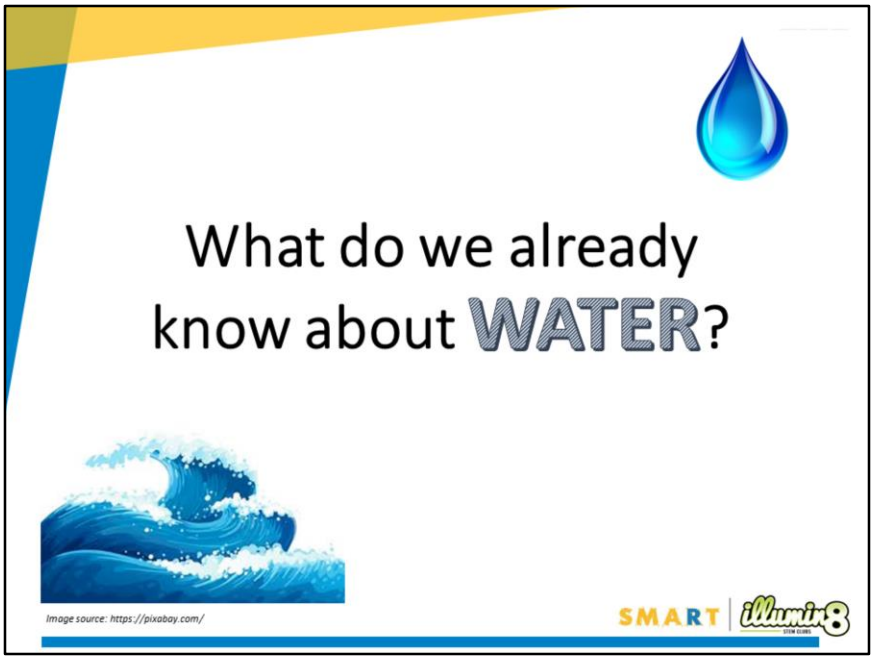
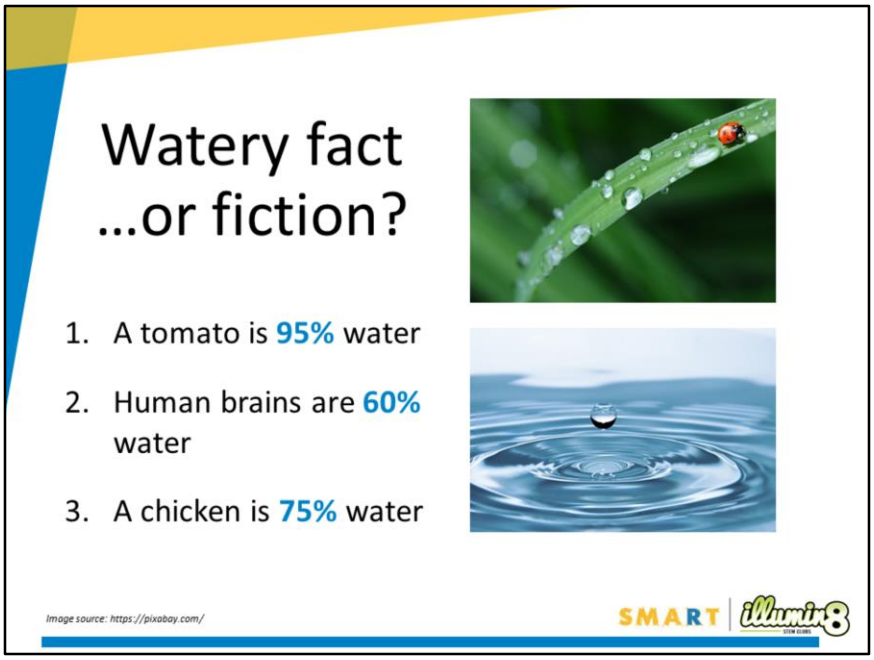
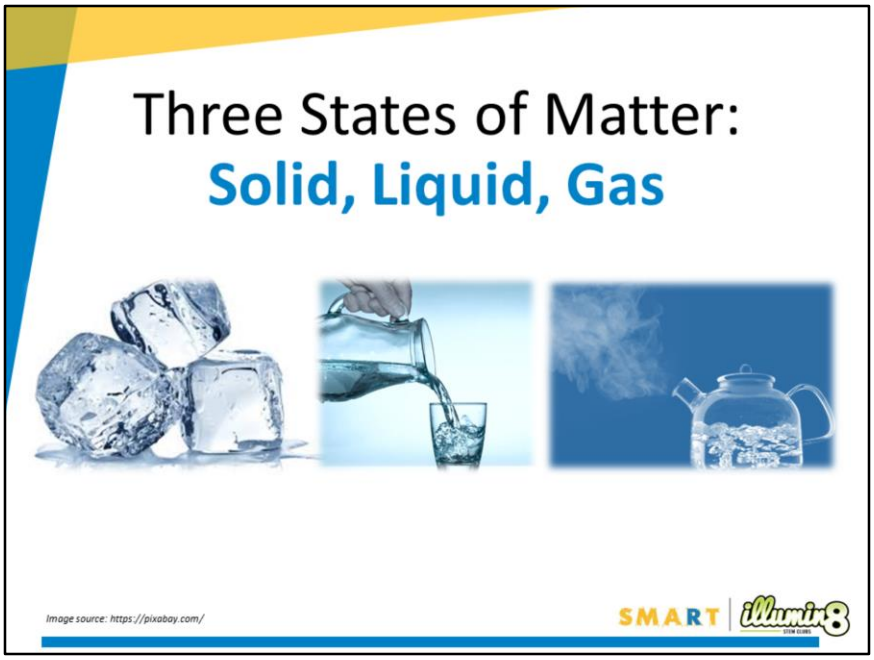
Welcome back, and welcome to new participants!
In Module 1, we explored the science around AIR.
In this Module, Module 2, we will explore the science around WATER!



