24 COOL SCIENCE EXPERIMENTS

ADVENT CALENDAR

AGE: 8–99

The Crazy Scientist®

MERRY CHRISTMAS

Biology

Chemistry

Mechanics

Optics

Magnetics

ADVENT CALENDAR

THE PURPLE COW

DAY 1

VOLCANO ERUPTION

DURATION:
approx. 15 minutes

ADDITIONALLY REQUIRED:
- an empty bottle
- a glass
- a soup bowl
- a spoon
- water
- a sachet of baking powder (approx. 15 g)
- food coloring
- a funnel
- dishwashing liquid (optional)


First, pour the baking powder into the bottle. Use a small funnel if the opening is very narrow.


Gradually add the citric acid to the colored water.


Carefully and slowly add the water-citric-acid mixture to the volcano.


The volcan erupts!

Experiment

Put on the safety goggles. Pour the baking powder into the bottle. If you want to produce a lot of "lava", you can use more powder. Place the bottle in a bowl or a soup plate and set it aside for a moment. Now, fill the glass half full with water. For a particularly effective volcanic eruption, you can dye the water with food coloring, preferably red. Add sufficient coloring to make the water dark red.

Gradually add the citric acid to the water and stir the mixture with the spoon handle. You can also add some dishwashing liquid to make the volcano foam better.
Now, carefully and slowly pour the water-citric-acid mixture into the volcano bottle.

NOTE:
Always use eye protection when doing these experiments! Also read again the safety notes on the first pages of this manual.

It will immediately begin to produce foam. You can see that the bottle fills up rapidly. This is because the reaction of the baking powder with the citric acid starts at once. While the baking powder and the citric acid react with each other, they release a lot of gas that produces bubbles and makes the volcano erupt.

TIPS:

Vinegar: Instead of citric acid, you can also use an equal amount of vinegar as vinegar is also an acid. The only drawback is its intense smell.

Volcano landscape: In this experiment, the volcano consisted of a simple bottle so that you could better observe what happens within. However, you can also build a real volcano landscape in which you incorporate the bottle. Let your imagination run wild! For instance, you can model a mountain from aluminum foil and decorate it.

DISPOSAL

After completing the experiments, you need to dispose of the remains of the volcano in the gutter or the household waste.

ACIDS AND BASES

The mixture immediately begins to react when the baking powders comes into contact with the acid as shown by the rapid rise of the foam in the bottle. Chemically speaking, citric acid is an acidic liquid while the baking powder is basic or alkaline. When these substances touch each other, a violent reaction occurs: the two highly different substances neutralize each other. In the process, they release carbon dioxide (CO_2), a colorless gas. It expands intensely and together with the dishwashing liquid, causes the bubble effect that makes the volcano erupt.
Incidentally, citric acid is very common in nature. It is not only present in citrus fruits but also in apples and pears and even in milk.

Carbon dioxide

Carbon dioxide, CO_2 in short, is a colorless gas consisting of carbon and oxygen. It is a natural component of air and is responsible for the bubbles in many beverages.
However, carbon dioxide is also a component of the exhaust gases produced by the burning engines of cars. Among others, these exhaust gases have been causing the amount of carbon dioxide in the Earth's atmosphere to increase for years. After all, there are lots of cars in the world that permanently blow exhaust gases into the air. This is harmful to the environment as CO_2 contributes to climate change and the greenhouse effect.

Citric acid is a widely used cleaning agent. It is especially good at removing calcium deposits or red wine stains from clothing.

DAY 2

THIRSTY POWDER

Experiment 1

For this experiment, you will need two glasses of the same size and some water. It works best with distilled water; however, tap water will also do.

WARNING!
Keep the SAP powder away from your mouth and your nose. When you swallow or breathe it in, it can block your respiratory passages or your throat. Keep it away from small children and use it only under supervision of adults.

Weigh the packet with the SAP powder on the kitchen scales. Including the packaging, it weighs a little more than 0.7 ounces. Pour the powder into one glass and fill the other glass with water. Then pour the water slowly into the glass with the powder. The powder immediately absorbs the liquid and inflates. Little by little, add all the water to the powder. In the process the powder becomes a white, granular mass. The liquid water is gone.

DURATION:
approx. 20 minutes

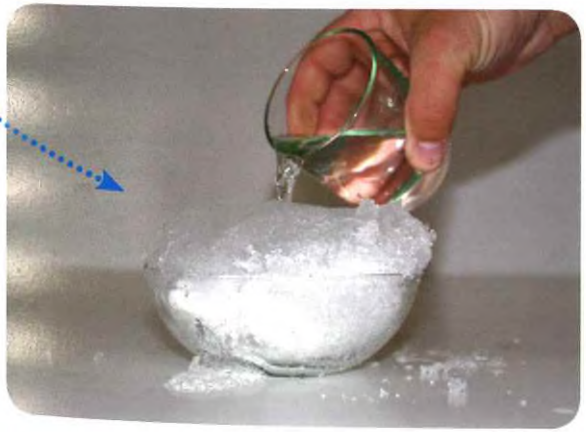
ADDITIONALLY REQUIRED:
- water
- kitchen scales
- two glasses of the same size
- a bowl

The glass is full. However, there is no longer any trace of water but only puffed up powder.

When you slowly pour the water into the glass, it is immediately absorbed by the powder.

When you touch the mass, it feels soft and somewhat moist. However, it won't wet your fingers. Weigh the mass again. If you have used a regular glass of water, the inflated mass will now be ten to twelve times as heavy as the original powder.

The powder continues to absorb water, even though it towers above the bowl.



DISPOSAL

After completing the experiments, you need to dispose of the SAP powder in the household waste.

Experiment 2

Put the inflated mass into a bowl and add another glass of water. The substance will continue to puff up. Try to add yet another glass of water. The mass begins to form a tower that looms above the bowl. When you add more water, part of it may land on the table. However, this is not water but powder full of water. Nonetheless try and let the SAP powder absorb several more glasses of water.

In our experiment, the SAP powder absorbed five glasses of water, i.e. 50 times its own weight.

WHAT IS SAP POWDER?

SAP stands for "Super Absorbent Polymers". These are synthetic materials capable of absorbing liquids up to multiples of their weight. This works particularly well with water. Simply put, the water molecules enter the interior of the super absorbent material and are held back by it. In the process, the SAP powder puffs up. It can take in liquids up to 1000 times its mass. This is partly due to the sodium ions contained in the powder as indicated by the chemical name of the SAP powder supplied with the calendar: it is called sodium poly acrylate.

Uses:

SAP powder is used to absorb liquid. Among its many uses, it is contained in diapers to keep the baby dry. While the diapers still feel dry after use, their added weight shows how much liquid they have absorbed. The powder is also used as an extinguishing agent and as an additive for potting soil.

DAY 3 WATER VORTICES

Experiment 1

For this experiment, you need two big bottles. Fill one of them with water; the other one remains empty. Screw the "vortex connector" on the full bottle, and then attach the empty bottle to the upper end of the connector.
Now turn the two connected bottles upside down so that the full one is on top. What happens? Nothing! The water stays in the upper bottle.

Why does this happen?
If the bottle is filled to the top, the air in the bottom bottle doesn't have a chance to escape upward. Basically, the water in the upper bottle rests on an air cushion.

DURATION:
approx. 10 minutes

ADDITIONALLY REQUIRED:
- two equally-sized bottles
- water

Connect the two bottles with the vortex connector.

If you turn the bottles so that the full one is on top, the water will not flow down to the bottom one.

After "stirring" the bottles, a vortex begins to build up and the water starts to flow down.

Experiment 2

Creating vortices
As you have seen, simply turning the bottles upside down is not sufficient for the water to flow down. You also have to move the bottles as if stirring with a cooking spoon. In the process, the water begins to swirl and an eddy or water vortex builds up.
When you try this several times, you will notice that the vortex looks different every time with the funnel shape more or less pronounced.

IMPORTANT:
The Vortex Connector is suitable for typical soda plastic bottles. Before usage, please remove the "neck" ring just under the cap.

Experiment 3

In which direction does the vortex turn?
Try to create a water vortex in the connected bottles several times in a row and observe its rotating direction. You can also watch the vortex of the water running out of a bath tub. You will realize that the vortex does not always turn in the same direction.

When you carry out the experiment several times, you will notice that the vortex looks different every time.

WHAT IS A VORTEX?

A vortex appears when a liquid drains out downward and moves in a circular or spiral pattern resembling a funnel. Vortices are also called eddies or whirlpools. However, vortices do not only appear in sinks and when emptying a bottle but also in the ocean and in rivers. They can become very dangerous for swimmers or even boats, pulling them down into the depths.
Once it was believed that a water vortex always turned in the same direction as dictated by the rotation of Earth and the Coriolis force. However, today we know that small vortices like those in your bottle or in a bath tub are too small to be affected by these forces. Their direction of rotation is basically random. There are other factors influencing the direction of vortices, e.g. small bumps in the drain pipes.

THE CORIOLIS FORCE

Every water vortex on Earth is affected by the Coriolis force. It acts on objects (like a vortex) in a rotating environment (including the Earth, as it spins on its axis). If the Coriolis force acted on a water vortex without any additional effects, the vortex would always turn in the same direction, namely counterclockwise on the northern hemisphere and clockwise on the southern hemisphere. On the equator, both directions of rotation would be possible.
As you have seen in the preceding experiments, both directions are possible. This is because the Coriolis force is rather weak. You would need optimum conditions to be able to observe its effects undistorted by any additional influences.

CONNECTED CONTAINERS

DURATION:
approx. 10 minutes

ADDITIONALLY REQUIRED:
- a glass
- a bottle
- water

When two vessels are connected by a hose, the fluid levels inside them are always equal.

Experiment 1

Communicating vessels

For this experiment, you need a glass full of water and the syringe. Attach the hose to the tip of the syringe. Push the plunger in completely before you dip the hose into the water. Slowly draw the plunger back and remove it completely from the syringe. You can now see that the water flows into the barrel. Depending on how high or low you hold the syringe, the water level changes: it will always remain on the same height as the water level in the glass.

Experiment 2

Water transfer

In order to transfer water, you again need the syringe with the hose, an empty glass and a bottle of water. Put the loose end of the hose into the full bottle. Draw back the plunger of the syringe so that water flows to the barrel.

First, suck in some water by drawing back the plunger.

Remove now the plunger from the syringe and watch the water run all by itself from the bottle through the hose and into the glass. It even flows better when you remove the syringe from the hose.

NOTE:
Keep the syringe and the hose safe as you will need them later on for several other experiments.

Experiment 3

Transporting water under pressure
Draw back the plunger to suck a little water from the cup into the barrel of the syringe. The vacuum within the syringe holds the water in the barrel. Even if the nozzle is open at the bottom, the water will not leak out. It only splashes out of the syringe when you press down the plunger.

Because of the vacuum, the water stays inside the syringe although it is open at the bottom.

COMMUNICATING VESSELS

When two or more open containers are connected, they are called "communicating vessels." If you pour in liquid, its level will be equal in all the vessels independent of their respective shape. Even if the containers are placed on different heights, the levels of the liquid will still adjust between them. Water pipelines work on this principle. This is because gravity and air pressure are constant.
The concept of communicating vessels is used for water level indicators. For example, if you connect a thin vertical glass tube to a big tank, the fluid level in the two vessels will be the same.

