ATMOSPHERE

Teacher Guide
including
Lesson Plans, Student Readers, and More Information

Lesson 1 - Composition of the Atmosphere

Lesson 2 - Air Pressure (Lab)

Lesson 3 -The Causes of Wind

Lesson 4 - Movement in the Atmosphere (Lab)

Lesson 5 - Pollution or Just Evolution

designed to be used as an Electronic Textbook
in class or at home

materials can be obtained from the Math/Science Nucleus

EARTH SCIENCES - ATMOSPHERE

Lesson 1 - Composition of the Atmosphere

MATERIALS:

reader

Objective: Students learn about the history of air and the composition of Earth's atmosphere.

Teacher note

The Earth is surrounded by a blanket of air called the atmosphere. The proportion of gases found in the atmosphere, changes with height. Four distinct layers have been identified using thermal characteristics, chemical composition, movement, and density. However, all of the "layers" grade into each other and it is difficult to define an upper and lower limit.

The troposphere is the layer in which we live. It has abundant water vapor to propel the water cycle. The other layers include the stratosphere, mesosphere, and thermosphere (ionosphere and exosphere).

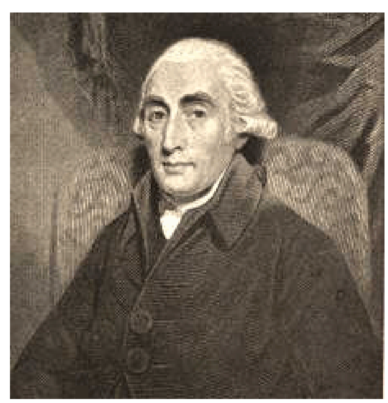
This reader will help students understand the difficulty of researching air. Sometimes, the very substance we are surrounded in, is impossible to see and understand.

Earth's atmosphere

We sometimes take the air we breathe for granted. Ever since our first breathe we have continuously taken oxygen out the air, without thinking how **oxygen** got there. Our body creates **carbon dioxide**, which we exhale and that gas is added into the atmosphere. Each one of us is changing the atmosphere.

In ancient civilizations, people could not understand the origin of many substances. **Wind** could be gentle as it brought a cooling effect, but could be devastating in a storm. Wind seems to come from outer space, but is invisible. You can feel and hear it, but you can't see it. Air as a mixture of gases, was not really understood until the late 1700's.

It took a few scientists to discovered the composition of air. Joseph Black in the mid 1700's discovered "fixed air," or what we call carbon dioxide. He described the gas that was released from magnesium carbonate. As he learned the properties of carbon dioxide, he could then isolate it in air.



Joseph Black

Joseph Priestly

Joseph Priestly was fascinated by gases. He lived near a brewery and noticed a heavy air with a distinct odor. He realized that this gas, carbon dioxide, could extinguish a fire and if bubbled through water would give it a pleasant and tangy taste (soda pop). He also discovered in 1774, oxygen or what some people referred to as "fire air" because it could burn. He also discovered that plants released oxygen, and mice could survive with a plant inside a glass jar. Priestly tried to adjust his discoveries with the **Phlogiston Theory**. Prior to the 1760's people felt that "phlogistons" were responsible for animals dying in an airtight container. Priestley told French chemist Antoine Lavoisier of his discovery.

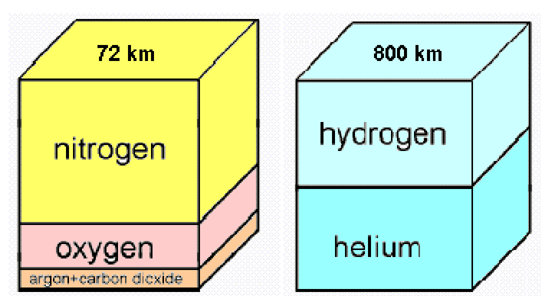
The Phlogiston Theory was then debunked by Lavoisier as he refined Priestley's experiments. This Frenchman used precise measurements to become one of the first chemists to suggest that air was composed of different gases.

Antoine Lavoisier

Gas (Symbol)	Percentage
Nitrogen (N)	78.03
Oxygen (O)	20.99
Argon (Ar)	.94
Carbon dioxide (CO2).	.035 -.04
Hydrogen (H)	.01
Neon (Ne)	.012
Helium (He)	.0005
Krypton (Kr)	.0001
Ozone (O3)	.00006
Xenon (Xe)	.000009

Air takes up space and has weight. It is made of a mixture of different gases which changes with altitude. At the surface of the Earth, air is a mixture of the gases including nitrogen, oxygen, argon, carbon dioxide, hydrogen, and various other rare gases. The percentage of carbon dioxide varies slightly depending on the presence of vegetation. There are also traces of **ammonia**, hydrogen sulfide, oxides, sulfur dioxide, and other gases. The percentage of dry air varies little at different locations on the Earth's surface.

However, as you travel upward in the atmosphere the percentage of the gases changes. At 800 km there is only hydrogen and helium in about equal proportions.

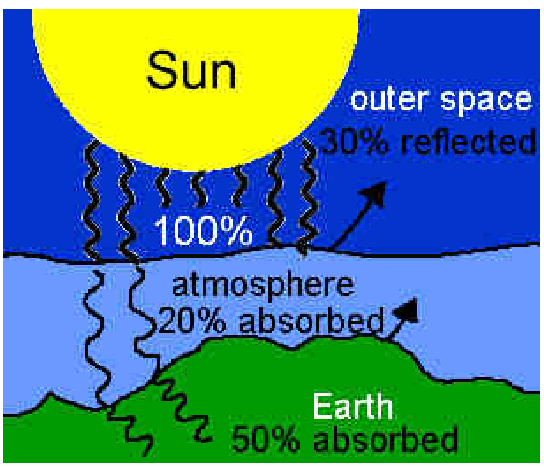


Changing percentages of air with altitude

Weather is created in the troposphere

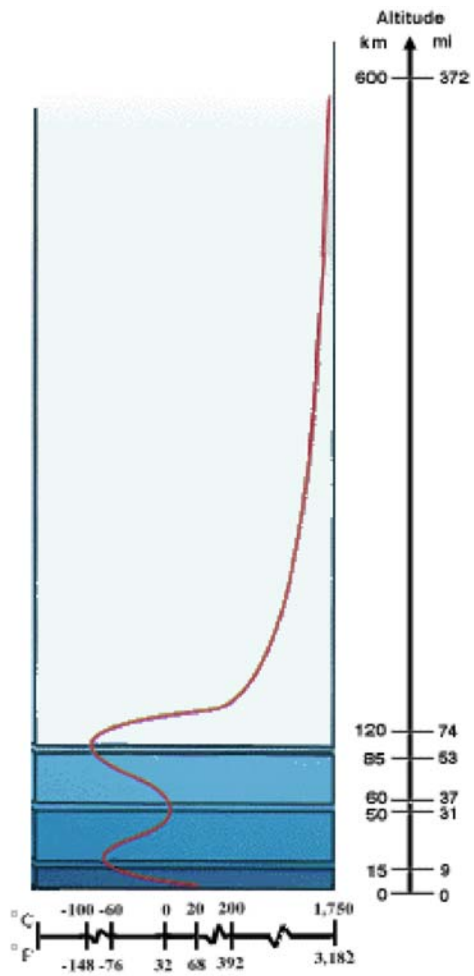
Air makes up the majority of the atmosphere. However, you have to include particular matter like water and dust to get a complete picture of our atmosphere. The atmosphere, a thin shell of gases that envelops the Earth's surface, is all around us. The pressure of air decreases with altitude. The average pressure at sea level is 760 mm Hg (mercury), at 4.8 Km it is about 400 mm Hg, at 16 Km it is about 40 mm Hg, and at 48 Km it is only 0.1 mm Hg.

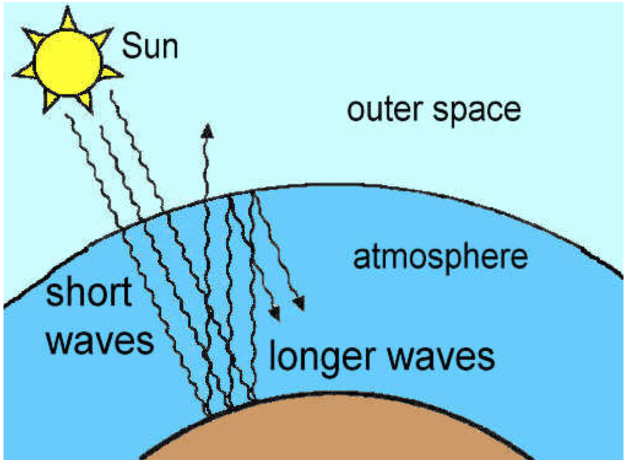
Without the atmosphere, the Earth would be very different. Without gases in the atmosphere, there would be no scattering of sunlight, so the sky would be black, not blue. Stars and planets would be visible, even in the day time. With no atmosphere, there would be no weather; the wind would not blow; and it would never rain.



If the Sun heats our Earth, why does it get colder the farther you go up in our atmosphere, and then it gets warm again just before going into outer space? If you have ever traveled by plane, you would have seen ice crystals form on the outside of the window.

