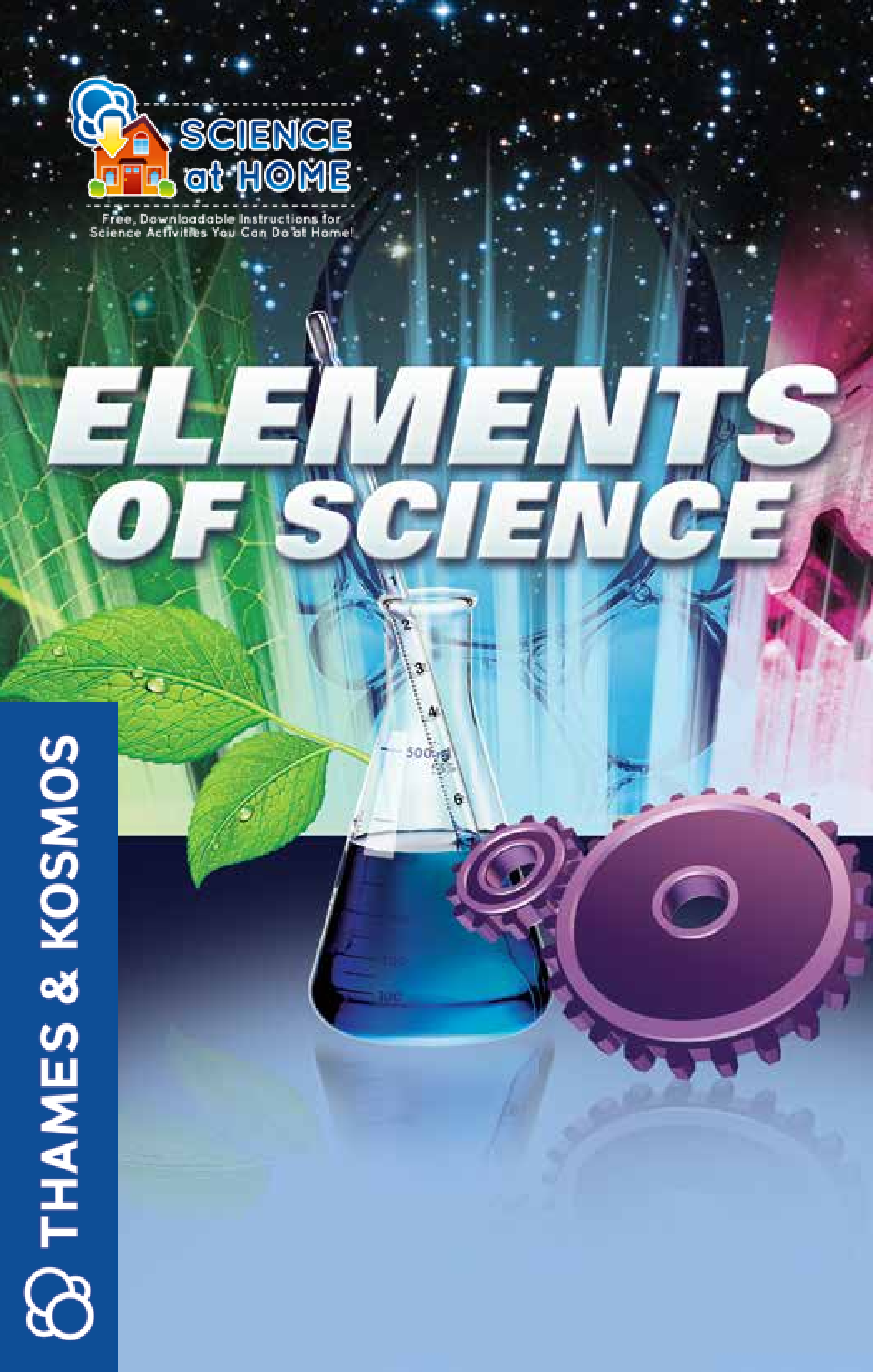


Advice for Supervising Adults

Children are curious by nature. They want to investigate, explore, and understand their environment. The Elements of Science experiment series will help your child do all those things.

