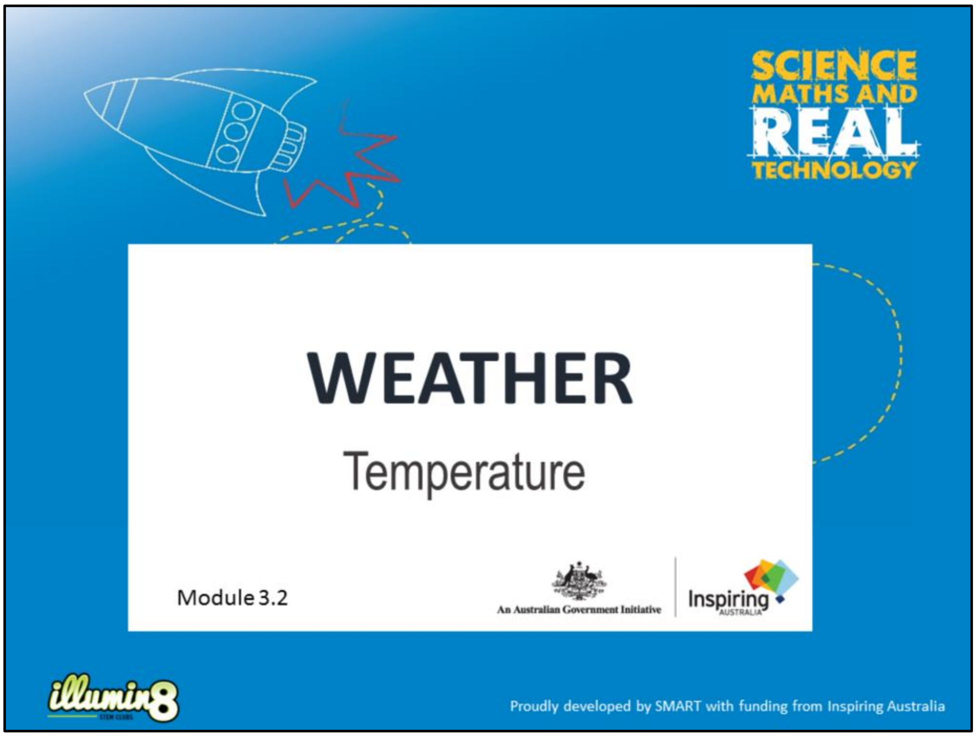

Both air temperature and ocean temperature are often included in a weather report!
Air temperature is the main value reported in weather reports.
It gives us a good indication of how the day will feel.
Does anyone know what the today's temperature is?
Before we get started exploring temperature, lets chat about the weather measuring devices and weather diaries we started in the last session…

Weather Diary!

How did you go with observing and forecasting?

Challenge M3.1 – Weather Diary

Weather Observer:					Location:		
Day of the Week	**Date**	**Time**	**Temperature** (Hot, Average, Cold)	**Cloud Types Visible**	**Rainfall (mm)**	**Wind Direction** (N, E, S, W)	**Air Pressure** (High, Medium or Low)

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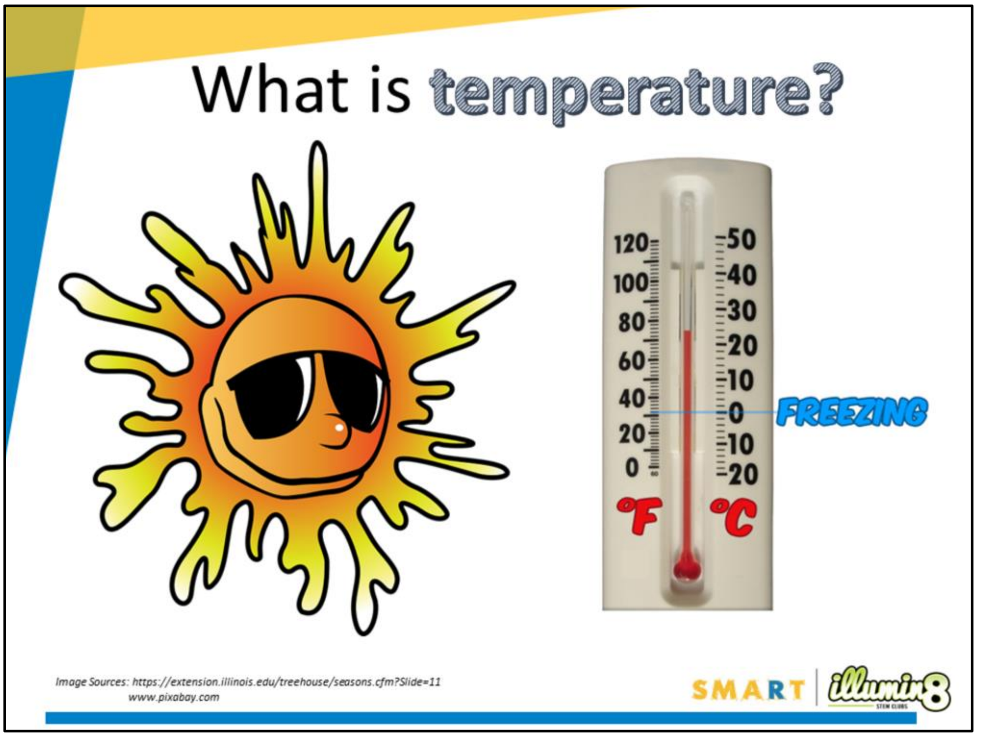
Bring along a printed weather forecast for the day of the session from the Bureau of Meteorology. Compare to student forecasts!
Discuss the weather between the last session and today with the students.
Did they observe any rainfall? Were they able to measure it?
Has it been hot or cold?
Has it been windy? Has there been one prevailing wind direction, or many directions?
Has the air pressure varied day to day? Has it varied morning to night?
Discuss weather diary entries with students, comparing their recorded values for similar days / times.
How similar were the readings from their devices?
Were there differences based on time of day, and location of device?
Have a discussion about how their devices performed.
Would they make the devices differently next time, or place them somewhere else?
Did anyone forecast the sessions weather for today? Were they correct?