What do we know about water?
Encourage students to share what they already know!
Ask students what words they think of when they think about water?
Perhaps: wet, drink, swim, droplet, ocean?
Maybe fluid, flow, liquid?
Ask students when they have noticed water in the world around them?
Perhaps on rainy days, swimming, washing dishes, filling up drink bottles?
In this module, we will explore what water is made of, learn some cool scientific words to describe waters properties, and perform some fun experiments!



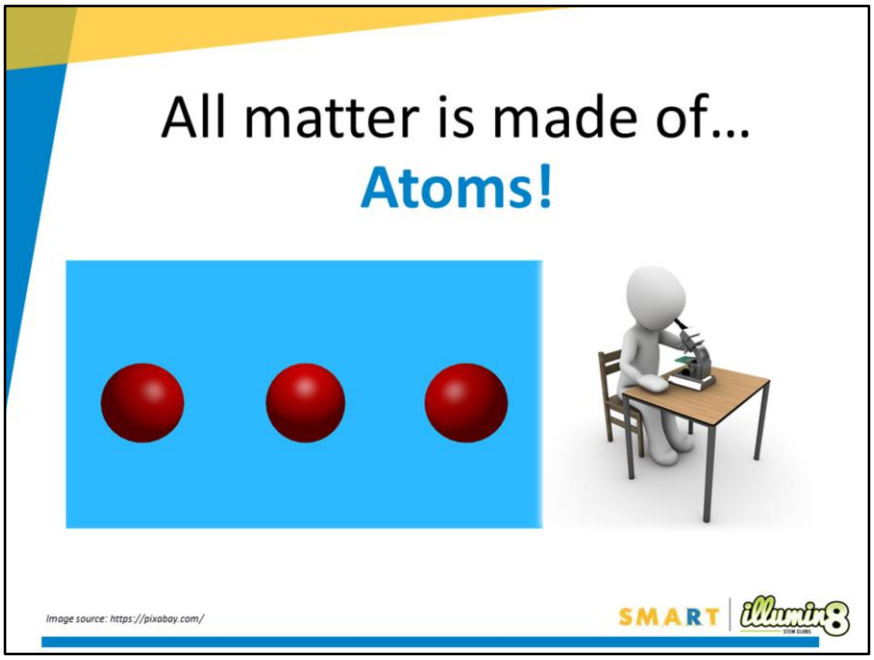
Intro Game: Fact or Fiction
Invite students to guess which of the three “facts” about water has been made up!
‘Facts’….
1. A tomato is 95% water
2. Human brains are 60% water
3. 75% of a chicken is water.
Answer: Number 2 is false – human brains are 75% water
Fact source: http://blueplanet.nsw.edu.au/water-facts/.aspx



