Dr Nadya Ben Bekhti researches distant galaxies in space.

Nadya Ben Bekhti, *Astronomer*

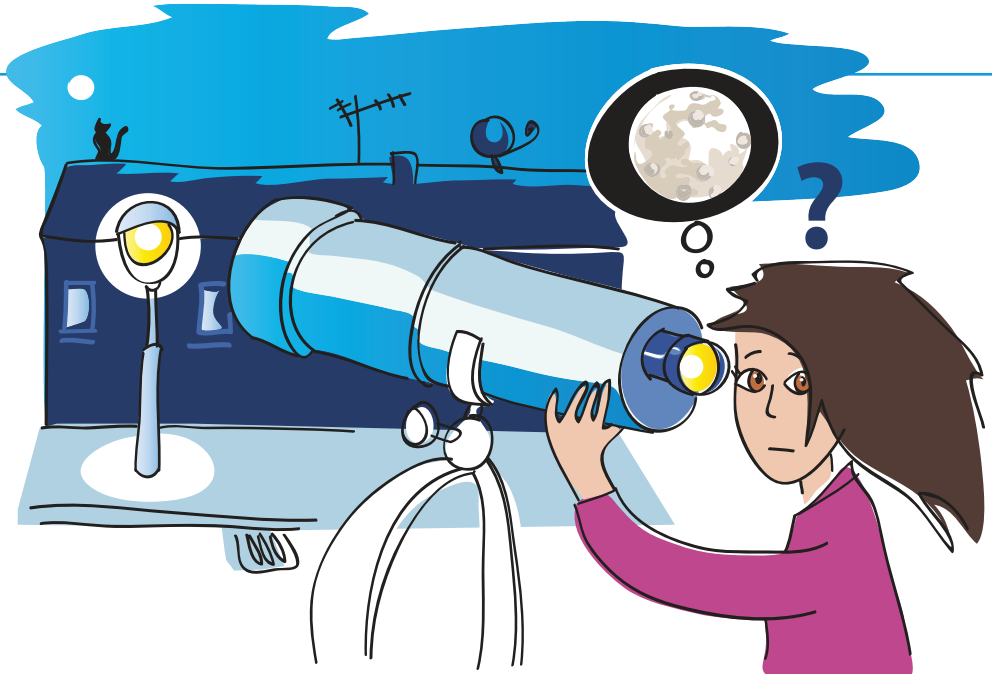
What would have happened if Nadya Ben Bekhti's father had not told his daughter about the stars and the planets?

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!

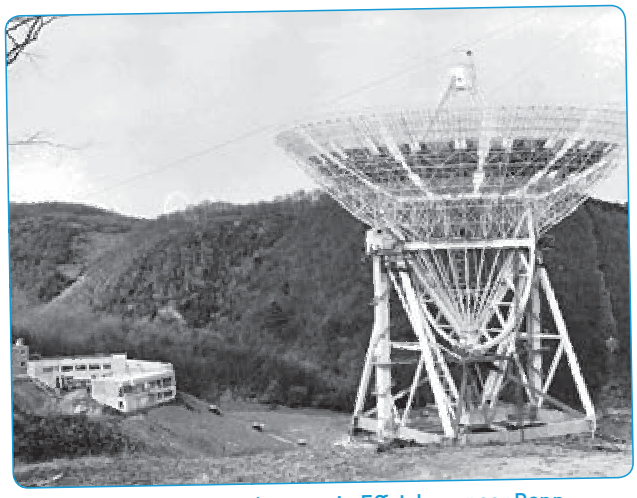
Today I use telescopes that are as big as a football pitch

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:

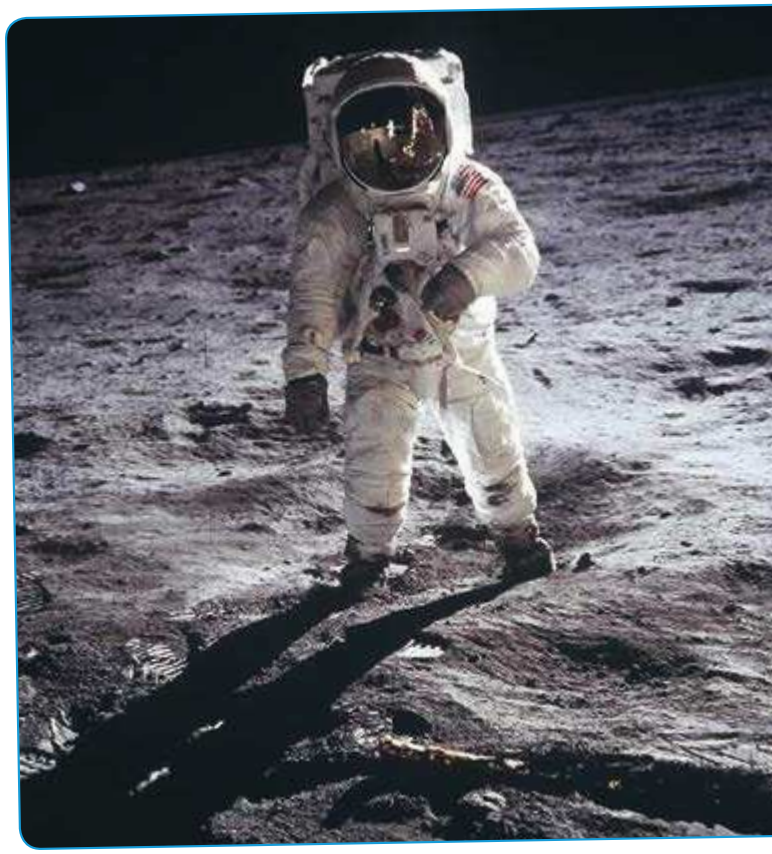
▷ Plaster
▷ Water
▷ A jar (to mix the plaster and water)
▷ A flat shoebox or its cover
▷ A big spoon

