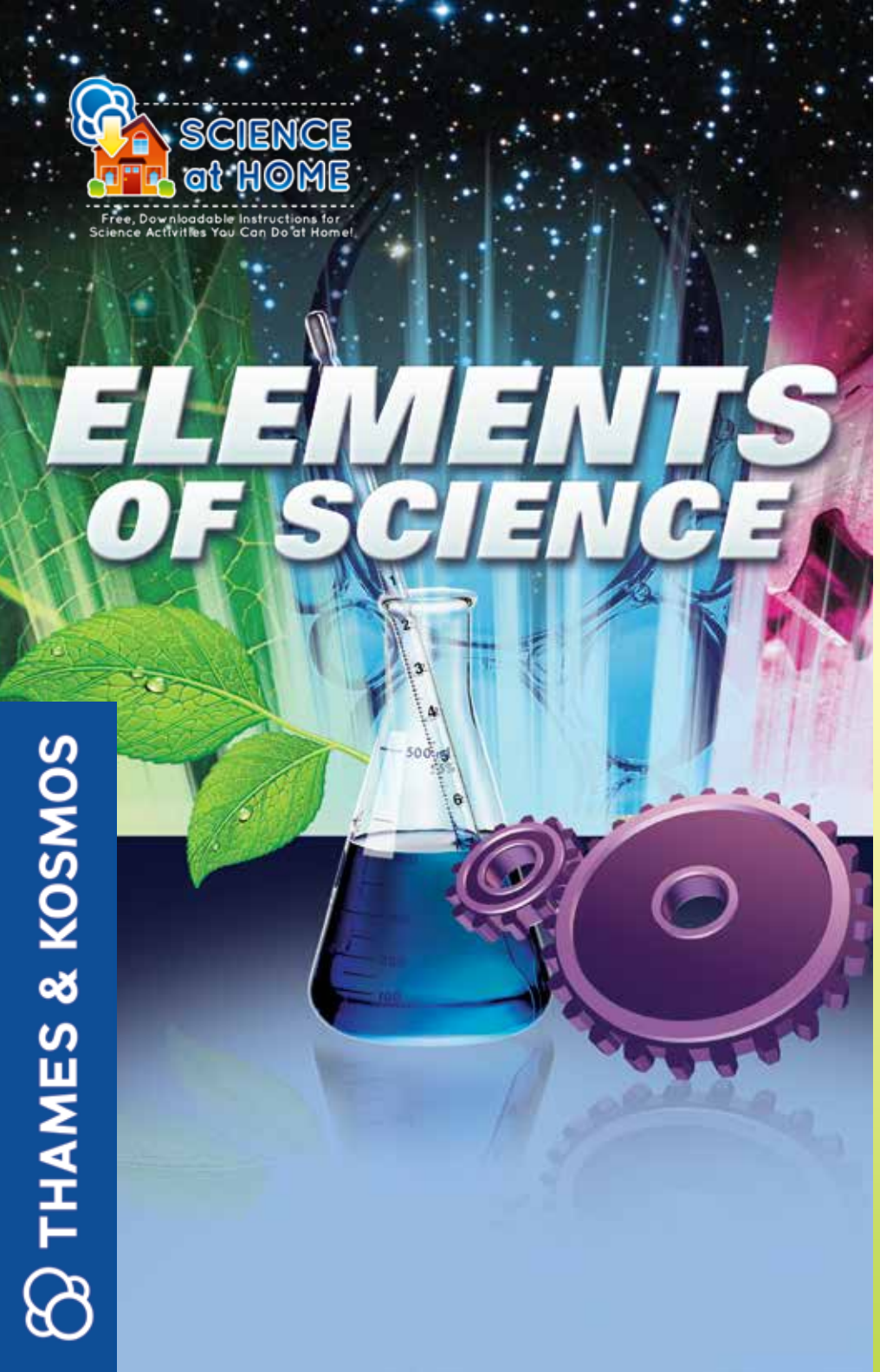


Advice for Supervising Adults

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 Heat

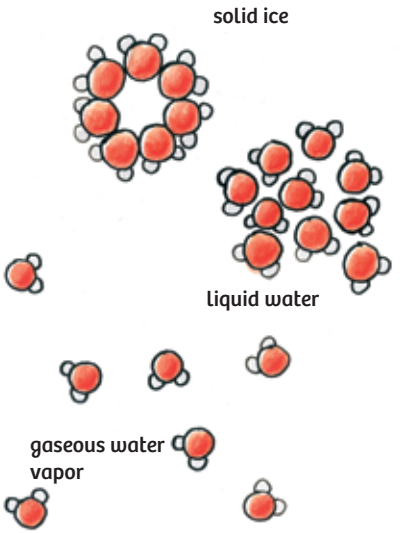
The sun, a candle flame, and a heater all dispense warmth. Refrigerators and ice cubes cool things. Some materials feel cool to the touch, others feel warm. These are many different observations, all having to do with temperature. At this point a researcher might become curious and ask, What are warmth and cold all about, anyway?

Water in Any Form

When you get too cold, you react with shivering and chattering teeth. And when you get too warm, your body reacts with sweat and flushed skin. But even nonliving things change in response to temperature variations.

You will need: 1 small measuring cup, *1 cooking pot, 1 tablespoon, freezer, hot plate or stove top, water*

Here's how: Fill the measuring cup with cold water and place it in the freezer. After a few hours, the liquid water will have frozen into solid ice. Push the block of ice out of the cup into a small cooking pot. After a few hours, it will have changed back into liquid water. If you now heat it slowly on the stove, it will start to simmer. First, bubbles will form, and then hot steam will begin to rise (careful, don't burn yourself!).



This steam is gaseous water. For proof of this, hold a cool spoon in the steam and water will appear in the form of droplets on the spoon.

What's going on? Water can appear in solid form, as a liquid, or as an invisible gas — depending on how warm or cold it is. It can change into any of these states and then back again. This kind of change of state can also be observed in other substances.

Condensed Water

Water vapor doesn't just rise from boiling water, it is also contained in the air. Because it is an invisible gas, we can't see it. But you can actually retrieve water from the air.

You will need: *water, 1 drinking glass, freezer, shallow plate*

Here's how: Place a drinking glass filled with water in the freezer for a few hours. Take it out, place it on the plate, and let it stand in a warm room for a few minutes. On the outside of the glass, tiny droplets of water will appear as if from nowhere.

