AIR

SUMMARY CARD

Children explore and understand the world holistically using all their senses. Therefore, when asked "What is air?" they often reach the limits of their imagination. This is because their usual strategies for deliberately engaging with an object – for example, examining its colour and shape, or touching, tasting, and smelling it – are not effective in this case. Consequently, it is not surprising that children quickly conclude that air is "nothing" or "totally boring". And yet, it is great fun to explore air and to play with it. Air is excitingly versatile: It blows, whistles, and moves things; it carries and pushes things; it transports things and makes them fly; you can capture it; you can even make music with it. And it surrounds us everywhere at all times.

The present set of cards provides ideas and suggestions about how you can jointly explore and investigate the various characteristics of air with the children in a playful way. Please read the red information card carefully. It lists the general rules to be observed when conducting scientific inquiry activities with children. Seven of the cards in this set invite the children to explore various characteristics of air. The suggested ideas enable the children to have initial basic experiences, and they show different ways of getting to know simple physical phenomena.

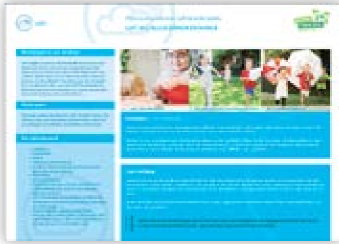
There is no prescribed sequence, but we recommend that you start with the exploration card "Experience air with all your senses". Following on from these explorations, two inquiry cards provide more in-depth learning opportunities. Using the "Inquiry Cycle" method, the children can pursue specific questions on the topic of air and practise using a scientific approach.

You can also find further suggestions and exciting background information on the topic of air at: **www.haus-der-kleinen-forscher.de.**

Note on working with different age groups

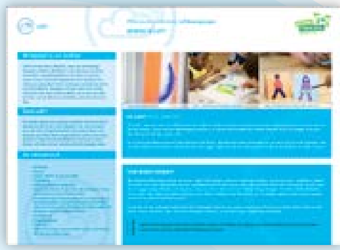
You will sometimes find this symbol on these cards. The "ladder" indicates that the inquiry activity in question, or the entire card, presupposes that children have already had certain basic experiences and/or developed certain skills (e.g., in the area of perception, cognition or motor development). As a rule, these experiences and/or skills are not acquired until children are of primary school age (i.e., between the ages of six and ten). Ideas and inquiry activities that do not bear this symbol are suitable for children of all ages.

A BRIEF OVERVIEW OF THE INDIVIDUAL CARDS:



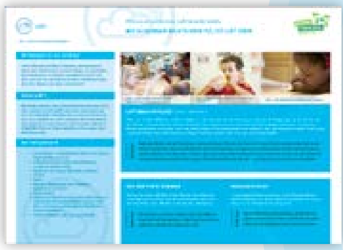
EXPLORATION CARD
EXPERIENCE AIR WITH ALL YOUR SENSES

The children experience the element of air with all their senses. They discover that air can be felt and heard and that you can capture it, lock it in, and make it visible.



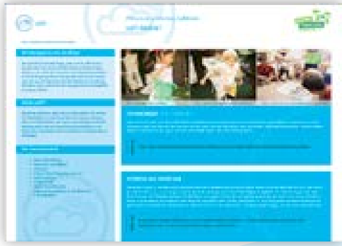
EXPLORATION CARD
MOVING AIR

The children feel a draught and go searching for moving air with a wind detector. They try out ways of purposefully fanning or blowing air. In this way, they move objects, paint, and even smells. The children also build a box that can be used to generate a strong puff of air.



EXPLORATION CARD
IT LOOKS EMPTY, BUT THERE'S AIR IN IT

The children discover that supposedly empty bottles are not empty but rather filled with air. They discover this by investigating how plastic bottles filled with air can be squashed, and whether it is possible to blow up a balloon in a bottle or blow little balls of paper into a bottle.They try to pour water into air-filled bottles, and they create a tornado in a bottle.

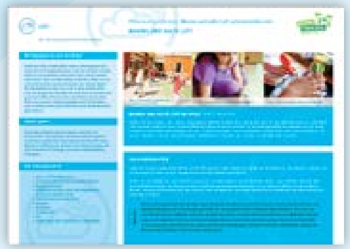


EXPLORATION CARD
AIR EXERTS PRESSURE

The children discover that air exerts pressure on everything. They run down the corridor holding plastic bags to their chests; they discover that it can be really difficult to lift a newspaper off the floor or to press a ruler down; and they try to make suction cups stick to different surfaces.

EXPLORATION CARD
WE BREATHE AIR

The children discover that they themselves breathe air in and out. They hear, feel, and see the air that they breathe. In addition, the children test how much air they have in their lungs and investigate the difference between fresh air and the air they breathe out.

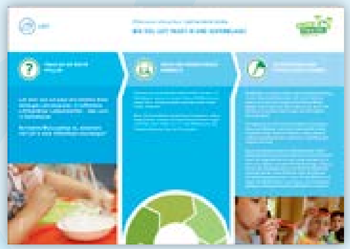


EXPLORATION CARD
HOT AND COLD AIR

The children discover how hot and cold air differ. They make genies appear from a bottle; they observe how a bottle crumples in the refrigerator; they make a paper curtain that moves in warm air; and they fly hot air balloons.

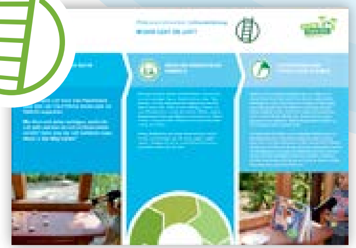
EXPLORATION CARD
AIR AND WATER

The children send a message in a bottle, investigate the behaviour of air bubbles underwater, raise a submarine, and make a Cartesian diver.



INQUIRY CARD
HOW MUCH AIR FITS INTO A SOAP BUBBLE?

The children investigate how they can capture as much air as possible in a soap bubble.



INQUIRY CARD
WHERE DOES THE AIR GO?

The children investigate air turbulence and the way in which little balls of paper can be carried away or individual candles can be blown out by a targeted puff of air.

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Explore the phenomenon: **Air is not nothing**

EXPERIENCE AIR WITH ALL YOUR SENSES

Where do we encounter it in everyday life?

Air surrounds us everywhere at all times. We need it to breathe, and we can survive only a couple of minutes without it. Nevertheless, many sayings equate air with "nothing". For example, something can "vanish into thin air" or be "plucked out of thin air," and someone can be called an "airhead". This is probably because air is invisible and we can't usually touch it or grasp it.

What it's all about

The children experience the element of air with all their senses. They discover that air can be felt and heard and that they can capture it, lock it in, and make it visible.

