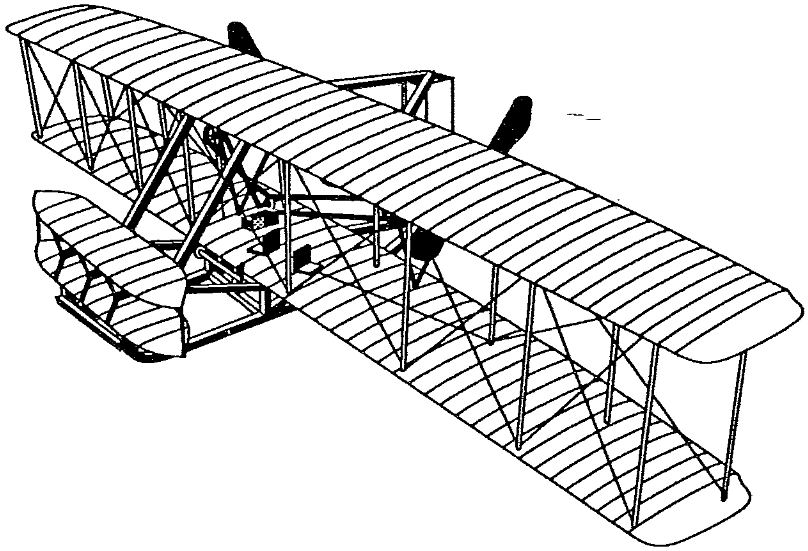
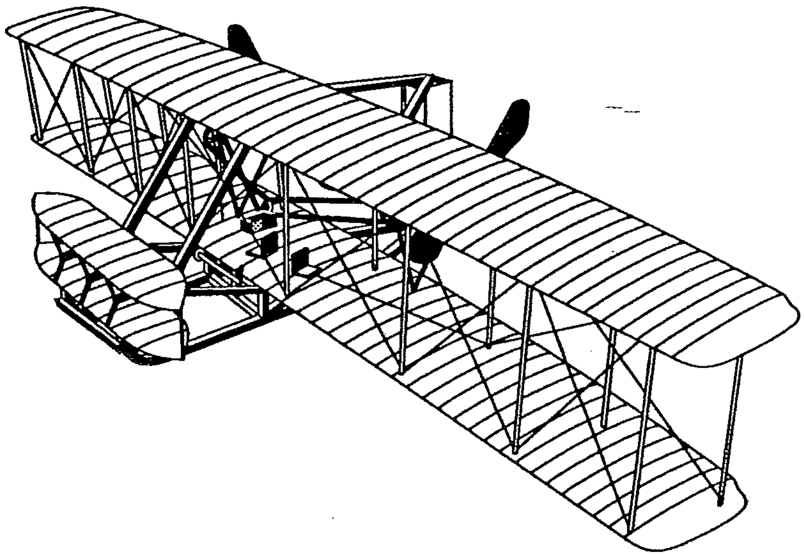
# AIR PRESSURE



# WE'RE SURROUNDED!

# LA PRESION DE AIRE



# NOS RODEA CONSTANTEMENTE

# BACKGROUND INFORMATION

Are you having a nice swim? No matter whether you're seated in a chair, riding in a car, or taking a walk, you are constantly swimming in a sea—a sea of air! This is a huge sea that blankets the entire earth. This is a sea of tiny pieces (molecules) of nitrogen, oxygen, and other gases that make up the atmosphere. Between these pieces (molecules) are open spaces. Close to the earth's surface, the sea of air is thicker, more dense. Up high, the sea of air is less dense with more space between the molecules of oxygen, nitrogen, and other compounds.

**Have you ever tried to run through the water when you're in a swimming pool or lake?**

It isn't easy, is it? That's because you have to push the water out of the way as you go. The same thing happens with air. As you walk across the room, you don't really *feel* the air pushing against you, but it is! If you were a fish, you probably wouldn't notice how thick the water is—it would just feel natural since that was the environment you were used to.

**Would the air push against me if I stood still?**

Yes! The pieces (molecules) of air are constantly in motion. A good way to think about air is like Ping-Pong balls bouncing around. Perhaps you've seen a lottery or bingo game where the Ping-Pong balls are bouncing all around inside a jar. The balls are constantly hitting the sides, top, and bottom of the jar. The air molecules do the same thing. They bounce around, bumping into each other and whatever they come up against—the inside walls of a bottle or balloon, your body, or a sail on a sailboat. When they hit these objects, they push against them. This push is air pressure. It may not seem like a single air molecule bumping into a big sail on a sailboat would have much effect. But think! At any split second, there are billions of air molecules hitting that sail—and that creates a lot of push!

**What are some things that affect air pressure?**

One factor is how far up you are from the surface of the earth. At sea level, the air is much more dense (that is, in every cubic foot of space there are more air molecules) than it is up on a high mountaintop. More air molecules mean more pushes and bumps, therefore, greater air pressure. You can see this demonstrated in the *Egg-In-A-Bottle* activity, where some of the air inside the bottle is burned up and the air pressure inside the bottle is reduced.

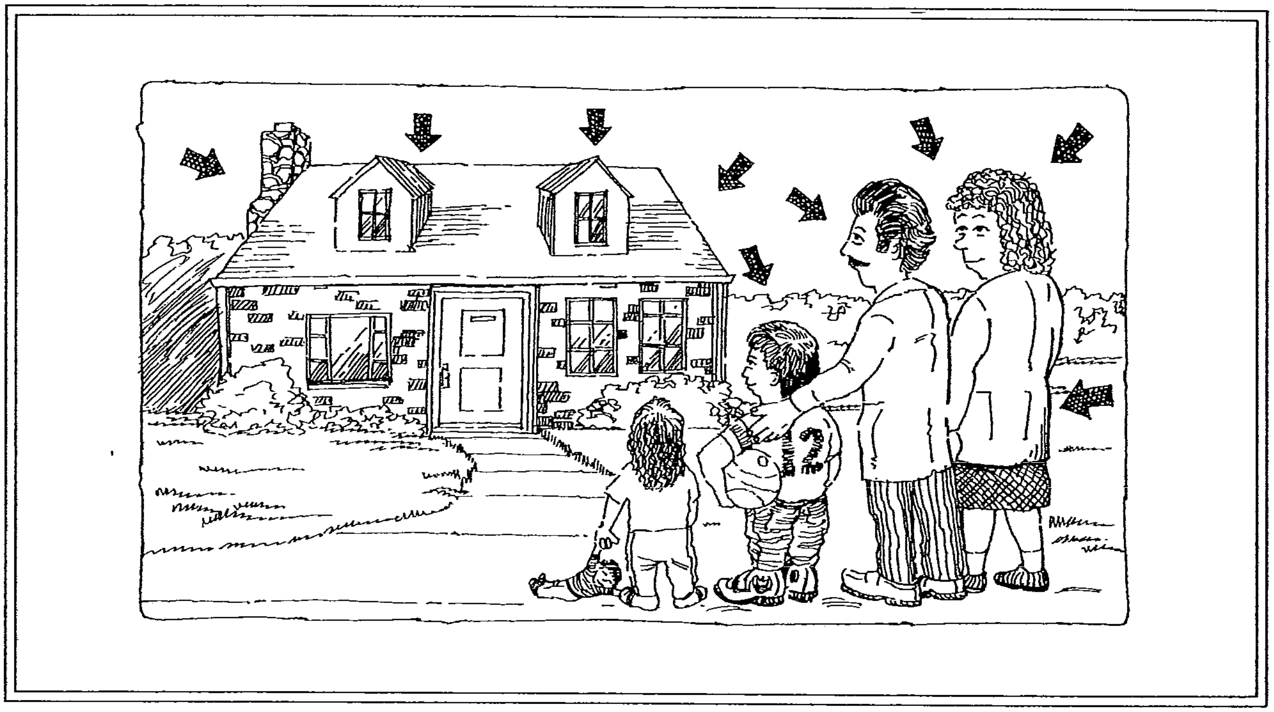
Another thing that can change the air pressure is temperature. The *Hot and Cold Air* activity demonstrates this. As air is warmed, the energy from the heat causes the molecules of air to move faster and farther apart. If the air is inside a container, the molecules begin striking the sides more often and harder. If the container is hard—like glass or heavy plastic—you probably won't see a visible change. But if it is stretchy—like a balloon—the increased air pressure will cause it to expand and eventually may break it. As the air gets colder, the molecules slow down and don't move as far apart. If we make the air colder and colder, eventually it will change from a gas to a liquid. You may have heard of *liquid oxygen*.

### How do we use *liquid* oxygen?

A good example is the use of liquid oxygen and liquid hydrogen in NASA's Space Shuttles. The big fuel tanks used during take-off are full of liquid oxygen and liquid hydrogen. By using the liquid form instead of the gas, a lot of oxygen and hydrogen can be put into a much smaller space, but the tanks must be very strong because the tightly packed molecules create tremendous pressure on the container. The tanks of the Shuttle seem big. But think how big they'd be if the same amount of oxygen and hydrogen were still in the form of a gas!

### How strong is the air pressure around us?

It's actually quite strong but you're used to it, so you really don't notice it. In fact at this moment, the air pressure pushing down on you is about equal to the weight of an automobile! On average, the atmospheric (air) pressure on earth is 14.7 pounds per square inch. That means that every square inch of your body; of the top, bottom, and sides of a table; and of the walls of your room has 14.7 pounds of air pressure pushing on it.

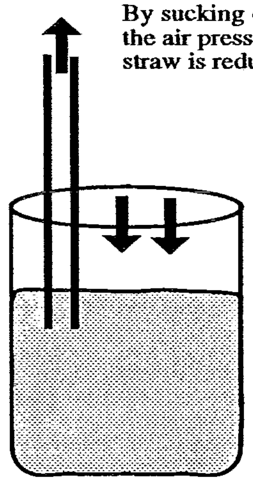


### Can air pressure be used to do work?

Yes! Usually we use differences in air pressure to do work for us.

### Can you give some examples?

Let's look at how a straw works. When you have a straw in a glass of water, you suck on the straw. What is happening inside the straw? When you suck, you pull some of the air out of the straw and, therefore, reduce the air pressure inside the straw. But the air pressure outside that's pushing down on the water is still the same, and it *pushes* the liquid up the straw. Take a look at the following diagram.




Have you ever had a small box of juice with a little straw that just fit through the hole so that no air could go around it? Did you notice how hard it was to suck the juice up through the straw? That's because you weren't letting air in around the straw to help push on the surface of the juice and push it up into your straw.

### Can you give another example?

Do you know how a vacuum cleaner works? It does *not* suck up dirt! There's a small fan inside the vacuum cleaner that blows air out of the back. Where does this air come from? It comes from inside the hose and handle. As the fan pushes air out, it reduces the air pressure inside the vacuum hose and handle. On the outside of the machine, the air pressure is then higher and air is pushed into the hose. As it does, it pushes dirt and hair along with it. Be sure to try the *Egg-In-A-Bottle* activity for a dramatic display of unequal air pressure and the work it can do.

### What about when air moves around like the wind?

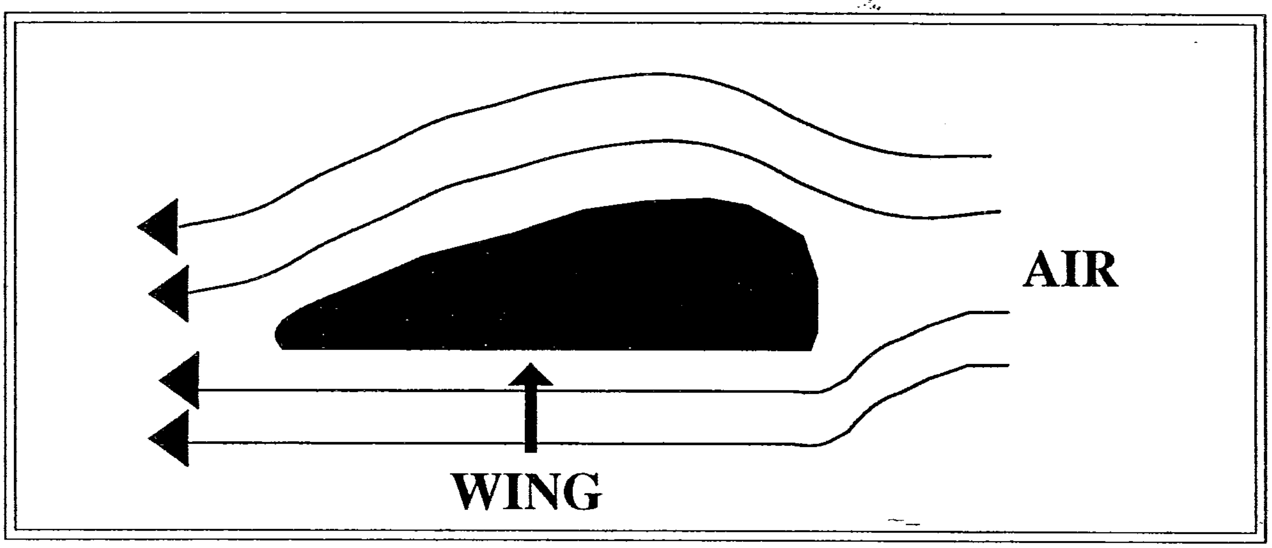
If you think about how big a jet airplane is, it is difficult to understand how it can take off and fly. Yet, just by understanding how unequal air pressure can create force (do work) and one more fact called Bernoulli's principle, you can understand how airplanes use moving air to create air pressure that literally pushes them into the sky.

