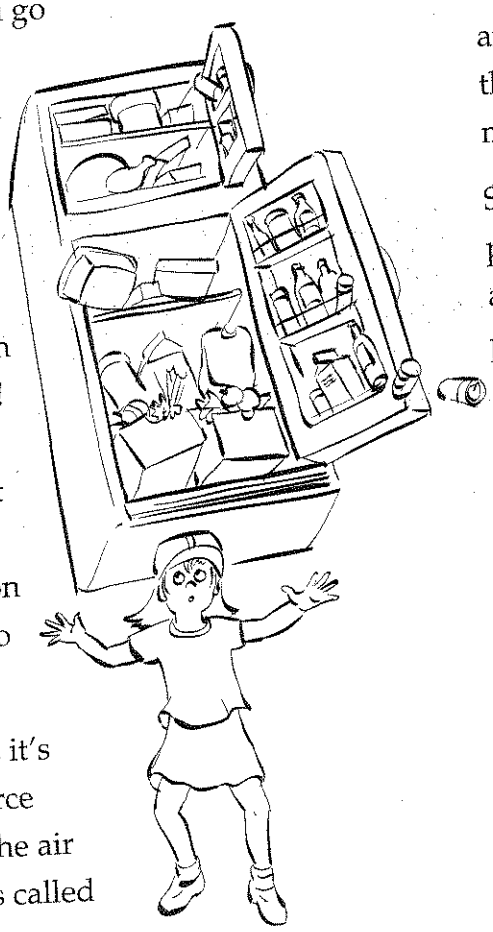
What Is Air Pressure?

The atmosphere is composed of air. Air has mass. In fact, a column of air 1 centimeter square (cm^2) extending up to the top of the atmosphere has a mass of 1.2 kilograms (kg). If the top of your head has a surface area of 150 cm^2, that means every time you go out and stand under the open sky, you have the pressure of 180 kg of air pushing down on your head! That's like wearing a hat with a refrigerator on it. Is it safe to go outside?



Don't worry, it's safe. The force applied by the air above you is called **atmospheric pressure.** Life on Earth has evolved in this high-pressure environment, so we are able to handle the pressure just fine. In fact, most of the time we are totally unaware of the pressure, except...

We do feel the air pressure when it changes quickly. Have you ever traveled to the mountains and noticed an interesting sensation in your ears as you go up or down the mountain? It's called popping your ears. Sometimes this happens in an airplane when it changes altitude rapidly or in a car going up and down a mountain road. If you have had that experience, keep it in mind as you think more about atmospheric pressure.

Sometimes you can see evidence of change in pressure even if you can't feel it. In an airplane, you might notice that packets of peanuts or chips are puffed up like balloons.

Or if you drain a plastic water bottle up in the mountains and screw the cap on tightly, it might get squashed a little as you drive down the mountain. These are examples of air pressure.

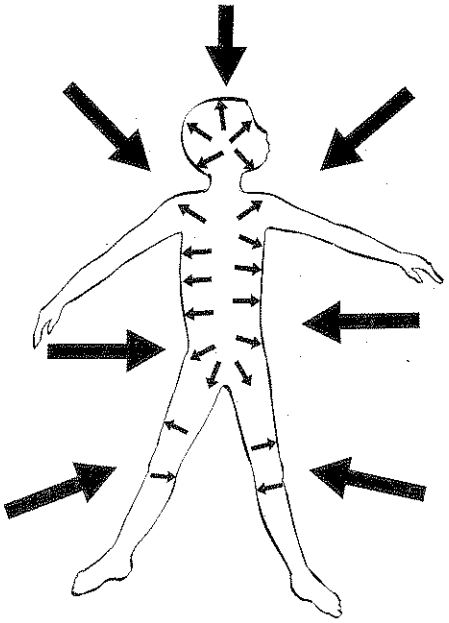
WHAT CAUSES AIR PRESSURE?

Molecules have mass, so they are pulled to Earth by gravity. The air surrounding Earth has weight. Atmospheric pressure is the weight of the air pushing on Earth's surface.

Remember, air molecules are zipping around individually. So what prevents gravity from attracting them all to the ground? Why aren't we walking around knee deep in a soup of oxygen and nitrogen molecules?

The answer is kinetic energy. The gas molecules have so much energy of motion that they are pushing each other away in all directions. They resist being crowded together by this constant banging into one another.