We think of temperature as how warm or cold something is. But what is it really? Temperature is a measure of energy or heat. There are several ways to determine temperature. One way is by just using your senses. Objects with more energy will be warm or hot to the touch. Things with less energy will be cool or cold to the touch. Temperature is measured with a device called a **thermometer**. A thermometer is usually made up of a small, hollow glass tube with swelling at one end, called a bulb. Inside the tube and bulb is a coloured liquid, often red, called alcohol. The alcohol is the same temperature as the air around it, and it expands or contracts when the surrounding temperature changes. The temperature can be found by looking a the top of the alcohol I the tube, and reading from the scale next to it.

In Australia, temperature is measured in degrees Celsius **(°C)**. The Celsius scale uses 0° for the freezing point of water, and 100° for the boiling point. It is sometimes called a Centigrade scale. This scale is named after **Anders Celsius.** He was a Swedish astronomer, physicist and mathematician who lived from 1701 to 1744. In the U.S.A and some other countries, temperature is measured using the Fahrenheit scale (°F). This scale has the freezing point of water at 32°, and the boiling point of water at 212°. This scale is named after **Daniel G. Fahrenheit.** He was a German physicist, inventor and scientific instrument maker, who lived from 1686 to 1736. Does this mean that water freezes or boils differently using Celsius or Fahrenheit? No! Water still freezes or boils at the same point, the scales are just a different ways of measuring the same thing.

Water Thermometer

Aim: To observe the effect of temperature on water

Materials (per group):

- Glass bottle
- Clear straw
- Cold water and hot water
- Food colouring
- Modelling clay
- Container/tub (wider than the bottle)

Procedure:

1. Form into groups and collect materials.
2. Add a few drops of food colouring to the bottle.
3. Fill the bottle up to the bottom of the neck with cold water (almost full).
4. Place the straw in the jar. Use the modelling clay to position the straw in the centre of the jar. Make the seal around the straw and jar as tight as possible, like a lid.
5. Add hot water to the container. Stand the bottle inside the hot water container.
6. Observe the results!

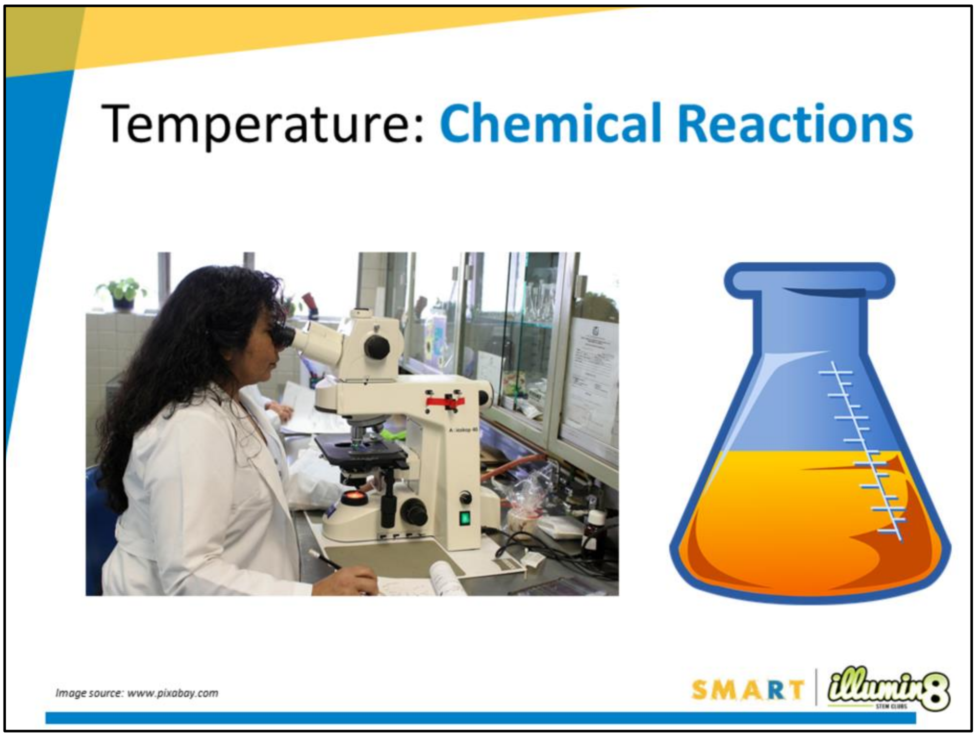
Note: Use a heat proof glove to remove the bottle from the hot water.
What happens if you place the bottle in a container of cold water?

Image Source: https://www.stevespanglerscience.com/lab/experiments/water-thermometer-sick-science/

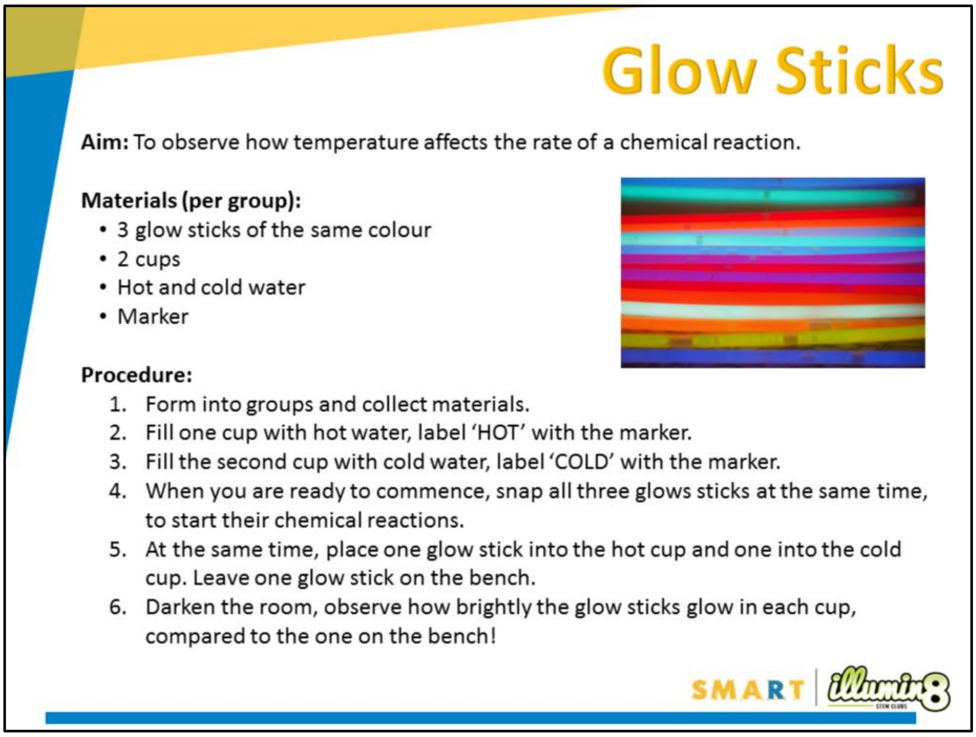
Let's take a look at making our own thermometer!
Refer to the Module 3 Risk Assessment before undertaking the experiment.
Refer to coordinators notes for Experiment E3.2.3.
Encourage students to form a hypothesis prior to conducting the experiment about what might happen. Discuss observations and results and compare to hypotheses after the experiment.

