Small – smaller – nano

nanokits for nanokids

Three experiments

to try at home

...for younger and

older children

NANORA
Nano Regions Alliance
Imprint

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Hi there!

My name is Nora. What’s yours?

_________________________

I have been working with nanotechnology for as long as I can remember. Never heard of it? No idea? Or perhaps you’ve heard of it but you still have no idea? That doesn’t matter!

Would you like to try a few experiments with me? Just like a real scientist? Then follow me, I’ll show you what to do! It’ll be fun: and then you can show your friends, parents, or grandparents what you have found and learnt.

Before we start, let me tell you a few exciting facts. Oh, and there is a little section for your parents to read (where it says ‘Dear parents’).
Dear parents,

Why does ketchup leave sticky red spots? Why don’t dirty clothes get clean by themselves? Why does it leave a mark when you scrape a toy car over a ‘real’ car?

Are you one of those parents who are bombarded with questions like these from your children all day long? That’s a good thing! Children want to know, find out, and investigate things.

Our nanokits for nanokids booklet aims to offer a fun way to introduce children to a technology which has turned previous scientific knowledge upside down. Nanotechnology includes elements of physics, chemistry, biology, material sciences, and medicine. Whether scratch-resistant paint, self-cleaning window panes, or compatible medical aids, the exciting discoveries of nanotechnology have opened up entirely new opportunities and they offer benefits for nearly all areas of life.

The three experiments in this booklet are suitable for children aged four to ten. They use materials which can be found in most households, or otherwise are available cheaply from any supermarket. Or perhaps a kind neighbour could help you out...

If you are interested in further experiments for students please see:
http://www.nanoschoolbox.com

Have fun!
Disclaimer

As children may handle the experiments differently depending on their age, all experiments should be supervised by an adult. Supervision is your responsibility. Whether your child performs the experiment by themselves or with your help, care must be taken to ensure that all instructions are followed and that only the experiments described here are performed. A sturdy table with a durable, heat-resistant surface would make a suitable working area.

The tools used are everyday consumer goods. However, no liability is assumed, either for the success of experiments or for any damage which may be incurred in doing so. We hope that you and your budding scientist enjoy exploring the nano world.
What is nanotechnology?

The word ‘nānos’ comes from Greek and means ‘dwarf’.

Nanotechnology works with the very smallest particles. A nanoparticle is so tiny that you can’t see it. This might be very hard to imagine, and so perhaps a comparison will help: a metre is to a nanometre as the earth is to a football. Or: a human hair is 70,000 nanometres thick.

In mathematical terms, a nanometre is a billionth of a metre or a millionth of a millimetre, and the abbreviation for nanometre is nm. In numbers, it looks like this:

\[1 \text{ nanometre} = 1 \text{ nm} = 10^{-9} \text{ m} = 0.000000001 \text{ m}\]

These tiny components are also known as nanoparticles. Nanoparticles can be made from a wide variety of materials. The following three experiments will show you why nanoparticles are so special.

I hope you have lots of fun!
One metre is to a nanometre as the earth is to a football.
1. Experiment: the lotus effect
You will need

- Various types of paper, e.g. printer paper, a piece of newspaper, filter paper, etc.
- Plant leaves, two of each type, e.g. nasturtium leaves, kohlrabi, red cabbage or a gum tree, lettuce, dandelion, blades of grass, etc.
- Measuring cup
- Teaspoon
- Water
- Some ‘dirt’, e.g. finely ground garden soil or fine dust
What to do

1. Always place two of the same leaves or pieces of paper next to each other. Put a bit of dirt on one and leave the other clean.
2. Use the teaspoon to trickle a few drops of water onto the leaves or paper.
3. Carefully pick up the leaves or paper one at a time in turn and move them gently to let the water run back and forth.
4. Repeat with all the pairs of leaves and paper that you have collected.
You can see

The droplets of water roll across some leaves and paper like a marble. On the nasturtium leaf or the cabbage leaf, for example, you will see wonderfully round droplets which you can roll back and forth. Where there is dirt, the drop of water absorbs it and leaves the leaf clean.

On some, like the dandelion, the droplets of water spread out. The coffee filter paper even completely absorbs the water.

How does it work?

The leaves and paper where you can see balls of water are water-repellent (hydrophobic). The more strongly a leaf repels water, the better the ball that is formed by the water will be, meaning that the droplet can pick up the dirt more successfully. The leaves and paper where the droplets spread out or even soak in are water-absorbent (hydrophilic).
Why is this?