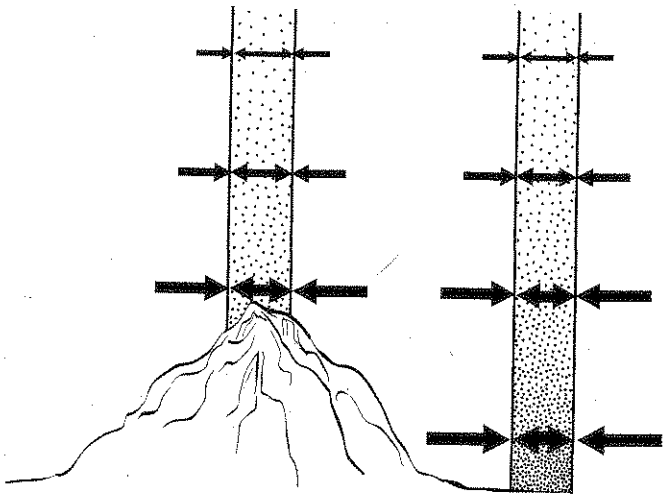
Here's an important point: The pressure is not only pushing down on Earth; the molecular banging is also pushing back with equal force on the air molecules above. Also, molecules are pushing back with equal force on the molecules trying to crowd in from the sides. Atmospheric pressure acts with equal force in every direction.



Atmospheric pressure is not the same everywhere. Air pressure is caused by the mass of air being pulled to Earth. But what happens if you go up into the atmosphere, high above Earth's surface?

If you have the good luck to go for a hot-air-balloon ride, you might find yourself 2 kilometers (km) above the land. Up there, 2 km of air is below you, so that 2 km of air is not applying pressure up where you are. The atmospheric pressure is less up in the balloon.

The greater the amount of air overhead, the greater the pressure. Also, the greater the pressure, the closer together the molecules are pushed. Remember, gases can be compressed. Pressure (force) drives gas molecules closer together. When more molecules are present in a given volume, the gas is denser. Because we live at the bottom of a sea of compressible air, the atmosphere is densest at Earth's surface. It becomes less and less dense as you go higher in the atmosphere.



As you go up in the atmosphere, pressure goes down. As pressure goes down, the air

expands (less force pushes the molecules together). As air expands, it gets less dense.

Mount Everest is over 8 km high. Up on top the atmospheric pressure is only one-third the pressure at sea level. Consequently, the air is one-third the density of air at sea level. Have you ever seen pictures of climbers laboring up the highest reaches of the mountain? Most of them are using oxygen supplies. Why? Because there is only one-third as much oxygen in each breath of air at that elevation. It takes an exceptional climber to reach the summit without extra oxygen.

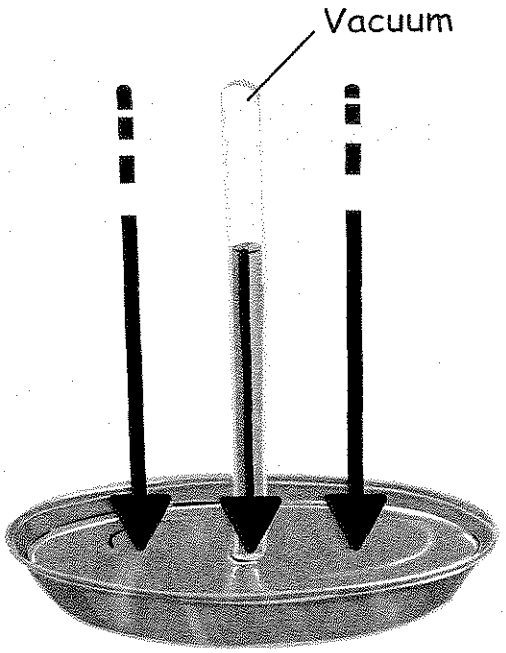
Now, about those ears popping when you travel through the mountains. Does it have anything to do with atmospheric pressure?

MEASURING AIR PRESSURE

The air pressure that meteorologists talk about on the evening news is the pressure exerted by the mass of air pushing down on a certain point on Earth's surface. Elevation is one factor that causes pressure to vary, but there are a number of other factors as well. These factors, and the resulting pressure, are of interest to weather forecasters.

Meteorologists use a **barometer** to measure air pressure. An Italian naturalist named Evangelista Torricelli invented the first barometer in 1643. He filled a long glass tube with mercury and turned it upside down in a dish also filled with mercury. A small amount of the mercury (not all of it) ran out of the tube and into the dish, leaving an empty space above the mercury.

This space was a vacuum. A vacuum is a space containing almost no matter, not even air.



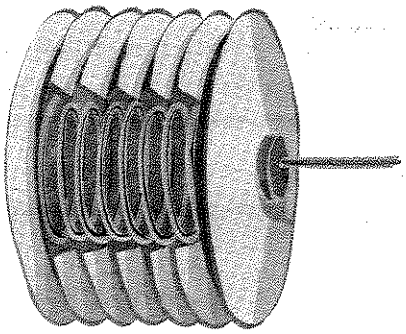
What was holding the heavy column of mercury up in the tube? Atmospheric pressure. Air pressure pushes down on the mercury in the dish. The pressure is distributed throughout the mercury, including the mercury in the tube. Remember, a column of atmosphere 1 cm^2 has a mass of 1.2 kg. If the column of mercury is 1 cm^2 in cross section, it will have a mass of...that's right, 1.2 kg. So, the air pressure is exactly balanced by the mercury pressure.

