THE WATER CYCLE
evaporation and condensation

Science background for teachers

Water is one of the most important substances on Earth, being essential to all living cells, 75% of our bodies is made up of it! Water covers 70% of the earth's surface and is the most common liquid we come across, 97% is salty and 3% is fresh. Of the fresh water, 85% is in the form of ice and the air we breathe includes **water vapour,** the gaseous state of water. It is continually recycled on our planet. Water from the earth's surface in the form of seas, lakes, rivers, down to puddles **evaporates** and returns to the atmosphere as water vapour. This becomes cooler, **condenses** to form tiny water droplets or ice crystals and forms clouds. When these water droplets become too heavy to remain floating in the air, they fall as rain or snow and this is known as **precipitation.**

Evaporation

VOCABULARY

Liquid, gas, gaseous, water vapour, steam, evaporation, condensation, precipitation, water cycle, conditions, rain forest, ice, crystals, transpiration, root system, cells, specialised, humid, atmosphere, floating, air stream, molecules, perimeter, surface, treatment, waste, sewage, reservoirs

When water boils at 100 °C it changes from a liquid into a gas that we call 'steam' and moves into the surrounding air. However, boiling does not need to occur for evaporation to take place. In any quantity of liquid, the molecules at the surface have less interaction with each other than those in the body of the liquid. These molecules leave the surface and evaporate into the air. This gas is not hot like steam, but cool and is called a **vapour.** As it happens at the surface and is dependent on temperature, the larger the surface area and the warmer it is the faster it happens. If a wind or stream of air is present to blow away the slowly evaporating liquid molecules, they move away faster allowing the next layer of liquid to evaporate, so speeding up the process. So large, shallow, puddles dry up faster than narrow, deep ones containing the same volume of water. They all dry up faster on a warm, sunny or windy day.

Another effect of evaporation is that of cooling. As surface liquid evaporates, energy is transferred from the liquid to the vapour resulting in the liquid becoming cooler. This happens in sweating, as the sweat on the surface of the skin evaporates the skin cools down. The faster this happens, the more dramatic the effect, eg surgical spirit on the skin evaporates very quickly leaving the skin feeling very cold.

Condensation precipitation and the water cycle

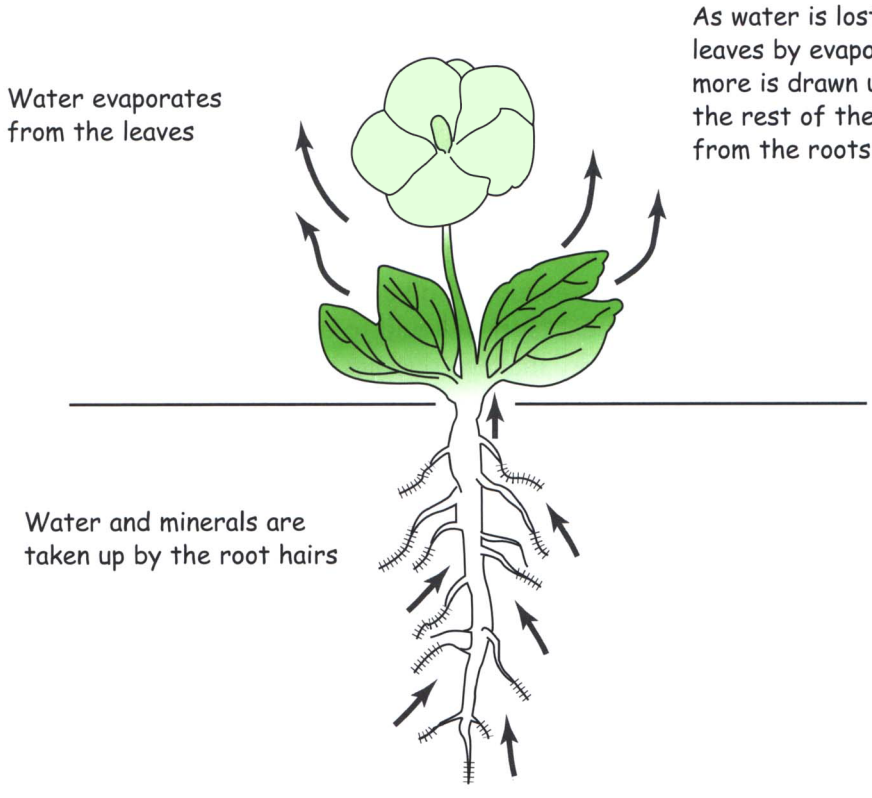
As water evaporates from the oceans, seas and rivers, which are two thirds of the Earth's surface, the air becomes filled with water vapour and may become humid. If this continues, it becomes saturated with water vapour and can hold no more, but this depends on the air temperature. The higher the temperature, the more water vapour can be held. As saturated air cools down, the water vapour changes back into the liquid state or **condenses** and then forms tiny water droplets in a cloud, mist or fog. If this is near the ground it is a mist or fog, but clouds form well above the ground and if they are cold enough, they consist of ice crystals. As these ice crystals or water droplets bump