What you need

- **Balloons**
- **Pins**
- **Umbrella**
- **Air pump or bellows**
- **Ribbed plastic hose (howling tube or washing machine hose)**
- **Bubble wrap**
- **Thin plastic bags**
- **Soap bubble solution:**
  Put two squirts of washing-up liquid and 1 teaspoon of sugar into a cup of water; mix well.
  TIP: 4 or 5 small holes in the middle of the straws prevent accidental ingestion of the soap solution!
- **Thick drinking straws, cotton wool if required**
- **Bicycle tube or swim tube, air mattress, ball, or other things in which air is trapped or that can be filled with air**

07/2013

Fig. 1: Feeling the puff of air

Fig. 2: What's it like to run with a closed umbrella?

Fig. 3: ... and with an open one?

FFFFHHHT! (WARM-UP)

Have the children pass around an inflated balloon that is tied with a knot. What do the children think is inside? The children can throw the balloon to each other; they can also squeeze it lightly.
Carefully make a small hole in the balloon with a pin. Before you do so, stick a little piece of sticky tape over the spot so that the balloon doesn't burst. Alternatively, the children can let some air flow out of the open neck of the balloon. They can feel the air escaping – on their arms, face or neck. How that tickles! And what does it sound like? Imitate the noise together: 'ffffhhht' or 'sssshhht'?

FEELING AIR

Have the children stand together with you in the playground or at the end of a long corridor that they can run up and down.
Give one child an umbrella and ask him/her to run down the corridor holding the closed umbrella. Now open the umbrella and have the child run back holding it in front of him/ her. Let the children take turns trying out the two variants.
What did they notice when doing so?
Do the children notice a further difference when they run with the open umbrella behind them rather than in front of them?

Look at this:

Air is not nothing. It pushes against the umbrella. That is why it takes much greater effort to run down the corridor with an open umbrella than with a closed one – especially when you are pulling the open umbrella behind you.

Fig. 4: Air flows out of a balloon with a squeak.

HEARING AIR

First, the children explore how an air pump or a bellows works. What does it sound like when the air is sucked in and then pushed out? The children then pump up things such as a balloon, a bicycle tube, an air mattress, etc., let the air flow out again, stop it escaping, or press the air out very quickly. Hold one end of a ribbed plastic hose (e.g., a washing machine hose) tightly with one hand and spin it around in the air. The sound is very different from the sound of air being squeezed out of bubble wrap.

With the children, try to find the appropriate words for the different sounds that air makes. It can hiss, whizz, squeak, squeal, whistle, scream, puff, buzz, pop, …. What other words can the children think of?

Look at this:

Air is not nothing. You can hear it clearly and produce many different sounds with it.

SEEING AIR

Distribute the plastic bags to the children. Now have them all try to catch a bag of air. Anything goes: running down the corridor, shaking the bag, blowing into it …. Who is first to fill their bag? In our everyday lives, there are also many things in which air is trapped. Go looking for them together: What contains air?

Soap bubbles are also a lovely way of packaging air. How much air can fit into a soap bubble? With younger children, you should first practise the difference between blowing and sucking (e.g., by blowing little balls of cotton wool across the table with a straw).

Look at this:

Air is not nothing. You can capture it and lock it in. In this way, you can also make it perceptible.

To investigate further, you can use the inquiry card 'How much air fits into a soap bubble?'.

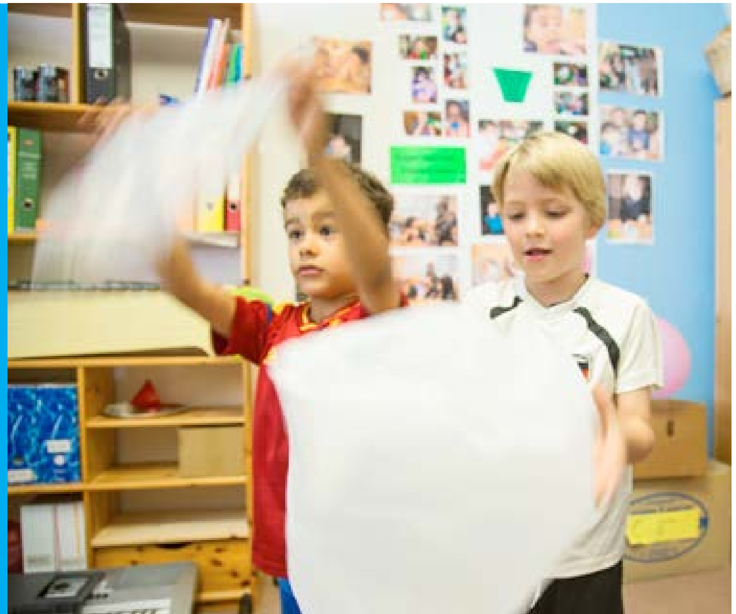

Fig. 5: Catching a bag full of air

INTERESTED ADULTS MIGHT LIKE TO KNOW

Air is invisible; you can't touch it; you can't taste it; and usually you can't smell it, either. We can survive for four weeks without food, four days without water, but hardly four minutes without air. It is the basis of life and one of the characteristic features of our planet, Earth.

Scientifically speaking, air is a mixture of different gases. It is primarily made up of nitrogen and oxygen (which is so essential for human life), but it also comprises noble gases, carbon dioxide, and water vapour.

Air fills every conceivable space and every corner of the Earth. However, the higher you go, the "thinner" the air becomes. It keeps diminishing until you reach outer space, where there is no more air at all. Outer space is a void – a so-called vacuum – where space is completely empty.

Explore the phenomenon: **Air movements**

MOVING AIR

Where do we encounter it in everyday life?

Air is always experienceable when it moves. Moving air rustles leaves in the trees, turns windmills, messes up our hair, and drives yachts across the sea. Draughts cause doors to slam and blow papers off the desk. Moving air can also be very turbulent: it swirls leaves through the air, breaks branches off trees, and whips waves up on the ocean.

What it's all about

The children feel a draught and head off with their "wind detector" in search of moving air. They try out ways of moving air purposefully by waving things or blowing. In this way, they move objects, paint, and even smells. The children also make a box that can be used to produce a strong puff of air.

What you need

- **Thread**
- **Scissors**
- **Feathers, cotton wool, table tennis balls**
- **Drinking straws**
- **Large pieces of cardboard for waving**
- **Self-made fans: Using a sheet of paper or thin cardboard, fold a small piece over, lengthwise; then fold in the opposite direction. Continue until you get a zig-zag fold and the sheet has become a strip.**
- **A-frame people: Fold a strip of paper (5 x 10 cm) in the middle; Draw the front view of a person on one side and the back view on the other side.**
- **Art paper, brushes and watercolours**
- **Shoe box**
- **Packing tape**

07/2013

Fig. 1: Is the feather shaking?

Fig. 2: Blowing paint to make pictures

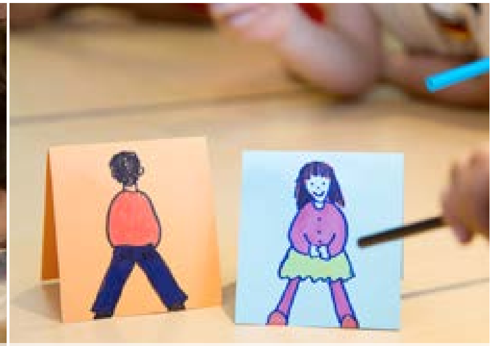

Fig. 3: A-frame people slide over the table..

