Creating Science – The Wind

Moving air is called wind, and sometimes it can be powerful enough to blow down an entire house! So just how does the air get moving on our planet? There are plenty of reasons, let's start with heat…
#CreatingScienceWindCannon

Suggested Outcomes

(NOTE: This is by no means an exhaustive list of possible outcomes, neither is it intended that ONLY these outcomes can or should be met. Science is a deeply interrelated activity, and you may find cross curriculum links you can and should use.)

Science understanding

- Earth and Space sciences Y6: Sudden geological changes and extreme weather events can affect Earth's surface (ACSSU096)
- Earth and Space sciences Y4: Earth's surface changes over time as a result of natural processes and human activity (ACSSU075)
- Earth and Space sciences Y1: Observable changes occur in the sky and landscape (ACSSU019)

Science inquiry skills

- Processing and analysing data and information 5: Construct and use a range of representations, including tables and graphs, to represent and describe observations, patterns or relationships in data using digital technologies as appropriate
- Communicating 5: Communicate ideas, explanations and processes in a variety of ways, including multi-modal texts

Science as a human endeavour

- Nature and Development of Science 5 & 6: Important contributions to the advancement of science have been made by people from a range of cultures

Science vocabulary words

Tier 1 (Everyday words) – weather, clouds, rain, wind, cyclones.

Tier 3 (Specialised vocabulary)

- Pressure – a push, in all directions, all the time. Both air and water have pressure.
- Coriolis Effect – the tendency for cyclones in the southern hemisphere to spin clockwise, and in the northern hemisphere to spin anticlockwise, due to the turning of the Earth.

Warning

- Fire and ice may both be used during this lesson as demonstrations, please exercise all appropriate caution.

- The air pressure wind cannon is fairly safe, but still requires several safety instructions, such as:
  - DO NOT use the wind cannon on another person without their express consent
  - DO NOT use the wind cannon near eyes – there may be dust that irritates them.
  - DO NOT use the wind cannon near ears – it can be surprisingly loud and very startling.

Preparation

- Something hot, and something cold. A block of ice and safety-conscious toaster will do.
- A model of the earth is convenient to refer to.
- Younger groups may benefit from having wind toys to explore, such as wind socks and pinwheels.
- You may wish to prepare and present the picture of the wind cells for advanced students.

Learning intent (student friendly)

'We are learning to' (WALT) – understand, measure, and explain wind.

Success criteria

'What I'm looking for' (WILF) – a thorough description of what causes wind, and a keen demonstration of it using either the wind cannon or wind spiral.

Student learning goals

Help students make a self-monitored learning goal for this lesson, such as;

- Find out what makes wind.
- Build and describe a toy that uses the wind.
- Find out how people measure wind, and how deadly it can be.

Evidence of learning

How will you know when the learning goal is achieved? What EVIDENCE do you have that your students have met or exceeded the learning expectations?

- A short oral or visual presentation on 'what is wind'.

Suggestions for other year levels

As always, more material is presented here than can be used by the average class during the average lesson time. However, since the students' questions can and should guide student learning, more material is presented for your convenience. Remember, it is not uncommon for students to only remember those points which answered their personal questions.

Younger:

This activity is well suited to this age group.

Middle:

Extension can flow naturally from this group as they attempt to draw the unseen air moving in a cycle – perhaps within a single room warmed by a heater or dozens of small people.

Teen:

Understanding planet-wide weather patterns is recommended, see details in the *Elaborate* section below.

Engage

⇨ Make sure all students write down any questions they may have generated during this phase regarding the topic for today.

Ask your students: What is wind?

⇨ You may like to engage in some wind making activities, such as playing with fans, wind socks, or pinwheels.

Explore

⇨ Encourage and validate student explanations of this phenomenon. You may like to ask students to write or draw their explanation personally to avoid embarrassment to students unfamiliar with this material. Remember, 'I don't know' is a valid explanation in science – it is the beginning of learning new things!

Have students place their hand over a toaster – AT A SAFE DISTANCE. Ask them if they can feel something. Have them try to explain what it is.

Hold a block of ice over the student's hand, and see if they can feel a cold air running past their hand. Have them try to explain what it is.