together and get bigger, they become too heavy to remain floating in the air on the upward air stream and they fall. This is called **precipitation.** If the air is warm, the ice crystals melt and fall as rain, if not, they fall as snow. This process of evaporation and condensation is the **water cycle.**

Transpiration and the water cycle

Plants also contribute to the water cycle during a process called **transpiration.** Water is taken up by their root system, is transported in specialised cells in the stem, travels up to the shoots and leaves where it evaporates. Trees lose vast amounts of water through transpiration, a large oak may transpire up to 360 litres (dm^3) of water per hour on a sunny day! This is especially significant in areas of the world where there are large forests, creating a humid atmosphere. This water vapour eventually falls as rain to continue the cycle, but where large areas are de-forested this cycle is disturbed changing the humidity of the air and the subsequent rainfall.

The Transpiration Stream



Domestic water cycle

There is also a domestic water cycle, the average personal use is about 273 pints or 155 litres (dm^3) per day and most of it leaves our houses as waste water from bathrooms and kitchens and goes into the sewers. This, together with water from industry must be treated before it returns to the distribution system in a form suitable for drinking.

Graphing package

Domestic Water Usage

Taking a bath	40 litres
Shower	20 litres
Flushing the toilet	10 litres
Washing hands or face	9 litres
Drinking water	1 litre
Brushing teeth	1 litre
Dishwasher load	30 litres
Washing machine load	100 litres
Other... cooking etc.	30 litres

At the waste water treatment plant (sewage works), screening removes large debris and a series of filters removes other matter. The water then either goes to a water treatment plant or is allowed into the rivers and seas where it continues the cycle of evaporation, condensation and precipitation. Rain water collects in reservoirs, and together with water from under the ground and from rivers it goes to a water treatment plant where it is disinfected, stored and pumped through the main distribution system to our homes, hospitals and industry.

SKILLS

- Fair testing, dealing with variables, repeating procedures.
- Working cooperatively, using apparatus and observing accurately.
- Using a thermometer and a stopwatch.
- Measuring volume and perimeter.
- Constructing a line graph.

Different liquids will evaporate (at different rates) if left uncovered

After a discussion about puddles drying up, clothes drying and the introduction of the word evaporation, simple activities can be set up to demonstrate the idea, depending on the age and experience of the children. After these activities discuss where the liquid went. It is also worth discussing with the children the fact that the liquid does not need to be hot to turn to a gas/vapour.

(a) Leave out dishes of different liquids, eg water, vinegar, lemon juice, salty water and tea for the children to observe. Duplicate some and cover them. What happens to the uncovered dishes? Is anything left behind? Can you smell anything, why?

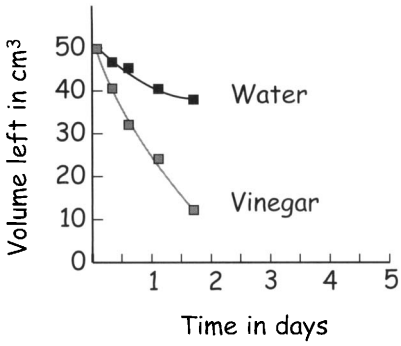
(b) The first part of the above activity may be carried out in a more quantitative way as an extension for the more able children or as an investigation, 'which liquid evaporates the fastest?' This will involve the idea of fair testing because the dishes, quantity of liquid, conditions in which they are left must remain the same. It is useful to calibrate the containers at the start or use calibrated beakers. The children can plan this investigation as a way of reminding them of the importance of fair testing and the variables involved. Older children can construct a line graph of the rate of evaporation of the different liquids, which would involve timing and measuring the liquids daily or more frequently depending on the temperature of the classroom and volume of liquid.

I predict water will evaporate the fastest.