Solar radiation enters the Earth's atmosphere usually is in the form of **electromagnetic waves**. As the Sun'S rays enters the atmosphere, the **radiation** gives off heat energy. As it reflects from the Earth's surface (land or water) it gives off heat energy as it reflects. Snow, soil, meadows, concrete, and clouds all have a different **albedo**. The albedo is the fraction of light that is reflected by a body or surface. The atmosphere and Earth interface like a house of mirrors, producing energy with each reflection.



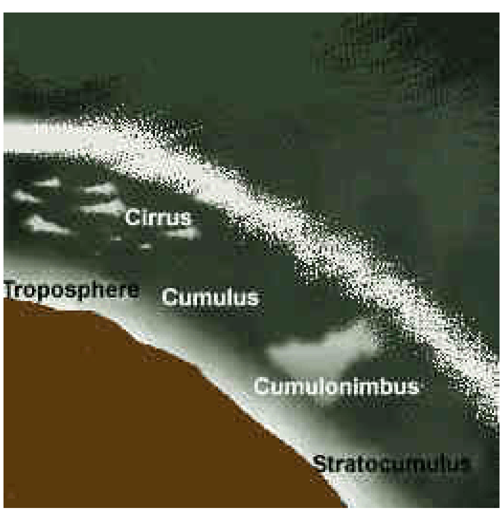


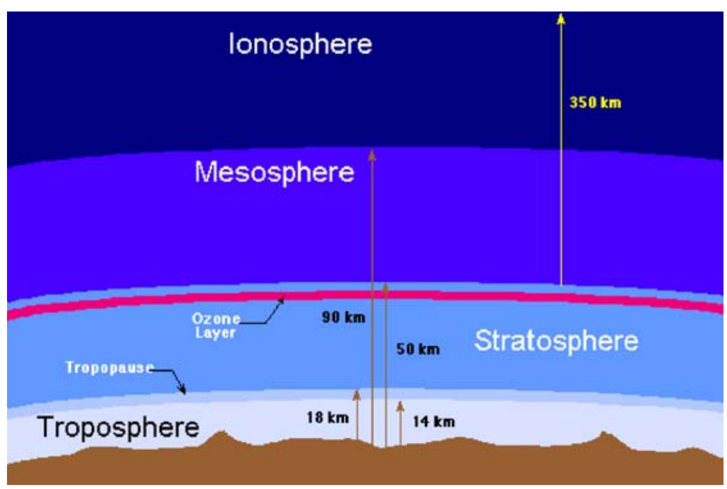
The atmosphere is also responsible for the **greenhouse effect**. Some atmospheric gases, especially carbon dioxide (CO_2) absorb heat, and keep the Earth's surface warm. The Earth's surface would be very cold. The surface temperature would probably be lower than freezing, so all water would be solid. Most life forms depend on liquid water, so, without an atmosphere, it is unlikely that life would have evolved on Earth.

The layering of the atmosphere through time, has created a stable environment. Organisms have adapted and evolved to take advantage of the gases needed for life that the atmosphere has to offer.

The atmosphere is layered between the surface of the Earth and outer space. The layer we live on is called the **troposphere**. The air moves up and down, the winds blow, moisture builds up, and different types of **weather** are created. The troposphere extends from the surface up to about 15,000 meters. As you increase height above the Earth's surface, the temperature drops from 17 to -52 degrees Celsius. Its limits are defined by an increase of temperature.

Almost all weather such as clouds, storms, rain, and snow occur in this region. It contains most of the atmosphere by weight.





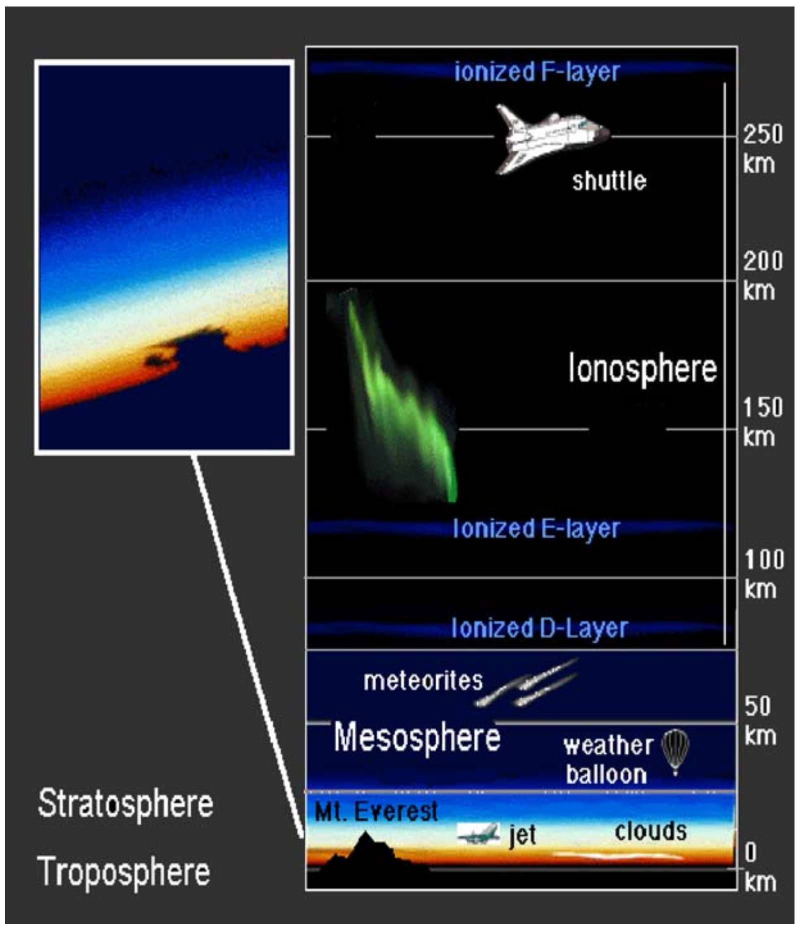
Division of the atmosphere

Stratosphere is above the clouds
shown in the darker brown

The layer above the troposphere is called the **stratosphere** which is 32 kilometers thick (20 miles). This is a region of horizontal air motion and where you find the jet stream. The jet stream is high winds blowing at about 300 km/hr. The jet stream helps airplanes go faster, when the plane goes in the same direction as the wind.

This stratosphere is usually devoid of clouds and has temperatures ranging from -50 to 60 C. The temperature increases gradually, due to the **absorption** of **ultraviolet radiation**. The upper part of the stratosphere contains a higher percentage of **ozone**. This layer of ozone is a form of oxygen that protects the surface of the Earth from the Sun's ultraviolet rays. The uppermost layer of the stratosphere is called the **stratopause**.

The next layer is called the **mesosphere** which is much colder than the stratosphere. The **thermosphere** is the next very thick layer of the atmosphere which is first exposed to the Sun's radiation. It can be extremely warm and can heat up to 600 degrees Kelvin. The thermosphere is divided into the **ionosphere** and **exosphere**. The ionosphere has slightly increasing temperatures and is composed of electrified particles or **ions**. The ions are caused by solar radiation acting upon gases. **Radio waves** from Earth hit the ionosphere and bounce back to Earth. This makes it possible for you to hear a radio station. The ionosphere has different layers labeled D, E, E2, F1, F2, and G. These layers act as a ceiling upon which radio and TV waves bounce back. D and E exist only when the Sun is shining on them. E reflects AM band on radio and F reflects AM, FM, and TV. At night the E and F combine into one layer.

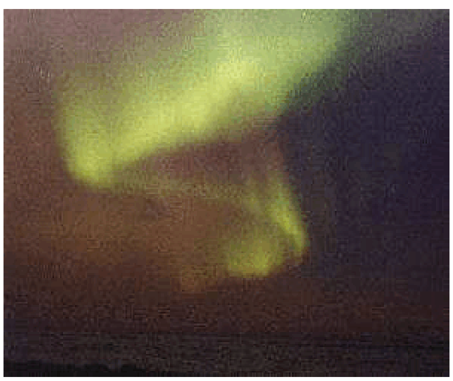


Exosphere

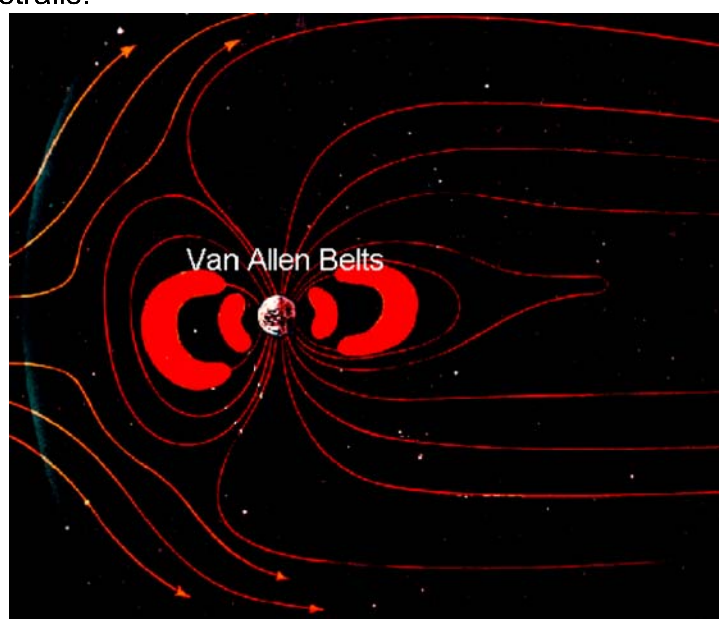
The exosphere is the upper part of the thermosphere and continues until it gradually merges with **interplanetary** gases or outer space. In this low density region hydrogen and helium are the prime components.