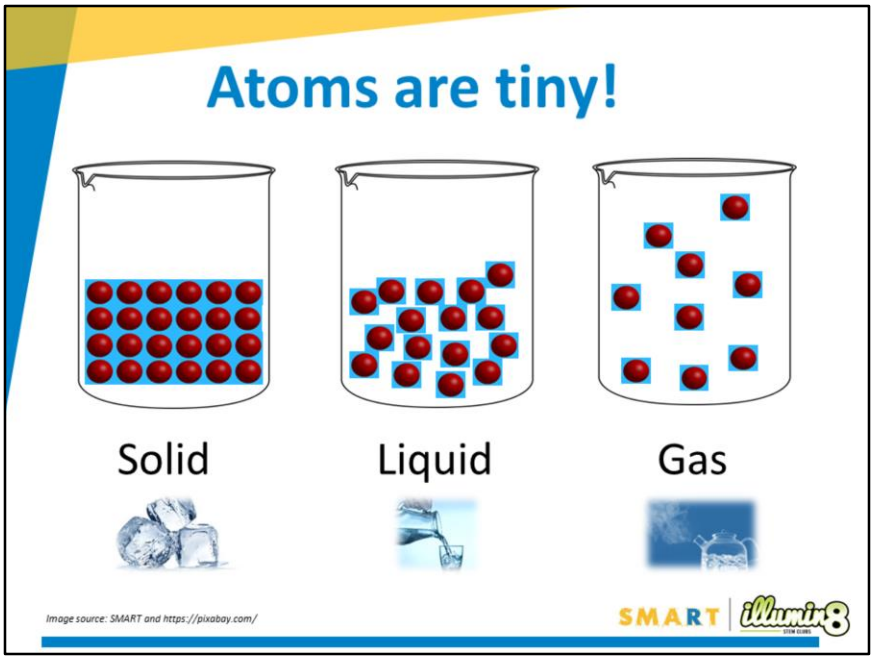
Scientists have a name for what things are made of: they call it “matter”.
Everything around us is made of matter – this room, your clothes – and you!
Some matter is so tiny, we need special equipment, like magnifying glasses and microscopes, to see it.
Some matter is invisible (like the air around us).
There are three main states of matter, and we call these: solid, liquid and gas.
Most substances can exist in all three states. They changes from one state to another depending on how hot they are. Water is the only matter that occurs naturally on earth in all three **states**: as liquid water, solid ice, and vaporous steam (gas).
Ask students when they might see water in it’s different states?
Examples:

- Frozen (solid) water: ice cubes, ice blocks, snow, snow flakes
- Liquid water: rain, running from taps, puddles, lakes, oceans
- Gaseous water: steam from kettles, steam from boiling pots.

Ask students what might cause water to change states?
Answer: heating, cooling.



All matter, or stuff, is made up of tiny building blocks called **atoms.**
An atom is very small, a bit like a tiny ball.
There are about 100 different types of atom, and these are all different sizes (though all very tiny).
Each type of atom makes one type of matter, called an element.
Some common elements are: iron, calcium, and gold.
Iron is used to make pans, cars, bridges.
Calcium is an element found in our teeth and bones.
We make jewellery from gold atoms.
A piece of paper, or a page in a book, can be more than 1 million atoms thick.
If you cup your hands together with some air inside, you'll be holding more than a thousand-million-million (1,000,000,000,000,000) atoms of air!

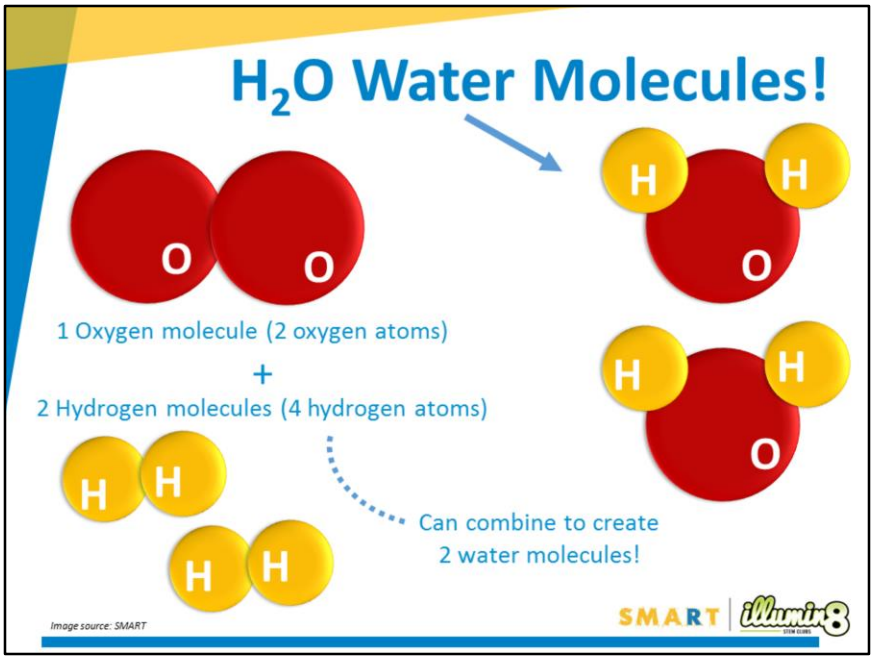


In each state of matter (solid, liquid and gas) atoms and behave differently. Substances change from one state to another depending on how hot, or how excited, their atoms are.