### What is Bernoulli's principle?

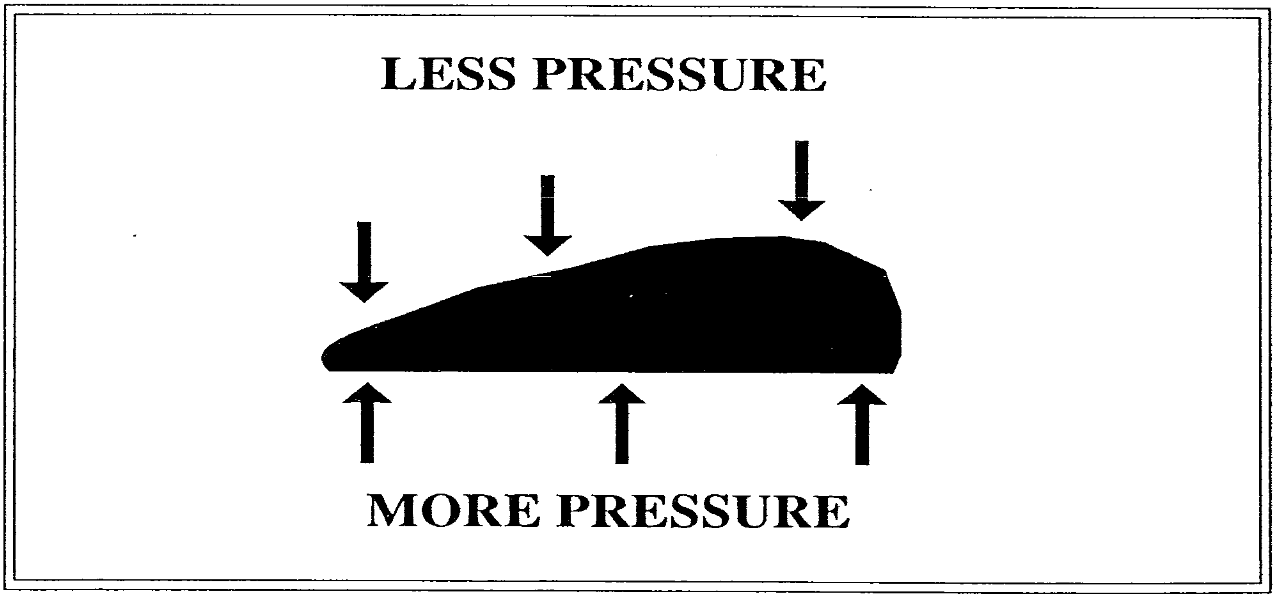
Daniel Bernoulli was a Swiss scientist who discovered that the faster fluid (including air) moves, the less sideways pressure it has. Most of the air molecules are moving in the forward direction so fewer are going sideways. To experience this phenomenon, try the *Air in Motion* activity.

**OK, so how does a plane fly?**

A plane can take off because its wings are designed to take advantage of Bernoulli's principle. If you look at an airplane wing from the tip end, it looks a little like this.




As the plane goes down the runway, the air rushes over and under the wing. However, because the top of the wing is curved, the air moves faster going over the top than it does under the bottom. Therefore, according to Bernoulli's principle, the air on top of the wing is pushing down less than the air on the bottom on the wing is pushing up! And the plane is *pushed* up into the air by air pressure pushing up from under the wings.




**It still doesn't quite seem possible. Little pieces of air push up a big plane?**

To convince yourself, try the *Trash Bag Airlift* activity. You'll see that a small amount of air pressure pushing on a large area (such as the trash bag or a big airplane wing), can create a tremendous amount of force (or push).

# INFORMACION BASICA

La presión del aire nos rodea constantemente, no importa donde nos encontremos: nadando, sentados, conduciendo un automóvil o caminando, siempre estamos sumergidos en una gran capa de aire que cubre toda la tierra. El aire es como un mar de pequeñas partículas o moléculas de nitrógeno, de oxígeno y dotros gases que forman la atmósfera; estas partículas o moléculas se encuentran separadas por espacios abiertos. La capa de aire cerca de la superficie de la Tierra es mucho más densa más pesada que las capas superiores, donde el aire es menos denso y donde hay más espacio entre las pequeñas partículas de oxígeno, de nitrógeno, y de otros compuestos.

**¿Alguna vez ha tratado de correr dentro de una piscina o de un lago?**

Si lo ha hecho, habrá visto que no es fácil, ya que tiene que apartar el agua para poder avanzar. Bueno, lo mismo pasa con el aire. Cuando usted camina por el salón, no siente la presión del aire que lo empuja, sin embargo, el aire está allí empujándolo. El pez, probablemente, no siente la densidad del agua, ya que el agua es su ambiente natural.

**¿Me empuja el aire cuando estoy de pie?**

¡Sí! Las partículas de aire están en constante movimiento. Podemos imaginar las moléculas de aire como bolas de Ping-Pong que rebotan alrededor. ¿Ha visto un juego de lotería o de bingo, donde las bolas rebotan constantemente contra todos los lados de un pote? Bueno, las moléculas de aire hacen lo mismo, rebotan, chocan las unas con las otras, con los lados del pote o del globo y contra todo lo que encuentran, bien sea un cuerpo humano o las velas de un barco. Cuando las partículas chocan contra los objetos, producen una fuerza o un empuje, esto es lo que se llama: presión del aire. Es difícil creer que moléculas de aire tan pequeñas produzcan una fuerza tan grande al chocar contra un cuerpo, como por ejemplo, las velas de un barco. Sin embargo, es cierto. En una fracción de segundo, billones de moléculas chocan contra las velas del barco y crean una gran energía o empuje.

**¿Cuáles son las cosas que afectan la presión del aire?**

Todo depende de la distancia en que se encuentre de la superficie de la Tierra. En el nivel del mar el aire es mucho más denso (es decir, hay más moléculas de aire en un pie cúbico de espacio), que en la cima de una montaña. Mientras mayor es el número de moléculas de aire más grande es el empuje y el choque, y por tanto, mayor es la presión del aire. El experimento *El huevo en la botella* nos muestra cómo se reduce la presión interna de la botella cuando se consume el aire dentro ésta.

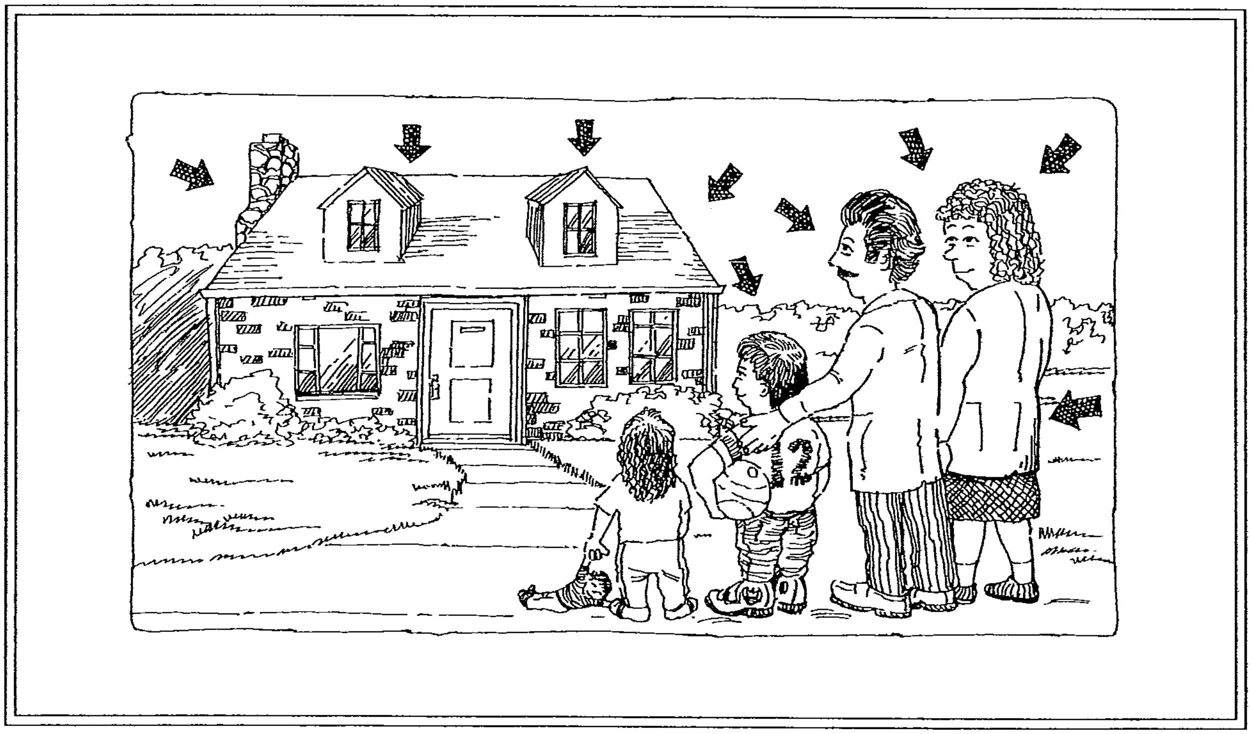
La temperatura también puede cambiar la presión del aire como se muestra en el experimento *Aire frío y caliente*. En el experimento el aire se calienta, las moléculas de aire se mueven con más rapidez y se separan aun más las unas de las otras. Las moléculas de aire en un balde, en un vaso o en cualquier otro recipiente, chocan con más frecuencia y con más fuerza contra los lados del recipiente. Sin embargo, este cambio no se puede ver cuando ocurre en un recipiente de material resistente, de vidrio o de plástico pesado. Pero si el recipiente es de material flexible, como un globo, entonces, si podemos ver cómo la presión del aire se hace cada vez más grande, y el globo se expande, hasta que por último explota. Cuando el aire se enfría, las moléculas se mueven más despacio y no se separan mucho. Si el aire se enfría mucho, se convierte en un líquido. Tal vez está familiarizado con el oxígeno líquido.

### ¿Cómo se usa *el oxígeno líquido*?

El oxígeno y el hidrógeno líquidos se utilizan para impulsar las naves espaciales. Los grandes tanques de combustible de las naves espaciales, se llenan de oxígeno y de hidrógeno líquido para utilizarlos durante el proceso de lanzamiento. Se puede almacenar en un mismo espacio, más cantidad de gas en forma líquida que en forma de gas. Sin embargo, para almacenar estos gases en forma líquida, se necesitan tanques de combustible muy resistentes porque en esta forma las moléculas crean mucha presión. Los tanques de las naves espaciales son bastante grandes, pero tendrían que ser mucho más grandes para poder almacenar la misma cantidad de oxígeno y de hidrógeno en forma de gas.

### ¿Qué fuerza tiene la presión del aire que nos rodea?

Tiene bastante fuerza. Sin embargo, estamos tan acostumbrados a la presión del aire que no la sentimos. En este momento, por ejemplo, la presión del aire que nos empuja, tiene casi el mismo peso de un automóvil. La presión atmosférica del aire sobre la Tierra es, en general, de 14.7 libras por pulgada cuadrada. Esto quiere decir, que cada pulgada cuadrada del cuerpo humano, de una mesa, y de un cuarto, siente el empuje de una presión de aire equivalente a 14.7 libras.

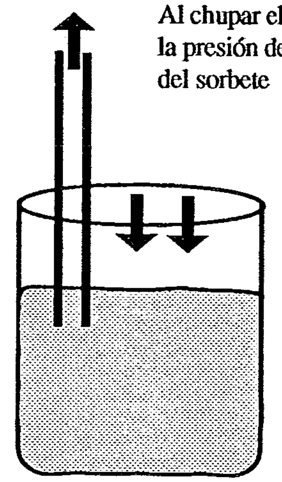


### ¿Nos ayuda la presión del aire?

¡Sí! Las diferencias de la presión del aire nos ayudan diariamente.

