Earth’s climate

Introduction

This topic explores the key concepts of Earth’s climate as they relate to:

- the composition of Earth’s atmosphere
- the ozone layer
- the greenhouse effect
- the weather.

Key concepts of Earth’s climate

The activities in this topic are designed to explore the following key concepts:

- The atmosphere consists of a thin layer of gases that surround Earth.
- The atmosphere is a mixture of gases: mostly nitrogen (78%) and oxygen (21%).
- Ozone in the atmosphere exists as a gas, the molecules of which consist of three oxygen atoms (O_3).
- The atmospheric temperature does not drop further from Earth’s surface; the different layers are at various temperatures, which are independent of the altitude of the layer.
- The ozone layer is comparatively warm, as it absorbs 90% of the UV radiation that reaches Earth from the Sun.
- The ozone layer is being depleted because of chemical gases called ‘chlorofluorocarbons’ (CFCs) produced by humans on Earth.
- The ionosphere, an atmospheric layer, absorbs highly energetic electromagnetic radiation from the Sun, creating a region of charged particles that reflect radio waves from Earth’s surface.
- Television signals are not reflected by the ionosphere.
- The greenhouse effect keeps the average temperature of Earth at 15 °C; without the greenhouse effect, life on Earth, as we know it, would not exist.
- Atmospheric pollution has led to global warming through an enhanced greenhouse effect.
- Air pressure changes with the density and temperature of the air: the higher the temperature or density, the greater the air pressure.
- Humidity relates to the amount of water vapour in the air.
- When saturated air cools, some of the water vapour in the air condenses and it rains.

- Hot air rises as it gets displaced by more-dense cold air.
- Wind arises through differences in air pressure. Global wind patterns are also affected by the spinning of Earth.

Students' alternative conceptions of Earth's climate

Research into students' ideas about this topic has identified the following non-scientific conceptions:

- Rain comes from holes, or funnels, in clouds.
- Rain comes from clouds sweating.
- Rain occurs because we need it.
- Rain occurs when clouds get scrambled and melt.
- Rain occurs when clouds are shaken.
- God and angels cause thunder and lightning.
- Clouds move because we move.
- The sun boils the sea to create water vapour.
- Clouds are made of cotton, wool or smoke.
- The oxygen we breathe does not come from plants.
- Gas makes things lighter.
- All rivers flow from north to south.
- The extent of the warming likely within 50 years is approximately a 10 °C increase in average temperatures.
- There is confusion about the ozone hole problem and the greenhouse effect.
- Recent warm weather is evidence for global warming.
- Ozone depletion is causing global warming. The hole allows more sunlight and UV rays to come through and 'warm' Earth—hence, global warming.
- The greenhouse effect is a very bad process.

Resources

AccuWeather.com

http://www.accuweather.com/
Provides four- to five-day weather forecasts for every city in the world. Also includes information about the weather (including the answer to 'Why is the sky blue?'). Has a glossary of weather terms and a hurricane section.

Atmosphere: layers

http://wings.avkids.com/Book/Atmosphere/instructor/layers-01.html
Provides details on the various layers of Earth's atmosphere.

Australian Government Bureau of Meteorology: learn about meteorology

http://www.bom.gov.au/lam/
Provides information and curriculum materials about weather.

Australian Greenhouse Office

http://www.greenhouse.gov.au/
Information about conservation and global warming.

Bad Meteorology

http://www.ems.psu.edu/~fraser/BadMeteorology.html
Provides answers to the many myths and misconceptions about the science of weather.

BBC Weather

http://www.bbc.co.uk/weather/weatherwise/index.shtml
Features information about weather and climate.

Clouds and precipitation

http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/cld/home.rxml
A guide to cloud types and precipitation, with links to other meteorological information.

Gander Academy: weather theme

http://www.stemnet.nf.ca/CITE/weather.htm
Provides teacher resources: clouds, temperature, hurricanes, weather lore, weather instruments and rainbows. Includes information on how to make weather instruments.

Hurricane: Storm Science

http://www.miamisci.org/hurricane/hurricane0.html
Provides background information and current data on hurricanes and storms.

Instructional Materials in Weather and Climate

http://www.cln.org/subjects/weather_inst.html
Covers topics including air quality, clouds, El Niño, floods, global warming/climate change, hurricanes, lightning, ozone depletion, tornadoes and water quality.

National Severe Storms Laboratory

http://www.nssl.noaa.gov/
Provides information about tornadoes, thunderstorms, damaging winds, lightning, hail, winter weather, flooding, with a section for children that includes weather map lessons.

Ozone Monitoring Network 2003

http://www.netspace.net.au/~vicozone/
A Global Classroom Project. The Ozone Monitoring Network is a project operating in Victorian schools to monitor atmospheric ozone.

Project Atmosphere Australia Online

http://www.schools.ash.org.au/paa/
Features curriculum material on weather.

Protect Our Planet Home Page

http://mars.ecesc.k12.in.us/units/planet/HOME~1.HTML
Explores specific topics, including ozone destruction, deforestation, recycling, acid rain and the destruction of the world's oceans.

Victorian Weather and Warnings

http://www.bom.gov.au/weather/vic/
Bureau of Meteorology weather information and maps for Victoria.

Weather: what forces affect our weather?

http://www.learner.org/exhibits/weather/
Provides information about the water cycle, powerful storms, ice and snow, forecasting, the changing climate and related sites.

Weather and Global Monitoring

http://www.csu.edu.au/weather.html
Features satellite pictures of Australia's weather by region.

The Weather Channel

http://www.weather.com/
Covers international weather conditions and forecasts.

World Meteorological Organization

http://www.wmo.ch/

The composition of Earth's atmosphere

The atmosphere consists of a thin layer of gases that surround Earth. The atmosphere interacts with the solid part of Earth, the lithosphere, and the water part of Earth, the hydrosphere, in ways that support life forms on our planet, the biosphere. The biosphere is under threat due to pollution created by humans, which may prove catastrophic for future generations. Atmospheric pollution is causing an enhanced greenhouse effect and the formation of larger holes in the ozone layer. These effects are beginning to produce changes in the normal patterns of Earth's weather.

Gases in the atmosphere

The atmosphere is a mixture of gases. Some are permanent and remain in constant amounts in the lower atmosphere. The remainder occur in variable amounts. Table 1 lists these gases.

TABLE 1: GASES IN THE ATMOSPHERE

Permanent gases		Variable gases	
Gas	**Per cent by volume**	**Gas**	**Per cent by volume**
Nitrogen	78	Water vapour	0–4
Oxygen	21	Carbon dioxide	0.034
Argon	0.9	Methane	0.0001
Neon	0.002	Ozone	0.000004
Helium	0.0005	Carbon monoxide	0.00002
Hydrogen	0.00005	Particles (dust etc.)	0.00001

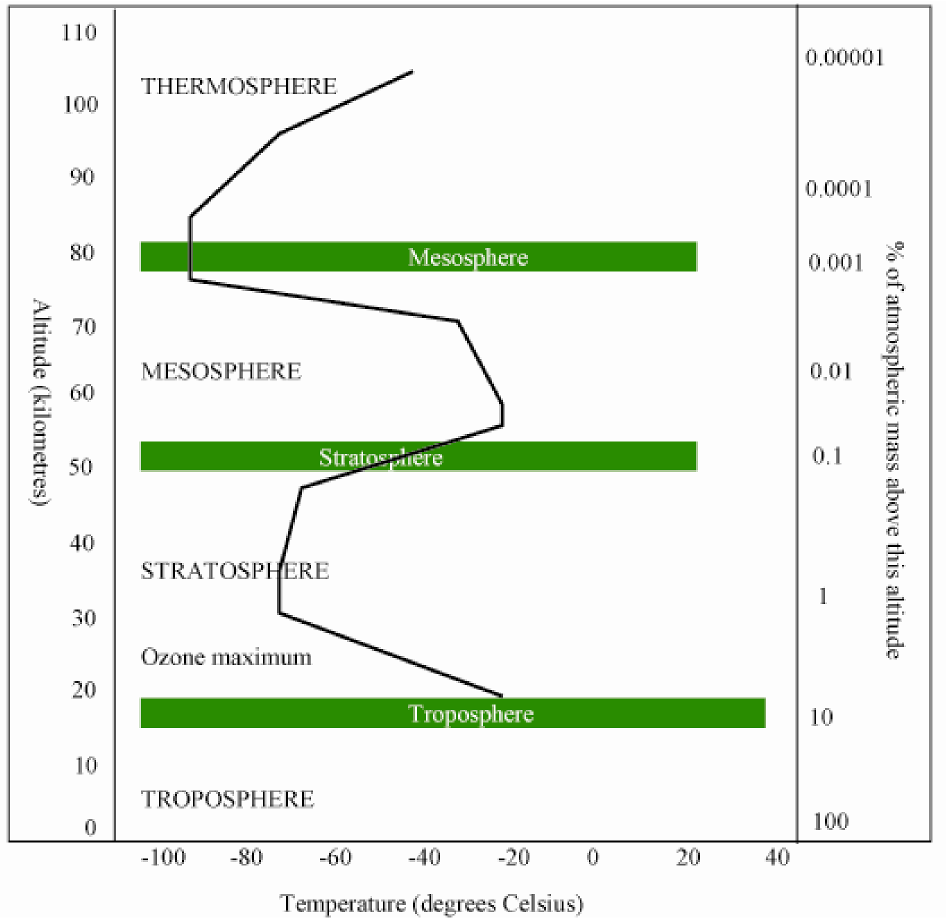
As can be seen in Table 1, nitrogen and oxygen make up approximately 99% of the atmosphere. The amounts of these gases remain in balance, as nitrogen is produced by the decay of plant and animal matter and is used up by bacteria in some types of plants. Oxygen is produced by plants during photosynthesis and is removed by the burning of fuels and the breathing of animals.