Solids: In solids, atoms are very close together. Atoms are fixed together firmly in a set pattern, in a fixed shape. The atoms in solids don't move far away from each other. When a solid is heated up enough, it melts and changes into a liquid.

Liquids: In liquids, atoms are less tightly packed together than in solids. The atoms in liquids can move around, and swap places. The means a liquid can flow and be poured into a container, or be separated into droplets. When a liquid is heated up enough, it turns into a gas.

Gases: In a gas, atoms are separate from each other, and can zoom around at high speeds. A gas spreads out and fills the area it is in. Gases have no shape and are often invisible.



When atoms group together, we call them molecules. Some molecules are made up of just one type of atom. Others are made up of different types of atoms joined together.
Oxygen is an element. It contains one type of atom – oxygen. An oxygen molecule is made up of two oxygen atoms.
Hydrogen is another element. A hydrogen molecule is made up of two hydrogen atoms. Hydrogen atoms are smaller than Oxygen atoms.
When one oxygen molecule and two hydrogen molecules meet, there is a chemical reaction. The atoms separate, and form two new molecules. Each new molecule has one oxygen atom and two hydrogen atoms.
These molecules make a new substance. It is unlike hydrogen or oxygen, and it is called WATER!
Because a water molecule is very tiny (microscopic) in size, it takes billions of water molecules to make even the smallest droplet of water.
*If you have access to a molecular modelling kit, it would be fantastic to use here to make a water molecule with participants (local schools and universities may loan out a molecular modelling kit).
Let's do an experiment to observe some cool properties of liquid water molecules!

Wobbly Water

Aim: To observe the properties of liquid water

Equipment (per group):

- 1-2 cups of water
- 1 small shallow bowl / jar
- 2 pipettes / straws
- 2 or more coins
- Paper towel

Procedure:

1. Form a group of 2 to 3 students.
2. Slowly fill the shallow bowl / jar right to the top with water.
3. Take turns to add additional drops of water to the 'full' bowl / jar using a pipette or straw.
4. Observe how many drops will fit in. Look closely at the edge of the bowl / jar at eye level. What can you see as more drops are added?
5. Now take turns to add drops of water onto a coin, using the pipette / straw. How many drops can fit on a coin?
6. What do you see?

Image source: SMART

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Now we're going to observe some of the cool qualities of wonderful water!
Before performing the experiment, reinforce the Scientific Method by discussing with the students a hypothesis about what might happen. Then assist students to perform the experiment to confirm or disprove the hypothesis. Discuss what was observed (the results), and explore student ideas on why this may have happened.
This experiment explores surface tension.
Refer to RISK ASSESSMENT for Module 2 before conducting experiment.
Refer to Experiment notes (E2.1.1 in Coordinator Notes for Module 2.1)

Sink or Float

Aim: To observe surface tension in a cup of water

Equipment (per group):

- 1 cup of water
- 1 Paperclip
- 2cm x 2cm piece aluminium foil

Procedure:

1. Form a group of 2 to 3 students.
2. Fill a cup with water.
3. Place a paperclip flat and gently on the surface of the water.
4. Observe. What do you see?
5. Place the paperclip gently on the water surface in a different way. What do you see?
6. Tear off a piece of aluminium foil (up to 2cm in width / length). Place it gently on the surface of the water.
7. Observe. What do you see?
8. Place the foil gently on the water surface in a different way. What do you see?

