A beginner's guide to the chemistry of water

Teaching Australian Curriculum: Science Chemical Sciences for primary and middle years

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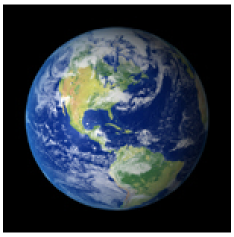
Why is water important?



Water is vital for life on our planet and, while it is an ancient renewable resource, human activities can reduce the amount of usable water we can access. Australia has a highly variable climate. Because of this, we need to manage our freshwater resources sustainably to ensure that we have sufficient to cope through our scorching droughts.

So it is critically important that we develop students' understanding about what water is and how it behaves in our environment. This resource explores the basic scientific concepts that underpin our understanding of water.

Water is old—really, really old!— Water has been in a liquid form on Earth for about 4.4 billion years. How do we convey these long time frames to our students? We can understand how long different periods of time take to pass using hand claps. Students can represent the passing of each year by one clap of the hands every second (Resource 1).

Exploring our water story in the Australian Curriculum: Science

Water is an everyday and vital material in our students' world and connecting students to their own experiences of water in their community is a great place to start their water explorations.

- Where does our water come from? How does it cycle through our landscape?
- Where does it go when we finish with it?
- What happens to the water in our environment?
- How is it affected by human actions?
- Where does our drinking water come from? How is it treated? Where does our wastewater go when we finish with it?

The familiarity of water as a material makes it a very useful context to teach science concepts in the primary years. If you explore the Australian Curriculum: Science, there are many content descriptions that can be taught using water as a context. These include:

- How do we use water?
- How do we manage our water resources?
- How does water cycle through our planet?
- What animals and plants live in our local waterway?

Chemical sciences in the Australian Curriculum: Science

Other water topics fit very well in the Australian Curriculum: Science—Chemical Sciences strand. By the end of Year 10, students need to engage with the following highlighted ideas:

> *The chemical sciences sub-strand is concerned with understanding the composition and behaviour of substances. The key concepts developed within this sub-strand are that: the chemical and physical properties of substances are determined by their structure at an atomic scale; and that substances change and new substances are produced by rearranging atoms through atomic interactions and energy transfer.*
>
> *In this sub-strand, students classify substances based on their properties, such as solids, liquids and gases, or their composition, such as elements, compounds and mixtures. They explore physical changes such as changes of state and dissolving, and investigate how chemical reactions result in the production of new substances.*
>
> *Students recognise that all substances consist of atoms which can combine to form molecules, and chemical reactions involve atoms being rearranged and recombined to form new substances. They explore the relationship between the way in which atoms are arranged and the properties of substances, and the effect of energy transfers on these arrangements.*

It is possible to incorporate water chemistry ideas in the Science Understandings content descriptions from Preparatory to Year 8. The relevant content descriptions are highlighted in yellow.

Table 1 Science Understandings

	Foundation	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
Chemical sciences	Objects are made of materials that have observable properties	Everyday materials can be physically changed in a variety of ways	Different materials can be combined, including by mixing, for a particular purpose	A change of state between solid and liquid can be caused by adding or removing heat	Natural and processed materials have a range of physical properties; these properties can influence their use	Solids, liquids and gases have different observable properties and behave in different ways	Changes to materials can be reversible, such as melting, freezing, evaporating; or irreversible, such as burning and rusting	Mixtures, including solutions, contain a combination of pure substances that can be separated using a range of techniques	All matter is made of atoms which are composed of protons, neutrons and electrons; natural radioactivity arises from the decay of nuclei in atoms

Water topics also provide plenty of scope to teach the Science Inquiry Skills across these year levels. There are many excellent 'fair test' investigations based on water that you can use to develop student inquiry skills. However, this paper focuses on developing student understanding of the chemistry concepts and won't address Science Inquiry Skills specifically.

Science as a Human Endeavour

Water topics support the teaching of 'Science as a Human Endeavour' ideas. For instance, science knowledge:

- helps people to understand the effect of different land uses on our waterways
- informs personal and community decisions about how we manage our water resources
- influences the development of practices in industry, agriculture and natural resource management
- from a range of disciplines is used by people in water-related occupations.

Aboriginal and Torres Strait Islander histories and cultures

Aboriginal and Torres Strait Islander communities have a rich cultural connection to their water places. This sense of identity can be explored within water topics.

Local community elders could be invited to share their stories—particularly those relating to water. For ideas about how to develop partnerships with local Aboriginal and Torres Strait Islander communities, go to the Department of Education, Training and Employment or the Queensland Studies Authority websites.

Historically, there are a wealth of stories and videos that explain how Aboriginal and Torres Strait Islander people survived and thrived in our highly variable climatic conditions. Make sure you also incorporate interesting contemporary stories that explain how Aboriginal and Torres Strait Islander people use and manage their water supplies currently.

Your local waterway or beach can be a special place for many people—Indigenous and non-Indigenous. Students can consider how local Aboriginal or Torres Strait Islander people view these special places using a framework developed by Uncle Ernie, a Dijirabal/Djirrabal Elder. This framework draws on a more holistic 'way of knowing' and is an interesting approach to developing students' thinking skills, particularly their systems' thinking skills.