Water vapour varies in concentration over Earth. In humid, tropical areas, the percentage of water vapour in the air can be as much as 4%, while in the Arctic deserts it becomes quite small. The other variable gases, although very small in quantity, play a big part in the maintenance of the biosphere, such as their role in the greenhouse effect and in the amount of radiation transmitted through the ozone layer. More information about these variable gases is given later in this topic.

Layers of the atmosphere

The atmosphere is subdivided into a number of layered regions according to their properties. The layers, described in terms of their temperature, are the troposphere, stratosphere, mesosphere and thermosphere. Figure 1 shows the heights of each layer and the percentage of the atmosphere's mass that lies above various points.

FIGURE 1: LAYERS OF EARTH'S ATMOSPHERE



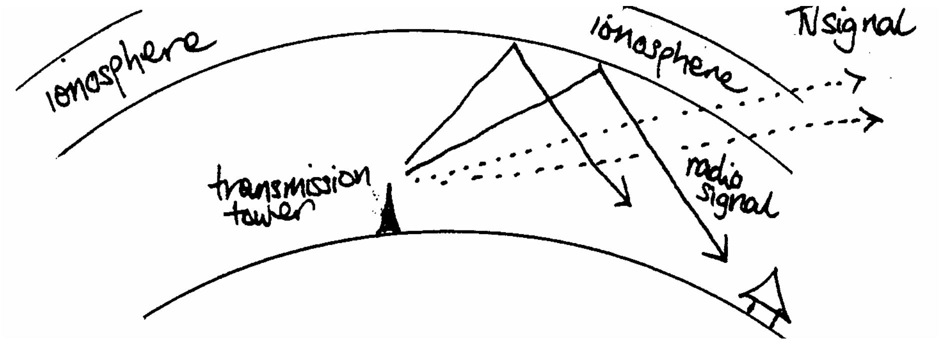
The readings from the graph in Figure 1 may seem surprising. You might have thought that the temperature keeps falling as you get higher up, just like the falling temperature as you climb a mountain. However, there are significant rises in temperature in the stratosphere and the thermosphere. In the stratosphere, the temperature rise is due to ozone particles in the air that absorb UV radiation. Ozone is a gas that is made of small particles called 'molecules'. Each molecule consists of three identical oxygen atoms. In contrast, oxygen gas is composed of molecules each consisting of just two oxygen atoms. UV radiation is one form of electromagnetic radiation (visible light is another form) that is emitted by the Sun. The rise in temperature in the thermosphere is due to absorption of higher energy by oxygen.

Another important reading from the graph in Figure 1 is that 99.9% of the atmosphere's mass lies within 50 km of Earth's surface. Therefore, spacecraft need not travel far from the surface of Earth to experience space conditions (see 'Space exploration' in the topic 'Astronomy').

In addition to the layers defined by varying temperatures, there are other zones or layers in the atmosphere. One such important layer is the ionosphere. The ionosphere is located at an altitude of between 80 km and 400 km. Therefore, it overlaps part of the thermosphere. In the ionosphere, a lot of harmful and highly energetic electromagnetic radiation in the form of X-rays and gamma radiation from the Sun is absorbed. This absorption creates a region of electrically charged particles. The ionosphere is the area of charged particles. The bottom of the ionosphere reflects radio waves (from radio transmission stations) back to

Earth. For this reason, radio stations can transmit their signal to greater distances over the surface of Earth than, say, television signals (these signals pass through the ionosphere; see Figure 2). Radio stations can be 'picked up' from more distant locations at night because the ionosphere is less thick during the night. Can you give a reason why?

FIGURE 2: RADIO AND TELEVISION TRANSMISSION



The ozone layer

The ozone layer is an important layer in the atmosphere because it acts as a barrier to harmful radiation from the Sun, which can be lethal to plants and animals in large doses. The ozone layer is thickest in the lower part of the stratosphere. As mentioned above, ozone is composed of small particles called 'molecules' that, in turn, are composed of smaller particles called 'atoms'. Ozone molecules are composed of three oxygen atoms bonded together. In contrast, oxygen gas molecules are composed of two oxygen atoms. Models of these two molecules are shown in Figure 3.

FIGURE 3: MODELS OF OZONE AND OXYGEN MOLECULES

Ozone molecule

Oxygen molecule

There is very little ozone gas in the atmosphere (0.00005% by volume) and yet its presence is of vital importance to those of us on Earth. Ozone absorbs much of the UV light (approximately 90%) that reaches Earth from the Sun. If it did not absorb UV light, our planet would very likely be uninhabitable.

In recent times, scientists have found that the ozone layer is being depleted. They attribute the depletion to chemical gases produced by humans on Earth. These gases come from fertilisers, fire-fighting equipment and CFCs used as refrigerants, as propellants for spray cans and in foam manufacture. These chemicals undergo chemical reactions with ozone molecules, thus breaking them up.

The most dramatic effect of the depletion of the ozone layer is on human health, because UV radiation is known to cause skin cancer.

ACTIVITY: THE DEPLETING OZONE LAYER

Look on the Internet and answer the following questions:

- **How serious is the ozone depletion problem?**
- **How is the presence of ozone measured?**
- **What is the hole in the ozone layer and does it extend over Victoria?**
- **What is the world doing about this problem?**
- **What can you do to resolve this problem?**

The greenhouse effect

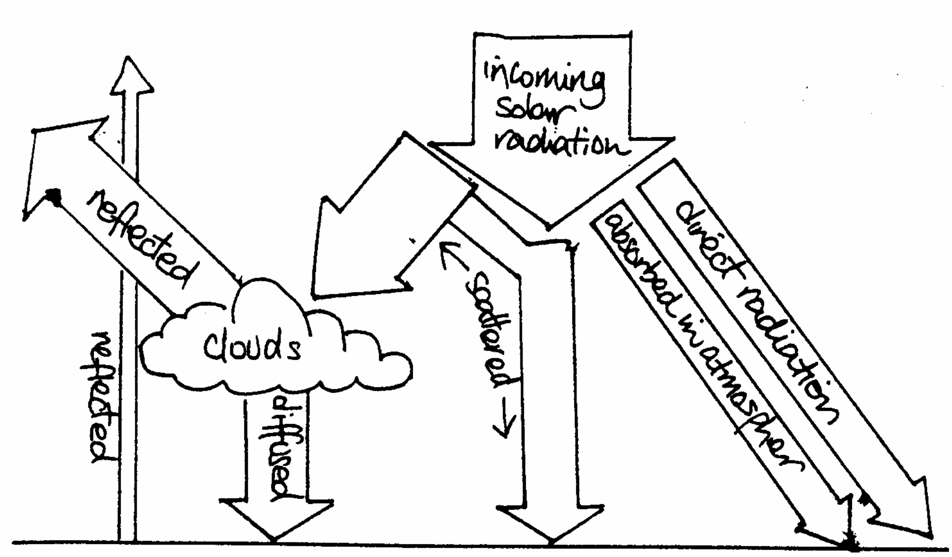
A major misconception for many people is a belief that the greenhouse effect is detrimental to our planet. This is not so. The greenhouse effect keeps the atmosphere and the surface of Earth warm; without it, Earth would be a very cold place indeed! The greenhouse effect provides an average temperature on Earth of 15 °C; without the greenhouse effect, the average temperature would be –20 °C.

The Sun is our most important source of heat in the form of solar radiation (some comes from Earth's centre). Approximately two-thirds of the solar radiation from the Sun that strikes the top of the atmosphere reaches Earth's surface either directly or indirectly (scattered).

As solar radiation reaches Earth's atmosphere, some of it gets absorbed and some gets reflected. Different surfaces reflect varying amounts of radiation. The albedo of a surface gives the percentage of solar radiation that it reflects. For example, fresh snow has an albedo of approximately 80%; clouds, 25–80% (depending on thickness); grass, 20%; and wet earth, 10%. On average, the albedo of the whole planet is 35%. The reflected solar radiation leaves Earth and its atmosphere. The absorbed radiation is converted into heat energy and the surface of Earth heats up.

The heated Earth re-emits radiation once it is heated. This radiation, called 'infrared radiation' (or 'terrestrial radiation'), is lower in energy than the radiation that it absorbed. Unlike solar radiation, infrared radiation cannot penetrate the atmosphere easily. Gases such as water vapour, carbon dioxide and methane in the atmosphere absorb it. The heated gases then re-radiate back to Earth. This trapping of radiation is the greenhouse effect. It is similar to what happens in a garden greenhouse. Solar radiation passes through glass plates and is absorbed by the plants and earth. The plants and earth heat up and emit infrared radiation that reflects off the glass plates to be reabsorbed by the plants. Figure 4 shows the interactions that take place to produce the greenhouse effect on a global scale.

FIGURE 4: SOLAR RADIATION INTERACTIONS WITH EARTH



The enhanced greenhouse effect

Atmospheric pollution has led to global warming through an enhanced greenhouse effect. Humankind is adding to the gases that absorb the infrared radiation emitted from Earth. These gases are known as greenhouse gases. As well as water, these other gases are increasing in volume in the atmosphere. Table 2 lists these gases, their sources and relative contributions to the enhanced greenhouse effect.

TABLE 2: GASES THAT CONTRIBUTE TO THE ENHANCED GREENHOUSE EFFECT

Gas	**Source**	**Contribution to the enhanced greenhouse effect**
Carbon dioxide	Burning of fossil fuels: coal, oil and gas. Deforestation: burning and decaying vegetation.	55%
Methane	Farm animals and rotting vegetation. Rubbish tips.	15%
Chlorofluorocarbons and halons	Refrigeration and airconditioning. Aerosol cans. Foam packaging. Fire extinguishers.	24%
Nitrous oxide	Fertiliser use. Motor vehicle emissions.	6%

Notice that some of the greenhouse gases also contribute to the depletion of the ozone layer.