The Earth is also constantly bombarded with the solar wind, which are **plasma particles** generated by the Sun. We are protected from this onslaught of radiation by the **magnetosphere** which is above our atmosphere. The envelope of gas becomes less and less as you go into space. The magnetosphere is a complex configuration of plasma, particles and electrical currents in a forever changing situation.

The magnetosphere interacts with the atmosphere occasionally, especially when the magnetosphere is disturbed by solar winds. The upper atmosphere is bombarded with charged particles. This sometimes interferes with transmission of electromagnetic waves and may affect the ozone layers. Along the poles this region is called the **auroral ovals**. In the North Pole they are called the Northern Lights or aurora borealis. In the southern area they are referred to as the aurora australis.



Aurora borealis or Northern Lights



EARTH SCIENCES - ATMOSPHERE

Lesson 2 - Air Pressure

MATERIALS:

reader
bottle or Erlenmeyer flask
matches, straw
ping pong ball
hard boiled egg

Objective: Students experiment with air pressure.

Teacher note

Atmospheric pressure refers to the weight of the air exerting a force or pressure on an object. All things, living and non-living, are subjected to this pressure. Students do not usually think of themselves being on the surface of the Earth with tons of air on them. They assume that they could not possibly be able to walk around with such pressures placed upon them.

Air has weight as evidenced by the pressure it exerts. It is a mixture of several gases, mainly nitrogen and oxygen. Nitrogen, which makes up the largest portion of air (78%) is relatively inactive chemically. Oxygen makes up only about 21% of the air, but is very important to us to live. The air also contains small amounts of inert gases such as argon and carbon dioxide. The important object of the following activities is to demonstrate to students that air has substance, which has weight and can exert pressure. These principles are important because they explain why we have different weather patterns.

There are many experiments on air that can be used to illustrate different concepts. Asking students how does their house get warm or cool, can bring a discussion on warm air rising and cool air sinking.

Air is all around us, so we forget to challenge why things happen in the atmosphere. Even tires for our cars or bicycles require air pressure to make movement easy. Ask students, why you can't move with a flat tire? If you get trapped in a burning room, why should you crawl on the bottom? Smoke is warmer and contains more carbon monoxide, the oxygen which is heavier drops to the lower portion of the room.

We suggest you demonstrate air movement by putting a balloon over the opening of a cool Erlenmeyer flask. Then put hot water in a pan and put the flask in the pan. The air will become warmer and expand, making the balloon larger. Having students experiment with air pressure in the three activities discussed in the reader and lab will help them understand the mystery of air.

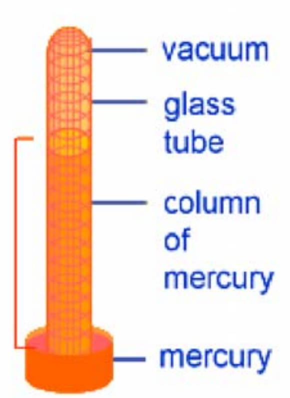
Air has weight and exerts pressure when contained. Air weighs more than five quadrillion tons, but yet we can't see, smell, or feel it. Air is a powerful force on Earth exerting pressure on all organisms. Even when you take a breath of air into your lungs, you are changing the pressure. When you blow in air, you increase the molecules of gas; when you blow, you decrease the pressure. The pressure inside your body actually prevents the **atmospheric pressure** from squishing you. However, if we visited Jupiter, the surface pressure would squish us like a bug.

Divers use pressurized tanks to breathe

Astronauts that go into space or divers that go under the ocean must take **pressurized air** with them. If we climb a mountain that is too high, the air becomes less and less breathable. The downward force exerted by overlying air causes greater pressure at the bottom of the atmosphere. Air molecules are actually "squeezed" by the weight of the air above. The pressure is measured as101,325 Pascals which is called 1 atmosphere of pressure on the surface of the Earth. We can live at 1 atmosphere, but once it gets below (outer space) or higher (under the ocean) we have to create pressurized cabins to keep our pressure at 1 atmosphere, so we don't "pop."

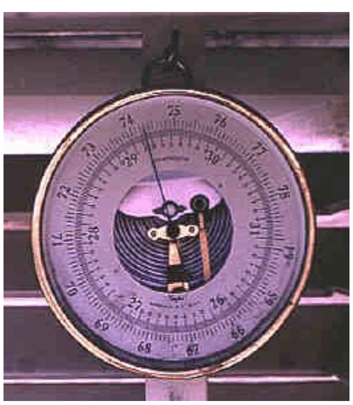
Astronauts required pressurized air for their entire body

An instrument called a **barometer** measures the atmospheric pressure. The barometer was invented using principles developed by Evangelista Torricelli in 1643. It uses a long glass tube with one end closed and the other open. Air pressure is measured by observing the height of the column of mercury in the tube. At sea level, air pressure will push on the mercury at the open end and support a column of mercury about 30 inches high. Barometers are used to measure the air pressure in "inches of mercury" or in millibars (mb). The typical pressure at sea level is 1013.25 millibars or 14.7 pounds per square inch.



Principle of mercury barometer

As atmospheric pressure increases, the mercury is forced from the reservoir by the increasing air pressure and the column of mercury rises; when the atmospheric pressure decreases, the mercury flows back into the reservoir and the column of mercury is lowered. There are other types of barometers that record the changing atmospheric pressure in the air.

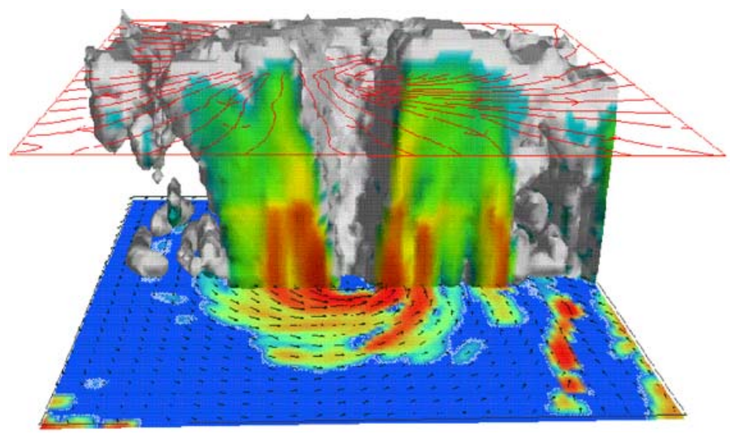


Barometer based on metal sensitivity

Centripetal force prevents you from falling

Gravity, including **centripetal force** of a spinning sphere, pulls on air molecules to stay on the surface. As the Earth spins, the gas molecules response by staying close to the ground. Imagine you are at the amusement park and you enter into a ride. It is circular and they strap you in a cell. The ride begins by spinning and spinning, then the floor starts to fall. You feel like you will fall with the floor, but you don't. You are still "stuck" to the sides by centripetal force.

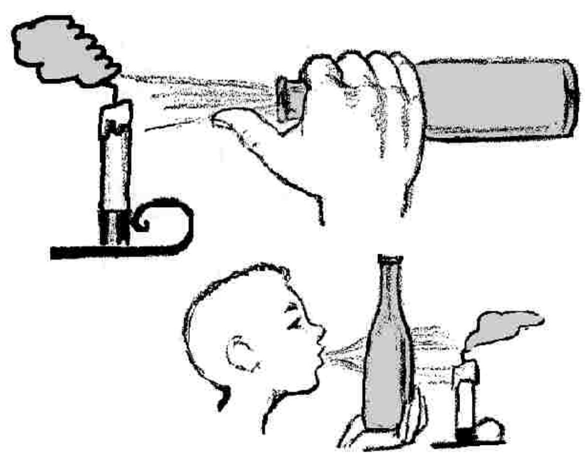
Movement of the air molecules is also caused by the density of each of the gases. For example, helium is lighter than oxygen so it tends to "escape" into the upper reaches of the atmosphere. Movement of air is dependant on temperature, rotation, and density. Air pressure also changes with height of the atmosphere. The interplay of air pressure can create "fun" activities. Once you do the following demonstrations in lab, you can create similar experiments to amaze your friends.



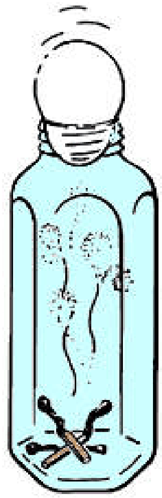
Vertical distribution of wind in a hurricane

Why does a small flame on a candle go out when you blow on it? Does the wind just "blow" it out, or is there something in the gas? If we exhaled pure oxygen, the flame would get larger, but because we exhale carbon dioxide, it **suffocates** the flame. Can you create a way to capture carbon dioxide and help extinguish the flames?

Put your thumb on an empty bottle then blow as hard as you can to trap exhaled air rich in carbon dioxide. Rapidly cover the opening. Aim the bottle at the candle flame and quickly remove your thumb. The "puff" puts out the flame.



