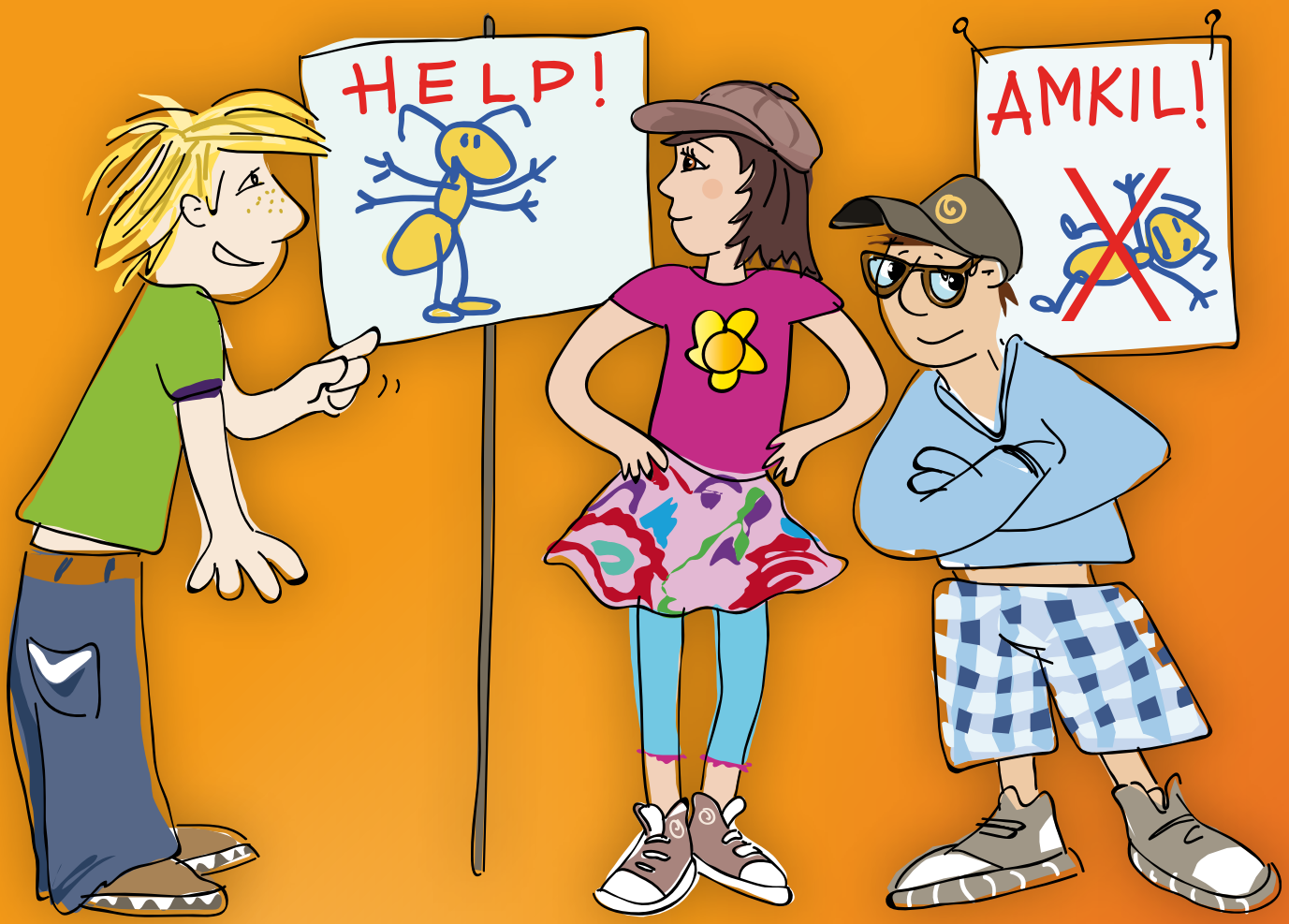
MATERIALS FOR CLASSROOM TEACHING

Lantern Moon and Hot Ears

Language promotion in primary school teaching through inquiry-based learning using biographies



THE EUROPEAN PLATFORM FOR SCIENCE TEACHERS

SCIENCE ON STAGE GERMANY

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For better readability, we have generally avoided using the "he or she/his or her" formulations in this publication. Although "he/his" is used throughout the text, the reference is always to both genders.

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Authors from three countries – Austria, Germany and Italy – wrote the following texts under the aegis of Science on Stage Deutschland e.V.

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Contents

Foreword

Putting the natural sciences on the stages of primary schools as well is a major objective of Science on Stage Deutschland. Our organization began in the year 2000 as a platform where teachers of the natural sciences could share their experiences; since then it has become a Europe-wide network for all teachers of the natural sciences, technology and mathematics.

The focus of our team is not primarily on the production of spectacular stage shows, although such shows are certainly a good way to get young people enthusiastic about the natural sciences. Instead, Science on Stage would like to provide teachers in all types of schools with ideas and tools that will help them put natural science topics "on stage" in their daily classroom instruction. The expansion of our scope beyond Germany has been extremely fruitful. The teachers who meet at the education festivals of Science on Stage come from 24 European countries and Canada, and they are particularly committed, curious and apt to enjoy experimenting in more ways than one.

This publication was written by members of a working group that formed at a Science on Stage Festival in Copenhagen in 2011. At that time we decided to stay in touch after the event was over and devote ourselves to an important theme that is currently attracting tremendous interest all over Europe: language promotion at the primary school level.

Lantern Moon and Hot Ears is a collection of texts with related hands-on tasks for pupils. The primary school teachers who work with this publication do not need to have a particularly deep knowledge of the natural sciences.

We would like to continue the Europe-wide sharing of experiences at Science on Stage on the topic of promoting language promotion through the natural sciences. We look forward to working with more and more committed educators who participate in this project!

Dr Ute Hänsler
Chair, Science on Stage Deutschland

Language promotion

Children come to school with a wealth of everyday experience. They have experiential knowledge about natural, social, cultural, technical and economic facts and relationships. Schools pick up on these experiences, expand them and systematize them. One of the most important aims here is to improve the children's ability to communicate and their language skills. Both of these are important areas of competence for dealing with daily life and for a successful education.

Inquiry-based learning about science topics in the classroom makes it possible to promote language skills in a special way. The pupils experience at first hand how they can profitably combine practical activities, sensory experiences and language-based decisions. That's because language is crucially important in inquiry-based learning. Language is something to examine and think about, but it is also a means of understanding the world and oneself and of sharing ideas with others. Educational researchers tell us that inquiry-based learning in the classroom offers outstanding opportunities to challenge pupils to communicate. The pupils repeatedly experience a sense of achievement as they carry out experiments, share ideas, talk in a purposeful way, document what they are doing, and present what they have learned.

The texts in this brochure make it possible to promote language skills through inquiry-based learning in the primary school classroom. At the same time, they offer insights into the lives of contemporary scientists and engineers. By learning about these scientists' biographies, the pupils find out how and why people arrive at insights in the natural sciences. This makes it easier for the pupils to learn about scientific topics. Learning about the biographies is especially effective if the pupils themselves are independently investigating the objects of the scientists' insights. Through their own research, the pupils get to know the working methods or the individual research issues dealt with by the scientists in question.

Numerous tasks accompanying the texts invite teachers to join their pupils as they marvel at natural phenomena and do the same kinds of research as the scientists they have read about. At the same time, the teachers will be taking advantage of the special opportunities to extend the pupils' language skills. This is because fascination is a good way to spark pupils' interest in the natural sciences and technology and thus to stimulate and encourage independent learning.

Some simplified texts can be used for classroom activities on the various themes.

We wish you great success and a lot of fun as you work with this publication.

Mario Spies
Executive Board,
Science on Stage Deutschland

Bert Hölldobler has investigated ants in many countries.

Bert Hölldobler, *Biologist*

What would have happened if Bert Hölldobler's parents had forbidden their son to keep ants as pets?

Bert Hölldobler is a world-famous ant researcher. He has found out how ants communicate by means of scents. "Communicate" is similar to "speak". People speak to each other in order to share information. Ants produce scents in order to tell each other important things. For example, a person might shout, "Watch out! Danger!" – but an ant releases a scent from a gland in its abdomen in order to warn other ants of a danger. The ants smell these scents with their antennae. Ants can also use scents to recognize one another and lay scent trails.

Together with other researchers, Bert Hölldobler discovered that all of the ants in an ant colony are related to one another. In other words, all of them are descended from a single ant ancestor. When we say "ant colony", we mean all the ants that live together in an anthill. All of the animals that live in the colony stick together and even sacrifice their lives for one another if they have to. Bert Hölldobler calls an ant colony a "superorganism". The idea behind this word is that the many thousands of animals in an ant colony live together so well and so smoothly that to an outsider it looks as though the entire anthill is a single creature.

Bert was an ant researcher even as a little boy

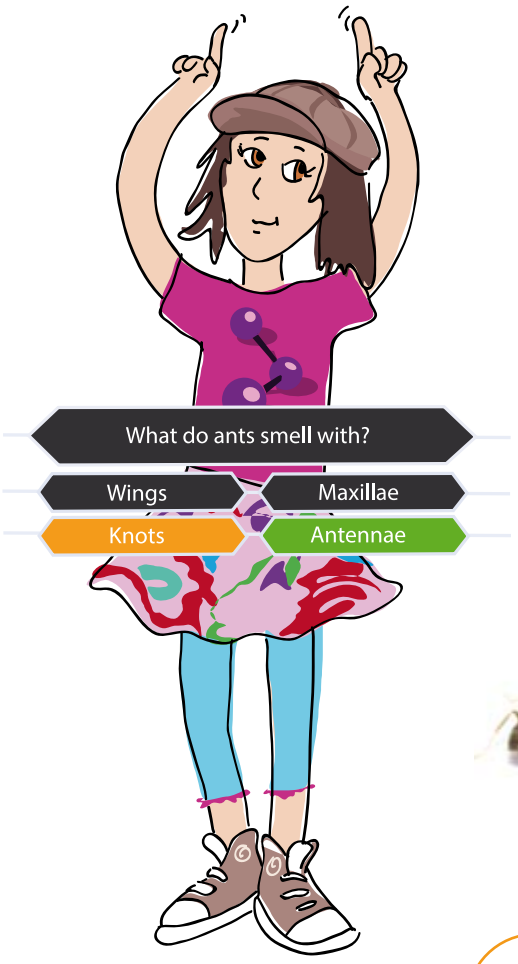
Bert Hölldobler was born in Erling-Andechs in Bavaria (Germany) on 25 June 1936. He was already an ant expert as a little boy. He spent lots of time watching ants in the forest, and he even kept ants as pets in an ant terrarium – which is also called a formicarium. Formica is the Latin word for ant.

As an adult researcher, Professor Bert Hölldobler has observed ants in their natural habitat in many different places all over the world – for example, in the deserts and forests of North and South America, and in Africa, Australia and Asia. He was always on the lookout for more knowledge about ants. He discussed his observations with other ant researchers, because researchers often gain new ideas and explanations through talks with their colleagues. For example, Bert Hölldobler worked out his idea of the ant "superorganism" together with other researchers. In the laboratory, Bert Hölldobler has also examined individual ants under the microscope and studied their body structure.

Since 2004, Bert Hölldobler has been doing his research at Arizona State University in Tempe, Arizona, in the USA.

Now it's your turn!

Photo: © Flagstaffotos



1 Drawing

Take a close look at a picture of an ant. Take a big piece of paper in landscape format and draw an ant in pencil.

2 Drawing

- Label your drawing. Mark the ant's body parts: head, antennae, compound eyes, adhesive pads, mandibles, maxillae, thorax, abdomen, legs.
- Look for information about ants in order to label your drawings correctly.
- Note the specific tasks of the different body parts.

3 Ant quiz

After you have labelled your drawings, you can find out more information about ants in books and on the Internet. Get together and think up five questions about ants and the right answers to them. Put together an ant quiz with other children from your class.

4 Mind game

Imagine this situation: An ambitious scientist has developed Amkil, an insecticide that kills ants. Now there's no hope left for the ants – with Amkil, even the last ant colony can be found and destroyed. For the first time, it's possible to remove every last ant from the planet Earth.

Should the scientist be allowed to sell Amkil?