ACTIVITY: THE ENHANCED GREENHOUSE EFFECT

Look on the Internet and answer the following:

- **How serious is the enhanced greenhouse effect in relation to global warming?**
- **What current effects on our weather are scientists attributing to the enhanced greenhouse effect?**
- **What does the future hold if the emission of greenhouse gases continues at current rates?**

- **What is the world doing about this problem? There have been a few international meetings. What have countries resolved to do?**
- **What is Australia doing about this problem?**
- **What can you do as an individual?**

Weather

There are few other aspects of the environment that affect our daily lives more than what is collectively termed 'the weather'. The clothes we wear and the activities we undertake are strongly influenced by the weather. The weather is the state of the atmosphere at any particular time. The scientific study of weather is termed 'meteorology' and the description of weather conditions is termed 'climate'. The elements of climate are:

- the temperature of the air
- air pressure (the pressure exerted by the air)
- the humidity of the air
- clouds (the type and amount of cloudiness)
- precipitation (the type and amount)
- wind (the speed and direction).

Each of the above elements of climate is discussed separately. However, it must be noted that the elements are interrelated and these interrelationships are discussed in the section 'The water cycle' later in this topic.

Air temperature

The temperature of a material is a measure of the kinetic energy of the particles that make up the material. Kinetic energy is a measure of how fast and how heavy an object is. For example, if a car and a truck are travelling at the same speed then the truck has more kinetic energy by virtue of its greater mass. The particles in a gas are moving around very fast. They collide with other particles so that if a gas is released in a room it soon fills the room. As the particles are moving, they have kinetic energy: the greater the kinetic energy, the greater the temperature.

If air is heated, air particles increase in temperature. A consequence of this is that the particles move faster. They have more collisions and therefore spread out more, and they have less density. Density is the amount of material in a given volume. A region of air that has less density than its surroundings will rise above the more dense area. This is the principle of floating. Even ships made of iron float on the surface of water as they are less dense than the water. Hot air rises, as it is less dense than the colder air surrounding it. Conversely, colder air is denser and so will fall below areas of hot air.

Heat energy transfers from one location to another in one of three ways: conduction, convection and radiation. The heat energy that comes from the Sun is transferred through radiation. This type of heat transfer does not require any material to travel from one object to another. Convection is a process where hot material moves from one location to another. This occurs in gases like the air. The volume of hot air rises from low-lying areas to higher positions. Conduction occurs in liquids and solids. The heat energy travels along the material without the material moving with it. For example, if you place one end of a metal bar in a fire, very soon the other end will be hot. The hot material at the fire end of the bar does not travel to the other end, but the heat energy does.

Thermometers measure the temperature of materials. Most thermometers work on the principle that hot objects expand when heated. The mercury (silver liquid) or alcohol (red liquid) inside common thermometers expands and contracts with the ambient temperature of the air. The glass surrounding the liquid also expands with heat but the expansion is negligible compared with that of the liquid. Try the following activities that involve the construction of model thermometers.

ACTIVITY: MODEL THERMOMETER

This activity is taken from Jennings 1986 (Experiments 81 and 82). There are two different model thermometers to construct.

Thermometer model 1

You will need:

- **a tall narrow bottle, such as a clear glass wine bottle**
- **a shallow dish, such as a pie dish**
- **a long narrow block of wood or a house brick**
- **red ink or red food colouring**
- **sticky tape**
- **sticky labels.**

Warm the bottle, either by holding your hands around it or by standing it on a radiator for a few minutes. When the bottle is warm, turn it upside down, with its mouth in a dish of water.

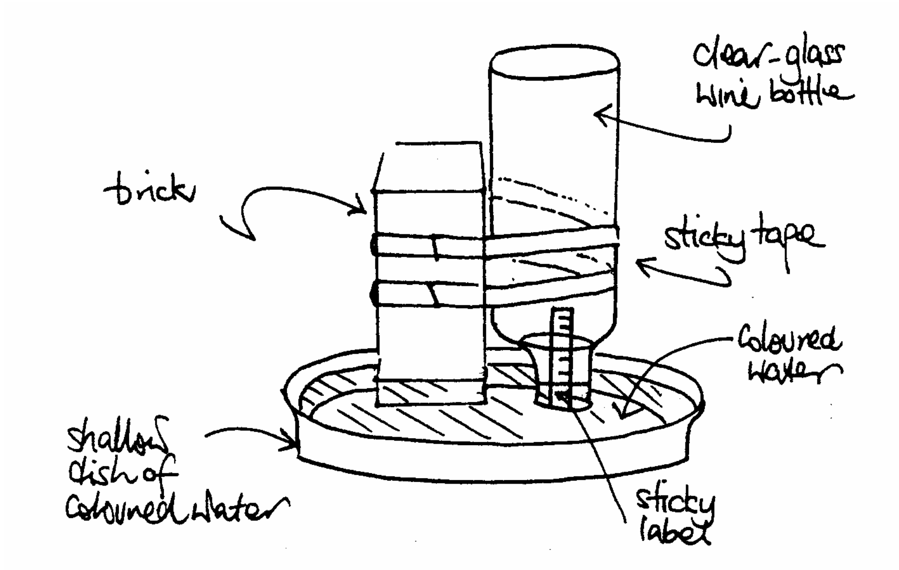
Colour the water with red ink or food colouring. Then tape the bottle to the block of wood or house brick as shown in the picture. Put a sticky label along the neck of the bottle.

As the air in the bottle cools, what happens to the level of the water inside the neck of the bottle? Mark the level of the water on a sticky label.

What happens to the level of the water in the neck of the bottle on a cold day? Why do these changes occur? Can you understand now how a thermometer works?

Use a real thermometer to help you draw a scale of temperatures on your model thermometer. Practise using your model thermometer to tell the temperature.

FIGURE: HOMEMADE THERMOMETER



Thermometer model 2

You will need:

- **a clear glass or plastic bottle approximately 18 cm high**
- **a drinking straw**
- **clay or plasticine**
- **red ink or red food colouring**
- **cold water**
- **a bowl of warm water**
- **a small bowl containing ice cubes.**

Colour a cupful of water with the red ink or food colouring. Put a layer approximately 3 cm deep in the bottle.

Soften the clay or plasticine by warming it in your hands or near a radiator. Use a lump of the clay or plasticine to seal the drinking straw into the neck of the bottle. The seal should be completely airtight. The drinking straw should reach down just below the surface of the coloured water.

Warm the bottle by wrapping your hands around it. Look carefully at the drinking straw. What do you notice?

Stand the bottle in a bowl of warm water. What happens?

Stand the bottle in a small bowl and pack ice cubes around it. What do you see?

Explain how this thermometer works. How does this thermometer differ from thermometer model 1?

For humans, the temperature of the air can feel a lot colder if the wind is blowing. Wind chill is a way of measuring how cold the weather will feel to your body if the wind is blowing. The following table gives the air temperature at different wind speeds. For a particular wind speed, the equivalent 'still air' temperature can be found. For example, if the temperature is 10 °C and the wind speed is 30 km/h, then the equivalent 'still air' temperature is 2 °C.

TABLE 3: AIR TEMPERATURE AT DIFFERENT WIND SPEEDS

Wind speed (km/h)	**Temperature (°C)**							
	10	**5**	**0**	**–5**	**–10**	**–15**	**–20**	**–25**
10	8	3	–2	–7	–12	–17	–22	–27
20	5	–1	–7	–13	–19	–25	–31	–37
30	2	–5	–11	–17	–24	–31	–37	–44
40	1	–6	–13	–20	–27	–34	–41	–48
50	–1	–8	–15	–22	–29	–36	–44	–51
60	–2	–9	–16	–23	–31	–38	–45	–53

Air pressure

We have already encountered the concept of pressure in the topic 'Astronomy'. Pressure is the amount of force applied per unit area. Although we cannot see the air, we can feel and see the wind's effects as it applies forces to our bodies and to tree branches. However, even if there is no wind, the air still exerts a pressure.

The gases in the air are made of fast-moving particles that collide with one another and with other objects. Each bombardment of a gas particle applies a force to very small area of our skin; that is, it applies a very small pressure. Given that there are 27 times 10^{12} (27 billion billion) air particles in a cubic centimetre of air near sea level, there are many, many particles applying pressure to the surface of our skin at any one particular time. This is air pressure.

The scientific unit of pressure is the pascal (Pa). To get a 'feel' for the size of a pascal, a 1.5-L bottle of coke applies a pressure of approximately 2000 Pa to your skin if you hold it by its base in the palm of your hand. The size of the air pressure at sea level is approximately 100 000 Pa. This is a very large pressure. We are not aware of this pressure as it is the same all around our bodies, inside and out. However, if we went to outer space, where the pressure is 0 Pa, we would have problems if we did not wear a pressure suit. The high pressure within our bodies would push our skin outwards and we would literally blow up! We are aware of pressure differences in our bodies when flying. The air pressure at altitude is lower than at sea level. At altitude, our ears 'pop' as the pressure inside them (which has remained at sea level) changes to match that inside the cabin.

While the scientific unit of pressure is the pascal, meteorologists (weather scientists) use 'hectopascals' (hPa). One hectopascal is 100 Pa. Therefore, the air pressure at sea level is approximately 1000 hPa. Another unit equivalent to the hectopascal is the millibar (mb). Therefore, 1 hPa = 1 mb = 100 Pa.