Explain

The toaster

As air heats up, it tends to rise upwards. This is because air is always pushing in all directions all the time, and the easiest way for it to push is upwards – where the pressure is less. They are actually feeling a warm *wind* move past their hands. (You may even be able to see the heat waves above the toaster. These occur when light bends as it enters the different temperatures of air, making the air seem to shimmer). Cool air then pushes itself into the space left by the hot air. The cool air may even run along the ground in a kind of 'air stream' to get there.

Ice block

As air cools down, it contacts, but it's still busy moving in every direction. It actually finds it much easier to burrow downwards through the less dense surrounding warm air, than to try and take the higher, warmer air out of the way. (You may even notice the gentle formation of clouds as the sudden drop in temperature allows the water to condense out of the air) Warm air then flows into the gap left by the now cool air, often from the sides in order to fill up the space left by the cool air. It then begins to cool down too, and we can get a cycle of air flowing around.

Wind

The idea of air flowing around because of changes in temperature is one of the key ideas around how wind is formed.

Brainstorm on a board: how else can air be heated and cooled down?

- When the morning sun shines through the air, it actually does not heat it up very much. But once the sunlight hits the ground all that light energy turns into something else, often heat. This heat can then transfer to the air as soon as the air touches the ground, making the air heat up. [1]
- Water is very good at holding its heat, much more than the ground is. So for most of the morning, the average sea is colder than the nearby shore. How do you think this affects the air? Will it rush out across the waters to rise at the warm shore? And at night, the sea cools down a lot slower than the shore, so will the wind then rush in the opposite direction to rise above the warmer sea? Is this what might be the cause of the 'sea breeze'?
- Heaters can warm air up, so is there a breeze above every heater in a cold room? Yup! And people are often warmer than the room they are in. Are YOU heating up the air and making a small breeze as air flows up around you?
- Whenever you open the freezer or fridge, they are full of cold air. Will all that nice, cold air go falling down from your appliance and spread out all over the floor, only to be replaced by humid, warm air from your room? Is looking in the fridge without knowing what you want to get terrible way of keeping the fridge cool? You bet!

Suggest: Do **you** think this principal (the movement of hot and cold air) might be how all wind is formed on earth?

---

[1] Thus, the coldest part of the night is often just *after* dawn, before the ground has had time to heat up!

Elaborate

⇨ Ask students if they can design new ways to test this explanation, is it really sufficient? Can they think of further or better explanations, and the experiments needed to test them?

High school focus: Air Pressure

Hold out a clear, clean, soft drink bottle (lid off). Ask what the bottle is filled with [air]. Ask what that air is doing [bouncing around, creating pressure on the sides of the bottle]. Ask if there is a student able to crush the air and stop the air from bouncing around.

⇨ Allow them to step on the bottle, if it's strong enough, and you think they can do it safely.

They will crush the bottle easily [because all the air is coming out of the bottle].

⇨ Now try it with the lid on (make sure it's on properly and the air cannot escape easily.

No one will be able to crush the bottle and stop that air from bouncing around. (Be careful of jumping on the bottle and making it explode somehow, don't do this.)

Explain: Air pushing, and its pushing very hard. When you squeeze the bottle the pressure increases, and it goes up and up until it is much stronger than any one person can push.

Ask: So what happens when the lid is off and we increase the pressure inside the bottle? [The air escapes – or in other words: it flows from a region of high pressure to a region of low pressure].

This is a key learning idea – air will flow from a region of high pressure to a region of lower pressure.

What are some ways to change air pressure?

- Heating air up increases the pressure. Air tends to flow upwards from hotter places.
- Cooling air down decreases pressure. High mountains cool air down as the wind if forced up their sides.
- Creating a lot of air increases air pressure – a large volcanic explosion (or meteorite) has the power to create enormous winds in the local area.

Where does hot air go?

