NANOTECHNOLOGY
PUBLIC ENGAGEMENT

Nanotechnology

A World of New Possibilities

Learner Handbook

science & technology
Department:
Science and Technology
REPUBLIC OF SOUTH AFRICA

NRF National Research Foundation | SAASTA South African Agency for Science and Technology Advancement

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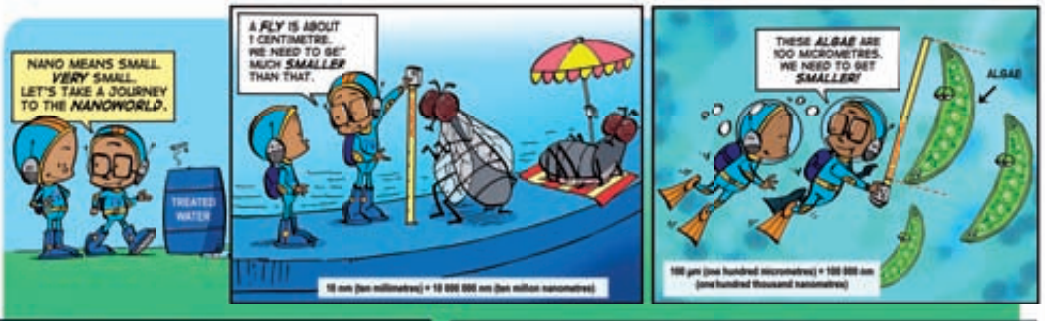
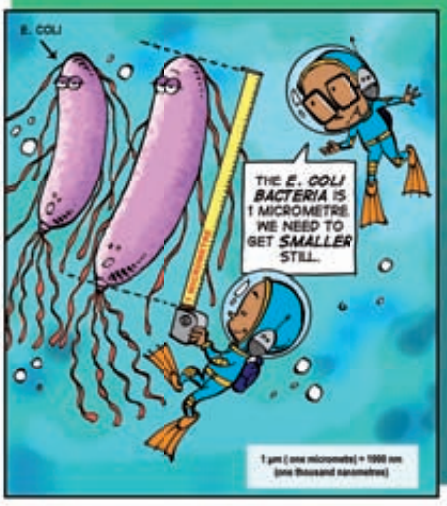
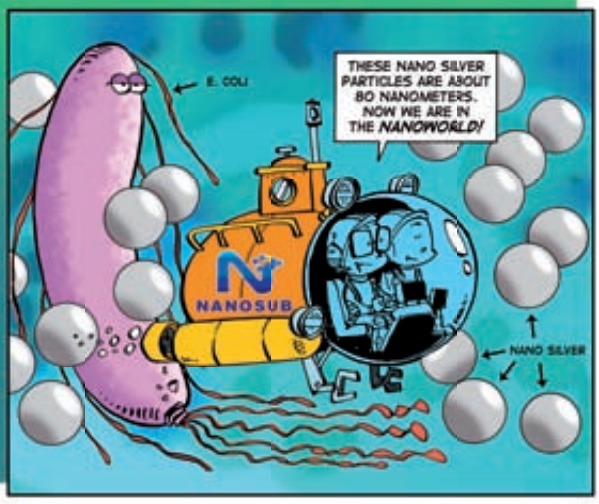
NANOTECHNOLOGY - A WORLD OF NEW POSSIBILITIES

NANOTECHNOLOGY
PUBLIC ENGAGEMENT

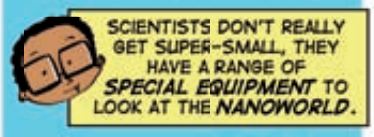
WATER PURIFICATION WITH NANOTECHNOLOGY

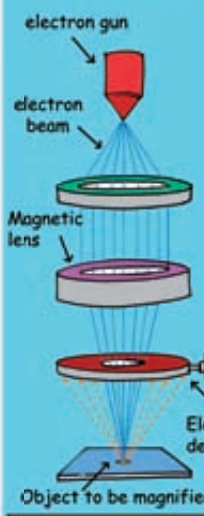




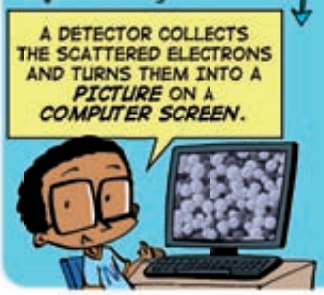


SCANNING ELECTRON MICROSCOPE (SEM)

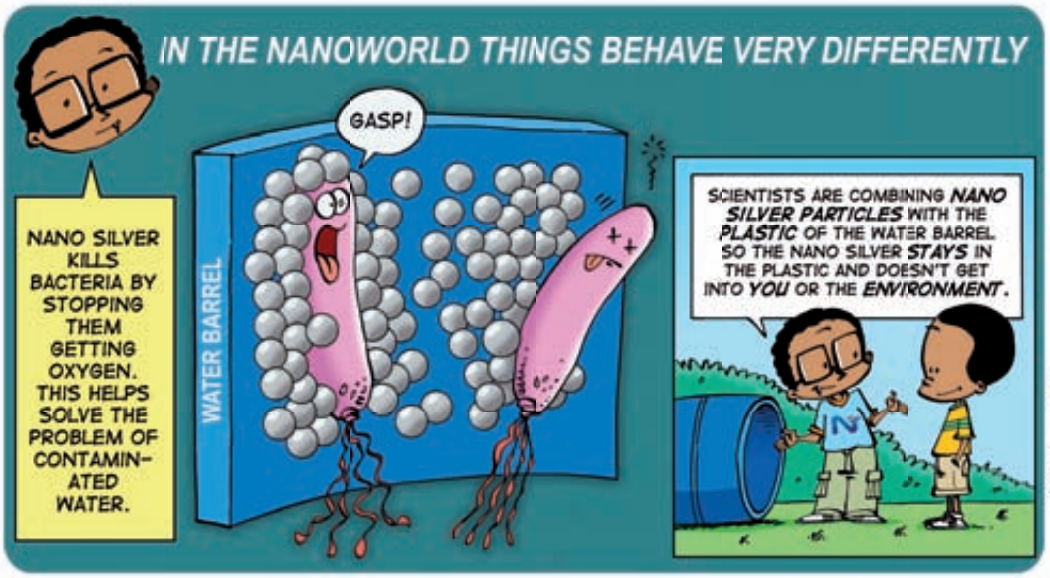




1. The SEM shoots electrons towards the object we want to look at.
2. The electrons are focused using magnets.
3. When the electrons hit the object, they bounce back in different directions.



IN THE NANOWORLD THINGS BEHAVE VERY DIFFERENTLY



NANO CAREERS

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LESSON 1

NANOTECHNOLOGY AND WATER

What will you learn in this lesson?

- What is nanotechnology?
- How small are objects in nanotechnology?
- Where does our water come from?
- How can nanotechnology make water safe to drink?

1. WHAT IS NANOTECHNOLOGY?

Ask yourself: What do you think the word nanotechnology means? Discuss your ideas with the class.

If you think about the word "nanotechnology", it is made up of two parts – "nano" (meaning very small) and "technology" (using science to meet human needs).

So nanotechnology is about the **science of very small objects**.

When things get very small, they behave in new and interesting ways. They can help us solve problems, like unsafe drinking water for example.

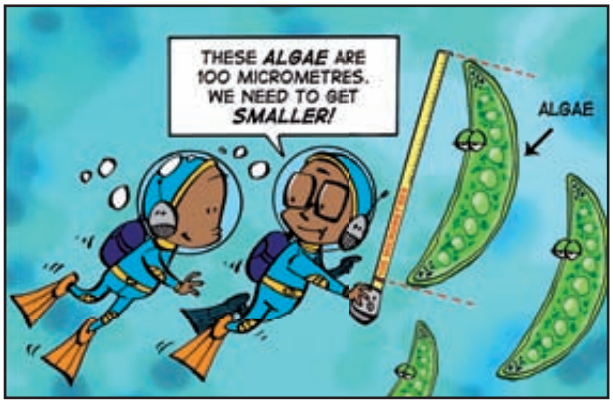
2. HOW SMALL ARE OBJECTS IN NANOTECHNOLOGY?