DAY 5

AMES ROOM

Preparation

Today, you will build an Ames room (An Ames room is a distorted room that creates an optical illusion).. To do so, cut out the two parts of the room from today's box. Cut out the large shaded area in the top side of the room and the white peephole in one of the narrow side walls. Fold the parts along the folding lines. Coat the white bonding surfaces with a little glue and stick the two parts of the room together as shown. Use very little glue so that the interior of the room remains unsoiled. Make sure that you also firmly press together the bonding surfaces with your fingers from the inside so that the structure cannot bend. As the Ames room is distorted, it is not easy to assemble. If you run into problems, ask your elder siblings or your parents for help.

DURATION:
approx. 10 minutes

ADDITIONALLY REQUIRED:

- scissors
- glue
- two small objects of equal size

Experiment 1

From the outside you can see that the Ames room is a distorted structure. But what does it look like when seen through the peephole? Try it yourself. You will realize that from this perspective, it looks like a perfectly normal room!

STOP!

Don't throw away the box after opening the first door! There is a little surprise for you: The backs of all the boxes in this advent calendar form the board of a little science game. Each day, fold the open box and put it back upside down. This way, your advent calendar becomes a game board day by day. You will also need the contents of some of the boxes for the game. This is indicated on the pages for the respective days in this manual. Pay attention to these notes! The rules of the game are printed on the final page of the manual.

Experiment 2

Take two objects of similar size from your toy collection, e.g. two dice or two game pieces. Place one of them in the left rear corner of the Ames room and the other one in the right rear corner. Look through the peephole.
As the two objects are at different distances from your eye, their apparent size also differs. However, due to the layout of the room it seems as if they stand next to each other and that one of them had suddenly become bigger.

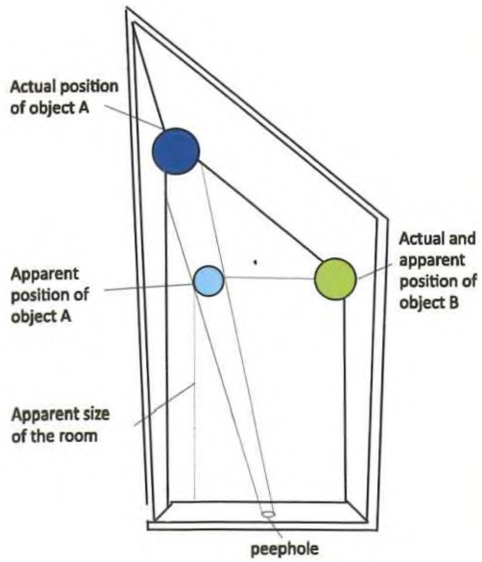
When you place the two objects side by side, you can see that they are of equal size.

Ames room, the two equally-sized bjects seem to be of different size.

A Matter of Perspective

An Ames room is a prime example of an optical illusion.
Our brain memorizes everyday experiences. For this reason, we assume that rooms and windows have right angles. The Ames room plays on this fact. Virtually everything in this room is askew. One of the rear corners is much farther away than the other one. Also, the ceiling is twice as high in one of the corners.
For a perfect optical illusion, the furniture has to be adjusted as well. For this reason, the pieces of furniture in the part of the room with a high ceiling are illustrated bigger than those in the front part. The illustrated bigger pattern of the floor is also distorted.
The secret of the Ames room is in the perspective. When you look through the peephole, everything seems the way you are familiar with from an ordinary room. Hence your brain assumes that this also is a regular room with the corners at right angles and a straight ceiling.

When you place two objects in the room it looks as if they were the same distance away but of different size. Depending on where they are, they seem to be shrunk, normal size or grown.
When you change the perspective, you realize the optical tricks used in the Ames room.



DAY 6

SURFACE TENSION

RAFFLE DAY !!

Experiment 1

A tower of water drops

For this experiment, you need a small plate. Place a toy brick in the middle and lay a coin on top.

Now fill the dropper with water. A dropper is closely related to a syringe. It also retains liquids through vacuum. This vacuum is produced by squeezing the back end of the dropper before dipping the tip into the water. When the tip is submerged, you release the pressure on the rear end so that the water can flow in.

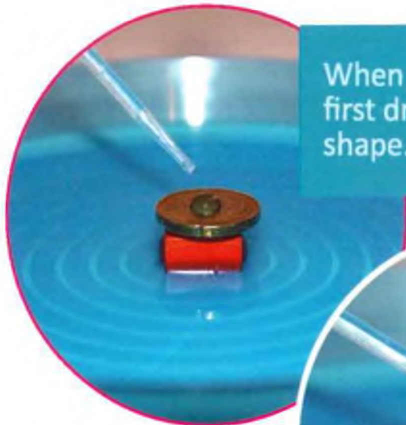
A dropper retains liquids through vacuum.

Now use the filled dropper to place a drop of water on the coin. As you can see, the drop does not immediately dissolve and spill all over the area of the coin but keeps its shape. When you add more water, drop by drop, the drop on the coin gets bigger and bigger. You have to add many drops until it reaches the rim of the coin. If you continue to add water, it will not only get higher but also grow beyond the rim. This is due to surface tension. It allows the drop to reach a diameter that is larger by 1 millimeter than that of the coin. The height of the drop can grow up to double the thickness of the coin. When the amount of water has become too high to be held back by surface tension, the water will spill over on on to the plate.

You can play this experiment also as a game with friends. The player whose tower first starts to spill over has lost.

DURATION:
approx. 10 minutes

ADDITIONALLY REQUIRED:
- water
- a plate
- a small toy brick
- a coin
- dishwashing liquid



When you place the first drop, it keeps its shape.

The water tower can become twice as high as the coin and even grow beyond its rim.

Experiment 2

Reducing the surface tension

Have another go at the coin game, but this time use water with a few drops of dishwashing liquid in it. This liquid dramatically reduces the surface tension of the water. While you can still erect a water tower, it will be rather small. The water will soon start to spill over.

When the water contains a little dishwashing liquid, the surface tension is reduced so that the water soon starts to spill over.

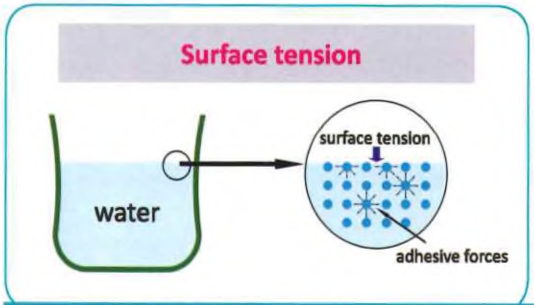
NOTE:
Keep the dropper safe as you will need it for further experiments.

SURFACE TENSION

Within the water, adhesive forces act in all directions between the water molecules and cancel out each other. However, this does not apply to the surface because there are no forces acting upward. The forces only act downward. Due to the forces between them, the molecules at the surface form a sort of membrane with a surprisingly high stability. Its surface tension has such a high load-bearing capacity that small insects, like the water strider, can even walk on the water.

Thanks to the high surface tension, small insects like this water strider can walk on the water.

Water tends to spread with the smallest possible surface area to reduce the surface tension to the required minimum. This is also the reason for the spherical shape of raindrops.



This figure shows the forces acting on water molecules on the surface and within the liquid.

The concept of surface tension can be observed in any liquid. Their load-bearing capacity is determined by their composition. It is specified in a unit called millinewton per meter (mN/m). Some values of surface tension are 73 mN/m for water, 15–40 mN/m for organic liquids and 435 mN/m for mercury.

DAY 7

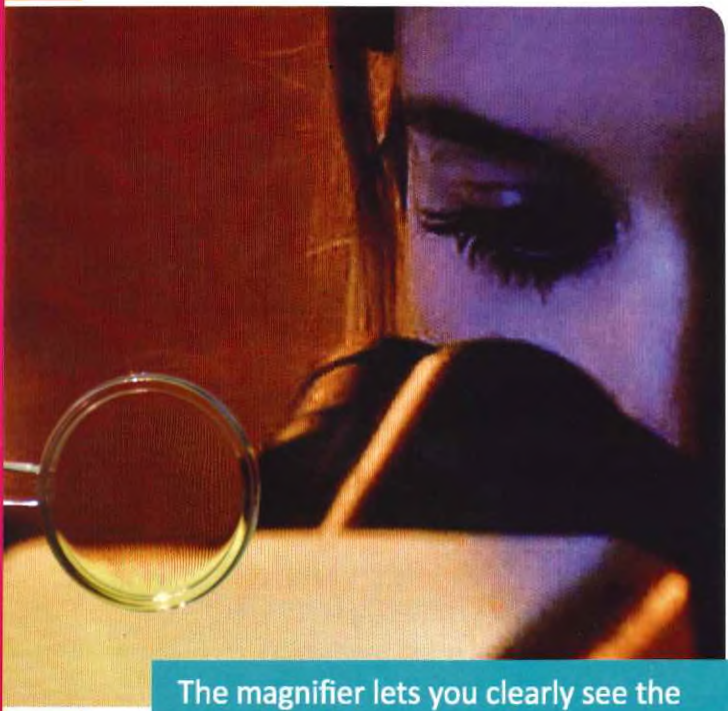
THE MAGNIFIER

DURATION:
approx. 10 minutes

ADDITIONALLY REQUIRED:
- TV set
- a flashlight
- a glass of water (plain glass)
- a book

Experiment 1

Details of a TV picture
A TV picture is composed of many dots shining in the primary colors red, yellow and blue. Hold the magnifier against the TV set while it is switched on. Now you can see the individual dots, which are called pixels.



The magnifier lets you clearly see the individual dots or pixels that make up a TV picture.

Experiment 2

A different use of the magnification effect
Hold the magnifier in front of a flashlight and direct the ray of light to a white wall. You can now use the magnifier to throw a very large image of the ray of light—or the individual LEDs of the flashlight as in the picture below—on the wall. To focus the image on the wall, change the distance between the magnifier and the flashlight.

The magnifier allows you to display the small light of a flashlight as a large image on the wall.

Experiment 3

Build your own magnifier
To build your own magnifier, you only have to fill a clear glass with water. If you put a book behind the glass, you can clearly see the magnification effect.

A glass of tap water acts as a simple magnifier.

Experiment 4

Changing the distance

Place the magnifier on a book page and slowly move it away from the page. First, the letters become larger and larger. Then there is a zone where one can't see anything through the magnifier as the image is out of focus. If you continue to move the magnifier away, the image is in focus again but now it is upside down.

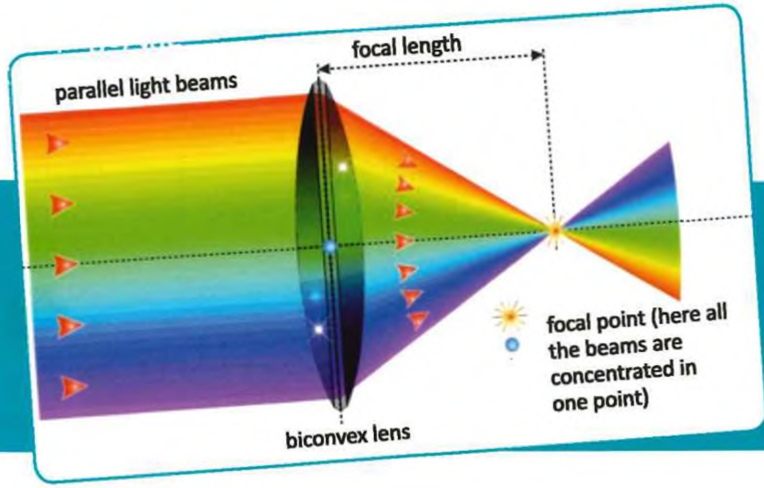
At a short distance above the page, the magnifier enlarges the letters.