Hot air can rise all the way up to the top of the atmosphere, but it can't go any higher because it has nothing else to climb on top of, and gravity is holding it down on the planet.[2]

Also, as gasses get higher, they lose pressure (because there is now less atmosphere on top of them). And whenever gasses lose pressure, they become colder. So, yes, hot air rises, and rising air cools…

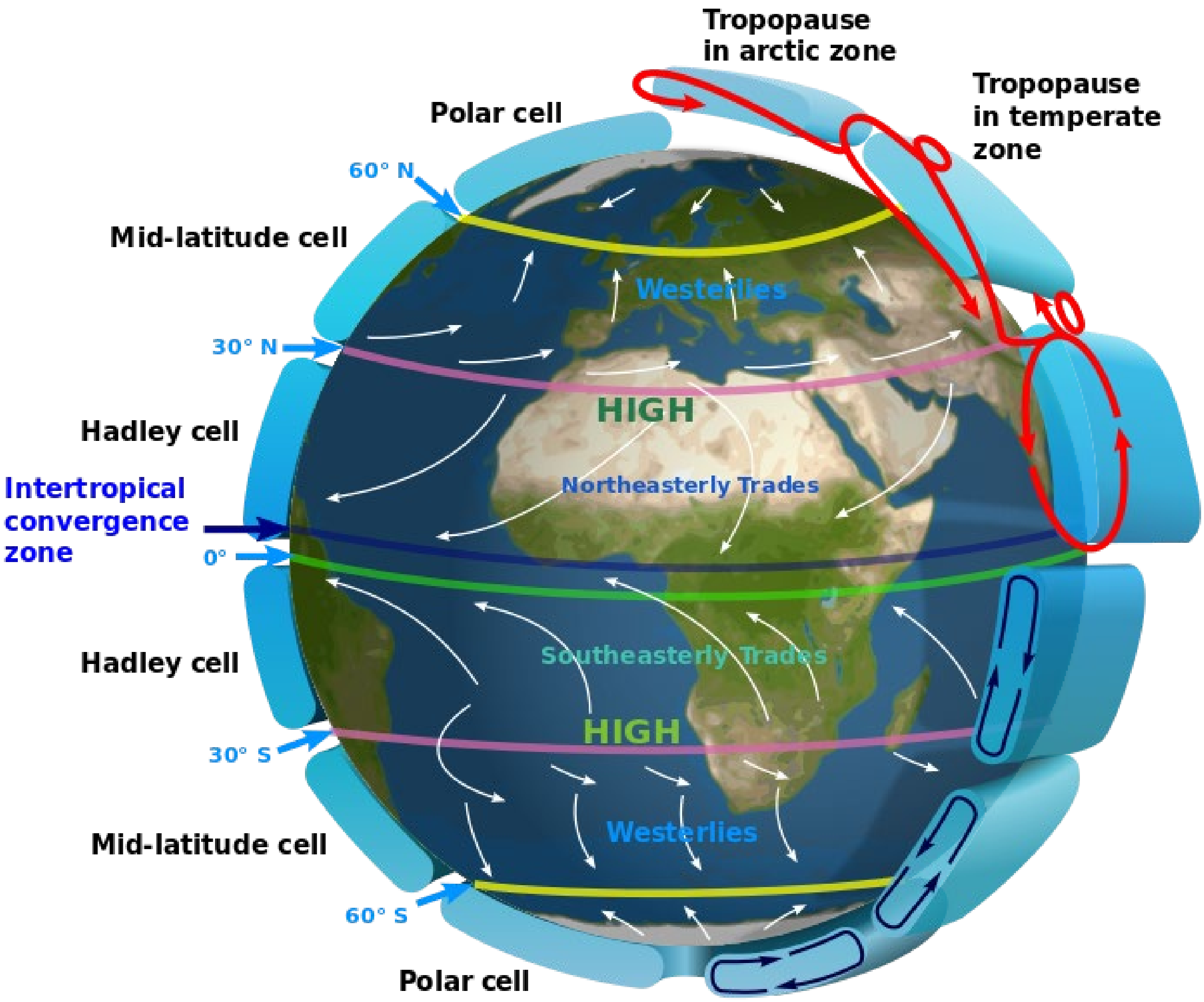
At some point, the air becomes so cold the water inside it begins to condense, and that's a big reason why we have clouds (but not the only reason – how's that for complex!)

[2] Sometimes the sun's particles can rip the uppermost atoms away into space, but it's not much. See https://en.wikipedia.org/wiki/Atmospheric_escape

Now, so far away from the earth that warmed it up in the first place, and so high up it's a lot colder, the air can begin to fall again, creating a cycle.

The earth has three main 'cells' in each hemisphere - places where air will circle up, around and back down again in a spiral. They are the polar, mid-latitude and Hadley cells. Where the hot air rises, rain tends to fall, creating, for example, the soaking wet equatorial regions. That air then is pushed away towards the polls, where it begins to cool and fall back down to earth. That air is now very dry, and helps to create, for example, the dry sandy deserts of the world.