A wealth of natural phenomena are explained in a simple and enjoyable style, and explored more closely in safe yet exciting series of experiments. This will also come in handy in school, because these same themes will come up in elementary school and again later in physics, biology, and chemistry classes.

We are, therefore, addressing this to you and filling you in on what you should do. Page through the activity sheets and pay special attention to the **safety rules**. Then select the experiments that seem the most appropriate for your child. Some of the experiments for which **assistance or supervision by parents** is especially necessary are marked with the adjacent symbol.

Before starting the experiments, discuss these safety suggestions with your child.

Read and follow the instructions, the safety rules and the first aid information and keep them for reference.

The incorrect use of chemicals can cause injury and damage to health. Only carry out those experiments which are listed in the instructions.

This experimental series is for use only by children over 10 years.

Because children's abilities vary so much, even within age groups, supervising adults should exercise discretion as to which experiments are suitable and safe for them. The instructions should enable supervisors to assess any experiment to establish its suitability for a particular child.

The supervising adult should discuss the warnings and safety information with the child or children before commencing the experiments.

The area surrounding the experiment should be kept clear of any obstructions and away from the storage of food. It should be well lit and ventilated and close to a water supply. A solid table with a heat resistant top should be provided.

Experiments with Air

We live at the bottom of a gigantic ocean of air. Yet even though we are constantly inhaling this thin gaseous mixture, we rarely spend any time thinking about it. Meanwhile, the air carries birds and jet planes, drives sailboats and windmills, and, when storm winds are raging across the land, it can even blow us over.

Air Needs Room

One reason we rarely think about air is we cannot see it. That is why we call an empty cup "empty." But is it really?

You will need: 1 large measuring cup, funnel, clay, *bowl, paper towel, 1 empty bottle, water*

Here's how: Fill the bowl with water and immerse the cup in the water with its open end down. The water will not rise into the seemingly empty cup at all, because the air inside blocks its way in.
Make a bet with a friend that you can keep a paper towel dry even if you hold it under water. Just stuff the paper towel into the measuring cup, turn the cup upsidedown, and immerse it. The trapped air will keep the water away from the paper.

What's going on? The cup wasn't really empty, it was filled with air. Even if air is invisible to our eyes, it still takes up a certain amount of space.

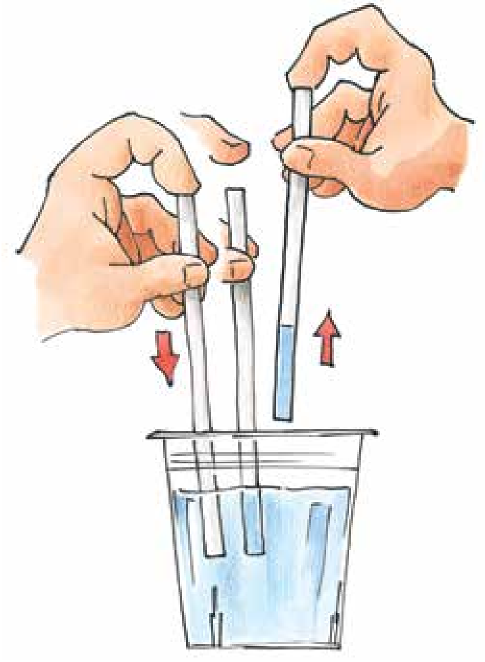
Did you know...

..that diving bells work just like an upside-down cup?

Diving bells are large chambers, open at the bottom, that are lowered to the ocean floor and supplied with compressed air from the surface. Divers can work in them without cumbersome suits because the air doesn't allow any water to enter.

Supplemental Experiment

Insert the funnel into the neck of an "empty" bottle and seal the bottle mouth around the funnel with clay. Fill the funnel with water. It will either not flow into the bottle at all or will only do so hesitatingly, because the trapped air is preventing it. Air bubbles may rise up inside the funnel. But if you remove the clay, the funnel will quickly empty into the bottle, because the air can escape from the bottle through the space between the funnel and the neck. The principle also works in reverse. You can pour something like juice more easily out of a can if you make a second hole for the air to enter as the juice flows out.