Liquid used for test		Amount of liquid left and other observations				
		Monday	Tuesday	Wednesday	Thursday	Friday
covered lemon juice						
uncovered lemon juice						
covered vinegar						
uncovered vinegar						
covered salty water						
uncovered salty water						
covered water						
uncovered water						

A graph to show the rate of evaporation of liquids.

Graphing package



We could draw more than one line using different colours for different liquids.

(c) If it is possible and it has been raining (or fake it!) monitor a puddle in the school playground by drawing around the perimeter with chalk at regular intervals throughout the day as the water evaporates. Before it completely disappears get the children to predict where the next chalk line will come. Reconstruct on paper in the classroom.

Evaporation is affected by various factors

Datalogging

The following activities may be set up as directed classroom activities, but all allow the opportunity for excellent **investigations** to take place. Many children would say for example, that puddles dry up faster when it is sunny or warm, why? How would they prove that temperature affects evaporation, and is it so for liquids other than water? These activities also allow for the introduction or revision of 'variables' and fair testing and line graphs.

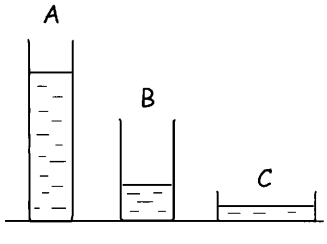
(a) **Temperature** Set up containers of liquids or just water in areas of varying temperature including the refrigerator and near radiators or the sunshine. Use wall thermometers to show the different temperatures of the different areas or leave thermometers or sensors in the liquids to monitor their temperature. The children can then record the different amounts of liquid.

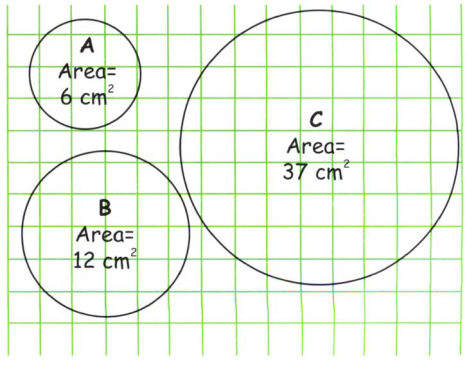
Safety!

- Spirit thermometers should be used.
- Care when handling glassware.
- Care when handling hot and cold things.

(b) **Surface area** **Investigate** which evaporates faster, the same volume of water in a wide, shallow container or a narrow deep container. Set up a variety of containers for this activity. If they are jars the children can draw around the openings onto squared paper to calculate the surface areas. This is an activity that most would have done in maths. Square or rectangular plastic boxes may also be used, and the areas of these can be calculated by multiplying their length by the breadth (for the more able children).

Keep the test fair... same liquid, same temperature, same volume of liquid. Which do you think will be the fastest?

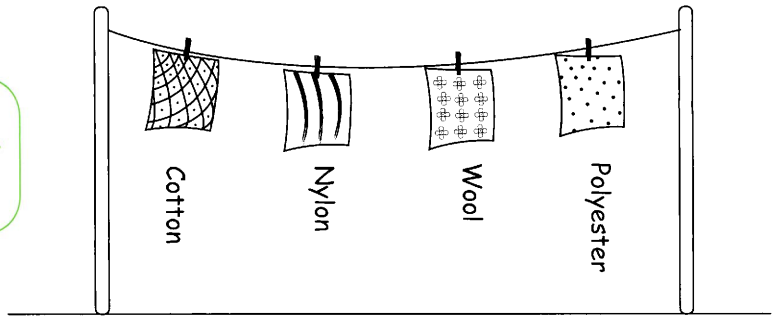




(c) **Wind factor** Some special equipment may be needed, an electric fan to supply the wind! This could be carried out as a demonstration using a small quantity of liquid in a shallow container standing in front of the fan and another behind it, just to demonstrate the point.

(d) **Everyday context** Set the above activity in an everyday context of washing drying on a line. Small 'washing lines' can be set up in different areas of the classroom, eg in front of the fan, over a radiator. Different groups of children can contribute identical sized but different types of material for each line. So, for example the 'cotton' group has identical sized pieces of cotton on different lines in the classroom. The pieces of material are wetted with the same volume of water. As there are two variables here, the type of material and classroom condition, this maybe more suitable for the more able children. Other children could carry out this activity with one variable only.