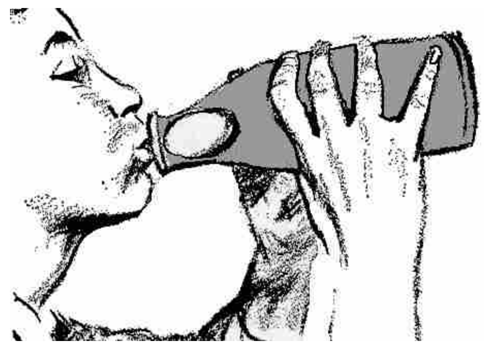
Light the candle again and hold the bottle between your mouth and flame. The bottle is in the way of the carbon dioxide, so why does the flame go out this time. The air moving past the bottle creates a partial **vacuum** behind the bottle (no oxygen) and the air rich in carbon dioxide rushes in to fill the vacuum and puts out the flame.


Egg in bottle

This experiment is traditionally called the "Egg in the Bottle." This is a dramatic way of demonstrating the effects of air pressure by putting a hard boiled egg into a bottle with a small opening and getting it out in one piece.

Get a boiled egg and remove the shell. Use a bottle **or Erlenmeyer flask** where the egg cannot go through the opening. The air in the bottle has no outlet, it will resist any pressure on the egg to slip in, unless you change the air pressure inside.

Drop a burning match into the bottle just before you put the egg on the top of the bottle. When the flame goes out, the air cools and contracts, forming a vacuum or low pressure. The egg will fall inside, all by itself. The greater pressure outside the bottle forces the egg into the bottle.

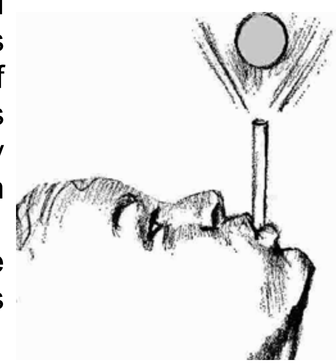


To get the egg out, you have to change the pressure again. Turn the bottle upside down so the egg falls into the neck. Tip back your head and blow vigorously into the inverted bottle. When you remove your lips, the egg will pop out quickly.


Daniel Bernoulli

If you blow over a piece of paper, it actually lifts up. This is caused when air flows over a surface and its speed increases and its pressure decreases. This is the **Bernoulli's Principle** and it explains how an aircraft wind can generate a lifting force, just like in the piece of paper. Daniel Bernoulli in the 1700's first developed different aerodynamic principles that helped explain not only planes but why roofs can just lift off a house during a hurricane.

By blowing hard and steady, you can demonstrate a version of Bernoulli's Principle. With a piece of straw and ping pong ball, you can demonstrate magical "floating. You need to shoot a stream of air directly up, as in the diagram. You can use a hair dryer if you are doing this at home. The air is in rapid motion. Its pressure is lowered. The floating ball is actually kept in place by the column of upward rushing air. If it wobbles, the "jet stream" on either side, forces the ball back to its optical illusion.



There are many tricks that you can perform with air. These exercises are meant to open your eyes to explain the mysterious "ghosts" that open and close doors in your house.

WATER SCIENCE - ATMOSPHERE

PROBLEM: Can air pressure cause movement?

HYPOTHESIS:

PROCEDURE: Follow the instructions below and record your observations.

EXPERIMENT 1. Blowing out a Candle

Materials: candle, match, bottle with small opening or Erlenmeyer flask

1. Light a candle.
2. Blow air into a bottle with a small opening. Use your thumb to capture the air inside.
3. Turn the small opening toward the flame and release the air. Record what happens.
4. Relight the candle, hold the bottle between you and the flame and blow. Describe what happens to the movement of the air.

EXPERIMENT 2. Egg in a Bottle

Materials: hard boiled egg, bottle with opening just small enough where egg cannot get through

1. Use a peeled boiled egg, a bottle with an opening just large enough to prevent the egg from falling through, a small piece of paper and a match.
2. Set fire to a small piece of paper.
3. Place the paper into the bottle, and quickly place the egg on the top of the bottle. Then try to get the egg out.
4. Record what happens. Can you explain why?

Experiment 3. The Floating Ball

Materials: straw, ping pong ball

1. Put straw in mouth and tip back of your head to make a vertical direction of the straw.
2. Put a ping pong ball a few cm above the straw while you blow with a steady, but forceful blow. You may have to experiment to make sure the stream of air is vertical.
3. Describe what happens.

CONCLUSION:

EARTH SCIENCES - ATMOSPHERE

Lesson 3 - The Causes of Wind

MATERIALS:

reader

Objective: Students learn about the movement of wind.

Teacher note

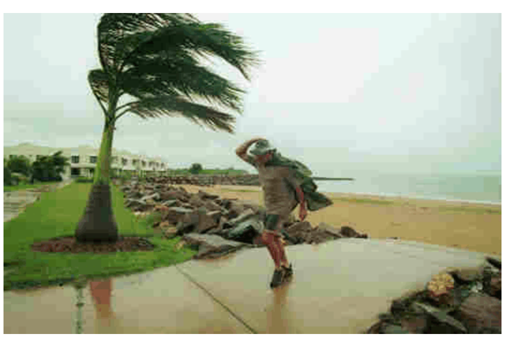
Students experience wind all the time, but many do not understand the causes of wind. Basically it is caused by the spacing of air molecules when air is cooled or warmed. The molecules of warm air are fewer and farther apart, compared to cool air. The warm air is lighter and moves upward. Cool air is denser and goes to the bottom forcing the warm air up even faster. Whenever you start movement, it has to displace other air.

The oceans are a fluid of water as the atmosphere is a fluid of air, and they are guided by similar principles. As in water, warm and cool air masses do not mix because their densities are different, and prevent co-mingling. An air mass is a large body of air that is homogeneous with respect to its temperature and moisture. These air masses displace other air masses, causing wind throughout the world.

Wind is a **paradox**, to some it causes damage, but to others it brings joy. The gentle breeze on a warm day can bring back good memories of childhood. Torrential winds in a hurricane, tornado, or **monsoon** can bring pictures of destruction. Wind to a sailor in the early days of shipping was a blessing, however, a lack of wind or too much wind could cause untold damages to the ship and crew. Just what is this wind?

Sail boarding

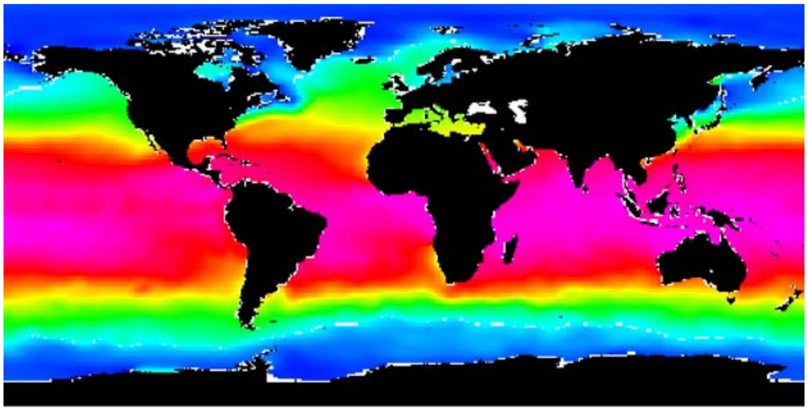
Wind's movement is dependant on several factors including temperature, rotation of the Earth, topography, and geography. These all play a vital role in determining the wind direction and speed. Wind is three dimensional, and changes throughout the column of atmosphere. There are many areas that are faster than others because of combined physical factors.



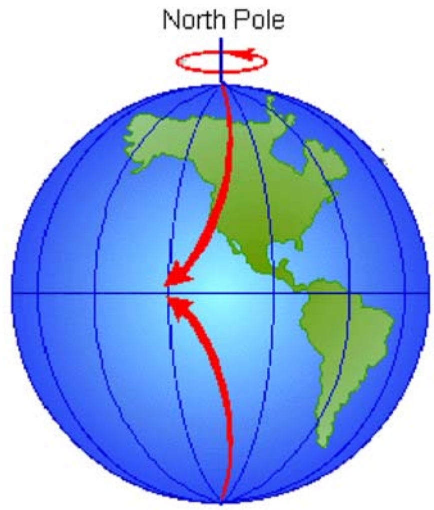
Extreme winds

The heating of air molecules from the Sun is the primary mover of air. The Sun's radiation and the tilting of the Earth on its axis cause uneven heating of our atmosphere. Unlike the land and ocean, the air responds quickly to heat changes. These differences in temperature help move the wind.

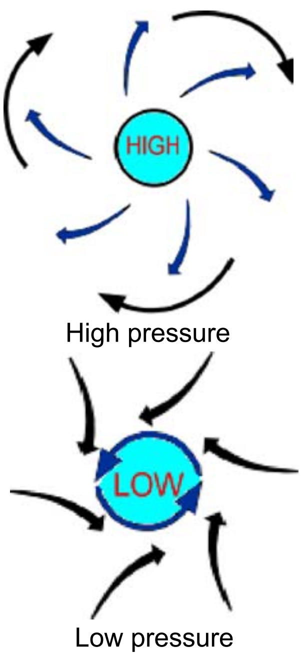
The other major cause of winds is the rotation of the Earth. The Coriolis effect, which we discussed as a cause of ocean currents, moves air currents as well.



