q8 The microscope must be kept upright when looking at the culture because .....

.....

Q9 A cover slip is put on top of the culture to .....

.....

Q10 The moulds that I saw were .....

INFORMATION: IDENTIFYING MOULDS (page 9)

Q11 Moulds can harm humans in the following ways .....

.....

Q12 Moulds can help humans in the following ways .....

.....

3 Bacteria

LOOKING AT BACTERIA

Q1 On the back of this page draw a picture of the bacteria as they appeared under the microscope.

Q2 The drops of culture are spread along the slide so that .....

Q3 The bacteria must be stained because .....

Q4 I made the bacteria stick to the slide by .....

Q5 The bacteria are shaped like .....

INFORMATION: MORE AND MORE BACTERIA (page 11)

Q6 When bacteria are warm and have plenty of food they .....

Q7 In 15 hours one bacterium can produce ..... bacteria.

Q8 In freezing conditions bacteria may .....

Q9 To make sure that bacteria would not grow on onions, I would treat the onions as follows .....

.....

4 Using Microbes

USING YEAST TO MAKE BREAD (page 12)

Q1 Loaf . . . . . is the largest after baking.

Q2 Loaf . . . . . feels the heaviest after baking.

Q3 I think yeast is used in bread-making to . . . . . .

. . . . . .

USING YEAST TO MAKE WINE (page 13)

Q4

Tube number	Contents of tube	Appearance of tube contents after one week	Smell of tube contents after one week	Taste of tube contents after one week

Q5 After one week there *was/was not* a difference between tubes 1 and 4.

Q6 My reasons for this are . . . . . .

. . . . . .

. . . . . .

Q7 After one week there *was/was not* a difference between tubes 1 and 2.

After one week there *was/was not* a difference between tubes 1 and 3.

Q8 My reasons for this are . . . . . .

Q9 Yeast is a kind of microbe called a . . . . . .

MAKING CHEESE AND YOGURT (page 14)

Q10 The milk and yogurt bacteria are left in a warm place because . . . . . .

. . . . . .

Q11 The yogurt looks like . . . . . .

. . . . . .

Q12 The cheese is squeezed in the muslin to . . . . . .

. . . . . .

Q13 The cream cheese looks like . . . . . .

. . . . . .

4 Using Microbes (continued)

INFORMATION: BREAD MAKING IN A BAKERY (page 15)

Q14 . . . . . makes the bread rise during proving.

Q15 In the hot oven the yeast . . . . . .

Q16 Bread is moved through bakery ovens by . . . . . .

Q17 The bread is not handled until it has been wrapped because . . . . . .

. . . . . .

. . . . . .

INFORMATION: MAKING WINE AND BEER (page 16)

Q18 Fermentation is . . . . . .

. . . . . .

. . . . . .

Q19 It is important to keep grape skins in the fermenting vats because . . . . . .

. . . . . .

. . . . . .

INFORMATION: MAKING CHEESE (page 17)

Q20 Curds are . . . . . .

. . . . . .

Q21 After the cheese is put in a mould or press it . . . . . .

. . . . . .

Q22 I think salt is added to the cheese to . . . . . .

. . . . . .

Q23 Other ways that we use microbes are . . . . . .

. . . . . .

. . . . . .

. . . . . .

5 Damage to our food

CHANGES IN FOOD WHEN IT GOES BAD (page 18)

Q1

Name of food	Appearance of fresh food	Appearance of bad food

Q2 The tweezers were held in a Bunsen flame to .....

Q3 The agar plates were kept in a warm place for 2 days to .....

Q4 After 2 days most microbes were growing on .....

Q5 The *fresh/bad* foods had the most microbes growing on them.

Q6 The microbes growing on the plates *were/were not* all the same type.

HOW MICROBES REACH FOOD (page 20)

Q7

Tube number	Treatment of tube	Appearance of tube contents:	
		when removed from pressure cooker	after one week

Q8 When the broth is cooked in the pressure cooker any microbes present .....