Make the pieces of fabric the same size and put the lines in different places.



Discuss the results and get the children to identify various situations in an everyday context where evaporation occurs, include the use of drying equipment such as hairdryers and tumble dryers.

Evaporation can be used as a way of recovering dissolved solids

This can be very simply introduced as shown in activity (a) as a basic principle by including salty water as one of the liquids left to evaporate. This can then be discussed along with the question, what would happen if you left out a sugar solution? The children could then prepare a series of solutions eg coffee, sugar, bicarbonate of soda and evaporate the water off. (This is further explored in the section on Separating mixtures of materials).

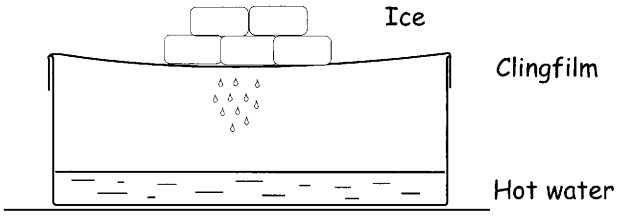
The concept of water vapour condensing to water as it cools needs to be introduced either at this stage or before. (Refer also to section on Heating and cooling materials, kettle experiment.)

Condensation and evaporation as part of the water cycle

(a) **Water vapour can condense to form water and this is the reverse of evaporation** This can either be a whole class or group demonstration. Set up a bowl of warm water, cover with a dish containing ice. As the water evaporates and hits the cold saucer, it condenses and 'rains'.

(b) Repeat the activity using cooler water, which just takes longer to work. Discuss this with the children. Water does not need to be

What happens if we use cold water and no ice?



hot to evaporate and condense, but the process is faster with hot water.

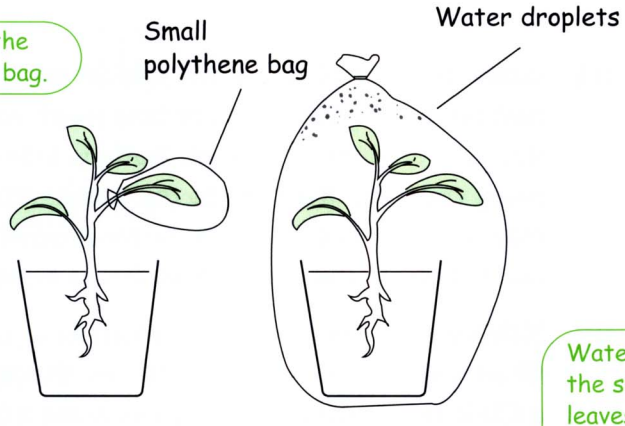
(c) Small groups of children can have their own screw top jar with ice inside. After about 5 minutes condensation is seen on the outside of the jar, where water vapour in the air has cooled against the cold glass.

Some children have great difficulty with the concept of condensation and are convinced that the ice melts and goes through the jar or the saucer. Try using a very cold glass straight from the refrigerator and eliminate the ice.

You could use the concept cartoon ***Ice cream*** here.

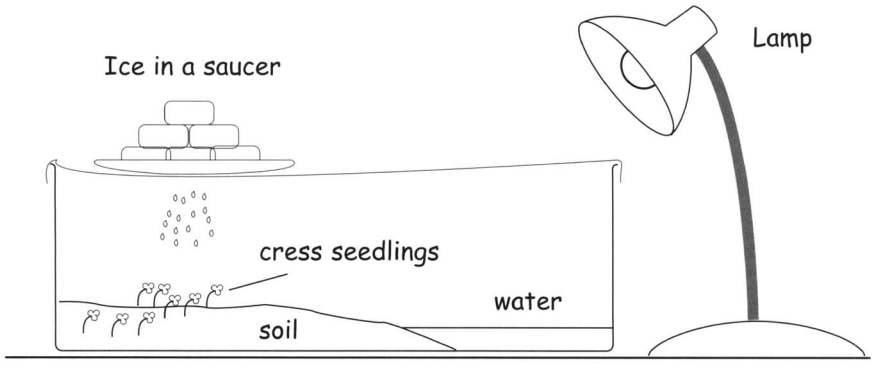
(d) **Plants are part of the water cycle, water evaporates from their leaves** A demonstration model can be set up to show that water evaporates from the leaves by covering a stem/leaf section of a pot plant with a small polythene bag. Water evaporates from the leaves and condenses on the inside of the bag. Also a mini-cycle can be set up, by enclosing the whole plant in a clear polythene bag. Water evaporates from the soil and the leaf surface, condenses on the inside of the bag and drips back onto the plant.