To understand the size of objects in nanotechnology, you will first need to learn about the units scientists use to measure very tiny objects. These units are called nanometres, and we use the symbol *nm* for short.

So how big is a nanometre?

There are 1 000 000 000 (1 billion) nanometres in 1 metre! This is difficult to picture, so we will take a journey to discover how small this is.

Pretend you are the size of a fly. You will be about **10 mm tall**. 10 mm is 10 000 000 (ten million) nanometres.



Now, pretend you are 100 times smaller: you will be **100 micrometres tall**. 100 micrometres is 100 000 (one hundred thousand) nanometres. At this height you will be a similar size to algae, tiny plants that live in water.

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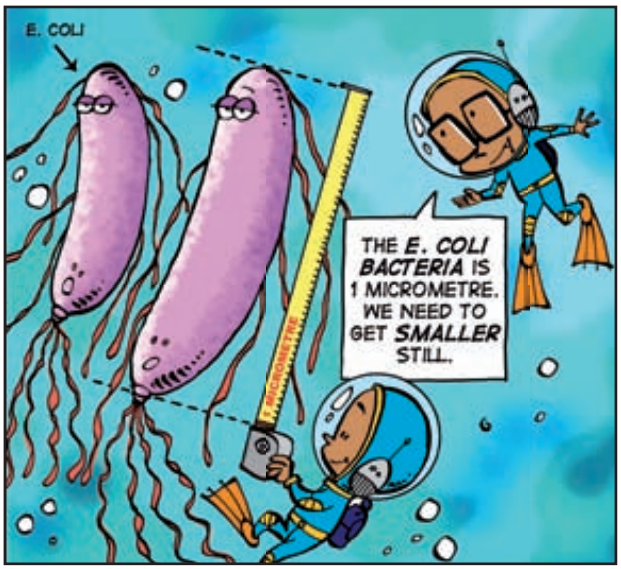
Now pretend you are 100 times smaller still: you will have a height of **1 micrometre**. 1 micrometre is 1 000 (one thousand) nanometres. Now you will be the size of an E.coli bacterium, a single-cell creature that can make you sick.



If you shrink down another hundred times, you will be **10 nanometres** tall. Now you are in the nanoworld.

The following table shows how some of the units for length are linked with nanometres.

Name of unit	Symbol	Number of nanometres
1 metre	m	1 000 000 000 nm (1 billion)
1 millimetre	mm	1 000 000 nm (1 million)
1 micrometre or micron	μm	1 000 nm (1 thousand)
1 nanometre	nm	1

3. WHERE DOES OUR WATER COME FROM?

The water we use comes from rain that has fallen on the earth. This rain water flows into rivers and is stored in dams for us to use. Some of it is absorbed by the ground and forms ground water, which sometimes flows out of the ground as springs.

Fresh water sometimes becomes polluted. If harmful bacteria grow in the water, it can be unsafe to drink. It is important that this water is properly cleaned.

Ask yourself: Where does your community's water come from? How is it cleaned so that it is safe to drink? Discuss your ideas with the class.

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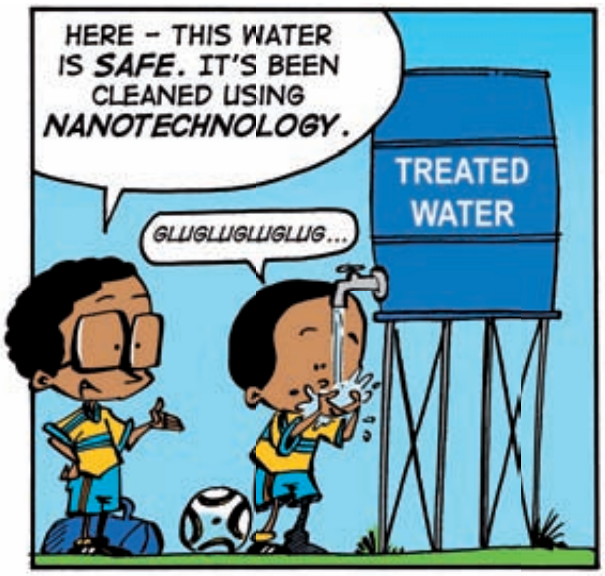
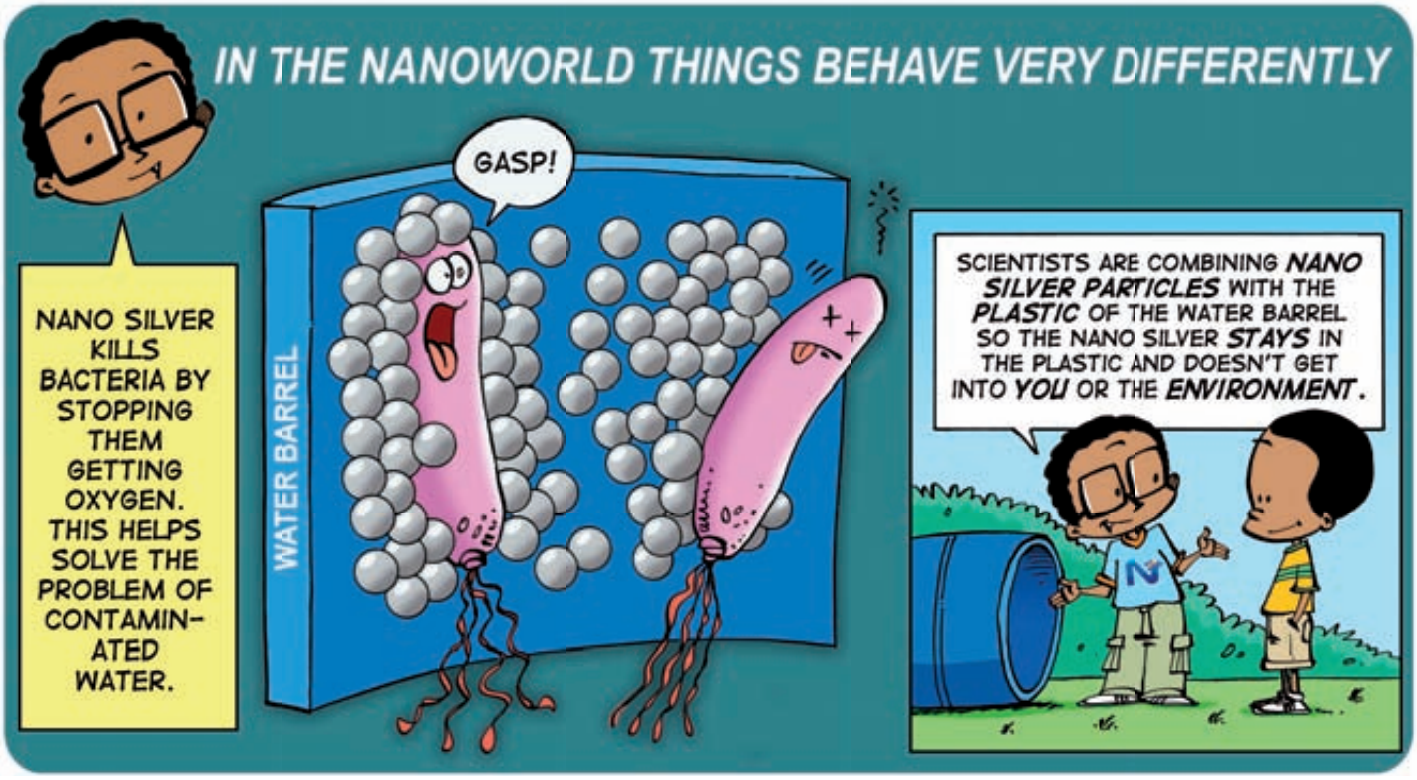
4. HOW CAN NANOTECHNOLOGY MAKE WATER SAFE TO DRINK?

Scientists make tiny silver particles, called nano silver. These are used to clean water because they are antibiotics. This means that they kill bacteria, such as E.coli, which causes diseases and sometimes death.

You can get plastic water barrels that contain nano silver particles.

The nano silver particles combine with the cell walls of the bacteria, and stop them from getting oxygen. In other words, they suffocate the bacteria. If you leave water in the barrel for a few hours, all the harmful bacteria will be killed.