- Find out if ants are useful or harmful in the natural world.
- Consider what it would be like for you yourselves if the world were free of ants.
- Then list the arguments for (pro) and against (contra) Amkil.

Organize a hearing in which the representatives of the pro and contra arguments present their ideas. There are three speakers on each side. You must prepare yourselves well so that you can convince all of the children in your class. That's because there will be a vote after the hearing to find out everyone's opinion: Who wants Amkil to be used and who is against it?

5 Research questions

Would you like to be an ant researcher too? There may be a meadow or a forest where ants live near your school. Here you could observe ants up close. Before you do this, think up some research questions you would like to be able to answer, and think up a strategy you can use to find the answers.

Here are some examples of research questions:

- Can ants hear?
- Do ants shy away from certain colours?
- Do ants run away when they smell perfume?
- What do various ant nests look like?
- What do ants eat?

You will certainly be able to think of other research questions.

As you do your research, make sure you don't hurt any animals or destroy the anthill!

Dr Nadya Ben Bekhti researches distant galaxies in space.

Nadya Ben Bekhti, *Astronomer*

What would have happened if Nadya Ben Bekhti's father had not told his daughter about the stars and the planets?

My name is Nadya. I first saw the light of day in the town of Neuss near Cologne (Germany) on 8 September 1978. My journey into space began about 30 years ago when I was four years old and saw the sky full of stars in all its beauty for the first time. Together with my parents, I had travelled to Algeria in North Africa to visit my father's family. My relatives lived on a typical Arab farm with lots of children and animals. Around the farm there were no cars, no factories, no noise – only fields and forests as far as the eye could see.

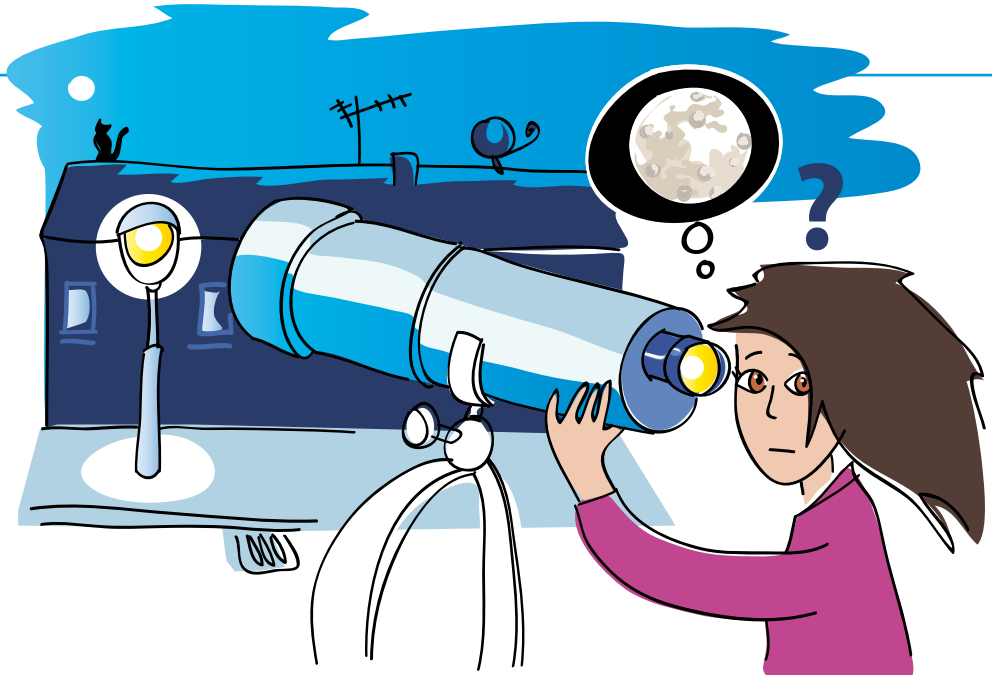
But the most beautiful things I experienced there were the Arabian nights. The sky was so black – as a child growing up in a big city in Germany, I had never seen it that way. And it was covered with countless tiny bright points of light. I was amazed when my father explained to me that these tiny points were distant stars just like our Sun: giant balls of burning gas. And the Moon seemed to be so close that I only had to stretch out my arms in order to touch it. It shone so brightly that we needed no lamps to find our way home. In one of those nights in Algeria I first felt my wish to fly to the stars.

When I was a child, I decided to become an astronaut

By the time we had got back, I had decided on my future career: I wanted to become an astronaut and do research in space. In kindergarten, the playground became a spaceship, and my friends and I did research in faraway worlds. When I was in primary school, I went to a planetarium for the first time. There the people who research the stars, who are called astronomers, showed us the paths of the stars and the planets on a gigantic dark screen that stretched above us like an artificial sky. Soon after that I decided not to be an astronaut but to become an astronomer instead.

At grammar school I studied physics for the first time. Our teacher showed us many experiments and explained to us how rainbows formed and why the sky is blue. I also learned that you need to do a lot of maths in order to understand space and the stars, because mathematics is like a language you have to master in order to describe the universe.

When I was twelve years old, my biggest wish came true. My parents gave me a telescope. I wanted to use it to explore the sky on my own. I could hardly wait for the first cloudless night sky. The first thing



I wanted to do was to look at the Moon with its many craters. And I wanted to find with my telescope the spot where the first man landed on the Moon. But the first time I looked through the telescope, with great excitement, I was very disappointed: all I could see was a bright light. I called out to my parents and told them my new telescope was broken. But after they took a short look at it, they started to laugh out loud. I, the astronomy expert, had pointed my telescope directly at the streetlight across the street. No wonder I couldn't see any Moon craters!

Today I use telescopes that are as big as a football pitch

Today I am grown up and I really do work as an astronomer at the Argelander Institute for Astronomy in Bonn (Germany). I conduct research on galaxies, which are among the biggest objects in the universe. If we compare the universe to a gigantic ocean, the galaxies would be islands. Each galaxy is unique, and they come in many different shapes, colours and sizes.

One galaxy is the Milky Way, which includes the Sun, the Earth and many thousands of other stars besides the Sun. In very dark places on the Earth, where there is no "light pollution", on clear nights you can see part of the Milky Way as a faint band of light in the sky.

I have been researching galaxies for six years now. In order to do that I observe space with the biggest telescopes in the world – for example, with a telescope in Effelsberg, a district near Bonn. The telescope is about as big as a football pitch, but round, and 50 metres high. It can be turned in all directions, depending on the direction you want to look in. With this gigantic telescope you can look especially far into the universe. Every time I look at the pictures I've taken with this telescope, I am amazed!

▷ **If you have any questions or suggestions, you can get in touch with me at any time: nbekhti@astro.uni-bonn.de. I will definitely answer!**

The almost completed telescope in Effelsberg near Bonn (1971), one of the biggest telescopes in the world. © MPIfR

Now it's your turn!

1 Observatory and planetarium

Find out where there is an observatory or a planetarium near you. Try to participate in a guided tour.

2 Constellations

- Find out which constellations you can observe in the evening at this time of year.
- Organize a constellation evening with your class. Who can identify lots of constellations? Who can find the North Star?

3 Experiment: Constellation viewer

What you need:

- Cardboard tube with a plastic cover (e.g. for crisps)
- Sharp scissors
- A big nail
- A hammer
- Black paper
- Cardboard
- Constellation patterns: available on www.science-on-stage.de/lantern-moon

How to do it:

- Roll up the black paper so that it fits inside the cardboard tube and glue or tape it down.
- Use the big nail and the hammer to make a hole in the bottom of the tube. Get help if you need it!
- Glue the constellation patterns on the cardboard. When it is dry, cut out the constellation patterns. Check to see if they fit into the plastic top.
- Use the tip of the sharp scissors to punch small holes in the constellation discs at the points representing the stars.
- Put the finished disc in the plastic top and put it on the cardboard tube.
- If you like, you can decorate your tube. Paint a picture on a sheet of paper and glue it to the outside of the tube.

If you now look through the tube at a light (for example, a flashlight), you can see the different constellations.

Memorize the constellations until you know them well and can find them in the night sky.

4 Moonwatching

- Observe the Moon with binoculars. Take a close look at its craters.

5 Moon craters in a shoebox

What you need:

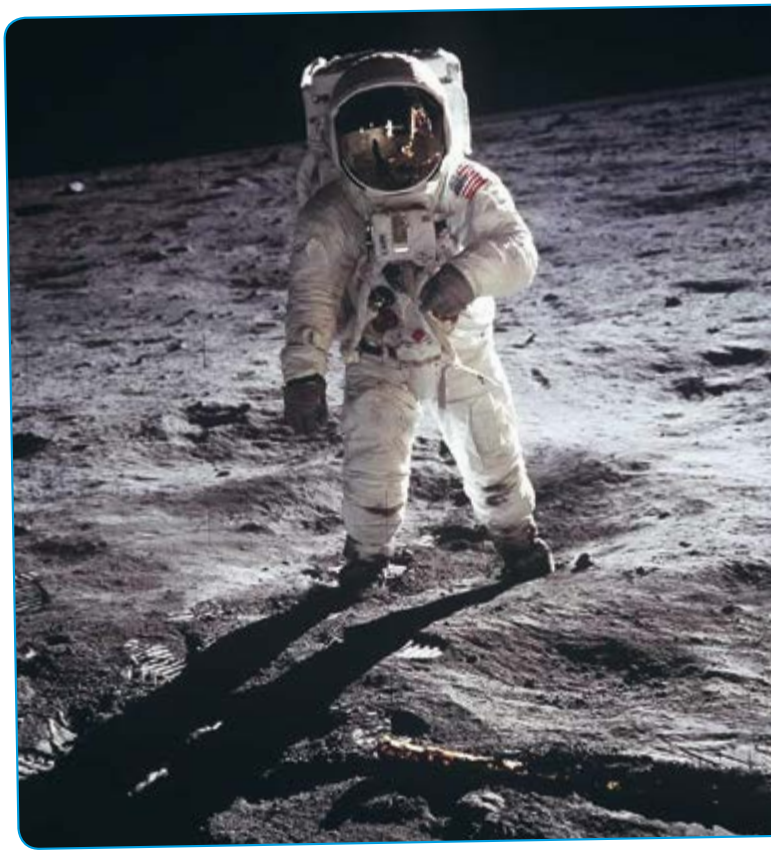
- Plaster
- Water
- A jar (to mix the plaster and water)
- A flat shoebox or its cover
- A big spoon

How to do it:

- Mix the plaster in the jar. Take two parts of plaster to one part of water. The mixture should not be too thin.
- Pour the mixture carefully into the shoebox and keep a small remainder in the jar.
- Take a spoonful of the mixture from the jar and shake it onto the plaster in a shoebox. You can do this with several small spoonfuls of the mixture. The plaster can splash, so look for the right place to do this experiment. If your craters have turned out especially well, you can let them dry.

6 Presenting the Planets

Find out information about the planets. In group work, make posters about the planets. Make presentations about your posters, as much as possible without notes.



The astronaut Buzz Aldrin on the moon (1969). ©NASA

7 Reading star maps

Find star maps and learn to read them. With these maps you will know where you can find stars and planets in the sky every night. Look at the sky and use the map to get your bearings.

Markus Riese is the head of a company that makes bicycles.

Markus Riese, *Engineer*

What would have happened if Markus Riese had not got cold ears while riding his bicycle?

Markus Riese is an engineer who designs bicycles. He was born in Darmstadt in 1968. Even when he was a little boy, he was interested in everything that ran on wheels. In the mornings he went to school. His favourite subjects were science, maths, arts and crafts and sports. In the afternoons he tinkered in his father's workshop. Most of all, he enjoyed working on bicycles. When Markus Riese rode his bike through his home town, he enjoyed being outdoors in the fresh air, free as the breeze.

After finishing his A-levels, Markus Riese studied mechanical engineering. One day it was bitterly cold – minus 15° Celsius, according to the thermometer. Markus Riese and his friend Heiko Müller were riding their bikes to the university. Both of them were wearing helmets so that they would be protected in case of a fall, but their ears were cold. With every kilometre he travelled, the pain got worse. Markus Riese became really cross. Bike riding was no fun anymore. But what should he do? Leave his helmet at home and wear a woollen cap instead?