At a greater distance from the object of interest, e.g. this mountain, the picture is flipped vertically and horizontally.

MAGNIFYING LENSES

The ancient Egyptians already knew that a drop of water had a magnifying effect. The Romans also studied this phenomenon. The magnifying glass was invented in the 11th century by the Arab mathematician Abu Ali al-Hasan ibn al-Haitham also known as Alhazen. His magnifier came in the form of a glass hemisphere.
In the Middle Ages, monks discovered Alhazen's records. They introduced the "reading stones," as these precursors of the magnifying glass were called, to Europe. At that time, book printing was not available, and hence all books had to be copied by hand. This was the task of the monks. As the eyesight of these scribes dwindled, they used the reading stones as a visual aid.
The reading stones were continually improved. In the course of time, they were developed into magnifiers, lenses, microscopes, telescopes, cameras, spectacles etc.
A magnifier consists of a collective lens with both sides bulging outward; this shape is called biconvex. As it allows you to see objects much larger than with the naked eye, it is also called a magnification lens. However, the magnification effect only works while the magnifier is not too far from the object of interest. Only then will the image be in focus. The respective range is called the focal length of the lens. When the lens is too far away, the picture is inverted horizontally and vertically.

How a magnifier works?

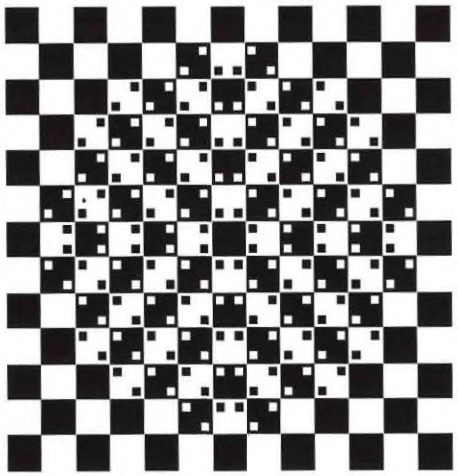


DAY 8 OPTICAL ILLUSIONS

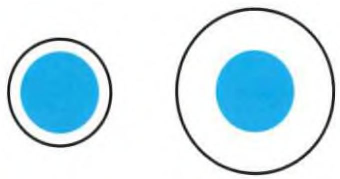
Look at each of the six illusion cards and describe exactly what you see. Put them aside and look at them again later. Chances are that you will now see different things than before.

DURATION:
approx. 10 minutes

ADDITIONALLY REQUIRED:
- nothing!

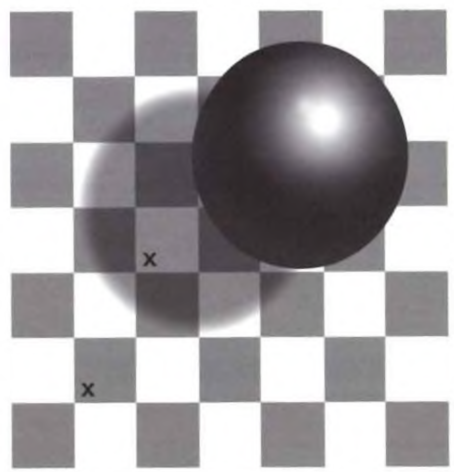


In this picture, the squares in the middle seem to be bigger and also bulge out like a sphere. Furthermore, the whole picture looks somewhat askew and wavy.
The reason is the small dots within the black and white squares. They are what confuses our eyes and our brain. In reality, all the squares are of the same size and all the horizontal and vertical lines are parallel to each other as you can easily check with a ruler.



When you look at the blue dots in the middle of the small circle on the left and the big one on the right, you get the impression that the left dot is significantly larger than the right one. However, they are actually of equal size, which you can check by measuring with a ruler. When you cover the two outer circles, the illusion will vanish and you can clearly see that the two dots are of equal size.

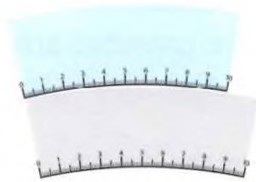
What do you see in the above picture? Obviously a tree! Close your eyes for a s while and have another look, this time concentrating on the trunk. Now you wi see the faces of two people looking at e other.



marked with an X. The sphere throws a shadow on the board, which also covers the white square with the X. At least, it seems to be of a lighter color than the grey X square. But the appearance is deceiving. In reality, both X squares are of exactly the same color. When you concentrate on the white X square in the shadows and look at it from different perspectives, it will suddenly seem much darker, and when you then compare it with one of the grey squares outside the shadow you will realize that they look the same.

Look at the figure below. Granted, this figure is rather difficult to see. Probably, you will first recognize a cube. However, the closer you look the more illogical and impossible it will seem. The illusion arises because you customarily interpret the dark areas as shaded surfaces.

To make this shape understandable, it is best to concentrate on the white, star shaped areas.



These two pictures convey the impression that the upper arc is shorter than the lower one. The scales enhance the illusion. Their centimeter divisions seem to be identically spaced; are they?

Solution

In reality, the two circle segments are of equal length and radius. The optical illusion arises from the fact that they are placed adjacent to each other. If you cut out the two segments and place them on top of each other, you would see that they are identical. This effect was described by the American psychologist Jastrow in 1892 and is named after him (Jastrow illusion).

For visual perception, our eyes and our brain work closely together. Our brain interprets what we see. In doing so, it draws on previous experiences. In most cases, this works very well—but sometimes, it doesn't. These wrong impressions are called optical or visual illusions and can come in many forms. It is possible to be mistaken when gauging spatial depth, recognizing geometrical shapes or even identifying colors.

It is possible to train your brain to a certain degree so that it does not fall that often for optical illusions, e.g. by concentrating on particular details when looking at pictures like these. There are more than 200 known figures that create optical illusions. It is still not known why some of them occur.

FINGERPRINTS

Experiment 1

Have you ever taken your fingerprints? First, apply a few drops of water to the ink pad and distribute them evenly with your finger. Be careful not to put too much water on the pad as this would result in smudged fingerprints. After these preparations, you can take the prints of your fingers one after the other. Slightly roll the tip of your finger to the left and to the right so that the ink gets evenly distributed on it. Now press the finger onto a sheet of white paper. Again, slightly roll it to both sides. The structure of your fingerprints should now be clearly visible on the paper. If not, simply try again.

After distributing a few drops of water on the ink pad, you can coat your finger with ink.

Experiment 2

Study your fingerprints and compare them with the classification sheet. Try to recognize the various structures like circular patterns or arches pointing left or right.

Which patterns do you recognize in your fingerprints?

NOTE:
You will later need the ink pad for the

DURATION:
approx. 10 minutes

ADDITIONALLY REQUIRED:
- a few drops of water
- a sheet of white (or at least light) paper

Experiment 3

Create a fingerprint database by collecting the fingerprints of your family members and friends. This will soon give you enough material to study the differences in fingerprints in detail. Maybe one day you can even use your collection of fingerprints to solve a crime—who knows!

Experiment 4

Find the crininal!
Someone has destroyed your tower of toy bricks! Of course, no-one admits it. But

The only thing you need to detect them is the fingerprint adhesive foil (a piece of regular adhesive film will also suffice). Remove the protective foil. Only touch the adhesive side at the end because otherwise, you would take your own fingerprint. Check the destroyed tower! On which of the bricks has the criminal left a trace? Pick up the chosen brick at the edges and glue the fingerprint foil to the spot where you expect a fingerprint. Remove it from the brick. And here it is: a clearly visible fingerprint! Now you only have to compare it with the fingerprints of your family in your database. The criminal is going to face charges very soon!

The foil clearly shows a fingerprint. The culprit is as good as identified.

...destroyed the tower? ...gerprint will solve the mystery.

THE PATTERNS ON OUR SKIN

On the inner side of our fingers, our skin displays many narrow lines called skin ridges. They form a pattern of arches and loops called a fingerprint. Every fingerprint in the world is unique; even twins have different fingerprints. Fingerprints remain unchanged after an injury.
The skin ridges at the fingers help us to better grip objects. Our toes and soles have similar structures that support our walking and help prevent slipping.
When you touch an object, you leave behind a fingerprint. You can see such a mark on a glass or a mirror but on most surfaces, the prints remain invisible to the human eye. The traces made by our fingers consist of 98.5% water plus a little grease and the dirt that has accumulated on our fingers since we last washed our hands.

Criminal scene investigators (CSI) use fingerprints to identify criminals. They powder objects that may have been touched by a criminal with iron dust. This substance forms a very thin layer on smooth surfaces and makes fingerprints visible.
The police have stored countless fingerprints on their computers. When they find a fingerprint at a crime scene, they compare it with known ones. This helps to identify the criminal.

A police investigator looking for fingerprints at a crime scene.

DAY 10

A BELL IN YOUR EAR

DURATION:
approx. 10 minutes

ADDITIONALLY REQUIRED:
- spoons of different sizes
- two empty yoghurt cups or tin cans
- nylon cord or string

Tie a spoon in the middle of the cord, and then wind the ends of the cord around your index fingers.

Put your index fingers in your ears.

Bend a little forward and make the spoon swing. When it hits an object, you can hear a loud ringing noise.

Experiment 1

Take the cord from today's box and tie a spoon in the middle. Then wind the ends of the cord around your index fingers on both hands, as near to the finger tips as possible. Put the fingers in your ears and bend a little forward so that the spoon can swing freely. Let it touch the side of a table. The impact makes the spoon vibrate, and these vibrations are transferred via the cord and your fingers to your ears so that you hear a loud ringing noise similar to a big bell.

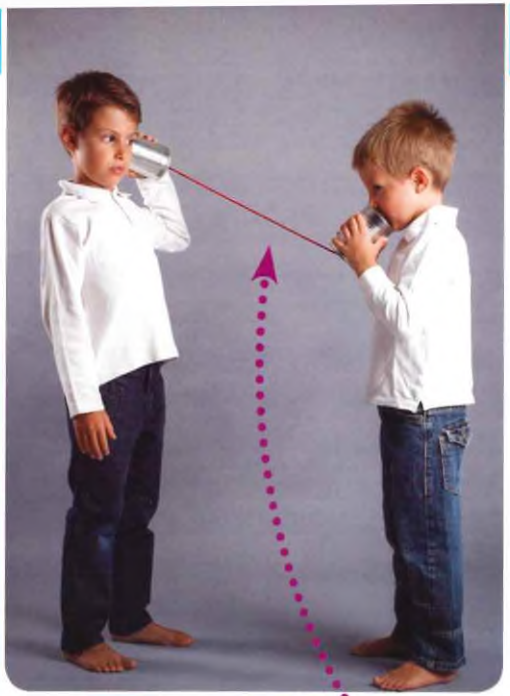
Experiment 2

Attach spoons of different sizes to the sound cord (you can also use forks). When you let them hit the side of the table as you did in the previous experiment, you will realize that every spoon makes a different sound. Small spoons produce a high note, larger spoons a lower note.