Straw Pipette

You will need: 1 large measuring cup, see-through drinking straw, *water*

Here's how: Fill the measuring cup with water and immerse a drinking straw into it vertically, holding your index finger over the top opening. The water will only rise a few millimeters up the straw, because it cannot push out the air. But if you lift your finger off, it will flow quickly into the straw. Press your finger over the opening again and lift the drinking straw out of the water. The water will remain inside and will only flow out when you lift your finger again. An instrument like this, which you can use to take samples of a liquid, is also called a pipette.

The Weight of Air

Air seems so thin and light. Does it have any weight at all? Try weighing it!

You will need: 2 balloons, wooden stick, *thread (thin),* a wire twist-tie (like used to close up a bread bag, *scissors, adhesive tape*

Here's how: First construct a sensitive scale. Suspend the wooden stick from the knotted thread, so that it can dangle freely like a balance scale.

Cut two pieces of wire twist-tie about 2 cm (1 in) each, bend them into hooks, and attach them to the ends of the stick, so they don't slip. Tie a loop of thread around the mouth of each of the (still empty) balloons. Hang the balloons on the scale and balance the scale by nudging the center thread to one side or the other. You should be able to get the stick to balance evenly with a little care and patience. Fix the position of the thread by attaching tape to the left and the right of it. Now remove a balloon, blow it up, knot it, and hang it on the hook again. Now one side will drop.

What's going on? The extra weight comes from the air that you blew into the balloon (there is more air in the blown-up balloon than there is in the same volume of surrounding air). In fact, air does have weight: one liter of dry air weighs about 1.3 grams (abbreviated g). In the U.S. system of units, one gallon of air weighs about 0.17 ounces. That is not much — one liter of water weighs 1,000 g, and one gallon of water weighs about 8.3 pounds. But on the other hand, the envelope of air around Earth is many miles thick, even if it becomes thinner as you go up. The column of air above you, therefore, presses down with a force of about 1 kilogram (abbreviated kg) on each square centimeter of your body, or 14.7 pounds per square inch. You don't notice this air pressure because it is applied from all sides and even gets inside your body by way of your lungs. The forces, therefore, balance each other out.

Tip

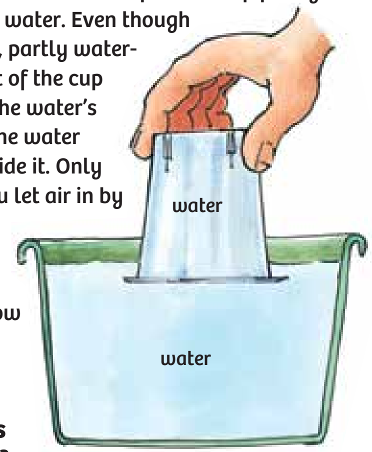
While you blow up the balloon, have a helper hold the scale more or less straight, so nothing slips.

Pressure from Above

Normally, we don't feel the pressure of the air weighing down on us. But it does become noticeable in several remarkable phenomena.

You will need: 1 large measuring cup, *bowl, water*

Here's how: Fill the bowl with water, then dunk the cup beneath the surface of the water and let it fill completely. Turn the opening downward and pull the cup partly out of the water. Even though the upper, partly water-filled part of the cup is above the water's surface, the water stays inside it. Only when you let air in by tipping the cup does the water flow out.



What's going on? The reason we don't feel the air's pressure is that it is the same everywhere. If the water were to run out of the cup, an empty space void of air, a **vacuum**, would be created. The air exerts its full force against that happening — and it is much greater than the weight of the water. Only if our cup were around 10 meters (33 feet) tall would the water outweigh the air pressure and would a vacuum be created above it.

Drinking Straws

Have you ever wondered while slurping a drink through a straw how it is that the liquid actually rises up the straw? After all, you're sucking on the straw, not on the drink itself.

You will need: transparent drinking straw, 1 large measuring cup, *water.*

Here's how: Dip the straw into the water-filled measuring cup and suck out the air with your mouth. The water will rise up the straw.

What's going on? In the last experiment, air pressure prevented the formation of a space free of air. You find the same thing here. When you suck the air out of the straw, the pressure of air pressing on the surface of the water pushes the water up the straw into the empty space.

Suction cups work by the same principle: you push the air out from under the rubber, and air pressure presses the cup against the wall.

Did you know...

...that air pressure is not the same everywhere?