The red is the hottest temperature and the blue is the coolest temperature for air masses



Deflection caused by rotating Earth

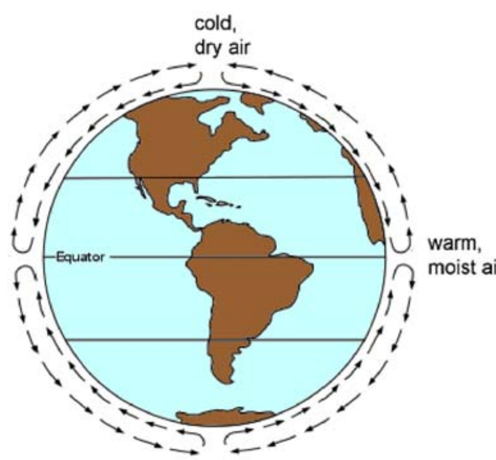


High pressure

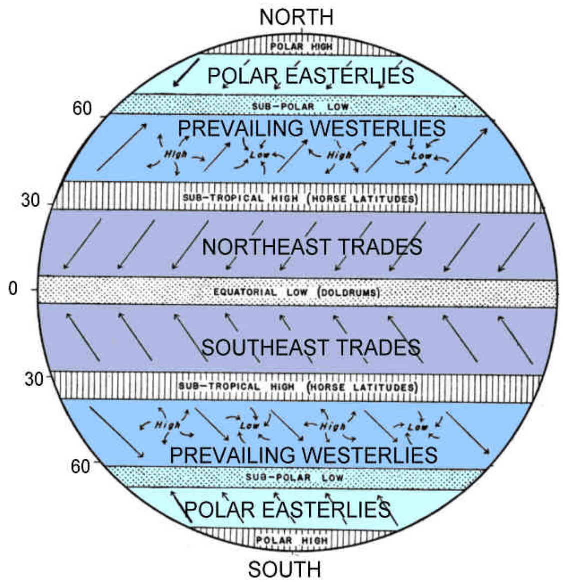
Low pressure

In zones where air ascends, the air is less dense than its surroundings and this creates a center of low pressure. Winds blow from areas of high pressure to areas of low pressure, and so the surface winds would tend to blow toward a low pressure center.

In zones where air descends back to the surface, the air is more dense than its surroundings and this creates a center of high atmospheric pressure. Since winds blow from areas of **high pressure** to areas of **low pressure**, winds spiral outward away from the high pressure. The Coriolis Effect deflects air toward the right in the northern hemisphere and creates a general clockwise rotation around the high pressure center. In the southern hemisphere the effect is just the opposite, and winds circulate in a counterclockwise rotation about the high pressure center. Such winds circulating around a high pressure center are called **anticyclonic winds** and around a low pressure area they are called **cyclonic winds**.



Basic movement of wind from warm to cool areas on the Earth

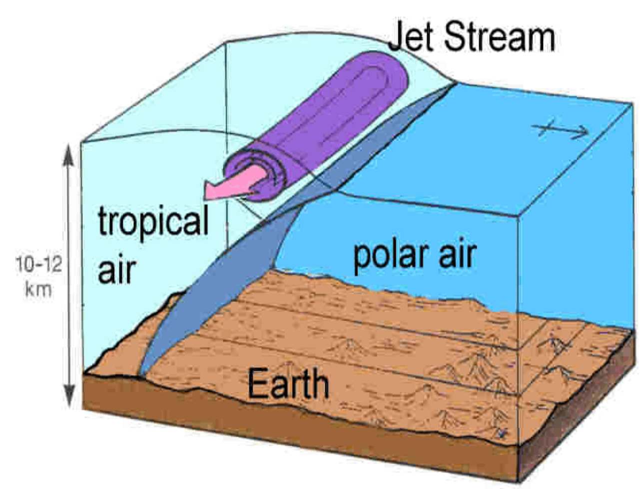


The **Coriolis Effect** provides a general wind pattern in belts. The rising moist air at the equator creates a series of low pressure zones along the equator. Water vapor in the moist air rising at the equator condenses as it rises and cools causing clouds to form and rain to fall. After this air has lost its moisture, it spreads to the north and south, continuing to cool, where it then descends at the mid-latitudes

Descending air creates zones of high pressure, known as subtropical high pressure areas. Because of the rotating Earth, these descending zones of high pressure veer in a clockwise direction in the northern hemisphere, creating winds that circulate clockwise about the high pressure areas, and giving rise to winds that blow from the northeast back toward the equator. These northeast winds are called the **trade winds**. In the southern hemisphere the air circulating around a high pressure center moves toward the left, causing circulation in a counterclockwise direction, and giving rise to the southeast trade winds blowing toward the equator.

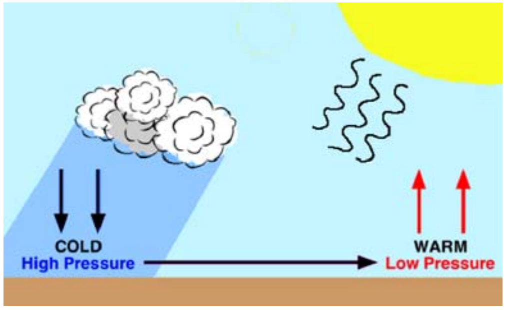
Air circulating north and south of the subtropical high pressure zones generally blows in a westerly direction in both hemispheres, giving rise to the prevailing westerly winds. These westerly moving air masses again become heated and start to rise, creating belts of subpolar lows.

The circulation pattern discussed above is mainly true on the surface movement. The atmosphere, like the oceans, have differences throughout the air column which cause changing weather. For example, when warmer air lies above polar air it, causes wind to blow parallel to where they meet. This produces a "jet" of strong air on a continuous basis referred to as the "**Jet Stream**."



Jet Stream

Atmospheric circulation is further complicated by the distribution of land and water masses on the surface of the Earth and the topography of the land. The oceans are the source of moisture and the elevation of the land surface helps control where moist air will rise. Climatic zones depend not only on latitude, but also on the distribution and elevation of land masses. In general, however, most of the world's desert areas occur along the mid-latitudes where dry air descends along the mid-latitude high pressure zones.



Heating air to create wind

When the Sun's rays beat down on the land near a coastal area, the rays heat the air over the land quicker than the air over the oceans. Circulation is started when a "sea breeze" of cool air sweeps in from the ocean, pushing up the air warmed by the land which then rises (less dense) and streams out toward the ocean. Air cooled by the sea sinks and flows landward to fill the area of low pressure created by the warm land, causing onshore breezes. At night, the land loses its heat more rapidly than the water. The air above it is chilled, while the ocean air is relatively warm. The colder air now sweeps from the land to the water, producing the "land breeze."


Fog moving into San Francisco Bay

This is best illustrated in the San Francisco area in California where you can see the wind blow the fog toward the hotter land. East of San Francisco the land gets very hot. The cold Pacific water is to the west. As the land heats up, the wind moves the **fog** quickly into San Francisco. It is very dramatic because there are coastal mountains that prevent the fog from going through most of the areas, so the fog rolls in through the Golden Gate bridge. Many people have never seen such a sight.


Horizontal wind power


Wind mill

Wind can be used to create energy. In the early days wind would turn windmills, which helped turn a grinding stone helping to grind agriculture products. Today wind is used in "wind farms" to harness the energy and convert it to electrical energy. Wind turbines have large blades to catch the wind, which turns generators to produce electricity. In many parts of the world, wind power is becoming more attractive. The Danish are noted for their use of wind power as a major source of electricity.


Vertical wind power

There are two types of wind powered turbines the horizontal and vertical. Horizontal-axis wind turbines have blades that spin in a vertical plane like airplane propellers. The wind moves rapidly over one side, creating a low pressure area behind the blade and a high pressure area in the front. The difference between these two pressures creates a force which causes the blades to spin. The vertical form uses the same principles, but have an egg beater look.

You are traveling to New York from California and it takes about five hours. However when you return to California from New York, it takes 5 ½ hours. Why is there a difference? Going to New York, the pilot knows to "ride" the jet stream. These winds make the plane go faster.

Understanding and charting wind direction and speed is important. Navigation in the air and the oceans requires this information to take advantage of these free natural rides. Wind direction is measured by a simple weather vane.

Speed is measured with an anemometer usually in kilometers per hour (or miles per hour). However, a navigator uses "knot" which is equivalent to 1.85 km/hr (1.15 mi/hr). Wind speed is also given as a force, called the Beaufort wind Scale which helps describe the effects seen on land and compare them to wind speeds.

Wind Vane

EARTH SCIENCES - ATMOSPHERE

Lesson 4 - Movement in the Atmosphere

MATERIALS:

reader
worksheet

Objective: Students chart the movements of air in the atmosphere.

Teacher note

In this exercise students trace air patterns onto an ocean current map. This skill helps them to visualize how the wind and air currents are similar or different.