### ¿Puede dar algunos ejemplos?

Fíjese cómo trabaja un popote, un sorbete o una pajilla dentro de un vaso de agua. Cuando usted coloca el popote o el sorbete en un vaso de agua y chupa a través de él, ¿qué ocurre? Bueno, lo que ocurre es que cuando chupa extrae el aire del popote o del sorbete y por tanto, reduce la presión que está dentro. Sin embargo, la presión externa del aire sobre el agua permanece igual y empuja el líquido hacia arriba, a través del popote o del sorbete. Vea el siguiente diagrama:




Es difícil chupar a través del popote de las cajas pequeñas de jugo, que tienen una abertura donde solo cabe el popote o el sorbete, y por tanto, el aire no puede penetrar por la abertura. Esto ocurre porque el aire no puede penetrar ni empujar la superficie del jugo y hacer que el jugo penetre en el popote o en el sorbete

### ¿Puede dar otro ejemplo?

¿Sabe usted como trabaja una aspiradora? La aspiradora NO aspira el polvo. Hay un pequeño ventilador dentro de la aspiradora que saca el aire por la parte de atrás. ¿De dónde viene el aire que el ventilador extrae por atrás? Viene de la parte interna de la manguera y de las manijas. Cuando el ventilador empuja el aire hacia fuera, se reduce la presión dentro de la manguera y dentro de las manijas de la aspiradora. Entonces, la presión del aire en la parte externa de la aspiradora, se hace mucho más fuerte y empuja el aire hacia dentro de la manguera, haciendo que arrastre el polvo y el pelo. (Haga el experimento *El huevo en la botella* y podrá ver cómo trabaja la presión desigual del aire y todo lo que puede hacer).

### ¿Qué pasa cuando el aire gira alrededor como el viento?

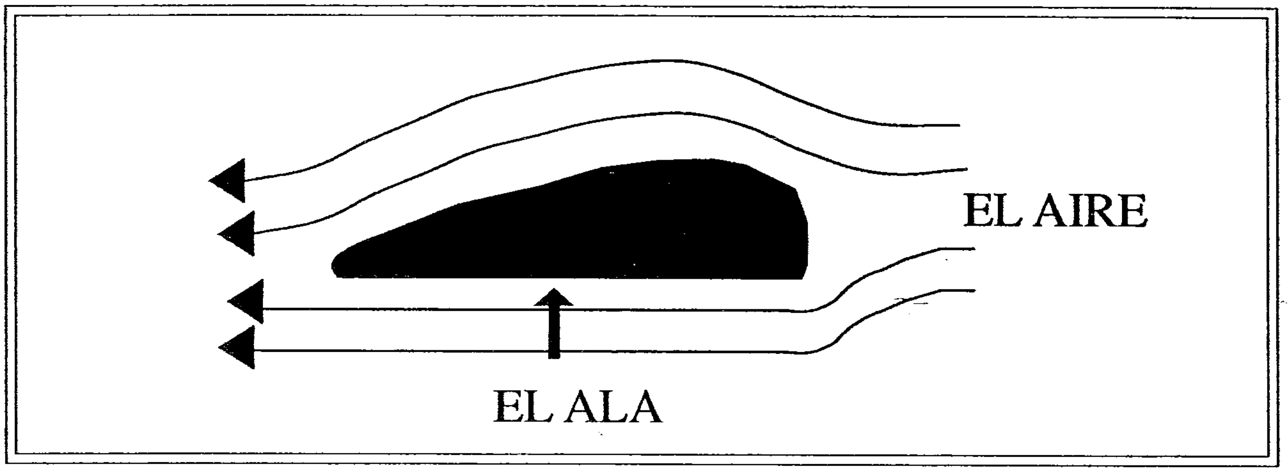
Es difícil entender cómo un avión tan grande puede despegar y volar. Sin embargo, si sabe cómo trabaja la presión desigual del aire y cómo se aplica el principio de Bernoulli, le será fácil entender cómo el avión crea la presión de aire que necesita para despegar.

### ¿Qué es el principio de Bernoulli?

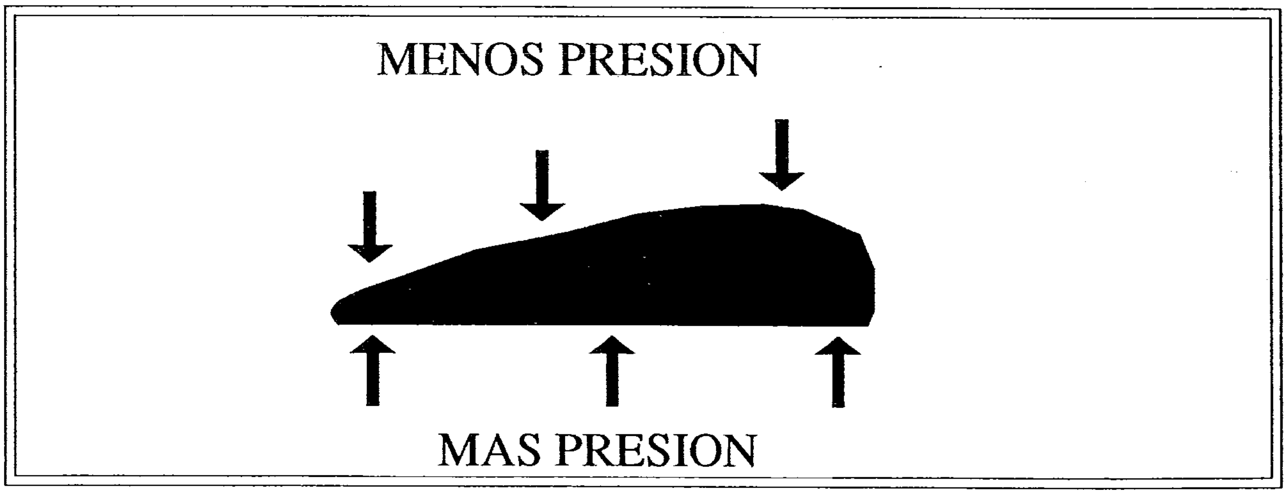
Daniel Bernoulli fue un científico suizo que descubrió, que cuando los líquidos (incluyendo el aire) se mueven rápidamente, producen menos presión a los lados, porque la mayor parte de las moléculas de aire se desplazan hacia adelante y muy pocas hacia los lados. Para entender este concepto, haga la actividad *El aire en moviemiento.*

### Está bien, ¿cómo vuela un avión?

El avión puede despegar porque sus alas están diseñadas para aprovechar el principio de Bernoulli. Si mira el ala del avión desde la punta, verá que tiene la siguiente forma:




Cuado el avión se desliza sobre la pista, el aire se precipita por encima y por debajo del ala. Pero la curva del ala superior del avión, hace que el aire se mueva más rápidamente por encima que por debajo. De acuerdo con el principio de Bernoulli, el aire por encima del ala, crea menos presión hacia abajo; mientras que el aire por debajo del ala, crea más presión hacia arriba. De esta manera, la presión del aire bajo las alas, empuja al avión hacia arriba.




**¡Aún parece imposible que partículas de aire tan pequeñas puedan impulsar al avión!**

Para convencerse, haga el experimento *La bolsa de basura.* Entonces verá cómo una presión de aire pequeña puede empujar un área extensa (cómo la bolsa de basura o el ala del avión) y crear mucha fuerza.

# CAN YOU PUSH AGAINST AIR AND WIN?

## *SUGGESTIONS FOR TEACHERS*

**WHAT'S THE POINT?**

To demonstrate that air takes up space and that air puts pressure (pushes) on everything around it.

**ESTIMATED TIME:** (older children will require less time)

| | |
|---|---|
| Setting up: | 5–10 minutes |
| Doing activity: | 10–15 minutes for each activity |
| Cleaning up: | 10 minutes |

**APPROPRIATE AGE GROUPS:**

_X_ K–3 _X_ 4–6 ___ 7–8

**DO ACTIVITY IN GROUPS OF: 2–4**

**MATERIALS NEEDED** (per group of 2–4 students):

- ✧ wide-mouth gallon plastic jar (restaurants, or hospital or nursing home cafeterias may be willing to give you one). Or, a small plastic bucket with an opening small enough for the plastic bag (next item) to fit over
- ✧ sturdy plastic bag (without holes) that is large enough to fit over the mouth of the container—not a zipper-lock-type bag
- ✧ strings or rubber bands large enough to fit around mouth of container
- ✧ bucket or large bowl of tap water
- ✧ plastic, clear drinking glass (so you can see through it)
- ✧ paper or cotton (wad to put in bottom of glass)
- ✧ towel for drying hands

**SAFETY CONSIDERATIONS:**

- ✧ Use plastic dishes and jars rather than glass when possible.
- ✧ Plastic bags are a potential suffocation hazard, so watch children (especially younger ones) when they blow air into the bags.

## ENRICHMENT FOR BILINGUAL STUDENTS:

- In small groups, students can construct sailboats. Students should experiment with different size sails and explore how sail size will make a difference in traveling speed.
- As a class, students should discuss famous navigators (Columbus, Pinzón brothers, Magellan) who sailed to the New World using their understanding of air pressure to decide which sails to use and how many were needed in different weather conditions.

## ADAPTATIONS FOR PARTICIPANTS WITH DISABILITIES:

- Students with visual impairments can feel what's happening to the bag in *An Empty Container* and to the paper in *High and Dry*.
- Students with hearing impairments should be able to do this activity without any modifications other than for communicating the instructions.
- Students with mobility impairments may need to work with a partner.

## BEFORE YOU BEGIN:

- Remove the chairs from a table, and place the gallon jar on it so that everyone will be able to stand around the table, see, and reach the container.
- Test the plastic bags for holes.
- Have extra bags handy since the first bag may develop holes as you do the activity.

## QUESTIONS TO ASK AS YOU DO THE ACTIVITY:

- What other things can you think of (or see in this room) that are full of air?
- When have you felt the force or pressure of air?
- What experiences have you had with strong wind?
- What experiences have you had filling a tire with air? Filling a balloon?

## CLEAN UP:

- Replace any bags that have gotten holes.
- Dry cups.
- Replace wet cotton or paper.

## WHERE CAN I GO FROM HERE?

For more activities involving air and other fluids, check the following books: *Amazing Air* by Henry Smith; *Bet You Can* and *Bet You Can't*, two books by Vicki Cobb and Kathy Darling (each of these books has a chapter on air); *175 Science Experiments to Amuse and Amaze Your Friends* by Brenda Walpole, which has an entire chapter on air.

## WHY IT HAPPENS:

First, be sure to read the background information in the introduction to this section.

### An "empty" container?

Inside the bucket and bag are thousands of air particles (called *molecules*) bouncing around like Ping-Pong balls in a big box. As they strike the sides of the bucket and bag, they create pressure on the inside. Similarly, the air on the outside of the bucket and bag are pushing on them, as well. When you push down on the bag, the air pressure *inside* increases because you are forcing the same number of air molecules into a smaller space and therefore, they are hitting the sides of the bag and bucket more often. What you feel then is this greater air pressure pushing up on the bag.

What about when you put the bag *inside* the bucket and then you pulled up? By pulling up on the bag, you increased the amount of space inside the bucket and bag. This gives the air molecules inside more space to bounce around so they hit the sides *less* often and produce *less* pressure.

So why was it hard to pull the bag up? Because the air pressure *outside* the bag and bucket is now greater than the air pressure inside. What you feel is the outside air pushing down!

### High and dry

If you held the glass straight up and down to put it into the water, you probably were able to put your glass completely underwater without getting the paper wet. If you tipped your glass a bit to one side, the air may have leaked out and the water in—and your paper got wet!

As you've probably guessed, the air inside the cup was pushing down on the water. This air prevented the water from coming up into the cup. The air pressure and water pressure were equal and so there was a *standoff!* However, if you tipped your cup, you gave some of the air a chance to float up to the surface of the water in the bucket. That air was replaced by water, which may have tipped your cup even further. Then more air escaped and more water came in and so on until you had a cup full of water!

NOTES

## REFERENCES:

Girls Clubs of America, Inc. 1986, August. *Operation SMART: A program to encourage every girl in science, mathematics and relevant technology.* New York: Girls Clubs of America, Inc.

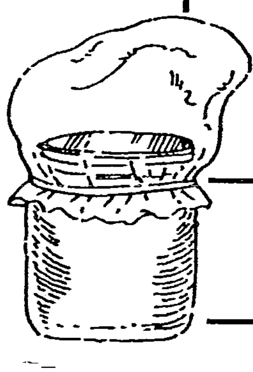
Walpole, B. 1988. *175 Science experiments to amuse and amaze your friends.* New York: Random House.

Wilkins, M. 1991. *Air, light, and water.* New York: Warwick Press.

