Atmosphere, pressure and wind – the story for teachers

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What is the atmosphere?

The atmosphere is a layer, or envelope, of gases around the earth. The mixture changes a bit from place to place and time to time. For instance, we are very aware of this when we experience a humid (or 'muggy') atmosphere. The atmosphere also changes with height. Most Everest climbers take extra oxygen because there is much less of it per lungful in the atmosphere at high altitudes.

Has the atmosphere got something to do with gravity?

It is a common misconception that gravity exists only inside the atmosphere. This misconception probably arises because we have heard that there is no atmosphere in space, and there appears to be no gravity – because things float, or weigh less on the moon. It is true that there is no atmosphere in space or on the moon, but there is gravity in these places, so our conclusion is wrong. It is correct to say that gravity is necessary to hold our atmosphere to the earth, but the atmosphere does not have any other connection to gravity and certainly does not cause it.

What's so important about air?

There are some important links with other parts of the curriculum. We need the oxygen that is in air; we need it for breathing. Carbon monoxide poisoning from improper ventilation of gas fires is a real but invisible threat to life. The amounts of carbon dioxide and other 'greenhouse gases' affect our climate – even though their combined percentage of the atmosphere is very small (0.038%).

What is water vapour?

One of the gases that make up the atmosphere is water vapour. Water vapour is an invisible gas – mist, fog and clouds also include visible, liquid, water droplets that can be seen. Water vapour is sometimes called 'steam', certainly in the context of (for example) steam engines (see table below). But in classroom discussions, it is perhaps best to be clear that steam which we can see is tiny liquid droplets, and that water vapour, which is invisible, is gas.

What are the atmospheric gases and what are their uses?

Excluding local pollution, the average lower atmosphere composition is given in the table below. When used industrially, these gases are usually extracted from atmospheric air. We should be clear, however, that while the examples of human 'uses' of the gases given in the third column may be important, their role in non-human processes may be much more important. The essential role of carbon dioxide in photosynthesis is a good example.

Gas	***Average percentage in air***	***Uses***
Nitrogen N_2	78%	Important in artificial fertilizers. Liquid nitrogen is used in refrigeration and freeze-drying foods.
Oxygen O_2	20%	We need oxygen to survive. It is also employed in processes that rely on burning, such as in car engines where the oxygen in air is used. Oxygen is also vital in the steel-making process.
Water vapour H_2O	1% (but very variable)	The gaseous state of water (often loosely referred to as steam – see discussion above) is of course used in pressurised boiling systems to create steam power. It is also used in saunas where atmospheric humidity is deliberately raised.
Argon Ar	0.9%	Widely used in industry but also used as the gas in light bulbs.
Carbon dioxide CO_2	0.03%	Widely used as a refrigerant and in fire extinguishers, and also for automatically inflating life rafts and life jackets, enhancing plant growth in greenhouses, slowing animals before slaughter and to make fizzy drinks.
Others	0.07%	

How far do I want to go with pressure and wind?

A variety of concepts is used in the following explanation that you may or may not wish to introduce to children at any given level of attainment. There is a danger that if you embark on explaining high and low air pressure, for example, you will be forced into discussing density and ultimately the particulate nature of gases.

What is the atmosphere?

The atmosphere is a mixture of gases that changes a little from place to place and from time to time (see above). Despite these variations, we generally call this mixture of gases ‘air’. ‘Air’ is a loose word that we often associate with human needs and breathing – i.e. the oxygen part of the mixture – but not really with any of the other gases that make up the atmosphere. ‘Seventy-eight percent of the air we breathe in is nitrogen,’ is a correct but surprising-sounding fact for this reason.

Air is made of a mixture of invisible gases. It requires a lot of imagination to believe that something you can’t see is physically there. It is even harder to begin considering what it is made up of. How do we show children that ‘air is there’? Common approaches include blowing fans and hairdryers or thinking about wind and asking ‘What am I feeling?’. It is my sense of touch that I am using, so something must be hitting me, even though I can’t see it.’ Turning a glass tumbler upside down in a bowl of water and showing that it doesn’t just fill up with water is another approach. Something is keeping the water out, even though it can’t be seen.

Why does the air move (how is wind caused)?

The particles that make up gases are constantly pushing away from each other. Where many gas particles are packed into a small space (higher air ‘pressure’), there is a tendency for them to drift away to areas where there are fewer particles (lower air pressure). When we blow up a balloon, we are stuffing lots of gas particles into a small space. The pressure they cause is what keeps the balloon’s skin expanded. If we hold on to the balloon and let the end open, the air particles rush out. If we point the end of the balloon at our face we feel the particles hitting us (like wind) as they escape. So, wind is the movement of air particles from ‘high pressure’ to ‘low pressure’ places.

Why does the atmosphere at the earth’s surface have high and low pressure areas?

Why do air particles build up in some areas and not others to create differences in air pressure? Some parts of the earth’s surface are warmer than others. Warm parts heat the air near the surface, causing it to rise up through the cooler air above (warmer air is less dense). This leaves less air near the ground (lower pressure) than surrounding areas that have cooler surfaces and more air particles near the ground (higher pressure). So air particles move from the higher pressure to the lower pressure areas, and this movement of air particles is wind. There are many different ways that these pressure differences can happen, and many things that can affect the route that air takes to get from higher pressure (more air particles) to lower pressure (fewer air particles). It can happen at many different scales (from inside a fridge, to a coastline, to a hurricane, to global wind circulation patterns like the Roaring Forties) but it always involves air moving from high to low pressure.