THERE'S A DRAUGHT (WARM-UP)

"There's a draught!" is what you say when a current of air intrudes into the building and sets lots of things in motion. Talk to the children about how to recognise the movement of air. For example, the curtains may move back and forth, doors may slam, you may feel the current of air on your skin, etc.
Tie a feather onto a piece of thread. Using this "wind detector", the children now head off in search of moving air, checking window frames, gaps between door frames and doors, and heaters. Even the tiniest draught will make the feather shake!

GONE WITH THE WIND

The children can move air and produce an airflow themselves using simple tools: They can blow through drinking straws and wave pieces of paper or self-made fans. They can feel the airflow on their skin and their hair when they fan or blow at each other. However, by fanning or blowing they can also move various things: table tennis balls, balls of cotton wool, feathers, and even A-frame people roll, waft, or flit across the table. Which objects are set in motion by the airflow? Which are not?

The children can also send droplets of paint flying across a sheet of paper by dropping a blob of paint on it and blowing on the blob through a straw. In this way, they can create very individual "air-blown" pictures.

Look at this:

Air can be moved. You can fan it and blow it. You can feel the resulting airflow on your skin and you can use it to move lots of things.

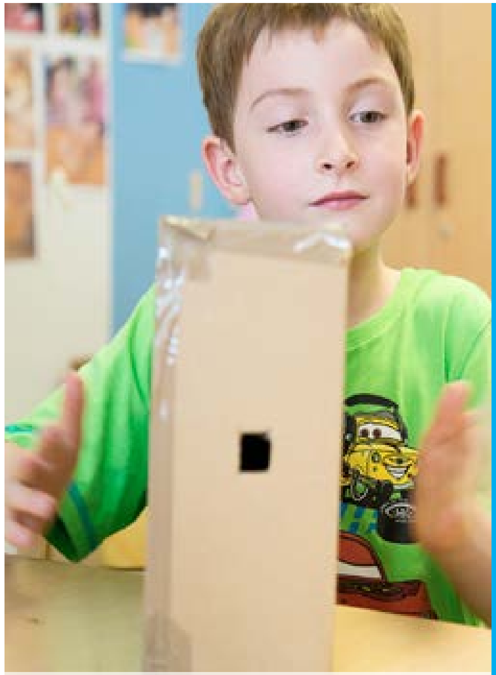

Fig. 4: A puff of air shoots out of the box when it is struck on the sides..

PUFF OF AIR FROM A BOX

Cut a hole (Ø 2 cm) in the narrow side of a shoe box with a pair of scissors; seal the box with packaging tape to make it as airtight as possible. Then stand the box upright and have one of the children strike the sides as if he/she wanted to clap his/her hands. Let the children feel the puff of air in front of the hole.

Then have the children hold a cloth at a slight distance from the hole and observe how it is moved by the puff of air. How far away from the box can the cloth be held and still be moved by the air? Could you also move the cloth by blowing it if it was the same distance from your face? Is it possible to roll a table tennis ball or blow out a tealight candle with the puff of air from the box? Where do the cloth, ball, or tealight candle have to be located for the puff of air from the box to reach them well?

Look at this: *Something happens only if the puff of air actually hits the object. The greater the distance between the box and the object, the weaker the puff of air and therefore the smaller the movement observed. Nevertheless, the puff of air from the box is very strong: It still moves the cloth or ball and blows the candle out when merely blowing no longer has any effect.*

You can investigate this further using the inquiry card 'Where does the air go?".

INTERESTED ADULTS MIGHT LIKE TO KNOW

Air, or the gases that it comprises, is made up of lots of tiny particles. These particles are so small that they cannot be seen with the naked eye or with the best microscope there is.

The air particles are constantly moving. This movement of air particles is known as random thermal movement or Brownian motion. It causes air to disperse evenly throughout a given space. When you wave a piece of cardboard or a paper fan, or when you blow through a straw, you push the air particles away and they can drag aromas or light objects along with them.

THERE'S AN AROMA IN THE AIR

You can smell lots of things even though you can't see them – for example the aroma of bread or cake fresh from the oven. What have the children smelled before without having seen it?
Place half an orange or something else with a strong smell in one corner of the room. Can you also smell it from the opposite corner? What happens when some of the children stand behind the orange and flap pieces of cardboard? Try this out in the playground or the yard as well. What is difference between the effect indoors and outdoors?

Look at this: *Smells spread in the air. If you move the air – for example by flapping something – then the smell moves as well. It can even be steered in a certain direction. In enclosed spaces, you can smell aromas for a long time. Outdoors, they spread out quickly and are hardly noticeable within a short time.*

Fig. 5: Can the smell of the orange be moved?

Explore the phenomenon: **Air is not nothing**

IT LOOKS EMPTY, BUT THERE'S AIR IN IT

Where do we encounter it in everyday life?

Air is everywhere; it is invisible; and it takes up space. We experience this in our everyday lives, for example when doing the washing up. Bottles and glasses still have air inside them when we hold them underwater: The air rises in bubbles to the top of the water and escapes.

What it's all about

The children discover that supposedly empty bottles are not empty, but rather are filled with air. In addition, they investigate how plastic bottles filled with air can be squashed, and whether it is possible to blow up a balloon in a bottle or to blow little balls into a bottle. They try to pour water into air-filled bottles and they create a tornado in a bottle.

What you need

- **Empty plastic and glass bottles (wide and narrow necked; 0.75 / 1 l)**
- **Balloons (previously inflated so that they have been stretched)**
- **Little balls of paper, silver foil, and cotton wool**
- **Funnels**
- **Play dough**
- **Water in a measuring jug or watering can**
- **Drawing pins or needles**
- **Strips of paper**
- **Vortex bottle connector (or make a bottle connector yourself by drilling a hole (Ø 6–7 mm) through the centre of two identical screw caps and by gluing the caps together by the flat side.**
- **Food colouring or ink as a colouring agent**

07/2013

Fig. 1: Air escapes when the bottle is squashed.

Fig. 2: Can the balloon be blown up in the bottle?

Fig. 3: The little ball pops out of the bottle.

AIR NEEDS SPACE (WARM-UP)

Fill a plastic bottle with water and screw the cap on tightly. Do the children think that they can squash the bottle with their bare hands? Try it out together. Then empty the bottle and close it tightly once again. Do the children think that anything is different? It is fairly surprising that the bottle can't really be squashed this time either. What could be the reason? And what happens when you take off the cap?

Look at this:

If you pour water out of the bottle, air takes its place. So the bottle isn't empty, it's full of air. If the lid is closed, neither water nor air can escape. In contrast to water, the air can be compressed easily, but you can still feel that there is something in the supposedly empty bottle. If you take the lid off the bottle of water, the water flows out when the bottle is pressed.
Air escapes in a similar way – but you can only feel it, not see it.