# CAN YOU PUSH AGAINST AIR AND WIN?

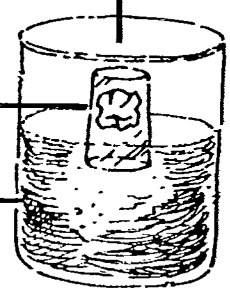
*ACTIVITY SHEET*

## Is it really empty?




1. Take a plastic bag, and put air into it by blowing into it or waving it through the air.
2. Clamp the opening of the bag around the mouth of a container, such as a jar or bucket, and fasten it tightly by either wrapping string around it two or three times and tying it or by putting the rubber band around it. The bag should be suspended over the container.
3. Now try to push the bag into the container. What do you feel as you push on the bag? Why do you think this happens?
4. Let everyone in your group try to push it in.
5. Remove the bag, and place it inside the container, like a liner.
6. Fold the top of the bag over the lip of the container (just like lining a trash can) and tie string tightly around it two or three times, or fasten it tightly with rubber bands.
7. Try to pull the bag up out of the container. What happens? How can you explain what happened?

## Keeping dry under water

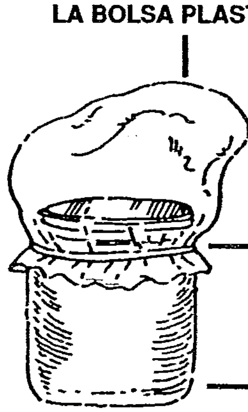



1. Fill a bowl or container about half full of water.
2. Take a glass and put a wadded-up piece of paper or some cotton inside the bottom of the glass, wedged in so that it won't fall out when you turn the glass upside-down.
3. Turn the glass upside-down. Put it in the water with the open end facing into the water. Hold the glass as straight up and down as you can. What do you observe? Take the glass straight up out of the water and feel the cotton or paper. Is it wet or dry? How can you explain what happened?
4. Tip the glass slightly to one side. Now what happens? Can you explain why?

# ¿SE PUEDE EMPUJAR AL AIRE Y UTILIZARLO?

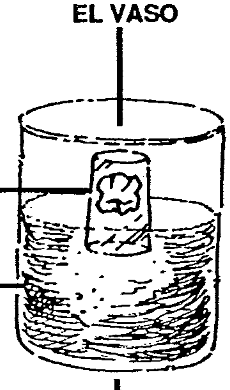
*HOJA DE ACTIVIDADES*

## ¿PODEMOS ENCONTRAR UN RECIPIENTE QUE ESTE COMPLETAMENTE VACIO?




1. Infle una bolsa plástica soplando directamente dentro de la bolsa o hágala flotar en el aire.
2. Ajuste la boca de la bolsa a la boca del recipiente y pase una cuerda firmemente alrededor dos o tres veces, o utilice un elástico. La bolsa debe quedar suspendida sobre el recipiente.
3. Empuje la bolsa dentro del recipiente. ¿Qué siente cuando empuja la bolsa? ¿Qué ocurre?
4. Haga que todos traten de empujar la bolsa hacia abajo.
5. Ahora, coloque la bolsa como forro o cubierta dentro del recipiente.
6. Ajuste la parte superior de la bolsa alrededor del recipiente (igual que se hace con las bolsas de basura) y pase una cuerda alrededor dos o tres veces o fíjela fuertemente con un elástico.
7. Luego, jale la bolsa fuera del recipiente. ¿Qué ocurre? ¿Cómo explica lo que ocurre?

## EXPERIMENTO CON UN VASO QUE SE MANTIENE SECO AUNQUE ESTA DENTRO DEL AGUA




1. Llene un recipiente con agua hasta la mitad.
2. Tome un vaso y ponga un pedazo de papel o de algodón en el fondo del vaso. Fíjelo, de manera que no se deslice cuando invierta la posición del vaso.
3. Invierta el vaso. Coloque el vaso dentro del agua, con la boca en dirección al agua. Mantenga el vaso derecho. ¿Qué ve? Saque el vaso del agua manteniéndolo derecho y toque el papel o algodón. ¿Está seco o mojado? ¿Cómo explica lo que ocurrió?
4. Incline el vaso ligeramente. ¿Qué ocurre ahora? ¿Puede explicar lo que ocurrió?

# AIR PRESSURE POWER

## *SUGGESTIONS FOR TEACHERS*

### WHAT'S THE POINT?

To demonstrate that air has mass and weight, that it puts pressure (pushes) on its surroundings, and that compressed air can do surprising work.

### ESTIMATED TIME:

| | |
|---|---|
| Setting up: | About 5 minutes |
| Doing activity: | About 10 minutes for each activity |
| Cleaning up: | About 5–10 minutes |

### APPROPRIATE AGE GROUPS:

_X_ K–3 _X_ 4–6 ____ 7–8

### DO ACTIVITY IN GROUPS OF: 2

### MATERIALS NEEDED:

For the entire group: (for both activities)

- ✧ large table or tables with enough room for everyone to have access to a flat area for working.

Per group of 2 persons working together:

- ✧ *Heavy News*
  1 ruler (12 inches or 30 cm, preferably wooden)
  1 full-size sheet of newspaper
- ✧ *Book Lift*
  plastic food storage bag (not zipper-lock type)
  a stack of 5–6 books

### SAFETY CONSIDERATIONS:

- ✧ *Heavy News*: Be careful not to break the rulers—it's easier than you think. Be careful of rulers being *flipped* up into the air and hitting someone.
- ✧ *Book Lift*: Plastic bags are a potential suffocation hazard, so be careful, especially with younger children. Watch out for heavy books falling onto people's feet!

## ENRICHMENT FOR BILINGUAL STUDENTS:

Contact local NASA regional centers, universities, or engineering industries to locate scientists (preferably Hispanic scientists) who could present to students a variety of ways compressed air (air pressure) is used in the space program, in research, and in manufacturing.

## ADAPTATIONS FOR PARTICIPANTS WITH DISABILITIES:

- Students with visual impairments can place their hands over the newspaper and lightly on top of the books to feel what happens.
- Students with hearing impairments can do this activity with the appropriate modifications in communicating the instructions.
- Students with mobility impairments may need to work with a partner.

## BEFORE YOU BEGIN:

- Clear a large space on the table(s).
- Move chairs away from tables so that everyone will be able to stand.
- Separate newspaper into individual sheets for *Heavy News*.
- Make sure plastic bags do not have holes in them for *Book Lift*.

## QUESTIONS TO ASK AS YOU DO THE ACTIVITY:

- What happened that was expected?
- What happened that was different from what you expected?
- When else have you felt the force or pressure of air?
- What experiences have you had with strong wind?
- What experiences have you had with compressed air holding things up (for example, air in the tire of your bicycle or automobile)?

## CLEAN UP:

- Replace any torn sheets of newspaper and any broken rulers for *Heavy News*.
- Replace any plastic bags that have holes in them for *Book Lift*.

## WHERE CAN I GO FROM HERE?

- *Air Push*
- After doing the *Book Lift* you may want to try the *Trash Bag Airlift*. It uses the same principle but in an even more dramatic and exciting manner!
- For more activities involving air and other fluids check the following books: *Amazing Air* by Henry Smith; *Bet You Can* and *Bet You Can't*, two books by Vicki Cobb and Kathy Darling. Each of these books has a chapter on fluids. *175 Science Experiments to Amuse and Amaze Your Friends* by Brenda Walpole, which has an entire chapter on air.

## WHY IT HAPPENS:

First, be sure to read the background information in the beginning of this section.

### Heavy News

The air above the newspaper pushes down on the whole surface of the newspaper in the same way that your body weight would push down on it if you were sitting on top of the newspaper. The average atmospheric pressure of the earth is 14.7 pounds per square inch. That means that every square inch of the surface of the newspaper has 14.7 pounds of air pushing down on it. If you figure out the total number of square inches of area on the surface of the newspaper (by multiplying the length of the sheet by its width), and then multiply those square inches by 14.7 pounds on each of them, you'll find out that the *weight* of the air above the newspaper sheet is quite large! For example, a typical 28-inch by 22-inch sheet of newspaper has over 9,000 pounds of air pushing down on it when laying flat on a table top! That's a lot to push aside with a ruler.

As you fold the paper, you reduce the area it covers and therefore, the amount of air pushing down on it. Eventually the ruler can push the paper up into the air when the paper gets small enough. As you walk, you have to push air out of the way just as you have to push water when you walk across a swimming pool. Think how easy it would be to walk if there were little or no air to push out of the way!

### Book Lift

As you blow into the plastic bag, more and more air is forced into that same small space (the inside of the bag). In order for more air to fit into the bag, the air that is already there has to be squeezed into a smaller amount of space, so that there will be room for the incoming air. When air is compressed into a smaller space, the air exerts greater pressure outward on its container, in this case the bag. The amount of air pressure pushing up on the bag is at least as great as the pressure pushing down on the bag from the weight of the books, and so the books can be supported by the compressed air. Many machines use compressed air and compressed liquid to do work in just this way. In fact, that is how *hydraulic brakes* that stop large trucks work.

**NOTES**

## REFERENCES:

Brown, R. J. 1984. *333 science tricks and experiments.* Blue Ridge Summit, PA: TAB Books.

Goldman, J. F. 1988. *The curiosity shop: A science sampler for the primary years.* Minneapolis, MN: T. S. Denison.

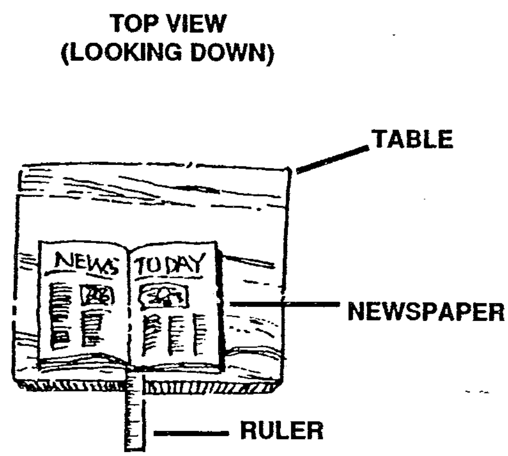
Mandell, M. 1989. *Simple science experiments with everyday materials.* New York: Sterling.

Walpole, B. 1988. *175 science experiments to amuse and amaze your friends.* New York: Random House.

# AIR PRESSURE POWER

*ACTIVITY SHEET*

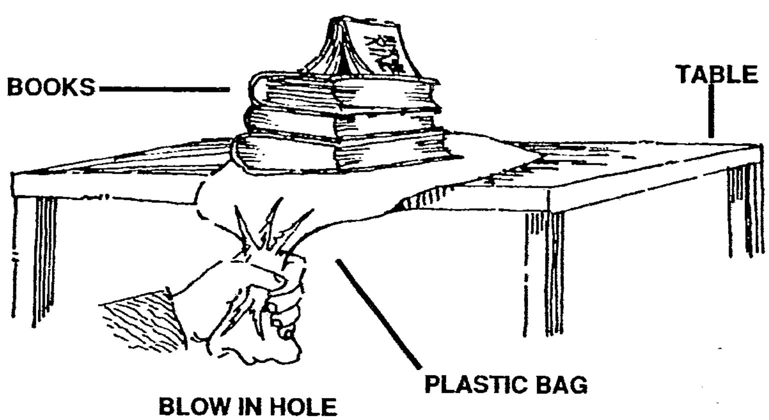
## Heavy News




1. Lay a 12-inch (30-cm) ruler on the edge of a table so that about 4 inches (10 cm) stick out over the edge of the table.
2. Open a full sheet of newspaper and lay it flat over the ruler and close to the edge of the table as in the diagram.
3. Predict what will happen if you push down hard on the edge of the ruler. Do you think that the paper will fly up into the air? Try it! (Hint: don't hit the ruler too hard or you might break it).
4. Did the paper fly into the air? Why or why not?
5. Now fold the paper in half and try it again. Keep folding the paper into smaller pieces. Is it getting easier or harder to move the paper? Why?

## Book Lift

1. Lay a plastic food storage bag flat on the surface of a table near the edge.
2. Set a stack of books on top, leaving the open end of the bag sticking out over the edge of the table.
3. Gather together the opening of the bag and blow into the bag like a balloon, keeping the opening as small as possible. What happens after a few blows? Did you topple the books?