When you look closely, what at first seems to be a smooth surface is in fact not smooth. If you examine the nasturtium leaf under a microscope you will see lots and lots of bumps.

The surface is actually very rough, rather like a hilly landscape. These bumps are in turn made up of lots of water-repellent wax crystals. The water molecules in the droplet are also pulled towards each other (cohesion). The combination of these two forces creates the remarkable droplet shape on the nasturtium leaf.
The dandelion does not have a waxy surface, and so the droplets spread out over the leaf. If you rub your fingers over the leaves and then trickle more water on the areas that you have rubbed, you will see that it doesn’t form round droplets this time. The rubbing has flattened the bumps on the surface, which significantly reduces or even entirely stops the bead effect. This means that the effect is entirely lost in the areas which you have rubbed.

**What does this tell you?**

Imagine if you spilled ketchup but it didn’t leave any spots! Or if you didn’t have to wash the family car anymore! Wouldn’t that be great? Researchers weren’t the ones who came up with such a great idea – it was nature!

Science has copied this phenomenon (known as the lotus effect) from nature and used it in a variety of areas. The lotus effect doesn’t just work with different leaves; it also works with various other materials like glass and some fabrics. The lotus effect is already used for varnish, windowpanes, glasses lenses, and roof tiles. There are even some self-cleaning fabrics such as awnings, tents, or outdoor clothing which use the benefits of the lotus effect.
And there’s more

A botanist from Bonn discovered the lotus effect more than 50 years ago. Professor Wilhelm Barthlott created the brand name ‘Lotus Effect®’ to describe this phenomenon which has occurred in nature for a very long time. This earned him the German Environment Prize in 1999. The ‘lotus effect’ is also sometimes called the ‘nano effect’. Making any sense now?
Colouring in

Black and white is boring.

Colour in the picture using your favourite colours.
2. Experiment: surface enlargement
You will need

- 8 sugar cubes
- 1 pen
- 1 sheet A4 graph paper
- Scissors

What to do

1. Use the 8 sugar cubes to build a big cube. Look closely at the surface of your big cube. Count all of the sides of the sugar cubes which are on the outside of the big cube – and don’t forget the ones on the bottom underneath. You should find a total of 24 sugar cube sides making up the big cube.

2. Take the graph paper, colour in 24 boxes in a row and cut out the shape.
3. Next, lay all 8 sugar cubes out separately, as a snake, circle, or however you like. If you compare this shape with the large cube you made before, you will see that the total number of sugar cube sides showing in this arrangement is much bigger.

**This is called surface enlargement.**

To see this more clearly, count up all of the sides of the small sugar cubes which you can see on the outside. You should count a total of 48 sides.

Now, colour in 48 boxes in a row on your graph paper and cut out the shape.
You can see

If we look at a big cube and then split it up into lots of small cubes, we can see that the total surface area of the small cubes is much bigger than the surface area of the single big cube.
How does it work?

If you cut the cubes into even smaller pieces, the surface will get even bigger. If you cut them up enough you will get a material that is nearly entirely made of the surface. This dimension, which is rather difficult to imagine, is known as nanoscale.

We can’t see it – it is invisible to us. You need a very special microscope called a scanning tunnelling microscope to see nanoscale particles. You can also use an atomic force microscope. Both microscopes are expensive, extremely sensitive, and found only in large research institutions. A ‘normal’ atomic force microscope costs about as much as a Mercedes.

Why is this?

If a material is in small particles, the material may behave completely differently to the same substance in larger particles. The increased surface area means that other substances which would perhaps not otherwise have reacted with the original substance have more surface area to ‘dock’. 
It’s a bit like a party: the more people there, the more conversations you can have, the more fun it can be, and the more exciting stories you can hear.

The behaviour of a substance depends on the size of the particles of which it is made. Large surface areas also mean better bonds between nanoparticles. We can say that the larger the total surface area is, the more properties a substance displays. This is something which we will look at in more detail in the third experiment by examining the solubility of a substance.

**What does this tell you?**

Science can produce materials on the nanoscale and thus manipulate substances so that they have entirely new properties. For example, we can make steel harder without it becoming heavier. This kind of steel made from lots of nanoparticles (nanostructured steel) can be used to build bridges which last longer and are more durable.
Nanostructured materials have lots of other benefits. For example, carbon can be used to produce what are called ‘carbon nanotubes’, or tiny tubes made of carbon atoms which are 400 times stronger than steel but still as light as a feather. These are extremely well suited to sports equipment such as tennis racquets. What makes nanoparticles so interesting, therefore, is the fact that they can be used to develop things which did not previously exist.