We know that we can measure temperature with a thermometer.
But why is knowing about temperature so important?
Temperature affects the physical, chemical and biological world in so many ways!
Can students think of examples of temperature affecting our world?
Examples:
Why do you need to wear warm clothes in cold weather? The biological systems in our bodies don't work well at very low temperatures.
What happens to water when the temperature drops below freezing? The physical properties of water change from liquid to ice, because of the temperature change.
In cold temperatures:
- Ice can form on top of lakes, precipitation is often snow or sleet, rather than rain.
- Ice and snow can change driving conditions, and impact out door activities.

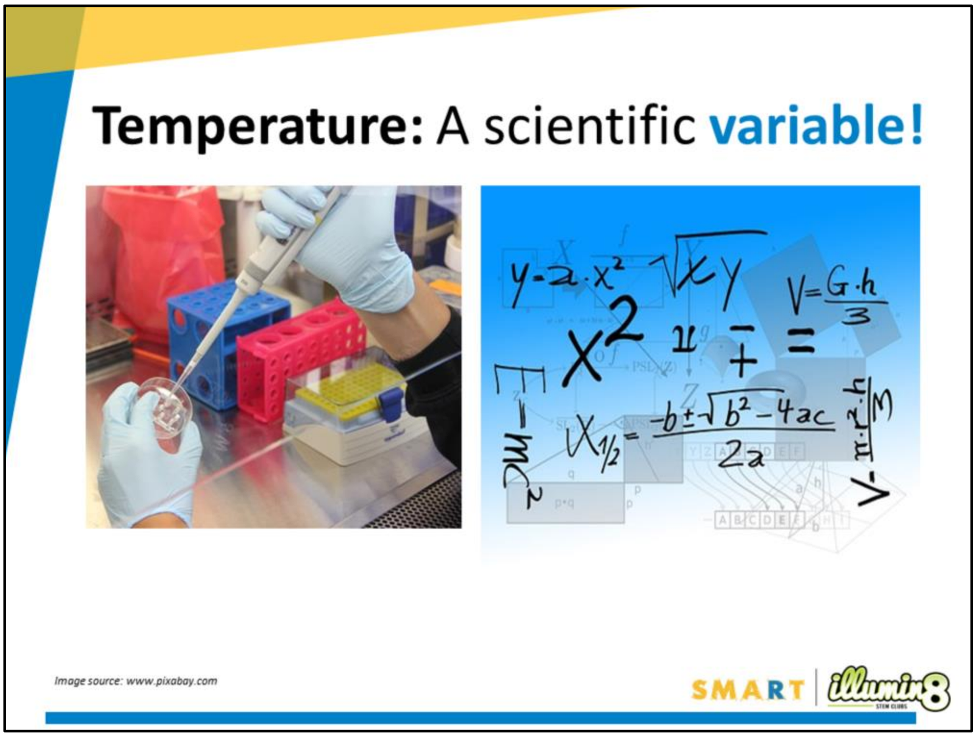
In hot temperatures:
- We might need to water our gardens more frequently, or our crops, and ensure our pets and animals have a cool place to shelter and rest.
- The risk of bush fires can increase, as areas of bushland and grass dry out in hot weather.



Chemical reactions can also be sped up or slowed down depending on temperature.
Chemical reactions are all around us!
They are the reason metal rusts, and the reason we can get energy from food.
How fast a chemical reaction takes place is called the "*rate of reaction".*
Changing the temperature of an experiment can affect the rate of reaction (how fast the reaction occurs).
Hot temperatures can make some chemical reactions speed up, and cool temperatures can make some reactions slow down.
Most scientific laboratory's are temperature controlled, that is, they have testing and experimenting zones set to known temperature conditions.
Let's try it!



Let's take a look at making how temperature affects chemical reactions!
Refer to the Module 3 Risk Assessment before undertaking the experiment.
Refer to coordinators notes for Experiment E3.2.1.
Encourage students to form a hypothesis prior to conducting the experiment about what might happen. Discuss observations and results and compare to hypotheses after the experiment.



In every science experiment, there are things that we are measuring and observing. There are also things that we can change, and things that we choose to keep the same. These things can be the chemicals or objects we are testing, the ways of doing something (e.g. stirring or shaking), or the environmental conditions we are working in (e.g. hot, cold, windy, still).