The nano silver stays in the plastic of the barrel, so it doesn't get into you – or the environment.

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LESSON 1 ACTIVITY SHEET

NANOTECHNOLOGY AND WATER

ACTIVITY 1

Use the table below to answer the questions:

Name of unit	Symbol	Number of nanometres
1 metre	m	1 000 000 000 nm (1 billion)
1 millimetre	mm	1 000 000 nm (1 million)
1 micrometre or micron	μm	1 000 nm (1 thousand)
1 nanometre	nm	1

1. If an object measures 15 mm, what is its size in nm? _____
2. How many mm are there in 1 m? _____
3. If you shrink from a height of 1 m to a height of 1 cm (10 mm), how many times smaller are you after you have shrunk? _____

ACTIVITY 2

1. Draw a picture to show where our water comes from. Use arrows and labels on your picture to show the movement of water between different places.

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2. Write a list of all of the activities in your daily life where you need water.

_____

_____

_____

_____

_____

3. Next to each item in your list, put a tick if it is important for the water that you use to be clean.

ACTIVITY 3

Look at the picture shown on the right. Write a paragraph to explain to Vusi's friend how nanotechnology is being used to clean water.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

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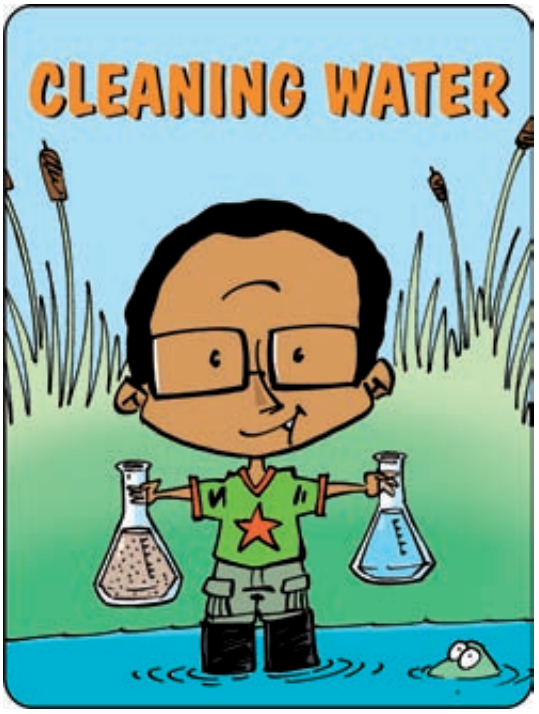
LESSON 1 EXTENSION ACTIVITY SHEET

NANOTECHNOLOGY AND WATER

The water that we use in our society comes from rivers and dams. In this activity you will examine a sample of water, and you will explore ways of cleaning your water sample.

INVESTIGATION ACTIVITY: UNPURIFIED WATER

For this activity you will need a glass jar, and some water from a river or dam that has not yet been purified. Do this activity in pairs.



Part A: Examining the water

1. Spend some time examining the water in your sample.
2. Make a list of all the different things that you see in the water.
3. In your list, make a note of any living things that you can see in the water.
4. Smell the water and write down your description of the smell.

Part B: Cleaning the water

5. Can you think of ways of getting rid of the objects in the water, so that your water sample looks clear? Write down a list of your ideas.
6. Test some of your ideas using materials that you have in your home or classroom.
7. Test different filtration materials to compare the degree to which each material is able to filter the particles present in the water.

QUESTIONS

8. Is there a possibility that there are things in your water sample which you cannot see with your eyes, but which make it unsafe to drink? Write down your thoughts.
9. Can you think of any ways of making your water safe to drink? Make a list of your ideas.

Note: The water you collect may contain harmful chemicals that are not removed by filtration. Do not drink it!

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NANOTECHNOLOGY - A WORLD OF NEW POSSIBILITIES

NANOTECHNOLOGY
PUBLIC ENGAGEMENT

CANCER TREATMENT with NANOTECHNOLOGY

HOW ARE YOU DOING TODAY?

STILL FEELING VERY SICK FROM THE CANCER MEDICATION. BUT TAKE A LOOK AT THIS ARTICLE.

YES! SCIENTISTS ARE WORKING ON REDUCING THE SIDE EFFECTS OF CANCER DRUGS THAT ARE MAKING YOU FEEL SO SICK, BY DELIVERING MEDICATION TO *ONLY* WHERE THE BODY NEEDS IT.

NANO PHARMACY
24 HOUR MEDICINE DELIVERY

IT'S CALLED TARGETED DRUG DELIVERY.

BUT *HOW* WILL IT WORK?

THROUGH *NANOTECHNOLOGY*, THE SCIENCE OF THE *VERY SMALL*. IT'S OPENING A WORLD OF EXCITING POSSIBILITIES. LET'S GO AND SEE MORE!

NANO MEANS SMALL. *VERY SMALL*. THE DOCTOR'S SYRINGE IS ABOUT 80MM. WE NEED TO GET MUCH *SMALLER* THAN THAT.

80 mm (eighty millimetres) = 80 000 000 nm (eighty million nanometres)

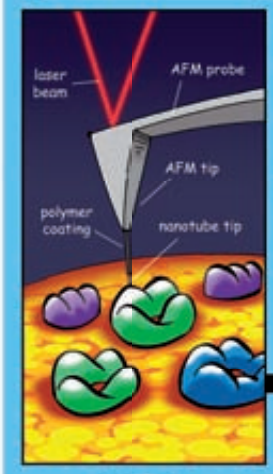
THIS NEEDLE IS USED TO INJECT MEDICATION INTO THE BLOODSTREAM. ITS THICKNESS IS 100 TIMES *SMALLER* THAN THE *SYRINGE*.

0.8 mm

800 µm (eight hundred micrometres) = 800 000 nm (eight hundred thousand nanometres)

ATOMIC FORCE MICROSCOPE (AFM)

THE NANOWORLD IS SO *SMALL* THAT IT CAN'T BE SEEN WITH THE NAKED EYE OR A REGULAR MICROSCOPE. SCIENTISTS HAVE TO USE SPECIAL EQUIPMENT LIKE THE *ATOMIC FORCE MICROSCOPE* (AFM). THE AFM "READS" THE NANOWORLD BY TOUCHING IT LIKE A BLIND PERSON READS *BRAILLE*.



- The AFM has a sharp tip that travels over the naroparticles
- As the tip follows the surface it goes up and down
- A laser beam senses the movement and forms an image on a computar screen

ATOMIC FORCE MICROSCOPES ARE BEING USED TO MEASURE HOW TIGHTLY LIPOSOMES ATTACH TO CANCER CELLS, WHEN THEY DELIVER MEDICATION.

THESE RED BLOOD CELLS CARRY OXYGEN AROUND THE BODY. THEY ARE 100 TIMES SMALLER THAN THE NEEDLE AND MEASURE 8 MICROMETRES.

8 µm (eight micrometres) = 8 000 nm (eight thousand nanometres)

WE NEED TO GET *SMALLER* THAN THAT.

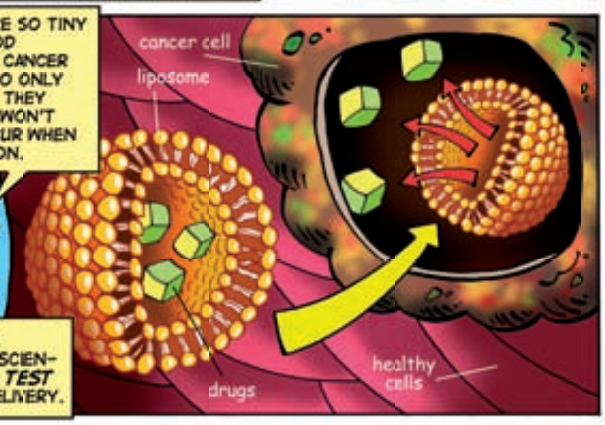
ARE WE IN THE NANOWORLD YET?

YES, AND THESE ARE LIPOSOMES: NANO-PARTICLES LOADED WITH MEDICATION TO DESTROY CANCER CELLS.

