



Lesson plan on investigative science

Evaporation

Evaporation

Pupils performed less well in the TIMSS test when assessed on applying their knowledge of evaporation in real life contexts. Lessons 1 and 2 provide teachers with classroom activities for pupils to learn about evaporation and apply their understanding when designing their own practical investigation based on a real life context.

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Lesson 1

What is the best dish for a bird water bowl? Planning an investigation

Lesson 1 objective To understand the process of evaporation and to plan an investigation to decide on the most suitable container for a bird water bowl.

Skills To observe a real life and compare a range of factors.

Prior knowledge

Understanding For this lesson pupils should already be familiar with the concept that water exists in different states - as a solid (ice), liquid and gas. They should be aware that water can change from one state to the other, although they may not understand the process of how this occurs.

Skills Pupils are going to be planning an investigation that will consider the other factors that may help them come to a conclusion in order for them to think they should have some prior experience of carrying out their tasks and understanding the principle of changing one factor while keeping the others the same.

Definitions The definitions below may be helpful for this lesson.


Evaporation/evaporate - the change in state from a liquid to a gas (e.g. water vapour).

Water vapour - the gaseous state of water. When water changes from a liquid into particles in the air.

Steam - also the gaseous state of water, when water molecules become particles, changing from a liquid to a gas.

Note for Teacher At Key Stage 2, pupils will only be expected to refer to water vapour and steam as a gas, but should be aware steam is only produced at very high temperatures (500°C) when water boils whereas water vapour exists in the air at all temperatures.

There is often confusion around water vapour and steam. Water vapour refers to the molecules of water which are present in the air. There is always water vapour in the air around us. Water vapour is invisible and cannot be seen in the air. As the temperature of the air around liquid water molecules, water molecules are continually breaking away into the air to reach the gaseous state. If the water molecules come in contact with a surface that is cooler than the air it will not break into liquid water. When water boils, it changes to a gas, called steam. Both steam and water vapour can be referred to as gaseous states of water.



Lesson 2

What is the best dish for a bird water bowl? Drawing conclusions

Lesson 2 objective To make the link between surface area and how much water evaporates in a given time. To recognise that evaporation is a temporary change and that water vapour can change back to liquid water by the process of condensation.

Skills Recording results, and concluding by drawing together information from different sources.

Prior knowledge

Understanding For this lesson pupils should have a solid understanding of the process of evaporation from the previous lesson; they should understand that evaporation is the process by which liquid water turns to gas (water vapour).

Skills For this conclusion of their investigation pupils will be recording results and drawing a conclusion based on a number of factors. They should have had some experience of how to record results and how to use the results to come to a conclusion. In this lesson they will be extending this skill to consider the other factors together with the one they have investigated.

Equipment required

- 1) Printouts of the group planning sheet.
- 2) Each group needs their dishes of water from the previous lesson.
- 3) Picture of the water cycle.

Pupils will need to work in the same groups as in the previous week to complete their investigation.

Definitions The definitions below may be helpful for this lesson.

Reversible change - a non-permanent change through which one can go back to its original form.

Condensation - the process by which water vapour changes back to liquid water. This happens at cooler temperatures or when water vapour comes in contact with a cool surface.

Water cycle - the continuous cycle of water on our planet. Water evaporates to the atmosphere, condenses to form clouds, falls as rain or snow, runs off into the sea, rivers and lakes, or soaks back to water in the lakes, rivers and seas, where the water vapour condenses and it rains.



Evaporation lesson 1

What is the best dish for a bird water bowl? Planning an investigation

Aim To understand that water exists in different states and that the process of evaporation occurs when liquid water changes to gas.

Tea drying



Evaporation lesson 2

What is the best dish for a bird water bowl? Drawing conclusions

Aim To make the link between surface area and how much water evaporates in a given time. To recognise condensation is the reverse of evaporation, when the gas changes back to liquid water.

Results

Conclusion

Lesson plans



Lesson 1

What is the best dish for a bird water bowl? Planning an investigation

Lesson 1 objective – to understand the process of evaporation and to plan an investigation to decide on the most suitable container for a bird water bowl.

Skills – to design a fair test and consider a range of factors.

Prior knowledge

Understanding

For this lesson pupils should already be familiar with the concept that water exists in different states – as a solid (ice), liquid, and gas. They should be aware that water can change from one state to the other, although may not understand the process of how this occurs.

Skills

Pupils are going to be designing a fair test and considering the other factors that may help them come to a conclusion. In order to do this they should have some prior experience of carrying out fair tests and understand the principle of changing one factor while keeping the others the same.