All of the things we can change or choose to keep the same in an experiment are **"variables".**

In the Glow Stick Experiment we chose to change the temperature of the water between the cups, and the water temperature became a <u>variable.</u>

<u>.............................</u>

<u>Extension:</u>

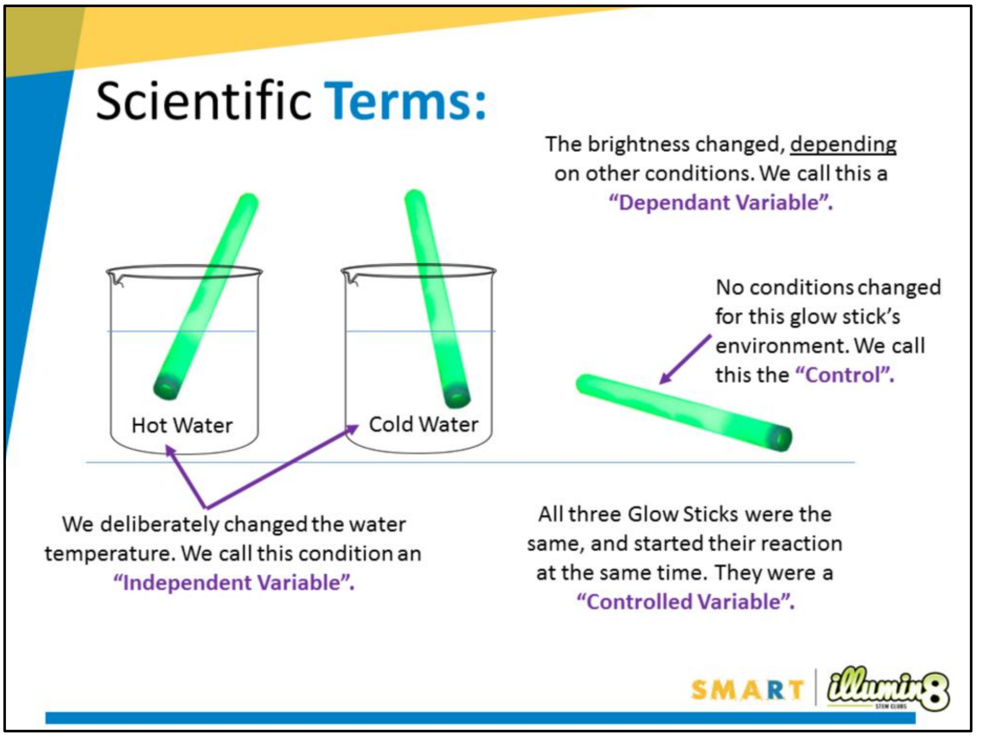
We call a variable that we deliberately choose to change, an **"independent variable".**

The water temperature in the glow stick experiment was the independent variable.

The brightness of the glow stick changed depending on the conditions we placed the glow stick in. We call the brightness in this experiment the **"dependant variable".**

We call the glow sticks in this experiment a **"controlled variable"** because all 3 glow sticks were the same, and were started at the same time.

We call the glow stick on the bench the **"**control". This is the version of the experiment where we didn't change any conditions (i.e. no water was added to the glow stick).



We call a variable that we deliberately choose to change, an **"independent variable".** The water temperature in the glow stick experiment was the independent variable.
The brightness of the glow stick changed depending on the conditions we placed the glow stick in. We call the brightness in this experiment the **"dependant variable".**
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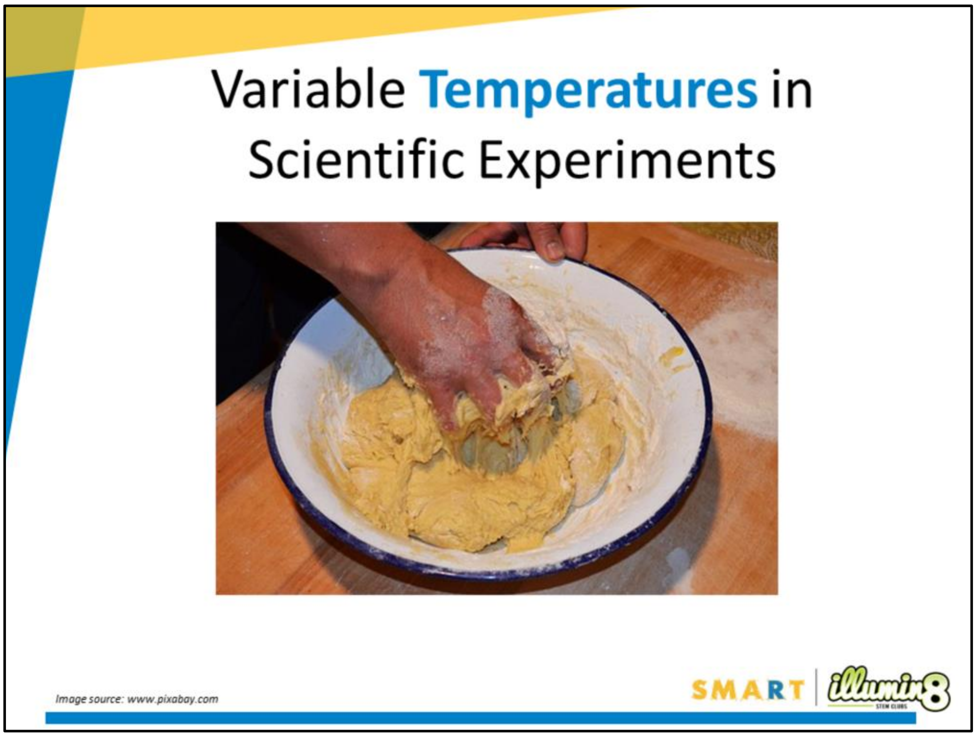
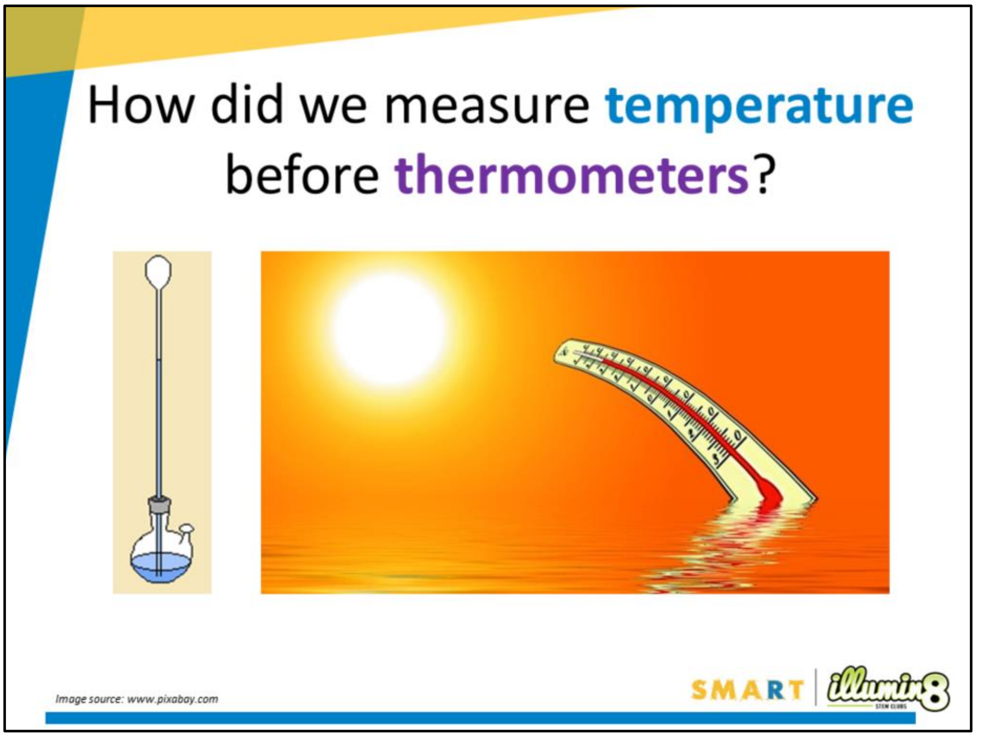