NANOSUB

THEY ARE 80 NANOMETRES, 100 TIMES SMALLER THAN A BLOOD CELL.

NANOPARTICLES LIKE LIPOSOMES ARE SO TINY THAT THEY CAN TRAVEL IN THE BLOOD STREAM, FINDING AND DESTROYING CANCER CELLS. LIPOSOMES ARE DESIGNED TO ONLY ATTACH TO CANCER CELLS WHERE THEY DELIVER THE MEDICATION, SO THEY WON'T CAUSE THE SIDE-EFFECTS THAT OCCUR WHEN HEALTHY CELLS ALSO GET MEDICATION.



WOW! NANOTECHNOLOGY REALLY IS OPENING NEW POSSIBILITIES – BUT SCIENTISTS WILL NEED TO BE CAREFUL TO *TEST* THE *SAFETY* OF TARGETED DRUG DELIVERY.

NANO CAREERS

NANOTECHNOLOGY IS NOT ONLY USED IN MEDICINE. IT'S OPENING A WORLD OF NEW POSSIBILITIES AND CAREERS IN SCIENCE AND TECHNOLOGY.

- CREATE NEW MATERIALS
- BUILD FASTER COMPUTERS
- DEVELOP CLEANER TECHNOLOGIES

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LESSON 2

NANOTECHNOLOGY AND MEDICINE

What will you learn in this lesson?

- What is nanotechnology?
- How does our blood move in our bodies?
- What is cancer?
- How can nanotechnology help to fight cancer?

1. WHAT IS NANOTECHNOLOGY?

Ask yourself: What do you think the word nanotechnology means? Discuss your ideas with the class.

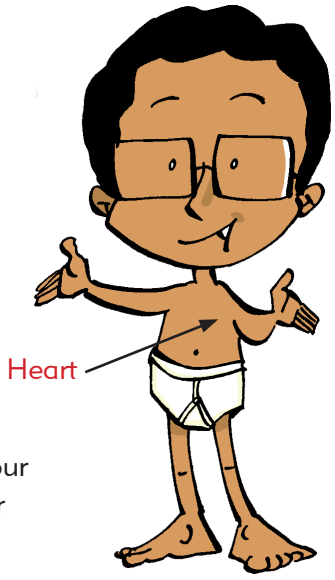
If you think about the word "nanotechnology", it is made up of two parts – "nano" (something to do with very small things) and "technology" (scientific advances to meet human needs).

So nanotechnology is about working with **very small objects to meet human needs.**

The particles used in nanotechnology are so small that they can be injected into our bloodstream, and so they can help us to fight diseases.

2. HOW DOES OUR BLOOD MOVE IN OUR BODY?

Ask yourself: Press your hands to your chest. What can you feel? What is happening and why is it so important?



All human beings have a **heart**. Your heart is a pump that pushes blood around your body.

The blood moves around inside small tubes, called **veins** or **blood vessels**. The blood is made up of blood cells, which take **oxygen** from our lungs to all of the other cells in our bodies. It also takes **food** and **water** from our stomachs to our cells, so that they stay strong and healthy. Our blood also helps to **clean** the cells of our bodies by taking away the waste products from the cells, and transferring them to our kidneys.

3. WHAT IS CANCER?

Cells are the building blocks of our bodies. They can have different shapes and sizes and they all do different things.

While we are growing and developing, our cells need to multiply. Sometimes they multiply too much, making more cells than we need. These extra cells form growths in our bodies, called **tumours**. Not all of these tumours are dangerous, but some of them can become **cancerous**, which means that the cells do not function properly and start to cause sickness in the body. These cancerous tumours are called **malignant** tumours. If they are not treated, the cancer can get into the bloodstream, and spread to other cells in the body.

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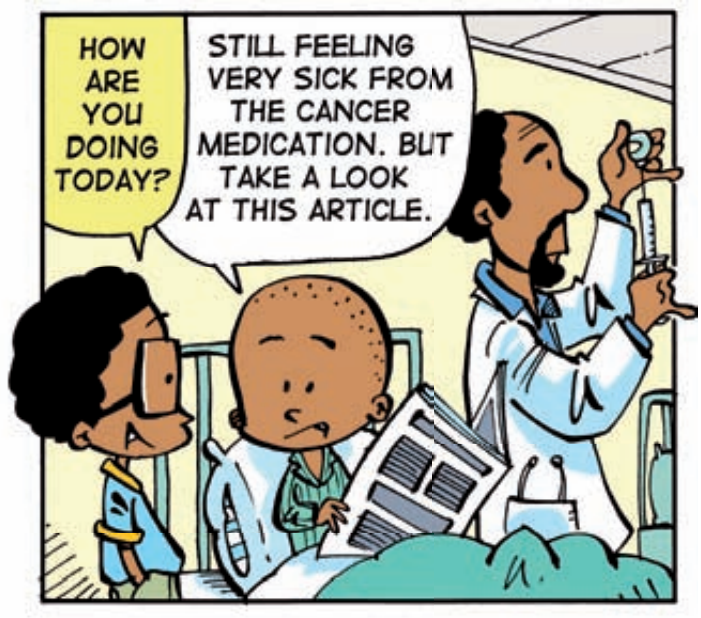
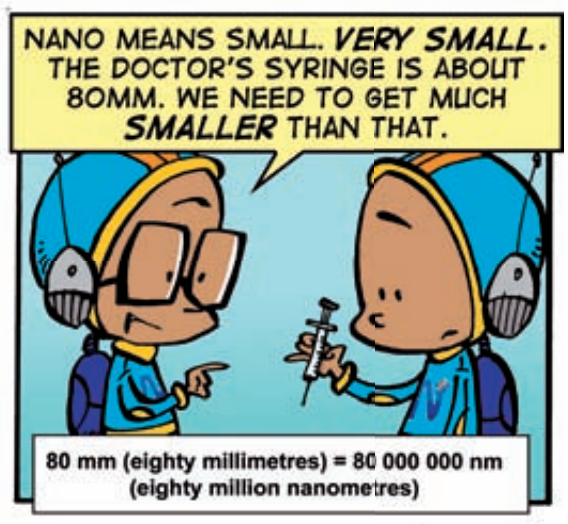
Doctors treat cancer using **chemotherapy** drugs. These drugs carry poison, which kills cancerous cells. But because the drugs carry poison, they cause other parts of the body to feel sick as well. Scientists are finding less harmful ways of treating cancer using nanotechnology.



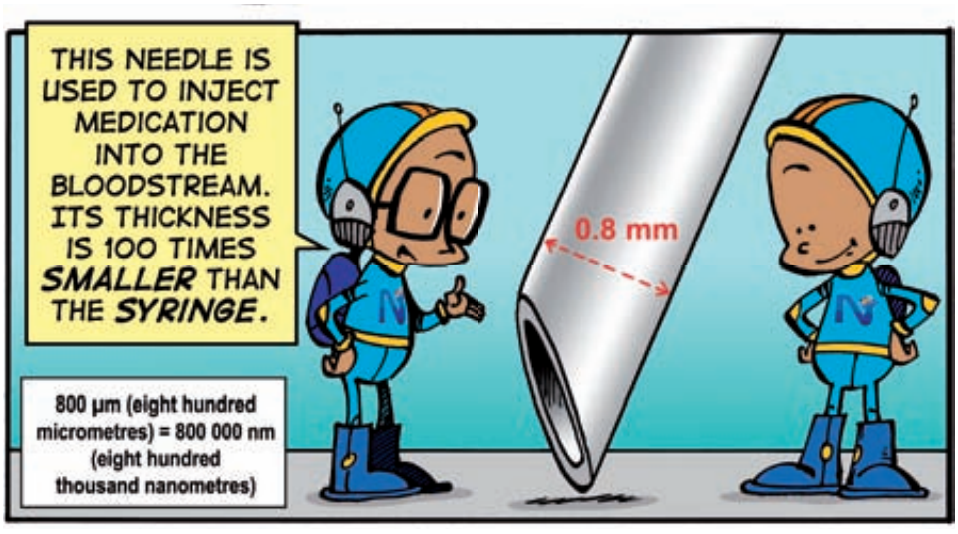
4. HOW CAN NANOTECHNOLOGY HELP TO FIGHT CANCER?