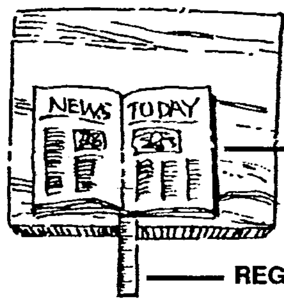


# LA FUERZA DE LA PRESION DEL AIRE

## *HOJA DE ACTIVIDADES*

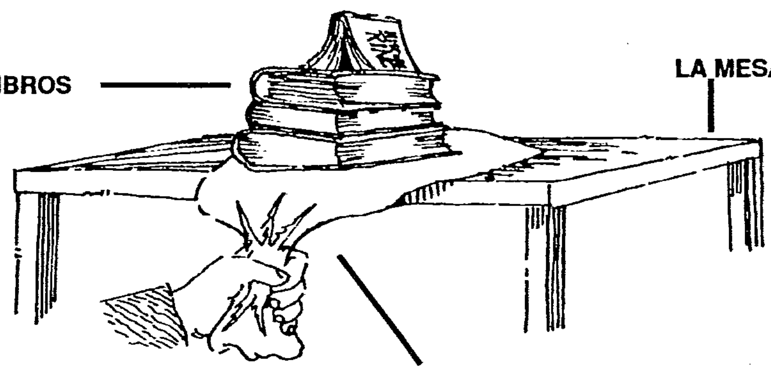
### EXPERIMENTO CON EL PERIODICO

1. Coloque una regla de 12 pulgadas (30 cm) en el canto o filo de la mesa, de manera que la regla sobresalga 4 pulgadas (10 cm).
2. Abra una hoja completa de periódico y póngala sobre la regla cerca del canto de la mesa, tal como se muestra en el diagrama.
3. ¿Qué ocurre si empuja hacia abajo la regla que se encuentra en el canto de la mesa? ¿Volará el periódico en el aire? ¡Haga la prueba! (advertencia: no golpee la regla muy duro porque se puede romper).
4. ¿Voló el periódico fácilmente? ¿Por qué? ¿Por qué no?
5. Doble el periódico por la mitad y haga la prueba nuevamente. Siga doblando el papel en partes pequeñas. Díganos, ¿Se hace más fácil o más difícil mover el periódico? ¿Por qué?




### EL EXPERIMENTO DE LEVANTAR LOS LIBROS

1. Extienda una bolsa plástica, del tipo que se usa para guardar alimentos, cerca del canto de la mesa.
2. Coloque los libros sobre la bolsa, de manera que la boca de la bolsa quede fuera del canto o del filo de la mesa.
3. Reduzca la boca de la bolsa y sople directamente dentro de ella como si fuera un globo; mantenga la boca de la bolsa reducida. ¿Qué ocurre cuando sopla? ¿Se movieron los libros?



# TRASH BAG AIRLIFT

## *SUGGESTIONS FOR TEACHERS*

### WHAT'S THE POINT?

To demonstrate that compressed air can do surprising work.

### ESTIMATED TIME:

| | |
|---|---|
| Setting up: | About 5 minutes |
| Doing activity: | About 10 minutes, plus additional time as more students want to try the activity |
| Cleaning up: | About 5–10 minutes |

### APPROPRIATE AGE GROUPS:

_X_ K–3 _X_ 4–6 _X_ 7–8

### DO ACTIVITY IN GROUPS OF: 4

(unless this is done as a demonstration)

### MATERIALS NEEDED (per group of 4 students):

- ✧ vacuum cleaner with hose, and with capability for attaching the hose to the exhaust outlet of the machine
- ✧ 3–4 feet (90–120 cm) of silver duct tape (one roll can be shared by the whole group)
- ✧ 4 large plastic garbage bags (one for each student in the group, in case they get holes on each try)
- ✧ piece of plywood large enough for student to sit on cross-legged
- ✧ extra bags on hand for the whole group
- ✧ towel or blanket to sit upon

### SAFETY CONSIDERATIONS:

- ✧ Help the student on the board to keep his/her balance so that he/she does not fall over when the bag begins to inflate.
- ✧ Look out for places on the plywood from which participants might get splinters. If the board is rough, you can put a towel or a blanket on top of it.
- ✧ Turn off the vacuum cleaner once you see that the bag is not inflating any further. Otherwise, the bag will probably pop, and the person on top may tumble over.
- ✧ Carefully monitor younger children's use of plastic bags and duct tape.

### ENRICHMENT FOR BILINGUAL STUDENTS:

- Discuss the difference in size of the sails on the Spanish vessels the Pinta, Niña, and Santa Maria. Have students compare the size of sails used during the time of the Spanish explorations and the size of sails today on vessels of similar size.

### ADAPTATIONS FOR PARTICIPANTS WITH DISABILITIES:

- Students with hearing impairments should be able to do this activity without any modifications other than for communicating the instructions.
- Students with visual disabilities can be directed to place their hands lightly on the bag and/or the rider to feel the bag being inflated and the rider rising.

### BEFORE YOU BEGIN:

- Make sure the trash bags do not have holes in them.
- Check the vacuum cleaner(s) to make sure it is possible to attach the hose to the exhaust outlet so that air will blow out of the back.
- For demonstrations, you may want to have the bag already sealed with duct tape and the hose already attached to the bag.
- Set up the activity in a large, clear area.

### QUESTIONS TO ASK AS YOU DO THE ACTIVITY:

- What happened that was expected?
- What happened that you didn't expect or was different from what you expected?
- When else have you felt the force or pressure of air?
- What other experiences have you had with compressed air holding things up?
- Would the same thing happen if you used a very small bag?
- What other things are full of air?

### CLEAN UP:

- Clean all duct tape off of the vacuum hose(s).
- Replace plastic bags. (Note: Seal holes in used bags with a piece of duct tape and use for your trash.)
- Check supply of duct tape.

### WHERE CAN I GO FROM HERE?

See the other activities in this section. For more activities involving air and other fluids check the following books: *Amazing Air* by Henry Smith; *Bet You Can* and *Bet You Can't*, two books by Vicki Cobb and Kathy Darling (each of these books has a chapter on fluids); *175 Science Experiments to Amuse and Amaze Your Friends* by Brenda Walpole, which has an entire chapter on air.

## WHY IT HAPPENS:

First, be sure to read the background information in the introduction to this section.

As air is blown into the bag, more and more air is forced into the limited space inside the bag. In order for more air to fit into the bag, the air that is already there has to be squeezed into a smaller amount of space, so that there will be room for the incoming air. When air is compressed into a smaller space, the pieces of air hit the sides of the container more often so the air exerts greater pressure outward on its container, which in this case is the trash bag. While the bag is inflating, the amount of force exerted by the internal air pressure is greater than the weight from the person sitting on top of the bag.

The explanation for this activity involves understanding the difference between *force* and *pressure*. *Pressure* is a basic push or pull, and *force* is created by a pressure being applied on a certain *area*. If you have a constant pressure, such as the air pressure coming out of the vacuum hose, then the strength of the force it applies will depend on the size of the area on which the air pressure is acting. The larger the area, then the larger the total force, and vice versa: the smaller the area the smaller the total force. By itself, the force of air from the hose of the vacuum cleaner is not enough to knock a person over or to hold a person up. For example, you could not *float* by being supported by the vacuum cleaner hose blowing upward! This is because the air blowing out of the hose usually only hits a small area of your body. But that amount of air pressure, created by the vacuum pushing on a larger surface (such as the garbage bag) creates a lot of force. In fact, you can write as a mathematical equation:

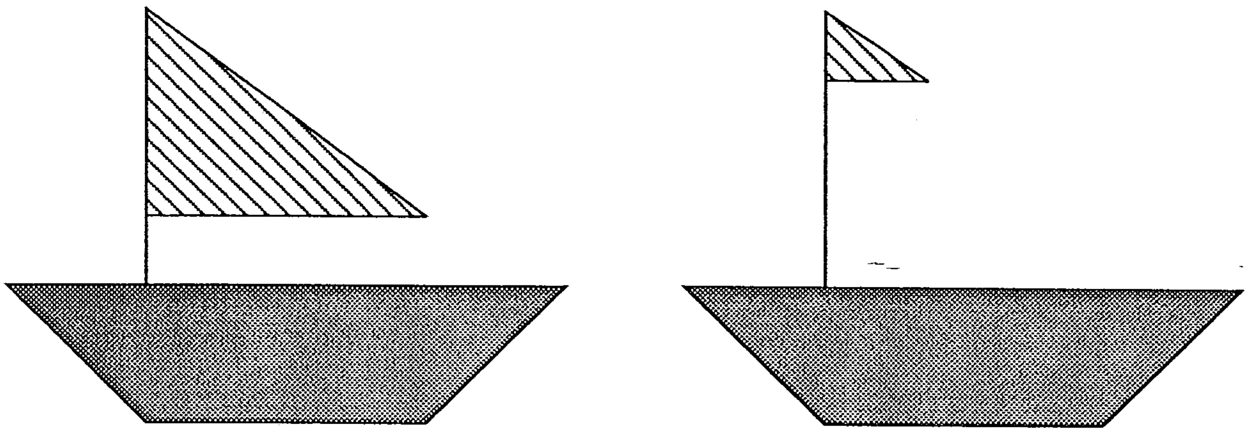
**Pressure (or push) = air force x surface area (of the bag)**

NOTES

## WHY IT HAPPENS: *continued*

The air blowing out of the vacuum hose fills the bag and increases the air pressure on the inside of the bag. As the air pushes outward against the bag, it creates a force pushing up, down, and outward on all sides. How strong is this force? Again, that depends on how big a surface it's pushing against. The larger the area, the stronger the force (or push).

Think of two sailboats. Which of the two boats will be pushed better by the wind?



You probably said the one on the left because the sail is bigger, correct? With a larger surface area, the same amount of air pressure (wind) would create more force to push the boat through the water.

In the case of our trash bag, the air is pushing out on a bag with a large surface area; this creates enough force to lift a person and a piece of plywood!

## REFERENCES:


Goldman, J. F. 1988. *The curiosity shop: A science sampler for the primary years*. Minneapolis, MN: T. S. Denison.

Minnix, R. B. 1987. Demonstration from the University of Virginia course, "Physics 551: Selected Topics on Classical and Modern Physics."

# TRASH BAG AIRLIFT

*ACTIVITY SHEET*

1. Attach the vacuum hose to the exhaust outlet of the vacuum cleaner, so that the air will blow out of the hose when the machine is turned on. The exhaust outlet is usually on the back of the vacuum cleaner.

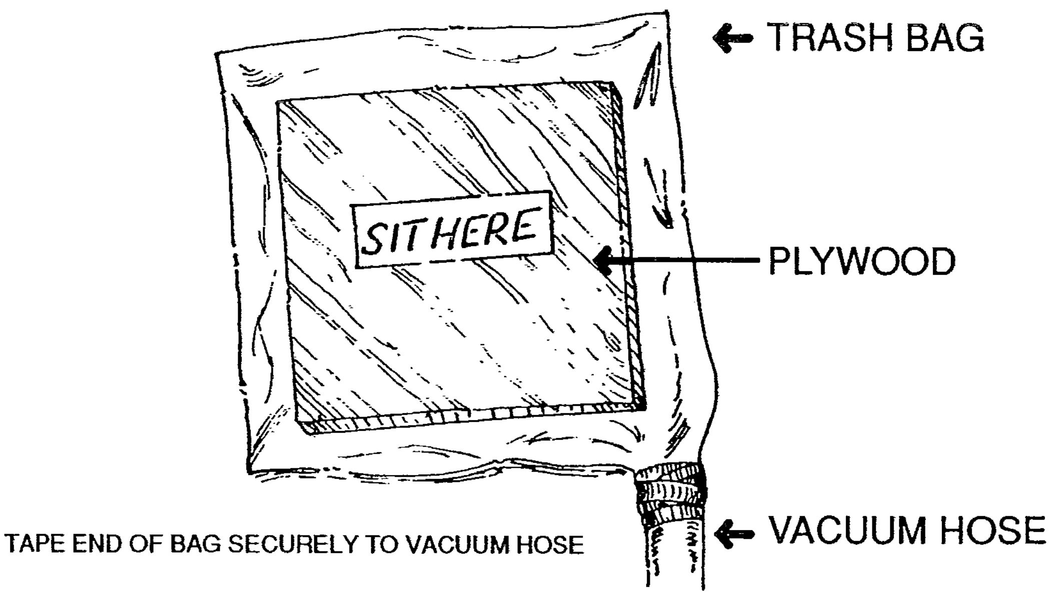
2. Using the duct tape, close and seal the open end of the trash bag except for a small opening at the end. Use the tape to seal the free end of the vacuum cleaner hose into that small opening so that the bag can be inflated through the hose.

3. Lay the trash bag on the floor or on a large, stable, flat surface. Lay the plywood on top of the bag to act as a stable platform. If the wood is rough, place a towel or blanket on top to sit upon.

4. Have one person sit on the board and balance carefully. Other members of the group should act as *spotters* to help the *board-sitter* keep balanced. What do you think will happen when you turn on the vacuum?

5. Turn on the vacuum cleaner and fill the bag enough to lift the person sitting on the board. It should happen fairly quickly. Turn off the vacuum cleaner once you see that the bag is not inflating any further. Otherwise, the bag will probably pop.