That would have been far too risky, because after all the helmet was supposed to protect his head. But then he had an idea. When he got home, he took an old pair of jogging pants, used a pair of scissors to cut small pieces of cloth out of them and attached them to the bike helmet to serve as ear warmers. They worked so well that he could barely focus on his studies the next day. He kept thinking about how he could make his ear warmers even better. Maybe he could use fleece or Velcro fastenings, or even sell his ear warmers? This is how "Hot Ears" were invented.

Two friends start a company

Markus Riese told all this to his friend Heiko, who was enthusiastic about the idea. Heiko wanted straight away to start a company to make Hot Ears, and in 1993 the two friends did just that. The banks didn't want to lend them any money for material and tools, so friends and relatives lent them the money. The two young men worked hard and were full of energy. Markus Riese went on tinkering with new ideas for bicycles.

He thought it would be a great idea if you could fold up your bicycle very small, put it in a bag and take it with you on a train, for example, then unfold it again when you arrive at your destination and ride it out of the station. Folding bicycles already existed, but they were not really good enough for sporty bikers like Markus Riese at that time. So he thought it over, tried some things out, and finally welded together pieces from two old bicycles to create the world's first full-suspension folding bicycle. It looked a bit odd, but it worked perfectly. The two friends then worked day and night to create a presentable model made of aluminium.

The jury of a competition liked this bicycle so much that it gave Markus Riese and Heiko Müller the first prize. But it still took some time before the folding bicycle could be sold in bike shops all over Germany. That's because people who want to produce lots of bicycles need a factory. At a bicycle fair, Markus Riese and Heiko Müller met George Lin, the director of a bicycle factory in Taiwan. He offered to work together with them, and the folding bicycle became a runaway success.

Riese the engineer has his best ideas at night

Markus Riese, who by now had his engineering diploma, wasn't finished experimenting. He invented new kinds of bicycles, and won more prizes. His company in Darmstadt got bigger and bigger, and today it has several employees who organize the production and sale of the bicycles. Markus Riese enjoys doing this work. But sometimes he doesn't have enough time to spend on his hobbies, such as going in for outdoor sports and making music.

He says that he gets his best ideas for new kinds of bicycles at night when he can't sleep. That's when he has the peace and quiet he needs to think through his designs, invent new things or improve old designs. For example, he has invented a kind of

Markus Riese builds one of his first self-designed bicycles.

bicycle on runners that you can use to ride down a snow-covered mountain.

His most recent big invention is an especially sporty electric bicycle. It has a small electric motor and battery. When the rider's own muscle power is not enough, he can switch on the motor. The next mountain will then seem a lot flatter!

Now it's your turn!

1 Discussion

Normal bicycles use the energy produced by our muscles. Battery-supported bicycles, which are called hybrid bicycles, have a motor and battery. You can ride them either with or without the motor. The motor needs electricity, which can come from many different sources – for example, nuclear or coal-fired power plants or from wind farms or solar cells. Discuss this question: Are hybrid bicycles environmentally friendly?

2 Calculation

Many people are in a hurry in the morning. If you have a fast hybrid bicycle in the city, you can usually get to your workplace at least as fast as you could in a car. A fast hybrid bicycle that carries one person 1,000 kilometres uses up the same amount of energy that is produced by one litre of petrol. A small car that carries one person 1,000 kilometres uses up the same amount of energy that is produced by 60 litres of petrol. How many hybrid bicycles will it take to use up the same amount of energy as a small car?

3 Discussion

Collect arguments for and against the use of battery-supported hybrid bicycles. Form two groups (pro and contra) and have a discussion.

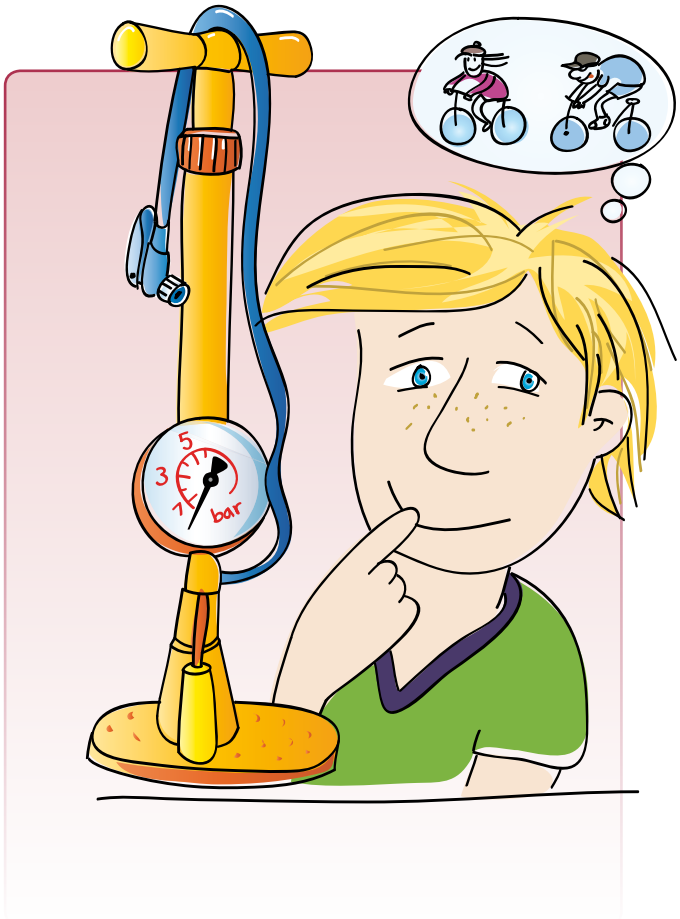
4 Bicycle design

What features should your bicycle of the future have? Do you want it to have special accessories? First, think individually about your dream bicycle, then tell each other what it would look like. You can also draw your dream bicycle and then present it to the whole class.

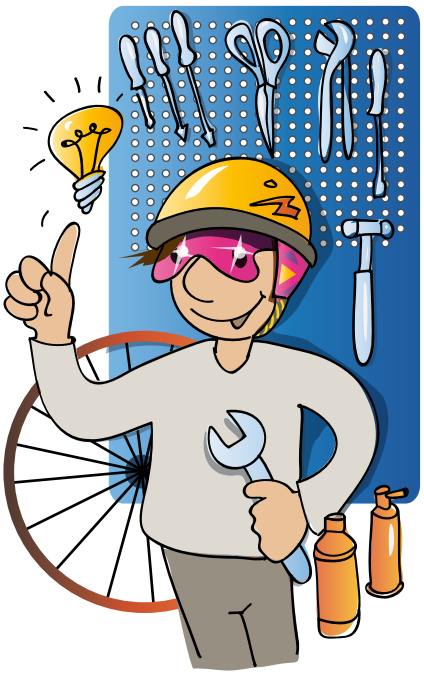
5 Experiment: Rolling resistance

For this you need a bicycle pump that also shows the air pressure. For the first bicycle the air pressure in the tires should be about 1 bar, and for the second bicycle it should be about 5 bar. In other words, the first bicycle should have almost flat tires and the second one should have fully pumped-up tires. Next, look for a cycle path that first goes slightly downhill and then is straight and level. Start your rolling resistance experiment at the top of the slope. The two riders should let themselves roll down the road without pedalling.

- Before you begin, guess which bicycle will roll further.
- Give reasons for your choice.
- Afterwards, discuss the results of the experiment.



Markus Riese – Engineer



Markus Riese was born in 1968.
He is an engineer who designs bicycles.
After school, he went to his father's workshop and tinkered with all kinds of things that have wheels.
He studied mechanical engineering.

One day it was very cold: minus 15° Celsius.
He was riding his bicycle.
He was wearing a helmet.
His ears got very cold and he got very cross.
Should he ride without a helmet – wearing just a cap?
He thought that was too risky.
So he cut pieces of cloth out of an old pair of jogging pants.
He fastened them to the helmet.
That made it warm.
He had invented "Hot Ears".
He told a friend about it.

The friend was enthusiastic.
The two of them wanted to start a company for selling Hot Ears.
But the banks didn't give them any money for it.
They had to borrow money from friends and relatives.
Markus Riese went on tinkering with new ideas for bicycles.
He made a bicycle that you can fold up very small and put in your bag.
He received a prize for this bicycle.
Many people wanted to buy it.
Markus Riese is still inventing things – for example, a sporty electric bicycle with a small motor.

Petra Mischnick is a food chemist who does research on carbohydrates.

Petra Mischnick, *Chemist*

What would have happened if Petra Mischnick had not wallpapered the apartment with her father when she was a child?

Petra Mischnick is a chemist. Besides doing her own research, she is the head of a school laboratory at the Technische Universität Braunschweig.

Professor Mischnick, what is a school laboratory?
Our school laboratory is a chemistry laboratory at the Technische Universität Braunschweig. Here, schoolchildren do research on many exciting things – almost like grown-ups. Mostly, school classes come to us with their teachers. Here they do various projects, for example "Chemistry and Magic" or "On the Trail of the Culprit".

Do you track down real criminals in the school laboratory?
(Ms. Mischnick laughs.) No, we don't. But police detectives depend on chemistry when they investigate crimes. For example, if they're trying to find out if a signature is genuine or counterfeit, in most cases the chemists in a State Office of Criminal Investigation carefully examine the ink. In our laboratory, we show the children exactly how this works. Then they can try it out for themselves.

Did you also do research when you were a child?
I was very curious, and I wanted to find out how things work. For example, I was very fascinated by fire. Of course that was not without risks. That's why a grown-up should always be present when children do experiments with fire.

When I was a child, I spent a lot of time with my father. He worked in a factory and was a very skilled craftsman. For example, he showed me how to make a mirror box so that I could look around corners. I thought that was really exciting!

Agnes Pockels (1862-1935)

The school laboratory at the Technische Universität Braunschweig is named after Agnes Pockels. Although she never went to a university, she received an honorary doctorate in 1931 for her impressive research results on the surface tension of water. Agnes Pockels was a housewife who observed that greasy washing-up water had some special characteristics. As a result, for more than ten years she investigated the surface of water to which she had added various ingredients. She even invented new devices that she used for her research.

When I was about seven years old, I was determined to do a certain experiment: I wanted to find out if people move in their sleep. So before I went to sleep I lay down in a certain position that I could remember very well. I wanted to compare it with the position I was in when I woke up. I thought that if both positions were the same, it would mean I hadn't moved in my sleep. If the two positions were different, I would have moved. I did this experiment countless times, but unfortunately there was no clear result. That's because I discovered that it took quite a long time in the morning before I was really awake and I remembered that I was conducting an experiment. During this waking-up period I moved around quite a lot. And unfortunately I didn't remember a single time what position I had been lying in before I started to move around. In other words, I could not answer my research question. At the time, I was very disappointed. Today I know that researchers have to have a lot of patience. In many cases, we have to think up new experiments again and again before we can answer our initial research question.

Did you also do chemical experiments when you were a child?

Once I wallpapered our apartment with my father. I was especially fascinated by the wallpaper paste. I secretly put a bit of wallpaper paste in a small jar and hid it in the attic; at that time I considered it a very precious treasure. Some time later I looked in the jar again, and I was fairly surprised: it looked as though the wallpaper paste had disappeared. Instead, inside the jar was a kind of small jar made of almost transparent material. At that time I didn't understand what had happened. The new structure must have been made of wallpaper paste, but why did it have the same shape as the jar in which it was formed?

What are you investigating now, Ms. Mischnick?

I am a food chemist. Many food chemists investigate the ingredients of food and the ways these ingredients change when the food is cooked or roasted. Others investigate things we often come into contact with in our daily lives, such as cosmetics, toys and packing materials. One of the important things to watch out for is that these things should not have any ingredients that would make us sick. The ingredients that are chosen must also match the features we want a product to have. For example, if I want to make good wallpaper paste, I have to choose ingredients that will make a thick mass without any lumps.

My working group deals with materials that are chemically similar to starch. Starch is a carbohydrate, and you can find it in grains and potatoes. We investigate and change starches and other carbohydrates and use them to make new materials that are used in industry for many different things, such as washing powder, tablets and construction materials. By the way, the main ingredient of wallpaper paste is a chemically altered carbohydrate!

Now it's your turn!

1 Investigating wallpaper paste

Try out Petra Mischnick's wallpaper paste experiment. Buy wallpaper paste that you can mix yourself from a do-it-yourself store. Mix the powder together with water in a yoghurt cup, according to the instructions on the package. Let the cup stand in a warm place for a while and watch what happens. Note that the experiment may last for several days!