Uncle Ernie's Framework is described in 'My Land, My Tracks' which can be accessed from the Department of Education, Training and Employment website. You can also view a useful video developed by Louise Alexander in which she effectively explains each component of the framework for a student audience. Both the framework and the video can be found using the search engine term 'Uncle Ernie's Framework'.

Cross-curriculum priority: Sustainability

Water topics provide many opportunities to discuss sustainable water management issues—particularly those related to your local catchments. Awareness of and understanding about sustainable water management encourages students to take action to address these issues.

Enabling actions include:

- monitoring water quality in your local creek or water body to inform management decisions
- revegetating a cleared area in or near your school to improve the biodiversity of your area
- making a personal or school commitment to reduce water use
- monitoring home or school water use
- developing a promotional campaign to reduce school or community water use.

Teaching the chemistry of water

Water topics, particularly those that relate to investigating your local waterway, provide a rich source of context for Australian Curriculum: Science. Of all these topics some teachers find teaching the chemistry of water challenging. Diving into the chemistry of water provides an accessible and understandable introduction to some of the chemistry concepts that students encounter in the upper years of schooling. However, from a chemistry perspective, there is one issue that needs to be addressed before you get started. Not to put too fine a point on it.....water is weird.

Why is water weird?

While water is a very familiar material for students to gain an introductory understanding of the chemistry of their world, it is worth highlighting upfront that water is not your typical substance. It has some weird properties. For instance, most solid substances are much denser than their liquid form. So you would expect the solid form of a substance to sink when placed in its liquid phase. What does ice do when you add it to a cup of liquid water? It floats—weird!

All substances are made of molecules or atoms. Water molecules are relatively small. The boiling point of substances can usually be related to the size of its molecule. The larger the size of the molecule that makes up a substance, the higher its boiling point. However, water boils at a higher temperature than you would expect from the size of its molecule. That might seems like an academic point but it means that at normal temperatures, water should be a gas. Imagine if all the water around you and inside you was in the form of water vapour! Without liquid water at normal temperatures on our planet, there would be no life as we know it.

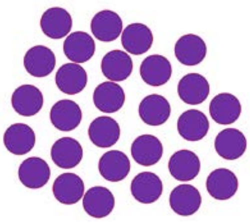
Water as a chemical

Have you caught up on the latest health warnings about dihydrogen monoxide? It is dangerous stuff (Resource 2). Just as well we know a bit about chemistry so we can critically evaluate these claims.

Despite the fact that water is a 'natural' product, water is a chemical. Indeed, everything in the universe is made of chemicals. How do students make sense of a chemical universe or a chemical world? Students can develop a chemistry understanding of water the same way scientists do—by using models.

Using models

What is a model? 'Models are external representations of mental concepts. Models can include diagrams, 3D physical structures, computer simulations, mathematical formulations, and analogies' (Krajcik and Merritt, 2012). Representing water molecules as tiny balls is a simple model.



We can think of water as made of millions and millions of very tiny particles (or molecules). Therefore, you can think of water as made up of tiny balls. The ball represents a water molecule and is a model to begin to explain why water behaves the way that it does. You can use any small balls to visually represent water molecules—polystyrene or plasticine for instance.

By the way……some students can be confused by the idea that a water molecule is made of two hydrogen atoms and one oxygen atom. They think that when water is heated and evaporated the hydrogen and oxygen atoms split apart. (Actually a fair proportion of secondary students think this too!) For this reason, it is probably beneficial when you begin to talk about water molecules to play down the idea of hydrogen and oxygen atoms.

Once they have a firm grasp of the idea that water molecules remain intact when water evaporates, then you can introduce the ideas about the molecular structure of water. Some students in your class will probably know that water is H_2O and that it is made of atoms—so it is important to acknowledge their ideas. It may not be a good idea to emphasise this point in the early stages. Having said that, it is not that difficult to split water into oxygen and hydrogen and students may meet this demonstration in the lower secondary years.

How do water molecules move in liquid water?

How do water molecules move in liquid water? Students can draw their initial ideas (or model) about what liquid water is made of (Resource 3).

Place a drop of food colouring in a clear plastic cup of water. What do you notice about the food colouring? What happens? Why does the drop of food colouring spread out through the cup of water? Students could revise their model by updating their labelled drawings in Resource 3. They could continue to revise their ideas as they explore new activities.

Role-playing water molecules

You can negotiate possible explanations to this question using role-play—a time-honoured and effective way to model the movement and arrangement of molecules.

Clear a big space in the room and nominate about ten students to act as water molecules in liquid form in the middle of the space. Everyone else stands around the outside of the open space—suggesting ideas for the class discussion. Use questions to prompt the students to think about the idea that the water molecules in liquid form are jiggling about and rolling over each other. The water molecules jiggle around—all the time.

This 'embodied' learning experience provides a great opportunity for students to try out their tentative ideas in a non-threatening context and to build an experiential understanding of the underlying concepts.

What happens when water is heated?

If water molecules in liquid form are jiggling about and rolling over each other, what happens when the liquid water is heated?

To explore this question, label one clear plastic cup—'warm'—and another clear plastic cup—'room temperature'. Half fill the 'warm' plastic cup with warm water and half fill the 'room temperature' plastic cup with water that is cooler—say at room temperature. Let the water in the cups 'sit' for a couple of minutes so that the water is still.