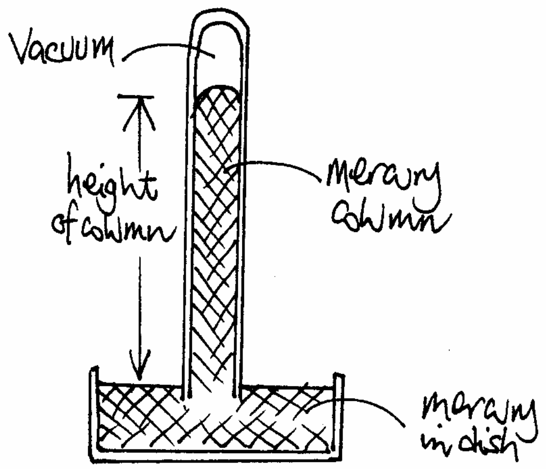
Air pressure changes with the density of the air and its temperature: the higher the temperature of a given volume of air, the greater the pressure. Imagine heating up a closed can of air. Very soon the top would fly off because the pressure inside would have increased. As the temperature increases, air particles move faster colliding more often and creating greater pressure. If the density of the air increases, air pressure also increases. Increasing the density means there are more particles of air for a given volume. More particles mean more collisions and therefore more pressure.

Atmospheric pressure falls off very rapidly with height above the surface of Earth. At sea level, air pressure normally varies between 970 hPa and 1040 hPa. At an altitude of 5500 km, the air pressure is 500 hPa, and at 10 000 km (a little higher than Mount Everest), the air pressure is as low as 300 hPa. The reason for the decrease in air pressure is that the density of the air decreases with altitude as most of the air is closest to the surface of Earth (because of gravitational attraction).

A barometer measures air pressure. Early barometers consisted of a glass tube filled with mercury placed in an open dish (see Figure 5). At sea level, the height of the column of mercury is approximately 760 mm. If the air pressure increases, the height of the mercury column rises. Why doesn't all the mercury fall out the bottom of the glass tube? The key clue here is the vacuum at the top of the tube. In a vacuum, the air pressure is zero (no particles).

Mercury barometers have been replaced recently by aneroid (meaning 'free of liquid') barometers. Aneroid barometers consist of a metal cell where some of the air has been removed. When the air pressure increases, the cell contracts. Alternatively, when the air pressure decreases, the cell expands. The activity *Homemade barometer* shows how to make a barometer.

FIGURE 5: MERCURY-IN-GLASS BAROMETER



ACTIVITY: HOMEMADE BAROMETER

There are two types of barometer you can make: a fluid barometer and an aneroid barometer. This activity is taken from Suzuki 1989, p. 22. A barometer measures atmospheric pressure: how much the air is pressing down. You can use it to forecast the weather.

You will need:

- **a clear plastic bottle**
- **a wide-mouthed jar into which the plastic bottle will fit snugly**
- **ink or food colouring**
- **a china marker or other marker that can write on glass**
- **a ruler.**

Choose a rainy day—when atmospheric pressure is low—to make this barometer (see the figure *Homemade aneroid barometer*); otherwise it will not work.

Put some water into the bottom of the jar. Add a little ink or food colouring to the water so that it will be easier to see.

Turn the bottle upside down and set it in the mouth of the jar, as shown in the figure *Homemade aneroid barometer*. The fit should be snug enough to keep the bottle from touching the bottom of the jar.

Is the water rising a little into the neck of the bottle? If not, add a little more water.

Let the barometer sit for 15–20 min; then check the water level. Make a little line on the side of the jar to show the water level. This is your pressure mark. Here's an important tip: the barometer should be at your eye level when you make your low-pressure mark. If you're looking down at the water (or up at it), you'll put the mark in the wrong place. Don't move the jar, because this will make the water slosh. Just bend your knees (or do whatever you need to do) to get the water even with your eyes. Then do the same thing when you take a reading.

Use a ruler to make a measurement 1 cm above the low-pressure mark. Make another little line. Do this twice more, so that you have three lines above the first line you made. The lines should be 1 cm apart.

Put your barometer on a flat surface where you can check it easily. Look at it every morning and every night. When the water is at the lowest mark, it means wet weather. The two middle marks mean that the weather is changing. The highest mark means fine, dry weather.

ACTIVITY: MAKING AN ANEROID BAROMETER

This activity is taken from Ainsbury and Mann 1976, pp. 11–12.

You will need:

- **a large, wide-mouthed bottle**
- **a rubber balloon**
- **rubber bands**
- **a drinking straw**
- **glue**
- **a card**
- **a pencil.**

Break the balloon and stretch it tightly across the top of the bottle (see the figure *Homemade aneroid barometer*).

Secure the balloon in this position by tightly winding rubber bands around it.

Lay a flattened drinking straw across one edge of the bottle and glue one end to the centre of the rubber top.

Fix a card near the end of the straw to make a scale. Draw a mark on it to show the present position of the straw.

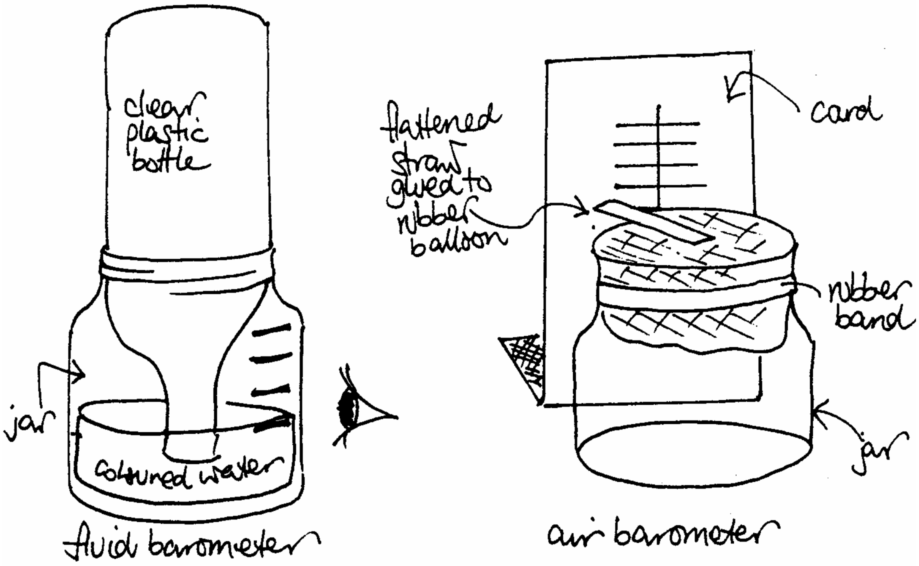
Examine the position of the straw after approximately 24 hours to see if it has moved.

Why does the straw move over the scale?

What other element of the weather might affect the barometer?

Why would it be better to use the old inner part of a vacuum flask rather than a bottle?

FIGURE: HOMEMADE ANEROID BAROMETER



Humidity

Humidity is the general term to describe the amount of water vapour (water in gas form) in the air. Several methods are used to quantitatively express humidity. Among these are absolute humidity and relative humidity.

Absolute humidity is the mass of water vapour in a unit volume of air. The unit used for absolute humidity is grams per cubic metre (g/m^3). There is a limit to the amount of water vapour air can hold at a given temperature. When the maximum amount is reached, the air is saturated. The absolute humidity increases with the temperature of saturated air. This means that more water vapour can remain in the air at higher temperatures. For example, the absolute humidity at 10 °C is 8 g/m^3, but at 30 °C it is 30 g/m^3.

Relative humidity is the ratio (expressed as a percentage) of the amount of actual water vapour in the air, for a given volume of air, to the amount of water required to saturate the air. Therefore, a relative humidity of 100% at a particular temperature means that the air is saturated and, therefore, no more water vapour can enter the air at that temperature. Relative humidity values are usually given to the public in weather reports.

As more water vapour can enter the air at higher temperatures, the relative humidity can change with temperature even though the amount of water vapour in the air remains the same. For this reason, the relative humidity decreases during the day when temperatures rise, and rise during the night when temperatures fall.

A device called a 'hygrometer' can measure relative humidity. Hygrometers use human or horse hair. The length of the hair changes with the magnitude of the relative humidity. The higher the relative humidity is, the longer the hair becomes (from 0% to 100% relative humidity, the hair lengthens by 2.5%). You can make your own hygrometer by following the directions in the activity *Homemade hygrometer*. Humidity can also be measured indirectly with dry- and wet-bulb thermometers. You may wish to research how these can be used to measure humidity.

ACTIVITY: HOMEMADE HYGROMETER

This activity is taken from Suzuki 1989, pp. 46–8. Human hairs stretch or shorten, depending on how hot and humid the weather is. You can use a human hair to make a hygrometer, which measures how much water is in the air.

You will need:

- **a straight human hair, at least 25 cm long**
- **a 1 L milk carton**
- **a Stanley knife**
- **a paperclip**
- **a darning needle with a big eye**
- **a small sheet of paper**
- **a 5¢ piece**
- **a toothpick**
- **sticky tape.**

Wash the milk carton with water and detergent (otherwise, sour milk will make the carton smell awful). Let the carton dry.

Cut a slit in the carton approximately 3 cm from the spout end.

Push the paperclip halfway into the slit in the carton.

With the knife, carefully make three cuts in the carton to form an 'H' shape. The cuts should be approximately 3 cm from the flat end of the carton, on the same side as the paperclip slit. Fold the two flaps you make so that they're sticking out from the carton (see diagram 1 in the figure *Homemade hygrometer*).

Push the darning needle through the two flaps. Twist the needle around a few times. The holes should be big enough so the needle can spin easily (see diagram 2 in the figure *Homemade hygrometer*).

Push a toothpick through the eye of the needle to make a pointer. Make sure the toothpick is not touching the carton.

Tie one end of the hair to the paperclip. Wrap the hair once around the needle (see diagram 3 in the figure *Homemade hygrometer*).

Tape the other end of the hair to a five-cent piece and let it hang freely from the end of the carton.