Definitions

The definitions below may be helpful for this lesson:

Evaporation/evaporate – the change in state when a liquid (e.g. water) changes to a gas (e.g. water vapour).

Water vapour – the gaseous state of water, when water changes from a liquid into particles in the air.

Steam – also the gaseous state of water, when water reaches boiling point, changing from a liquid to a gas.

Note for Teacher

At Key Stage 2, pupils will only be expected to refer to water vapour and steam as a gas, but should be aware steam is only produced at very high temperatures (100°C, when water boils) whereas water vapour exists in the air at all temperatures.

There is often confusion around water vapour and steam. Water vapour refers to the molecules of water which are present in the air. There is always water vapour in the air around us. Water vapour is invisible and cannot be seen in the air. As the temperature of the air around liquid water fluctuates, water molecules are continually breaking away into the air to exist in a gaseous state. If the water vapour comes in contact with a surface that is cooler than the air it will turn back into liquid water. When water boils, it changes to a gas, called steam. Both steam and water vapour can be referred to as gaseous states of water.



Equipment required



- 1) The picture of tea leaves drying (to display on a screen).
- 2) Each group will need:
 - three dishes with different sized openings
 - measuring jug
 - access to water
- 3) The groups may identify other equipment needed in planning their investigation, for example, a fan – but this could be brought in the following day.

Pupils should work in groups of 3-5. Each group should have access to the range of equipment they require for the task – ideally they would be able to choose this for themselves from a central area.

Links to everyday life

In this lesson, pupils will be learning about the process of evaporation, and planning an investigation in which evaporation will occur, to decide on the best dish to use for a bird water bowl. Pupils are likely to have had everyday experience of situations in which evaporation has occurred although they may not recognise this. They should be given time to consider various situations and see if they can think of more examples of situations in which evaporation occurs. The following can be used as starters for discussion or research:

- Cooking food in water on the hob, e.g. peas, rice, pasta. What happens to the water? What happens to the food? The food will absorb some of the water, but the overall volume of water will decrease because some will evaporate. When the water is boiling the water will be evaporating quite quickly.
- When do we need water to evaporate? Possible examples include: when we are drying clothes, painting with water soluble paint, making concrete.

- Opportunity to link to evaporation in biology, for example, water in sweat evaporating from the skin, dogs panting, water evaporating from the leaves of plants.
- Opportunity to link to the water cycle. Pupils could research the water cycle and find out when evaporation occurs. Think about a puddle of water – why does it disappear over time and not remain permanently? Discuss how the same process is happening to water in seas, lakes and rivers – only these generally have so much water we don't notice that some has evaporated. Discuss that evaporation is a reversible process, so liquid water changes to gas, but the gas can change back to water. (Lessons 1 and 2 could both lead to further work on the water cycle.)
- Hand sanitiser – when you put hand sanitiser on your hands, why do your hands become dry quickly? (the liquid evaporates quickly on your hands because it contains a high concentration of alcohol which evaporates more readily at lower temperatures than water – this could lead to a discussion on how it is not just water that evaporates; encourage students to consider that different liquids evaporate at different temperatures.)