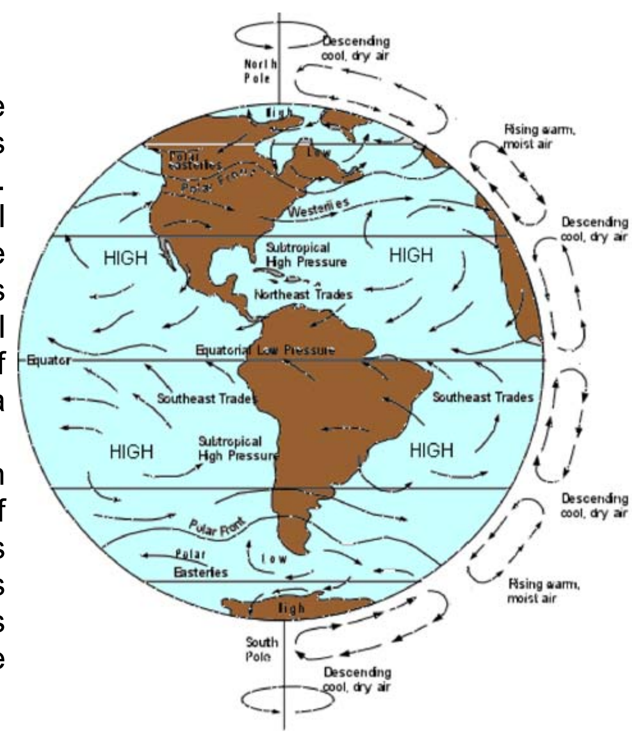
The students' answers may differ depending on which map they use to transfer the information. Basically, the wind maps are more complicated than the ocean current maps. The ocean currents are only in the ocean, while the air currents are world wide. The land is a barrier that the oceans cannot overcome, while the wind may be deflected, but easily sails over the land.

If students want to find wind speed at their location in the United States they can consult the following web site:

http://www.wunderground.com/

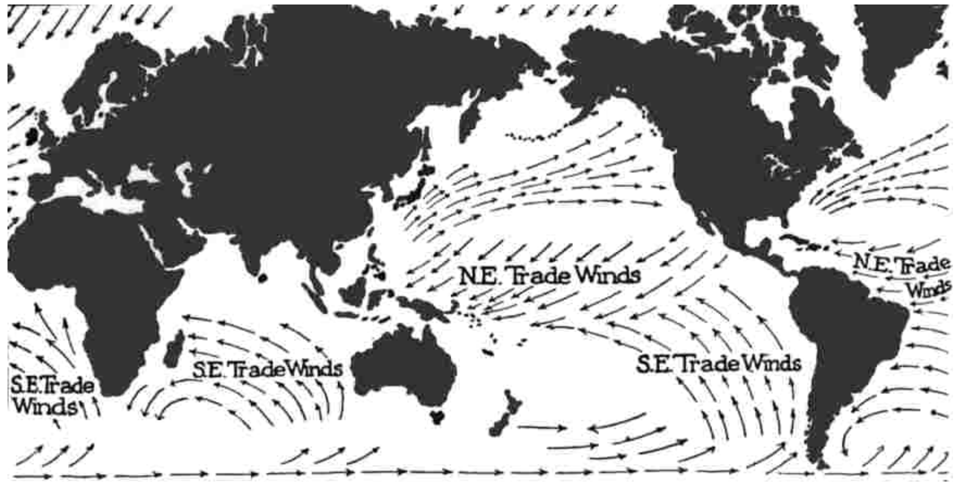
The Earth is a rotating sphere. The atmosphere, as well as the hydrosphere (oceans and large lakes), move because of this rotation. There is a difference between local and general worldwide winds. General winds include those that stretch thousands of miles over the Earth's surface with almost permanent directional patterns. Local winds are characteristic of particular geographical regions and exert a pronounced influence on the local climate.

The pattern of the general wind circulation is primarily determined by the unequal heating of the atmosphere at different latitudes and altitudes and by the effects of the Earth's rotation (Coriolis effect). The general wind pattern includes doldrums, jet stream, polar easterlies, trade winds, and westerly winds.



Doldrums refer to a quiet area along the equator where the wind doesn't blow for long periods of time.

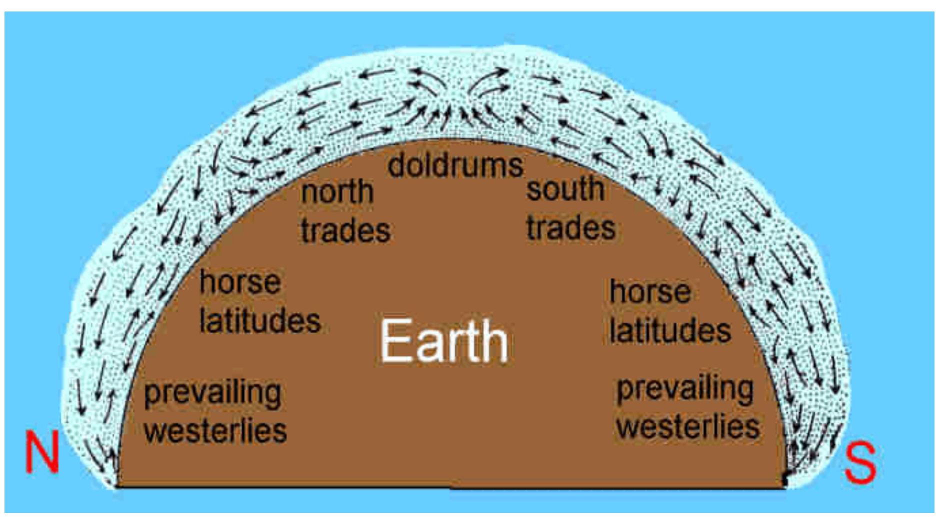
The trade winds are characterized by the steadiness of their direction and speed, especially over the oceans. The jet stream refers to a narrow current of strong westerly winds in the upper troposphere.



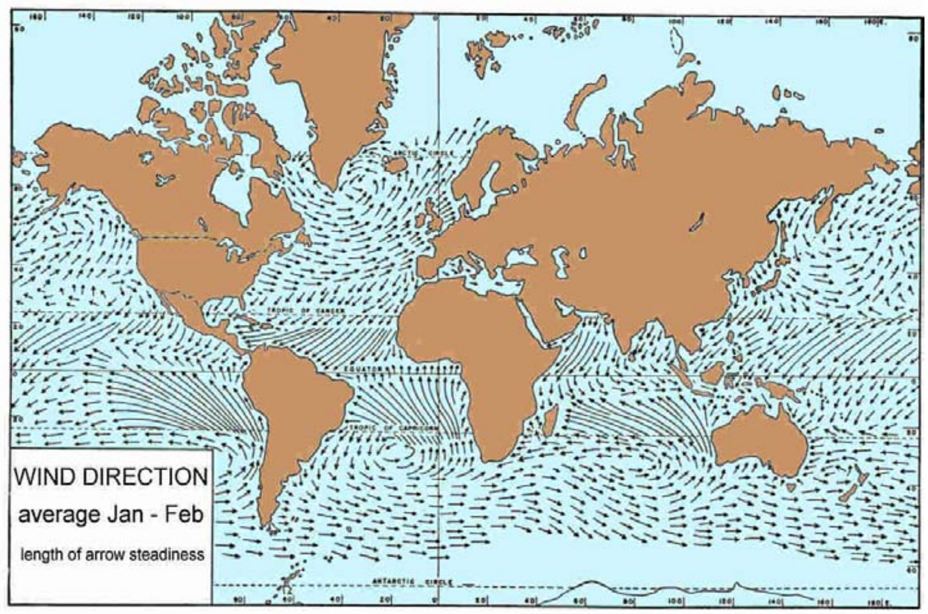
The polar easterlies refer to an easterly wind belt found between the weak polar high pressure area and the westerly depression. The trade winds are predominately easterly winds that blow steadily over the ocean areas. The westerly winds are strong winds blowing from the west.

The wind pattern also changes with altitude. The air flows as a mass and like the oceans they can be layered within the troposphere. The warming and cooling of the air masses can change the direction rapidly. However, the Coriolis Effect will always imprint the general circulation pattern.

The land will also play a part in some areas more than others. For example, the air over the Indian Ocean does not change as quickly as the air masses over the Eurasian continent. This causes major directions of wind depending on the season, which are cause monsoons. These are seasonal changes in wind patterns.



Use the different wind direction maps in this and the previous reader and transfer the information onto the map of the ocean currents that is included as a worksheet. Answer the questions and see how the circulation patterns are different or the same. This will become important in understanding and predicting the weather, which is the interaction of the atmosphere and the ocean and land patterns.