OUT OF BREATH

Holding the neck of a balloon, push it into the top of a bottle. Then roll the neck of the balloon over the outside of the bottleneck. Now have the children try to blow up the balloon inside the bottle.

Look at this:

The bottle isn't empty but full of air. If you want to blow more air into it by blowing up the balloon, it isn't possible.

CANNONBALL

Lay a bottle down and place a small paper ball in the neck of the bottle. Then have the children try to blow it into the bottle.

Look at this:

Instead of falling into the bottle, the little paper ball keeps popping out. This is because the bottle is still full of air and there is no room for the little ball.

Fig. 4: The water stays in the funnel.

A BOTTLE FULL OF AIR

Put a funnel into the top of an empty bottle and seal the connection using play dough. Now ask the children to try to fill the bottle with water. They can use a measuring jug or a watering can to pour water into the funnel.
But does the bottle fill up?

Then make a tiny hole in the upper half of the bottle with a needle or a drawing pin. What happens now? Hold a small strip of paper in front of the hole and observe the puff of air with the children.

Look at this:

The bottle isn't empty, but rather it is full of air. That is why only a small amount of water flows into the bottle and the rest remains in the funnel. When the bottle has a small hole, the air can escape from the bottle through the hole. Space is made for the water, which can then flow into the bottle. By holding the strip of paper in front of the hole, you will see how the air flows out of the bottle when the water flows in.

TORNADO IN A BOTTLE

The children take two identical plastic bottles, fill one of them about two-thirds full of water, and add some colouring agent to the water. They then screw the vortex bottle connector tightly onto the bottle and screw the other bottle into the connector.
Then they turn the whole thing upside down so that the empty bottle is at the bottom. What do the children think is the reason why the water doesn't flow from the full bottle into the empty one?
What could they do to make that happen?
First, ask the children to squeeze the upper and lower bottles and then to jointly create a tornado: To do this, the children hold the lower bottle firmly with one hand and quickly rotate the upper bottle. What can they observe?

Look at this:

The lower bottle is not empty, but rather it is filled with air. In order for the water to flow downwards, air must flow upwards in exchange. Squeezing the lower bottle causes air bubbles to rise and the same amount of water flows downwards in exchange. If you create a tornado, air rises upwards through the centre of the vortex and water flows downwards very rapidly.

Fig. 5: Watching the vortex together

INTERESTED ADULTS MIGHT LIKE TO KNOW

All the inquiry activities on this card relate to an important physical insight – namely, that it is impossible for something (in this case, water) to be in exactly the same place at exactly the same time as something else (in this case, air). Or, metaphorically speaking, it is impossible for Peggy to sit in exactly the same place as Stephanie. She can sit beside her, or on her lap, but not in exactly the same place. The supposedly empty bottles contain air. Only when the air escapes from the bottles and makes space is it possible to fill the bottles with another substance.

AIR

Explore the phenomenon: **Air pressure**

AIR EXERTS PRESSURE

KLEINE FORSCHER Naturwissenschaften und Technik für Mädchen und Jungen

Where do we encounter it in everyday life?

Air presses on everything, including us. But we notice this only when the external air pressure changes quickly, for example when we are travelling in a very fast lift, sitting in an aeroplane that is taking off or landing, or driving high up into the mountains. In these situations we feel an unpleasant pressure in our ears.

What it's all about

The children discover that air exerts pressure on everything. They run down the corridor holding plastic bags to their chest; they realise that it can be really difficult to lift a newspaper off the floor or to push a ruler down; and they attempt to stick suction caps onto different surfaces.

What you need

- **Thin plastic bags**
- **Paper (A4, A3 sheets)**
- **Newspapers**
- **Small piece of cardboard (30 x 30 cm)**
- **Thick cord**
- **Long ruler**
- **Small plastic bottles**
- **Things with suction cups on the back, e.g. cup hooks**


Fig. 1: The bag sticks to your body.


Fig. 2: The newspaper also seems to be stuck on.


Fig. 3: Can you lift the 'newspaper puppy'?

BAG RACES (WARM-UP)

Every child gets a thin plastic bag. The children hold the bags at chest level close to their body. They start to run, and while they are running they let the bags go. What happens to the bag? And what happens when the children don't go on running but rather stand still? Does this work with a sheet of paper or newspaper?

Look at this:

The bag, paper and newspaper seem to stick to your body when you run. If you stand still, they fall to the ground.

STUBBORN PUPPY

The children use a pencil to make a hole in the middle of a sheet of newspaper and in the middle of a small piece of cardboard. Then they push a piece of cord (approx. 1–1.5 m long) through the hole in the newspaper and then through the hole in the cardboard before tying a big knot or taping the end of the cord to the underside of the cardboard. The children can now pull the other end the cord and pull the newspaper along, as if they were taking a puppy for a walk. It follows them very obediently. But what happens when they want to pull the "puppy" up? Try this out together on different surfaces. How does the "puppy" behave on a smooth surface or on a rough surface, such as a carpet?

Look at this:

It is very difficult to lift the sheet of newspaper up from a smooth floor – it really sticks to it. It is slightly easier with a rough surface, such as a carpet.

Fig. 4: What happens when you strike the ruler?

NEWSPAPER TRICK

Place a long ruler on a table top in such a way that half of the ruler protrudes over the edge. Now have one of the children deliver a sudden sharp blow to the protruding part of the ruler with his/her fist. As expected, the ruler falls off the table with a loud bang.

For the second inquiry activity, have the children place an unfolded double sheet of newspaper over one half of the ruler – leave the protruding half uncovered. Smooth the newspaper out flat, and have one of the children strike the ruler again sharply with his/her fist. Oops! Could it be that the child didn't strike hard enough?

Look at this:

Once again, the air is pressing down on the entire surface of the newspaper. That's why the ruler can't be pressed down and doesn't fly through the air when you strike it with your fist.

SUCKED ON

The children put the opening of a small plastic bottle into their mouth and suck the air out – suddenly the bottle is hanging on their lips. What has happened? Suction hooks in the kitchen or bathroom work in a similar way.
Have the children press suction hooks firmly against a wall. What do you need to do to make the hook stick well?
Try other surfaces out, too: How well do the suction cups adhere to tiles, woodchip wallpaper, plaster walls, or window panes?

Look at this:

Regardless of whether you suck air out of a bottle or press on a suction cup, the same thing happens: The things suddenly stick firmly. However, this works only if air cannot flow back in from outside. In other words, the opening of the bottle must be completely sealed by your lips, or the suction cup must be pressed onto a smooth surface and there must be no small gaps between the cup and the surface.

Fig. 5: Where do suction cups stick?

INTERESTED ADULTS MIGHT LIKE TO KNOW

One litre of air weighs 1.3 grams. That may not sound like a lot, but the Earth is surrounded by a dense layer of air that is almost 100 km thick. Consequently, 10,000 kg of air are pressing down on every square meter of the Earth, and therefore also on our bodies. It's as if two elephants were sitting on us!