Where air tends to rise we thus have wetter areas, and where it falls (such as the Sahara desert or directly on top of the polar ice caps) we get hardly any rain all year around.



[3]

---

[3] https://en.wikipedia.org/wiki/File:Earth_Global_Circulation_-_en.svg taken 21 dec 2016

There is more to it than simply 'hot and cold' air – including the influence of gravity and the earth's turning motion, but this is a good place to start.

Destroying things with wind – or can it help?

Destructive things wind can do:

- Destroy structures, blow away people and recourses.
- Turn trivial objects into deadly projectiles.
- Send invasive species into new areas.
- Take away millions of tonnes of top soil.

Helpful things wind can do:

- Encourages and assists evaporation, cooling us down.
- Spreads the heat out around the world, helping balance world temperatures.
- Encourage evolution and adaptation by moving species around the world.
- Make infertile places more fertile by moving soil and resources.
- We can use it to generate electricity.

The Slightly Dangerous Air-Pressure Wind-Cannon - Experiment away!

The high pressure/wind gun – see activity in the book Creating Science by Dr Joe.

Try using it to knock over some paper figures.

Now EXPLORE – what are some ways you can make this toy more effective? Don't make it larger, or more dangerous – simply more effective for the size that it is.

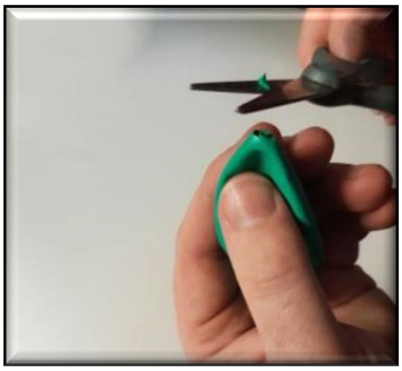
Some brilliant student suggestions have been included (teachers, DO NOT give these away right away):

- Making the hole smaller
- Making the hole rounder
- Making the hole end solid, instead of squishy
- Who said you have to squish the far end? Squeezing the container will increase the pressure – maybe even more.
- Make a whole lot of hot air – on second thought, don't do this, it sounds dangerous.

While predominantly a technical challenge, the understanding of air pressure is vital to making it work. Remember to contain yourself to a single cardboard tube, as other materials (such as flanged steel canisters and high explosives) might make genuinely dangerous projectile devices.

How to make the Slightly Dangerous Air Pressure Wind Cannon

1. Cut the end off two balloons, and
2. Tape the balloons on to a cardboard roll.
3. Make a hole in the end of 1 of them.


To use, pull the balloon without the hole back and let it go.


Air pressure and wind

Advanced groups will benefit from using this knowledge to research cyclones and tornadoes.

Air never sucks – it only ever pushes.

So you don't get sucked into a cyclone or whirlpool – you get pushed in by the higher pressure materials behind you.

The wind can be enormous, enough to turn even trivial items into deadly projectiles.