TOP VIEW
(LOOKING DOWN TOWARD THE FLOOR)




6. Why do you think the vacuum could lift the person?

# COMO LEVANTAR LA BOLSA DE BASURA

## *HOJA DE ACTIVIDADES*

1. Conecte la manguera al extractor de la aspiradora, de manera que el aire salga de la manguera cuando se prenda la máquina. El extractor, está ubicado por lo general, en la parte de atrás de la aspiradora.

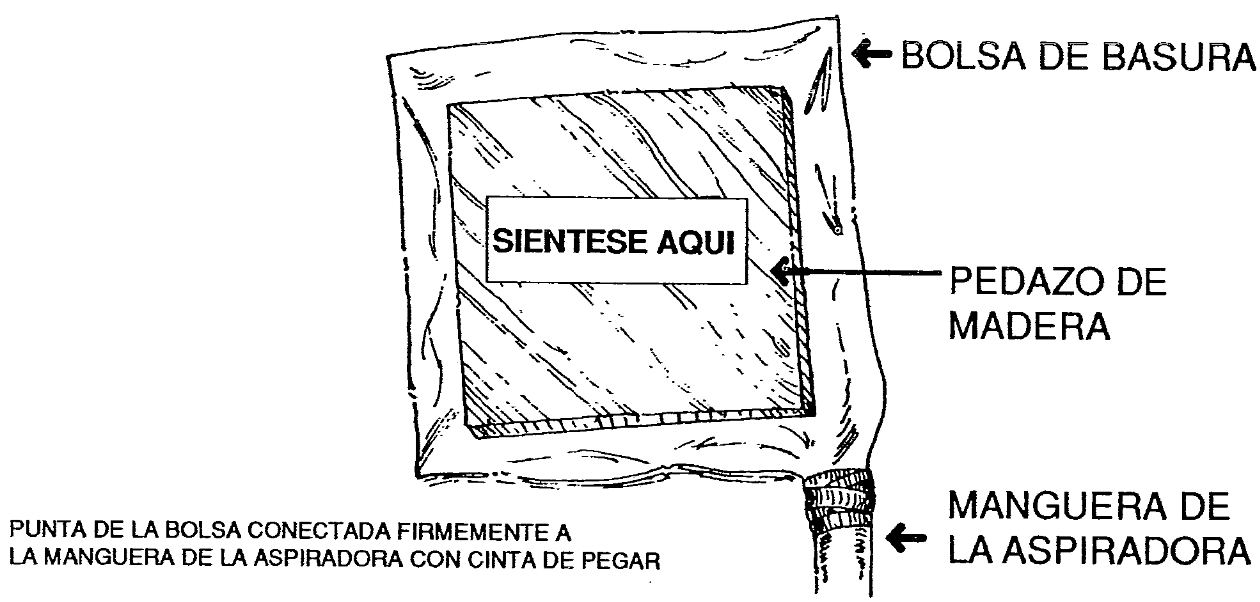
2. Selle la boca de la bolsa de basura con la cinta de pegar, dejando una pequeña abertura en una punta. Utilice la cinta de pegar, para conectar el otro lado de la manguera de la aspiradora a la pequeña abertura de la bolsa, de manera que la manguera infle la bolsa.

3. Extienda la bolsa de basura sobre una superficie plana. Coloque el pedazo de madera sobre la bolsa para formar una plataforma firme. Si la madera es rugosa, coloque una toalla o una manta antes de sentarse.

4. Ayude a la persona a sentarse sobre la tabla y a mantener el equilibrio. Otros niños del grupo, pueden ayudar a la persona a mantener el equilibrio. ¿Qué ocurre cuando prende la aspiradora?

5. Prenda la aspiradora e infle la bolsa, lo suficiente para levantar a la persona que está sentada sobre la madera. Esto debe ocurrir rápidamente. Cuando vea que la bolsa ya no se infla más, apague la aspiradora porque de otra manera la bolsa puede explotar.

VISTA DESDE ARRIBA




6. ¿Por qué levantó la aspiradora a la persona?

# HOT AND COLD AIR

## *SUGGESTIONS FOR TEACHERS*

### WHAT'S THE POINT?

Air pressure can be increased by increasing the amount of air in a container, as in the *Book Lift* (see *Air Pressure Power*) or the *Trash Bag Airlift* activities. But, air pressure also depends on the temperature of the air. This activity demonstrates what happens to the air pressure in a bottle when you raise the air temperature and then lower the air temperature.

### ESTIMATED TIME:

| | |
|---|---|
| Setting up: | About 10 minutes |
| Doing activity: | About 10–15 minutes |
| Cleaning up: | About 5–10 minutes |

### APPROPRIATE AGE GROUPS:

_X_ K–3 _X_ 4–6 ___ 7–8

### DO ACTIVITY IN GROUPS OF: 2

### MATERIALS NEEDED (per group of 2 students):

- 1 balloon
- 1 plastic or glass bottle (such as a 16-oz. or 473-ml soda pop or catsup bottle—glass ones work best)
- 2 deep bowls, buckets, or kettles, deep enough so that at least half of the bottle will be in water
- enough hot water to halfway fill one bowl (hot tap water will do)
- enough ice cold water to halfway fill the other bowl (water with ice works best)
- (optional) a rubber band

### SAFETY CONSIDERATIONS:

- If glass bottles are used, be careful of breakage.
- Use care when handling hot water to avoid burns.

## ENRICHMENT FOR BILINGUAL STUDENTS:

- Hot air balloons and gliders are two examples of how we use differences in air pressure. Arrange a trip to a local airport to see a glider or arrange for a Hispanic pilot to visit the school/classroom to explain air pressure.
- Have children build model gliders using paper and wood. Children can experiment flying their model glider over blacktop areas and grass areas. What differences do the students observe? Do the students observe differences in the birds flying over these different areas?

## ADAPTATIONS FOR PARTICIPANTS WITH DISABILITIES:

This experiment can be repeated many times. Allow students with visual disabilities to hold the balloon lightly so they can feel the change.

## BEFORE YOU BEGIN:

- Clear a large enough working area so that every one has room.
- Check balloons for holes.
- Check bottles to make sure there are no cracks or rough places that may cut fingers or put a hole in the balloon.

## QUESTIONS TO ASK AS YOU DO THE ACTIVITY:

- What happened that was expected?
- What happened that you didn't expect or was different from what you expected?
- Have you had any experience with hot air rising or expanding, or putting pressure on something? (Good examples include a lid on a pan of boiling water, a car radiator, and a steam whistle.)
- Can you think of other examples of situations where hot and cold air work this way?

## CLEAN UP:

- Replace all balloons that have holes in them.
- Check bottles to make sure no cracks or chipped areas have developed.

## WHERE CAN I GO FROM HERE?

For more activities involving air and fluids, check the following books: *Amazing Air* by Henry Smith; *Bet You Can* and *Bet You Can't*, two books by Vicki Cobb and Kathy Darling (each of these books has a chapter on fluids); *175 Science Experiments to Amuse and Amaze Your Friends* by Brenda Walpole, which has an entire chapter on air.

## WHY IT HAPPENS:

First, be sure to read the background information in the introduction to this section.

When you put the bottle in the bowl of hot water, the hot water heats up the air inside the bottle. As the air gets warmer, the particles of air (or molecules) bounce around more quickly and spread farther apart. This causes the air to take up more space. Since no air can escape from the bottle (as long as there are no holes in the bottle or balloon), the faster moving air molecules create greater pressure on the insides of the bottle and the balloon. The bottle should be strong enough to withstand the pressure exerted by the air without changing, but the balloon responds to the increased pressure by stretching and expanding. There is the same *amount* of air inside of the bottle and balloon, but now it occupies more space because the balloon has expanded. The air inside the bottle is therefore *less dense* than it was before the balloon expanded. A good example of this is the hot air balloons in which people ride. They have a heater at the bottom to heat the air inside so that it expands and fills the balloon. Since it is less dense, and therefore lighter than the air outside the balloon, the balloon floats upward!

When you put the bottle in the bowl of ice water, the air inside the bottle becomes cooler. As the air gets cooler, its molecules move more slowly and do not move as far apart. Therefore, the air begins to take up less space. Again, since the same *amount* of air is inside the bottle and balloon, and since the air molecules hit the sides of the container less often as they got cooler, there is less pressure on the sides of the container. As the air inside the bottle and balloon occupies less space, the balloon shrinks, too, and the air in the bottle is more dense than it was before the air was cooled. In fact, the balloon may be blown up inside the bottle by the higher pressure, warmer air outside.

## REFERENCES:

Brown, R. J. 1984. *333 more science tricks and experiments.* Blue Ridge Summit, PA: TAB Books.

Goldman, J. F. 1988. *The curiosity shop: A science sampler for the primary years.* Minneapolis, MN: T. S. Denison.

Hoffman, J. 1989. *Backyard scientists, series two.* Irvine, CA: Backyard Scientist.

Walpole, B. 1988. *175 science experiments to amuse and amaze your friends.* New York: Random House.

**NOTES**

# HOT AND COLD AIR

*ACTIVITY SHEET*

1. Partially blow up a balloon, and then let the air out of it. This stretches the balloon a little so you get a more dramatic result in the rest of the experiment.

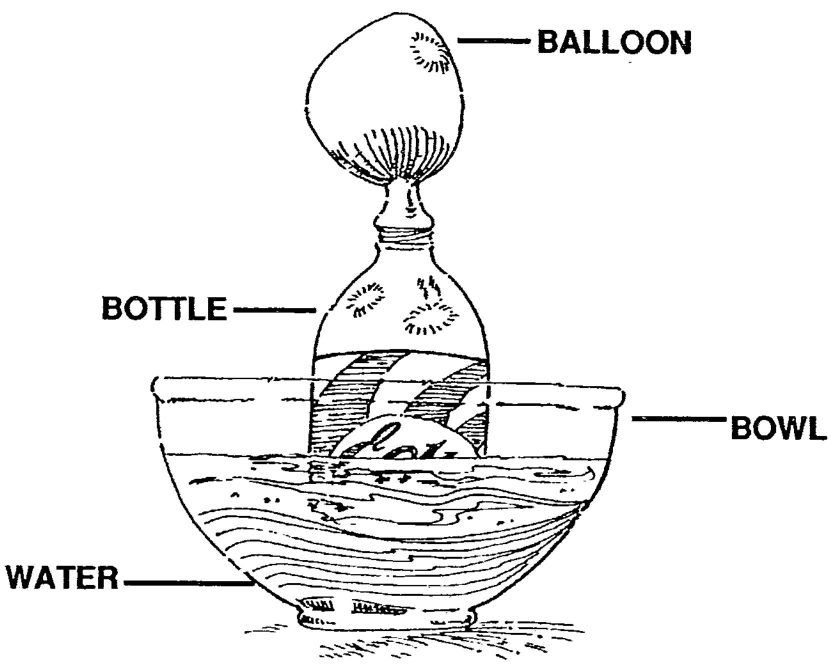
2. Stretch the opening of the balloon over the mouth of a plastic or glass bottle, such as a 16-oz. (473-ml) soda bottle. Make sure you have a good seal between the balloon and the bottle (add a rubber band around the balloon and bottle mouth if needed).

3. Fill one bowl halfway with hot water and fill the other bowl halfway with ice water.

4. Stand the bottle in the bowl of hot water; hold the top of the bottle so it won't tip over. What do you think will happen to the balloon? Why?

5. After a few minutes, take the bottle and place it in the bowl of cold water. Now what happens to the balloon? Can you explain why?

6. Describe what you think happened to the air pressure inside the bottle.



# AIRE FRIO Y CALIENTE

## *HOJA DE ACTIVIDADES*

1. Infle un globo hasta la mitad y deje que el aire se escape. ¿Vió lo que pasó? Bueno, ahora verá un resultado más dramático en el resto del experimento.