Add one drop of food colouring to each cup of water. What happens? Does the food colouring spread throughout the water faster in one cup than the other? Students can predict what they think will happen before they try this activity. Again they can role-play their explanatory ideas.

If you leave liquid water out in the sun, the heat energy from the sun is transferred to the water molecules and they move faster and faster.

When you heat liquid water, the molecules move faster and faster. They also move further and further apart. Eventually some molecules fly out of the liquid phase to become a gas called water vapour. They mix with other molecules that make up the air around us.

The same thing happens when you put an ice cube on the bench, the molecules start to move faster and the ice cube eventually melts.

What happens when water cools?

When you cool water down, the molecules move more slowly. You can use students' everyday experiences with condensation to explore these ideas.

The 'foggy mirror' concept cartoon (Resource 4) can identify students' prior knowledge about condensation. The same concept cartoon could be used at the end of a lesson sequence to assess student learning over the unit. Students could record responses that they think are correct in their 'water' journal and explain their choice. If students have an alternative idea, they record that idea and explain it.

Student ideas about evaporation and condensation

Some students struggle with even the most basic ideas such as what a cloud is made of. They can hold a range of alternative conceptions about molecules including water and how water molecules behave. They also seem to find the processes of evaporation and condensation particularly challenging to understand.

Some students may believe that when water evaporates, it ceases to exist. In the case of condensation, some students believe that:

- water comes through the glass
- coldness comes through the glass
- the cold surface and dry air (oxygen and hydrogen) react to form water
- water in the air sticks to the glass.

Student ideas about matter and the particle theory of matter are further explored in Appendix A.

Solid, liquid and gas—the properties of water

The property of a substance describes what it looks like or how it behaves. If you consider solid water (ice), it has a particular shape. The water molecules seem to be frozen in one spot. However, the molecules in ice are still jiggling about but they are jiggling in the one position. They are not moving over and around each other—as they do in a liquid. Do other substances take a particular shape in their solid form?

> **Jiggling molecules—**If you are wondering about the term 'jiggling' in this context, Nobel Prize winning physicist, Richard Feynman used the term to explain how water molecules move. Find an online video in which he talks about the movement of atoms and also discusses the idea that scientists need to do a great deal of imagining.

You can pour a cup of liquid water into any shaped container you like. It always takes on the shape of the container it is poured into. It has no particular shape itself. The water molecules in liquid water are rolling over and around each other. Does this property apply to other liquids—not just water?

If you think about water vapour as a gas, it doesn't take any particular shape. The water molecules just spread out in all directions. So, the water vapour expands to fill its container.

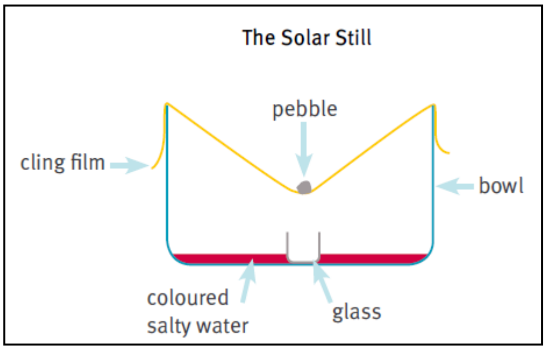
Put a balloon over the top of a plastic bottle and stand it in a bowl of hot water. What does the balloon do? The balloon begins to expand. If you then put the plastic bottle with the balloon in a bowl of cold water, what happens?

The balloon begins to shrink down. Students could role-play this phenomenon and discuss possible explanations for these observations. When the water molecules in the water vapour are heated they move further apart and when the water molecules are cooled down, the molecules move closer together.

When you cool down water molecules, the opposite happens. The molecules slow down and come closer together. As water vapour cools, the molecules move more slowly and come closer together to form liquid water. If you keep cooling the liquid water, the water molecules will form ice.

To reinforce these ideas about what happens when water changes state from ice to liquid to water vapour, you can show the 'Matter and evaporation' learning object (The Learning Federation TLF L1490). Students could then complete a worksheet to indicate their level of understanding (Resource 5).

You can use the solar still activity (Resource 6) to assess students' understanding about what happens when you place a simple solar still in the sun.



Energy and change of state

A change of state—for instance, from liquid to vapour—is caused by the addition or loss of energy in the form of heat. So when you add heat to water, the water molecules gain energy. How does this apply to the process of evaporation?

Water molecules in liquid water that are in contact with air above it are constantly leaving the surface of the liquid form to become vapour. At the same time, water molecules are also returning from the vapour form to the liquid form. You can think of the liquid form and vapour form in this situation as a system.

When you heat the liquid/vapour system, all the molecules gain energy. The number of molecules with enough energy to escape the surface greatly exceeds the number of molecules returning to the liquid. This is called evaporation.

When you boil water, bubbles form. What's in the bubbles? The bubbles are made of water molecules in a vapour form. You can see the bubbles rising to the surface where they release water vapour into the air. Water vapour in the air contributes to humidity.

Condensation occurs when water in the form of vapour cools and individual molecules lose energy. They are more likely to collide and not rebound, clinging together to form droplets. Condensation most often occurs on a cool surface where there is a large difference in temperature between the air and the surface. Gas molecules colliding with the cold surface rapidly lose energy.