- Think about how you want to make your observations.
- Decide on an observation plan.
- Note your observations and make sketches, drawings or photographs.
- Try to find explanations for your observations.
- Discuss your results with the whole class.

2 Experimenting with starch

Buy cornflour at the supermarket. Take a strong plastic cup or a small plastic bowl and mix the cornflour with water in it until you have a thick paste. Your container should be full of this starch paste to a depth of about two centimetres.

Do the following experiments and compare them with one another.

- **Experiment 1:** Let a spoon slowly sink into the paste. Watch closely and describe what happens.
- **Experiment 2:** Carefully tap on the paste with a spoon.
- **Experiment 3:** Pick up the paste and roll it around in your hand. What happens when you stop rolling it around?

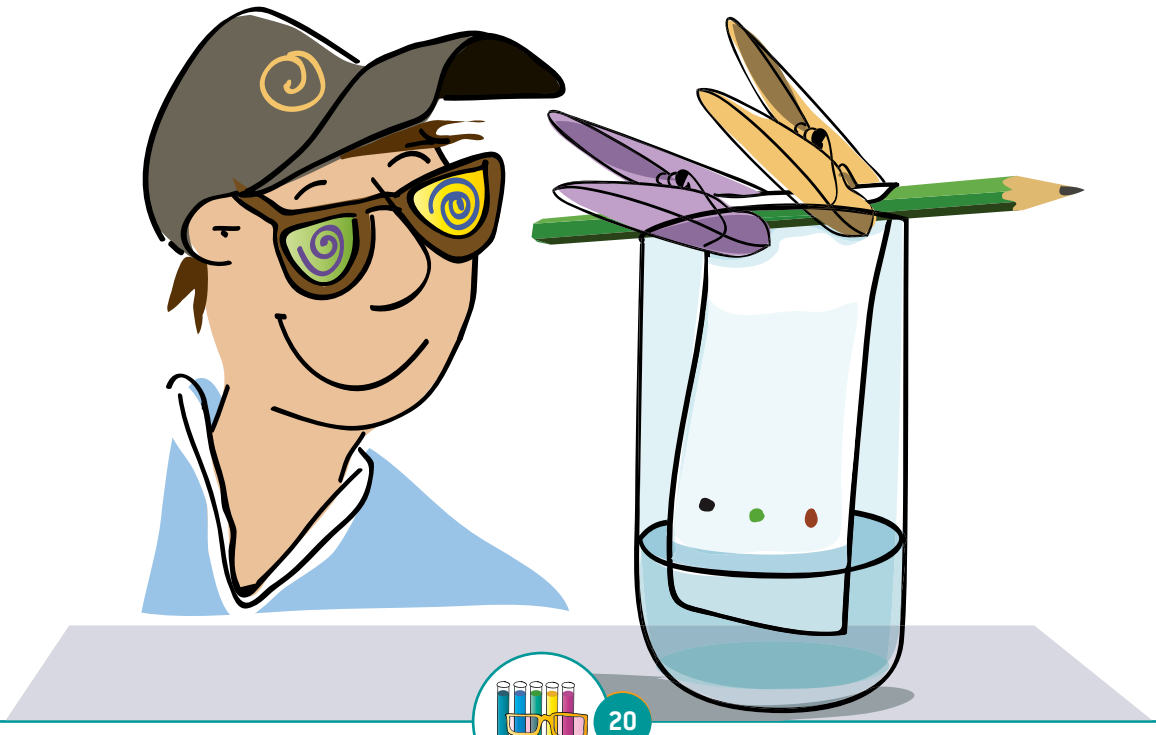
What did you observe? Discuss your results with the class.

3 Comparing felt-tip pen inks

Get the following materials:

- 1 tall water glass
- Several pieces of white filter paper (such as white coffee filters)
- 1 long pencil
- 2 clothes pegs and several felt-tip pens with water-soluble ink

This is how to test the ink: Build a device like the one in the illustration below. Use the felt-tip pens to make a black dot and one or two coloured dots on the filter paper about one centimetre above the



bottom edge of the paper. The dots should be about one centimetre apart from one another. Now attach the filter paper to the pencil with the clothes pegs and hang the pencil carefully across the water glass. The water in the glass should reach to just under the dots on the filter paper. Watch closely and discuss what you have seen.

- Look for explanations of your observations.
- Think about doing experiments with other colours and other arrangements of dots. (It will be especially interesting to compare several different black felt-tip pens.)

4 Design a new experiment

When Petra Mischnick was a child, she wanted to find out if she moved while she was sleeping. Form research teams and think about what you would like to investigate. Design an appropriate experiment and present it to the class. Can you actually do the experiment?

School classes at all age levels do research at the Agnes Pockels School Laboratory.

Benno Baumgarten from Italy was interested in stones even when he was a boy.

Benno Baumgarten, *Geologist*

What would have happened if Benno Baumgarten's father had brought home medicinal herbs from his hikes?

Stones are really interesting, and you can find them everywhere: on the street, on the beach, in the forest and on mountain slopes. Have you ever looked at stones very carefully? Do you have any stones among your treasures?

In South Tyrol in Italy there is a very curious geologist and researcher who is interested in stones: Benno Baumgarten. Geologists investigate the structure and composition of the Earth, among other things. Even as a young child, Benno Baumgarten was very interested in the many different kinds of stone in his home region. He collected lots of them and guarded them like small treasures. He tried to find out where they came from, how they were formed, and whether there were secrets and stories about them.

Benno Baumgarten was born in Bolzano, the capital of South Tyrol province in Italy, on 24 June 1956. When he was a child, he lived together with his parents and his grandmother. His grandmother was a very clever woman who could make all kinds of things, such as soap, herself from just a few materials. Benno liked that, and he wanted to investigate all the things he was curious about, just like his grandmother. That way he learned at an early age how to do experiments with many different materials.

Even as a boy, Benno Baumgarten collected all kinds of stones

Over time, he focused more and more on stones and minerals. He was fascinated by the great variety of stones. He soon realized that every stone was beautiful and fascinating in its own way. He especially liked to find things out about stones on his own. He looked for stones on his way to school and in the neighbourhood. His father and his older brother were enthusiastic mountain climbers, and when they came back from their hikes they often brought back new treasures and gave them to Benno. He didn't think it was important to have big stones in his collection. He much preferred to

have many different small ones. He especially liked opals. Opals are stones that can be used to make jewellery because they shimmer in different colours when you move them.

Many questions led Benno to a stone expert

The more stones Benno had, the more he wanted to find out about them. So he asked questions of his teacher and other experts who lived nearby. For example, one of the neighbours of Benno Baumgarten's family was a man who laid flagstones and polished semi-precious stones. He visited this man again and again to show him his new stones and find out something about them. This mysterious man was a real stone expert. Over time Benno became especially fond of crystals, because they sparkle so beautifully.

In middle school, Benno Baumgarten found two close friends who were also interested in stones. The three boys bonded through their research into minerals, and they developed a secret logo as a symbol of their friendship.

When Benno was a bit older he went to the grammar school in Bolzano. He especially liked the subject of chemistry, because he loved to do chemical experiments. One day he had the bright idea of setting up his own chemical laboratory in the cellar at home. His parents let him do it, but they thought it was more important for him to study music and learn to play the organ. Benno didn't like this idea at all, because he was interested in discovering, investigating and understanding aspects of natural science.

He needed many devices and chemical substances for his chemical laboratory in the cellar, and he bought many of them at flea markets. He also subscribed to a magazine for chemical lab assistants. His chemical experiments were extremely unusual, and they fascinated him greatly. And they inspired him to do more and more experiments.

When he finished grammar school, he went to Munich to study geology. Today Benno Baumgarten has a degree in geology and is the Director of the Geology Department of the Museum of Nature South Tyrol in Bolzano. There children and adults can find out a lot about stones and their history.

Do you know the geologist's most important tools?

They are a hammer and a magnifying glass. The geologist uses a hammer to smash stones apart in order to create a fresh break. He can then use a magnifying glass to take a close look at the stone without any vegetation or deposits getting in the way. A hammer and a magnifying glass are simple tools, but a geologist could not work without them. Many geologists have a microscope in their laboratory so that they can examine thin sections of the stones. A thin section is a stone sample that is between 0.02 and 0.03 millimetres thick – that's only half as thick as a human hair!

Now it's your turn!

1 Stone collecting hike

Go on a hike with your class. Choose a place where you can take your time and look for stones. Decide whether you want to form teams that look for certain kinds of stone. Look carefully in all the places where you can find stones. Collect stones and take them back to your classroom. Figure out how you can make sketches to show where you found your stones.

2 Sorting stones

What you need:

- Magnifying glass
- Ruler
- Scales
- Stones

How to do it:

- Every pupil brings along ten stones. You can form groups of pupils. Take a close look at the stones and consider how you can sort them into groups. The following concepts can help you do that: size, weight, circumference, shape, surface, colour, brightness, smell, hardness.
- Present your results to the whole class and give reasons why you put the individual stones into their groups.

3 Becoming a stone expert

Choose a type of stone and become an expert on it. Prepare yourself by using books, the Internet and other information sources for your research, and make a short talk or presentation about what you have learned.

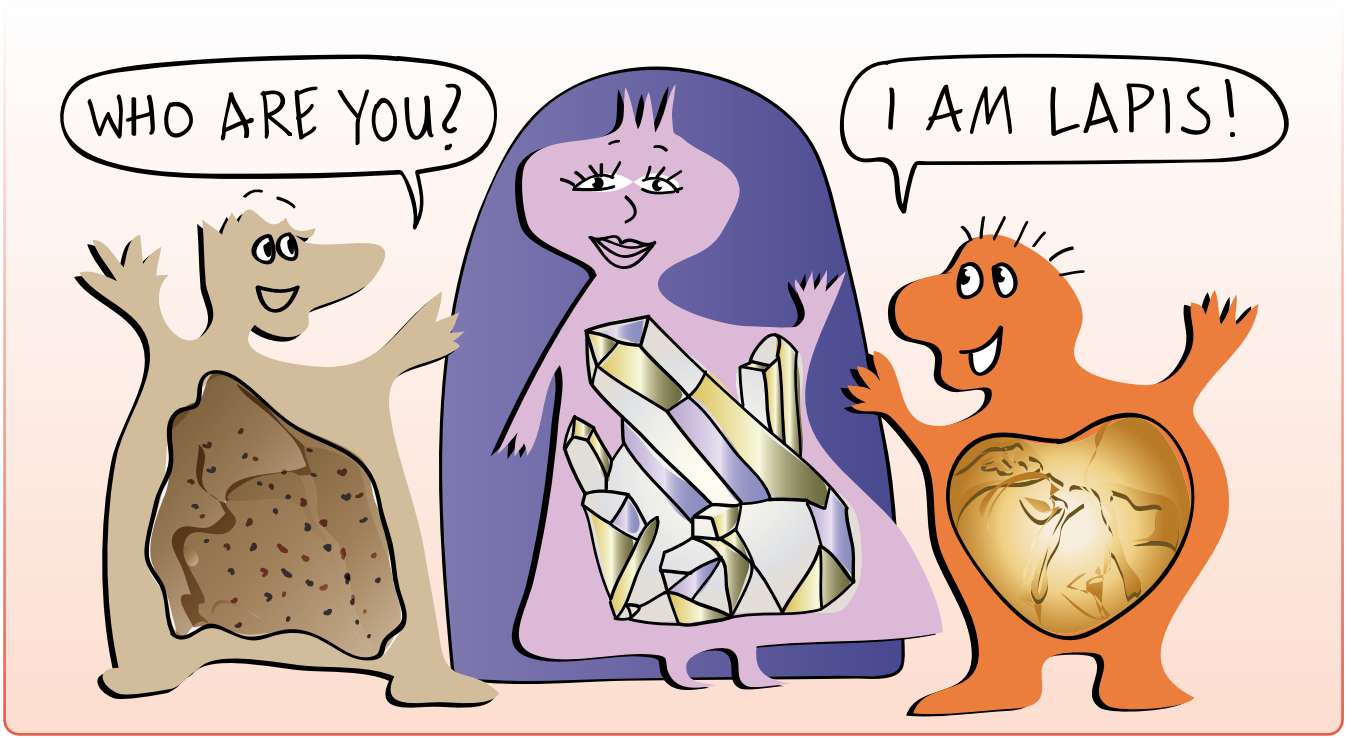
4 Telling stories

What you need:

- One or more of your favourite stones

How to do it:

- Give the stones names and tell or write their story. It can be a fantasy or a true story, for example a story about the place where you found them or about the way they were formed.