Image source: http://sciencewithkids.com/

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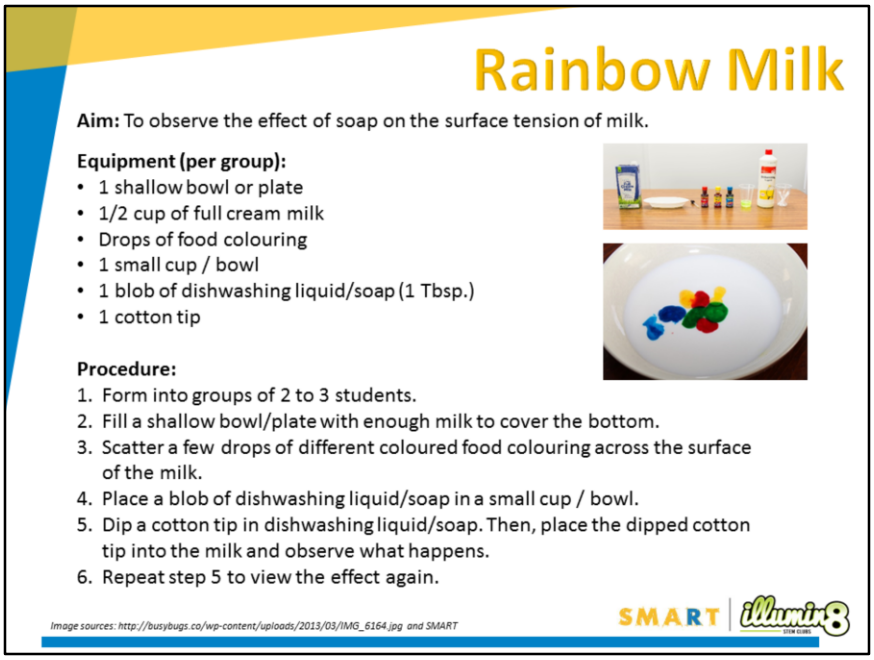
This experiment demonstrates surface tension.
Before performing the experiment, reinforce the Scientific Method by discussing with the students a hypothesis about what might happen. Then assist students to perform the experiment to confirm or disprove the hypothesis. Discuss what was observed (the results), and explore student ideas on why this may have happened.
Refer to RISK ASSESSMENT for Module 2 before conducting experiment.
Refer to Experiment notes (E2.1.4 in Coordinator Notes for Module 2.1)

Explanation: Water molecules want to stick to other water molecules, and they hold on tightly to their neighbours below and next to them. When molecules 'stick' or "bond" together, we call this **COHESION.**
The water molecules on the surface of the water have water molecules below them, and next to them as neighbours. Because there are no water molecules above them, only air, the water surface acts like it has a thin 'skin'. We call this **Surface Tension.**

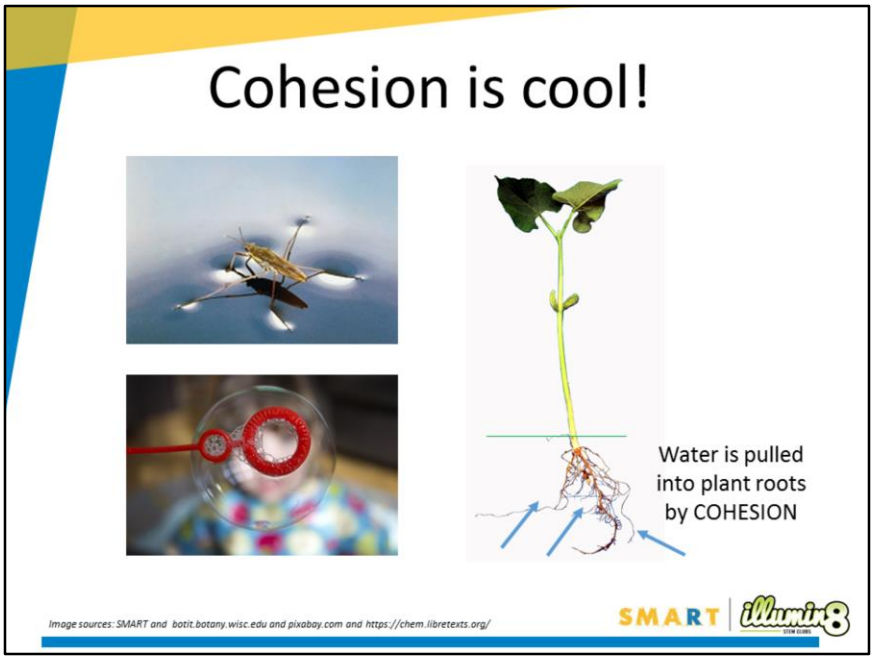
Wobbly Water:
As you add more drops onto the coin (or into the jar/bowl), the force of **gravity** (pulling downwards) becomes stronger than the force of attraction among the water molecules at the surface. This causes the water to spill over the edge of the coin/jar.