This is how clouds form. Water vapour molecules move in all directions. This also means moving upwards into the atmosphere where the temperature drops allowing the vapour to condense, forming clouds.

The water molecules gather on tiny particles of dust, dirt or pollutants that are floating in the air and condense into a tiny droplet around each particle. When billions of these droplets come together they become a visible cloud.

When water cools, the molecules lose energy so that very few molecules have enough energy to escape the liquid. Eventually the jiggling of the water molecules slows down to the point where the molecules are only vibrating in a set pattern. When molecules do not have sufficient energy to move past each other a solid is formed. This process of solidification of water is called freezing.

When heat is applied to ice the water molecules gain more energy and slide over each other in liquid motion. The temperature of the melting mass remains the same as the all the heat energy is used to mobilise the molecules. There is no increase in temperature until the whole solid mass becomes liquid.

Understanding the water cycle

Students need to understand evaporation and condensation to understand the water cycle—a key Earth and Space Sciences content description for Year 7. It is tempting to teach the water cycle using explicit teaching and cloze diagrams.

However, providing students with a deeper understanding of some of the concepts underlying the water cycle is not without its challenges. Some students struggle with even the most basic ideas such as what a cloud is made of or what happens to water in a puddle on a hot day. This is where a basic mental picture of water molecules and how they behave when they heat up and cool down can greatly assist students to understand how the water cycle works.

In addition, students often have difficulty translating the abstract concepts of the water cycle to their own local catchment. For this reason, it is very beneficial to use your local catchment as the context for teaching ideas about the science of water.

Why does ice float?

For most substances, the molecules in their liquid form cool down and move closer and closer together to form the solid—just like melted chocolate. This means the molecules that make up the solid form of the substance are very close together and form a solid that is denser than its liquid form. When you put solid chocolate in a bowl of melted chocolate, the solid chocolate sinks to the bottom of the bowl. What happens when you put solid water (ice cubes) into liquid water—they float.

If the solid form of water (ice) had molecules that were closer together than the liquid water, what would happen when you added ice to a cup of water? Use the ball model to predict what you think will happen.

As liquid water cools, the balls representing the water molecules in the ice should be packed closer together. The balls in ice should be packed as close together as they can be.

When you place an ice cube in liquid water it should sink. But it doesn't.

There is something wrong with our model. The prediction we made with our model doesn't hold true. If ice is less dense than liquid water then they aren't packed as closely together as possible. There must be cavities in the structure that the water molecules form in ice.

We have to refine our model to account for our new observations.

Don't panic—this is just how scientists work.

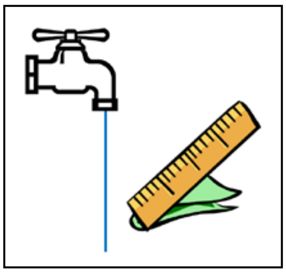
Scientists refine their models

Scientists start with a number of ideas or models that could explain the phenomenon they are investigating. They make predictions based on their initial models and design experiments to test whether the prediction holds true. On the basis of their experiments, they reject those models that don't work and refine those models that do.

With this new observation—that ice floats on liquid water—draw a diagram to show how the balls may be arranged in ice. Students could use the water molecule role-play to try out different ideas.

There are other clues you can use to solve this problem. What other properties of water can students explore to give them extra clues?

Why does water bend?



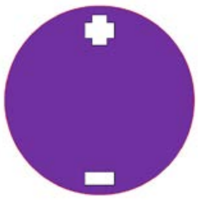
You can pick up another clue by charging a plastic ruler by rubbing it with woollen or synthetic cloth. Hold the ruler next to a thin stream of water coming out of a tap. What happens?

The thin stream of water bends away from the ruler. Therefore, the water molecules must be charged in some way.

Why is water sticky?

Observing water drops provides another clue. For instance, you can predict how many drops of water will fit on a five cent coin. If you try this activity you will usually find that you can fit a lot more drops than you think. Why?

The water drop on the five cent coin gets bigger and bigger and bulges up to form a dome on the coin. It even bulges over the sides of the coin. The water seems sticky. Why is this?



In fact, water molecules are both positively and negatively charged. One end of the water molecule has a slight positive charge and the other end of the water molecule has a slight negative charge. This type of molecule is called a polar molecule because it has two 'poles' of charge.

What happens when two water molecules come close together? How would they line up? Students can try out their ideas with their ball models. Mark one end of each ball as the positive end and the other end of the ball as the negative end.

Alternatively, students can role-play the idea that a water molecule has a positive charge on one end and a negative charge on the other end. For each student 'water molecule', stick a piece of masking tape with a plus sign on it on one arm and a piece of masking tape with a minus sign on it on the other arm. Students can then move around and role-play how their arms would be attracted or repelled to other students' arms. Thanks to Andrew Nye, St Helens State School, for this idea.

Water molecules tend to stick together when the positive end of one molecule is attracted to the negative end of another water molecule. In ice, the water molecules are arranged in a fixed structure. The water molecules still jiggle but they stay in one position.

Now that you have a basic grasp of what water is and how it behaves, you can begin to explore what happens when water is mixed with other things in our environment and how this water is cleaned so we can drink it.

What happens to water in the environment?