Air pressure fluctuates slightly with the weather. Falling air pressure usually predicts bad weather, while rising air pressure is a sign that good weather is probably on its way. That is why an air pressure meter (barometer) is often used to predict the weather. Also, air pressure drops as altitude increases. So airplane pilots and mountain climbers use an air pressure gauge to determine their altitude.

Water Flows Uphill

Do you think water always flows downhill? You're in for a surprise!

You will need: *sink (in bathroom), pail or bowl, water,* tubing

Here's how: Fill the sink halfway with water. Place the empty pail under it. Immerse the tubing in the sink so that it fills completely with water. Hold one end of the tubing firmly under the water's surface. Then bring the other end of the tubing down to the pail, keeping your thumb firmly over its opening. The important thing is that this end has to be lower than the surface of the water in the sink.

Now the water flows down into the pail, even though it has to climb up over the edge of the sink in order to get there.

What's going on? The water is pulled downward by its own weight in the longer section of the tubing. In the process, suction is created in the upper section (much like the suction in a drinking straw), which ensures that air pressure pushes water from the sink into the tubing. This kind of apparatus is called a **siphon**. It is very useful for transferring liquids — for example, when emptying an aquarium.

Magic Ball

This experiment may appear at first to be magic, but in science we try to find a logical explanation for everything.

You will need: styrofoam ball, or a ping pong ball, *hair dryer (on the cold air setting)*

Here's how: Turn on the hair dryer (cold air) and aim the airstream straight upward. (Remove any nozzle attachments first.) Now hold the ball about 10 to 20 cm (4 to 8 inches) above the nozzle and let it go. Instead of just getting blown away or falling to the ground, as you might expect, it will actually dance in the stream of air.

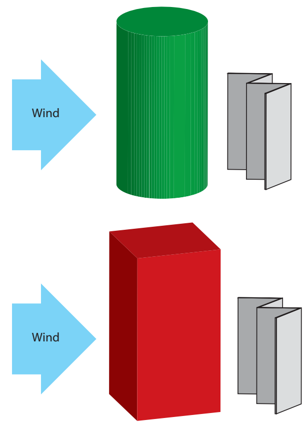
What's going on? What's at work here is something called **Bernoulli's Principle**. It says that the pressure in flowing gases (or liquids) is lower than the pressure in ones that are still. So the ball is dancing in a region of lower air pressure. If it tries to break out to the side, the normal (higher) air pressure there pushes it back.

Defenseless in the Wind

Have you ever tried taking shelter from the wind behind a round pillar and found out that it does you no good?

You will need: *1 square bottle or box, 1 round bottle, paper,* 1 large measuring cup, 2 striped drinking straws, some clay

Here's how: Fold the paper 3 times, in an "M" shape, so that it can stand up on its own. Place the folded paper an inch or so behind the square bottle and blow against the bottle's surface. The paper does not blow



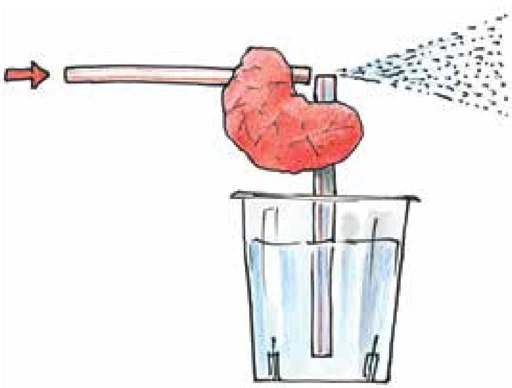
The upper paper is blown over, the lower one is not.

over — square angles apparently provide shelter from the wind. Repeat the experiment with the round bottle: now you will have little difficulty blowing the paper over.

What's going on? Once again, the culprit is air pressure. Because of Bernoulli's Principle, the air pressure in the stream of air is lower than outside it. This principle says that the pressure in flowing gases (or liquids) is lower than the pressure in ones that are still. So the external air pressure pushes the air against the wall of the round bottle, and behind the bottle it keeps flowing and hits the paper. With the square bottle, on the other hand, the airstream gets so turbulent that there's a wind-free zone behind it.