What's going on? The cold water cools down the surrounding air. In the process, a portion of the water vapor contained in it becomes liquid water (one says that it **condenses**) and collects on the outside of the glass.

Windows in the bathroom or car get steamed up in the same way. When you can see your breath on a cold winter's day, it is also because of fine water droplets that

show up, because breath is rich in water vapor. Fog banks form in the same way, when air rich in water vapor cools off in the evening or night, or comes into contact with approaching cold air. The clouds in the sky are usually nothing more than collections of tiny water droplets that condense in the cooler upper air.

Warmth in Flow

Water flows in rivers. Electricity flows in wires. And how does warmth flow?

You will need: a measuring spoon, *1 small piece of chocolate, paper towel, mug or teacup, water, microwave or stove*

Here's how: Break the chocolate (milk chocolate works best) into tiny crumbs. Space the crumbs about 0.5 cm (0.25 in) apart on the measuring spoon, beginning about 2 cm (1 in) from the end of the spoon, and press them down lightly so they stay in place. Wrap a piece of paper towel around the other end of the spoon so you can hold it — it will protect your fingers in case the spoon gets too warm. Fill the mug with water and heat it in the microwave until it is nearly steaming. You can also use the stove to heat the water. Carefully place the end of the measuring spoon in the hot water and hold it there. The chocolate crumbs will gradually melt and drip down, starting at the hot end.

What's going on? The heat gradually spreads out in the metal. The temperature is hottest in the cup, but the temperature also gradually rises along the spoon because of heat conductance.

Heat-hungry Black

Supplemental Experiment

Have you ever noticed that on warm summer days people tend to walk around in light-colored clothing? There is a very practical reason for that.

You will need: black paper, white paper, *sand, water,* 2 large measuring cups, *sunshine*

Here's how: On a sunny day, lay the white paper and the black paper side by side next to each other in the sun. After a few minutes, check their temperature with your hand. You will notice that the black paper is much warmer.