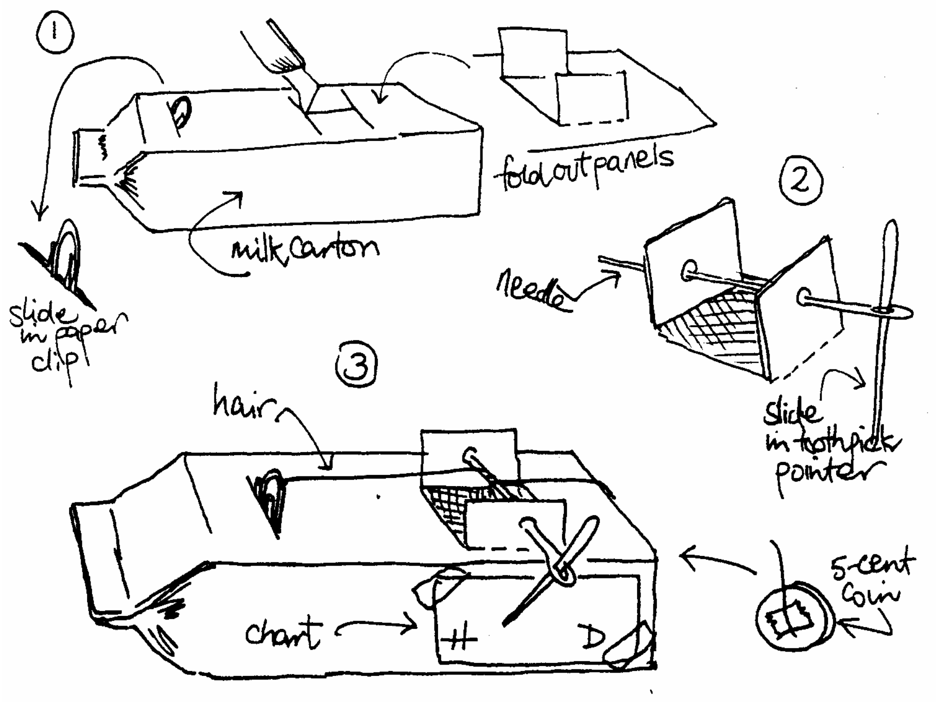
Tape a piece of paper to the side of the carton, under the pointer.

Now take your hygrometer into the bathroom after someone has had a shower and it is still hot and steamy. Watch as the hair stretches and the pointer moves. Wait

until the pointer stops moving. Mark an 'H' (for humid) on the paper where the toothpick is pointing. Mark a 'D' (for dry) on the other side of the paper.

Set your hygrometer on a table or shelf and watch it from day to day. You will see the pointer move a little towards 'H' when it rains and a little towards 'D' when it is dry.

FIGURE: HOMEMADE HYGROMETER



Clouds

Many people, young and old, are fascinated with clouds. How many times have you lain on the grass looking up at the clouds, making out different shapes in the cloud patterns? The key concepts to cloud formation are evaporation, saturation and condensation. Consider the following points that relate to cloud formation:

- Areas of liquid water on Earth's surface are continually evaporating into the air (where do puddles go after it rains?). Evaporation is the process by which a liquid converts into a gas; liquid water changes into water vapour.
- We have already encountered the term 'saturation' in 'The humidity of the air' in this topic. The air is saturated when it can no longer contain any more water vapour.
- Saturated cool air holds less water vapour than saturated warm air. Therefore, if saturated air is cooled, some of the water vapour in the air must condense. Condensation is where a gas changes state into a liquid. In this situation, water vapour condenses to liquid water.
- Unsaturated air rising in the atmosphere will become cooler. This may result in the air becoming saturated. Further cooling will result in condensation of some of the water vapour and in the formation of a cloud. Clouds are just small droplets of water suspended in the air.

- Small particles in the air, called 'condensation nuclei', are required for cloud formation, but, in practice, there will always be sufficient nuclei for cloud formation in the atmosphere.

There are four mechanisms by which air rises:

- Air is heated at Earth's surface. Warmed air becomes less dense and rises above the colder air above it. Conversely, the colder air is denser and so falls to the surface of Earth. The air cools as it rises, it becomes saturated, water vapour condenses and small particles of water appear to form clouds.
- Air flows over mountains. As air rises over mountains it cools and the process of cloud formation begins (as described above).
- Air is forced to rise in the vicinity of cold or warm fronts. A cold front is a body of cold air coming horizontally along Earth's surface—for example, wind coming from the Antarctic. In this situation, warm air is forced upwards as the cold front moves in. Once again, as the warm air rises it cools and the process of cloud formation begins. A warm front is a body of warm air coming horizontally along Earth's surface. As it meets a cold body of air it rises above it, much like a car going up a ramp. Again, as the hot air rises it begins to cool and the process of cloud formation begins.
- Air converges into an area of low pressure, causing a cyclone. We know from the section 'Flight' in the topic 'Astronomy' that air will tend to move from a high-pressure region to a low-pressure region. In this situation, the air tends to spiral into the low-pressure region and ascend. Again, as the air ascends it cools and the process of cloud formation begins.

Scientists have a classification system based on four main cloud types using Latin names:

- cumulus: a puffy cloud
- cirrus: a wispy cloud
- stratus: a sheet-like cloud
- nimbus: a rain cloud.

Other clouds can be described by combining these basic types. For example, nimbostratus is a rain cloud that occurs in layers.

Clouds are also described as high clouds, middle clouds, low clouds and clouds with vertical development. The following table gives the altitudes of these cloud types.

TABLE 4: ALTITUDES OF DIFFERENT CLOUD TYPES

Cloud	**Tropics**	**Middle latitudes**	**Polar regions**
High	6–18 km	5–13 km	3–8 km
Middle	2–8 km	2–7 km	2–4 km
Low	Surface to 2 km	Surface to 2 km	Surface to 2 km

To investigate clouds further, consider the following activities.

ACTIVITY: CLOUDS

Investigate the following on the Internet:

- **Look at images of cloud types. See if you can name them based on the four basic types, or combinations of them.**
- **Why do rain clouds look dark?**
- **How are fog and mist related to clouds?**
- **How is cloud seeding to make rain carried out?**

ACTIVITY: HOW IS MIST FORMED?

You will need:

- **a clear glass bottle or a bottle made of clear plastic**
- **an ice cube**
- **a sheet of black paper**
- **hot water.**

Warm the bottle by pouring a little hot, not boiling, water into it. Tip some of the hot water out, but leave a layer approximately 2 cm deep in the bottle.

Rest the ice cube on the open top of the bottle. Hold the piece of black paper behind the bottle. What do you see? Describe what has happened.

ACTIVITY: WHAT HAPPENS TO MOISTURE IN AIR WHEN IT IS COOLED?

You will need:

- **a tin can**
- **ice cubes**
- **a duster or a piece of cloth.**

Clean the label off the can and rub the outside of the can with a cloth so that it becomes shiny.

Fill the can with ice cubes. Be careful to wipe the outside of the can dry if it gets wet while you are putting the ice cubes in the can.

Stand the can in a warm room. After a few minutes, look at the outside of the can.

What do you see? Where has the water come from? Can you see how dew is formed on the surface of plants, stones and cars during the night? How could you prove that the water on the outside of the can has not come from the ice inside the can?

ACTIVITY: MAKING CLOUDS

Method 1

You will need:

- **a large jar or wide-necked bottle**
- **a large round balloon**
- **rubber bands**
- **water**
- **matches.**

Cut the balloon up, making a piece to fit over the top of the jar.

Pour a 2 cm layer of water into the bottom of the jar and cover with the rubber. Light a match and, while it burns, ask a partner to uncover the jar.

Flick out the match and, while it is still smoking, lower it into the jar. Quickly cover the jar so that some smoke is trapped inside. Fasten the rubber covering

with rubber bands. Press down on the rubber cover, holding it for approximately 5 s, then pull it up fast and hard. Droplets should form inside the jar. The droplets can be seen better in a darkened room with torchlight.

Can you explain how the cloud forms? What happens when you depress the rubber cover? What is the significance of the smoke?

Method 2

You will need:

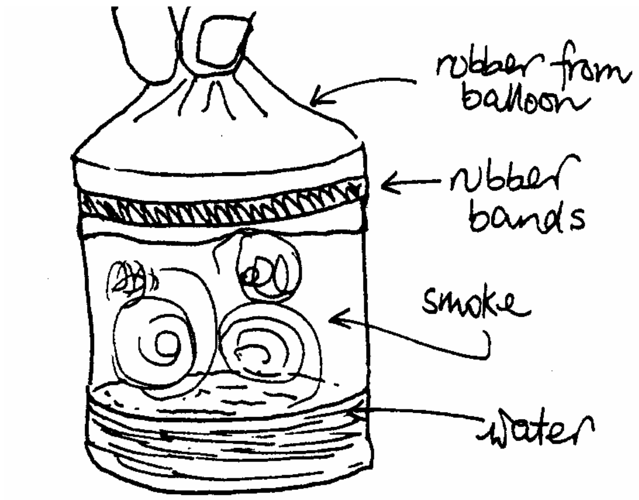
- **a pump**
- **a large, clear bottle, like a flagon used for wine**
- **a cap for the bottle**
- **a measuring cup**
- **a bicycle pump.**

Pour approximately 125 mL of water into the bottom of the bottle. Give the bottle a shake to wet the sides.

Punch a hole (5 mm in diameter) into the top of the bottle. Place the cap on the bottle upside down. Hold the pump against the cap and make two or three strokes on the pump. Quickly pull the cap away. You'll hear a popping sound, and then see a cloud in the bottle.

How is the cloud formed by this method? Are there any similarities between the methods?

FIGURE: MAKING CLOUDS



Precipitation

The particles of water that fall to Earth from clouds are called 'precipitation'. We give various names to this precipitation, depending on its type; for example, rain, hail, snow, sleet and drizzle.