Identifying misconceptions

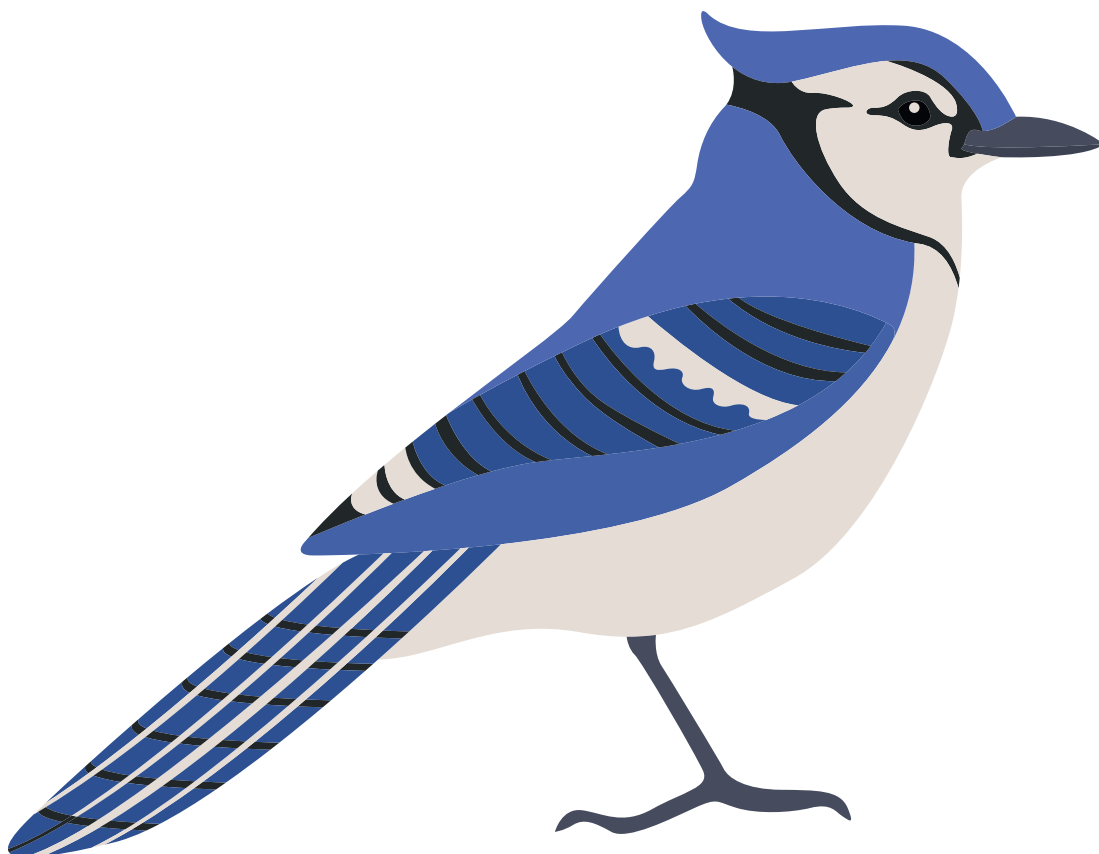
Pupils may have misconceptions about what happens to materials when they dry out. They may understand that a material may feel dry, but not fully appreciate that this is because the water in a material is changing state and turning into a gas. They may think the water has disappeared or turned into air. A learning point is to recognise that water usually exists as a liquid at room temperature. However, as the temperature increases it changes to a gas or water vapour and the process of water changing to a gas is called evaporation. They may not be able to link this process to different contexts, e.g. a puddle of water getting smaller, wet clothes drying on a washing line.



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The scenarios below can be used during the introduction of the lesson as discussion points to find out if pupils recognise in which situations evaporation is occurring. Ask pupils to first identify in which scenarios evaporation is taking place. Then each scenario can be discussed in more depth to see if pupils can explain what is happening. Some guidance is provided in brackets after each one, and a printout is provided for copying each one onto individual cards:

- **Hanging wet washing on a washing line.**
(Yes - the wet clothes will become dry as the water evaporates. Discuss the factors that will increase how quickly this process occurs e.g. temperature, humidity, wind - warmer temperatures, dry air, and a windy day will all increase the rate of evaporation.)
- **Putting a bottle of water into a freezer.**
(No - a freezer will cool the water in the bottle so it will turn from liquid to solid ice.)
- **Stirring salt into water.**
(No - this is the process of dissolving.)
- **Leaving wet clay to dry.**
(Yes - the water will evaporate leaving the hard, dry clay.)
- **Boiling a kettle.**
(Yes - when water is boiled in a kettle, the temperature of the water reaches boiling point and the water will evaporate quickly. The gas leaving the kettle is a white colour and is called steam. Steam is very hot and can burn you.)



Introduction for the task

The aim of this lesson is for pupils to understand that water exists in different states (i.e. solid, liquid, gas) and that evaporation is the process in which liquid water changes to its gaseous state, water vapour or steam.

Start the lesson by finding out if pupils can think of situations in their everyday lives in which water has turned to gas. To help them, you could ask if they can think of examples when something wet has dried out, or water seems to have disappeared. Discuss some of the prompts in the 'Links to everyday life'. Even if they did not recognise these examples as evaporation, they may now start to link to similar examples.

Tea production is an example that relies on a large scale evaporation process. Ask the pupils what tea is made from? (leaves); where are the leaves grown? (mainly Asia – China, India, Sri Lanka and Kenya); tea plants need warmth and plenty of water. When the leaves are picked they have to be dried. One method is by spreading out the tea leaves on large, shallow bamboo baskets and leaving them in the sun. Show pupils the picture of tea leaves drying. See if pupils can explain why the leaves dry when left in the sun. What is lost from the leaves for them to become dry? (water)

Where does the water go? (into the air, as a gas / water vapour)

What effect does temperature have on wet materials / objects? (when it is warmer, materials / objects dry out more quickly because the water turns to a gas more quickly. See if pupils can come up with everyday examples where they have noticed this e.g. washing dries more quickly outside on a hot day.)