When you pick a sheet of newspaper up from the floor, a hollow space forms beneath it. The air particles suddenly have much more room to spread out. That means that the air pressure under the newspaper is much lower than in the surrounding area. In order to equalise the pressure, the surrounding air flows towards the area of low pressure, thereby pressing the newspaper to the floor. A very great difference in air pressure between "inside" and "outside" is also responsible for the fact that suction cups stick to surfaces. When you press a suction cup against a smooth, hard surface, you force the air out of the cup. When you let the cup go, it yields a little, but no more air gets into the space beneath it. As a result, the pressure inside the cup is lower than the pressure on the outside. The suction cup is held in place by the force of the outside air. Uneven surfaces are unsuitable because air can flow back into the cup, thereby equalising the air pressure.

AIR AND WATER

Where do we encounter it in everyday life?

Kids love blowing bubbles into their full tooth mugs or in the bath. When they use a drinking straw, they often prefer to blow air into their drink instead of sipping it through the straw, and they delight in the bubbles they produce. Things that are filled with air float on water. For example, inflatable armbands and swim rings help people who can't swim properly to remain on the surface of the water.

What it's all about

The children send a message in a bottle, investigate the behaviour of air bubbles underwater, raise a submarine, and make a Cartesian diver.

What you need

- Large and small plastic bottles (with caps)
- Paper and pencil
- Large bowl of water
- Drinking glasses
- Flexible drinking straws (transparent if possible)
- Narrow tube
- Paperclips
- Play dough

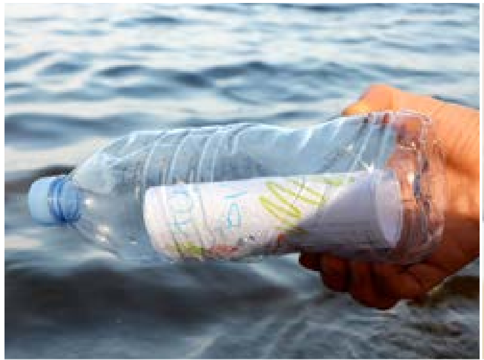

Fig. 1: Sending a message in a bottle.

Fig. 2: Pulling out the water-filled glass.

Fig. 3: Air bubbles rising from one glass into another.

MESSAGE IN A BOTTLE (WARM-UP)

Send a message in a bottle with the children. This involves putting messages from the children into an empty plastic bottle, screwing the lid on tightly and putting the bottle in a river, a lake, or the sea. Don't forget to put the address of your institution in as well and maybe someone will get back to you. Do the children have any ideas as to why the bottle floats on the surface and is carried away?

POURING AIR FROM ONE GLASS TO ANOTHER

It is best if the children work on this task in pairs: One child lays a glass in a bowl of water so that it fills with water completely. The child then turns the glass upside down and pulls it partly out of the water. However, the rim of the glass must stay below the surface of the water in the bowl. The other child now pushes a second glass underwater with the opening downwards, thereby trapping air inside. He/she then tilts the glass slightly. Is the child able to get escaping air bubbles to rise up into the glass filled with water?

Look at this:

The empty glass isn't empty but full of air. Tilting the glass allows air to rise up into the glass filled with water. The air takes up more and more space there, forcing the water out. So there is an exchange of the contents of the glasses. Air goes into the upper glass and water comes out, while air goes out of the lower glass and water comes in..

Fig. 4: Blowing into the bottle causes it to rise.

RAISING A SUBMARINE

The children sink a small plastic bottle without a cap (the submarine) in a bowl of water. They then blow air into the bottle using a flexible drinking straw or tube. Can the children find other ways of raising the sunken submarine?

Look at this: *Submerging the bottle in water causes the air inside to bubble out; the bottle fills up with water and sinks. If you use a drinking straw to blow air back into the bottle, it resurfaces.*

CARTESIAN DIVER

Make a Cartesian diver with the children. To do so, the children bend a flexible drinking straw at the neck, cut the long side to match the short side, and connect the two sides using three or four paperclips, taking care not to squash the straw. The diver's ability to float must be tested first: He should float upright in the water like a capital 'A'.

If he just lies on the surface of the water, the children can make him heavier by using another paper clip or some play dough. However, he must not sink to the bottom. If the floating tests have been a success, the children place the diver in a plastic bottle filled with water. The bottle should be so full that water runs out when the cap is screwed on. Once the cap is firmly on, the children squeeze the bottle tightly.

Look at this: *When you squeeze the bottle, the water rises up into the straw, the air bubble in the straw becomes smaller, and the diver sinks. When you let go of the bottle, the water flows out of the straw again, the air bubble becomes larger, and the diver rises. The children can observe this very well if the drinking straws are transparent.*

Fig. 5: If you squeeze the bottle, the Cartesian diver sinks.

INTERESTED ADULTS MIGHT LIKE TO KNOW

If you turn an apparently empty glass upside down, you won't see anything falling or flowing out. Under water it's very different: As soon as the glass is tilted, air bubbles escape and rise to the surface. Air is considerably lighter than water. A litre of air weighs only 1.3 grams whereas a litre of water weighs 1,000 grams. Because of gravity, the heavy water always "falls" downwards, pushing the light air upwards in the process.

And how does the Cartesian diver work? In contrast to air, water cannot be compressed. If you squeeze the bottle, the water transfers this pressure to the air bubble in the drinking straw. The air bubble is compressed and is therefore too small to give the straw with the paper clips enough buoyancy. As a result, the diver sinks. When you let go of the bottle, the air bubble in the straw expands again. It displaces the water and gives the diver so much buoyancy that he rises.

Explore the phenomenon: **Hot and cold air differ**

HOT AND COLD AIR

Where do we encounter it in everyday life?

When we boil an egg, we usually prick one end with a pin to allow any air inside to escape during the boiling process, thereby preventing the eggshell from bursting. When we make jam, we pour the mixture into jars while it is still hot and we screw the lids on. However, besides jam there is also air in the jar. Both the jam and the air in the jar gradually cool down; the cold air contracts and produces the familiar clicking of the lid when we open the jar. The curtains above a warm heater move, and the warm updraught of air from the Advent candles causes the Christmas pyramid to revolve and the angel chimes to ring

What it's all about

The children learn how hot and cold air differ. They make genies appear from a bottle; they observe how a bottle crumples in the refrigerator; they make a paper curtain that moves in the warm air; and they fly hot air balloons.

What you need

- Glass and plastic bottles
- Bowls filled with hot and cold water
- Coins (20 cents)
- Balloons (previously inflated ones so that they have been stretched)
- Refrigerator or freezer
- Scissors
- Thread
- Crepe paper
- Hair dryer
- Bin bags or other large, thin plastic bags

Fig. 1: When it's warm, the air particles need more space.

Fig. 2: You can faintly hear the tinkling of the coin.

Fig. 3: Balloons seem to self-inflate.