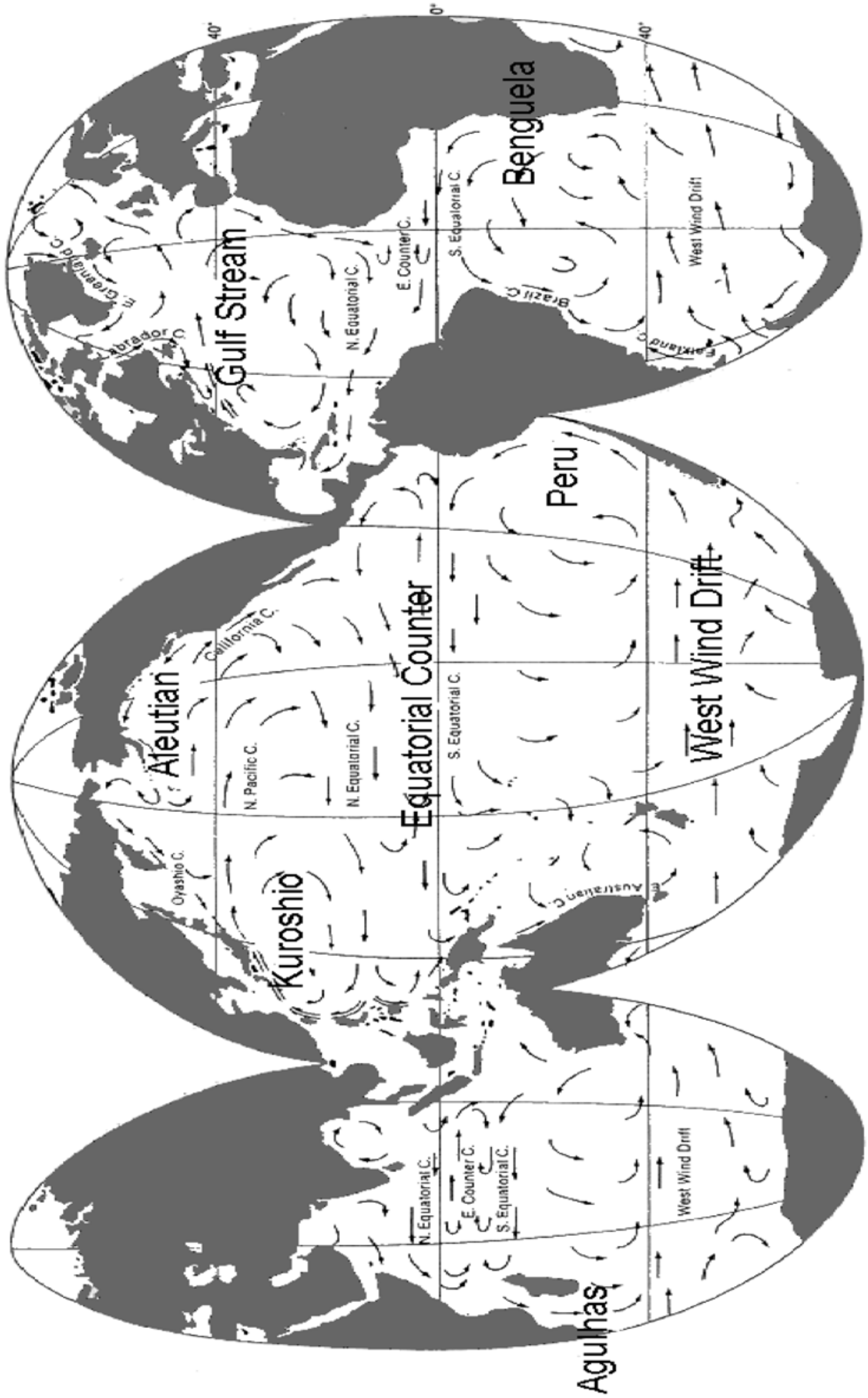
EARTH SCIENCE - ATMOSPHERE

PROBLEM: How does the ocean circulation pattern compare with the air circulation pattern?

HYPOTHESIS:
MATERIALS: simplified map of ocean currents, maps or internet on wind direction
PROCEDURE: Use the map on the enclosed sheet and trace the air patterns listed below on the map using the information found in the reader. Then answer the questions below.

	List the ocean current or land masses associated with the wind circulation.
Polar easterlies (north)	
Prevailing westerlies (north)	
Northeast trades	
Doldrum	
Southeast trades	
Prevailing westerlies (south)	
Polar easterlies (south)	

1. What causes the main directions of the wind currents?
2. What part of the atmosphere are these wind currents located?
3. What gets in the way of the air and ocean directions?


Benguela
Gulf Stream
E. Greenland C.
Labrador C.
N. Equatorial C.
E. Counter C.
S. Equatorial C.
Brazil C.
Falkland C.
West Wind Drift
Peru
Aleutian
California C.
N. Pacific C.
N. Equatorial C.
Equatorial Counter
S. Equatorial C.
West Wind Drift
Oyashio C.
Kuroshio
Australia C.
N. Equatorial C.
E. Counter C.
S. Equatorial C.
West Wind Drift
Agulhas
40°
0°
40°

EARTH SCIENCES - ATMOSPHERE

Lesson 5 - Pollution or Just Evolution

MATERIALS:

reader

Objective: Students explore the early atmosphere and how it has changed.

Teacher note

The atmosphere of today is not the same as earlier atmospheres. Organisms evolved as an atmosphere provided the ability to survive. Evolution of organisms have changed the components of the atmosphere, and will continue.

The question facing the students is to consider if human pollution is just a continuation of this evolution. Would different species evolve to thrive in such an atmosphere and would others become extinct.

Our atmosphere is fragile and humans, unlike other organisms may be able to control how the atmosphere will evolve. Can we destroy our atmosphere with burning or other daily uses of chemicals? Yes, we can. It just depends on how much we as a society want to keep our atmosphere the way it is. But there are also other organisms that are contributing and outside natural forces that are happening in the magnetosphere and thermosphere that might also be affecting our life giving atmosphere.

Pollutants in the air slowly attack the environment. Awareness of the problem and what it actually causes can help students get an idea of what is happening to the surroundings.

High air pollution levels have been associated with increased respiratory health problems among people living in the affected areas. According to the Healthy People 2000 report, each year in the United States -

* The health costs of human exposure to outdoor air pollutants range from $40 to $50 billion.
* An estimated 50,000 to 120,000 premature deaths are associated with exposure to air pollutants.
* People with asthma experience more than 100 million days of restricted activity, costs for asthma exceed $4 billion, and about 4,000 people die of asthma.

For more information consult the following web site:
http://www.epa.gov/oar/

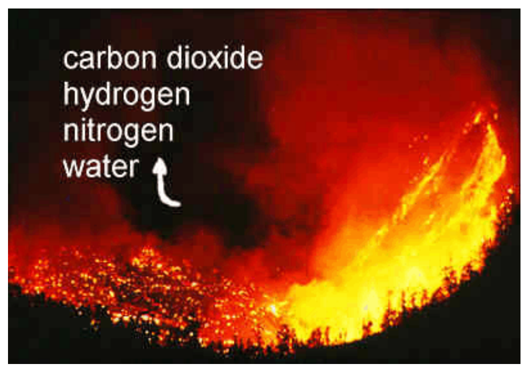
The atmosphere on Earth has evolved during its last 4.5 billion years of existence. The early Earth was probably an accretion of cool particles, possibly composed of compounds of silicon, iron, and magnesium. The particles compacted and eventually produced heat internally. The early atmosphere may have been hydrogen and helium, but it would have been lost quickly into outer space. Therefore, the Earth was devoid of an atmosphere.

Artist view of origin of atmosphere

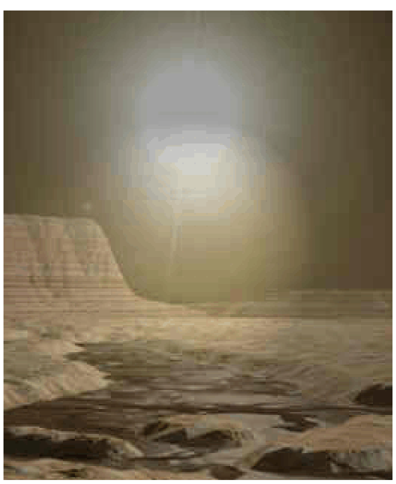
The early Earth had no oceans. Life was not even a possibility. The rocks on Earth have only witnessed the last 3.5 billion years, so we can only speculate on the early atmosphere.

Bombarding particles

The beginning of a permanent atmosphere would have formed by outgassing of volcanoes. This refers to the release of gases trapped in the interior of the early Earth. The oceans may have started to form about 1.5 billion years after the formation of the Earth. The early atmosphere was not preserved. Gases produced were probably similar to those created by modern volcanoes (H_2O, CO_2, SO_2, CO, S_2, Cl_2, N_2, H_2) and NH_3 (ammonia) and CH_4 (**methane**).



The volcanoes produced a change on Earth. The Sun's radiation probably was able to begin chemically altering the products of the volcanoes. Ultraviolet rays are noted for breaking up water molecules to produce oxygen and ozone. Enough ozone could have created a protective shield in the forming atmosphere. The atmosphere, hydrosphere, and lithosphere were all becoming suitable for life.



Can life start here?

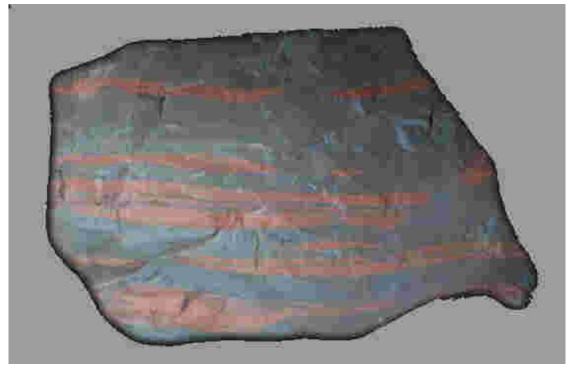
Life had a profound effect on the atmosphere. The new little critters evolved to make use of the gases available and give off other gases. It seems that organisms changed the atmosphere as they evolved through time.

Life evolved on Earth by at least 3.8 billion years ago. By about 3.5 billion years ago, primitive organisms evolved that could perform photosynthesis. **Photosynthesis** is a chemical reaction in which plants take carbon dioxide (CO_2) and water and convert them into energy using sunlight. The main byproduct of this reaction is oxygen (O_2). Oxygen thus accumulated in the Earth's atmosphere as more and more photosynthetic organisms evolved.