To be able to discover how nanotechnology helps to fight cancer, we will take a pretend journey into the bloodstream to see what happens there. On this journey we will need to shrink (get smaller) with each step that we take, until we are the size of nanoparticles. Nanoparticles are measured in units of nanometres (nm for short). 1nm is so small that you can fit 1 000 000 000 nm into 1 metre!



We will start with the doctor's syringe. This is about 8 centimetres long. (We can write this as 8 cm for short). Since there are 10 millimetres (mm) in 1 cm, we can also write the length of the syringe as 80 mm. But this is not small enough to see what the nanoparticles are doing, since there are 80 000 000 nm in 80 mm.

If we look at the tip of the needle of the syringe, it is a hundred times smaller than the length of the syringe. It is **0,8 mm** wide. There are 800 000 nm in 0,8 mm.



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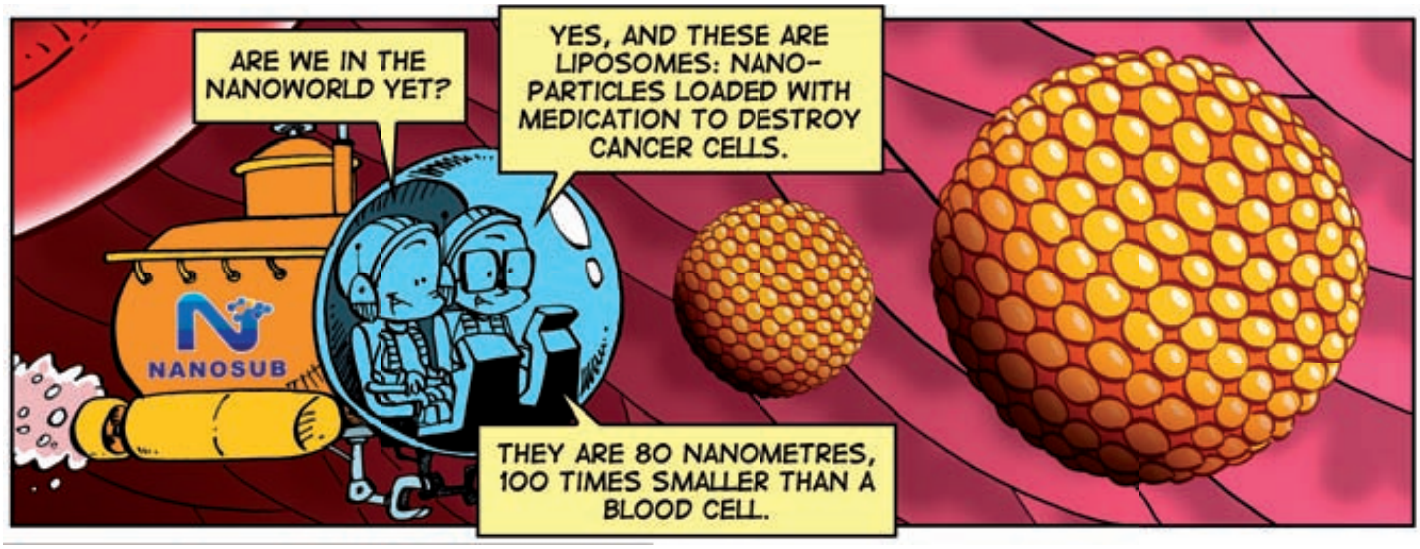
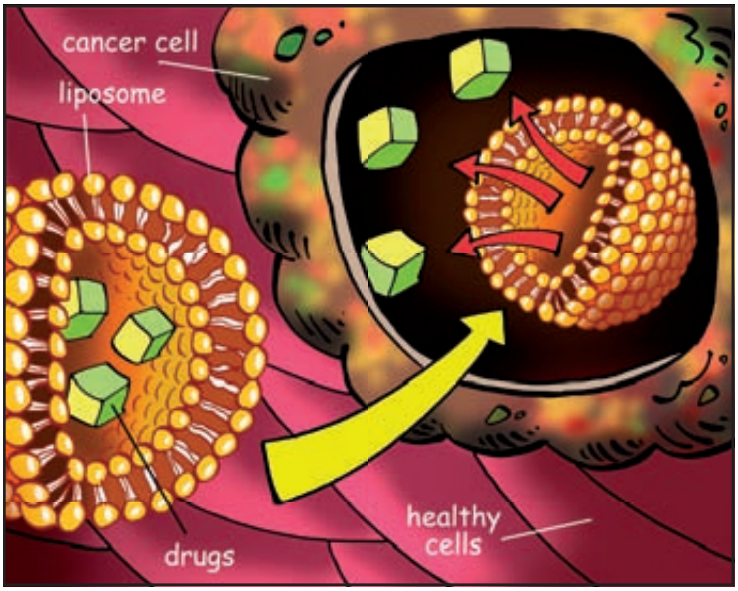
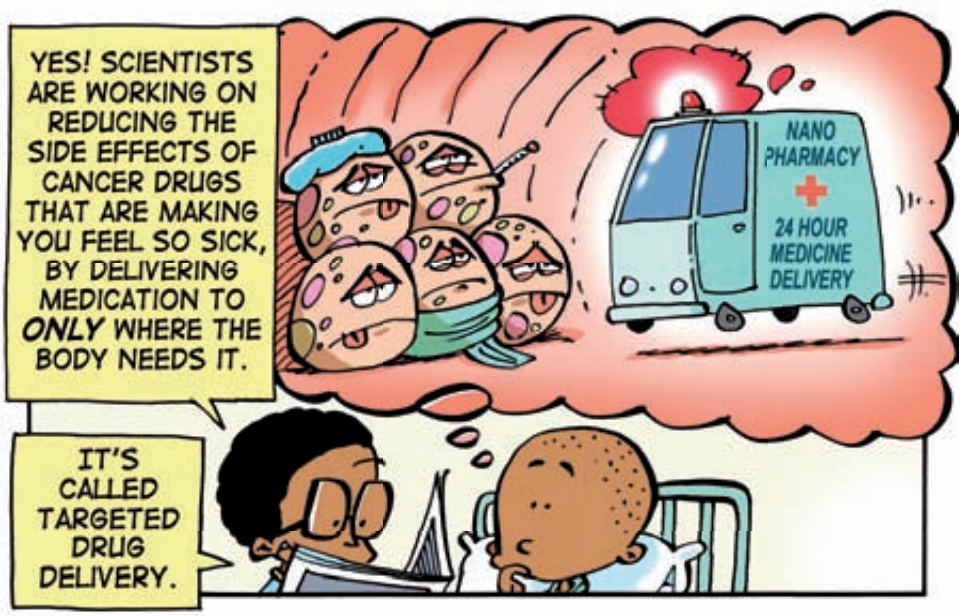
From this size of 8 micrometres, if you shrink down in size another hundred times, you will have a height of **80 nanometres**. Now you are small enough to see the medicine particles that are used to fight cancer.



These particles are called **liposomes**. Scientists have designed liposomes so that they carry chemotherapy drugs along the bloodstream and become attached to cancer cells.





They can unload these drugs into the cancerous tumours. The chemotherapy drugs can then destroy the tumour, but the rest of the body is not affected by the drugs. This is called **targeted drug delivery**.

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LESSON 2 ACTIVITY SHEET

NANOTECHNOLOGY AND MEDICINE

ACTIVITY 1

Fill in the missing words in the sentences below:

Blood cells take _____ from our lungs to all of the cells in our bodies. Blood also takes _____ and _____ from our stomach to our cells. Our blood also helps to _____ the cells of our bodies by taking away the waste products from the cells and transfering them to the _____.

The blood is pumped through our bodies by the _____. Our blood travels through small tubes called _____.

ACTIVITY 2

Link the words in the left-hand column with the correct description in the right-hand column.