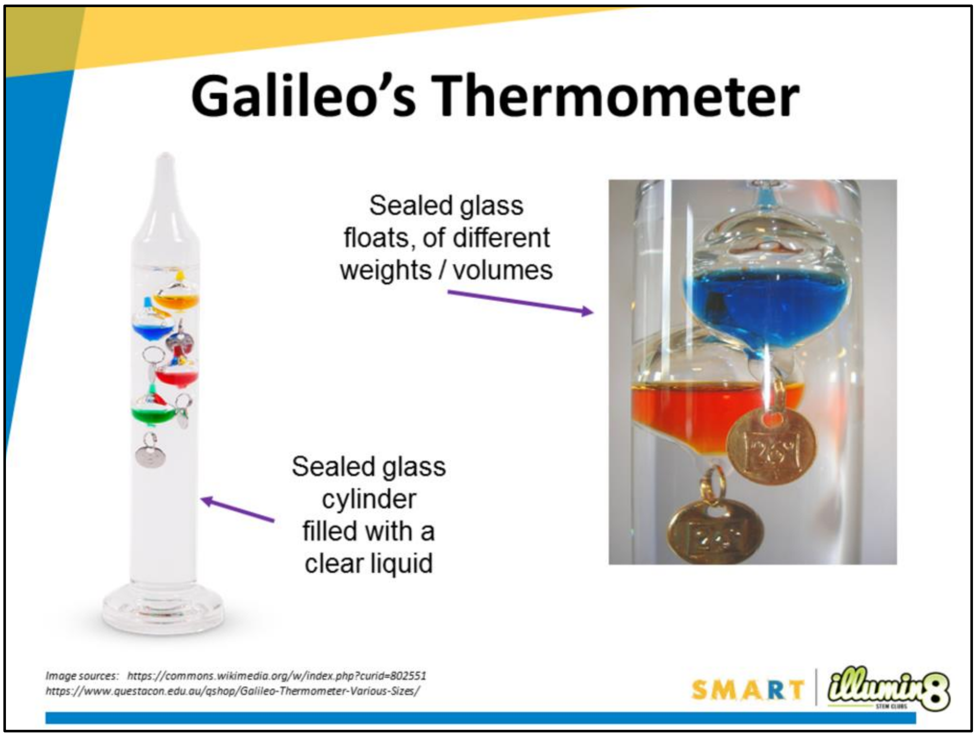
Bread is made from ingredients mixed together to form a dough.
Bread dough rises, or grows, in the mixing bowl, before being baked (cooked) in an oven.
Imagine we were doing an experiment, to observe how air temperature affects bread dough rising.
In this experiment, we have two bowls of bread dough.
We place one bowl of dough in a cold room, and one bowl of dough in a hot room.
* The air temperature is the **"independent variable"** – the thing we are deliberately changing.
How much the dough rises (the thing we are measuring) is the **"dependant variable"**.
* We want to keep everything else the same. So we make sure both rooms are the same (except for their air temperature). We make sure dough has the same ingredients, and each bowl is the same size. These are our "**Controlled variables".**
Who thinks the bread dough would rise faster in the cold room, or in the hot room?
Would it rise faster or slower in either room, compared to a room with 'normal' air temperature?
*Some experiments also add a **control.** This is the version of the experiment where you don't change anything. In our bread dough experiment, the control would be a bowl of dough sitting in a room with "normal" air temperature, i.e. not hot, and not cold. We would then observe the dough in the hot, cold and normal (control) rooms, to observe if air temperature actually impacts dough rising, or, if rising may also be impacted by something other than air temperature.*



The first thermometers as we know them today, were invented in the 1700's. Early thermometers were called "thermoscopes".
In 1714 Daniel Gabriel Fahrenheit invented both the alcohol and mercury thermometers. They were both very accurate and we still commonly use the alcohol thermometer today!
What else do you think people could have used to measure temperature, before thermometers were invented? Any ideas?
The behaviour of materials could have been observed to help identify changes in temperature.

- Different materials contract (shrink) and expand (grow) at different temperatures.
- Different materials melt at different temperatures (change state from solid to liquid).

Scientists and inventors experimented with devices containing water and air, and other materials, including the chemical element mercury and alcohol, to try and find a consistent, reliable way to measure temperature.
…………………………………………..
Extension:
Mercury is a silver coloured, metallic element that is in liquid form at room temperature (it's melting temperature is -39 degrees Celsius). Mercury is toxic (poisonous) if swallowed, and some countries have banned it's use in products like thermometers, batteries, lights and medical applications. Australia is investigating phasing out the use of mercury.