See if any misconceptions are identified here. For example, did the pupils think that the water just disappears into the air and no longer exists?

Refer to the 'Identifying misconceptions' section on page 5, and discuss this prior to starting the task.

Then tell the pupils they will be carrying out an investigation that will be exploring the evaporation of water from different dishes, and introduce the task as described below.

Task

Tell the pupils that they need to decide on the best dish for a bird water bowl (the picture or the printouts of birds at a water bowl could be shown on screen). They are going to carry out an investigation to find out if the width of a dish affects the amount of water that evaporates from it. The context is as follows: a family is going on holiday for a week. They always leave water out for the birds and would like to leave water out while they are away. However, no one can replenish the water.

The family has found out that the weather will be quite warm while they are away, and that unusually it is not forecast to rain. They want a dish from which not too much water will evaporate otherwise there may not be enough water left or the birds may not be able to reach the water level. They have some different dishes they could use. Show the pupils three dishes of different widths. (The narrowest dish may need to be tallest to ensure it fits the same amount of water as the widest dish.) Tell the pupils they are investigating if the width of the dish makes a difference to how much water evaporates, because this affects the surface area of the water in

contact with the air. Hold up the widest dish. Indicate that the surface area of the water will be the size of the opening of the dish. (See what dishes you can find to use for this investigation, or ask pupils to bring some dishes in from home.) If different groups test dishes of different sizes that is fine, as long as each group has three dishes with different width openings. Possibilities are flower pots, empty baked bean cans, glass ramekin dishes, pet water bowls. Make sure narrower dishes can still hold the same amount of water as a wide dish (with a centimetre or two of water covering the base.)

Tell the pupils they are going to be investigating how much water evaporates from each dish. For this investigation they will leave the dishes indoors so they do not have a problem if it rains. However, they can consider other conditions in planning their investigation such as temperature and wind.

Someone from each group will need to collect the three dishes their group will test from a central area. If individuals have brought in dishes they particularly want to test they could use these provided they have a range of sizes with different width openings.

Each group needs to plan their method. They can either use the printouts provided, or a laptop. For their plan, pupils need to consider the following:

- What is the variable that they are changing? (The width of the opening, which is the surface area of the water in contact with the air. The height of the dishes is also different but explain that in investigations it is not always possible to control all variables. This will just be something to consider when making a conclusion.)
- How much water will they put in each dish? (This should be the same for each dish. They may want to pour some water into the widest dish and then pour it out into a measuring jug to determine how much to use. The water should cover the whole base of the dish and have at least a centimetre or two of depth. Make sure that this same amount of water fits in the narrowest dish. This is why the narrower dish may need to be taller. It is the water that is the most important factor in this investigation, since it is the water that will be evaporating. Therefore it is more important to control the amount of water than the height of the dish.)
- What other factors will they keep the same? (The place to keep all the dishes – they may choose to find a warmer spot to make the conditions similar to good weather, or they could decide to bring in a fan to turn on for a set time each day to create some wind so their investigation can reflect the conditions there may be outside.)
- How will they measure their results? (They can measure the total amount of water at the end of the week, to compare with the total amount at the start. They should not be measuring the water depth or height of the water level from the top of the dish as this may vary between dishes.)



The aim of this lesson is for pupils to understand the process of evaporation



- Are there any measurements they need to take at the start of the investigation? (They will need to record the amount of water they use in each dish. They should also record the width of each dish. If they wanted they could estimate the surface area by drawing round the dish on cm² paper and counting the number of squares and part squares.)
- How long will they leave the dishes? (This will be until the next lesson which is assumed will be about a week. However, if needed, this could be two weeks.)

After pupils have written up their method, they can set up their dishes with water.

Discussion

After the investigation is set up, ask pupils to think about other factors that could affect the water level in the dishes, or the suitability of the dishes as a water bowl for birds. They are investigating one aspect, but what other factors are there in real life?