Experiment 3

Tin can phone

A tin can phone uses the same principle to transfer sound. You can easily build one yourself. All you need is two empty yoghurt cups and a piece of nylon cord or string (e.g. an old kite string). The cord must be sufficiently long to reach e.g the next room. Pierce a tiny hole in the bottom of each cup so that you can just about insert the cord through it. Caution: Get help from your parents for this! Thread the cord through the holes and tie as many knots in both so that the cord won't slip through the holes. The cord has to be stretched tight when you use the phone. While a friend talks into one can, you hold the other one next to your ear. This way, you can understand what he or she says. For better sound quality, use old tin cans. Make sure that they do not have any sharp edges. Better let your parents make the required holes.

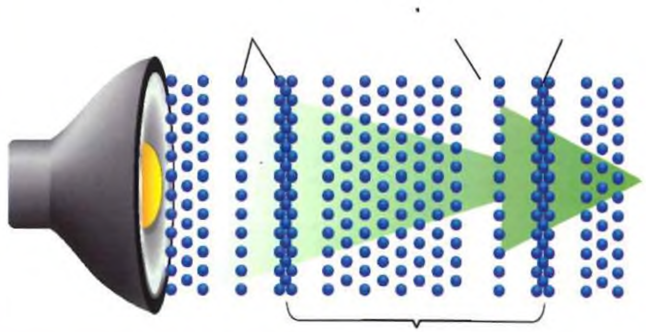


You only need two tin cans and a piece of string to phone a friend.

A tin can phone can easily cover a distance of 65 to 130 feet. In the past when there were no real phones, people used devices like this to talk over distances of up to a quarter of a mile.

SOUND TRANSMISSION

Since 1664, people have known that sound, e.g. human speech, can be transferred from one point to another via a wire or cord. After all, sound is nothing but a running sequence of vibrations or a pressure wave like waves in water. Air is compressed by the sound and then expands again. This produces the so-called sound waves. Your ear is tuned to perceive these waves. This is done by the eardrum, which the sound waves vibrate. As the experiments have shown, sound propagates not only in air but also in other elastic mediums like the cord or the bones of your fingers.



Sound waves: air is compressed and expands again.

DAY 11

MAGNETISM

Experiment 1

Take one ring magnet into each hand and move them towards each other. If you happen to approach the north pole of one magnet with the south pole of the other one, the magnets will be pulled towards each other and stick together. This is because opposite poles attract each other. However, if two north poles or two south poles meet, they repel each other. In this case, it is not possible to press the magnets together. The repelling force of the magnetic field causes you to experience resistance. The more you bring the two magnets together, the greater the resistance.

Depending on how you hold the magnets, they will either attract or repel each other. In both cases you will feel the magnetic force.

Experiment 2

Place a ring magnet standing on its edge on a table and move a second one towards it. Find out how near you can get to the magnet before it starts to roll away. Then try to let the magnet on the table roll as far as possible by steering it with the magnet in your hand.

How near can you get to the left magnet before it starts to roll away?

Experiment 3

Tie a thread of approx. 1 ft to each of the ring magnets. Tape the ends of both threads to a table about 4 inches apart so that the magnets are suspended side by side and can freely move. Watch what happens.

DURATION:
approx. 10 minutes

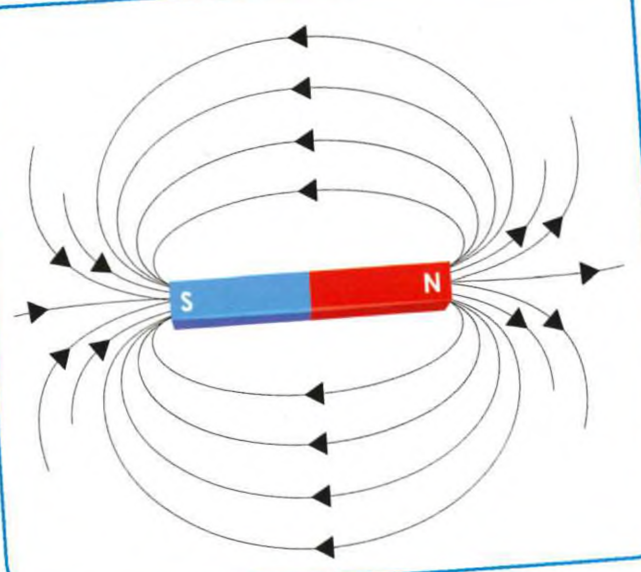
ADDITIONALLY REQUIRED:
- adhesive tape

At first, the two mag nets swing randomly

...but eventually they will attract each other.

MAGNETS

Magnetism is a natural phenomenon. Every magnet has two poles. The north pole and the south pole are connected by invisible magnetic lines forming the magnetic field. At the poles, the attractive force is strongest. When a magnet breaks in two pieces, the remains form two magnets with a weaker attractive force than that of the original magnet.
Earth also has a magnetic field and thus is a giant magnet. However, its magnetic south pole is near the geographic north pole and vice versa. The Earth's magnetic field helps birds, dolphins and whales find their way on their long flights or sea voyages, respectively.
Magnets attract iron and a few other metals. Permanent magnets are made from steel or ceramic. They can be found e.g in compasses, microphones or electrical measuring devices. Electromagnets are only magnetic while an electric current is running through them.



This figure shows the north and the south pole of a magnet and the magnetic field lines.

ELECTROMAGNETS

When electric current runs through a wired coil, a magnetic field builds up. An iron object within the coil, e.g. a nail, enhances the field and results in magnetic force. When the current is switched off, the electromagnet loses its magnetic effect. Electromagnets are used in industrial applications. They are capable of carrying loads of many tons.

Basic design of an electromagnet

NOTE:
Keep the magnets safe as you will need them for further experiments and for the science game.

DAY 12 EXPERIMENTS WITH COLORS

DURATION:
approx. 30 minutes

ADDITIONALLY REQUIRED:
- water
- three glasses for the dye tablets
- a toothpick

FOR EXPERIMENT 1:
- cooking oil
- two glasses .
- the dropper from day 2 (or a different dropper)
- a fizzy tablet

FOR EXPERIMENT 2:
- a big, flat basin, e.g. a deep baking tray
- approx. 25 fl. oz. (3/4 l) milk
- the dropper from day 2
- dishwashing liquid
- cotton swabs

Preparation

The dye tablets are water soluble. For the first experiment, you only need one color. So at this stage only dissolve one tablet. Take a glass, fill in no more than 0.5 inch of water and add one of the dye tablets. Wait 15 minutes for it to dissolve.

For the dye tablet you need a glass with about 0.5 inch of water.

Stir with a toothpick once in a while.

Experiment 1

Pour some water into an empty glass an fill up with cooking oil. While the oil will penetrate the water, it will neither sink t the bottom nor mix with the water. Instead, it will rise again. This is because oil is lighter than water. It therefore floa on water and does not mix.
Now, draw some dye into the dropper and drip it slowly on to the center of the oil's surface. As the dye is dissolved in water, it is heaver than the oil and sinks drop by drop through the oil. First, the dye
accumulates at the interface between t oil and water but a little later, it will sink further.

NOTE:
Don't use the complete amount of this dye for experiment 1. Leave something for experiment 2.

Now drop another dye tablet into the glass. It will slowly dissolve and produce tiny bubbles, which take the dye upward again. You can see more and more colored bubbles rise.

Drip a little dye on the oil's surface. The colored drops will slowly sink through the oil.

The dye first accumulates at the oil-water interface.

When you drop a fizzy tablet in the liquid, the bubbles let the colored droplets rise again.

Experiment 2

Drawing on milk

First, you have to dissolve the two remaining dye tablets in two glasses of water as previously described. Now you have three colors. Use the dropper to take up a little of one dye. Pour some milk into a basin, preferably a deep baking tray. You need just enough milk to completely cover the bottom surface. Now take your loaded dropper and drop little color dots on the milk surface. Put them wherever you like but don't produce too many of these dots. When the dropper is empty, thoroughly clean it with water and then use it for the next color.

Next, you need a cotton swab. Put some dishwashing liquid on its tip but not too much—it must not drip down. Carefully touch the centers of the dots of color with the swab. The color seems to run away from the swab and to form rings. You can also wipe the cotton swab through the milk so that the color escapes to the sides, forming whirls. This way, you can produce fascinating patterns in the milk. The reason is the different surface tension of milk and dishwashing liquid. You'll learn more about this effect tomorrow.

Put color dots onto the surface of the milk.

When you dip a cotton swab moistened with dishwashing liquid into the milk, fascinating colored rings appear.

Why does this happen?

Dishwashing liquid has a lower surface tension than milk. At the point of contact, some of the dishwashing liquid mixes with the milk and reduces the surface tension. This causes the dye to escape outward.

DISPOSAL

After completing the experiments, you need to dispose of the remains in the household waste.

DAY 13

MAGIC SPIRAL

DURATION:
approx. 10 minutes

ADDITIONALLY REQUIRED:
- a bowl
- water
- a toothpick
- dishwashing liquid
- paper or sponge rubber
- scissors

Experiment 1

Making the spiral turn

Fill a small bowl with water and place the spiral inside. Take a toothpick and dip its tip in dishwashing liquid. Then touch the water in the center of the spiral with the tip. The spiral begins to turn although you haven't touched it. First, it rotates quite fast and then it slows down. The spiral will even continue to turn when you remove the toothpick from the water.

The spiral starts to rotate as soon as you stick the dishwashing liquid-coated tip of the toothpick in its center.

Experiment 2

Driving a mini boat

Cut an isosceles triangle of approx. 1.5 inc width from paper or sponge rubber. This i best shape to make our "boat" move in a straight line.
Place this "boat" in a bowl of water.
Take a toothpick and dip its tip in dishwas liquid. Then touch the water surface behi the boat. The boat will immediately start t speed to the opposite side of the bowl.

TIP!

Change the water after each experiment because even one remaining drop of dishwashing liquid from the first experiment can reduce the surface tension so much that any further experiments won't work.

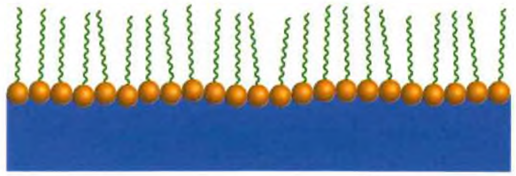
Place the boat in a bowl of water.

As soon as you stick a dishwashing liquid-coated toothpick in the water behind the boat, the vehicle will speed to the opposite side.

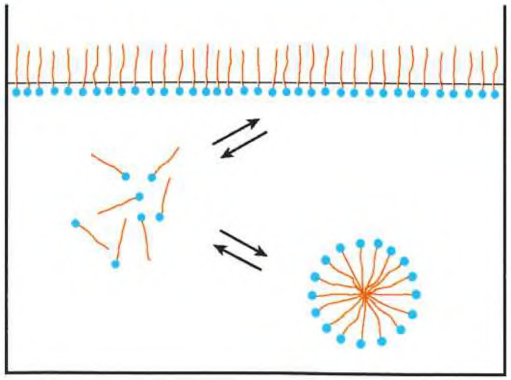
THE MAGIC OF DISHWASHING LIQUID

On the second day, you already learned that water molecules attract each other and that this effect produces the surface tension. Dishwashing liquid and soap contain so-called surfactants. These consist of molecules that attract water on one hand and repel it at the other hand. When you use the toothpick to add some dishwashing liquid to the water, the attracting parts of the dishwashing liquid molecules push themselves between the water molecules while the repelling parts initially stay at the surface reducing the surface tension. Hence the "skin" of the water breaks.