Because mercury is very dense, a column of mercury exactly 76 cm high will balance a column of atmosphere 600 km high at sea level. As Torricelli observed his new invention closely, he noted that the level of mercury moved up and down a little from day to day. He reasoned that the changing level of mercury was due to changes in the

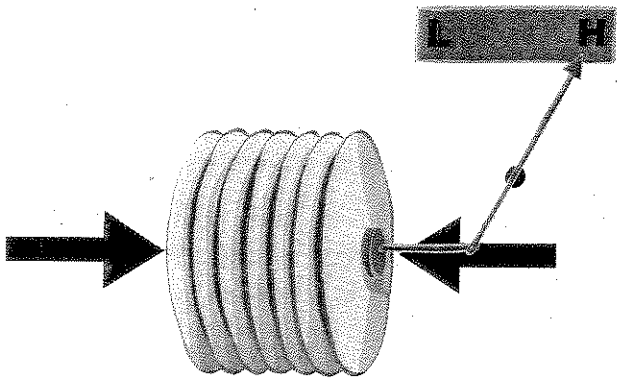
atmospheric pressure. Torricelli had invented the first barometer—an instrument for observing and measuring changes in atmospheric pressure.

Today, meteorologists often use another type of barometer called an **aneroid barometer.** Aneroid barometers are much smaller and more versatile than mercury barometers.

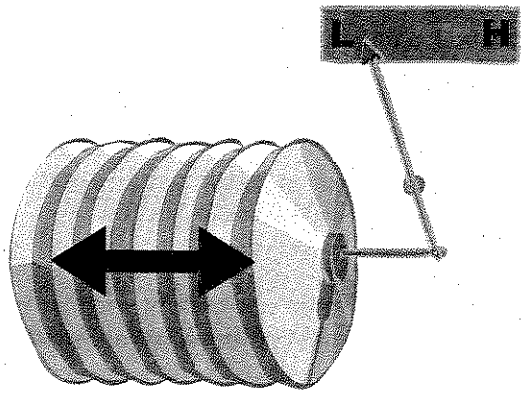
At the heart of an aneroid barometer is a sealed bellowslike chamber with a spring inside. All the air is removed from inside the bellows. Air pressure tries to squash the bellows flat, but the spring inside pushes back to keep that from happening. The force of atmospheric pressure and the force exerted by the spring are balanced.



If the atmospheric pressure increases, it will push on the bellows. The ends of the bellows will be pushed closer together until the force pushing back by the spring is equal to the increased air pressure. A pointer attached to the bellows moves along a scale to show the change in pressure.



Lower pressure allows the spring inside the bellows to push the ends of the bellows farther apart.



Sometimes a pen is attached to the bellows. The pen records the air pressure on a rotating cylinder to obtain a continuous record of pressure changes. If an electronic sensor and a transmitter are attached to a barometer, pressure information can be radioed from a weather balloon back to a receiving unit on Earth.

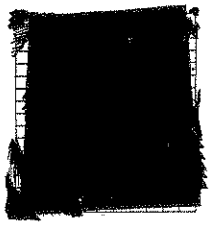
Because pressure changes with elevation, airplanes use a type of barometer to monitor how high the plane is. This application of a barometer is called an **altimeter.**

Scientists and meteorologists use several different units to report pressure. For historical reasons, inches or centimeters of mercury are used in science experiments. Meteorologists, on the other hand, look at the average atmospheric pressure at sea level and call that 1 bar. If you are relaxing at the beach (sea level), the pressure around you will be 1 bar (or close to it).

The bar has been subdivided into 1000 equal parts called **millibars (mb).** Standard atmospheric pressure is 1000 mb. These are the units you used to record your local atmospheric pressure on the class weather chart.

In practice, standard pressure is actually 1013 mb. Any pressure below 1013 mb is lower than normal pressure, and over 1013 mb is higher than normal.

THINK QUESTIONS



1. *When you drive down a mountain, what makes your ears experience those interesting and sometimes uncomfortable sensations?*

2. *Why doesn't air pressure crush an empty soda can sitting on a table?*

3. *If a meteorologist says that the air pressure is getting lower, what would you expect to see happen to Torricelli's mercury barometer?*

4. *If Torricelli had drilled a little hole at the top of the glass tube holding his mercury column, what would have happened to his barometer?*