Q9 After one week the broth had gone bad in tubes .....

Q10 After one week the broth had not gone bad in tubes .....

Q11 The broth had gone bad in some tubes, but not all, because .....

.....

Q12 The microbes that made the broth go bad must have come from .....

INFORMATION: DISCOVERING MICROBES (page 21)

Q13 The broth in Pouchet's open flask went cloudy and bad because .....

.....

Q14 The microbes were trapped in the s-bend of Pasteur's flask because .....

.....

.....

Q15 In my experiment tube ..... was a copy of Pasteur's flask.

Q16 I *did/did not* get the same result as Pasteur with my tube.

6 Stopping food damage

HOW WE CAN STOP MICROBES GROWING ON FOOD (page 22)

Q1

Tube number	Treatment given to tube	Appearance of tube after 2 days

Q2 The tubes were sealed with foil because .....

.....

Q3 Tube 9 was left untreated and containing no microbes so that .....

.....

Q4 Distilled water was added to tubes 1 and 2 because .....

.....

Q5 Microbes *do/do not* grow in sweet (sugar) solutions.

Q6 Microbes *do/do not* grow in salt solutions.

Q7 Microbes *do/do not* grow in acid solutions.

Q8 Sodium nitrite *is/is not* a preservative.

Q9 A low temperature *does/does not* affect the growth of microbes.

INFORMATION: PRESERVING FOOD (page 24)

Q10 The disadvantage of buying food preserved by freezing is .....

.....

Q11 If oxygen got into vacuum-packed foods .....

.....

Q12 The importance of the 'sell by' date on foods is .....

.....

7 Milk

TESTING MILK FOR FRESHNESS (page 25)

Q1

Tube number	Treatment of tube	Colour of tube contents:			
		at start	after 15 minutes	after 30 minutes	after 45 minutes

Q2 If the amount of oxygen in a container goes down fast, this means that the number of microbes in the container is .....

Q3 The milk sample that changed the colour of the methylene blue quickest was .....

Q4 The milk sample that had the most microbes in it was .....

Q5 I left tube 3 untreated because .....

.....

WHY MILK TURNS SOUR (page 26)

Q6

Age of milk	Smell of milk	Appearance of milk	Appearance of agar after 2 days

Q7 Make drawings in the table to show what the milk looked like after 2 days.

Q8 The milk sample that had the most microbes in it was .....

Q9 Milk goes sour because .....

Q10 The changes in milk as it goes sour are .....

.....

7 Milk (continued)

INFORMATION: PRESERVING MILK (page 27)

Q11 Pasteurized milk turns sour in a sealed bottle because .....

.....

Q12 Sterilized and UHT milk do not turn sour in their containers because .....

.....

Q13 The difference between pasteurization and UHT treatment is .....

.....

.....

Q14 The process of pasteurization is named after .....

8 Food preservation

PRESERVING BEETROOT (page 28)

Q1

Date at start and two weeks later	Appearance of beetroot after treatment:		
	freezing	bottling	pickling
(start) date:			
(end) date:			

Q2 Freezing preserves food by .....

Q3 Bottling preserves food by .....

Q4 Pickling preserves food by .....

INFORMATION: PROCESSING AND PRESERVING FOOD (page 29)

Q5 In the processing of potatoes they are peeled by .....

Q6 The chips are fried for .....

Q7 The 2 methods of preserving used in potato processing are .....

.....

Q8 Two other possible ways of preserving potatoes are .....

.....

9 Microbes in the kitchen

HOW EFFECTIVE IS YOUR WASHING UP? (page 30)

Q1

Bowl and plate number	Method of washing up	Appearance of plate after dusting

Q2 In the table above, make drawings to show what the plates looked like after dusting.

Q3 The method of washing up which left most grease on the plate was .....

Q4 The method of washing up which removed most grease from the plate was .....

TESTING FOR BACTERIA ON WASHED CONTAINERS (page 31)

Q5 One agar plate was left unused because .....