However, as water always try to form the smallest possible surface area, they withdraw. The spiral visualizes this effect as the sponge rubber adheres more to the water than to the dishwashing liquid. Dishwashing liquid hence reduces the surface tension of water.



attracts water



DAY 14

THE COMPASS

Experiment 1

Building a compass

A compass can be built easily. All you need is a cup of water, a magnet and the needle and the foam pad from the Advent calendar. Magnetize the needle by rubbing it against the magnet. Make sure that you always stroke in the same direction, not back and forth. Do this for one minute (approx. 60 strokes).
Stick the needle through the middle of the foam pad, place the pad with the flat side facing down onto the water in the cup, and your compass is ready! Keep the compass away from touching the walls of the cup.
After you placed the foam with the needle on the water, it will start to rotate and eventually stop moving. Notice the direction of the needle. Turn the foam into another direction. Notice that when you let it go, it will turn back to the previous direction - to the North!.

In order to work properly, the compass must not touch the walls of the cup.

Experiment 2

Manipulating the compass

You can deflect the compass needle with a magnet. Find out how close the magnet has to be to the compass so that the needle turns towards it.

NOTE:

You will later need the compass for the science game. Keep it safe!

DURATION:
approx. 10 minutes

ADDITIONALLY REQUIRED:
- a cup
- water
- the magnets from day 11

Live wires, adapters and electrical devices in general are surrounded by fields that deflect compasses. The stronger the field, the stronger the deflection.

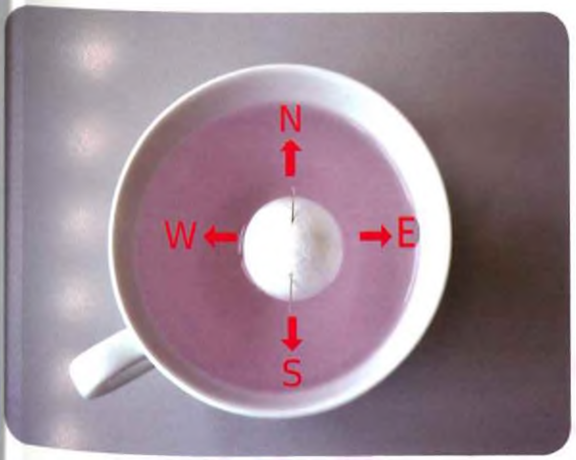
The compass needle in our example does not only turn towards the magnet but it is also attracted by it.

Experiment 3

Which way is north?

The end of the compass needle that can be deflected by the magnet points north. In our example, it was the eye of the needle. Remove the magnet and nudge the float foam. The compass will now re-align with the magnetic field of the Earth, so that the eye points north again and the tip points to the south.

Clockwise from the north is east, and on the opposite side is west.

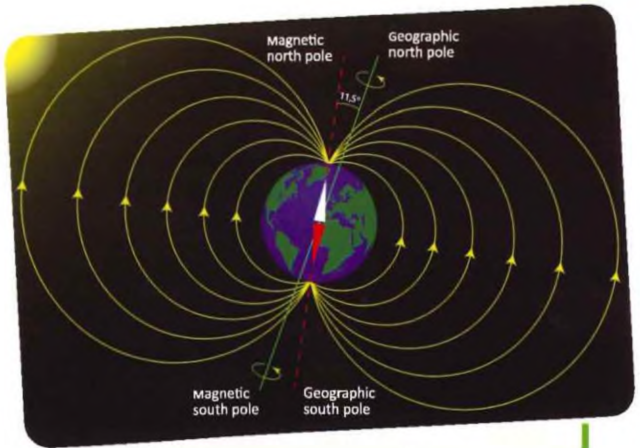


THE MAGNETIC FIELD OF THE EARTH

The compass was invented in China around 300 to 200 BCE. In the 12th century, i.e. more than 800 years ago, the Arabs introduced it to Europe, and in the 13th century, Italian sailors developed the compass rose. The compass then became one of the most important instruments for navigation. By means of a compass, you can identify the cardinal directions and thus find the way to your destination. It was arguably the most important instrument for expeditions on land and water and it is still considered one of the most important inventions in history.

As you have already learned on day 11, the Earth also has a magnetic field. Its magnetic field lines run from the geographic south pole—where the magnetic south pole is located—to the geographic north pole with the magnetic north pole.

The magnetic compass has a pivoting needle made from a ferromagnetic material. It is either magnetic on its own or it has the capability to align itself along the lines of a magnetic field. The compass needle aligns itself along the magnetic field lines of the Earth and thus shows the north-south direction. As opposite magnetic poles attract each other, e.g. those of the Earth and of the compass, the needle always points in the same direction: the white part points north and the red one south.



HYDRAULICS AND PNEUMATICS

RAFFLE DAY !!

Experiment 1

Creating a vacuum

Take the syringe out of today's box. You can effortlessly pull the plunger backwards to the rear stop. However, if you will only be cover the nozzle with your thumb, able to pull it back to the middle of the barrel.

When you close the nozzle, you won't be able to pull back the plunger very far.

Experiment 2

Hydraulic power transmission

For this experiment, you also need the syringe and the hose from day 4 and some water. Take one syringe and push the plunger all the way in. Pull out the plunger of the second syringe so that it is open at the rear and attach both syringes to the hose. Now, fully open the syringe and fill it with water. Hold it upright and pull back the plunger of the first syringe a little. Due to the developing vacuum, the first syringe sucks in some of the water so that the level in the open syringe drops. Now you can re-insert the plunger in the second syringe. While doing so, you can observe that the plunger in the first syringe moves outward. You can now push in one of the plungers and by doing so push out the other one without touching it.

Why does this happen?

Water cannot be compressed easily. It thus acts as a power transmission medium and pushes out the second plunger with the same amount of force that you used to push in the first plunger.

DURATION:
approx. 10 minutes

ADDITIONALLY REQUIRED:
- water
- syringe and hose from day 4

When you push in the plunger of the first syringe, the plunger of the second syringe moves outward at the same rate.

In both syringes as well as the connecting hose, vacuum develops.

Experiment 3

draulic power transmission the other y around?

ould it also be possible to pull the unger of the second syringe inward by lling the plunger of the first one tward? Try it yourself! While it is relaely easy to pull the plunger of one ringe outward, the plunger of the other ringe won't move inward.

hy does this happen?

u have noticed that there is not only ater in the syringes and the hose but so a little air. While it is nearly possible to compress water, you can sily compress air. Just think of blowing a balloon. While you pull the plunger, e air pressure inside goes back to ormal or even to a slightly lower value. both cases the area without water ithin the syringe becomes visibly larger.

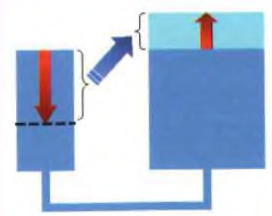
POWER TRANSMISSION BY WATER AND AIR

Hydraulics and pneumatics are related concepts. Both refer to contained systems that move certain elements (for example , cylinders). The two terms contain the Greek words for water or wind, respectively. This already explains the essential difference: in a hydraulic system, a liquid is used for power transmission, while a pneumatic system employs pressurized air.
Liquids cannot be compressed. Therefore, hydraulic liquids are able to transfer forces without delay and with high precision. This makes it possible to implement high-precision hydraulic controls.
Air or gases in general are easily compressible and hence transfer force with a certain delay.
Afterwards, they expand again, which makes it impossible to use them for precision control systems.

Compared to hydraulic liquids, air only allows the transmission of small forces.

Hydraulic power transmission

Hydraulic systems make it possible to move heavy objects with little effort. For example, lifting a car heavier than 1000 kg is easy with a hydraulic car jack.



A heavy object (right) can be lifted by applying a small force (left). in this example, to lift the heavier object (right) we will need to push the smaller object (left) very deep as the object on the right side has to be raised.

Hydraulic systems allow the transmission of significantly higher forces than pneumatic systems.

DAY 16

THE OOBLECK

DURATION:
approx. 10 minutes

ADDITIONALLY REQUIRED:
- a bowl
- a spoon
- approx. 3 to 4 tablespoons of tap water

Experiment 1

In your first experiment, you will produce a non-Newtonian fluid, sometimes called an oobleck. You need a bowl, a spoon, tap water and the packet of corn starch from today's box.

The mixing ratio of starch to water is approx. 2:1, i.e. you need about twice as much corn starch than water. It is best to approach the ideal mixture step by step.

Put three tablespoons of water into the bowl and add most of the starch (6 tablespoons). Stir with the spoon. If the mixture is still thin, add a little more starch. At the correct ratio, the mixture will feel lumpy while you stir.

When you lower the pace of the stirring, you will feel the resistance ease. If you prod the non-Newtonian fluid with the spoon, the surface will tear open.

For the photos below, we used a little more starch than your packet contains (and hence more water). For the amount of starch you have, you only need three to four tablespoons of water.

At the correct mixing ratio, the surface of the fluid will tear open when stabbed with a spoon

Experiment 2

Dipping and hitting

Try to dip the spoon slowly into the fluid. This will succeed just like dipping it into water. However, if you shove the spoon into the fluid, it will remain on the surface for a few seconds and then sink slowly.

You can also try and hit our non-Newtonian fluid with your fist. Again, you won't be able to push it in. Instead, it will feel as if you hit a gym mat, so it won't hurt! Pushing down slowly, you can completely immerse a spoon or your finger in the oobleck.

The fluid is so strong that you can even build a tower with it that'll stand erected for a few seconds.

Why does this happen?

When you press hard against a non-Newtonian fluid, the water molecules within are pushed aside. At the same time, the remaining starch molecules get tangled up and thus form a solid mass. When the pressure is released, water flows back between the starch molecules so that the non-Newtonian fluid becomes fluid again.

The load-bearing capacity of a non-Newtonian fluid can be so high that you could walk on it without sinking in.

DISPOSAL

After completing the experiments, you need to dispose of the oobleck in the organic or the household waste.

NEWTONIAN FLUIDS

Water is always equally fluid whether you dip your finger slowly or jump in as a cannonball. It always feels and behaves the same. The same holds true for nearly all liquids as well as for gases like air. This revelation was discovered by the British scientist Isaac Newton (1643–1727) and hence named after him. Water is thus a Newtonian fluid.

Non-Newtonian fluids

Non-Newtonian fluids are not always equally fluid. In physics, this property is called "variable viscosity." When you dip your finger slowly into a non-Newtonian fluid, it behaves like a regular liquid.

However, when you hit it with your fist, it reacts like a solid material so that your hand won't dip in. The fluid will not even splash! Among other substances, pudding, ketchup, blood and mixtures of sand and water are all non - Newtonian fluids.

DAY 17 ELECTROSTATICS

RAFFLE DAY !!