Atmosphere, pressure and wind – upper primary

By using a range of materials and activities, we aim to focus on these outcomes and targets:

Pupil Learning Outcomes

- The atmosphere is the envelope of gases surrounding the earth.
- Weather occurs in the lowest part of the atmosphere called the troposphere.
- Air pressure is the weight of the air on top of us.
- Air pressure is high when molecules in the air are tightly packed together and low when
- Molecules in the air have plenty of space.
- Air pressure decreases with height.

Scotland: 5–14 Environmental Studies

People and place: the physical environment

- Level C: describe some main types of weather and climate in the world and ways in which
- people adapt to them.
- Level D: describe how extremes of weather and climate can disastrously affect people and places.
- Level E: describe and explain simply the main weather and climate patterns in Britain and the wider world, including extremes, and explain the effects on ways of life.

People and place: using maps

- Level D: describe the main features of a range of maps at different scales, e.g. climate maps.

Skills in social subjects – enquiry

- Level D: select and use known enquiry methods and/or equipment to access, select and record relevant information from a variety of straightforward sources.
- Level D: select techniques to process/classify information in a variety of ways.

Skills in science – investigating

- Level C: select and use appropriate measurement devices or make appropriate observations.

England and Wales National Curriculum

Geography

Key Stage 2

- 1b: collect and record evidence
- 2a: use appropriate geographical vocabulary
- 2b: use appropriate fieldwork techniques
- 2c: use atlases and globes, and maps and plans at a range of scales
- 2d: use secondary sources of information
- 3a: identify and describe what places are like
- 3d: explain why places are like they are
- 7b: study a range of places and environments in different parts of the world

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WALT

We are learning to …

Describe the layers in the atmosphere.

Understand air pressure.

Phase 1 Overview

Establish the children's prior knowledge:

- What is atmosphere?
- What is air pressure?

Phase 2 Input

Show the children the structure of the atmosphere diagram (resources download). Explain to them that weather occurs in the lowest part of the atmosphere which is called the 'troposphere'. The boundary between the troposphere and the stratosphere is called the tropopause. Likewise, the boundary between the stratosphere and the mesosphere is called the stratopause.

The diagram shows the approximate heights of significant items such as aeroplanes and mountains to help to demonstrate to the children the different heights of each part of the atmosphere.

Phase 3 Process

Air pressure is the weight of the air all around us. It is high when the air is compressed. As you move up through the atmosphere the pressure decreases, so that at the top of a mountain the air pressure is less. Children may have experienced their ears popping when experiencing a change in altitude, e.g. in an aeroplane. This is due to the air pressure balancing between inside the ear and outside.

A change in air pressure is the most important indicator of a change in the weather. The following activities allow the children to experiment with air pressure.

Make a home-made barometer

Barometers measure the air pressure. A barometer can therefore be used to predict a change in the weather. When air pressure is high, we can expect settled weather. When air pressure is low, we can expect changeable weather.

What you need:

- a tray
- a brick
- an empty bottle
- a ruler
- sticky tape
- copies of barometer worksheet (resources download)

Fill the tray with water. Fill the bottle halfway with water, and invert it into the tray quickly so as not to lose much water. Stand the brick next to the bottle and carefully lean the bottle against it. Secure the bottle to the brick using the sticky tape. Now attach the ruler to the side. Over the next few days record the changes in the water level. When the air pressure increases, the water will rise inside the bottle. When the air pressure decreases, the water level will fall.

Ask the children to compare their results to the weather conditions outside. Use the table on the worksheet to record the results.

Crackly container

What you need:

- a bowl of ice-cold water
- an empty screw-top plastic bottle
- a supply of hot water
- balloons

Unscrew the bottle lid, fill the bottle with hot water and pour it out again. Do this several times in order to heat up the air inside. When the bottle is hot to touch, pour out all of the water and replace the lid tightly. Now immerse the bottle in the bowl of ice cold water. The bottle should crumple in. This shows that cooling air reduces the pressure it exerts.

Repeat the experiment, but this time stretch a balloon over the mouth of the bottle. What happens to the balloon?

Pressure rocket

This experiment is best carried out in the playground as it can be a bit messy and lights may get broken!

What you need:

- an empty film case
- Vitamin C fizzy tablets
- water
- tape
- use a small bit of tape to attach the vitamin C tablet to the lid of the film case
- fill the case a quarter full of water
- replace the lid and turn the case cap down on the ground

The rocket (film case) will shoot up in the air because of the pressure of gas inside the case (the gas is released from the fizzing tablet). You can decorate the film case with a paper cone and fins to make it look more like a rocket!

Straw sucker

What you need:

- a jar with a lid (1 for each pupil)
- a bottle of juice
- a straw (1 for each pupil)
- plasticine

Carefully poke a hole through the lid of each jar, in order to create a hole big enough for a straw. Fill the jar with some juice. Replace the lid tightly, insert the straw and seal up any holes around it with the plasticine. Now try to drink the juice.

What happens? The air pressure has been blocked so there is no air pressure to help push the juice up through the straw.

Candle in a jar

What you need:

- a candle
- plasticine
- matches (for teacher use only)
- a jar
- a tray of water
- four erasers (or something similar in size)

Fill the tray with water. Secure a candle in the middle with some plasticine. Place the four erasers around the base of the candle in the water. Light the candle. Carefully position the jar on top of the erasers over the candle. As the candle burns, it will use up the oxygen inside the jar. When the oxygen has been completely used up, the candle will go out. Water will rise in the jar because of a pressure change; there is less air as the oxygen particles have been used, so the air pressure outside will force the water into the empty space.

Phase 4 Review

Through discussion the following questions can be asked:

- What is the atmosphere?
- What is air pressure?
- What has air pressure got to do with weather?
- How does measuring air pressure help us to predict weather?