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.

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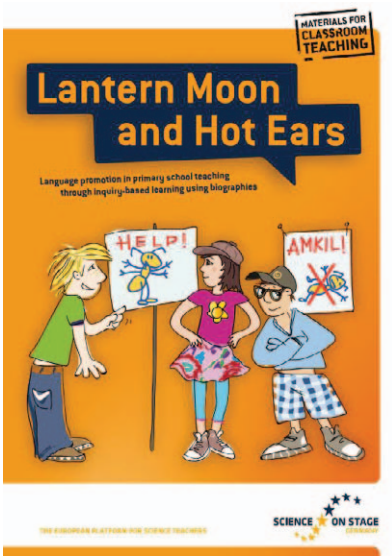

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Petra Mischnick is a food chemist who does research on carbohydrates.

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?

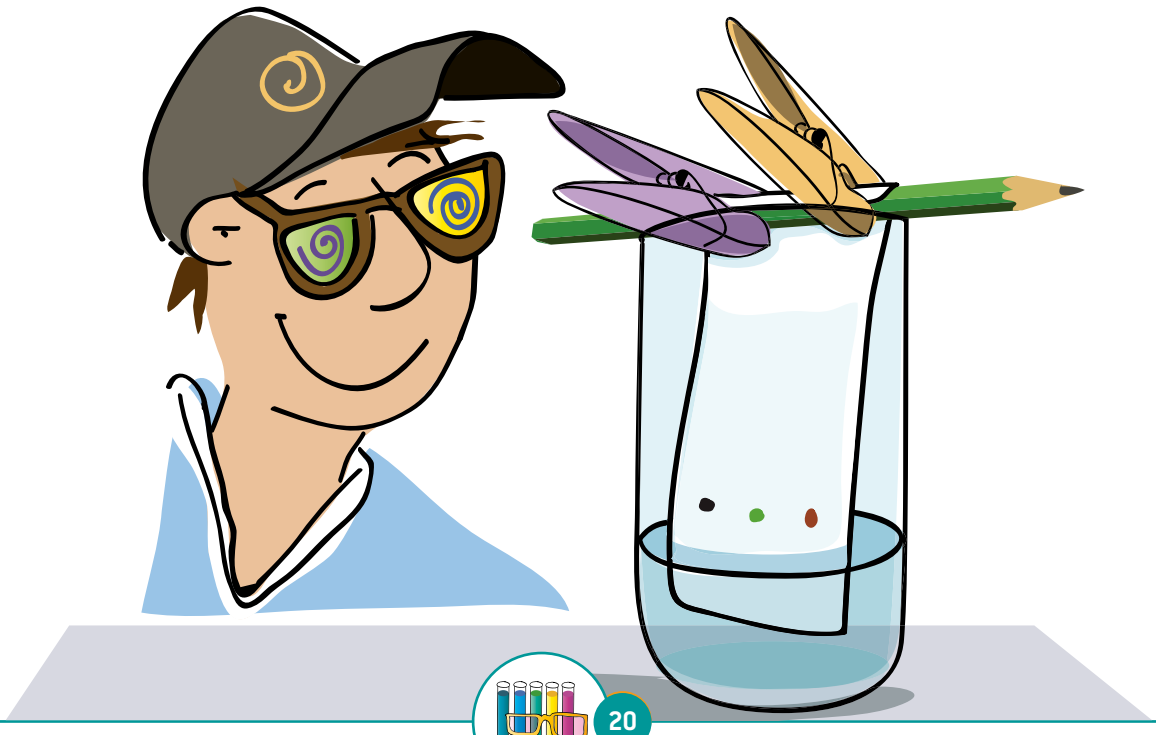
What did you observe? Discuss your results with the class.

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.

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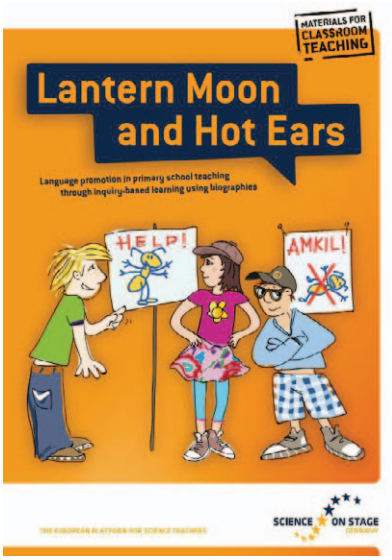

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Mona Goudarzi does research to find out how wind turbines can be made taller and lighter.