Experiment 1

Lifting paprika without touching

For this experiment, sprinkle a little finely grounded paprika in the center of a piece of paper.

Next, you will need to charge the plastic ruler electrostatically. This is easily done: simply rub it over and in your hair. Doing this for five to ten seconds should suffice. When you now approach the paprika with the ruler, you can observe two effects: part of the paprika will "flee" the ruler. At the same time, other parts of the paprika fly towards the ruler and cling to it. The longer you charged the ruler in your hair, the stronger the effect will be.

Paprika grains are attracted by the ruler.

If you keep the ruler horizontally, even more paprika grains will accumulate.

Experiment 2

Diverting a stream of water

Open a tap a little so that only a thin stream of water runs out. Charge the ruler again and slowly approach the stream with it without letting it touch the water.

DURATION:
approx. 15 minutes

ADDITIONALLY REQUIRED:
- a piece of paper
- paprika (from the kitchen)
- a tap with running water
- oil
- a plate

As long as the charged ruler is sufficiently far away, the water runs down in a straight line.

When the ruler is a few millimeters away from the stream, the water will be attracted by the electrostatic field of the ruler. It will no longer run down in a straight line but slightly toward the ruler.

When the charged ruler is sufficiently near the water, the stream is diverted.

Experiment 3

Picking up oil drops

You may not believe it but it actually works: when you hold the charged ruler a little above some vegetable oil on a flat plate (better let your parents pour it for you!), several drops jump up to the ruler and cling to it.

When you hold the charged ruler a little above the vegetable oil, some of the drops jump independently to the ruler.

The same effect occurs when you rub a balloon in your hair.

STATIC ELECTRICITY

You may have already experienced a little spark or felt a slight pinch when you shake hands or touch a door knob. This can happen when you e.g. wear a woolen pullover or walk on a wool carpet with rubber soles.

These and similar effects are caused by electrostatics. As you probably know, all objects are made up of atoms. These atoms consist of a positively charged core or nucleus and a shell of negatively charged electrons. Some substances, e.g. plastic, not only bind their electrons very strongly but also attract electrons from other substances. This effect is accelerated and enhanced when you e.g. rub a ruler in your hair or on wool. In the process, the ruler picks up negative electrons and is hence charged negatively. This effect is called separation of charge. Other substances, e.g. paprika, tend to have a positive charge and are hence attracted by the ruler.

When you touch an object that is charged positively, the excess and lack of electrons equalize within a fraction of a second.

Depending on how heavily you are charged, a voltage of up to several thousand volts may occur. However, as the current is very low and amounts only to a few milliamperes, there is absolutely no danger involved.

MAGIC MIRRORS

Experiment 1

Remove the protective foil from the mirrors. Now you can see the mirror images. Squeeze the mirror without the hole so that it alternately bends forwards and backwards. Watch yourself in the mirror. When the mirror is bent towards you, your mirror image looks very small but wide. While you reduce the bend, the image becomes normal. When the mirror is bended inward, you will be surprised at your long nose, and then, if you keep bending it, your image is suddenly upside down.

When the mirror is bent outward, the mirror image shows a lot of the environment but is distorted.

Experiment 2

Place the two mirrors face to face upright at a distance of approx. 12 inches (30 cm). The easiest way is to lean them against toy bricks. Place the mirror with the hole in such a way that you can easily peep through toward the second mirror. What do you see?
When two mirrors face each other, an exciting optical effect occurs: the mirror image of the first mirror is reflected in the second one.

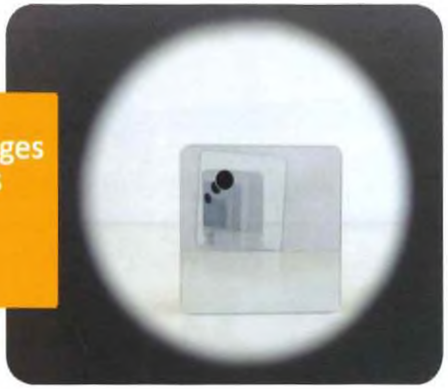
When you bend the mirror inward, the mirror image is suddenly upside down.

DURATION:
approx. 10 minutes

ADDITIONALLY REQUIRED:
- toy bricks
- a small object (e.g. a tealight)

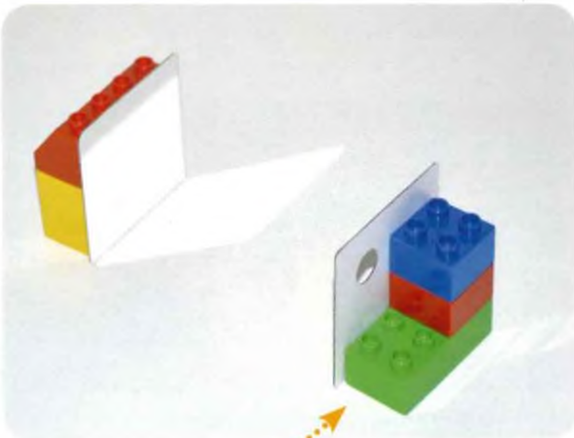
This second mirror image is in turn mirrored in the first mirror, and so on. Theoretically, you can thus see an infinite number of mirror images when you look through the hole.
To enhance the effect, put a small object between the mirrors, e.g. a burning tea light. (ask for adult assistance) How many tealights do you now see in the mirrors?

Place the two mirrors facing each other by leaning them against toy bricks.



The mirror images of both mirrors are reflected infinitely.

Depending on the angle you look through the hole in the mirror, you will see more or fewer tea lights.



MIRRORS AND MIRROR IMAGES

Mirror, mirror on the wall, who is the fairest of them all? While your magic mirrors won't answer that question for you, they may make you chuckle. These distortion mirrors are similar to those used in the fun houses of amusement parks. Due to their special design, they make you appear larger, smaller, broader or thinner than you really are.

Convex mirrors

Convex mirrors, also called diverging mirrors, bulge outward and thus widen the angle of view. They mirror not only what is in front of them but also reflect objects far away at the sides. This way, they give a good overview of the environment. This is the usual design for traffic mirrors or security mirrors in shops.

Concave mirrors

Concave or converging mirrors bulge inward. The shape of the images in this kind of mirror depends on the distance from the original object. At a small distance, the object is magnified, at a medium distance the mirror image shows the real size and at a greater distance, you will see a smaller image. Furthermore, the image is properly oriented only at a small distance. At a greater distance, it is vertically and horizontally inverted.

Due to their magnifying effect, concave mirrors are used as make-up and shaving mirrors as well as for medical examinations.

Magic mirrors in a fun house show distorted images of everything in front of them.

Traffic mirrors are convex and have a diminishing effect.

DAY 19

SALT, ICE AND MOUNTAINS

Experiment 1

Liquefied salt

The packet contains 20 g of a salt called sodium acetate. You will need most of it for the first part of this experiment; however, you should set aside a few grams for further use.

First, dissolve approx. 15 g salt in distilled water. To do so, you will need 1.5 ml distilled water (very little amount). The mixing ratio of water to salt is 1:10, i.e. for one part of water you need ten parts of salt.

Use the syringe to measure the correct amount of water. For the salt to dissolve properly, the water has to be warm. The warmer the water, the better the sodium acetate dissolves. The ideal temperature is around 122 °F to 131 °F (50 °C to 55 °C). That is a little warmer than a regular bath. You will need to heat up the water only for a short time to reach this temperature.

First, put 15 g of sodium acetate and 1.5 ml of water into a glass and heat it up in a bain-marie or water bath. It is best to ask an adult to help you with this experiment. Put the pot of water on the stove. The water in the pot heats up and thus heats the glass with the sodium acetate-water mixture.

When it gets sufficiently warm, the sodium acetate will dissolve completely. You can also stir a little with a spoon. You will notice that the whole batch of sodium acetate actually dissolves in a few drops of water!

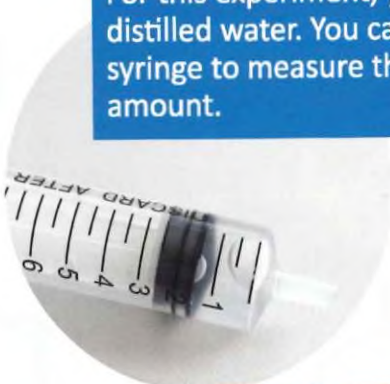
You can also heat up the distilled water in a microwave oven or on a stand above a candle. However, this will take more time. Make sure that you use an appropriate glass for this purpose!

DURATION:
approx. 30 minutes

ADDITIONALLY REQUIRED:

- distilled water (no tap water!)
- the syringe from day 4
- a spoon
- a glass
- a pot of water to be used as a bain-marie
- a plate

For this experiment, you need 1.5 ml distilled water. You can use the syringe to measure the proper amount.



The candle heating option - as in the picture below - heat to approx. 122 F.

The work is done: the solid sodium acetate dissolved in a few drops of water.

Experiment 2

Building an iceberg
Let the glass with the liquefied salt cool down and then put it in the fridge. In the meantime, sprinkle a part of the remaining sodium acetate. in the middle of a plate. When the liquid has cooled down, pour it on the grains of sodium acetate. It will immediately change from the liquid to the crystalline state and form a column. This way, you can build an iceberg.

When you pour the cool liquefied salt over the sodium acetate, the supersaturated liquid re-crystallizes and forms an iceberg.

In the first experiment, the sodium acetate is dissolved in the added water and formed its own crystallization water. At higher temperatures, this works so well that the liquid looks like water. When the liquid cools down, you get what is called a supersaturated solution. At room temperature, it contains more salt than technically possible. One should expect the salt crystals to leave the fluid when it cools down. However, some sort of "ignition spark" is needed to trigger this process. Such a state is called "metastable". It is unstable but it lacks the energy to change. The contact with the newly added salt crystals supplies the required energy to start the process, and thus the solution re-crystallizes. This is how you created the iceberg in the second experiment.

The hand warmer principle
Your iceberg is white but far from cold. This is because the re-crystallization process releases heat. To be precise, exactly as much as you heated it up when you liquefied the salt. Fascinatingly, the liquid has stored the energy of the heat. The amount of heat released during re-crystallization can be tremendous. Incidentally, this is basically how hand warmers work, they also contain sodium acetate.

Sodium acetate
Sodium acetate is a type of salt that has a slight smell of vinegar. Its melting point is at approx. 124 °F. Melting results in a supersaturated liquid which remains fluid even below its melting point. In order to prevent unintentional crystallization, the liquid has to be stored in a clean and smooth container.

DISPOSAL
After completing the experiments, you need to dispose of the sodium acetate in the household waste.