Words	Description
1. heart	A. Drugs used to treat cancer
2. veins	B. Nanoparticles that carry chemotherapy drugs to the cancerous tumours but not to the rest of the body
3. tumours	C. This is the same size as 10 mm
4. malignant	D. Pump that moves blood around in our bodies
5. chemotherapy	E. Growths that form in our bodies when cells multiply too much
6. centimetre	F. A tumour that is cancerous
7. micrometre	G. The small tubes that blood flows through
8. liposomes	H. This is the same size as 1 000 nm

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ACTIVITY 2

Answer the following questions:

1. What is a malignant tumour? (2) _____

_____

2. What does the term "targeted drug delivery" mean? (2) _____

_____

3. Why is this a better way of treating cancer than normal chemotherapy drugs? (3)

_____

_____

_____

4. Explain what is happening in the picture below: (3)

_____

_____

_____

_____

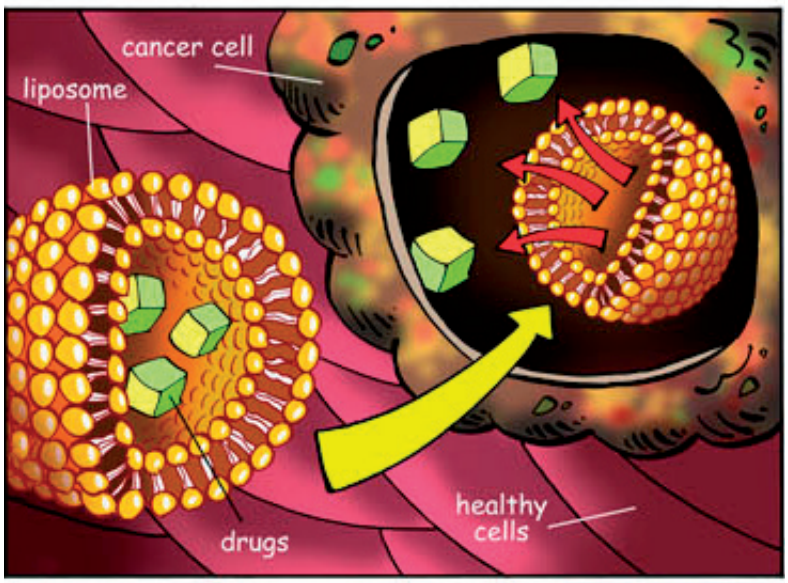
_____

_____

_____

_____

_____



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LESSON 1 EXTENSION ACTIVITY SHEET

NANOTECHNOLOGY AND MEDICINE

WORDSEARCH

See if you can find all of the words from the list below. Some may appear from top to bottom, others from left to right, right to left or diagonally.

O	S	T	I	G	M	B	L	D	O	O	L	B	U	A
O	M	B	D	E	L	I	V	E	R	Y	E	O	R	Y
H	A	I	L	L	P	I	D	T	E	O	O	M	P	E
Y	G	O	L	O	N	H	C	E	T	O	N	A	N	D
H	D	A	S	L	O	X	Y	G	E	N	R	L	D	R
G	M	O	S	E	I	D	T	R	A	E	H	I	O	U
S	M	S	B	U	T	M	S	A	H	E	E	G	O	G
E	M	I	C	R	O	M	E	T	R	E	O	N	F	S
S	O	V	S	T	H	R	O	T	R	E	T	A	W	P
Y	C	E	N	T	I	M	E	T	R	E	E	N	U	M
R	E	I	D	H	E	M	U	C	R	E	A	T	L	U
I	L	N	E	H	O	M	S	G	N	U	L	M	O	P
N	L	S	C	N	O	S	T	O	M	A	C	H	T	Y
G	S	A	A	U	C	O	O	R	O	O	C	P	S	M
E	T	N	R	O	E	E	R	L	T	D	I	E	A	M

LIST OF WORDS:

NANOTECHNOLOGY
SCIENCE
SMALL
BLOOD
BODY
HEART
PUMP
VEINS
OXYGEN
LUNGS
CELLS
FOOD
WATER
STOMACH
TUMOUR
CANCEROUS
MALIGNANT
BLOODSTREAM
CHEMOTHERAPY
SYRINGE
NANOMETRE
CENTIMETRE
MILLIMETRE
MICROMETRE
LIPOSOME
TARGETED
DELIVERY
DRUGS

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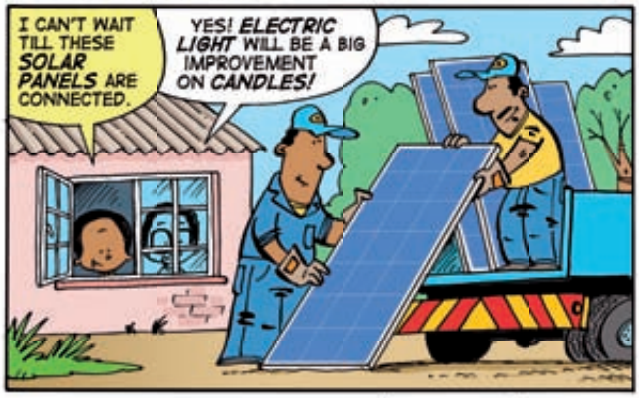
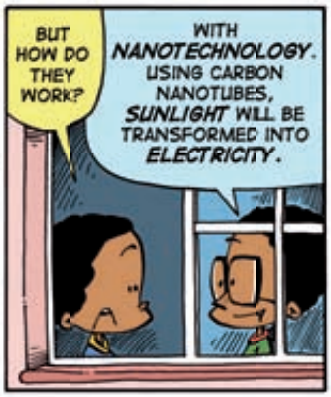
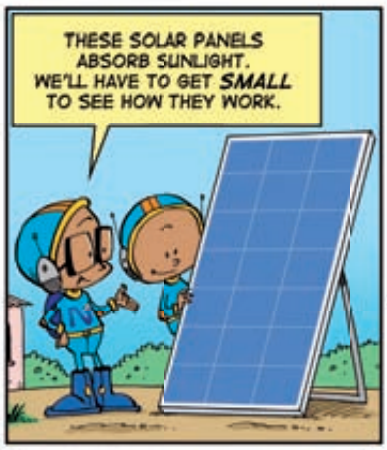
NANOTECHNOLOGY - A WORLD OF NEW POSSIBILITIES

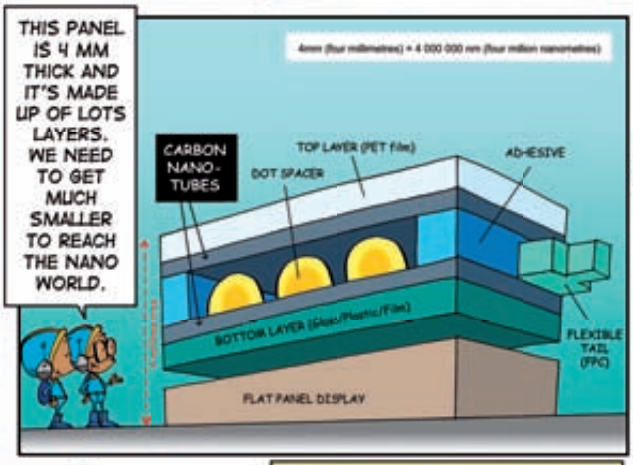
NANOTECHNOLOGY
PUBLIC ENGAGEMENT

SUNLIGHT INTO ELECTRICITY USING NANOTECHNOLOGY



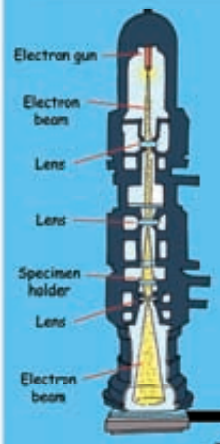




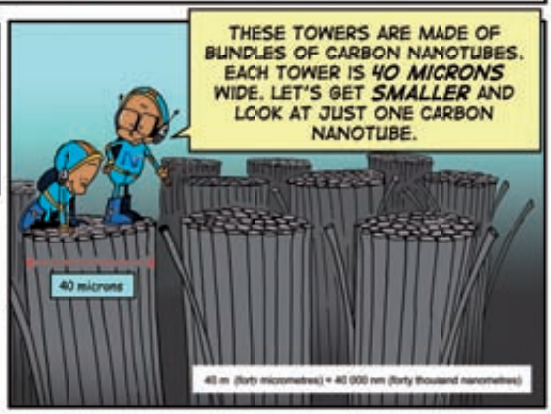


TRANSMISSION ELECTRON MICROSCOPE (TEM)