HOT AND COLD AIR AT PLAY (WARM-UP)

Explain to the children that air consists of many small particles which are so tiny that we cannot see them. Each child then pretends to be such an air particle. When it is cold, the children snuggle up to each other and hardly move at all. The warmer it gets, the more they move. At first, they just sway back and forth a little, but after a while they start to dance about more and more forcefully. The children soon realise that they need much more space to do this.

GENIE IN A BOTTLE

Place a moistened coin on the opening of a glass bottle that has come straight from the freezer. Ask the children to rub their hands together and wrap them around the bottle. Can they summon the genie?

Fetch one bowl of hot water and one bowl of cold water. Have the children roll the neck of a balloon over the neck of a glass bottle. Now stand the bottle with the limp balloon in the bowl of hot water for about a minute. Does the genie rise from the bottle? What happens when the children stand the bottle in the bowl of cold water?

Look at this:

Hot air needs more space than cold air. When the children wrap their hands around the cold bottle, the air inside warms up and requires more space than is in the bottle. The air escapes and causes the coin to clink. For the same reason, the balloon inflates and becomes upright once the bottle is standing in the hot water. The effect can also be reversed. If you stand the bottle in cold water, the air then requires less space and the balloon deflates; sometimes it is even sucked into the bottle. This can be repeated until the water in the bowls is no longer hot or cold enough to produce the effect..

Fig. 4: The bottle from the refrigerator is totally crumpled.

CRUMPLED BOTTLE

The children put a sealed, empty bottle made of thin plastic in the refrigerator in the morning. They check on it throughout the day. How does the bottle change over time? And what happens to it when they take it out of the refrigerator again?

Look at this:

Cold air requires less space. It contracts inside the bottle and causes the bottle to crumple. If you take the bottle out of the refrigerator, the air in the bottle warms up again and expands so that the bottle regains its former shape after a little while.

DANCING SNAKES AND HOT AIR BALLOONS

Make a paper curtain with the children. To do so, the children cut crepe paper into long strips. Stretch a piece of string between two points over a warm heater or a floor lamp so that the children can hang their strips of paper on it. If possible, the lamp should be adjusted to shine upwards. Caution: It could get very hot! What do the children observe? What happens when the heater or the lamp is switched off again? And what do you feel when you hold your hand over the warm heater or the lamp?

In the second inquiry activity, the children use a hairdryer to blow hot air into a large bin bag. For comparison purposes, an identical bin bag is filled with normal room air by waving it about. Both bags are then sealed tightly with string and released outside.

Look at this:

Hot air rises, and when it does it can move things – for example strips of paper and plastic bags.

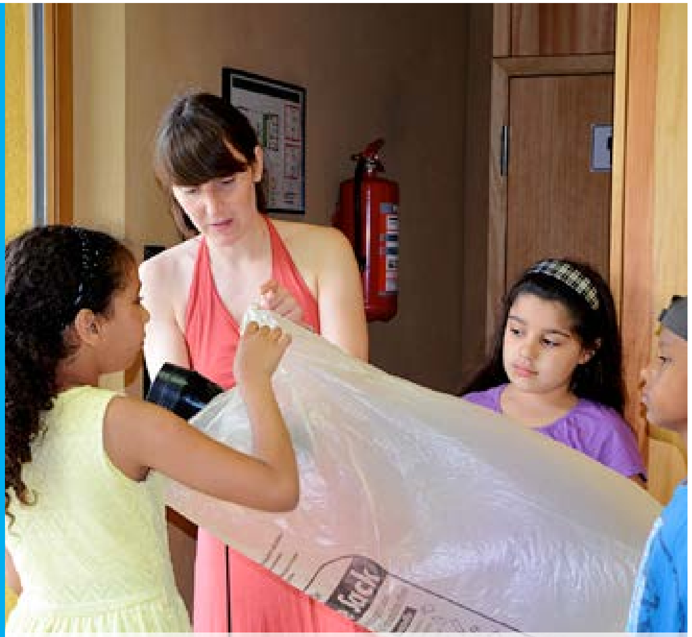

Fig. 5: A bin bag being filled with hot air.

INTERESTED ADULTS MIGHT LIKE TO KNOW

Air is made up of lots of tiny particles that are in constant motion. The movement of air particles is known as random thermal movement or Brownian motion The warmer it is, the faster these particles move. The air particles repel each other so that the distance between them becomes larger and larger. Therefore, when the air is warm, the particles of the same amount of air take up more space.

In the inquiry activities with the “genie in a bottle,” the bottle, and thus the air inside the bottle, is warmed up. As a result, the air expands and needs more space. However, the glass bottle cannot change its shape and expand. Therefore, the air has to escape, and It flows into the balloon.

Because the air particles move further away from each other as the air gets warmer, warm air is less dense and therefore lighter. A litre of cold air is heavier than a litre of warm air. Therefore, it falls downwards and presses the warm air upwards. In this way, light objects, for example the strips of paper, which are in the warm updraught are moved.

AIR

Explore the phenomenon: **The air that we breathe**

WE BREATHE AIR

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Where do we encounter it in everyday life?

We are seldom aware of our breathing, which is automatic. We notice it only in certain situations – for example when we get out of breath during sport and suddenly breathe much more deeply and rapidly, when we have a cold and have trouble breathing, or when daddy is snoring loudly.

What it's all about

The children discover that they breathe air in and out. They hear, feel, and see the air that they breathe. Moreover, they test how much air they have in their lungs and investigate the difference between fresh air and the air we breathe out.

What you need

- **Objects with an opening that you can breathe through, e.g. a snorkel, cardboard tubes, a loose-knit scarf**
- **Flexible drinking straws**
- **Transparent measuring jugs**
- **Thick hose (approx. 1 m long)**
- **Large bowl of water**
- **Two tealight candles or other candles on a fire resistant base**
- **Two identical large jars**
- **Two long-nozzle lighters**

07/2013

Fig. 1: Taking deep breaths

Fig. 2: Feel how your stomach rises and falls.

Fig. 3: Seeing your breath on a mirror

BREATHE DEEPLY (WARM-UP)

Give the children different things that they can breathe through, for example a snorkel, cardboard tubes, a loose-knit scarf, etc. (Please do not use any closed objects, such as buckets!). Have the children concentrate on breathing in and out through the objects. Does breathing feel any different than usual? What sounds are produced?

HEAR, FEEL, AND SEE THE AIR THAT WE BREATHE

Have the children lie on their backs and relax, breathing in and out loudly through their mouths. Listen together to the whistling and puffing. The children can also watch each other and see how their chest rises when they inhale and falls when they exhale. When they breathe in and out with their hand in front of their mouth, they can feel how the air is sucked in and blown out again and how warm their breath is. Afterwards, have the children breathe onto the mirror in the bathroom until it fogs up.

Compare these things together: How many breaths do you take per minute when you are lying down quietly? And how many breaths do you take per minute after jumping up and down on the spot at least 15 times? How does your breath feel in each case?