Sink and Float:
You can think of surface tension a bit like a thin film on top of the water (like a spider web, or thin trampoline mat). When a weight/object lands on the water surface, it bends down. If the force (pressure) from the weight is more than the strength of the surface tension of the water molecules, the object will break through the surface and sink.

Cohesion and surface tension forces are present in other liquids too.
We can observed surface tension when we added drops of water to the bowl/jar and onto the coin. When the surface tension was weakened, the water molecules were held less tightly together, and the liquid flowed out of the jar and off the surface of the coin.
Let's do a fun experiment with milk, soap and food colouring to see if we can see surface tension in action in a different way.



Cohesion and surface tension forces are present in other liquids too. Milk is made mostly of water, but it also contains vitamins, proteins and suspended fat droplets.
Before performing the experiment, reinforce the Scientific Method by discussing with the students a hypothesis about what might happen. Then assist students to perform the experiment to confirm or disprove the hypothesis. Discuss what was observed (the results), and explore student ideas on why this may have happened.
So what is happening? The colours swirl and zoom around when the soap is added.
Milk stays together as one liquid, because of cohesion and surface tension between the milk molecules. The surface tension acts like a thin skin.
When you add the soap, it breaks the surface tension (skin) of the milk in one spot. The pull of the surface tension from the milk at the edge of the bowl/plate then causes the milk in the centre to move toward the edge, taking the colours along with it.
The colours will keep moving until the soap stops affecting the surface tension of the milk.
(Explanation adapted from: http://www.csiro.au/en/Education/DIY-science/Chemistry/Amazing-detergent)
Refer to RISK ASSESSMENT for Module 2 before conducting experiment.
Refer to Experiment notes (E2.1.2 in Coordinator Notes for Module 2.1)
…….
EXTENSION: Molecules that reduce the surface tension of other liquids are called surfactants. Dishwashing liquid is a common surfactant.



Remember COHESION is the name for when molecules **of the same substance** 'stick' or 'bond' together.

Ask students where we might see cohesion in nature, or in everyday life?

Blowing bubbles: Cohesion makes the surface of the bubble liquid behave like a stretchy, rubber sheet, and hold together around the air inside.

Water Bugs: The water strider, can run across the surface of water, due to the cohesion of the water molecules, and the force of the strider which is evenly distributed to its legs.

PLANTS: Cohesion actually allows plants to draw water (and nutrients) into their roots. Plants need water and nutrients to stay alive, so this is a vital process in plants. The force of cohesion allows this process to work without the plant having to use its own energy.

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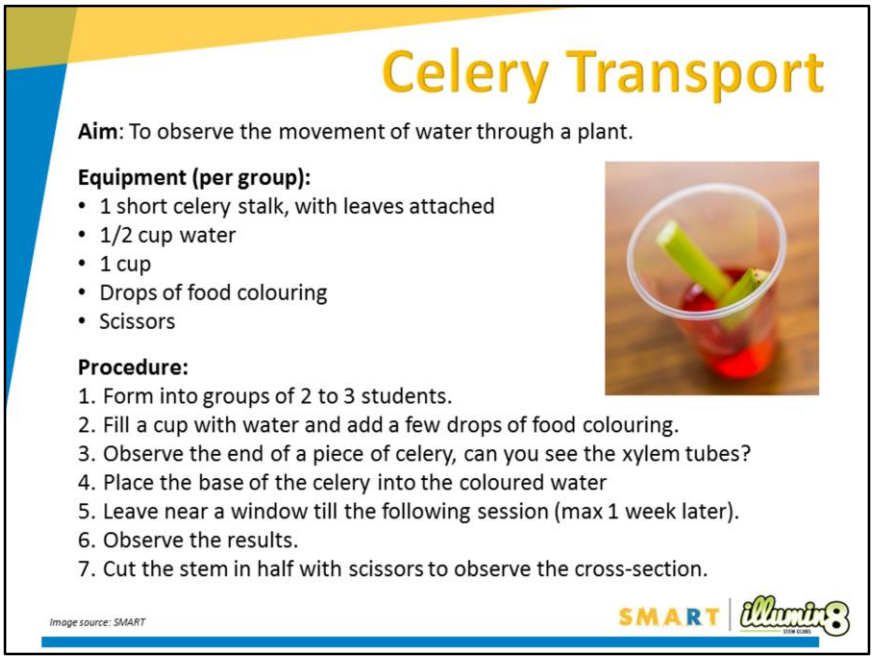
Extension: This entire process in plants is called TRANSPIRATION! Water evaporates out of plants into the atmosphere (through their leaves). This process creates a continuous pull of cohesion through the plant, from the leaves to the roots, drawing water (and dissolved nutrients) into the plant.