Points for discussion:

- The weather – the forecast is for warm and dry, however if it does rain what effect will this have? The temperature won't be constant. How do they think variations in temperature could affect the water level? Do they think warmer or cooler weather will have more of an effect? Discuss why. See if they can identify that water evaporates faster when warm. Use examples to prompt discussion i.e. washing dries more quickly outside, puddles dry up more quickly after the rain if it is warmer. Are there any other weather factors that might have an effect? (e.g. wind) Do they think more wind will speed up or slow down evaporation? Have they any evidence or examples to back up their thoughts?
- Other animals – if the water bowl is left outside then other animals could get to it. If they only want birds drinking from it, where would be the best place to put it? (e.g. on a bird table – this is high up, and can only be accessed by flight)
- Birds using as a bird bath – if the bowl is wide enough, birds may splash about in the water and water could be lost.
- If the bowl is narrow, birds may have trouble reaching the water if the water level goes down too much.
- Any other points? (e.g. the material of the bowl – if it is too light it might get blown over in the wind)

Get pupils to note down the main points as they will need to take these into consideration when making their conclusion for the best water bowl, together with their findings about how the width of the dish (or surface area of the water) affects how much water evaporates.

Extension

If pupils have time, and have written up their method for the investigation, they can consider different methods for drying tea leaves. How else could tea be dried apart from in the sun? Pupils can discuss their ideas and then do their own research using the internet. Can they find out the other most common methods for drying tea? What are the advantages and disadvantages of the different methods?

Alternatively, pupils could research how evaporation is used in the manufacture of another product such as salt, e.g.

- Salt evaporation ponds (e.g. Pedra de Lume, Sal island, Cape Verde; Tamil Nadu, India; San Francisco Bay)
www.youtube.com/watch?v=Xba7nHpycDU
www.youtube.com/watch?v=KEIG_jbSeAg



The aim of this lesson is for pupils to understand the process of evaporation

Plenary

Ensure all pupils have understood the process of evaporation and can explain what happens when water evaporates.

Can pupils identify some different contexts in which evaporation takes place? Can they remember any factors they discussed that may influence how quickly evaporation occurs? (They will be thinking about this further in Lesson 2.)



Lesson 2

What is the best dish for a bird water bowl? Drawing conclusions

Lesson 2 objective - to make the link between surface area and how much water evaporates in a given time. To recognise that evaporation is a temporary change and that water vapour can change back to liquid water by the process of condensation.

Skills - recording results, and concluding by drawing together information from different sources.

Prior knowledge

Understanding

For this lesson pupils should have a solid understanding of the process of evaporation from the previous lesson. They should understand that evaporation is the process by which liquid water turns to gas (water vapour).

Skills

For the completion of their investigation, pupils will be recording results and drawing a conclusion based on a number of factors. They should have had some experience of how to record results and how to use the results to come to a conclusion. In this lesson they will be extending this skill to consider other factors together with the one they have investigated.

Equipment required

- 1) Printouts of the group planning sheet.
- 2) Each group needs their dishes of water from the previous week.
- 3) Picture of the water cycle.

Pupils will need to work in the same groups as the previous week to complete their investigation.

Definitions

The definitions below may be helpful for this lesson:

Reversible change - a non-permanent change in which a material can go back to its original form.

Condensation - the process by which water vapour changes back to liquid water. This happens at cooler temperatures or when water vapour comes in contact with a cool surface.

Water cycle - the continuous cycle of water on our planet from water in the lakes, rivers and sea into water vapour in the atmosphere, back to water in the lakes, rivers and seas when the water vapour condenses and it rains.



Links to everyday life

Opportunities to discuss evaporation in everyday life and the reverse process of condensation. These could include:

- **Red grapes** – when they are dried the water inside them evaporates and the grapes turn into raisins.
- **Harvesting sea salt** for use in food and industry. Sea water is pumped into shallow pools where the water evaporates, leaving salt crystals that can then be used in industry. (Some pupils may have had a chance to research this in the extension activity of the previous lesson – this could be an opportunity for them to describe to other pupils what happens.)

Example of a use of evaporation and condensation:

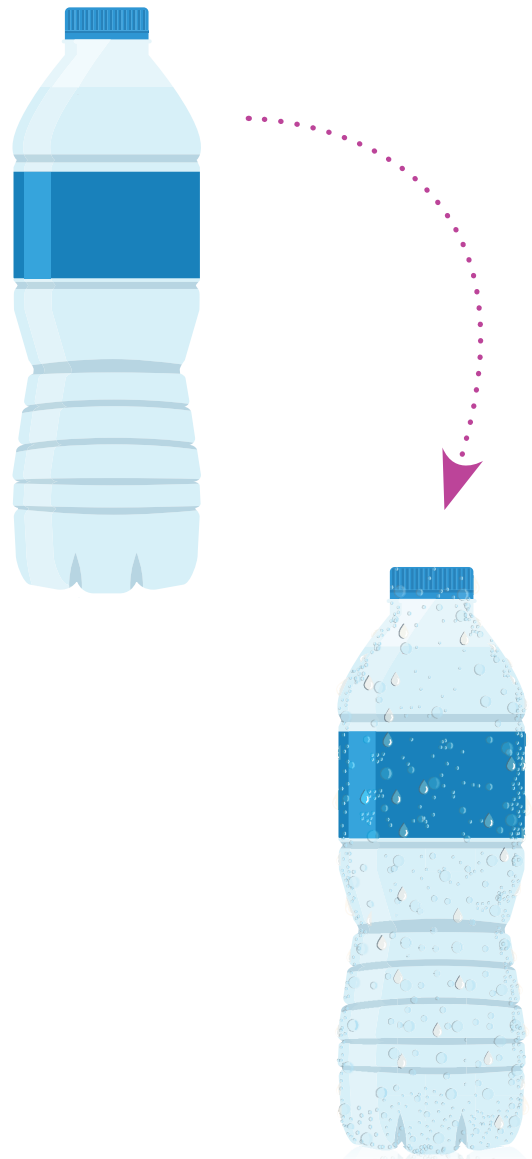
- **Desalination plants** – In some countries which are very dry and there is not enough freshwater for drinking they make drinking water from salty sea water. To do this they heat the sea water so that the water evaporates leaving the salt. The water vapour is then condensed and turns back into water with the salt removed. This can then be used for drinking.

Identifying misconceptions

Pupils may have some misunderstandings about what has actually happened to the water when it evaporates, and where it comes from when condensation takes place. Because water vapour is invisible, it is easy to imagine that the water has disappeared when it evaporates. When they see condensation, they may have some confusion to where the water came from.

The demonstrations below can be used after discussing the investigation results and conclusion, or could be used for another lesson.

Have a frozen bottle of water ready. Wipe the outside dry with a cloth and then place it on a table so all the class can see. Have a pupil touch the bottle just after you have dried it so they can feel it is dry. Then wait a few moments and the outside of the bottle will start to become wet. Invite some pupils to feel that the surface of the bottle is wet with their finger.



Why does the bottle become wet on the outside?

Where is the water coming from?

If you are unable to show the actual demonstration, here is a youtube video to illustrate condensation: www.youtube.com/watch?v=mjBiHck2V2A

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If you have hot water available, add some hot water to a bowl. Take a dry plate. Show the pupils it is dry. Place the plate over the bowl and wait a few moments. Let the pupils see that the top of the plate is dry.



Bowl with hot water



Cool plate placed over the bowl

Then lift the plate so the pupils can see the plate is wet underneath.

How has the water got to the plate from the water in the bowl?

Try using a very cold plate, and see if there is any difference. (Use a plate that has been in the fridge for a few hours, or cool the plate with some ice.)



Introduction for the task

Tell the pupils that in this lesson they are going to record the results from their investigation. They are then going to make a conclusion for their investigation about how the width of the dish / surface area of the water affects evaporation, and then use this information and the other points they noted from the discussion last lesson to decide which dish is the best bird water bowl and why.

Task

Each group needs to first carefully collect their dishes. They can then start to measure how much water is left in each dish and record their results. There is a printout provided for this.

The pupils should then complete the printout to write a conclusion for their investigation and then make a decision about which dish is best. Display the points from the previous discussion on a screen or whiteboard. Tell the pupils they should discuss these points together with the results when making their decision.

Ask each group to place their chosen dish at the front of the classroom so they are able to compare the choices of different groups. A photograph could be taken with the best dish from each group and displayed on a screen if easier.

Discussion

Look at the dishes. Did each group choose a similar size dish as their best dish? If not, why? Can the groups give their reasons? What were the main factors that influenced their choice? Discuss how the groups came to their conclusion and if they found it hard to make a decision with the other factors in consideration (apart from the results of the investigation).

What did the groups learn about how quickly water evaporates and the width of the dish / surface area of the water? Make sure all groups recognise that more water will evaporate from dishes with a wider opening, as more water is in contact with the air.

The surface area will affect how much water evaporates in a given time. However, there are other factors that affect how quickly the water evaporates. What are these factors? Did any groups consider these in their method? Did any groups choose to use a fan, or leave the dishes somewhere warm? If so, did where pupils leave the dishes affect how much water evaporated from each dish? Or did all groups get fairly similar results? If all groups left their dishes in similar conditions, what differences would the pupils have seen if they had left their dishes in a very hot place, or a very cold place? What effect may a windy environment have had on the rate of evaporation?

Can pupils give examples of where evaporation occurs naturally outside?

Then move the discussion on to introduce the process 'condensation'.

Condensation

Evaporation is a reversible change. Water changes to water vapour but changes back again. The change from water vapour to water is called condensation.