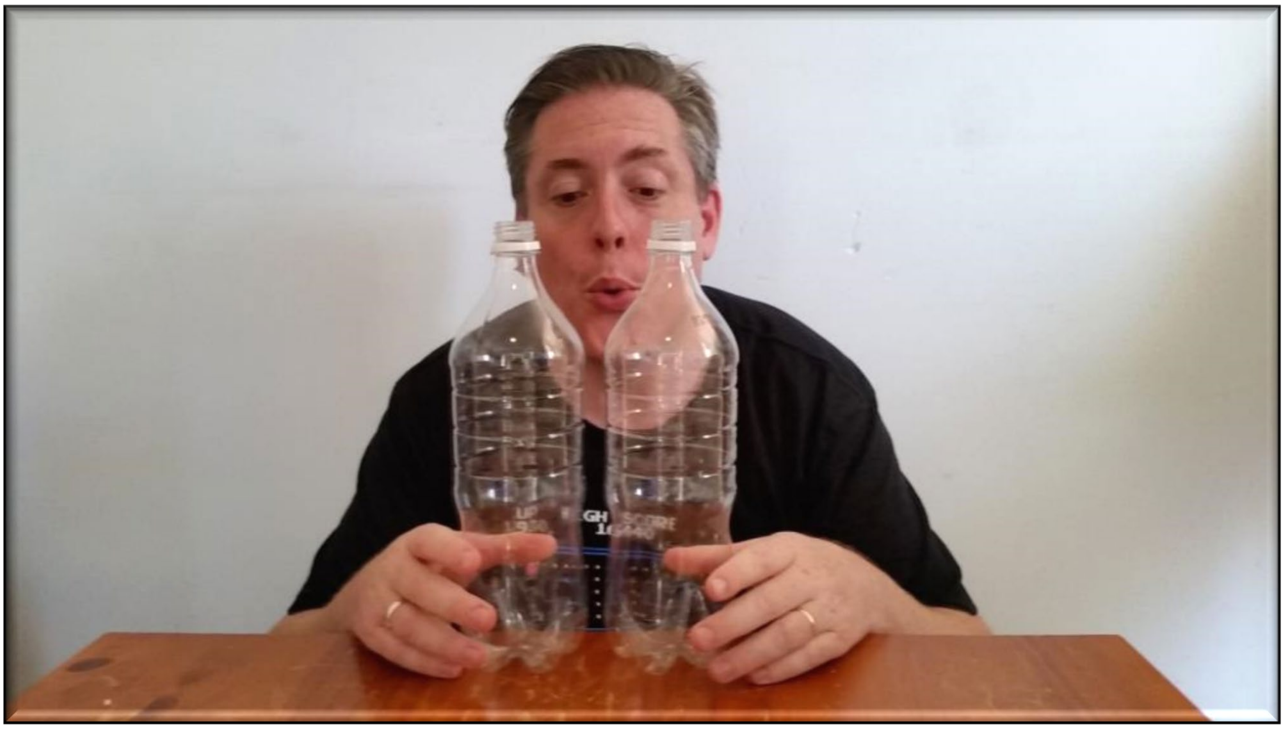
And while buildings can be pushed over by wind, the air pressure can be even more destructive. Here, the science of a man named Bernoulli[4] can help. For example, as air falls on its way over a roof it can be sped up by gravity, thus losing pressure in the sideways directions. So the air inside

[4] https://en.wikipedia.org/wiki/Bernoulli%27s_principle

the roof is now pushing harder than the speeding up air above it, resulting in the roof being pushed up and out, into the storm. Pushed, not pulled.

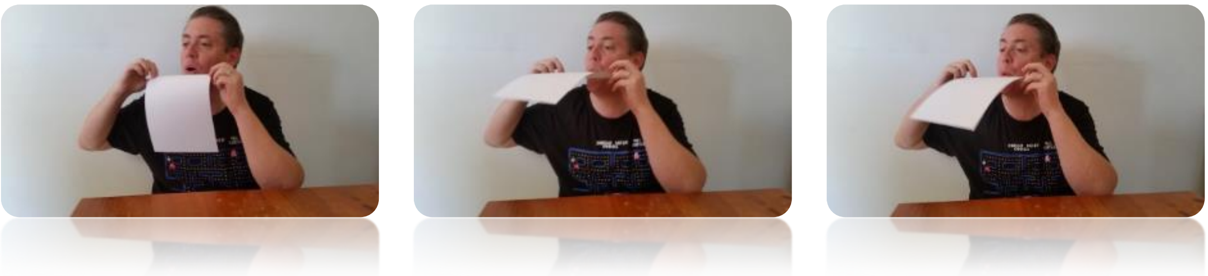
Also, air can speed up as it goes between two buildings, making the air outside and within those buildings push into that gap much more than usual. Windows can be forced out into the gap in a solid breeze, and entire buildings smashed together if the pressure is low enough. Methods of construction must often be developed to counter this effect. But you can demonstrate it easily enough – sit two empty soft drink bottles on the table, about 2 centimetres apart, and blow between them.

As the air accelerates thought the narrow gap, it loses pressure, meaning the air in the room is now pushing more. It can even push enough to push those two bottles together. Then your continued wind will push those bottles away.



Blow between two bottles and they fall together, not away!?!

Try blowing over the top of a single sheet of paper. What pushes it up and into the stream of air???



Coriolis Effect

The turning of the earth also means the air tends to move in a spiral – clockwise in the northern hemisphere, anticlockwise in the southern. It's called the Coriolis Effect, and if the earth didn't turn we would see the air move in a straight line across the surface of the earth, just as described by the law of inertia.