The size of cloud droplets determines whether they fall to Earth. The diameter of a typical cloud droplet is 0.01–0.02 mm, whereas a typical raindrop has a diameter of 1–2 mm. The size of droplets in thunderstorms can range from 5 to 8 mm. The small cloud droplets are so lightweight that they fall very slowly to Earth. Instead of falling, they are kept aloft by the rising air. Rain eventuates when cloud droplets combine or coalesce. However, in most clouds the temperature is such that rain starts out as ice crystals. In most cases, the falling ice crystals melt to form drops of rain.

Drizzle drops (0.2–0.5 mm in diameter) will fall if up draughts are gentle and the cloud cover is low. Drizzle droplets will evaporate if the cloud base is high. The strong up draughts in thunderstorms can keep large droplets aloft. This allows them to coalesce into even larger droplets, but droplets with diameters greater than 8 mm are unstable and break up.

If temperatures are low, the ice crystals do no melt into drops but remain as crystals that grow into snowflakes. The formation of hail results after violent up draughts in rain clouds (nimbus) keep ice crystals falling and rising in several cycles. During these cycles the ice crystals grow in size. Hailstones can grow to the size of oranges.

ACTIVITY: CONSTRUCTING A RAIN GAUGE

You will need:

- **a transparent plastic squeeze-top bottle (like the type used for dishwashing detergent) or a glass beaker and a funnel that fits snugly into the beaker**
- **a test tube**
- **an indelible marking pen**
- **scissors.**

Cut the plastic bottle approximately one-third of the way down, and then invert the top section so that it fits snugly into the bottom to make a simple funnel. Otherwise use your beaker and funnel. This is your rain gauge.

Without the funnel, pour water into the gauge to a depth of 1 mm (measure this carefully!), then pour this into the test tube. This will make an insignificant amount of water appear more obvious. Mark the level and amount on the test tube. Then measure 2 mm on your gauge and pour this into the test tube. Mark this level and amount. Repeat until the test tube contains 10 mm of water. Now you have a fairly accurate way of measuring small amounts of water.

Leave the rain gauge outside in a safe place—there may be a variety of sites chosen. Make sure it cannot be blown over. At the same time each day, measure the water collected over the previous 24 h and empty the gauge. Is it all rainwater? Do certain areas of the school receive more rain than others?

Use your rain gauge to monitor precipitation levels over a period of time. Compare your results with those of the Bureau of Meteorology. See the Bureau of Meteorology website <http://www.bom.gov.au/climate/rainmaps/> for recent rainfall data in your location.

ACTIVITY: MODEL SNOWFLAKES

You will need:

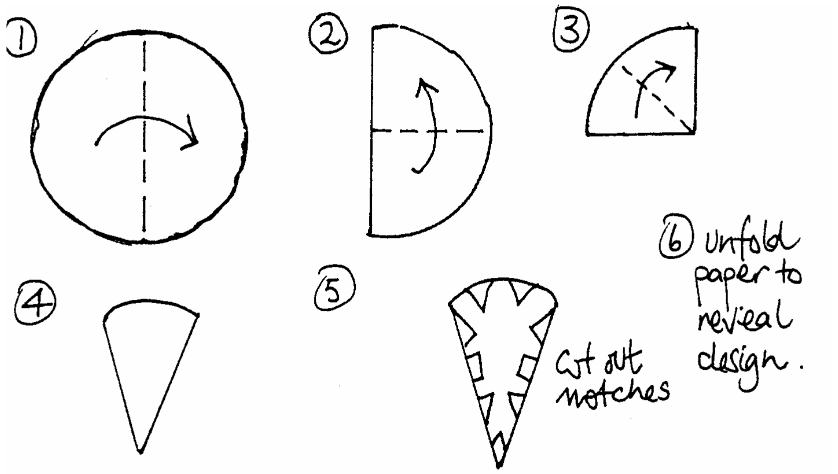
- **some circles of thin paper**
- **scissors**
- **a pencil.**

Fold one of the circles in half and then fold it in half again. You should now have a shape that is quarter of a circle. Fold this quarter circle in half again. Cut some notches and slots around each edge of the 'piece of pie' shape. Then open out the

paper. You should have a symmetrical shape like a snowflake. Note: real snowflakes always have a pattern that has six arms.

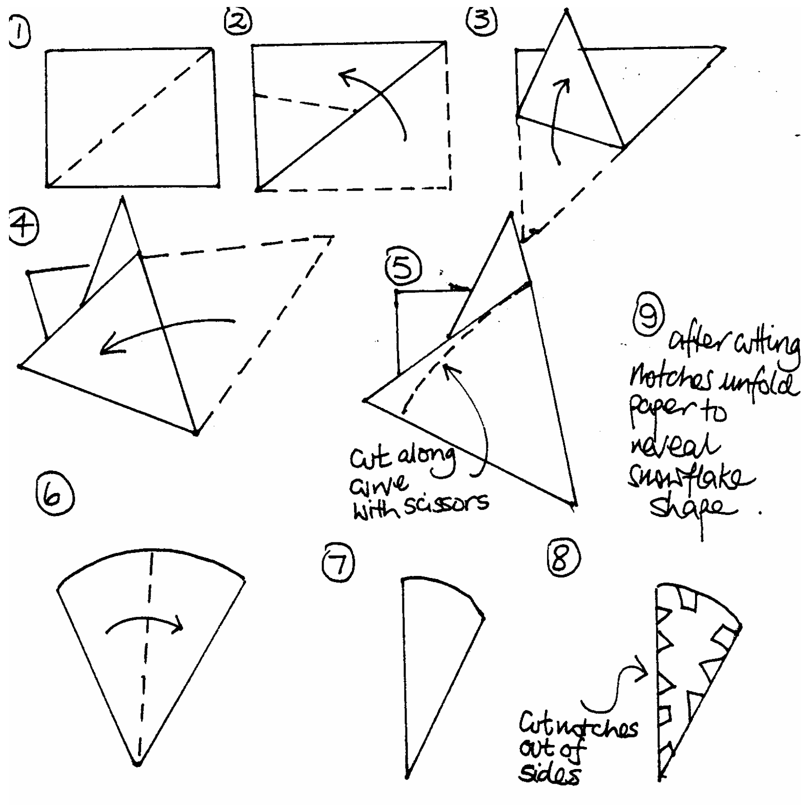
Take two identical 'snowflakes'. Screw one up into a tight ball. Drop them from the same height. Which reaches the ground first? Why is this? Do you know why real snowflakes float gently to the ground whereas hailstones fall to the ground with great force?

FIGURE: FOLDING SNOWFLAKES



For your snowflakes to be more realistic, they need to have a pattern that has six arms. To achieve this, follow the folding sequence in the figure *Model snowflakes*.

FIGURE: MODEL SNOWFLAKES



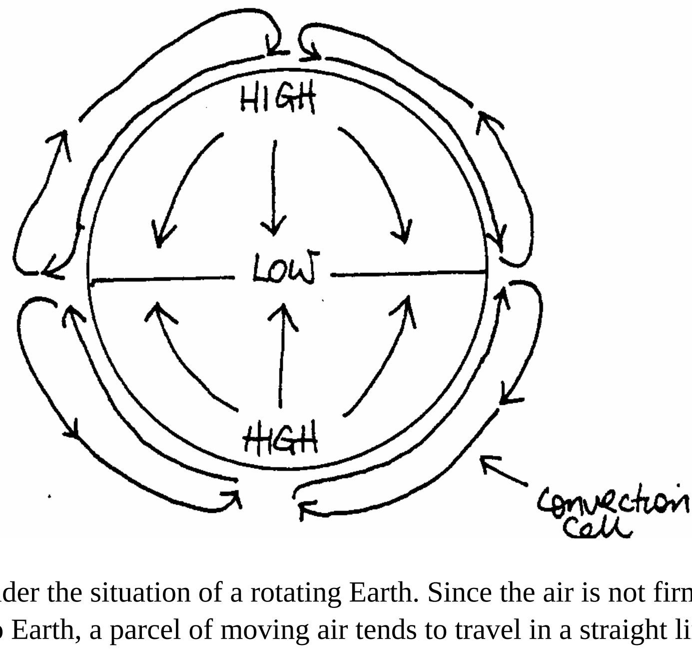
Wind

We have discussed the upwards motion of air and its importance in cloud formation. The horizontal motion of air is called 'wind'. Air rises because it is less dense than the surrounding air. Air moves sideways because of horizontal differences in air pressure. Air moves from high-pressure areas to low-pressure areas.

Differences in air pressure arise through unequal heating of regions of Earth's surface. Therefore, solar radiation is the driving force of wind. In coastal areas during the day, the land heats up more quickly than the sea. The heated air above the land expands creating a low-pressure region. The air above the sea is cooler and so is at a higher pressure. The pressure difference between the sea and the land creates sea winds that occur in the afternoon. During the night, the land cools quickly but the sea cools slowly, so by morning, the air above the sea is hotter than that above the land. This results in a breeze travelling from land to sea. In inland areas, there is variable heating of the earth because of different surfaces. For example, grass absorbs approximately 75% of solar radiation, whereas forests absorb 90% of the incident solar radiation.

On a global scale, the direction the wind takes is more complicated, as the rotation of Earth needs to be taken into account. Consider first the simple case of a non-rotating Earth. As the equatorial regions heat up more than the polar regions, there is a low-pressure region above the equator and high-pressure regions above the poles. Therefore, winds should be directed from the north and the south. The winds are part of convection cells that rise to the troposphere to make loops of moving air on a global scale (see Figure 6).

FIGURE 6: GLOBAL WIND PATTERNS IN A NON-ROTATING EARTH



Now consider the situation of a rotating Earth. Since the air is not firmly attached to Earth, a parcel of moving air tends to travel in a straight line, maintaining its original speed and direction. However, Earth rotates as the parcel of air moves and so the parcel of air will trace out a curved path on Earth's surface. To appreciate this effect, complete the following activity.