Ask the pupils if they can give any examples of when condensation happens.

Ask the pupils to think about our planet, and all the seas and rivers. If all the water kept evaporating into water vapour what would happen?

When does water vapour turn back to liquid?

The water in the water bowl evaporated, but if left outside how may it get filled up again?

What temperatures do they think will speed up condensation?

See the demonstrations provided under 'Identifying misconceptions' on page 12 and if time show the pupils one or both of these.



Decide which dish is the best bird water bowl and why

Extension

Give each group a picture of the water cycle or display on a screen or SMART board. Talk through the picture so pupils can identify it is a continuous circle of water evaporating to water vapour, water vapour condensing back to water and so on. See if pupils can identify where the labels should be written on the diagram.

Tell pupils you want them to design a model to illustrate the water cycle. They can use plastic pots of different sizes, a lid or cling film and water. See if they can come up with a design and label it to show how the water cycle works.

You could ask groups to bring in some containers the following week and they could make their model.

Plenary

Ensure pupils are secure in their understanding that with the same volume of water, more will evaporate if the surface area of the water exposed to the air, or width of the container the water is in, is larger. See if pupils can identify that warm temperatures and windy weather will speed up evaporation. (These concepts could be explored in further lessons.)

Check pupils understand evaporation is a reversible process and that condensation is the reverse process by which water vapour changes back to water.

Check pupils recognise both these processes occur in everyday life, and these two processes keep the water cycle going on our planet.

Resources

Links to some useful resources on evaporation and condensation:

Animation on evaporation and condensation: www.bbc.co.uk/guides/zydxmnb

Great pictures of evaporation in different contexts: www.nationalgeographic.org/encyclopedia/evaporation/

Concept cartoon for evaporation: <http://blogs.bearwood.sandwell.sch.uk/year4atbearwood/2012/09/27/concept-cartoon-for-evaporation/>

Picture of a bird bath with bird in it: <https://files.allaboutbirds.net/wp-content/uploads/2009/04/Birdbath-algae.jpg>



Lesson printouts



Evaporation lesson 1

What is the best dish for a bird water bowl? Planning an investigation

Aim: to understand that water exists in different states and that the process of evaporation occurs when liquid water changes to gas.

Tea drying



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Identifying misconceptions

Hanging wet washing on a washing line.

Putting a bottle of water into a freezer.

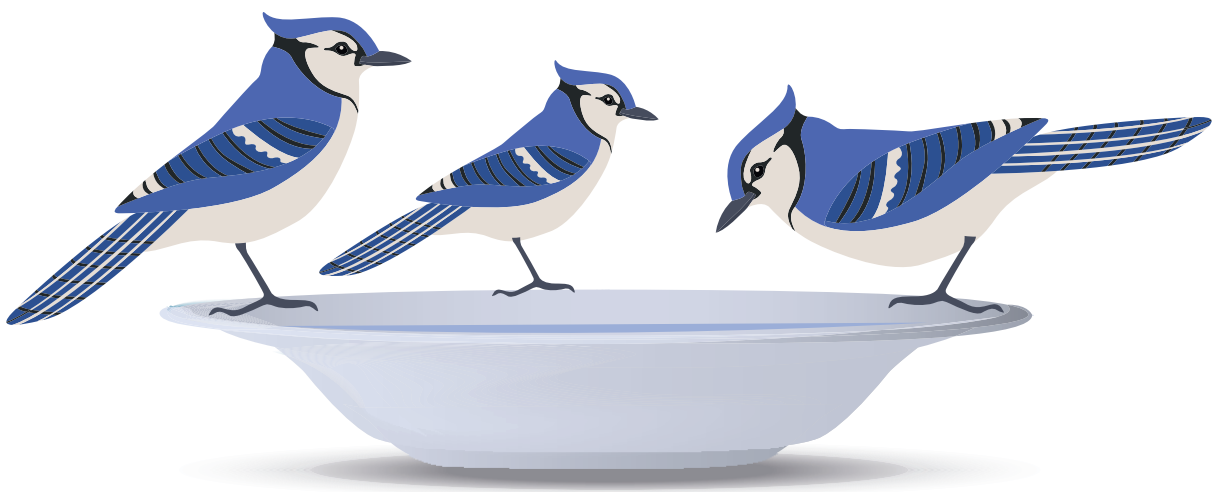
Stirring salt into water.

Leaving wet clay to dry.

Boiling a kettle.

Task - finding the best bird water bowl

Answer the following questions in your groups.



Investigation to find out if the width of a dish affects how much water evaporates

What is the variable being changed?