So does that mean the water in a sink or toilet will also turn the same way as a cyclone depending on the hemisphere you're in? You'll have to find out for yourself![5]

Evaluate

- ⇨ Review with students what they felt they learnt from this lesson. Did they have any questions at the start that they feel were answered?

Success criteria

- ⇨ Review the Learning Intentions of this lesson with students. Was it met?

At the end of each class, review the learning objective and see how we did. Ask:

- ⇨ Did you achieve your learning goal?
- ⇨ What did ***you*** learn?
- ⇨ What worked to help you achieve it?
- ⇨ What might you do better next time?
- ⇨ (If needed) where can you go for extra help or information?

Assessment

Prior learning:

Take time to learn what students already understand about air, wind, weather, and air pressure. Observing their discussions during the engage process is important, and writing down the questions which indicate what they are ready to learn is vital.

Formative:

As the program develops, take time to explore your students' growing understanding of the phenomenon. Give them space to express doubt and misunderstandings. Some of the following as a kind of formative test may assist you both;

---

[5] No. The Coriolis Effect only really counts for very large things – like the weather. When it comes to tiny things, compared to the surface of the earth, local effects like the direction of the water initially or angle of the plug, have a much bigger effect. See https://en.wikipedia.org/wiki/Coriolis_force#Draining_in_bathtubs_and_toilets

1. Can you make wind if there is none around? [Easily, moving your hand against the air creates wind that students can feel, and so does breathing.]
2. What does air do when it heats up? [It rises.] Why? [Because it is always pushing in all directions, and it finds it easier to push lower pressure air above it out of the way.]
3. What can cool down the air? [Ice, refrigerators, lower pressure, a colder object such as the sea mid-morning, etc.] What does it do once it is cooler than surrounding air? [Once cooler, it will fall, burrowing through the other air.]
4. When there is no wind, are the air particles still moving? [Yes, it has pressure, and the air particles are constant and frantic in motion all the time].

Summative:

Help students consider ways they can communicate their new understanding to others, just as scientists need to do. Perhaps they can build a wind spiral from the associated activity (attached), and give an oral presentation of why it moves when placed over the heat source (i.e., toaster).

So what?

It is at times difficult to credit certain kinds of knowledge to a specific scientist, since the topic has been around for a very long time and we don't know who came up with the ideas. Wind has been used by mariners and adventurers since before writing. Even air pressure is an idea that seems to have surfaced around 400 years ago, and we're not sure who came up with it, but Torricelli from Italy was one of the first to successfully use it to explain nature (water pumps, to be precise).

Remember:

- Wind is created by hot air rising, and cold air falling. At higher altitudes, wind is created as high pressure flows towards low pressure, and temperature is one important way of causing this.
- The whole planet has wind patterns, beginning with the Polar, Mid Latitude, and Equatorial (Hadley) Cells.

Creating science

Science understanding

As we learnt about wind, weather and water, we saw that;

- Earth and Space sciences Y6: Sudden geological changes and extreme weather events can affect Earth's surface (ACSSU096)
- Earth and Space sciences Y4: Earth's surface changes over time as a result of natural processes and human activity (ACSSU075)
- Earth and Space sciences Y1: Observable changes occur in the sky and landscape (ACSSU019)

Science inquiry skills

As we built our slightly dangerous wind cannon, and explored the models of wind with the cold block and warm toaster, we had the chance to;

- Processing and analysing data and information 5: Construct and use a range of representations, including tables and graphs, to represent and describe observations, patterns or relationships in data using digital technologies as appropriate.

As we shared our ideas of how wind is made though aural or written presentations, we took the opportunity to;