.....

Q6 The agar plates *did/did not* have colonies of bacteria on them.

Q7 Washing up *does/does not* remove bacteria from dishes.

INFORMATION: DANGER IN THE KITCHEN (page 32)

Q8 A pathogen is .....

Q9 Botulism is .....

Q10 Places shown in the drawing where there may be lots of microbes are .....

.....

.....

.....

.....

Specimen post-unit questions

1 A pupil was using a microscope. He had a X10 eyepiece and a X40 objective lens in position. What was the magnification? Tick (√) the answer.
a) X4000 b) X140 c) X50 d) X400 e) X40

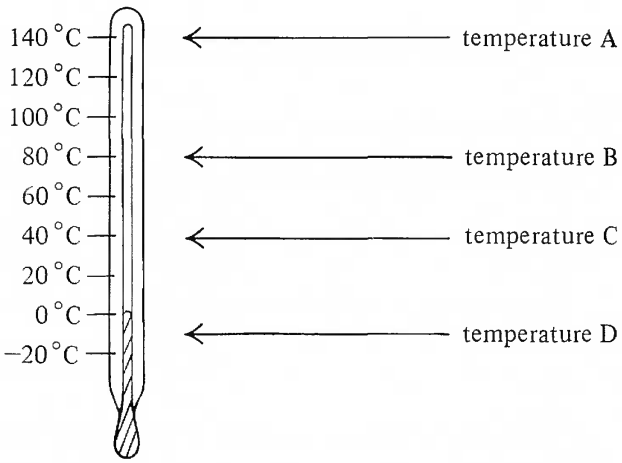
2 Why is a stain sometimes used when looking at microbes with a microscope? Tick (√) the answer.
a) To make the microbes stick to the slide.
b) To make the microbes look bigger.
c) To kill the microbes.
d) To focus the microbes clearly.
e) To colour microbes that are transparent.

3 If supplied with food and warmth, how many bacteria will be produced from one bacterium in 15 hours? Tick (√) the answer.
a) $\frac{1}{2}$ million bacteria
b) 1 million bacteria
c) 5 million bacteria
d) 10 million bacteria
e) 100 million bacteria

4 Which of the following is added to water to make beer? Tick (√) the answer.
a) Yeast, hops and barley.
b) Yeast, grapes and hops.
c) Yeast, flour and sugar.
d) Yeast, barley and grapes.
e) Yeast and grapes.

5 Which method would be the best way to sterilize a test tube? Tick (√) the answer.
a) Soak it in acid for 5 minutes.
b) Heat it in a Bunsen burner flame.
c) Heat it in a pressure cooker for 15 minutes.
d) Dip it in a beaker of boiling water.
e) Wash it in hot, soapy water.

6



The diagram shows a thermometer. Complete the sentences below by putting the correct letter in the gap.
a) At temperature . . . nearly all bacteria would be killed.
b) At temperature . . . bacteria would grow quickly.
c) At temperature . . . bacteria would be alive but not growing.

7 Some of the statements below are true and some are false. Write down whether each statement is true or false in the spaces provided.
a) Pasteurization does not kill all the bacteria in milk. . .
b) Methylene blue stays blue when the amount of oxygen near it gets less. . .
c) Sodium nitrite is used as a food preservative. . .
d) Pickling kills all the bacteria in pickled onions. . .
c) Vacuum-packing kills all the bacteria in the food packed. . .

8 Microbes are **not** used to make one of the foods listed below. Tick (√) the answer.
a) cheese b) cream cheese c) cream
d) bread e) yogurt

Reference books

For teachers and technicians:

The Microbiology in Schools Advisory Committee (MISAC) publishes a list of local advisors which can be found in the *Journal of Biological Education*, 1979, Vol. 13, No. 2, pages 156-158. MISAC is administered by the Institute of Biology. Any further advice can be obtained by writing to MISAC, c/o Education Officer, Institute of Biology, 41 Queens Gate, London SW7 5HU.

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