And there’s more

If science can manipulate materials and break substances down into nanoparticles, it makes you wonder whether nanomaterials could be dangerous to either humans or the environment. However, as yet, there has been no indication of any danger based purely on something being or becoming smaller. Of course, something which is dangerous in a large format will still be dangerous when smaller. Five hundred years ago there was a doctor, philosopher and researcher who said that it all depends on the dose: his name was Paracelsus and his theories still apply today.
Can you help Nora reach the sugar?

Although Nora is an excellent scientist, she has lost her way in our maze. Please help her to reach the sugar!
3. Experiment: the link between surface enlargement and solubility
You will need

- 1 level teaspoon of granulated sugar (normal white retail sugar)
- 1 sugar cube
- 1 piece of rock sugar (approx. 0.5 cm in diameter)
- 3 glasses
- 1 teaspoon to stir
- Warm tap water
- 1 stopwatch or watch with a second hand
- 1 piece of paper
- 1 pen
What to do

1. Fill three glasses with the same amount of water and place them on a table.

2. Get your watch or stopwatch ready. Place the level teaspoon of granulated sugar in the first glass, the sugar cube in the second, and the small piece of rock sugar in the third, and stir each glass ten times with the teaspoon.

3. Now begin to measure the time that passes. See how long it takes for each type of sugar to completely dissolve. Write the three times on a piece of paper.

4. Compare the times you have written down. Which type of sugar dissolved the most quickly?
You can see

The granulated sugar dissolves the quickest, followed by the sugar cube and finally the rock sugar.

How does it work?

In the surface enlargement experiment, you learnt that smaller particles have a larger surface area than bigger particles. We discovered that a larger surface area can change how a substance behaves, and saw that larger surface areas offer more opportunities for reaction with other particles.

The granulated sugar particles here are the smallest and have the largest surface area. This means that they react more quickly with the surrounding water and dissolve the quickest compared with the sugar cube and rock sugar. Rock sugar, on the other hand, is made from extra-large crystals. This means that the surface touching the water is much smaller than for granulated sugar, and so the rock sugar takes the longest to dissolve in the water.
Why is this?

Nanoparticles are the smallest particles and, therefore, have the largest surface area. This means that they are extremely reactive. Our example using sugar shows how much reactivity increases as the surface area grows. All three are made of the same material, namely sugar – the only thing which has changed is the shape of the sugar and, therefore, the size of the individual sugar crystals.

What does this tell you?

By changing the size of substances, we can determine and change their reactivity. This opens up a wide range of potential applications. One extremely exciting discovery was when scientists made nanoparticles out of gold. Suddenly, the gold was no longer gold in colour, but red! As early as the Middle Ages, people used to colour glass such as church windows with gold to get a red colour, but at the time no one knew that this was because the gold had been broken down into gold nanoparticles. Nanotechnology has, therefore, been used for centuries without our knowing it. Today, we know how the particles are produced, and we can change the colour as much as we like by changing the size of the particles. On your next trip, go into a church and look for a window with a bright red colour. Then ask the priest where the red colour comes from – you can bet that they won’t know!
And there’s more

Even the Egyptians worked with nanoparticles without knowing it. They used an ink which contained a special type of soot – today we would say that the ink contained carbon nanocomponents.
**Who can draw the prettiest Nora?**

Nora has been looking after you and showing you what nanotechnology can do. Now we want to see what your Nora can do!

Draw or paint a Nora in whatever way you like. Cut her out and send her to us.

You can also ask someone to take a picture of your Nora picture and email it to us:

info(at)nanobionet.de

Please also tell us your name and age. We will publish the best pictures on our website: www.nanobionet.de or on www.nanora.eu

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**Our address**

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What is NANORA?

NANORA – the Nano Regions Alliance – funded by the European Union through the INTERREG IVB NWE Programme, aims at improving framework conditions and support infrastructures for nanotechnology stakeholders.

Its objectives are:
- to develop joint cross-regional business collaborations and supports for companies using nanotechnology expertise to develop more competitive products
- to open new market opportunities for SMEs by taking joint transnational actions for new target markets and
- to ensure outreach to policy level and long-term anchoring of the Alliance in the regions.

The project is based on the conviction that the European regions need to engage in concerted action to be successful in the global competition for nanoenabled economic growth.
NANORA Partners

NANORA unites participants from nanotechnology-strong regions from Belgium, France, Germany, Great Britain, Ireland and the Netherlands committed to supporting nanotechnology as a key enabling technology.