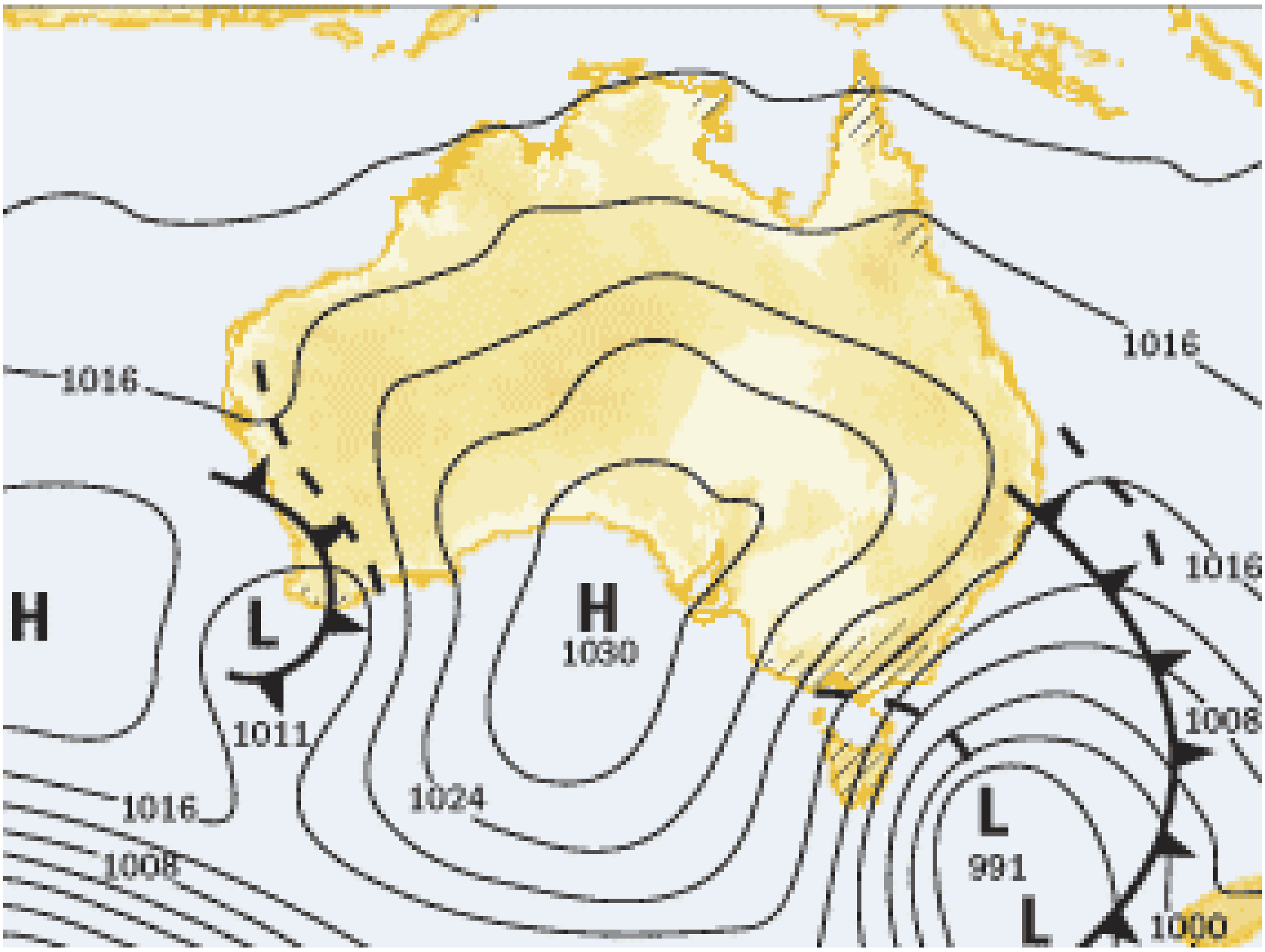
- Communicating 5: Communicate ideas, explanations and processes in a variety of ways, including multi-modal texts

Science as a human endeavour

It's not known who invented the idea of wind or even of air pressure – but it was certain to be a collaborative effort stretching back hundreds of years, showing us that;

- Nature and Development of Science 5 & 6: Important contributions to the advancement of science have been made by people from a range of cultures

Synoptic Chart

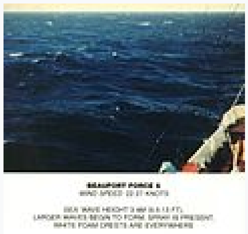
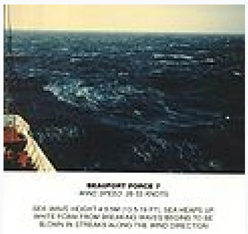


In this chart, wind will generally flow in a clockwise direction from a region of high pressure to a region of low pressure. The drop in temperature as the low fills with cooling air can be quite noticeable as a 'cold front'.