Large areas of the Sahara Desert are covered with sand. This desert is so wide that Germany could fit into it 26 times.

5 Investigating sand

Sand consists of many tiny stones – grains of sand. How many grains of sand are in one kilogram of sand?

What you need:

- A magnifying glass or a stereoscope
- Millimetre paper
- Scales (accurate to within one gram)
- Playground sand, tweezers

How to do it:

It would be very difficult to count every single grain of sand in a kilogram of sand. But you can use the following trick to figure out roughly how many grains of sand are in one kilogram of playground sand. Weigh out one gram of playground sand. Decide how you want to count the grains of sand. The millimetre paper may help you here. How can you use the number you find out to answer the original question?

Incidentally, your results will be correct only for the playground sand you have used. There are many different kinds of sand.

The geologist Benno Baumgarten

What would have happened if Benno Baumgarten's father had brought home medicinal herbs from his hikes?

Stones are really interesting, and you can find them everywhere: on the street, on the beach, in the forest and on mountain slopes.
Have you ever looked at a stone very carefully?
Do you have any stones among your treasures?

In the South Tyrol region there is a researcher who is interested in stones.
His name is Benno Baumgarten, and he is a geologist.
A geologist studies stones and knows a lot about them.
Even as a child, Benno loved stones.
He collected lots of them and guarded them like treasures.
He tried to find out where they came from, how they were formed, and whether there were secrets and stories about them.

Benno Baumgarten was born in Bolzano on 24 June 1956.
When he was a child, he lived together with his parents and his grandmother.
His grandmother was very clever and could even make her own soap.
Benno wanted to try things out, just like his grandmother, so he did various experiments when he was a child.

More and more, Benno liked to look at stones very carefully and find out something about them.
Every stone was different, and that fascinated him.
He looked for stones everywhere.
His father and his brother were mountain climbers, and when they came back from their hikes they often brought back stones for him.
He was very happy to have many different little stones.
He especially liked opals.

Opals are stones that shimmer in different colours when you move them.
People can use opals to make jewellery.

The more stones Benno had, the more he wanted to find out about them.
He asked questions of his teacher and a man who lived nearby.
This man laid flagstones and polished semi-precious stones.
He was a real stone expert.
Benno especially liked crystals, because they sparkled so beautifully.

In middle school, Benno Baumgarten found two friends
who were also interested in stones.
This small research group even had its own secret logo.

Later on, Benno went to the grammar school in Bolzano.
He especially liked the subject of chemistry, because he enjoyed doing experiments.
He even set up his own laboratory in the cellar at home.
His parents let him do it, but they would have been much happier if he had been
learning a musical instrument.

Benno bought many devices and chemical substances at flea markets for his
chemical laboratory in the cellar.
He also bought a magazine for chemists.
He just couldn't stop experimenting.

When he finished grammar school, he went to Munich to study geology.
Today Benno Baumgarten has a degree in geology and is the Director of the
Geology Department of the Museum of Nature South Tyrol in Bolzano.
There children and adults can find out a lot about stones and how they are formed.

Mona Goudarzi does research to find out how wind turbines can be made taller and lighter.

Mona Goudarzi, *Mechanical Engineer*

What would have happened if Mona Goudarzi's brothers hadn't played with their little sister?

Mona Goudarzi grew up in Iran. Even as a little girl, she was very interested in a certain technical device: the television. For example, she wondered how the people, animals and objects got inside the TV. Fortunately, she had two older brothers who were also interested in technology and liked to tinker with remote-controlled cars and small home-made robots. Mona was often there when her big brothers did their technical experiments, and she closely watched what they were doing. They often let her help them build their devices.

Mona's two brothers told her a lot about technology and tried to show their little sister how images are transmitted on TV. She didn't understand everything right away, but she did learn something very important: It's good to think about something for such a long time that in the end you really understand it.

Mona Goudarzi came to Germany when she was 16 years old. Her teachers quickly saw that she enjoyed thinking about technical problems, and they advised her to choose a technical profession. Mona studied at a university and became a mechanical engineer. After she received her engineering degree, she joined a research group that works with wind turbines at the Institute for Integrated Production (IPH) in Hanover.

How does a wind turbine work?

A wind turbine converts the energy of the wind into electricity. To do that, the wind turns the rotor blades – the "wings" – of the turbine. The rotor blades are connected to a dynamo called a "generator". The generator produces electricity, and this electricity flows through thick cables into the power grid. A wind turbine basically works like a giant bicycle dynamo. The bicycle dynamo converts muscle power into electricity for the bicycle lamp, and the wind turbine converts wind power into electricity for households, factories and many other places.

To make sure everything works smoothly, a control computer regulates all the processes in the wind

The wind blowing up high is stronger than the wind blowing near the earth's surface. (©fotolia.com/Günter Menzl)

turbine. It is located in the nacelle (machine pod), at the foot of the turbine, or outside the tower. For example, wind measuring devices on the wind turbine send data about the current wind strength and wind direction to the control computer. The control computer then sends information to the yaw motors, which turn the entire nacelle so that the rotors are facing into the wind. The straighter the wind turbine is facing into the wind, the more electricity it produces.

A device that measures wind speed is called an anemometer. It consists of small bowls that the wind turns in a circle, and it is attached to the nacelle. When the wind is very strong, 90 kilometres per hour or more, the computer turns the wind turbine off. Otherwise the rotors might break.

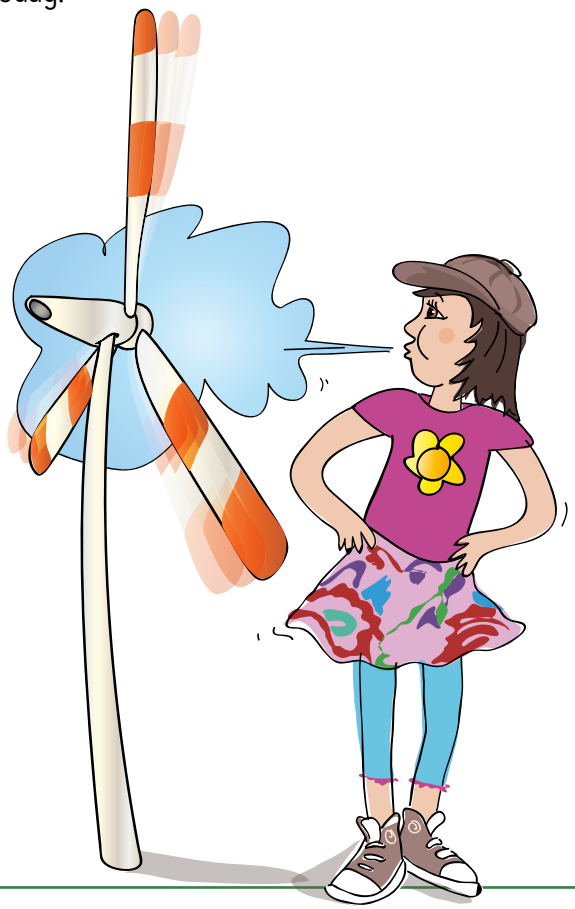
Up high, the winds are strong

The basic rule for wind turbines is that the rotor blades should be turning as high as possible above the ground. That's because the higher up you go the stronger the wind gets, and that means the rotor blades can turn faster and produce more electricity. Today wind turbines can reach up into the sky as high as 180 metres. It is not possible to build them any taller at the moment. That's because the taller the towers are, the stronger they need to be in order to securely support the nacelle and the rotor blades even in a strong wind. At some point this makes the towers so heavy that they could collapse under their own weight.

Lightweight construction is needed

It may be possible to build wind turbines higher in the future, but only if the towers and the rotors can be made strong and light. Mona Goudarzi is carrying out research to find out which materials and which kinds of construction can be used to do that. For example, so far the towers have been made of thick rings of steel or concrete that are placed on top of one another. But new kinds of construction material are also promising. With these materials, the tower is made of an inside steel band and an outside steel band, with another material filling the space between them. This material could look like a honeycomb, because the six-cornered shape of a honeycomb is especially strong but also very light.

Mona Goudarzi and her team must do a lot more research and tinkering before this kind of new wind turbine can be built. If they succeed, in a few years we may have much higher wind turbines than we do today.



Now it's your turn!

1 Wind turbines near you

Look for a wind turbine near you. Visit the wind turbine during a class trip and look at it from up close. You may be able to find a specialist who can explain to you how the wind turbine works. Find out about wind turbines from the companies that sell electricity where you live. Take the information you have learned and use it to make posters about the topic of wind turbines.

2 Building a device to measure wind speed (anemometer)

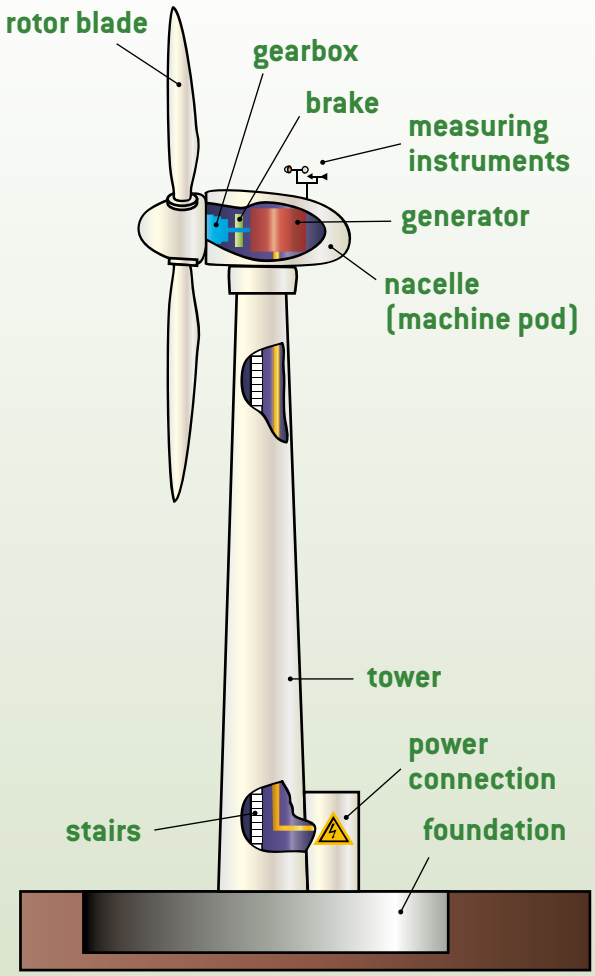
Look for a picture of an anemometer in books or on the Internet. Look at the device carefully and think about how you can build such a device yourself. Form small groups and decide on a design for your anemometer, then gather the materials you need. Make sketches of your anemometer and build it. Write a set of instructions as you go along. Test your anemometer and present it to the other groups. Talk about the advantages and disadvantages of your different designs.

3 Discussing wind turbines

Wind turbines are enormous structures that can't be missed. Some people think we should build fewer wind turbines so that we can stop spoiling our landscapes. Form small groups that look for reasons in favour of wind turbines (pro) or against them (contra). Think about how you want to present your arguments, and tell the others about your points of view. Discuss this topic in your class.

4 A construction made of paper

Form small groups and think about how you can make a structure out of paper. It should be tall and strong, but also light. It doesn't necessarily have to be shaped like a pipe. There are also wind power plants that are held up by lattice towers (made of girders). Look for pictures of such towers. Discuss in your classroom how you can find out which tower is the best one. Work together to make rules for the best paper construction. Use only paper and glue.



Mona Goudarzi – Mechanical Engineer

Mona Goudarzi grew up in Iran.
Even as a little girl, she was very interested
in technical devices.
For example, she wanted to know how animals and people got
inside the television.
Her two older brothers told her a lot about technology.
In this way she learned something very important:
it's good to think about something for a long time
until you really understand it.

Mona Goudarzi came to Germany when she was 16 years old.
Her teachers saw that she enjoyed thinking about technology.
They advised her to choose a profession in this area.
Mona Goudarzi studied mechanical engineering.
She joined a research group that worked with wind turbines.

Wind turbines produce electricity.
Up high, the wind is stronger.
The rotor blades turn faster.
More electricity is produced.
Today wind turbines are about 180 metres high.