As water moves through our landscape it continually picks up substances. For instance, rain collects carbon dioxide from the atmosphere as it falls to Earth. The water in our rivers, lakes and oceans contain many different kinds of contaminants. The 'Story of a river' activity is a very useful introduction that graphically demonstrates how different land uses impact on river water. Humans need to use water from the environment for drinking—so how do we clean it?

How do we clean our water for drinking?

In Australia, we use a range of sources for drinking water. These sources include rivers, dams, weirs, bores and the ocean. The water from each water source contains different contaminants. For instance, rivers contain contaminants gathered as rainwater runs through the river catchment. In this case, the types of contaminants are largely determined by the geology of the catchment and the land uses in that catchment.

What does the word 'pure' mean when used scientifically? From a science perspective, a pure substance only has one kind of molecule while a mixture has two or more types of molecules.

That's it!

In contrast, bore water is underground water or groundwater, which started at the surface but has percolated through different layers of sediment and rock. Groundwater picks up different minerals from the layers in the form of different kinds of salts. Eventually, the groundwater collects in a porous layer that has an impermeable layer underneath it—forming an aquifer. The bore sucks the water out the aquifer.

The water from each of these sources is a mixture. Water treatment technicians must understand the composition of the 'raw' water from their water source so they can treat the water to a safe drinking water standard as economically as possible.

There are a number of different types of mixtures including solutions and suspensions.

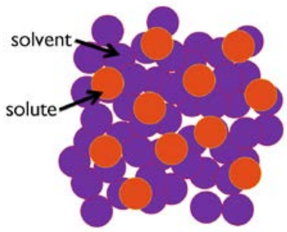
Solutions

Dissolve a teaspoon of cooking salt in a cup of water. What happens? The salt disappears. If the salt is made of particles, where have the salt particles gone? You can gain another useful piece of evidence by filling a clear plastic cup half-full and marking the level of the water on the cup. Add a teaspoon of salt to the water and stir. What happens to the water level on the cup when you add the salt?

Why does the salt disappear? Students can role-play this problem to explore different explanations. Four or five students can wear party hats to designate them as salt particles. The salt particles mix evenly among the water molecules and fill in spaces between the water molecules.

In a solution, one type of particle mixes evenly through a different type of particle; in this case, table salt dissolves in water to form a solution.

We say that one substance has dissolved in another substance. The substance that dissolves is called the solute. The substance it dissolves in is called the solvent. The solute is evenly distributed through the solvent. Scientists use



the term 'homogeneous' to describe the even distribution of a solute through the solvent.

Solutions can be solid and solid (sand and sugar), liquid and liquid (cordial and water) or gas and gas (oxygen and nitrogen). They can even be solid and liquid, or liquid and gas as long as every part of the mixture is exactly the same as any other part.

Why do some substances dissolve in water?

If a substance doesn't dissolve in a solvent, it is insoluble. Different substances can range from very soluble to partly soluble to insoluble—depending on the type of solute and solvent.

Why is water such a good solvent? Because a water molecule has a positive charge at one end and a negative charge at the other end it is attracted to other molecules or particles that are charged. When you mix a substance with water, if the attractions of the water molecules to the molecules of the substance are stronger, the water molecules pull the substance molecules apart and the substance dissolves.

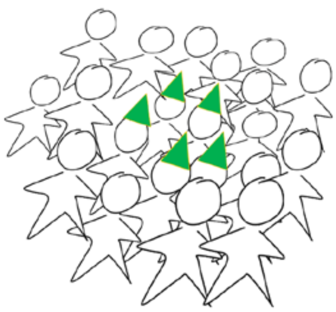
The molecules that make up the solute substances vary in the amount of attraction their molecules have for each other. This means that different substances have different levels of solubility.

Investigating solubility

Groundwater can dissolve different kinds of salts as it percolates through layers of sediment and rock. You can explore what happens when you dissolve different salts in water. For instance, you can compare how much of each type of salt—for instance, cooking salt, baking soda or Epsom salts—dissolves in water.

Suspensions

Many drinking water sources contain some clay. What happens when clay is mixed with water? The clay water mixture is cloudy and you can still see tiny clumps of clay floating around in the water. If you shine a torch into the mixture, the light doesn't shine through the mixture.



Clay doesn't dissolve in water. Students can role-play what the clay particles do when they are mixed with water molecules. The clay particles form clumps and don't mix evenly through the water molecules.

This type of mixture is called a suspension. Often the clumpy substance will settle out of the suspension to form a sediment layer on the bottom of the container.

Some of the clay in a water mixture settles out but some of the clumps of clay remain suspended in the water. The reason is that clay particles are negatively charged and repel each other so they bounce around in the suspension without settling. Technically, in a suspension, the particle clumps settle to the bottom of the container. If they don't settle—as in the case of the very fine clumps of clay—the mixture is called a colloid. Some everyday examples of colloids include homogenised milk and paint. This distinction could be left to high school—if you choose.

Water treatment technicians need to add special substances (flocculants) to river water that contains high levels of clay (like the Brisbane River) to help the clay form clumps large enough to settle out of the suspension. These flocculants work in the same way as a pool flocculant to clear the cloudiness from a swimming pool.

The Water Island game

Seqwater published an interactive Water Island Game for students that show how clay particles can be removed in a water treatment plant using dissolved air flotation.