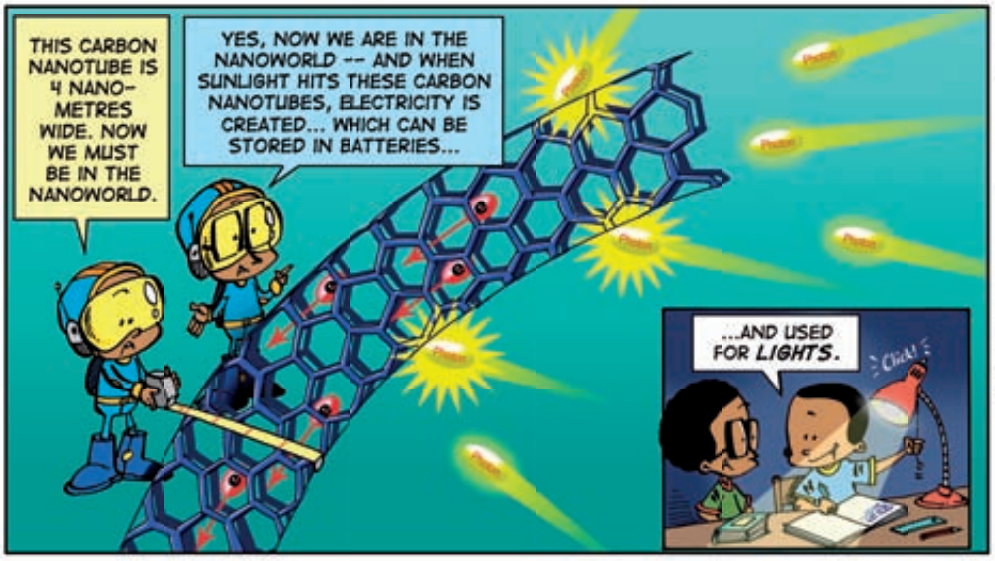
THE NANOWORLD IS SO SMALL THAT IT CAN'T BE SEEN WITH THE NAKED EYE OR REGULAR MICROSCOPE. SCIENTISTS DON'T REALLY SHRINK, THEY HAVE SPECIAL INSTRUMENTS TO LOOK AT THE NANOWORLD.



- This microscope focuses electrons at an object to be viewed.
- The electrons move through the object and form an image.
- The image is captured by a camera and sent to a computer screen.



A TRANSMISSION ELECTRON MICROSCOPE HELPS SCIENTISTS LOOK THROUGH MATERIALS TO SEE INSIDE THEM – LIKE THESE CARBON NANOTUBES.



NANO CAREERS

NANOTECHNOLOGY IS IMPACTING OUR LIFE IN MANY WAYS. A WORLD OF CAREER AND RESEARCH OPPORTUNITIES IS WAITING TO BE EXPLORED.

- AUTO AND AEROSPACE INDUSTRIES
- ENVIRONMENTAL MONITORING AND CONTROL
- FOOD SCIENCE INCLUDING QUALITY CONTROL AND PACKAGING

science & technology
Department: Science and Technology
REPUBLIC OF SOUTH AFRICA

NRF SAASTA

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LESSON 3

NANOTECHNOLOGY AND ENERGY

What will you learn in this lesson?

- What is nanotechnology?
- Where does our energy come from?
- What are solar panels?
- How can nanotechnology help to build better solar panels?

1. WHAT IS NANOTECHNOLOGY?

Nanotechnology is about **the science of very small objects.**

Particles that are used in nanotechnology are so small that they can be used in all sorts of new and powerful ways to solve problems that we've never been able to solve before. Nanotechnology can even help us in getting the energy that we need in our homes. In this lesson you will find out more about how nanotechnology is used to turn sunlight into electrical energy.

2. WHERE DOES OUR ENERGY COME FROM?

Ask yourself: Where does your community's energy come from? Are any of these sources renewable? Discuss your ideas with the class.

In our everyday lives we need energy for all of our activities. We need heat energy to warm our water or to cook our food. We need energy to make our cars or buses work. We even need energy for our bodies to be able to move. All of these forms of energy come from **energy sources.**

There are many different energy sources that we make use of. Some examples are wood, paraffin and coal. Food is another source of energy which gives our body the energy that it needs to stay alive.

Most of our energy sources originally get their energy from the sun. Plants absorb sunlight, and by a process called photosynthesis they are able to turn this sunlight into a form of energy which animals and humans can get by eating the plants.

The crude oil and coal come from plants that have been buried underground for millions of years, and have slowly turned into substances that we can use as an energy source. When crude oil or coal burn, it releases the sun's energy as heat.

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3. NON-RENEWABLE AND RENEWABLE ENERGY SOURCES

The energy sources that we use can be divided into two categories: non-renewable energy sources and renewable energy sources.

Non-renewable energy sources are energy sources that get used up, and will eventually run out. Examples of these are crude oil and coal. These non-renewable energy sources cause pollution adding to global warming which has a negative effect on our environment.

The petrol in the cars that we drive is a non-renewable energy source, because it is made from crude oil which comes out of the ground. This crude oil has been formed from plants and animals that lived in the sea a long time ago. When they died they were covered by sand, and over millions of years they were slowly turned into oil. Crude oil is also used to make paraffin, diesel and other fuels.

The electricity that we use in our homes is also a non-renewable energy source, because it is made using **coal**. This coal is burnt to provide heat that boils water. This creates steam which turns large turbines. This movement energy is then turned into the electrical energy that we use in our homes. Coal is dug up from underground mines, and it will one day run out.

Renewable energy sources are energy sources that come from natural processes, so they do not get used up. Examples of these are energy from the sun (solar energy), wind (wind power) or water (hydropower).

http://commons.wikimedia.org/wiki/File:Old_Windmill.jpg
Patrick Bolduan from Tokyo, Japan

Wind power electricity is the energy that is produced by windmills or wind turbines. These have blades that are turned by the wind. This movement energy can be used to pump water, or it can be turned into electricity or other forms of useful energy.

Hydropower is the energy that comes from moving water. Hydropower is captured by the movement of water in a river, the water released by a dam or the movement of the waves or tides in the sea. This water movement drives turbine engines, which convert the movement into electricity.

http://upload.wikimedia.org/wikipedia/commons/b/bb/Hull-2_Pont_des_Chaudières.jpg
Pierre Tourigny from Gatineau, Canada

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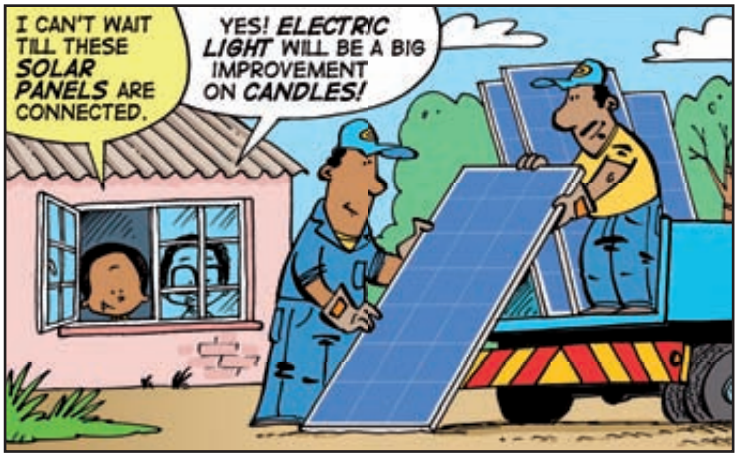
Solar energy is the energy that is captured from the sun's rays. This energy can be used to heat buildings or water, and to produce electricity.

Scientists have developed devices which capture solar energy. These devices are called **solar panels**. Some solar panels can be used to heat water. They are made with lots of little water pipes. These pipes are made from materials that capture lots of heat energy from sunlight, and this energy is then used to heat the water in the pipes.