Water moves through plants from their roots to their leaves. The 'pipes' which transport the water are called XYLEM. In this next experiment, we are going to see how water is pulled through a plant's XYLEM using water COHESION.



Hand out the celery (cut the bottom of the stems so there is a clean cut to view the xylem) to the students and ensure that each student can see the xylem tubes. These are the 'water pipes' of plants.

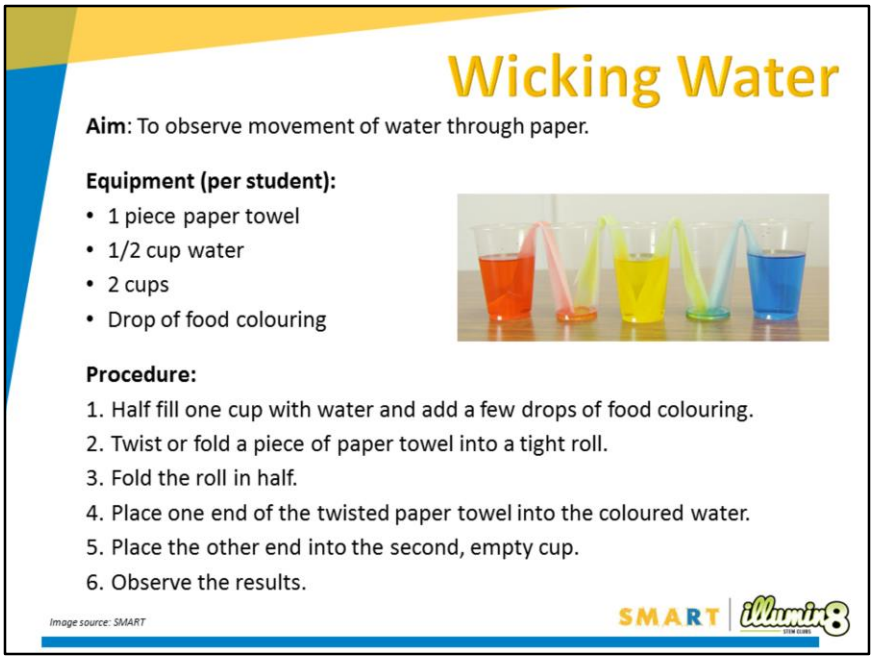
Results take more than 2 hours to appear. Students will need to view the results at the beginning of their next science club session (max 1 week later) or you can allow students to take the experiment home.

Optionally, the facilitator may choose to conduct the experiment up to 1 week before / the night before, to show students the results they can expect – particularly recommended if students take the experiment home.

Before performing the experiment, reinforce the Scientific Method by discussing with the students a hypothesis about what might happen. Then assist students to perform the experiment to confirm or disprove the hypothesis. Discuss what was observed (the results), and explore student ideas on why this may have happened.

Refer to RISK ASSESSMENT for Module 2 before conducting experiment.

Refer to Experiment notes (E2.1.3 in Coordinator Notes for Module 2.1)



This experiment can be conducted instead of, or in addition to, the Celery Transport experiment.
Before performing the experiment, reinforce the Scientific Method by discussing with the students a hypothesis about what might happen. Then assist students to perform the experiment to confirm or disprove the hypothesis. Discuss what was observed (the results), and explore student ideas on why this may have happened.
Refer to RISK ASSESSMENT for Module 2 before conducting experiment.
Refer to Experiment notes (E2.1.5 in Coordinator Notes for Module 2.1)

We have talked about how important (and cool!) cohesion is. Remember COHESION is the name for when molecules of the **same substance** 'stick' or 'bond' together. ADHESION is a very similar concept. This is the word we use to describe **the attraction between molecules of different substances!**
For example, the water molecules in the picture are sticking to, or bonding to, the pine needles of this tree.

When you fill a measuring cylinder or cup with water, you can see that the surface of the water is curved.

This is called the meniscus! The meniscus forms because of cohesion between the water molecules, and adhesion between the water molecules and the glass.

The adhesive attraction between the water and glass makes the water want to stick to the glass, and that's why it curves up at the sides.

Ask students from which part of the meniscus they should measure to get the volume in a measuring cylinder…. (edge, centre, etc.)

Answer: When measuring liquid in a cylinder you should always measure from the **centre of the meniscus**. In the picture on the slide, the measuring cylinder is 21 millilitres full, not 21.2 millilitres.