Supplemental Experiment

In a perfume atomizer, Bernoulli's Principle and air pressure are once again at work together. You can easily assemble one out of two drinking straws and some clay as shown in the picture. Stick the bottom part in a water-filled measuring cup and blow strongly through the horizontal tube. The lower pressure in the airstream will pull water up through the vertical tube, and when the water reaches the top, the airstream will atomize it into tiny droplets.



Wing of an Airbus A 340

Did you know...

...why Bernoulli's Principle is also important for airplanes?

With an airborne plane, air flows much faster over the upper surface of the wing than over the lower surface. That is due to the bulge in the wing's shape but even more importantly to complex turbulence patterns that form in the air stream. The result is a lifting force that carries the airplane upward. This can be illustrated with a simple experiment: If you hold a strip of paper in front of your lips and blow strongly over its top surface, the paper will be sucked upward by the low pressure in the stream of air.

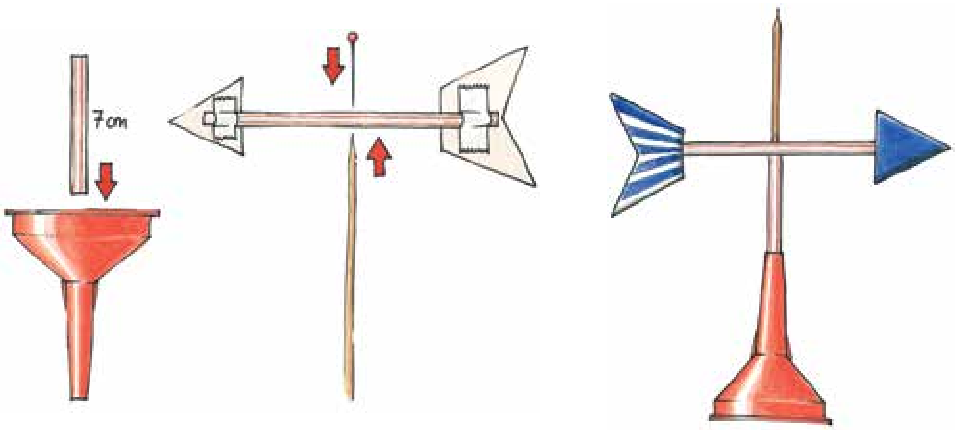
With the Wind

Have you seen those weather vanes on top of buildings that automatically turn toward the direction of the wind? Maybe there's one on a church steeple somewhere near where you live. So how do these simple metal gizmos actually know where the wind is coming from? Here's your chance to find out by building one yourself.

You will need: funnel (or plastic cup), wooden stick, needle, striped drinking straw, head and tail of wind vane (you cut out from paper), *tape, scissors, hair dryer, ruler*

Here's how: First cut the drinking straw into two pieces, one shorter (about 7 cm or 2.5 in) and one longer. Pierce the longer piece through its center point with the needle: This is the hole through which you will insert the wooden stick. Then cut out the head and the tail of the vane and attach them with tape to the two ends of the section of straw through which you bored the hole. Finally, push the shorter section of straw through the funnel (or plastic cup) so that it is lodged in firmly and sticks out as far as possible. Now insert the wooden stick into the drinking straw in the funnel. To be safe, you can tape down the funnel or cup to the surface it is resting on. Now blow at the vane with the hair dryer at various angles from a distance of about 3 feet away: It will always turn so that its tip points in the direction the wind is coming from — that is, at the hair dryer.

What's going on? The explanation is air resistance. You have probably noticed that riding a bike against the wind is harder than riding when the air is still. The reason for that is the force with which the wind pushes against you. The strength of this force depends on the size of the surface the wind hits. This is why racing cyclists bend down when they ride, in order to provide the smallest possible surface of impact. It is the same with liquids: If you try to move your open palm quickly through the water, it is a lot harder than if you slice through the water with the edge of your hand. With our weather vane, if the wind blows against the triangle, the vane will rotate so as to make its exposed surface as small as possible. And that will be the case, as you can see, when its tip is pointing exactly into the wind.



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Thames & Kosmos
A Kosmos International Company
89 Ship Street
Providence, RI 02903, USA

phone: 401.459.6787
toll free: 800.587.2872
fax: 401.459.6775

email: contact@thamesandkosmos.com

www.thamesandkosmos.com