ACTIVITY: GOING STRAIGHT ON A ROTATING BALL

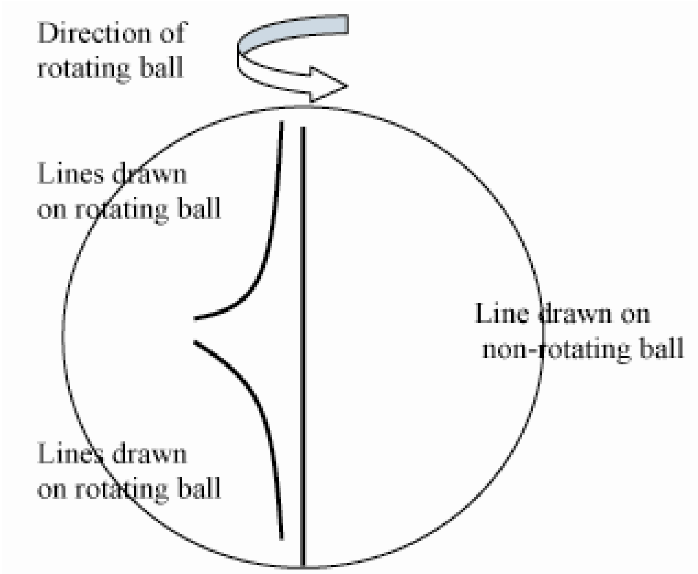
You will need:

- **a soccer ball or volleyball**
- **some coloured chalk or a water-based marker.**

Have your partner hold the ball steady while you draw a vertical line from the top of the ball to the bottom. Now have your partner begin rotating the ball while, again, you draw a vertical line from the top of the ball but this time stopping half way. Look at the line drawn and compare it to the previous line. Try this process again, but this time begin by drawing a vertical line from the base of the ball to the middle. Compare the lines drawn when the ball is rotating with those drawn when it is not rotating.

The patterns formed should be like those in the figure *Going straight on a rotating ball*.

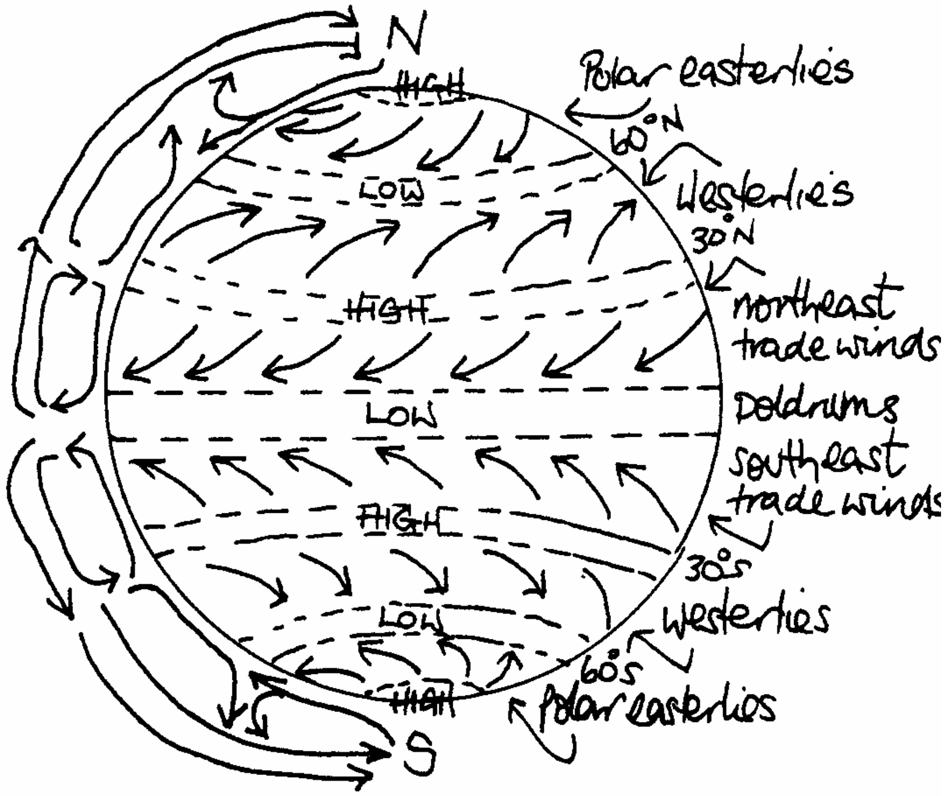
FIGURE: GOING STRAIGHT ON A ROTATING BALL



The low-pressure regions at the equator are called the 'doldrums', but, instead of having only high-pressure regions at the poles, Earth may be considered to have bands of high-pressure regions. Air will tend to move from a high-pressure region to a low-pressure region, but, with the rotation of Earth, this will result in curved paths for the movement of air. See Figure 7 for a representation of the patterns formed. The consequence of these wind directions is that Earth generally has:

- trade winds at the equator that blow from the north-east in the Northern Hemisphere and from the south-east in the Southern Hemisphere
- westerlies in the middle latitudes in both the Northern Hemisphere and the Southern Hemisphere.
- polar easterlies.

FIGURE 7: SIMPLIFIED DIAGRAM OF EARTH'S PRESSURE BELTS AND WIND CIRCULATION PATTERNS



The above description of global wind circulation is a very simplified view indeed. High- and low-pressure regions do not remain in specific locations on Earth's surface. The weather maps found in newspapers and shown on television can attest to this. A weather map shows lines of equal pressure called 'isobars'. The maps also highlight where the pressure is highest, a high, and where it is lowest, a low. Highs and lows are in constant movement over Earth's surface.

When looking at a weather map, strong winds will occur where the isobars are close together (large pressure difference) and light winds will occur where the isobars are spread out. In addition, because of Earth's rotation, the wind direction curves to such an extent that air movement becomes parallel to the isobars. A major reason for this is that there are friction effects between the moving air mass and Earth. The general rules for wind direction then become:

- In the Northern Hemisphere, air flows anticlockwise around low-pressure systems and clockwise around high-pressure systems.
- In the Southern Hemisphere, air flows clockwise around low-pressure systems and anticlockwise around high-pressure systems.

These rules apply only over large areas where the effect of Earth's rotation is significant. They do not apply on a local scale—for example, for the sea breezes at coastal locations. The same phenomenon occurs with water as with the wind. Ocean currents flow clockwise in the Northern Hemisphere and anticlockwise in the Southern Hemisphere. However, the belief that water always flows down a plug hole clockwise in the Northern Hemisphere and anticlockwise in the Southern Hemisphere is not true. The effect of Earth's rotation on an amount of water this small is negligible.

A device called an 'anemometer' measures wind speed, and wind direction is determined by use of a weather vane. An anemometer is usually made from a freely rotating wheel with three or four spokes. At the end of each spoke is a cup to catch the wind. The speed of rotation of the wheel determines the wind speed. A common scale of wind strengths is the Beaufort scale (see Table 5).

TABLE 5: BEAUFORT SCALE

Force	**Descriptive name**	**Effect**	**Speed (km/h)**
0	Calm	Smoke rises vertically	<1
1	Light air	Wind direction shown by smoke drift	1–5
2	Slight breeze	Wind felt on face; leaves rustle	6–11
3	Gentle breeze	Leaves and twigs in constant motion	12–19
4	Moderate breeze	Dust, loose paper and branches move	20–28
5	Fresh breeze	Small trees sway	29–38
6	Strong breeze	Large branches sway; whistling heard in telephone wires	39–49
7	Near gale	Whole trees sway	50–61
8	Gale	Difficult to walk	62–74
9	Strong gale	Slight damage to buildings	75–88
10	Storm	Considerable damage to buildings	89–102
11	Violent storm	Widespread damage	103–117
12–17	Hurricane	Devastation	>117

ACTIVITY: WIND DETECTORS

There are many designs of wind detectors that can be made. Try the following or design your own.

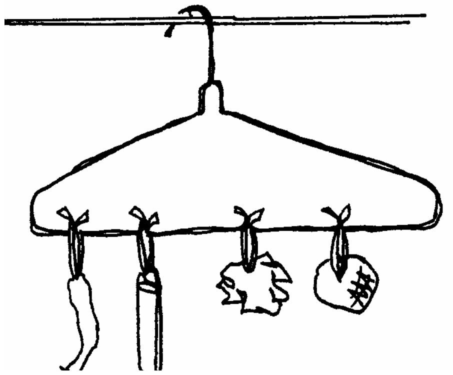
Simple wind indicator

You will need:

- **a wire coathanger**
- **an icy-pole stick**
- **a marble-sized piece of plasticine**
- **a crepe paper strip (12 cm × 1 cm)**
- **a piece of aluminium foil (30 cm × 10 cm)**
- **a 60 cm length of wool**
- **scissors**
- **sticky tape.**

Using the wool, attach each of the other items so that they dangle from the coathanger (see the figure *Simple wind indicator*). Each item will move with varying strengths of wind.

FIGURE: SIMPLE WIND INDICATOR



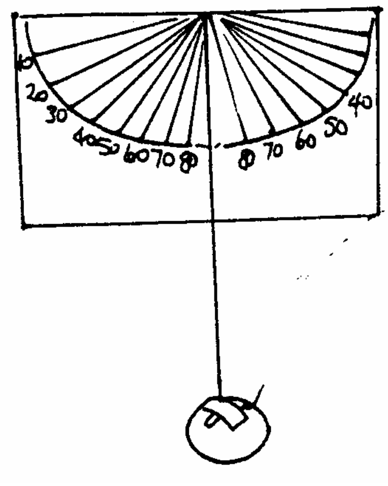
Wind speed meter

You will need:

- **a piece of cardboard (15 cm × 15 cm)**
- **a protractor**
- **cotton thread (approximately 40 cm long)**
- **a table tennis ball**
- **adhesive tape.**

Put a mark on the centre of the cardboard. This side will be the top of your wind meter. Put the centre of the flat side of the protractor against the centre mark. Draw a line around the edge of the protractor. Mark ten-degree intervals around the edge of the protractor. Label the bottom mark 90º. On each side of this mark, label the other marks as 80º, 70º and so on. Attach the thread to the centre point of the top of your meter. Attach the table tennis ball to the other end of the thread. Use your meter. Hold the top of the meter horizontally. Keep the meter 'side on' to the wind Mark where the string is on the scale you drew. Label this mark with the type of wind (breeze, wind, gale etc.).