One of the most interesting thermometers still in use today, was designed around 400 years ago, in 1666 by a group of academics in Italy. They called it **Galileo's Thermometer,** as it uses some of the principles the scientist Galileo Galilei had discovered.

The key features of Galileo's Thermometers are:

- A sealed, glass cylinder, usually containing a clear, paraffin liquid, and a small amount of air. Paraffin responds to changes in temperature faster than water.
- Blown glass baubles, which are carefully weighted, so they will swap from floating to sinking at different temperatures.
- Attached to each of the baubles is a metal tag, showing the temperature for that bauble.

This thermometer works because of the principles of buoyancy and density (explored in Module 2.3). The paraffin and air inside the cylinder expands and contracts as the outside air temperature changes.

Water could also be used, however, paraffin responds to temperature changes faster than water. As the temperature of the paraffin falls, and becomes denser, (cold days) the baubles will rise. When the temperature of the paraffin rises (hot days), and becomes less dense, the baubles will sink. To read the Galileo Thermometer, simply note the temperature written on the tag of lowest floating bauble.

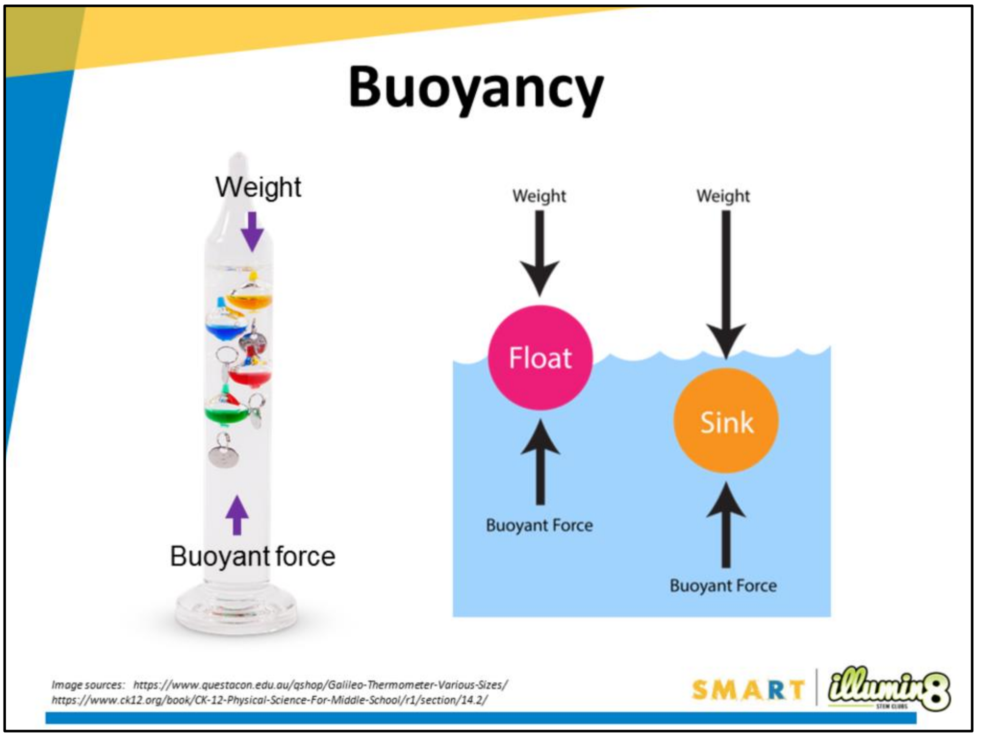
A Cartesian Diver is made of an object which is filled with some air and some water, open at one end, and placed inside a plastic bottle filled with water and sealed. The diver moves up and down (sinks and floats) when the bottle is squeezed.

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 3 before conducting experiment.

Refer to Experiment notes (E3.2.2 in Coordinator Notes for Module 3.2)

The divers will sink and float when you press and release the plastic bottles.
Why?
When we squeeze the bottle, we change the pressure of the air and water inside the bottle.
We have learned in previous modules that air can be compressed, it can be squashed into a container and placed under pressure. Water isn't so easy to compress. As we squeeze and increase the pressure in the bottle, the air in our diver is compressed so that more water can enter the straw. When more water enters the straw, the diver becomes more dense, because water weighs more than air. It has less buoyancy force and more gravity force, and so it sinks. When the pressure is reduced (we stop squeezing) the air expands inside the straw, pushing the water back out, and the diver floats again.
Did you notice that the water level inside the straw got higher when the diver sank?
…………………………….
Extension:
Density = mass/volume
Although the **volume** of our diver remains the same, its **mass** changes depending on how much water or air is inside it (water is more massive than air). We are able to change the mass of the diver by applying/releasing pressure to the bottle. Pressure effects the **density** of the diver as we are squashing the air molecules together. As the diver became more dense than the water in the bottle, it sank (its buoyancy decreased).



Remember, as we explored in Module 2.3, when an object enters a liquid, two forces act on it.

There is a **downward force** (gravity) that is determined by the objects weight.