Source: <www.seqwater.com.au/education/water-island-game>

Resource 1 Clapping time

For teachers

One way to understand how long different periods of time take to pass is to use hand claps. We can represent the passing of each year by one clap of the hands every second.

Ask a student to volunteer his or her age. The class claps it out. Clap out the ages of two or three students.

Europeans landed in Australia 240 years ago. How long will it take to clap out 240 years that Europeans have been settled in Australia? How long is 240 seconds? If there are 60 seconds in a minute, how many minutes in 240 seconds? [4 minutes]

Aboriginal people have been in Australia for at least 60,000 years. If there are 60 seconds in a minute, how many minutes are there in 60,000?[1000 minutes] If there are 60 minutes in an hour, how many hours would it take to clap out 60,000 years? [about 16.7 hours]

Geologists think that the Earth was formed about 4.5 billion years ago. The heat generated from the Earth's core caused massive eruptions from huge volcanoes, releasing gases into a primitive atmosphere; one of these gases was water vapour.

By about 4.4 billion years ago, the Earth cooled to below 100° C and the water vapour in the atmosphere condensed—forming the seas and oceans we have today. If 4.4 billion years is 4,400,000,000 years, how many hours would you have to clap out 4,400,000,000? [about 140 years]

For this activity you can choose any touch-down points in history that are of interest to your class.

Complete the activity with a creative thinking exercise. Think about the water that is in your body. Where has that water been in the last 4.4 billion years?

This activity was adapted from: Clary R. & Wandersee J. (2009). *How old? Tested and trouble-free ways to convey geologic time.* Science Scope, National Science Teachers' Association.

Resource 2 Dihydrogen monoxide FAQs

Dihydrogen monoxide (DHMO) is a colourless and odourless chemical compound. Each year, dihydrogen monoxide is a known causative component in many thousands of deaths and is a major contributor to millions upon millions of dollars in damage to property and the environment.

Some of the known hazards and impacts of dihydrogen monoxide are that:

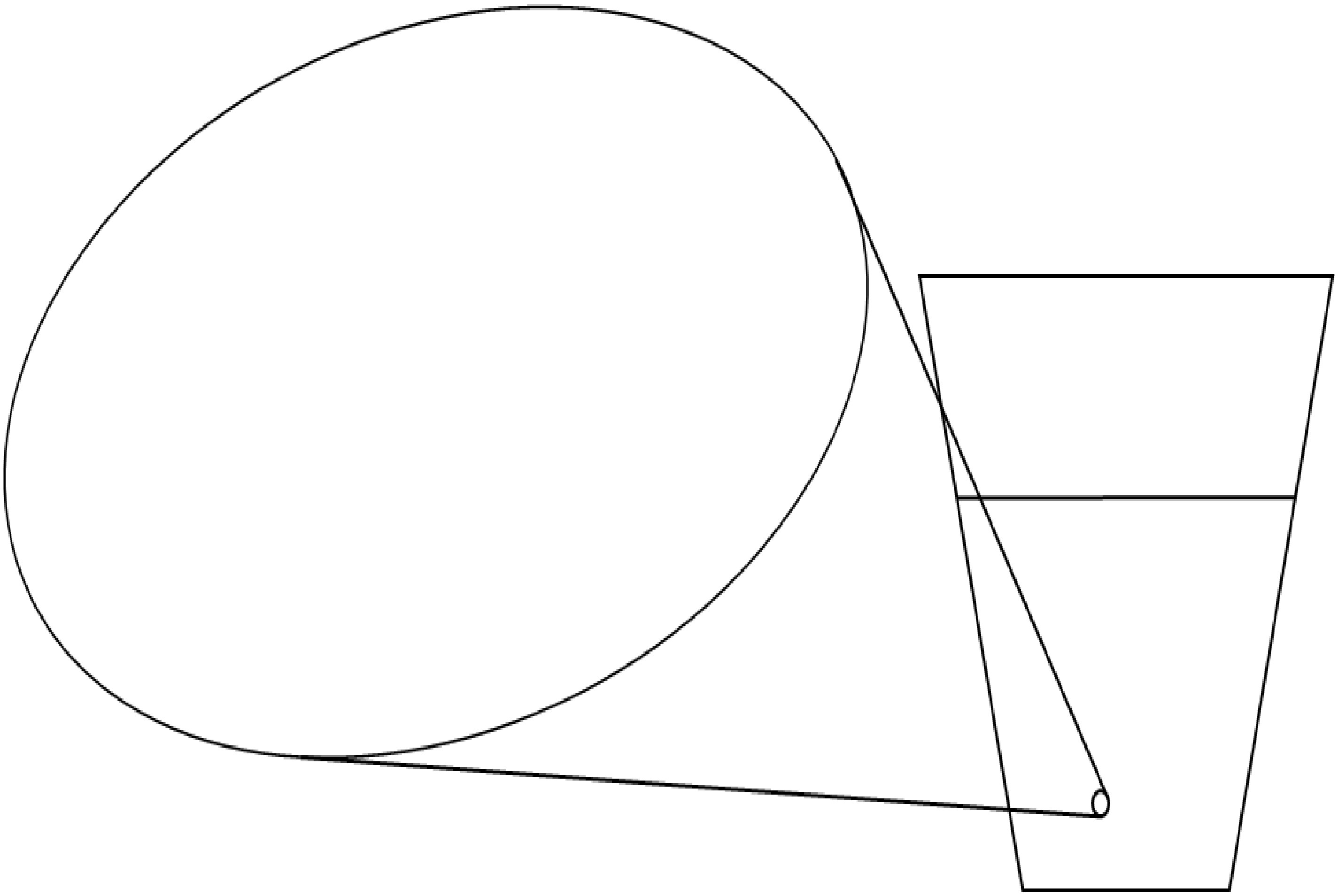
- accidental inhalation of DHMO—even in small quantities—can cause death
- death from excessive ingestion have been reported—DHMO has a toxicity level (LD50) of 90 mL/kg in rats
- prolonged exposure to solid DHMO causes severe tissue damage
- gaseous DHMO can cause severe burns
- DHMO contributes to soil erosion
- exposure to many metals leads to corrosion and oxidation
- Contamination of electrical systems often causes short-circuits
- exposure decreases effectiveness of automobile brakes
- DHMO is found associated with biopsies of pre-cancerous tumours and lesions
- it is often associated with extreme weather events such as cyclones and flooding and weather phenomena such as el Niño events and is a major component of acid rain