FIGURE: WIND SPEED METER

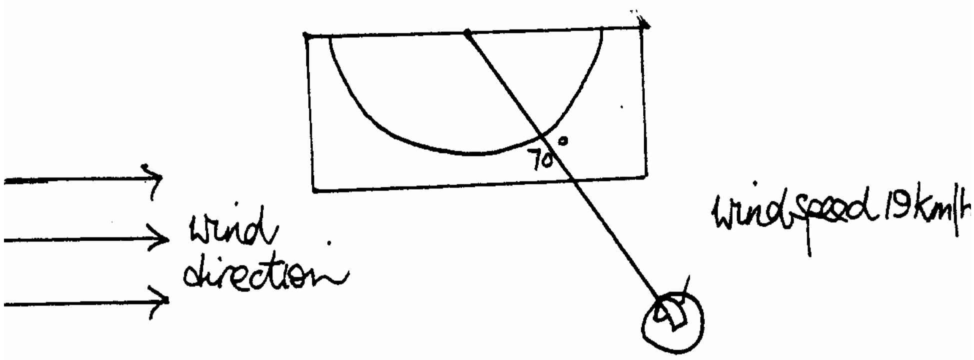


Test out your wind speed meter in windy conditions outdoors, or in wind from fans, or simply by blowing air from your mouth. Use Table 6 to estimate the speeds of wind that you measured. Compare the wind speeds found with the Beaufort scale of wind strengths in Table 5.

TABLE 6: WIND SPEED METER

String angle (º)	Wind speed (km/h)
90	0
80	13
70	19
60	24
50	29
40	34
30	41
20	52

FIGURE: DETERMINATION OF WIND SPEED



ACTIVITY: WHERE IS THE WIND?

This activity involves making a weather vane. There are many designs. Here is just one.

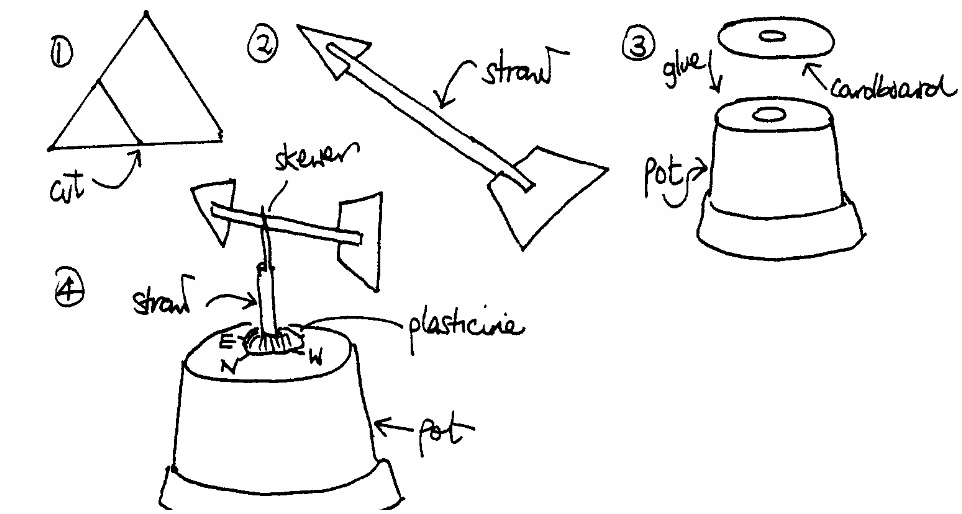
You will need:

- **a clay flower pot**
- **cardboard**
- **a bamboo skewer**
- **plasticine**
- **two plastic straws**
- **marking pens.**

Cut a triangle from the cardboard and cut off the top of the triangle. Cut slits at both ends of a straw. Push the top of the triangle into one of the slits and the base into the other end. You should now have made an arrow. Push the end of the skewer through the middle of your arrow.

Place the pot upside down and fix a circular cardboard covering over the top. Place a hole through the centre of the pot. Put the other straw through this hole holding it in place with plasticine. Now insert your arrow.

FIGURE: DIRECTION OF WIND



The water cycle

The water cycle is the process by which water, in some form, circulates from Earth to the atmosphere and back down to Earth. The first phase of the cycle is the evaporation of water from the surface of Earth. Most evaporation occurs in the oceans, as they take up 71% of Earth's surface, but evaporation also occurs in rivers and lakes. In addition, water comes from plants in a process called 'transpiration'. Water vapour in the air is carried vertically by hot air currents in a number of ways (see the section on clouds above) and horizontally by winds (see the section on winds above). This results in clouds forming not only over regions of water but also over land areas. Precipitation from clouds brings water in different forms (water, snow, hail) back to water and land areas on Earth's surface (see 'Precipitation' earlier in this topic). Mountain areas get more water than flat desert areas. The water in mountain areas flows in streams above and below the surface of the land eventually reaching the sea. Some of the water does not reach the sea as it evaporates, fills lakes or is consumed by plants and animals. Once the water is on Earth's surface again, the cycle is repeated.

ACTIVITY: MAKING AN EVAPORIMETER

This activity is taken from Ainsbury and Mann 1976, pp. 26–7.

An evaporimeter measures the extent of evaporation from a container. The simplest device uses a ruler that stands in a dish of water. By reading the measurements on the ruler, you can determine the number of millimetres of water that has evaporated. However, a more sensitive device can be made using the following materials.

You will need:

- **a square, flat container**
- **a cork**
- **a length of stiff wire shorter than the side of the dish**
- **a piece of white cardboard (as long as the dish and twice as high)**
- **sticky tape or glue.**

Fasten the card to the side of the dish with sticky tape or glue.

Make a hole, just large enough for the wire, through the card and the dish, 2 to 3 cm from the top of the dish and approximately one-quarter of the way along the side.

Make two right-angle bends in the wire approximately one-quarter of the way along its length and approximately 0.5 cm apart. Push the cork onto the short end.

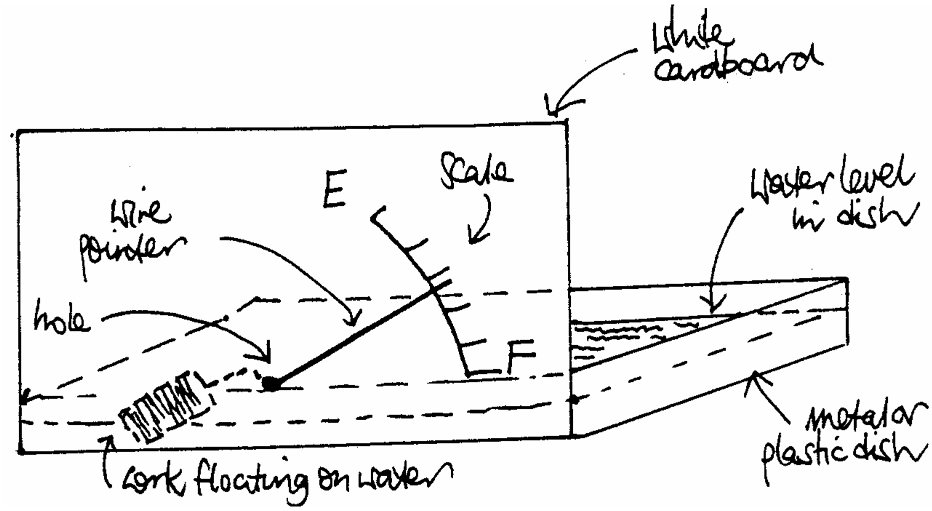
Thread the wire through the hole so that the cork is on the inside and the bent section is in the hole. The long end of the wire makes a pointer.

Mark a scale on the card by filling the dish 1 cm at a time until the water level reaches the hole in the dish.

Will the water in the dish evaporate more rapidly if it is left in the sun or in the shade, or will there be no difference?

Will it make any difference if there is a wind blowing?

FIGURE: HOMEMADE EVAPORIMETER



Weather maps are commonplace in daily newspapers and on the nightly news. The most obvious features of the weather map are patterns of high and low pressure with lines of equal pressure called 'isobars'. The weather map also shows barbed lines indicating cold and warm fronts.

ACTIVITY: WEATHER MAPS AND FORECASTING

Access the Bureau of Meteorology website <http://www.bom.gov.au/>. This site has a section that describes aspects of the weather map. Read through this material. The site also has daily weather maps and current satellite pictures. Collect a series of weather maps and their companion satellite pictures. Answer the following:

- **Are there any relationships between the satellite pictures and their companion weather maps?**
- **Do you see any regular pattern changes from one daily weather map to the next? Are you able to predict what the weather map will look like the next day? (See the section 'Resources' in this topic for websites relating to forecasting.)**

ACTIVITY: INVESTIGATING STORMS

Hurricanes, tornadoes, cyclones etc. all arise through large variations in atmospheric pressure. Search the Internet to explore one of these phenomena. Answer the following:

- **Under what conditions does this type of storm arise?**
- **Where in the world is this type of storm most frequent? Why? Does Australia have them?**
- **What effect on the environment does this type of storm have?**
- **Can they be predicted? What precautions should people take?**

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