THE PH SCALE

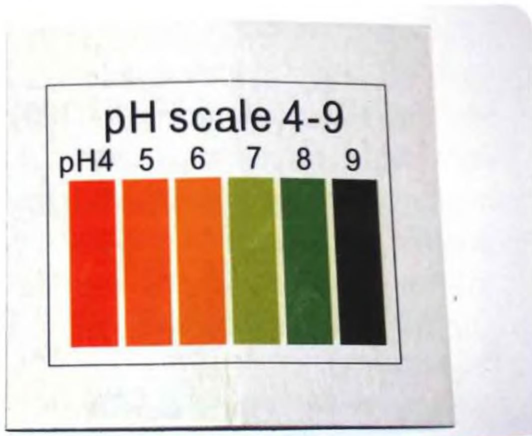
Experiment 1

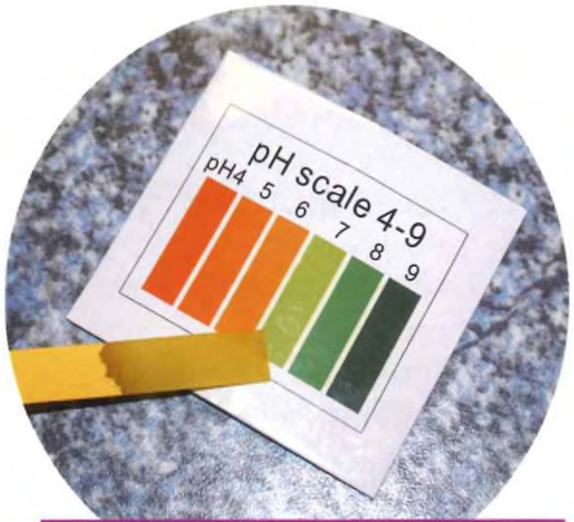
Measure the pH of different liquids like water, milk, vinegar and liquid soap. To do so, pour just a little of the fluid into a clean bowl so that you can dip in the approximately. a third of the measuring strip. Each measurement requires approx. 10 seconds. During this time you can watch the strip change color.
To determine the pH, compare the color of the dipped strip with the pH scale.

Each pH measuring strip can be used only once. For every measurement you need a new strip.

DURATION:
approx. 10 minutes

ADDITIONALLY REQUIRED:
- milk
- vinegar
- liquid soap
- bowls or glasses





According to the scale, the pH of our milk was between 6 and 7.

The pH of our vinegar amounted to approx. 5.

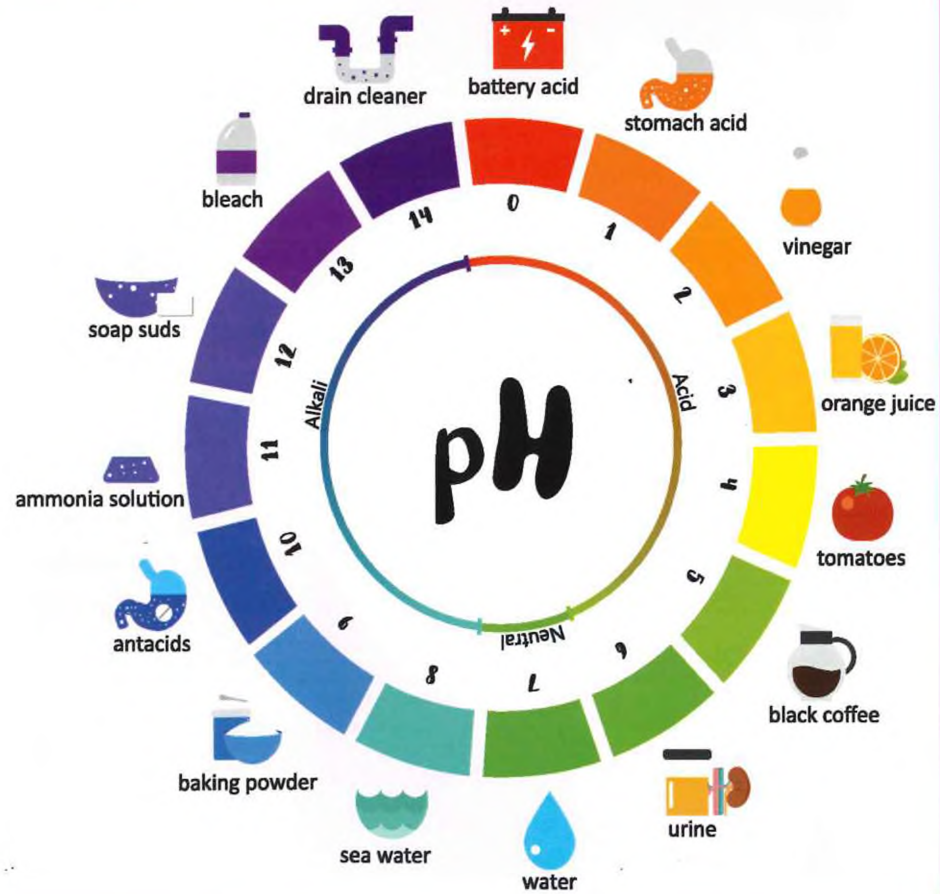
You can clearly see the color changes of the two measuring strips.

NOTE:
You will later need a few pH strips for the science game.

ACIDS AND BASES

The pH specifies the acidity. For liquids, it can be easily determined with measuring strips that change color depending on acidity. The pH scale ranges from 0 to 14. Liquids with a pH from 0 to 6 are acidic. Strong acids like citric acid have a pH around 2, while the pH of weaker acids amounts to 5 to 6.
Pure water has a pH of 7 and is hence a neutral liquid.
Liquids with a pH of more than 7 are called lyes, alkaline or basic liquids or bases. They feel like soap water, and soap and other detergents actually belong to the bases.
Acids and bases are corrosive and can be very dangerous depending on their concentration. Acids can affect and destroy various metals, namely the so-called base metals. Clothing can be dissolved by acids. Skin contact with acids result in chemical burns.
Bases on the other hand damage many substances that are nearly unaffected by acids. In particular, they affect natural substances like hair, skin and fat. With the exception of aluminum, they do not damage metals.

Chemical burns caused by acids or bases have to be immediately and thoroughly rinsed with water. Affected clothing has to be taken off. Thoroughly rinse your eyes if they came into contact with such a liquid and immediately visit a doctor.



FACET LENS

Experiment 1

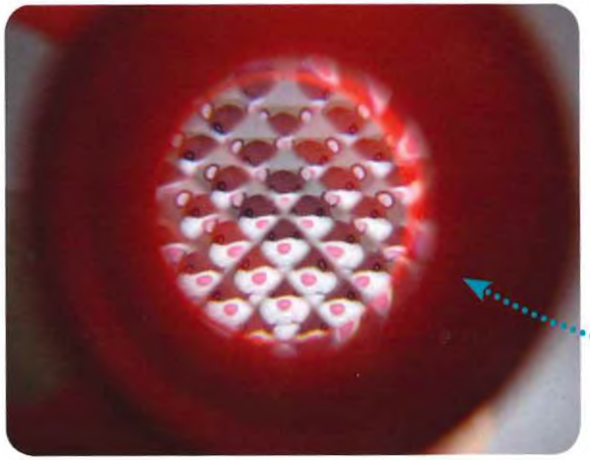
Seeing the world through a facet lens
Look through the facet lens with one eye while closing the other. Instead of a single view, you will see many tiny images arranged side by side and on top of each other, each one only showing a small part of your surroundings. If you have a closer look at the single images, you will notice that they all look slightly different. Those on the right show more of what is situated to your right, those on the left more of what is to your left etc.

Experiment 2

Photographing through the facet lens
The facet lens enables you to take extraordinary pictures showing your surroundings in a way similar to what insects see. Just hold the facet lens in front of the camera lens of a smartphone. After switching to camera mode, watch the screen to control whether the facet lens is at the correct position.

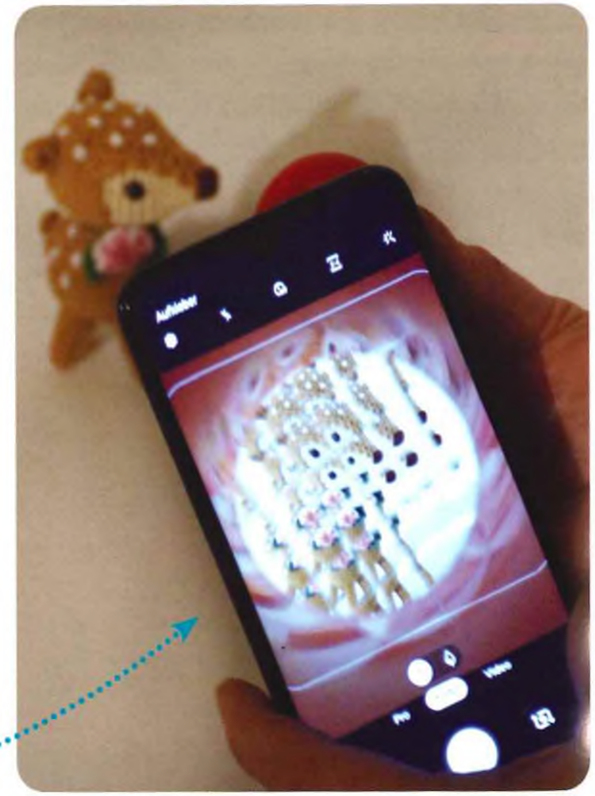
DURATION:
approx. 10 minutes

ADDITIONALLY REQUIRED:
- a smartphone with a camera



While looking through the facet lens, you will see many similar images; however; each of them shows a slightly different section of the overall view.

Hold the facet lens in front of your smartphone's camera lens.



Now you can go hunting for pictures. The lens enables you to take awesome and stunning photos. For variation, you can also tip it a little.

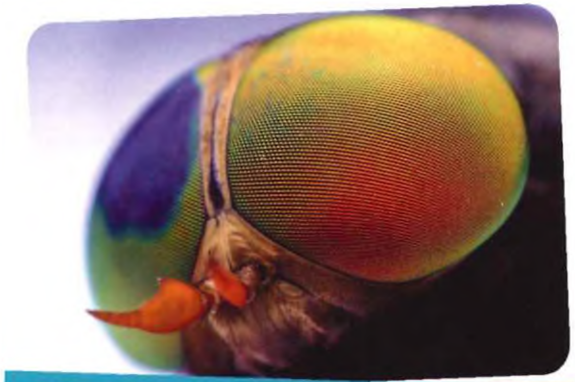
The facet lens offers a lot of creative leeway and allows you to take fascinating photos.

FACET EYES

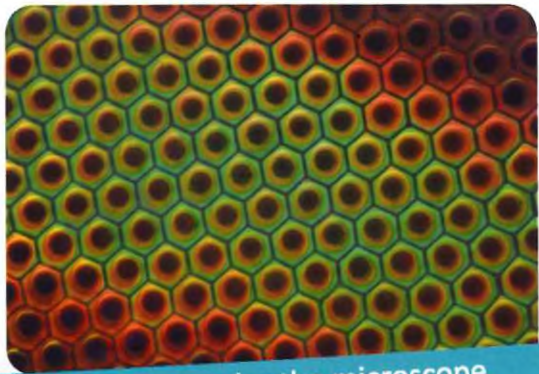
Many insects have facet eyes consisting of many tiny individual eyes called ommatidia. For instance, the eye of a dragonfly is made up of 30,000 ommatidia. In a similar way to your facet lens, the overall view is composed of the many individual images of the ommatidia.

The structure of a facet eye is completely different from that of a human eye. First and foremost, facet eyes are immovable and situated at the sides of the insect's head. This allows insects to perceive their entire surroundings at one glance, so to speak. They always know what happens around them without having to focus their eyes on a certain object. In contrast, we humans only look at a single detail at a time while the rest of our field of vision is sidelined.