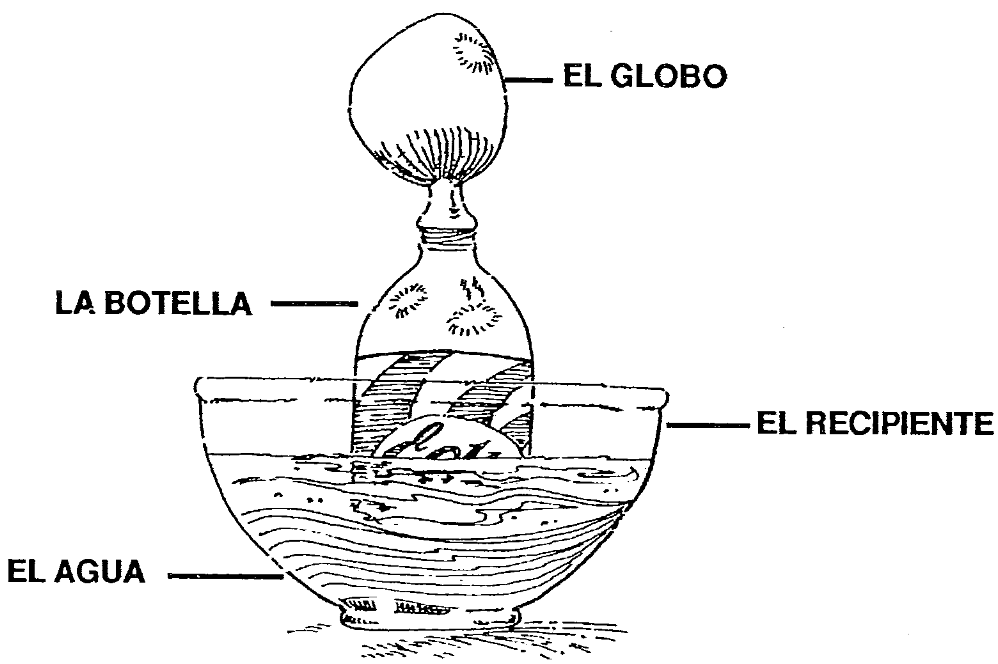
2. Estire la boca del globo para que cubra la boca de la botella plástica o de vidrio (puede ser una botella de soda de 16 onzas/473 ml). Fíjese que el globo quede bien adaptado a la botella (coloque una banda elástica en el sitio donde se unen el globo y la botella, si cree que es necesario).

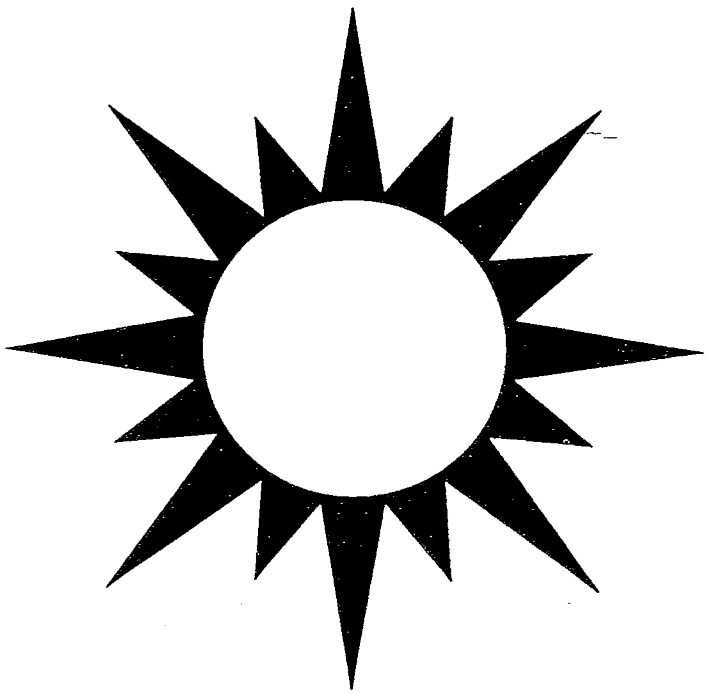
3. Llene un recipiente con agua caliente hasta la mitad, y el otro recipiente con agua helada, también hasta la mitad.

4. Coloque la botella de pie en el recipiente de agua caliente; sostenga la parte de arriba de la botella de manera que no se incline de ningún lado. ¿Qué le ocurre al globo? ¿Puede explicar por qué?

5. Después de unos minutos, coloque la botella en el recipiente de agua fría. ¿Qué le ocurre al globo? ¿Puede explicar por qué?

6. Explique lo que paso dentro de la botella.





# EGG-IN-A-BOTTLE

## *SUGGESTIONS FOR TEACHERS*

**WHAT'S THE POINT?**

To demonstrate that air can push objects from higher pressure toward lower pressure areas.

**ESTIMATED TIME:**

| | |
|---|---|
| Setting up: | About 20 minutes to boil the eggs, plus time to gather all materials |
| Doing activity: | About 5–10 minutes for demonstration |
| | About 10 minutes for activity |
| Cleaning up: | About 10 minutes |

**APPROPRIATE AGE GROUPS:**

_X_ K–3 _X_ 4–6 __ 7–8

**DO ACTIVITY IN GROUPS OF: 2–3**

**MATERIALS NEEDED:**

**For teacher demonstration**

- hardboiled egg, cooled and peeled
- glass bottle (do not use plastic, since there will be a flame inside) with a neck slightly smaller than the egg. Suggested types include a wine carafe, a bottle in which ready-to-drink juice is sold at grocery stores, an old-fashioned milk bottle, or an 8-oz. (240-ml) glass baby bottle.
- A piece of paper or paper napkin
- a match or candle or lighter
- a small glass of water to dip the egg into
- enough water to rinse the burned paper and ashes
- sink or container (such as a bucket) into which the rinse water can be poured

**For student activity**

- hard-boiled egg, cooled and peeled
- glass bottle with a neck slightly smaller than the egg
- 2 large bowls
- enough ice to half fill 1 bowl
- enough water to half fill 2 large bowls

## SAFETY CONSIDERATIONS:

- Please note that there are two ways to do this activity: One involves fire and matches and the other does not.
- Closely supervise the use of matches and fire.
- Closely monitor the use of glass bottles.
- Watch out for slippery floors if water gets spilled.
- When you blow into the bottle to get the egg out, be aware that the egg can pop out very quickly!

## ENRICHMENT FOR BILINGUAL STUDENTS:

Arrange for a meteorologist (preferably one who is Hispanic) to visit the school/ classroom to elaborate on air pressure and how high and low pressure affect us (for example, tornadoes). Contact local television and radio stations to locate meteorologists who could talk to several classes at once.

## ADAPTATIONS FOR PARTICIPANTS WITH DISABILITIES:

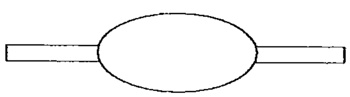
- Students with hearing impairments can participate fully, with appropriate modifications in communicating the instructions.
- Students with mobility impairments may need a partner for this activity.

## BEFORE YOU BEGIN:

- Boil enough eggs for all groups plus several extras. Boil them long enough to make sure they are *completely* hardboiled. Allow time for the eggs to cool. Peel them.
- Make sure the bottles are not cracked and do not have rough or chipped rims.

## QUESTIONS TO ASK AS YOU DO THE ACTIVITY:

- What happened that was expected?
- What happened that you didn't expect or that was different from what you expected?
- When else have you experienced the force or pressure of air?
- What would happen if you poked a hole through the middle of the egg using a straw before you did the experiment?



## CLEAN UP:

- Check to make sure that none of the bottles have become cracked or chipped.
- Rinse all egg residue out of bottles.

## WHERE CAN I GO FROM HERE?

See the other activities in this section. For more activities involving air and fluids check the following books: *Amazing Air* by Henry Smith; *Bet You Can* and *Bet You Can't*, two books by Vicki Cobb and Kathy Darling (each of these books has a chapter on fluids); *175 Science Experiments to Amuse and Amaze Your Friends* by Brenda Walpole, which has an entire chapter on air.

## WHY IT HAPPENS:

First, be sure to read the background information in the introduction.

### Getting the egg into the bottle

As any material burns, it uses up oxygen in the air around it. On average, the air in the earth's atmosphere contains about 20% to 21% oxygen (the rest of our air is mostly nitrogen gas). So, as the paper inside the bottle burns, it potentially can reduce the actual amount of air inside the bottle by 20%. The egg seals the neck of the bottle so that no more air can get in to replace the oxygen. As the amount of air in the bottle is reduced, the air pressure inside the bottle is reduced, but the air pressure *outside* of the bottle has not changed. Therefore, the air pressure inside the bottle is less than the air pressure outside the bottle, and the egg is *pushed* by the greater pressure outside toward the area of lower pressure inside the bottle. As soon as the egg is in the bottle and the bottle is open, some air rushes into the bottle. This makes the pressure inside and outside become equal again. You can hear this rush of air as a pop when the egg enters the bottle.

Before the egg was pushed into the bottle, it may have bounced around a bit. This is caused by the gases inside the bottle being heated by the flame and expanding. Some of these gases may be forced out past the egg, which acts as a one-way valve. The second way to get the egg into the bottle uses the same principles we learned in the *Hot and Cold Air* activity. By placing the bottle in warm water first, you warm the air inside, and the pieces (molecules) of air speed up and create more pressure inside the bottle. Then by capping the bottle with the egg and placing it in cold water, you chill the air inside. The pieces of air slow down and create less pressure inside the bottle. The outside air is still warm and, therefore, exerts more pressure downward on the egg than the cold air inside the bottle that pushes up on the egg. If the temperature difference (and thus the pressure difference) is great enough, the egg will be pushed into the bottle.

**NOTES**

## WHY IT HAPPENS: *continued*

### Getting the egg out of the bottle

When you blow air into the bottle, the egg acts as a one-way valve, allowing air into the bottle but not out as long as the egg stays in the neck. If you have forced enough air into the bottle, then the inside air pressure becomes larger than the normal pressure outside the bottle. Again, the egg is pushed by the greater air pressure (this time inside the bottle) toward the lower pressure area (this time outside the bottle).

The second way to get the egg out of the bottle uses the same principal that we learned in the *Hot and Cold Air* activity and that we used to get the egg in the bottle. By first placing the bottle in cold water, the pieces of air slow down and create less pressure inside the bottle. Some of the warm air outside rushes into the open bottle. Then by placing the bottle in warm water, thereby *warming* the air inside, the pieces of air speed up and create more pressure inside the bottle. If the air pressure difference is great enough, the egg will be pushed outside the bottle.

## REFERENCES

Goldman, Jane F. 1988. *The curiosity shop: A science sampler for the primary years.* Minneapolis, MN: T. S. Denison.

Herbert, Don. 1980. *Mr Wizard's supermarket science.* New York: Random House.

Mandell, M. 1989. *Simple science experiments with everyday materials.* New York: Sterling.

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# EGG-IN-A-BOTTLE

## *TEACHER DEMONSTRATION*

1. Peel the hardboiled egg carefully. Check to see that the egg will just fit into the neck of the bottle without falling through. It should rest snugly on the neck of the bottle. With the egg sitting in the neck of the bottle, is there any difference between the air pressure inside and the air pressure outside the bottle? Now remove the egg and set it aside for the moment.

2. Next, get a burning piece of paper inside the bottle. This can be done in either of these two ways:

   ✧ lightly crumple the piece of paper and drop it into the bottle. Then light the paper by using a long candle or match or by dropping a lighted match into the bottle; or

   ✧ lightly crumple the piece of paper into a long, narrow shape. Use the match, candle, or lighter to light one end of the paper. Then hold the bottle sideways and quickly slip the burning paper into the bottle. Turn the bottle upright and set it on the table.

3. Quickly dip the egg into a glass of water to dampen it, and then set on the neck of the bottle so that the egg forms a seal. (Dampening the egg helps form a complete seal and also helps to lubricate the egg.) Watch what happens. Try to explain why this happens!

4. If the paper is still burning, put it out by pouring some water into the bottle.

5. Sometimes the egg breaks as it is forced into the bottle. If the egg is still whole, you can try to get the egg back *out* of the bottle!

   ✧ Put some water into the bottle to rinse out the burned pieces of paper. Use your finger to hold the egg away from the opening of the bottle while you pour out the paper and ashes.

   ✧ Hold the bottle upside-down so that the egg rests in the neck of the bottle and seals off the opening as it did before it was pushed into the bottle.

   ✧ Keep the bottle upside-down with the egg in the neck and then quickly blow some air into the bottle past the egg. Keeping the bottle upside-down, move the bottle away from your mouth, but be ready to catch the egg as it is pushed out of the bottle.

# EGG-IN-A-BOTTLE

***ACTIVITY SHEET***

Can you think of another way to get the egg into the bottle? If you did the activity, *Hot and Cold Air,* you may be able to think of a way using a bucket of ice-cold water!

Try this:

1. Check to see that the egg will just fit into the neck of the bottle without falling through. It should rest snugly on the neck of the bottle. With the egg sitting in the neck of the bottle, is there any difference between the air pressure inside and the air pressure outside the bottle? Now remove the egg and set it aside for the moment.

2. Fill a bucket or a bowl with ice. Add a little bit of water.

3. Fill the second bucket or bowl with warm tap water.

4. As in step 1 above, place the egg on top of the bottle.

5. Place the bottle with the egg in the bowl with the warm water. You may have to hold onto the neck of the bottle to keep it from tipping over. Add water as needed to nearly fill the bowl. What is happening to the egg? Is it moving?