Stromatolites in Australia

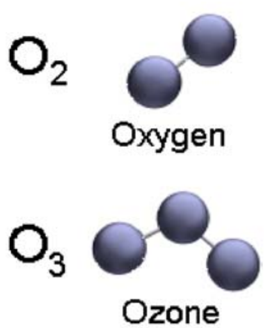
There is evidence of free oxygen in rocks, like the banded iron formation. The red is caused when iron reacts and forms oxides. Weathering became an oxygen consumer, taking free oxygen and combining it with elements. This must have been the start of an abundant supply.

Without molecular oxygen life could not have evolved to its present form. It probably originated with **cyanobacteria** (like present day **stromatolites**) creating free oxygen as a by-product of photosynthesis.


Banded iron from Wisconsin

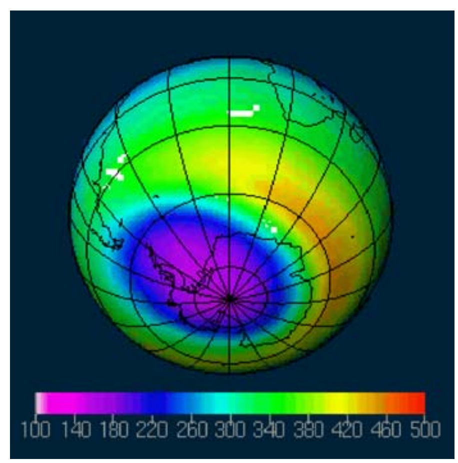
During the **Proterozoic** the amount of free O_2 in the atmosphere rose from 1 - 10%. Most of this was released by cyanobacteria, which increase in abundance in the fossil record 2.3 billion years ago. Present levels of O_2 were probably not achieved until about 400 million years.

The atmosphere has constantly changed through geologic time. Chemical reactions using gases have always occurred. Organisms seem to evolve their structure to the atmosphere. Every organism on Earth interplays with these ever-changing environments.



For instance, humans have changed their atmosphere in the short time we have been on Earth. As we discovered fire and created a use for different forms of energy we also change our atmosphere. As we discharge substances into the atmosphere, we can change its vertical structure, which may cause harm later on.

One of the concerns of our atmosphere today is the deterioration of the ozone layer which protects us from excessive ultraviolet radiation. There is a thinning of ozone over Antarctica that occurs each Antarctic spring. Up to 70% of the ozone normally found over Antarctica is destroyed. Some of the reasons for this depletion are complex. Evidence that human activities affect the ozone layer has been building up over the last 20 years, ever since scientists first suggested that the release of **chlorofluorocarbons** (CFCs) into the atmosphere could reduce the amount of ozone over our heads. But could it be other factors? How we affect it and to what degree is still being monitored and researched.



Ozone thinning in the Antarctic

Pollution directly attributed to humans in the air can cause serious problems. Problems that result from air pollution are numerous including damage to plants, animals, and people. Many of the pollutants are gases but others can be particulate matter that can obscure vision, cause lung illness, grime on buildings, and erode metals **Particulates** are a variety of sizes of particles. The primary sources are fuel, combustion, and industrial discharge.

Chihuahua, Mexico, air pollution

Burning releases pollutants into the air

Sulfur oxides are created from the burning of sulfur-bearing fuels, especially coal and low-grade petroleum products. The most abundant of the gases include sulfur dioxide, which is a colorless gas that is very corrosive to many metals. Sulfur oxides cause leaf and tree injury and irritate upper respiratory tracts in humans. They also corrode metals, disintegrate book pages and leather, destroy plants, and erode statues.

Carbon monoxide is an odorless and colorless gas. It is considered the largest single air pollutant caused by the incomplete combustion of fuels like gasoline. Carbon monoxide reacts with the blood's hemoglobin and decreases the capacity for transporting oxygen to the body's tissue. It can also cause headaches, dizziness, nausea, and impair mental processes. It can be lethal.

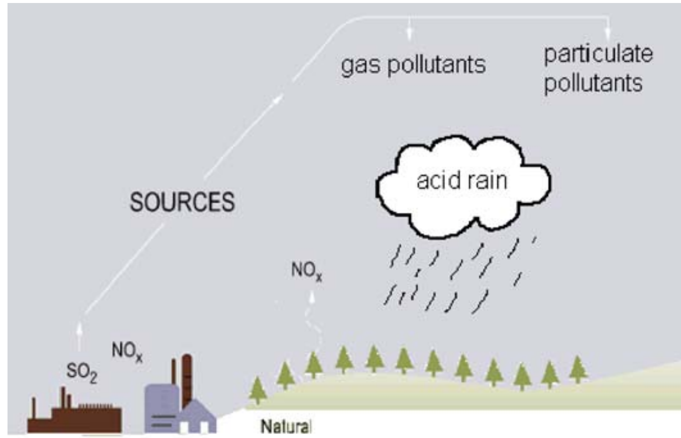
Industrial output into the atmosphere

Nitrogen oxides are yellow to brown gases with a pungent, irritating odor. It causes leaf damage, irritates eyes and nose, stunts plants, corrodes metals, and damages rubber. The haze that it produces in the air is sometimes referred to as **smog**.

Shenandoh Valley, Virginia, smog

Hydrocarbons are a complex group that forms reactions from inefficient combustion of carbon-based products. It may be carcinogenic (cancer producing), retard plant growth, and cause abnormal leaf and bud development.

Certain changes take place when chemical reactions take place among other pollutants. These would be classified as **photochemical** pollutants. For example, when sunlight acts on nitrogen oxides and certain organic compounds, ozone is produced. Sulfuric acid is another common pollutant when sulfur dioxide combines with oxygen and when combined with water forms an irritating and **corrosive** acid. Photochemical pollutants can cause discoloration of the upper surface of leaves of many crops, trees, and shrubs. It can damage and fade textiles and cause deterioration of rubber. It also is an irritant to the lungs and irritates the eyes, nose, and throat.




Effects of acid rain

Acid rain occurs when pollutant gases react in the atmosphere with water, oxygen, and other chemicals to form various acidic compounds. Sunlight increases the rate of most of these reactions. The result is a mild solution of acid like sulfuric acid and nitric acid.

Most of the pollution is caused by transportation (including cars and planes) and fuel combustion in stationary sources such as power generation. It has been estimated that over 12 billion dollars is spent on air pollution damage annually in the United States.


Pollution from cars


Papua, New Guinea

In 1990, American industry emitted more than 2.4 billion pounds of toxic pollutants into the atmosphere. Air pollution is a problem for all of us. The average adult breathes over 3,000 gallons of air every day. Children breathe even more air per pound of body weight and are more susceptible to air pollution. Many air pollutants, such as those that form urban smog and toxic compounds, remain in the environment for long periods of time and are carried by the winds hundreds of miles from their origin.

But as our atmosphere changes both naturally and by humans, evolution of the organisms within that habitat will take place. That is just the nature of change on Earth.

Earth Science - Atmosphere - Unit Test

Part 1. Definitions. Match the number of the term or concept in Column 1 with the letter of the correct definition in Column 2.

Column 1	Column 2
1. Doldrums	a. early theory on composition of air
2. Cold, dry air	b. where weather occurs
3. Greenhouse effect	c. lower part of the thermosphere
4. Ionosphere	d. considered a pollutant
5. One atmosphere	e. a molecule of oxygen with three atoms
6. Troposphere	f. Gases keep atmosphere warm
7. Trade winds	g. air masses found in polar regions
8. Phlogistons	h. quiet band around the equator
9. Ozone	i. Northeast winds
10. Sulfur oxides	j. 101,325 Pascals

Part 2. Multiple Choice. Choose the best answer to complete each statement.

1. The following gas is not found in the lower atmosphere
   a. nitrogen
   b. carbon dioxide
   c. helium
   d. oxygen

2. The following two gases are found around 800 km.
   a. oxygen and hydrogen
   b. hydrogen and helium
   c. helium and nitrogen
   d. nitrogen and carbon dioxide

3 The percentage of the Sun's radiation absorbed by Earth
   a. 50%
   b. 20%
   c. 30%
   d. 40%

4. A layer that is not part of the ionosphere
    a. D
    b. E
    c. G
    d. M

5. The Van Allen's belts are part of what layer?
    a. troposphere
    b. stratosphere
    c. magnetosphere
    d. exosphere

6. An anemometer measures
    a. temperature
    b. direction
    c. ocean speed
    d. wind speed

7. Which is not a cause of wind direction?
    a. Jupiter
    b. rotation of Earth
    c. temperature
    d. land

8. Which air current is found in the upper troposphere
    a. westerlies
    b. trade winds
    c. jet stream
    d. doldrums

9. Which substance is not considered a pollutant?
    a. oxygen
    b. carbon monoxide
    c. hydrocarbons
    d. nitrogen oxide

10. Atmospheric pressure refers to
    a. temperature and weigh of air
    b. weight only in the stratosphere
    c. the weight of air exerting force on an object
    d. weight of oxygen exerting force

ANSWERS:

Part 1.

1. H
2. G
3. F
4. C
5. J
6. B
7. I
8. A
9. E
10. D

Part 2.

1. C
2. B
3. A
4. D
5. C
6. D
7. A
8. C
9. A
10. C