What's going on? The sun emits light rays that produce warmth when they strike a surface, to the extent that the surface is able to absorb the warmth of the rays. White materials reflect a lot of light (which is why they look white), while black materials swallow the light and heat up.

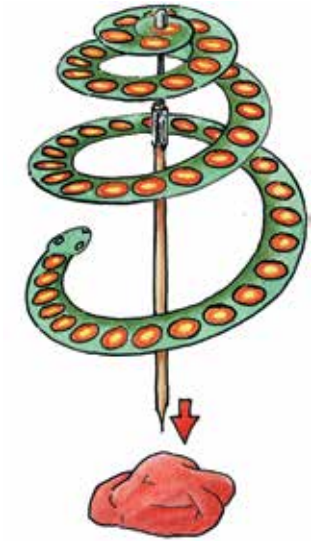
Fill one measuring cup with water and the other with sand, and place both in the full sun for two hours. During this time, test their temperature several times near the surface with your hand. You will get a rough impression of where the temperature is higher. Sand gets much warmer than water because it absorbs the sun's heat more quickly. Let the measuring cups sit in the sun for a whole day, then take another temperature reading half an hour after the sun has set. You will find out that the sand cools off much more quickly than the water. On a larger scale, you observe the same kind of phenomenon in spring when the land warms up much more quickly than the ocean, which remains cool well into summer. In the autumn, though, it holds the warmth longer than the land. That is why the climate along the coast is more moderate than in the land's interior.

Dancing Paper Snake

Have you ever seen a Christmas Pyramid? It's a multitiered wooden structure that uses candles to heat the air to move fan blades, which then spin figures and ornaments below. You can construct something similar here: a rotating paper snake.

You will need: wooden stick, clay, 1 needle, a paper plate or piece of construction paper to make a spiral snake, *tape, scissors, some glue*

Here's how: Carefully cut out the paper snake from the construction paper or bottom of the paper plate by cutting in a



spiral similar to the snake pictured. Use a needle to puncture a very small hole in the center of the tail of the snake. Now attach the needle, sharp tip pointing upwards, to the wooden stick with some adhesive tape. **Caution! Do not prick yourself with the tip of the needle!**

A lump of clay at the foot of the wooden stick will help it stand upright. Next, place the snake carefully on the needle tip. Check to make sure that the snake turns easily. It will work especially well if you place it over a warm heater or in a sunny window.

What's going on? Air — just like most substances — expands when warmed. When it does this, the same volume of air weighs less. Ten liters of cold air weighs 12 g, while ten liters of air heated to 160° C only weighs around 8 g. To put this in U.S. units, ten gallons of cold air weighs 1.6 ounces, while ten gallons of air at 320° F only weighs about 1 ounce. So the warm air rises, and the air stream makes the snake dance. Hot air balloons are carried by nothing more than the warm air inside them.

Ice Needs Room

In nature, there are always exceptions. Most substances expand when warmed and contract when cooled. But water is different.

You will need: 1 large measuring cup, plastic plate, *freezer, water*

Here's how: Fill the measuring cup up to the brim with water and place the plate on it. Place both in the freezer. The next day, the water will have hardened into ice and pushed the plate upwards.

What's going on? When you cool water, at first it contracts just like other substances. At 4° C (or 40° F), 1 kilogram of water takes up the least amount of space. If you keep cooling it, you will get a surprise: It will start to expand again. When it hardens into ice, it makes an expansive leap and suddenly takes up a tenth more space. The reason for this is that the water molecules arrange themselves into an especially wide-meshed structure. In this structure, they take up more room than when they sit closely side by side in a liquid state.

Wanna Bet?

This is the kind of question that can really stump someone: If you float an ice cube in a container filled to the brim with water, part of it will peek above the water's surface. When it melts, will the container overflow? This is the kind of question that a scientist likes to answer by actually doing it and seeing what happens.

You will need: 1 large measuring cup, *ice cube, water, shallow plate*

Here's how: Place the measuring cup on the plate. Drop an ice cube into the cup and fill it to the brim with water. The ice cube will float and part of it will stick out of the water. Wait until it has melted. Amazing! The cup doesn't overflow!