6. After a minute, transfer the bottle to the bowl with the ice. You may need to add more water.

7. Observe the egg for a few minutes to see what happens. Try to explain why the egg moved.

8. Sometimes the egg breaks as it is forced into the bottle. If the egg is still whole, you can try to get the egg back *out* of the bottle!

    ✧ Turn the bottle upside-down so the egg fits snugly in the opening.

    ✧ While keeping the bottle upside-down, place it in the bowl with warm water.

    ✧ Be ready to catch the egg as it comes out of the bottle.

# EL HUEVO EN LA BOTELLA

## *HOJA DE ACTIVIDADES*

¿Sabe otra manera de introducir el huevo en la botella? Si hizo el experimento del *Aire caliente y frío* puede utilizar un balde de agua helada. Haga el experimento:

1. Ajuste el huevo al cuello de la botella. Cuando coloca el huevo en el cuello de la botella, ¿nota alguna diferencia entre la presión interna y externa de la botella? Remueva el huevo y déjelo a un lado por un momento.

2. Llene un balde o una tetera con cubos de hielo o hielo picado. Agregue un poco de agua.

3. Llene otro balde o una tetera con agua tibia de la pila.

4. Coloque el huevo en la botella tal como se indica en el paso #1. Humedezca el huevo para que se deslice facilmente.

5. Coloque la botella con el huevo dentro del balde con agua tibia. Sostenga el cuello de la botella para que no se incline a ningún lado. Agregue la cantidad de agua necesaria para llenar el balde casi completamente. ¿Qué ocurre con el huevo? ¿Se mueve?

6. Ahora, coloque la botella con el huevo dentro del balde con hielo y agua.

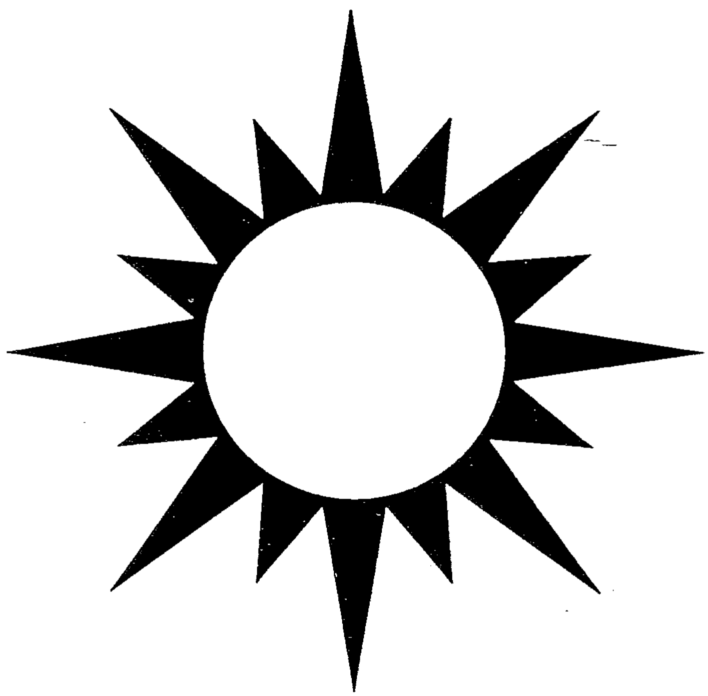
7. Observe el huevo por unos minutos para ver lo que ocurre. Explique por qué se mueve el huevo.

8. Algunas veces el huevo se quiebra cuando se trata de introducir en la botella. Si el huevo está entero puede sacarlo de la botella.

   - Invierta o voltee la botella, haciendo que el huevo se coloque en el cuello de ésta como una tapa.

   - Teniendo cuidado que el huevo selle el cuello de la botella, acueste la botella en el balde con agua tibia, por un minuto.

   - Saque la botella del agua para que salga el huevo.



# AIR IN MOTION

*SUGGESTIONS FOR TEACHERS*

### WHAT'S THE POINT?

To demonstrate the difference in sideways pressure when air is in motion compared to when air is at rest and to learn how Bernoulli's principle helps airplanes take off.

### ESTIMATED TIME:

| | |
|---|---|
| Setting up: | About 5–10 minutes to gather all materials. If you cut paper ahead of time, add another 5–10 minutes |
| Doing activity: | About 5 minutes (15 minutes if participants cut paper) |
| Cleaning up: | About 5 minutes |

### APPROPRIATE AGE GROUPS:

X K–3 X 4–6 X 7–8

### DO ACTIVITY IN GROUPS OF: 1

### MATERIALS NEEDED (per student):

- paper strips, 2 inches (5 cm) wide by 8.5 inches (21 cm) long
- paper sheets, 8.5 inches (21 cm) wide by 11 inches (28 cm) long
- scissors, if needed, to cut the paper to the appropriate sizes
- crayons and markers if children want to decorate their papers

### SAFETY CONSIDERATIONS:

Use safety scissors with younger children.

## ENRICHMENT FOR BILINGUAL STUDENTS:

Contact local NASA regional centers, universities, or engineering industries to locate scientists (preferably Hispanic scientists) who could present to students a variety of ways compressed air (air pressure) is used in the space program, in research, and in manufacturing.

## ADAPTATIONS FOR PARTICIPANTS WITH DISABILITIES:

- Students with hearing impairments only need to have modifications in the instructions. Otherwise, they can easily do this activity.
- Students with visual impairments can do this with a partner.

## BEFORE YOU BEGIN:

You may want to have the paper already cut to the appropriate sizes.

## QUESTIONS TO ASK AS YOU DO THE ACTIVITY:

- What happened that was expected?
- What happened that you didn't expect or that was different from what you expected?
- What experiences have you had where something was *sucked* into a moving stream of air?
- Where else have you experienced the force or pressure of air?

## CLEAN UP:

Replace any torn or damaged sheets of paper.

## WHERE CAN I GO FROM HERE?

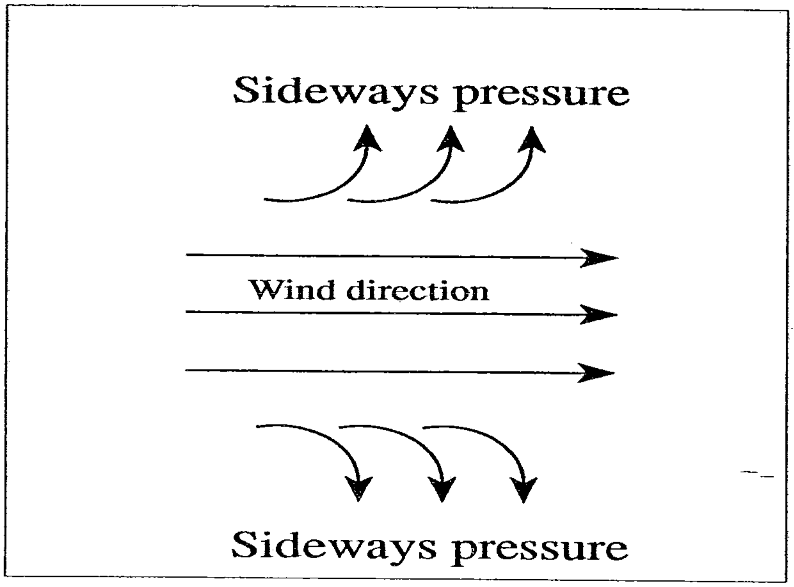
See the other activities in this section. For more activities involving air and fluids check the following books: *Amazing Air* by Henry Smith; *Bet You Can* and *Bet You Can't*, two books by Vicki Cobb and Kathy Darling (each of these books has a chapter on fluids); and *175 Science Experiments to Amuse and Amaze Your Friends* by Brenda Walpole, which has an entire chapter on air.

## WHY IT HAPPENS:

First, be sure to read the background information in the introduction to this section. Among other things, you'll read about how differences in air pressure allow airplanes to fly.

**WHY IT HAPPENS:** *continued*

When air (or any fluid) moves, it does not exert as much sideways pressure as it does when it is still. The faster a fluid moves, the lower the sideways pressure it exerts (see diagram).




This principle was discovered in the eighteenth century by a Swiss scientist named Daniel Bernoulli, and so is called the **Bernoulli principle.** A good example of this is a rushing stream. Even though the water is moving swiftly down the stream, it does not rush sideways toward the bank. Therefore, the water is usually calmer at the edges of the stream. The Bernoulli principle also means that the greater the difference in speed between the fast-moving and slow-moving (or still) fluid, then the greater the difference in pressure will be between the fast-moving and slow-moving fluid. Objects will be pushed from the higher pressure, slower fluid areas toward the lower pressure, faster fluid areas.

In the first part of this activity, the strip probably rose up, instead of being pushed down as you might have expected. In the second part of this activity, the paper sheets probably came together, instead of being pushed apart as you might have expected. These observations can be explained by the Bernoulli principle. In both cases, you created a stream of air that was moving faster than the surrounding still air. The pressure was greater in the still air outside the sheets than in the moving air inside the sheets. Therefore, the paper sheets were pushed by the greater air pressure toward, rather than away from, the moving air.

NOTES

**WHY IT HAPPENS:** *continued*

As an additional factor, in the case of the paper strip you had to create enough of a difference in pressure so that the downward weight of the paper strip would be overcome by the air forces making the paper rise upward. This probably could not be done with an object much heavier than the paper, unless the air was moving very fast! For example, objects can be pushed into the extremely fast-moving air of a hurricane or a tornado with great force.

## REFERENCES:

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Ehrlich, R. 1990. *Turning the world inside out.* Princeton, NJ: Princeton University Press.

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Walpole, B. 1988. *175 science experiments to amuse and amaze your friends.* New York: Random House.

# AIR IN MOTION
## *ACTIVITY SHEET*

### Activity 1

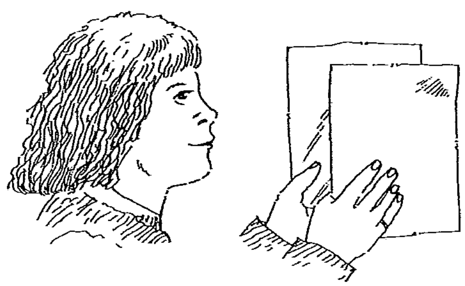
1. Cut a strip of paper about 2 inches (5 cm) wide by 8.5 inches (21 cm) long.

2. Place the end of the strip against your chin as shown.

3. What do you think will happen if you blow across the top of the paper? Try it. Blow straight outward in a steady stream across the top of the paper. Direct your air stream outward and not downward at the paper. What happens to the paper? Why do you think this happens?

### Activity 2

1. Take two 8.5-inch (21-cm) by 11-inch (28-cm) sheets of paper and hold them in front of your face, about 2 or 3 inches (5 to 8 cm) apart, side by side so that you are looking at the edges and the flat sides are facing each other (see diagram).



2. What will happen if you blow a steady stream of air between the sheets? Try it. Blow a steady stream of air between them to try to blow them apart. What happens if you blow even harder? What could be causing the paper to move this way?

# EL AIRE EN MOVIMIENTO
### *HOJA DE ACTIVIDADES*

## ACTIVIDAD 1

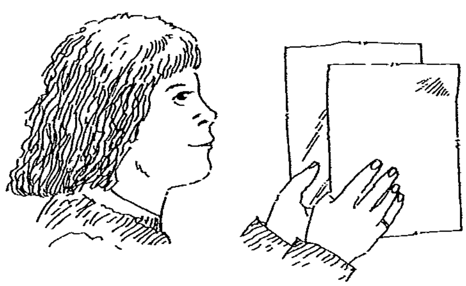
1. Corte un pedazo de papel de 2 pulgadas (5 cm) de ancho por 8.5 pulgadas (21 cm) de largo.

2. Como en el dibujo, coloque la punta del papel sobre su barbilla.

3. ¿Qué ocurre cuando sopla directamente sobre la parte de arriba del papel? Haga la prueba. Sople sobre la parte de arriba del papel, no sobre la parte de abajo. ¿Qué ocurre con el papel? ¿Por qué ocurre?

## ACTIVIDAD 2

1. Como en el dibujo, tome dos hojas de papel de 8.5 pulgadas (21 cm) por 11 pulgadas (28 cm) y ponga cada hoja a una distancia de 2 o 3 pulgadas (5 a 8 cm) de su cara, una hoja de cada lado de la cara de manera que pueda ver el filo de las hojas, y fíjese que los lados planos de las hojas queden uno frente a otro.



2. ¿Qué ocurre si sopla en forma constante entre las dos hojas? Haga la prueba. Sople constantemente entre las hojas para tratar de separarlas. ¿Qué ocurre si sopla con más fuerza? ¿Por qué se mueve el papel de esa manera?