Look at this:

You can hear, feel, and see the air that you breathe. You get out of breath when you exert yourself physically; you then breathe faster and deeper than when you are resting.

Fig. 4: The exhaled air fills the measuring jug.

BREATH-MEASURING DEVICE

The children can test how much air they have in their lungs. This entails submerging a transparent measuring jug in a large bowl of water. The jug must be completely filled with water. It is then turned so that the base is sticking up out of the water. However, the mouth of the jug must always remain under the surface of the water. Have one child take a deep breath and blow hard into the measuring jug through a hose.

Look at this:

The more breath you have, the more water will be forced out of the jug by the air you exhale. You can easily see how much air you have exhaled by reading the scale of the measuring jug.

Further discoveries can be made using the "Air and water" exploration card

INTERESTED ADULTS MIGHT LIKE TO KNOW

We inhale fresh air and exhale spent air continuously. That means that we "use up" about 300 million litres of air in the course of our lifetime. Adults take 15 breaths per minute, on average. Children take even more. Most adults find it very strenuous to hold their breath for more than one minute. However, there are divers who can hold their breath for eight minutes or more.

The amount of air the lungs can hold depends on a person's age, height, and sex. A thirty-year-old man who is 1.75 meters (five foot nine) tall has an average lung capacity of four litres. The lungs of a woman of the same age and height can hold approximately only 3.5 litres of air.

FRESH AIR AND EXHALED AIR

What is the difference between fresh air and the air that we breathe out? Aren't they both the same? What do the children think? For example, what does the air smell like in a room full of people that has not been aired for a long time?

Capture fresh air and exhaled air in two separate large glass jars. To capture fresh air, go outdoors and wave the jar back and forth through the air. Then quickly put the jar over an unlit candle. The second jar is already standing upside down over an unlit candle. Have some of the children use flexible straws to breathe into it several times. Lift the jars and light both candles at the same time with the long-nozzle lighters and quickly lower the jars over the candles again. What do the children observe?

Look at this:

Both candles go out after a little while. But the candle under the jar with the children's breath goes out much faster than the one under the jar with the fresh air.

And how long do the candles burn if they are lit again?

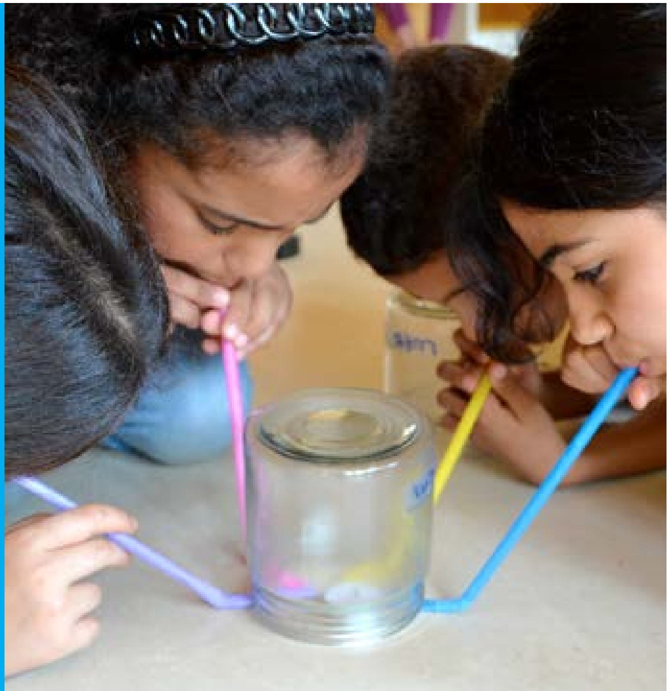


Fig. 5: A glass being filled with exhaled air

Investigate the phenomenon: **Air is not nothing**

HOW MUCH AIR FITS INTO A SOAP BUBBLE?

ASK QUESTIONS ABOUT THE NATURAL ENVIRONMENT

Air can be captured and packaged in many different ways: in balloons, air mattresses, bubble wrap – and in soap bubbles.

How is it possible to catch lots of air in a soap bubble?

COLLECT IDEAS AND ASSUMPTIONS

Collect ideas with the children: What things do we need to make soap bubbles? Do the children have any ideas about how really large soap bubbles are created?

Before you start the inquiry activity, younger children should practise the difference between sucking and blowing, for example by blowing a ball of cotton wool or a table tennis ball right across the table.

TRY THINGS OUT AND CONDUCT INQUIRY ACTIVITIES

Have the children tip a small amount of soap bubble solution into a flowerpot saucer. Then have them blow into it with a straw and make different bubble structures. If the children dip their straws into the solution only briefly and then blow, the soap bubbles will fly across the room.

In order to capture as much air as possible in the soap bubbles, the children can test drinking straws of different thicknesses. Different "blowing techniques" should also be tested: first quickly and forcefully, then slowly and gently.

Make a drinking straw propeller together. This involves making four 2cm-long cuts in the bottom end of the straw and then bending the four "strips" outwards. You can also make bubble wands out of wire or pipe cleaners. The wire rings must be covered with fabric or gauze before the children dunk them into the bowl of soap solution. Let the children try out all the possibilities. How is it possible to conjure up an especially large bubble?

07/2013

Materials:

- *Soap bubble solution: 2 squirts of dishwashing liquid and 1 teaspoon of sugar per cup of water or: A mixture of 1 part glycerin (from the pharmacy), 1 part dishwashing liquid, and 2-3 parts water (The second mixture works better, but it should be used only if the children can blow well and don't swallow the soap mixture by mistake! Tip: Four or five small holes in the middle of the straw prevent accidental ingestion of the soap solution!)*
- *Thick and thin drinking straws*
- *Plastic flowerpot saucer*
- *(Gardening) wire or pipe cleaners*
- *Fabric remnants or gauze bandages*
- *Scissors*

OBSERVE AND DESCRIBE

What associations do the children make when they look at their soap bubbles? Do the bubble structures in the saucers look more like a strawberry or a sheep? Jointly observe the interplay of colours on the soap bubbles. What colours can you see when you look at the bubble from different angles?

Have all the children observe what happens when the soap bubbles fly through the air. Do the bubbles rise or fall – or do they begin to float? Is there a difference between the very large and somewhat smaller bubbles? How can the children keep the bubbles up in the air for as long as possible? How long does a soap bubble "live"? And what happens when it bumps into something?

In addition to general observations of the soap bubbles, have the children describe what they do to produce really big soap bubbles.

DOCUMENT RESULTS

Each child can make their own small "inquiry activity log," in which they note down – or draw – their method and the size of the soap bubble.

What works better? A thick or thin straw? Blowing gently or forcefully? What produces the largest soap bubbles: the straw propeller or the bubble wand made of fabric-covered wire?

DISCUSS RESULTS

With the children, take another look at their "inquiry activity logs" and collect the following information: Which method was particularly successful in capturing lots of air in a soap bubble? Did the children discover combinations with which particularly large bubbles could be created – for example, cutting a thick straw to form a propeller and then blowing into it very carefully and gently?