Enclose part of the plant in a plastic bag.

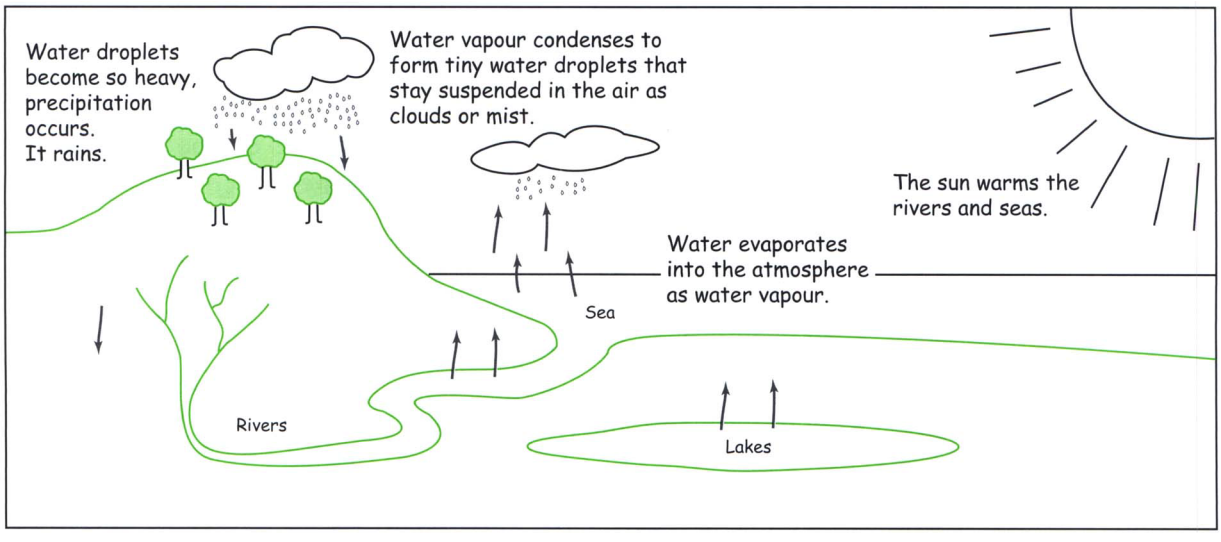


Water evaporates from the surface of the leaves (and soil). It condenses on the inside of the bag and drips back onto the plants.

(e) Water evaporates from the Earth's surface, condenses to form clouds and falls as rain Discuss all the previous activities in the wider context of the water cycle and the weather. A demonstration model can be set up to simulate this using an aquarium with land and water, cover with cling film and put ice in a saucer on the top, which can be renewed. Use this as a model to get the children to draw their own water cycle from what is happening. Then draw the water cycle on a larger scale in real terms.



The Water Cycle



(a) How much water do we use or waste? It is worth making the children aware of how much water we use, especially since the amount of available water is a life-threatening issue in many countries. Referring to the 'Usage table' page 105, get the older children to calculate how much water they or their family use in a week. They can record this as a chart.

The domestic water cycle

(b) Where does water come from and our waste go? Older children could research this for themselves using books or a CD-ROM. Alternatively, they can make a pictorial cycle from a list of sentences you give them about the domestic cycle. Local water boards will often give free information leaflets or visit the school to give a talk.

Salty Wave Salty, sea, water evaporates leaving the salt behind on your skin.

Chippy Breath Condensation occurs when water vapour hits a cold surface and changes to a liquid. See page 84.

Steamy Shower Hot water evaporates, then condenses in the bathroom, dripping of the ceiling. See page 85.

Hot Pants The hot air in a tumble drier speeds up evaporation making the clothes dry quickly. See page 85.

Grandad's Airer Water evaporates from the clothes on an airer, making them dry. See page 85.

Thirsty Land The sun's heat makes the water evaporate from the land, drying up the land. See page 85.