Measuring wind

The Beaufort Scale - this is not the only measure of wind speed and damage, but one of the most common. Taken 2017 from http://www.australia.gov.au/about-australia/australian-story/natural-disasters

Beaufort number	Description	Wind speed	Wave height	Sea conditions	Land conditions	Sea state photo
0	Calm	< 1 km/h < 1 mph < 1 knot < 0.3 m/s	0 m 0 ft	Sea like a mirror	Smoke rises vertically.	
1	Light air	1–5 km/h 1–3 mph 1–3 knots 0.3–1.5 m/s	0–0.2 m 0–1 ft	Ripples with appearance of scales are formed, without foam crests	Direction shown by smoke drift but not by wind vanes.	
2	Light breeze	6–11 km/h 4–7 mph 4–6 knots 1.6–3.3 m/s	0.2–0.5 m 1–2 ft	Small wavelets still short but more pronounced; crests have a glassy appearance but do not break	Wind felt on face; leaves rustle; wind vane moved by wind. Wind vanes begin to move.	
3	Gentle breeze	12–19 km/h 8–12 mph 7–10 knots 3.4–5.5 m/s	0.5–1 m 2–3.5 ft	Large wavelets; crests begin to break; foam of glassy appearance; perhaps scattered white horses	Leaves and small twigs in constant motion; light flags extended.	

4	Moderate breeze	20–28 km/h 13–18 mph 11–16 knots 5.5–7.9 m/s	1–2 m 3.5–6 ft	Small waves becoming longer; fairly frequent white horses	Raises dust and loose paper; small branches moved.	
5	Fresh breeze	29–38 km/h 19–24 mph 17–21 knots 8–10.7 m/s	2–3 m 6–9 ft	Moderate waves taking a more pronounced long form; many white horses are formed; chance of some spray	Small trees in leaf begin to sway; crested wavelets form on inland waters.	
6	Strong breeze	39–49 km/h 25–31 mph 22–27 knots 10.8–13.8 m/s	3–4 m 9–13 ft	Large waves begin to form; the white foam crests are more extensive everywhere; probably some spray	Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty.	
7	High wind, moderate gale, near gale	50–61 km/h 32–38 mph 28–33 knots 13.9–17.1 m/s	4–5.5 m 13–19 ft	Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind; spindrift begins to be seen	Whole trees in motion; inconvenience felt when walking against the wind.	
8	Gale, fresh gale	62–74 km/h 39–46 mph 34–40 knots 17.2–20.7 m/s	5.5–7.5 m 18–25 ft	Moderately high waves of greater length; edges of crests break into spindrift; foam is blown in well-marked streaks along the direction of the wind	Twigs break off trees; generally impedes progress.	

9	Strong/severe gale	75–88 km/h 47–54 mph 41–47 knots 20.8–24.4 m/s	7–10 m 23–32 ft	High waves; dense streaks of foam along the direction of the wind; sea begins to roll; spray affects visibility	Slight structural damage (chimney pots and slates removed).	
10	Storm,[7] whole gale	89–102 km/h 55–63 mph 48–55 knots 24.5–28.4 m/s	9–12.5 m 29–41 ft	Very high waves with long overhanging crests; resulting foam in great patches is blown in dense white streaks along the direction of the wind; on the whole the surface of the sea takes on a white appearance; rolling of the sea becomes heavy; visibility affected	Seldom experienced inland; trees uprooted; considerable structural damage.	
11	Violent storm	103–117 km/h 64–72 mph 56–63 knots 28.5–32.6 m/s	11.5–16 m 37–52 ft	Exceptionally high waves; small- and medium-sized ships might be for a long time lost to view behind the waves; sea is covered with long white patches of foam; everywhere the edges of the wave crests are blown into foam; visibility affected	Very rarely experienced; accompanied by widespread damage.	
12	Hurricane force [7]	≥ 118 km/h ≥ 73 mph ≥ 64 knots ≥ 32.7 m/s	≥ 14 m ≥ 46 ft	The air is filled with foam and spray; sea is completely white with driving spray; visibility very seriously affected	Devastation.	

http://www.australia.gov.au/about-australia/australian-story/natural-disasters

Wind Spiral

Simply colour in, then cut out the spiral along the line,

Attach a string to the X,

And hold it about a meter over a small fire to see wind in action!!