The exact structure of insect eyes varies with the species. For instance, the facet eyes of fast-flying insects have more ommatidia than those of slowflying species. Facet eyes allow insects to perceive up to 300 single pictures per second while humans only manage to see 60 pictures per second.



Details of the facet eyes of a fly.



A facet eye under the microscope. The ommatidia are clearly visible.

DAY 22 CARGO BOAT

Experiment 1

Fill a glass up to three quarters with water. Use adhesive tape to glue a paper strip on the glass and mark the water level with a pen. Take about a third of the modeling clay and hold it in your hand. You will notice that it does not weigh much. It even floats when you put it in water. But can it also bear a load?

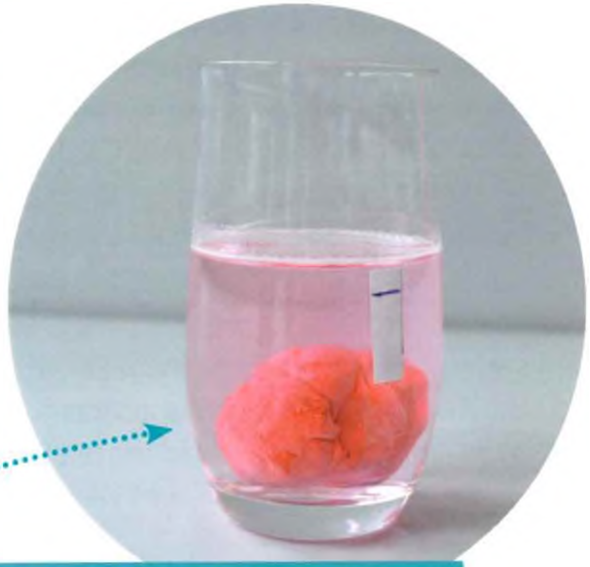
Have a try: put an object in the mass of modeling clay and shape the clay into a ball so that it completely encases the object. Now put the ball into the water.
Notice that the ball will sink. You will also notice, that the water level rises by the volume of the sunken clay ball. This is called displacement.

DURATION:
approx. 10 minutes

ADDITIONALLY REQUIRED:

- a glass of water
- one or more objects as weights (e.g. a wrench socket); use weights of approx. 40 g and position it as in the picture on the left.
- pen, adhesive tape and paper strips

The object in our example is a wrench socket from a toolbox.



The clay ball sinks and the water level rises by the volume of the ball.

Experiment 2

Remove the object from the ball and shape the modeling clay into a boat. It is best to make a sphere first and then press in a hole. This results in high walls so that you can place the object safely in the boat. Put the object inside the cargo boat and into the water. Lo and behold, it floats! Check the water level again. As the modeling clay only submerges a little, it displaces less water than in the first experiment.

The cargo boat floats!

Experiment 3

Get creative: Find out how much weight you can put in your cargo boat until it sinks. You can also use the remaining clay to build bigger and smaller boats to find out how much they can carry.

BUOYANCY

The experiments have shown you that the weight is not the only factor that determines whether a body floats or sinks. The shape is also relevant. This is because in liquids, all bodies are affected by the so-called hydrostatic lift, better known as buoyancy. The phenomenon is described by Archimedes' principle stating that the greater the submerged volume of a body, the higher its buoyancy. That is, at the same time, the volume of the liquid displaced by the body matches the volume of the submerged part of the body.

Sinking, floating, rising and swimming

A body sinks when the buoyancy of the liquid is smaller than its weight, as it is e.g. the case with a stone in water.

When buoyancy and weight are equal, the body floats in a given depth like a fish.

When the weight is smaller than the buoyancy, the body rises. You can observe this behavior when you try to push a beach ball under water.

In a swimming body like a ship or a nutshell, buoyancy and weight are balanced. In contrast to floating, a swimming body only submerges partially while the rest of it remains above the surface.

Density also matters

Another decisive factor is the density of the body, i.e. the ratio between its weight and its volume. Think of an iron ball and a balloon of the same size. The iron ball is so heavy that you can't lift it: it has a high density. The balloon, however, contains air. This makes it very light, so that its density is very low. The modeling clay also contains a lot of air.

A big ship with lots of cargo can float because it contains tanks full of air so that its density is lower than that of water.

DAY 23

THE MESH HOSE

Experiment 1

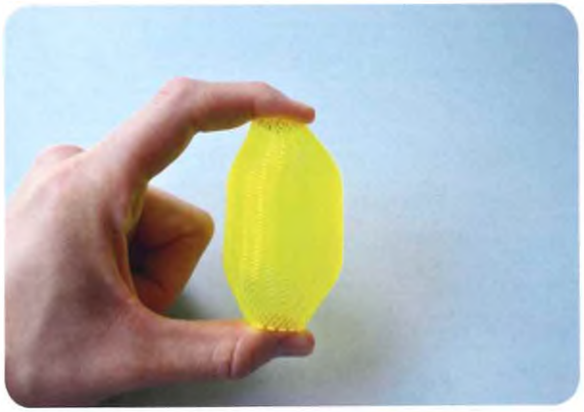
Shape shifting
Try to give the mesh hose different shapes, e.g. by pressing or stretching. You can make it very thin, very thick or rounded. But what happens when you let it go?
Exactly: it returns to its original shape! To do so, it uses the energy that you put in while deforming it.

Experiment 2

Jumping
There is a much more effective and fun way to use the energy that you put into the mesh hose. Place the hose on the table and press it down from above. Then quickly pull away your hand. You will be surprised at how far the hose jumps.

DURATION:
approx. 10 minutes

ADDITIONALLY REQUIRED:
- a small, light ball, e.g. a ping pong ball



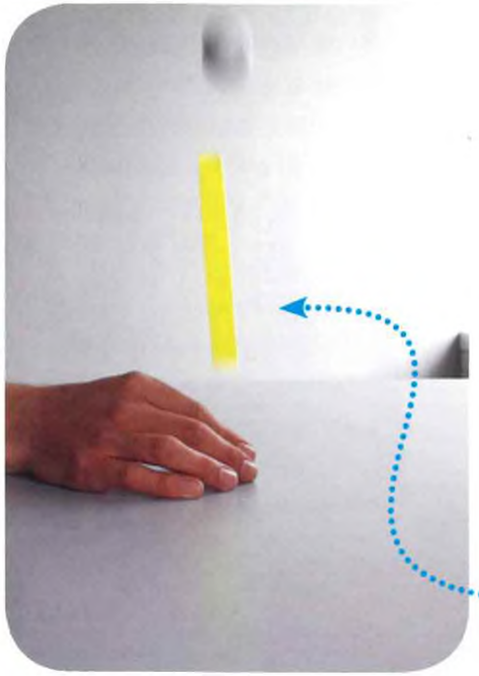
Regardless of how you compress or stretch the mesh hose, it reverts back to its original shape.

To get an even more exciting effect, place a ball on the mesh hose, e.g. a ping-pong ball or a Styrofoam ball. Press them both down. As soon as you move your hand away, both objects will jump high into the air.

CONSERVATION OF ENERGY

Energy is one of the most important subjects in physics. One of the fundamental properties of energy is that it cannot vanish. Instead, it can be converted into other forms of energy or even stored. This kind of energy conversion takes place e.g. in cooking where the cooking pot converts electric energy to heat. Another example is a lamp that converts electric energy to light and also to heat.

As heat was not intended (only light), it is called "lost energy." All this is stated by one of the fundamental laws of physics, namely the law of conservation of energy. Simply put, it means that energy can only be converted but that it can never be lost. There are various forms of energy, e.g. electrical, magnetic, light and motion energy. The latter usually being called kinetic energy.



Place a ball on the mesh hose and press both down. As soon as you move your hand away, the mesh hose jumps and the ball is thrown up into the sky.

NOTE:

You will later need the mesh hose for the science game. Keep it safe!

ALUM EXPERIMENTS

DURATION:
approx. 10 minutes

ADDITIONALLY REQUIRED:
- an egg
- a bowl
- a small spoon
- safety goggles (from day 1)

Experiment 1

Coagulating egg white

For this experiment you need an egg, a small bowl, a spoon and approximately one teaspoon of alum. Crack the egg into the bowl taking care not to break the yolk. It will be best to ask one of your parents for help.
Put on the safety goggles. Add some alum powder to the transparent egg white and stir it without breaking the yolk. You will notice that the egg white soon becomes stiff and changes from a liquid to a jelly. This is called coagulation.
Maybe you are already aware that alum is a white powder. The chemical name of one type of alum is potassium aluminum sulfate. It is used for the production of modeling clay and deodorants, amongst other things. As it makes egg white or protein coagulate, it is also used for medical purposes to stopbleeding.

NOTE:
Always use eye protection when doing these experiments! Also read the safety notes on the first pages of this manual again.

First, crack the egg into the bowl.

Then add some alum powder to the egg white.

Mix the alum with the egg white. You will soon notice that the egg white coagulates.

TIP

(for the experiment in the next page)
How much alum dissolves in distilled water depends on the water temperature. The colder the water, the less alum will dissolve. When you slightly heat up the distilled water, e.g. to the temperature of bathing water, it will take up more alum powder so that you can grow bigger crystals. Let your parents help you with heating the water.

Experiment 2

Growing crystals

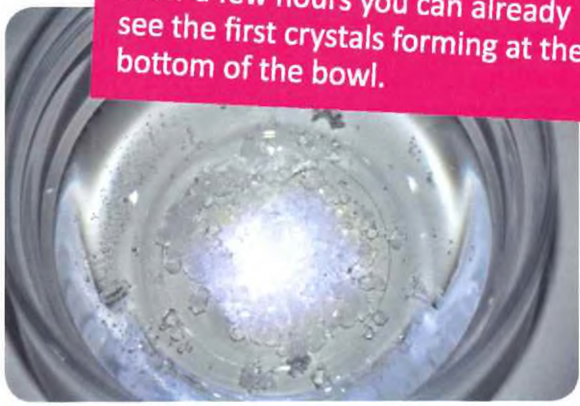
The combination of alum and distilled water can result in fascinating crystals with beautiful, geometrical shapes. However, this takes a while. So for this experiment , you have to allow more time. It will be best to do this experiment during the Christmas holidays.

Pour a glass of distilled water, i.e. approx. 200 ml , into a bowl.

Put on your safety goggles. Gradually add the alum to the water. To do so, put a little alum on a spoon, add it to the water and stir until the powder has completely dissolved. This can take a while – don't give up! Repeat this step until you notice that the alum no longer completely dissolves. At this point, the water is fully saturated with alum. Take the pipe cleaner, bendit into any form (e.g., heart shape) and insert it into the bowl so that the crystals will accumulate on the cleaner.

Mix the alum with the distilled water until it is completely dissolved.

After a few hours you can already see the first crystals forming at the bottom of the bowl.



After a few days, you will get beautiful crystals.

DURATION:
several hours or days

ADDITIONALLY REQUIRED:

- a bowl
- a small spoon
- distilled water
- safety goggles (from day 5)

Place the bowl where it is not in the way and doesn't have to be moved. The most important aspect of growing alum crystals is allowing enough time, and this counts in hours or even days. You can watch how the crystal growth starts and how more and more and bigger and bigger crystals form. It is important not to touch, move or take the bowl during this time as this would interfere with the crystal growth.

DISPOSAL

After completing the experiments, you need to dispose of the remains in the gutter or the household waste.