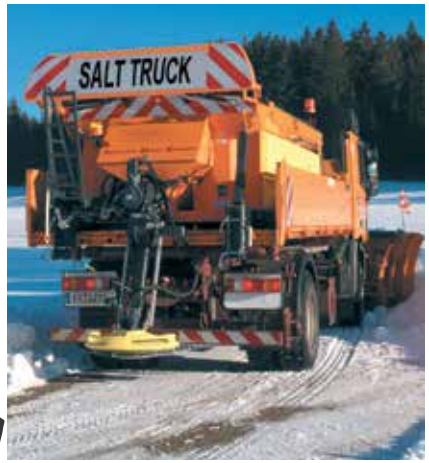
What's going on? Let's assume that the part of the ice cube under the surface of the water takes up volume X. Then the entire ice cube has a volume of X plus 1/10. This tenth of the volume is what is sticking out of the water. This is precisely the tenth by which the water increased its volume when it froze.

Did you know...

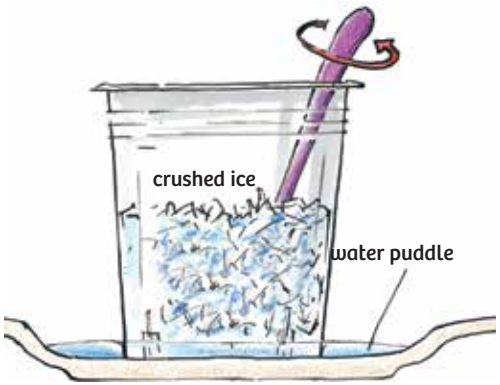
...how important it is that water expands when it freezes?

Because water expands when it freezes, ice floats on the surface of oceans and lakes. For ships, floating icebergs pose a danger. In 1912, for example, the *Titanic* sank after colliding with one. But if ice didn't float, it would sink to the bottom of the ocean in winter and then it wouldn't thaw out in summer. Eventually, the oceans could completely freeze up and Earth would cool down. Only a few living things would be able to survive on such a cold planet. It's a good thing that can't happen! Even in the coldest winters, seas and deep lakes will not freeze all the way to the bottom. Cool water of about 4° C (40° F) collects deep down below. At that temperature, fish and frogs can survive the winter, whereas ice would kill them.

Now imagine that you were to let the ice cube melt in a different container. Then, you would get volume X of liquid water, because the extra tenth would disappear in the process of melting. The entire quantity of water, in other words, would take up the same volume that was taken up by the part of the ice cube that was under water. So the cup can't overflow.



Summertime Frost



Frost and ice are nothing special in the wintertime. But you can make the measuring cup freeze solid on the plate in the middle of summer, too.

You will need: 1 large and 1 small measuring cup, *1 shallow plate, 5 ice cubes, 1 teaspoon, table salt, plastic bag, hammer or rolling pin, (older) wooden or plastic cutting board*

Here's how: Crush the ice. A good technique is to put the ice into a plastic bag, put the bag on the cutting board, and hit it with the hammer or rolling pin. Place the large measuring cup in the center of the shallow plate and fill it halfway with the crushed ice, then add five teaspoons of salt and stir vigorously. Keep stirring. Before long, frost will start to accumulate, and if a little puddle has formed on the plate it will freeze solid. Now pour a little water into the small measuring cup (enough to cover the bottom) and place it inside the large one. Just like in an ice machine, the water in the small measuring cup will freeze to ice. In an actual ice machine, there's a knife that shaves the ice crystals from the cold walls as they form. That keeps the ice mass nice and smooth.

What's going on? The name for this kind of ice-salt mixture is a **freezing mixture**, because it chills things to temperatures far lower than the freezing point of water (down to -20° C). The way it works is that when the ice melts it absorbs a lot of heat, thereby generating cold. The salt forces the ice to melt quickly, which in turn takes the necessary warmth out of its environment. The temperature drops.

In the winter, icy streets are sometimes strewn with salt. This causes some of the ice to melt, making the streets less slippery.

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