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.

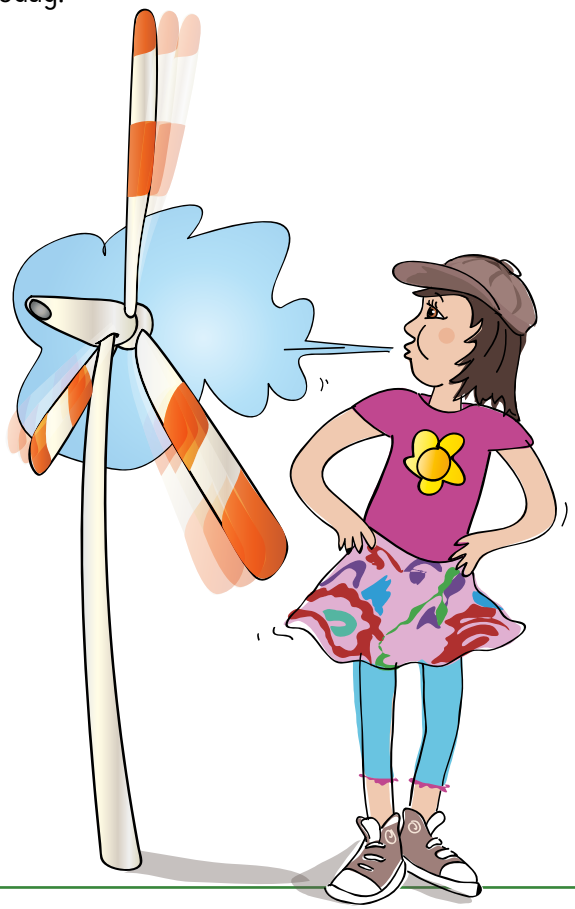
Up high, the winds are strong

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)

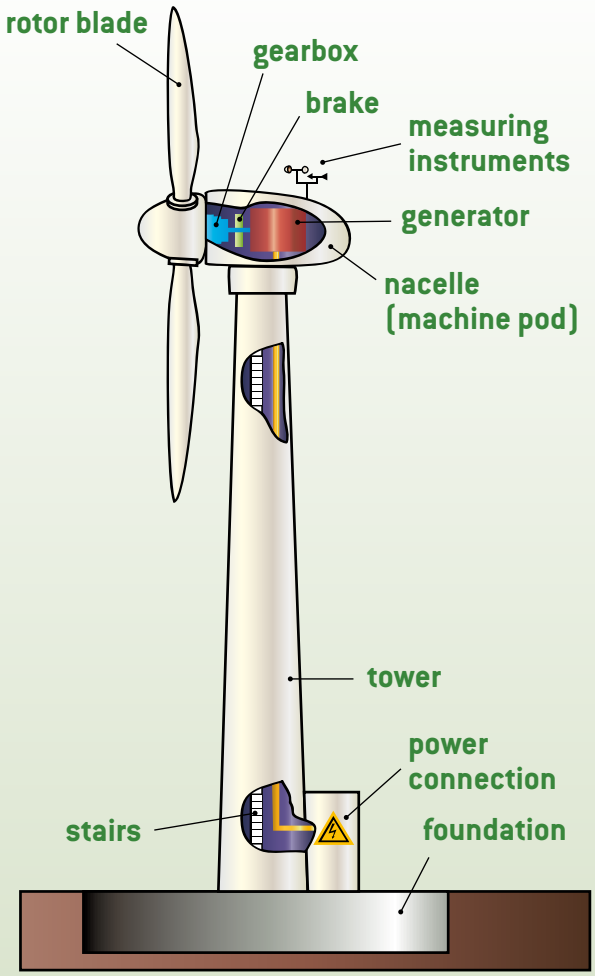
Look for a picture of an anemometer in books or on the Internet. Look at the device carefully and think about how you can build such a device yourself. Form small groups and decide on a design for your anemometer, then gather the materials you need. Make sketches of your anemometer and build it. Write 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

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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.
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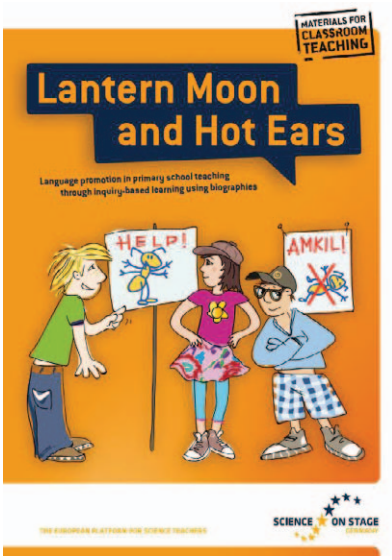

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