(Adapted from <www.dhmo.org/facts.html>)

Resource 3 Drawing a model of liquid water

Imagine that you have a special magnifying instrument that allows you to see what makes up liquid water. The large circle in the drawing below represents a spot that is magnified many times so you can see it up close.

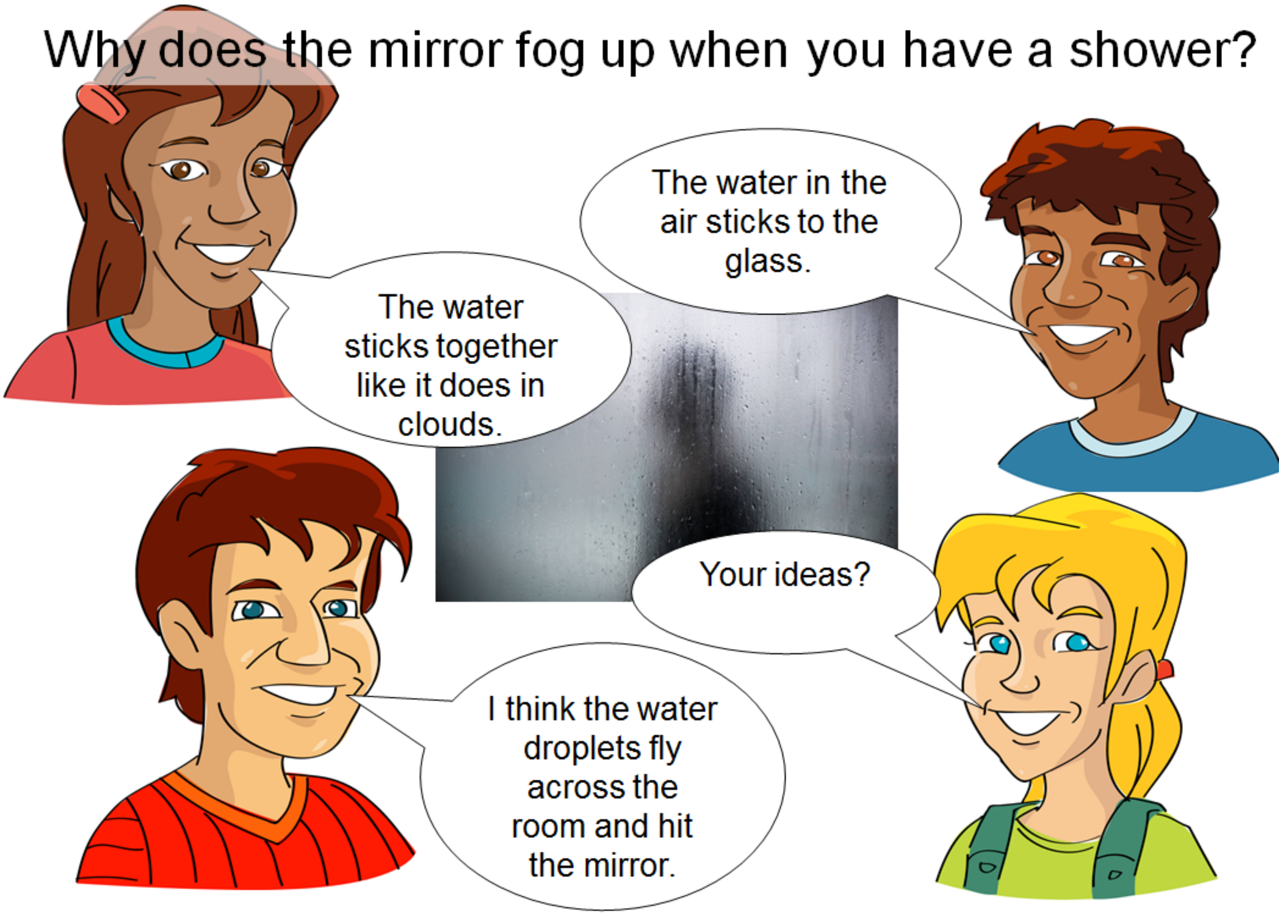
Create a model of what you would see if you could focus on one tiny spot in the area inside a cup of water.