The material has to be very light.
But the wind turbine also has to be stable enough.
The tower has to support the nacelle and the rotor blades even if the wind is strong.
Mona Goudarzi is doing research to find out how wind turbines
can be made even higher and more stable.

Prof Otto Lührs with his daughter Elena in his lab in the cellar

Otto Lührs, *Physicist*

What would have happened if Otto Lührs' father had not had a telephone?

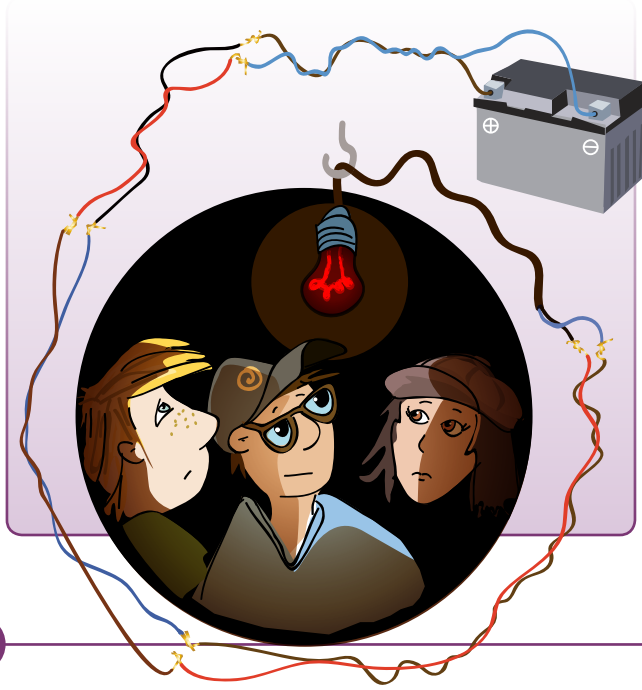
My name is Elena. My father, Otto Lührs, is an electrician, a physicist and an artist. As an electrician he learned to lay cables. As a physicist, he was fascinated most of all by how the eye perceives objects, how the brain processes these impressions, and how we are sometimes fooled by these impressions. I'll talk more about that later. My father built devices to illustrate these themes, and he showed them in exhibitions, like an artist. Now I'll tell you how all this happened.

My father was born in 1939 and grew up on a farm in Lower Saxony. When he was about nine years old, he collected wires and cables that other people no longer needed. Together with his friends, he had dug out a cave, and he wanted to have a light in it. He connected the cables, which had a light bulb hanging from them, to my grandfather's motorcycle battery. But the light bulb didn't shine – it only put out a dim glow. My father and his friends were fairly disappointed. Only much later did they find out why their homemade lighting system couldn't work.

When Papa was a boy, he often watched his uncle Johann, who was very interested in technology. Johann was always trying to improve his reception of distant radio stations. He stretched wires between the house and a cherry tree to form a homemade antenna. The reception was sometimes better and sometimes worse.

As an electrician, my father learned how radios, televisions and telephones work

When my father was a young man, he did an apprenticeship as an electrician – specifically, as an electrical installer. Among other things, he learned what he hadn't known when he had tried to light up the cave he had dug out with his friends. The old cable he had used back then, which was about 100 metres long, used up so much energy itself that there was very little energy left for the light bulb.



Otto Lührs, about nine years old

Most of all, my father liked learning about radio, television and telephone technology. After he finished his apprenticeship, he moved to Bremen and worked for the Post Office, which at that time was still responsible for the telephone wires. A new city neighbourhood was being built, and Papa and his colleagues laid new telephone wires. Back then he never wanted to own his own telephone. He thought he would never use it, because there were public telephones all over the city and he could always use those. People seldom used the telephone in those days.

My father wanted to learn even more, so after work he went to evening classes in Bremen and completed his A-levels there. Not long after that, he was on a visit to my grandparents out in the country. While he was there, he got a phone call from his friends. Papa still didn't have his own telephone, but his father had one because he was something like the mayor. Papa's friends invited him to come with them to Berlin. He agreed, his friends picked him up in a car and they all drove to Berlin. That trip changed his life.

Papa built his first physics artwork with light-emitting diodes

Papa ended up studying electrical engineering in Berlin. He thought this was a good way to continue what he had been doing until then. Later he changed his field of study to physics. He also tinkered with physical phenomena in his free time. He began to do experiments with light-emitting diodes, which are known as LEDs for short. An LED is a small modern lamp that consumes very little electricity but is very bright.

Papa took a music record, drilled tiny holes into it and put a lot of tiny coloured LEDs on it. He connected the record to an electric wire from below and turned it – slowly at first, then faster and faster. When he turned the record slowly, he could see the individual LEDs, but when he turned it fast, big circles appeared on the record and the individual LEDs could no longer be seen. This is because when the LEDs move, they leave a trail of light behind them. If the next LED follows close behind, we cannot distinguish the LED from the trail of light, because our brains put together what we are seeing into a continuous circular line. Our eyes and our brain seem to be playing a trick on us.

My father became the director of the first "hands-on" science museum in Germany

But let's get back to my father. When he finished studying, Papa did further training as a cultural worker. He had already made several devices that he could display in art exhibitions. Artworks made of technical components were considered very modern in those days.

At that point he got a job in which he could combine his interest in technology and his interest in art. At the Museum of Technology in Berlin he organized an exhibition that later became Spectrum, the first Science Center in Germany. It's a kind of museum where you can try out the experiments for yourself. Go and see it the next time you're in Berlin!

Papa built many exhibits that help people get to know physical phenomena, and visitors to Spectrum are still using them today. Are you getting curious? If you are, you can make your own exhibit, a "disc rotography". It's described on the following pages. You'll be astonished by what you see. Have fun!

Now it's your turn!

1 Building a disc rotography

"Rotography" was my father's name for his experiment with the light-emitting diodes on the record. He often presented it in a similar form in exhibitions. You can also put together a rotography experiment!

What you need: (Tips on materials on page 45)

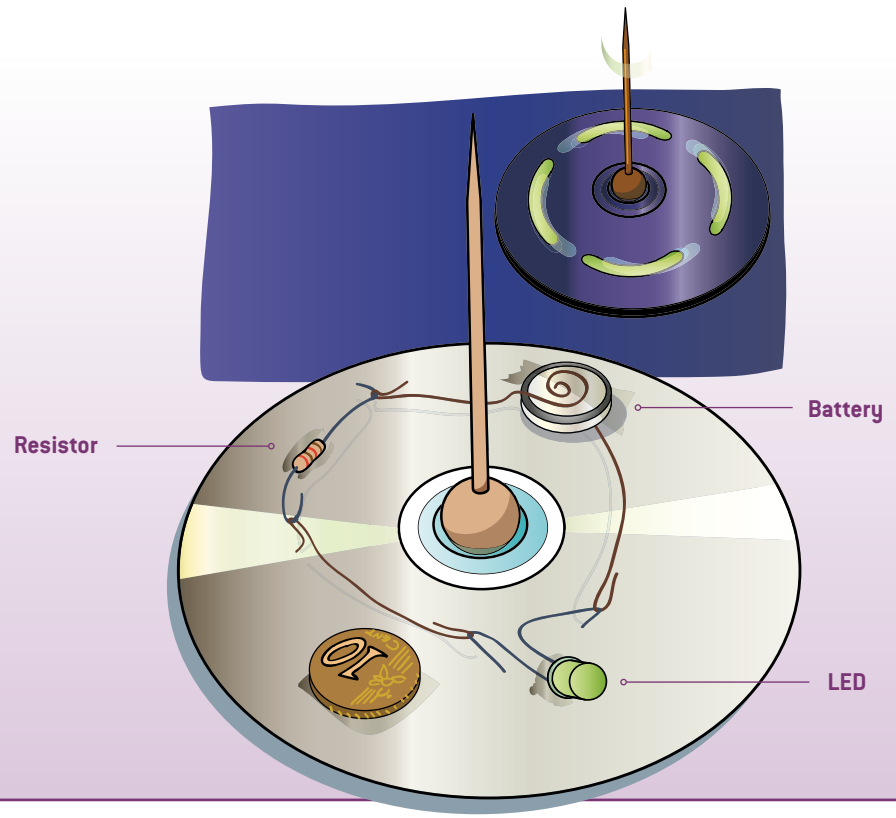
- 1 disc (for example, a blank CD)
- 1 light-emitting diode (LED)
- 1 battery
- 1 resistor
- 1 wooden ball with a hole drilled in it
- 1 toothpick
- 2 short wires (about 8 centimetres long)
- 1 longer wire (about 18 centimetres long)
- 1 coin to balance the battery
- Double-sided stickers
- Sticky tape
- Glue, scissors and a ruler

How to build the disc rotography experiment:

- Put the toothpick into the drilled hole of the wooden ball and glue the wooden ball into the hole of the disc with fast-acting glue, so that the toothpick is standing straight up. This will work best if you first lay the CD on a cup.

- When everything has dried, stick a double-sided sticky pad onto the disc and stick the coiled end of the long wire on top of it. Press the battery on top of the wire. Fasten one of the short wires to the top side of the battery with a piece of tape.

- Now bend the wires of the resistor slightly upwards and glue the resistor to the disc. After the glue dries, you can connect the short wire that is stuck to the battery to the resistor. Fasten the other short wire, which you have not yet glued to anything, to the free end of the resistor.



- Before you glue the LED to the disc, you have to test it. Bend its wires upwards. Hold one wire to the wire coming from the battery and the other end to the wire coming from the resistor. If the LED lights up, glue it to the disc in this position. If it does not light up, simply swap the wires around and then glue it to the disc.

- **Note:** Make sure the wires don't touch each other. If you do, there will be a short-circuit.

- Now take the coin and use a double-sided sticky pad to fasten it to the place on the disc where it will balance the battery. Now switch off the lights and turn the disc!

2 Questions about the text

- Find information about the profession "electronics engineer"
- Find out what kind of work a physicist does.
- What is a light-emitting diode?
- Think about what it would be like to live without a telephone or a mobile phone, and describe it to the class!

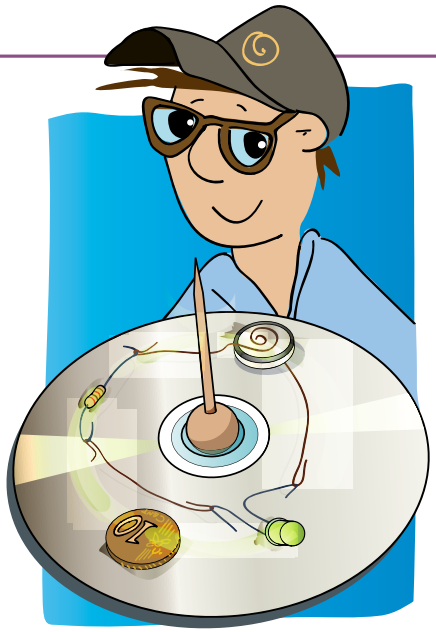
This model W48 telephone was the standard telephone of the German Post Office from 1948 until about 1970. What do you notice about it?

Resistance in the electrical circuit?

The disc rotography you have built is an electrical circuit. The battery generates electricity that flows through the LED and makes it shine. But without one more component, the electric current would be so strong that it would destroy the LED. The resistor keeps the strength of the current to a level that keeps the diode whole.

3 Pupil experiment

Look directly into the eyes of a classmate. In the middle of each eye you will see a black point, the pupil. Note the size of the pupils. Now ask your classmate to look out of the window or at a brighter part of the room. How do the pupils react? Describe this reaction.



Otto Lührs – Physicist

Otto Lührs was born in 1939.
He grew up on a farm in Lower Saxony.
When he was a child, he collected wires and cables.
He dug out a cave with his friends.
They wanted to have light in the cave.
Otto Lührs put together many small pieces of cable and laid a power line.
But the light bulb did not burn brightly – it only put out a dim glow.
Why?

Otto Lührs became an electrician.
He found out that many small cables use up too much energy.
That's why the light bulb did not burn brightly.
Otto Lührs was interested in radio, television and telephones.
He wanted to learn even more.
He got his A-levels certificate and studied electrical engineering and physics in Berlin.