You can also try to produce soap bubbles with very unusual shapes. For instance, you get oval soap bubbles when you cut off the tip of the straw diagonally. What happens if you bend the fabric-covered wire into the shape of a rectangle, triangle, or oval rather than a circle? And how do you make lots of tiny soap bubbles?

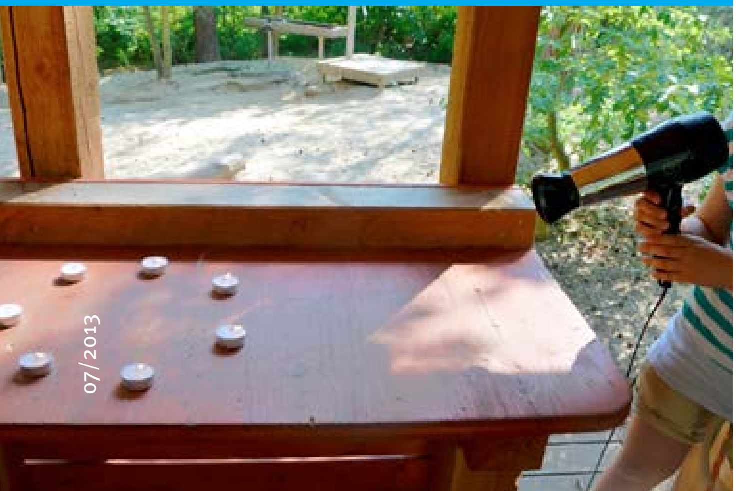
Investigate the phenomenon: **Air turbulence**

WHERE DOES THE AIR GO?

ASK QUESTIONS ABOUT THE NATURAL ENVIRONMENT

You can use moving air to make little paper balls flit across the table or blow out a tea-light candle.

How can you track where the air goes and how it spreads around the room?



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COLLECT IDEAS AND ASSUMPTIONS

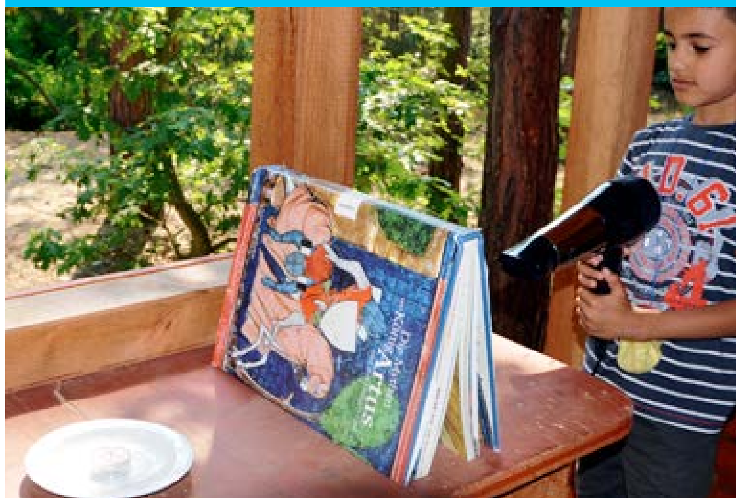
With the children, think about how you can protect yourselves against gusts on a windy day. For instance, you could hold an open umbrella in front of your body or wait for the bus in the bus shelter rather than on the footpath. What other possibilities can the children think of? Does it make sense to hide behind a big tree or an advertising pillar? What do the children think?

Do the children have any assumptions about the best shapes to use as protection against gusts of wind? You can suggest undertaking a small inquiry activity to check where the air goes.

TRY THINGS OUT AND CONDUCT INQUIRY ACTIVITIES

Place a little paper ball or a tealight candle on an empty table. Using a hairdryer or the shoe box they have prepared, have the children direct the airflow at the object. What happens? The children can arrange more little balls or tealight candles on the table (e.g., in a circle). Using the hairdryer or the shoe box, they should blow from directly in front. What things are reached by the airflow and what things are not?

In the third step, erect different barriers in front of the little balls or tealight candles. What happens when, for example, you place a glass bottle in the airflow? What other barriers would the children also like to test? Have the children change the distances between the hairdryer or shoe box and the respective barriers. Try out different positions of the hairdryer or shoe box and the paper balls or tealight candles.



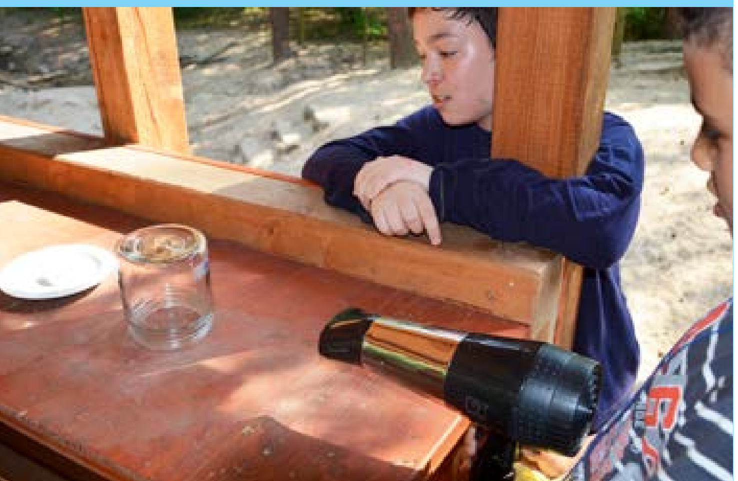
Materials:

- *Little paper balls or tealight candles*
- *Hair dryer or pre-prepared shoe box (see “Puff of air from a box” on the “Moving air” exploration card).*
- *Differently shaped objects as barriers (e.g., glass bottle, thick candle, book, cardboard triangle, ball, wide ruler, CD)*

OBSERVE AND DESCRIBE

How can the children tell whether the paper balls have been hit by the airflow? How do they notice this in the case of the tealight candle?

Observe with the children which flames or balls are hit by the airflow when you blow with the hairdryer or the box from straight in front. What changes if you place a barrier in the airflow? Does the airflow reach the paper balls or tealight candles if a barrier is replaced with another object – for example, if the glass bottle is replaced with a thick book?



DOCUMENT RESULTS

The children can note down their observations in a table: What similarities and differences do they notice between the results obtained using different methods?

Drawings are also a very good way of recording where the air goes. Drawn arrows visualise the respective airflows: Where does the air hit a barrier and in which direction is it deflected? Which little balls move and which tea lights are extinguished? Does the airflow change direction if the barrier is a different shape? What route do the arrows take when the object is round? And what route do they take when the round object is replaced with a square barrier?

DISCUSS RESULTS

With the children, recapitulate all the things that they have found out. Jointly consider under which conditions the paper balls or tealight candles were best protected from the airflow. Do the results correspond to the children’s assumptions?

As a supplementary exercise, you and the children could think about how to build a particularly good windbreak. What shape is the most suitable? And does it really make sense to hide from the wind behind a big tree or an advertising pillar?