Label the parts of your model, so that someone who looks at it will know what the parts represent.

(Adapted from:Krajcik, Joseph and Joi Merritt (2012) Engaging students in scientific practices: What does constructing and revising models look like in the science classroom? Understanding A Framework for K-12 Science Education. *Science Scope* March 2012)

Resource 4 Why does the mirror fog up when you have a shower?



Adapted from: Hunt J & Thrupp R. (2008). Conversations about science. Central Queensland University: Bundaberg.

Resource 5 Matter and evaporation

Ice (solid water)

Draw a labelled diagram to represent ice (solid water) at the molecular level.	Describe in your own words the way water molecules interact with each other when they are part of a solid.

Liquid water

Draw a labelled diagram to represent liquid water at the molecular level.	Describe in your own words the way water molecules interact with each other when they are part of a liquid.

Water vapour

Draw a labelled diagram to represent water vapour at the molecular level.	Describe in your own words the way water molecules interact with each other when they are part of a gas.

Adapted from Teacher Resources – Vischem Project DVD

Resource 6 Solar still activity

Predict–Observe–Explain

The solar still is a device that uses solar energy to purify water. Different versions of a still are used to desalinate seawater, in desert survival kits and for home water purification. It is very easy to splash salty water into the small cup in the middle of the solar still so be very careful, as this will affect the result of the activity!

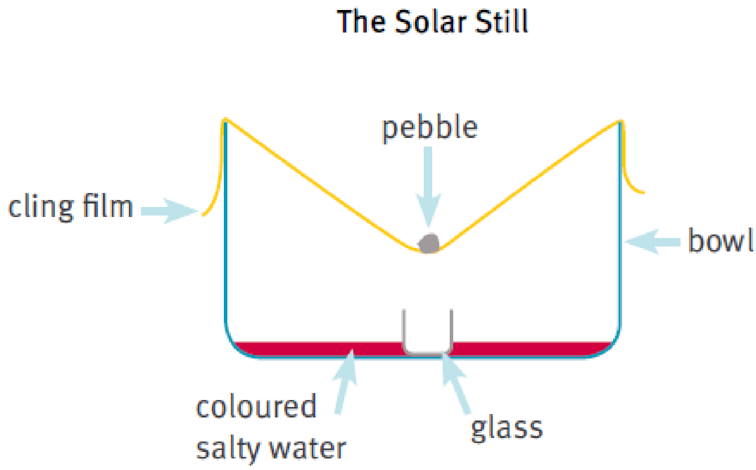
Before you begin this activity, write your prediction on the worksheet on the next page. What do you think will happen?

What will you get in the small cup in the middle of the solar still?

Equipment

For each group of three students:

- one 2-litre plastic ice cream container
- small, shallow plastic cup or shot cup (clean)
- Blu-Tack (or similar)
- cling film (wider than the bowl)
- pebble
- hot water
- food dye
- salt
- disposable drinking straws



Method

1. Take all the equipment out to a sunny, level place.
2. The teacher will pour 1 cm of the coloured salty water into your ice cream container.
3. Place a small piece of Blu-Tack on the bottom of the small cup so that it will stick to the bottom of the ice cream container.
4. Carefully place the plastic cup in the middle of the ice cream container, making sure no salty water splashes into the small plastic cup.
5. Cover loosely with cling film so that it sags slightly in the middle. Seal the film to the rim of the ice cream container with a large rubber band.
6. Place the pebble in the middle of the film above the cup.
7. Leave the still for at least half an hour (the longer the better).
8. Remove the cling film and take out the cup without splashing any water into or out of the cup.
9. Record your observations about the water in the plastic cup on this worksheet. Is it coloured? What does it taste like? Students can taste the water using a straw.
10. Complete the worksheet by explaining your ideas about why you got your results.

Adapted from a resource developed by Dr Tony Wright, School of Education, The University of Queensland.

The solar still activity—student worksheet

Predict

I think that ______________________________

____

____

because ______________________________

____

____

Observe

Our group found that ______________________________

____

____

____

Explain

I think that ______________________________

____

____

____

____

Use the following words in your explanation:

- evaporate
- liquid
- vapour
- condense
- molecules

____

____

Appendix A Student ideas about matter

Students in the 11 – 13 year old age group are often at the transition stage between the visible and the invisible. Particle theory is therefore a challenge.

Children tend to see water as the typical liquid against which all others are compared.

Students have their own ideas about dissolving. These misconceptions can be very firmly entrenched and difficult to change. Where possible, monitor student ideas throughout the unit and provide opportunities for students to disprove their naïve ideas with evidence.

Student ideas about evaporation and condensation

Student ideas	Reasoning
Students may believe that when matter disappears it ceases to exist	Young children rely on sensory information and because gases are often invisible they have no evidence of their existence
Matter has a materialistic core to which various random properties having independent existence are attached	Matter can 'disappear' whereas it's properties such as sweetness can continue to exist completely independent of it
Weight is not an intrinsic property of matter—weightlessness can be accepted	This may be because of fantasy images of floating
Students associate gases with the use and function of objects e.g. balls, balloons, tyres.	The effect that a gas has on an object is visible
Water molecule in steam are larger than those in ice	Water as steam occupies more space therefore the particles are bigger