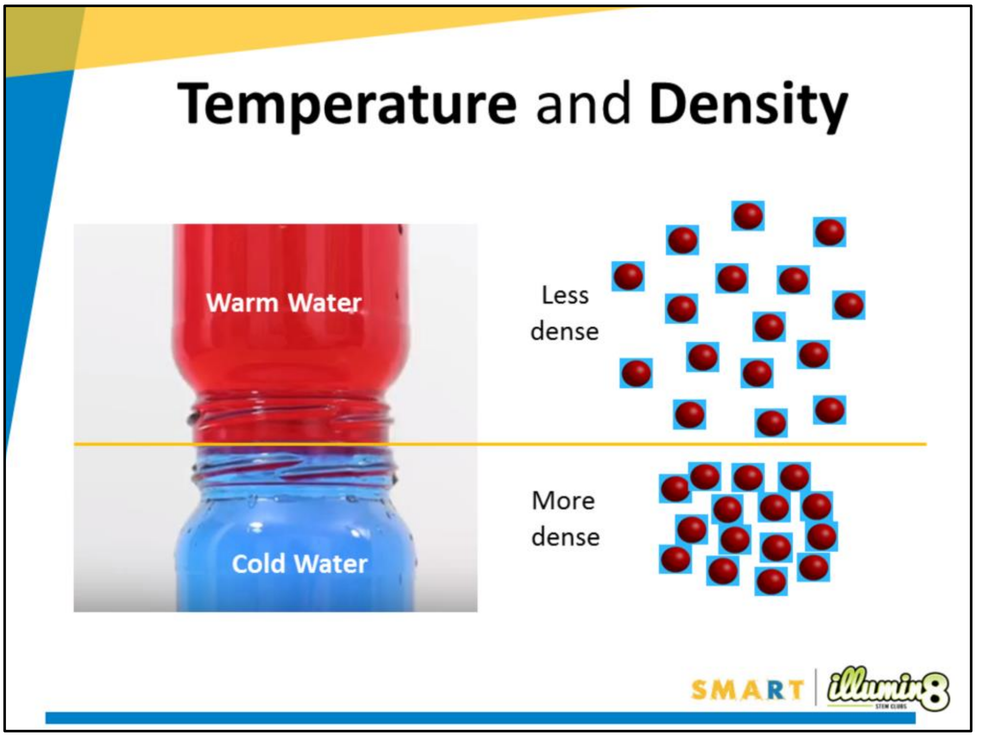
There's also an **upward force** called buoyancy, that's determined by the weight of the water displaced (or pushed aside) by the object.

Which force is greater determines whether an object sinks or floats!

If the buoyant ("up") force is bigger than the gravitational ("down") force, the object will float.

So in other words, an object will float, if it weighs less than the amount of water it **displaces** (pushes aside).

In the image on the slide, the object labelled "float" weighs the same as the buoyant force acting on it, so the object floats. The object labelled "sink" weighs more than the buoyant force acting on it, so the object sinks.

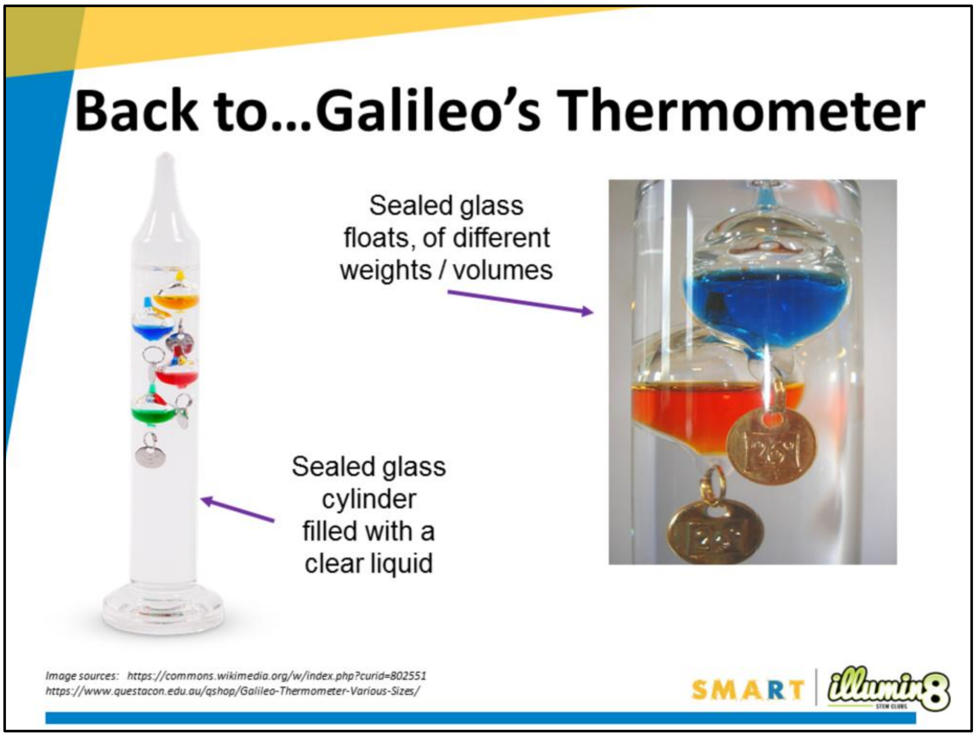


Remember, as we explored in Module 2.3, all objects contain matter, or “molecules”. **Density** is a measure of how tightly packed together matter is inside a substance. Cold water and warm water have different **densities.**

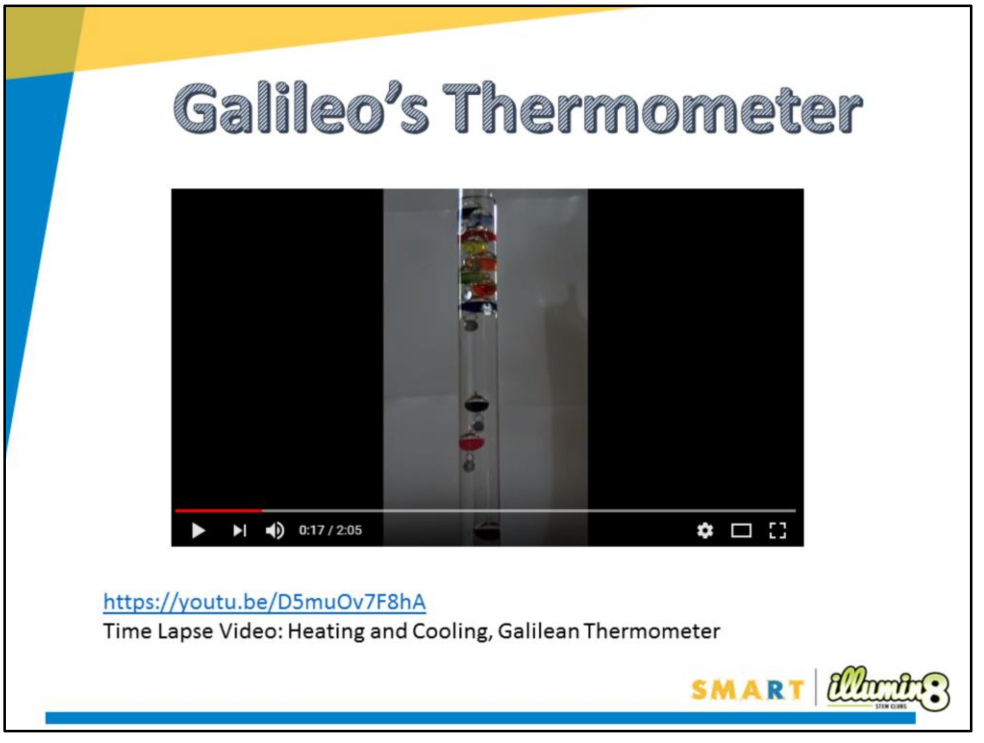
When you heat up water, the water molecules start moving around faster and faster. They bounce off each other and move farther apart. Because there's more space between the molecules, a volume of hot water has fewer molecules in it and weighs a little bit less than the same volume of cold water. So hot water is less dense than cold water.