Some liquids will have a 'convex' meniscus (curving at the top). Mercury has a convex meniscus in glass.

Water has a 'concave' meniscus (curving at the bottom) in glass. In some containers, for example a container made from Teflon, water will form a convex meniscus!

Water Transport Challenge!

Water is needed!

The town of **Waterloo** is out of water!
The town's taps have run dry.

During your investigation, you've discovered the water pipes from the town's dam have broken.

How will you get water to the town, while the engineers fix the broken pipes?

The Challenge:

Transfer water from the dam, to the town, using only the powers of cohesion, adhesion and surface tension!

Water transport teams will be scored on:

- How much water makes it to the town
- How many drops of water make it onto the storage stations (coins)!

This video demonstrates adhesion, water “sticking” to a string.
https://www.youtube.com/watch?v=iJBHckmq_o0

This video demonstrates surface tension, cohesion and adhesion. Water molecules 'stick' to the mesh. Cohesion between the water molecules themselves creates surface tension. The combined forces prevent the water from flowing out through the mesh.
https://www.youtube.com/watch?v=94yRLJfqyv8
The Module 2 Video includes a demonstration of this activity.

Water Transport Rules

Dam

- The dam is high up in the mountains! You must first transport the water from the dam into your water vessel (cup) using only a piece of string and tape.

Road to Town

- Travelling to the town is dangerous, so the water in the water vessel must be transferred into a special transport container (bottle) using only a straw.
- With the water in the transport container, you can now start your journey to the town, however, the container has no lid... and must be transported to the town upside down! You have a rubber band, a plastic card and a piece of mesh to assist you. The plastic card must not leave the dam area.
- If water is spilt and it does not land on a towel, it must be cleaned up immediately! The road to the town must remain dry!

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Water Transport Rules

Town

- You have made it back to town! Pour your water into a measuring cup (the holding tank!), and ask a supervisor to record the volume of water you were able to transport to town.
- Now that you have recorded how much water you transported to town, the water must be stored!
- The more water drops you can place onto the storage stations (20c coins) the further the water supply will reach across the town.
- Transfer as many drops onto the three coins as you can, without the water overflowing. Transfer to one coin at a time. A supervisor or a student from another team will need to watch the storage process, to help count how many drops you store on each coin.

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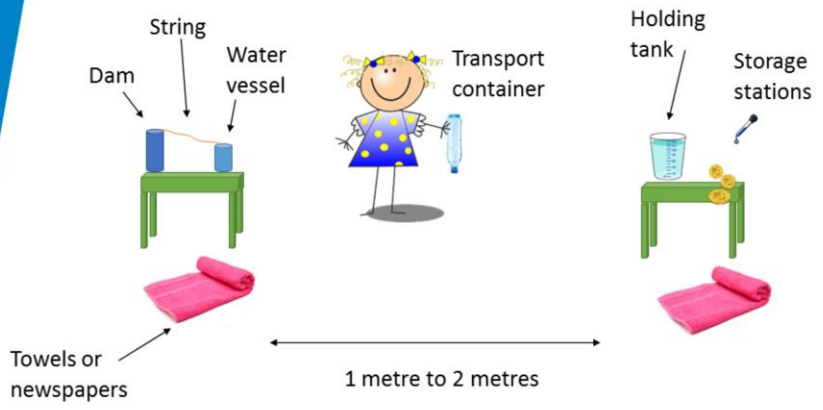
Challenge Set Up



References

- **Anti-gravity water**
  https://www.stevespanglerscience.com/lab/experiments/water-screen/
- **Water travelling on a string**
  https://pbskids.org/zoom/printables/activities/pdfs/wateronastring.pdf
- **Water on a coin**
  https://www.questacon.edu.au/outreach/programs/science-circus/activities/count-the-drops
- **Wicking Water**
  http://www.sciencekids.co.nz/experiments/escapingwater.html
- **Rainbow Milk**
  http://splash.abc.net.au/home#!/media/2191105/rainbow-milk-experiment
- **Properties of Water & Water Facts**
  http://blueplanet.nsw.edu.au/water-facts/.aspx
  http://splash.abc.net.au/home#!/media/103352/the-surface-tension-of-water
  https://water.usgs.gov/edu/waterproperties.html
  https://www.kidsdiscover.com/teacherresources/water-buoyancy-cohesion-adhesion/

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https://www.youtube.com/watch?v=8O8PuMkiimg
Water on a coin demonstration.
The Module 2 Video includes a demonstration of this activity.