He liked to do experiments with LEDs.
He fastened LEDs to a record.
He spun the record – first slowly, then fast.
The separate points of light became trails of light.
He built many devices like this one and displayed them in art exhibitions.
Later he was the head of the first "hands-on" science museum in Germany – the Spectrum in Berlin.

Regina Palkovits studies renewable raw materials.

Regina Palkovits, *Chemical Engineer*

What would have happened if Regina Palkovits had not gone to a summer academy when she was in school?

Can you imagine a banana peel serving as fuel for a car? This is only one of the interesting problems Regina Palkovits deals with in her work at RWTH Aachen University. She was born in Essen (Germany), in the middle of the Ruhr region, in 1980. In earlier times this was a region where coal was mined and burned for energy. So it's probably not a coincidence that today Professor Regina Palkovits is looking for ways to generate energy from renewable raw materials.

Wood, for example, is a renewable raw material. If you chop down a tree in order to use it for heating or for making furniture, a new tree can grow in its place. But this is not true of petroleum, natural gas or coal. They will not be renewed in the foreseeable future.

Chemical engineers do a variety of things

In primary school, Regina Palkovits' favourite subjects were maths and art; later on she also liked chemistry. When she was in an upper form at grammar school, she went to a summer academy. This is a kind of holiday camp where the campers really have to use their brains. There she did a lot of experiments in the area of renewable energy. She found this topic so exciting and important that she decided to become a chemical engineer. Chemical engineers are needed wherever large amounts of materials are changed into other materials – for example, potatoes into crisps, oils and other ingredients into cosmetics, and renewable raw materials into energy. To manage these processes, you need expert knowledge in technology as well as the natural sciences. A chemical engineer can do research and development, planning, building, improving and controlling, as well as operating and managing big production plants.

Research and development was exactly what Regina Palkovits wanted to do. She has already done research in many different areas. At the moment she is looking for a new way of making fuel for cars.

Alcohol as a fuel?

Petrol or diesel, which are used to fuel most cars, are made from petroleum. But petroleum is not available in unlimited amounts, so researchers are working to find a substitute. This could be a certain type of alcohol called ethanol, for example. It can be

made by allowing sugar beet, maize or grain to ferment. This creates ethanol, in the same way that allowing grape juice to ferment makes wine.

Because we also need grain for food, Regina Palkovits is looking for a way to make new kinds of fuel from plant waste, such as stems or wood scraps. Such plant waste consists largely of cellulose, a material that contains a lot of energy. Unfortunately, it is fairly difficult to extract this energy. You need a special helper material called a catalyst to change cellulose and make fuel from it. Regina Palkovits discovered a catalyst of this kind and received a patent for the process she invented. If someone has a patent, other people who want to make the same thing first have to ask the person who owns the patent and pay that person.

Making our environment a better place to live

Regina Palkovits says she enjoys doing research mainly because it allows her to really change things and help make our environment a better place to live. That won't happen overnight, but over the years new production processes will be developed, and one day our cars may really run on fuels that come from plant waste – possibly including banana peels!

Regina Palkovits also enjoys talking to young people about science and getting them interested and enthusiastic. For example, she supports the young people who are doing projects for the "Jugend forscht" science and technology competition in Germany.

When she finds a spare minute in her busy schedule, Regina Palkovits likes to do karate. She finds it very relaxing, because she has to concentrate on it so hard that there's no room in her mind for anything else. She also used to go jogging, but her co-workers made her stop. That's because while she jogged she got so many ideas for new research projects that her co-workers couldn't keep up with them.

What does a person need in order to be a good researcher? Regina Palkovits says, "Above all, you have to be curious and enthusiastic."

Maize is a versatile plant. It provides food and can also be processed into fuel.
(©fotolia.com/JLV Image Works)

Now it's your turn!

1 Renewable raw materials

Find out about renewable raw materials and renewable sources of energy and look for various examples.

2 Petroleum

Find out how petroleum is created and how long this process takes.

3 Fuel from renewable raw materials?

Can you imagine why many people are against the idea of processing raw materials such as sugar beet, maize or grain into fuel? Collect arguments for and against this idea and discuss them.

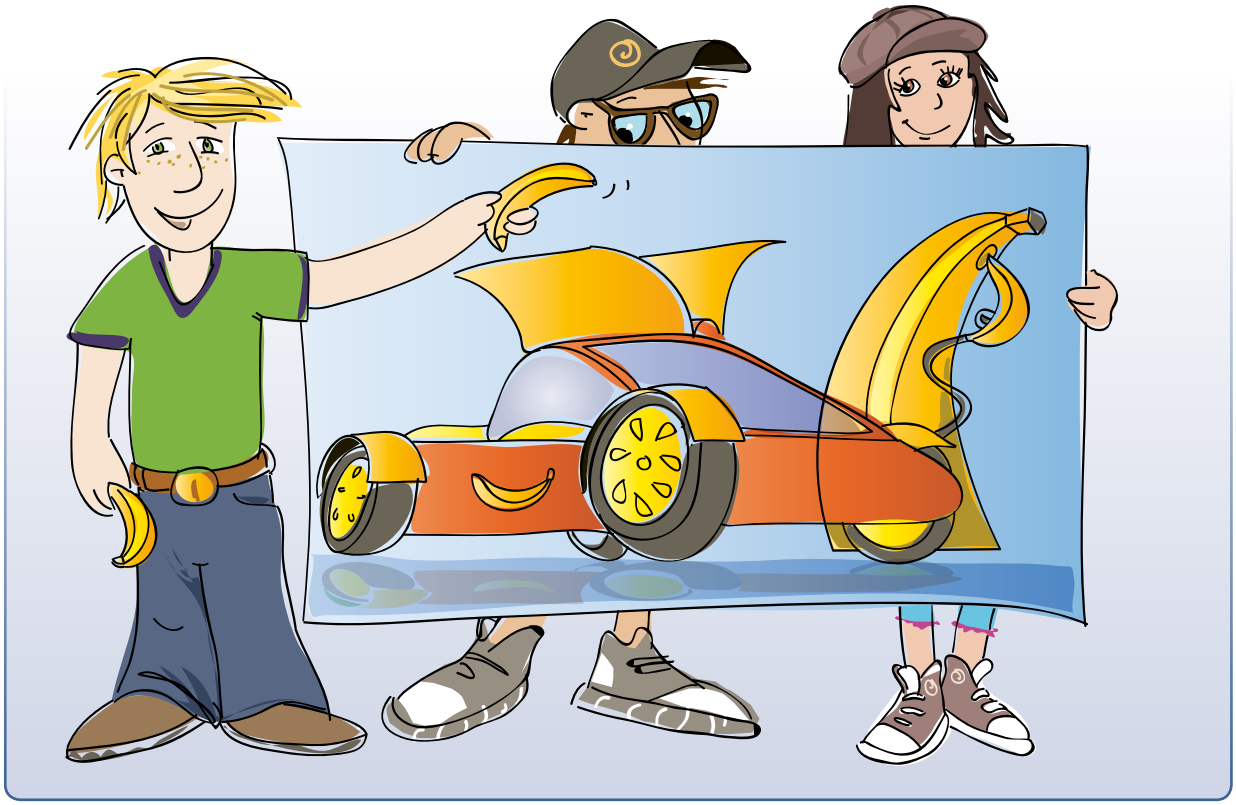
4 Catalytic converter

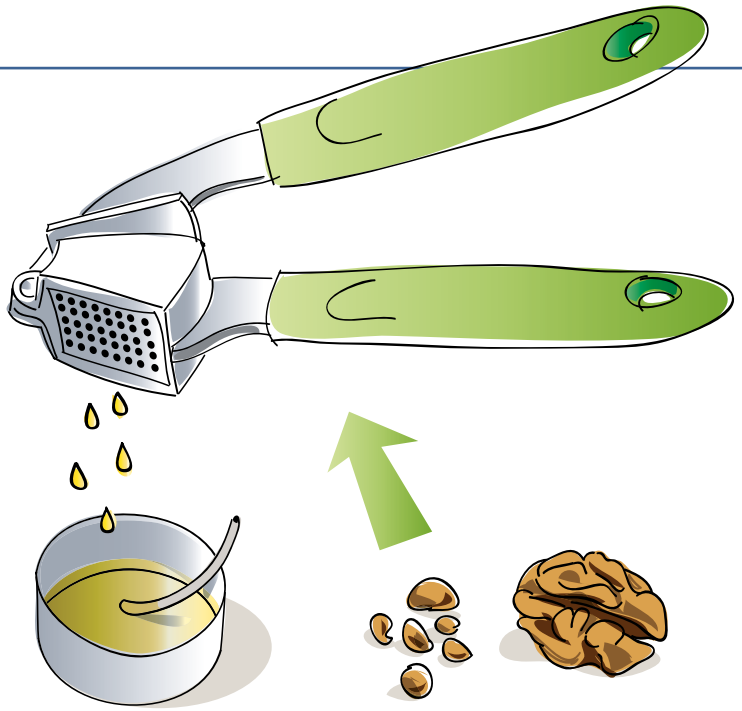
Find out what a catalytic converter is and then select the right answer:

- A catalytic converter is a kind of fuel that makes cars run faster.
- A catalytic converter is a kind of cleanser that makes hazardous materials disappear.
- A catalytic converter is a kind of matchmaker between different materials. It enables two materials to react with each other without being changed itself.

5 Chemical engineer

What do chemical engineers do? Find out the answer (for example on the internet) and collect as many verbs about it as possible.





6 Experiment: Making lamp oil

Make a lamp that burns a renewable raw material.

What you need:

- 1 aluminium cup from a tea-light
- 1 short piece of wick
- 2 or 3 walnuts
- 1 nutcracker
- 1 kitchen knife
- 1 cutting board
- 1 garlic press
- Matches

How to do it:

- Crack open the walnuts, remove the shells and cut the nuts into small pieces with a kitchen knife.
- Cut off a piece of wick that is about 3 centimetres long and put it in the aluminium cup so that it partly stands up along the side.
- Put the walnut pieces into the garlic press and press the oil directly into the aluminium cup.
- When you have pressed out a few drops of oil, you can light the wick.

7 Seeds that contain oil

Your lamp burns nut oil. Do some tests to find out if other kinds of seeds also contain oil. Take different kinds of seeds, put them between two paper towels and gently pound them with a hammer. Now hold the paper towel against the light. What do you see?

8 A play

You've made a nut oil lamp. Now imagine the following situation:

You are a small team of researchers (three or four people) that has just invented this wonderful lamp. In a meeting with other scientists and representatives of industry, you report on your work and try to persuade the factory managers to manufacture this lamp.

Act out this scene as a short play, taking on different roles.

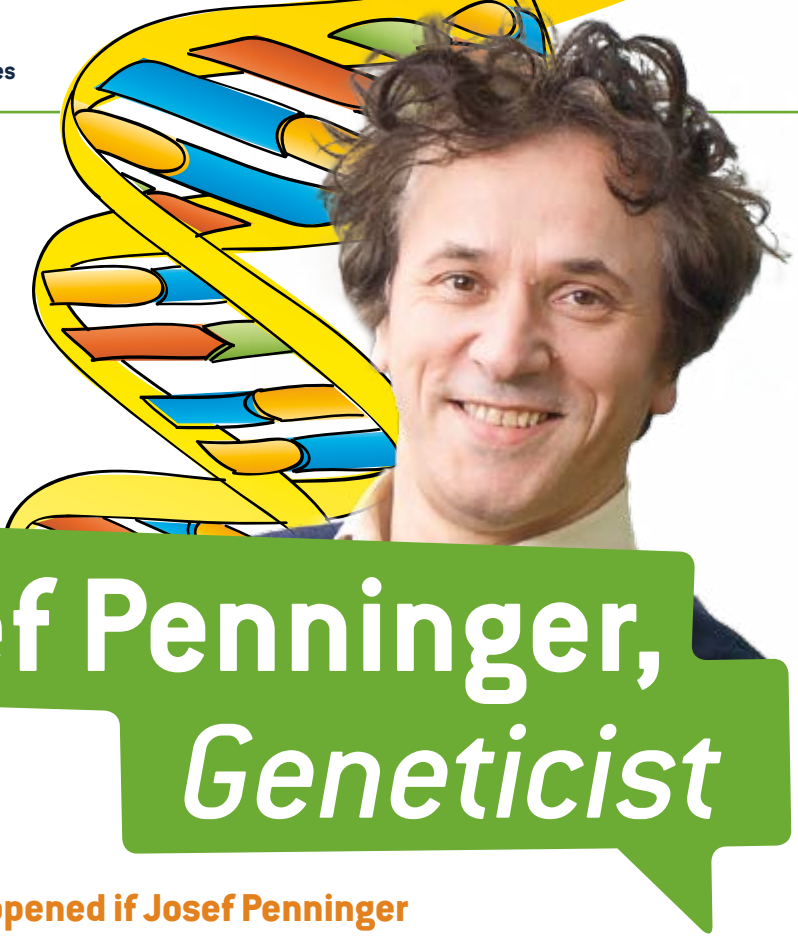
Regina Palkovits – Chemical Engineer

Regina Palkovits was born in the Ruhr region
in Germany in 1980.
People used to mine coal there in order to get energy.
Regina Palkovits works to get energy too.