Salty Wave

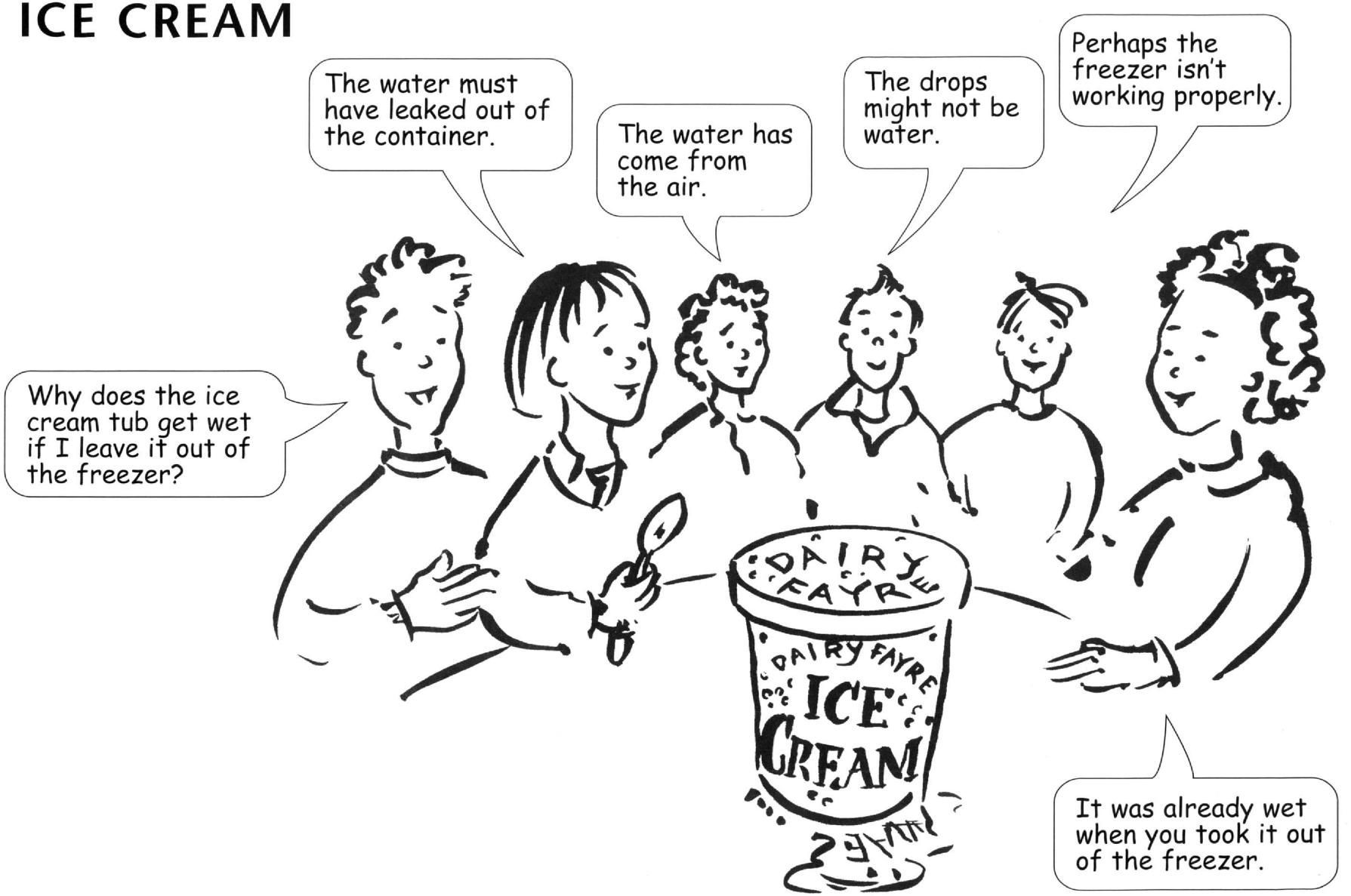
When I went through the wave I gobbled a great gulpful of salt-water.

That night in bed my hand nestling on my neck found tiny crusts; white grains.

And when I licked my finger-tip, it was as salty as a crisp – or a wave.

ICE CREAM

RS•C



CONCEPT CARTOONS

Ice cream

Although the children will have experience of condensation they are unlikely to have well-formed ideas about where the condensed water comes from. The concept cartoon invites them to consider and investigate a number of possibilities, and they may well think of other possibilities themselves. The fact that the condensation comes from the air may appear to be the least likely possibility to many of the children. Wrapping the ice cream tub in polythene or aluminium foil and observing where the condensation forms should help to clarify their ideas. Investigations such as this help to lay the foundation for later work on the structure of matter and conservation of mass.

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