[Dotted-line response box]

How much water will we put in each dish?

[Dotted-line response box]

What variables will be kept the same?

[Dotted-line response box]

How will we measure the results?

[Dotted-line response box]

What measurements do we need to take at the start of the investigation?

[Dotted-line response box]

How long will we leave each dish?

[Dotted-line response box]



Evaporation lesson 2

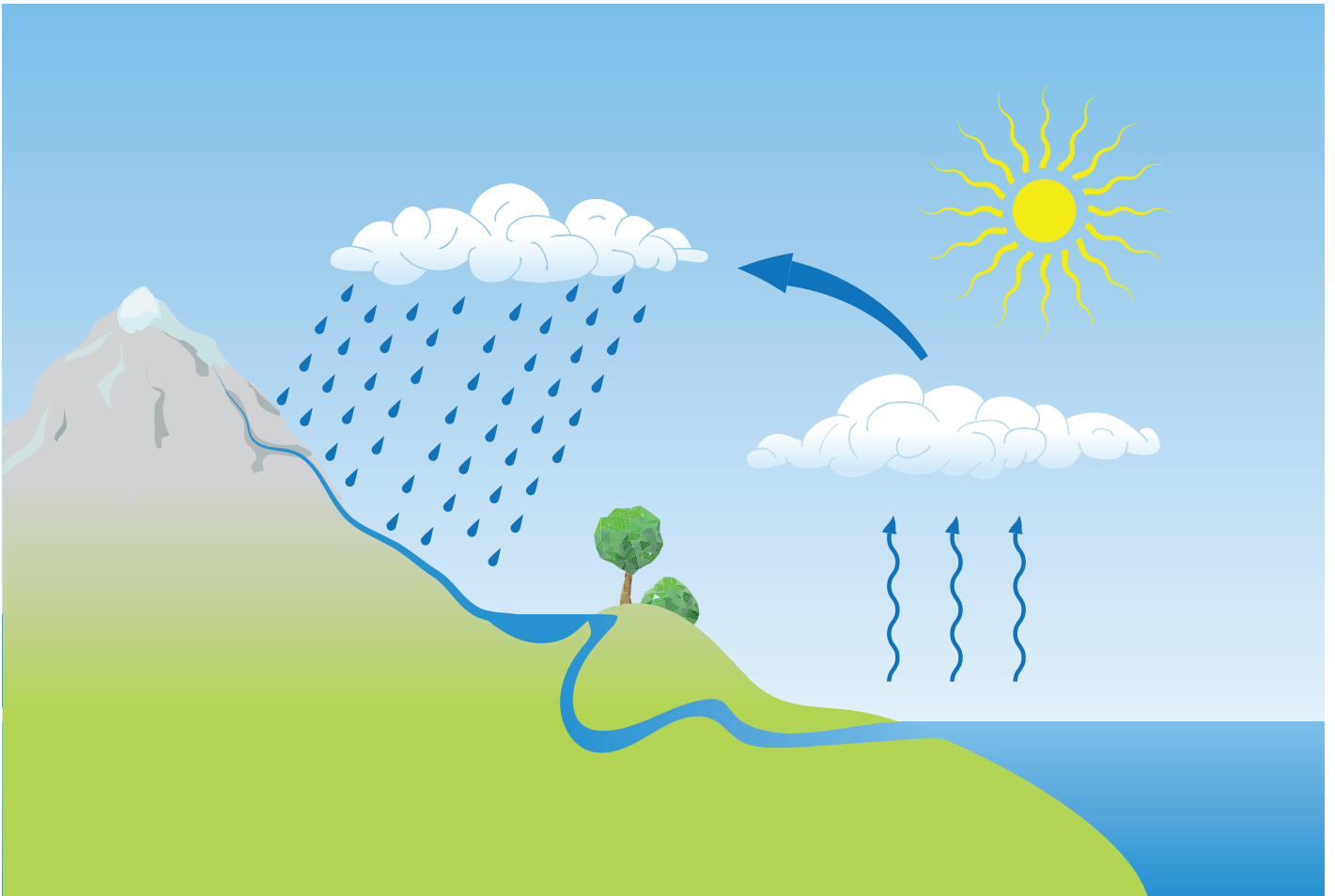
What is the best dish for a bird water bowl? Drawing conclusions

Aim: to make the link between surface area and how much water evaporates in a given time.
To recognise condensation is the reverse of evaporation.

Results

Conclusion

The water cycle



Where should each of the following labels be written on the diagram?

Evaporation

Condensation

Rain