This difference in density means that warm water always “floats” above cold water, and cold water will always “sink” into warmer water.

In a Galileo thermometer, as the temperature of the liquid in the cylinder cools, it becomes denser, and the baubles will float higher in the cylinder. When the temperature of the liquid in the cylinder rises, it becomes less dense, and the baubles will sink.



Back to Galileo's thermometer…
The Cartesian diver helped us to see that changes in **density** can change an object's **buoyancy**.
If the object is **more dense** than the liquid it is in, it will **sink** to the bottom.
Galileo's thermometer uses the same principle as our divers, but instead of relying on **pressure** to change density, it relies on **temperature**
The liquid inside the glass cylinder heats up and cools down, depending on how hot the air around it is.
If it is a 30 degree Celsius day, the liquid inside the thermometer cylinder will also be 30 °C.
On a hot day, the liquid inside the thermometer cylinder will be less dense than on a cold day.
The buoyancy of the baubles floating in the liquid is affected by the liquid's density, and the density is affected by the temperature of the surrounding air.
Mathematical formula's allow us to calculate the temperature and density at which each of the different baubles will float and sink, allowing us to use Galileo's thermometer to correctly measure temperature.



https://youtu.be/D5muOv7F8hA
Time Lapse Video: Heating and Cooling, Galilean Thermometer

Uses heat source to show baubles sinking as temperature increases, then fan to show baubles floating as temperature decreases.

How does it work?

Average Day: When the liquid’s density and the bauble’s density are equal (the same), the baubles float toward the middle of the cylinder

water density = ball’s density

Cold Day: When the liquid’s density is greater than the bauble’s density, the bauble’s float up to the top

water density > ball’s density

Hot Day: When the liquid’s density is less than the density of the baubles, the bauble’s sink down to the bottom

water density < ball’s density

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Galileo's Thermometer Challenge!

Can we construct a
Galilean Thermometer
… out of everyday materials?

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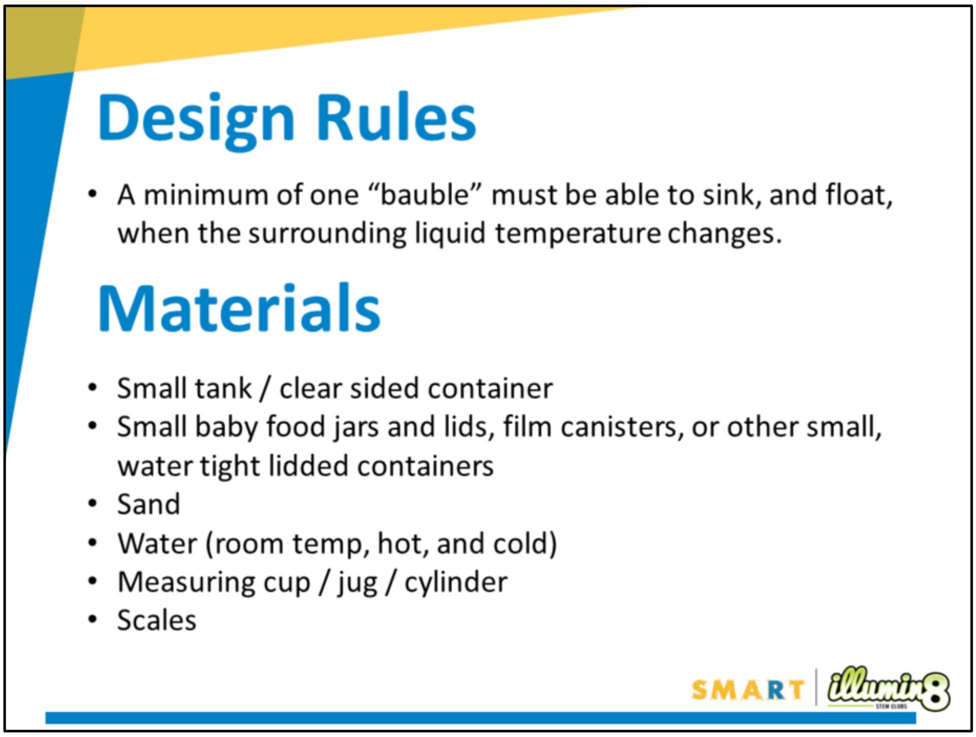

Encourage students to design and test one "bauble" to get the concept. Use one bauble per group to start with, then test this in hot water, cold water, and room temp water to observe change.
Allow students to make additional baubles as time permits.

…………………………………

Extension:
Support students who wish to be more accurate and extend their math's skills to calibrate their baubles to a temperature. Refer to Coordinator Notes for Module 3.2 for details.

References

Temperature

- https://extension.illinois.edu/treehouse/seasons.cfm?Slide=11

Water Thermometer

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Density, Buoyancy

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