In grammar school she went to a summer academy.
This was a holiday camp with lots of experiments.
After that she wanted to go on doing research.
She became a chemical engineer.
Chemical engineers look at how materials change:
for example, how potatoes become crisps or how oil becomes cosmetics.
Regina Palkovits has done lots of research.
Now she is working on a new way to make fuel for cars.

Cars can run on a type of alcohol called ethanol.
People now make ethanol from sugar beet, maize and grain.
But we need these things for food.
Regina Palkovits has found a way to make ethanol from plant waste.
To do that, she needs a special helper material, a catalyst.
She has a patent for this material.
Other people have to pay if they want to use it.

What does a person need in order to be a good researcher?
Regina Palkovits says, “You have to be curious and enthusiastic.”



Josef Penninger from Austria investigates how genes work in the human body.

Josef Penninger, *Geneticist*

What would have happened if Josef Penninger was still afraid of mice today?

Josef Penninger was born in Gurten, a small village in Austria near the border with Bavaria, in 1964. His parents owned a farm. Because they had to work so much of the time, they sent Josef to boarding school. When he was a child, he often had terrible nightmares about scary rats. He therefore had an awful fear of rats and mice.

Back then, neither he nor his teachers suspected that one day he would become a scientist – a very famous one, in fact. As a boy, Josef himself dreamed of being a professional footballer or a doctor. Later on he studied medicine, art history and Spanish in Innsbruck. After graduating he began to do research on the human immune system. "I worked in the laboratory from morning till night, and even on holidays and during my vacations," he recalls. "I wanted to be able to explain where killer cells go to 'school' and how they learn to kill other cells." Killer cells are the cells in the immune system that know whether other cells of the body have been attacked by bacteria or viruses that can make them ill. They immediately kill these sick cells and are therefore very important for human health.

Genes determine people's characteristics

Together with his team, Josef Penninger investigates human genetic material, which contains many thousands of genes. There are genes in every individual cell of the human body. The skin consists of skin cells, the heart consists of heart cells, and so on. These types of cells are very different, because after all the skin is very different from the heart, but all of these cells contain genes. The genes are in effect the command headquarters, or the bosses, of the cells.

The genes determine if the eyes are blue or brown or whether a person has a snub nose or ears that stick out. Children inherit their genes from their parents, so characteristics such as black or blonde hair are also inherited. That's why children often look very much like their parents.

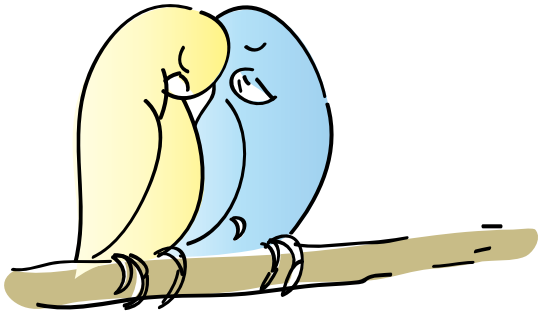
As a geneticist, Josef Penninger investigates what other effects genes have. Experimenting with human cells is allowed only in exceptional cases, so he generally does his research with cells from other animals, such as mice. Before he could do that, he had to learn to overcome his awful fear of these little animals. "It took me a year before I could walk into a room where there were cages full of mice," he says. It's an interesting fact that mouse genes are very similar to human genes. Some of the results of researchers' experiments with mice can therefore be transferred to human beings.

Genes regulate our day-and-night rhythm

For example, Josef Penninger recently discovered a gene that regulates the biological clock of mice. The biological clock of animals and of human beings ensures that these creatures live according to a day-and-night rhythm, as if they were guided by something like a clock. At certain times they are wide awake, and after a relatively constant number of hours they feel tired and have to go to sleep. Of course this "biological clock" is not a real clock, but it acts like one. Josef Penninger investigated mice whose "biological clock gene" did not function properly. These animals did not have a healthy day-and-night rhythm. The scientists also investigate the role that genes play in cancer and illnesses of the heart, lungs and bones. They would also like to find out how genes influence the immune system, which protects us from illnesses such as cancer and the flu. The goal of Josef Penninger and his colleagues is to gain new knowledge about genes that could help to develop new medicines in the future.

The main purpose of knowledge is to protect the world

Josef Penninger worked as a geneticist in Canada from 1990 to 2002. After that he returned to Austria with his wife, a Chinese doctor, and his three children. Since then he has been the Director of the



Institute of Molecular Biotechnology (IMBA) of the Austrian Academy of Sciences.

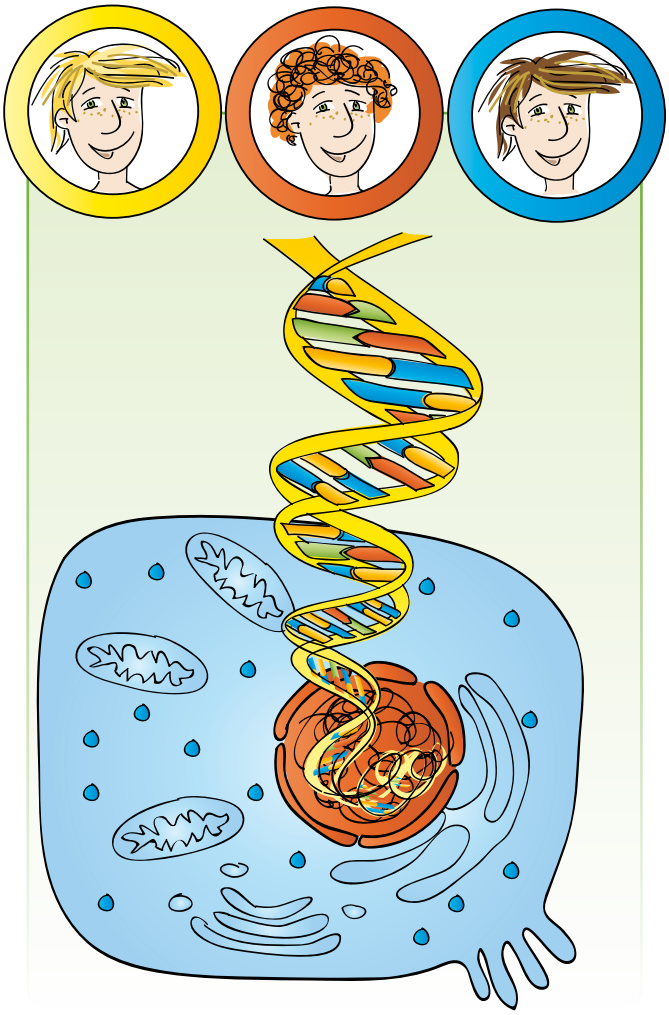
"Being a scientist is one of the coolest jobs you can have, even though it often takes years to get results," says Prof Josef Penninger. "It's exciting to do research in an area nobody knows anything about yet, to be allowed to ask uncomfortable questions, and not to have to believe everything other people tell you. Having more knowledge will be the real power of the future."

Genes control the "biological clock" of animals and human beings. The "biological clock" regulates our periods of sleeping and waking. (©fotolia.com/PhotoSG)

Now it's your turn!

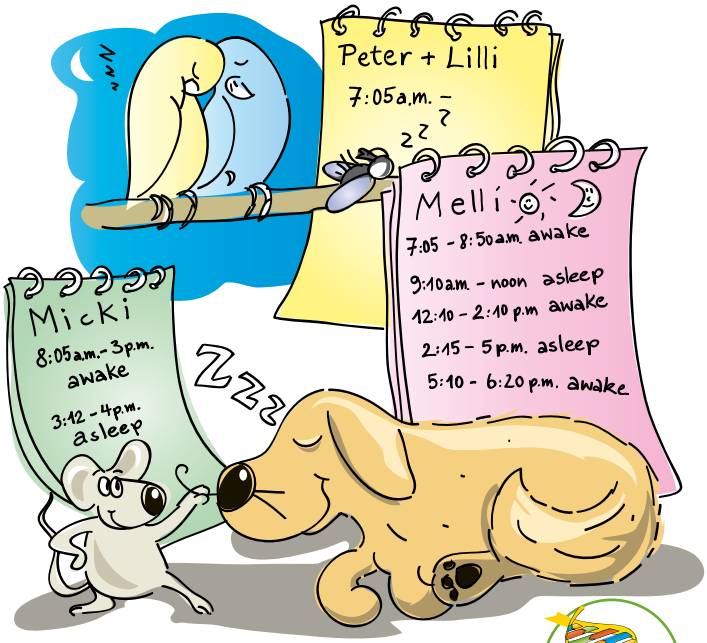
1 Questions about the text

- Josef Penninger investigates certain cells of the immune system that find sick body cells and kill them. What are these special cells called?
- Experiments with human cells are allowed only in exceptional cases. That's why Josef Penninger works with animals. Why did he choose mice, even though he wanted to investigate the characteristics and sicknesses of human beings?
- Josef Penninger and his research group want to find out how genes function in the cells of the body. How could the findings of this research help people?



2 The "biological clock" of animals

- Find animals that you can observe for a longer period of time.
- Observe these animals' waking and sleeping times.
- Record your observations in such a way that you can compare them with your classmates' observations.
- Consider what other questions you would like to investigate.



3 Making a model of a body cell

- Look in books or on the Internet for pictures of body cells in which you can clearly see the different parts of the cell.
- Use the pictures to build a model of the cell. Use materials that you can find at school or at home.

For teachers

Tips on the experiment "Building a disk rotography experiment" (page 34)

Disk rotography is an inexpensive and effective experiment. Most of the materials can be bought at a specialist electronics shop or an Internet mail-order website. Inexpensive batteries can be bought at one-euro shops, and wooden balls and wire are available at hobby shops.

Materials for a construction kit:

- 1 disk (e.g. blank CD or old CD)
- 1 light-emitting diode (5mm, green, non-blinking)
- 1 battery (3 volt button cell, e.g. CR2032, CR2025 or CR2016)
- 1 resistor (carbon-film resistor, ¼ watt, 47 ohm)
- 35 cm wire (copper wire, 0.3 mm)
- 1 wooden ball (with a hole drilled halfway through, 15 mm, 2 mm hole diameter)
- 1 toothpick
- 1 coin
- 2 double-sided sticky pads (10-20 mm)
- Sticky tape
- Glue (liquid all-purpose glue or fast-hardening two-component epoxy adhesive)
- Scissors and a ruler (for measuring and cutting the wires)

It is important to glue the wooden ball with the toothpick into the CD so that the toothpick is standing straight up. Only then will the record spin smoothly. The gluing will go fastest with two-component epoxy adhesive, which hardens in five minutes. If all-purpose glue is used, it would be advisable to glue the wooden ball into the CD on the previous day.

You can download 'Lantern Moon and Hot Ears' at
www.science-on-stage.de/lantern-moon

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The association

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Science on Stage …
…is a network of and for science and technology teachers of all school levels.
…provides a European platform for the exchange of teaching ideas.
… highlights the importance of science and technology at school and among the public.

Science on Stage enables teachers to broaden their horizons and be inspired by the ideas and experience of their European colleagues. In accordance with the guiding theme of Science on Stage, 'for teachers by teachers', both the international festivals and the follow-up events focus on teachers, including training courses and workshops.

The ultimate goal of Science on Stage is to improve science teaching and thus encourage more schoolchildren to consider a career in science or engineering.

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Since 2005 Science on Stage offers primary school teachers the following activities:

- Participation in the national and European Science on Stage festivals
- Travel scholarships for the exchange of teachers from different countries
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