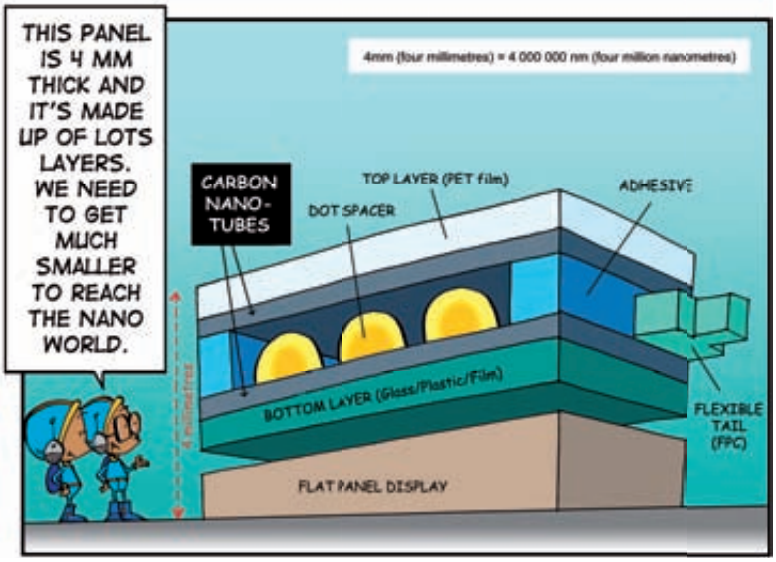
http://commons.wikimedia.org/wiki/File:Solar_heater_dsc00632.jpg

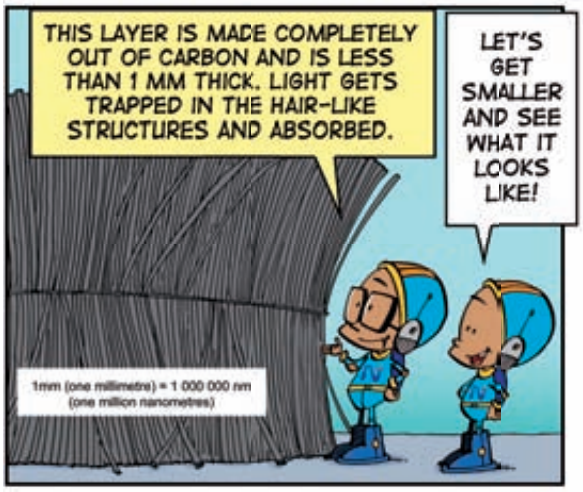


There are other types of solar panels that are made from **solar cells**. These cells are made from special materials, called semiconductors, which can turn energy from the sun into electrical energy.

4. HOW CAN NANOTECHNOLOGY HELP TO BUILD BETTER SOLAR PANELS?

Solar panels are made up of many layers. Some of these layers are made from carbon nanotubes.





Carbon is the same material that you get when wood or a candle wick burns and turns black. The carbon layers are made from lots of hair-like structures that are packed together. This allows them to absorb a lot of energy from sunlight.

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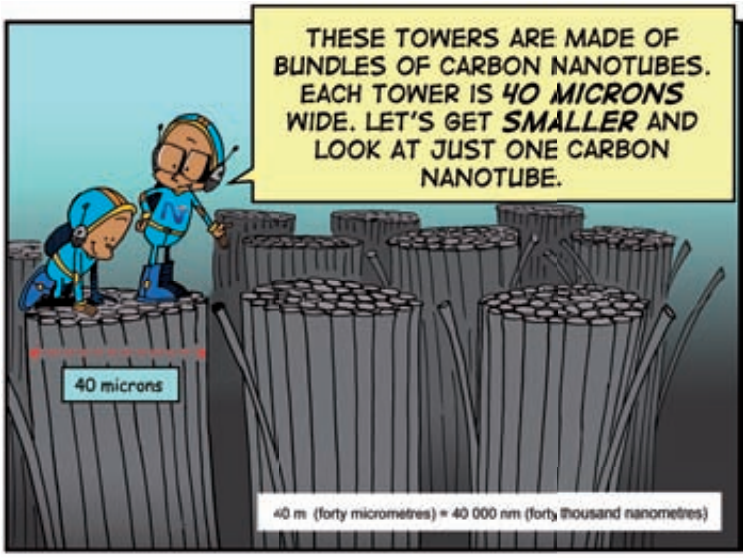
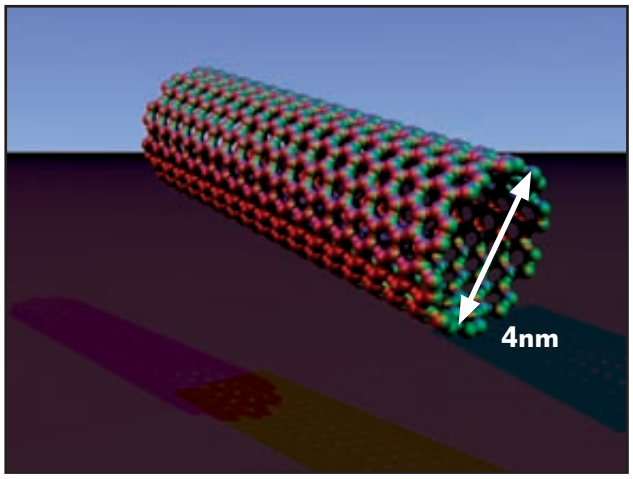
Each of the hair-like structures is a tower that is 40 micrometers wide. (This is half of the width of a human hair!) The towers are made of bundles of carbon nanotudes.

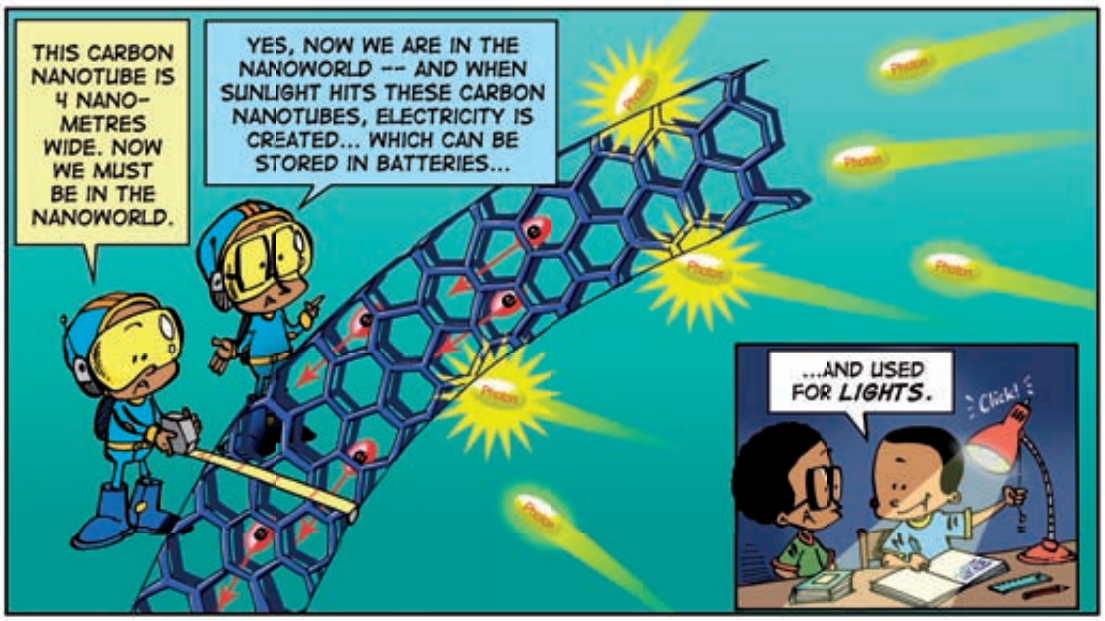




http://commons.wikimedia.org/wiki/File:Carbon_nanotube_armchair_povray.PNG

The carbon nanotubes are tiny tubes that are made from carbon. They are just 4 nanometres wide, in other words, 250 thousand of these would fit into 1 millimetre.

When the carbon nanotubes absorb sunlight, they convert it into electrical energy. This electrical energy can be stored in batteries, and can be used to supply electricity to people's homes.



Scientists have found a way of making these solar panels that is just like painting or printing on a piece of paper. So instead of the old heavy, expensive solar panels, they are now much cheaper and lighter, so they are easier to install.

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LESSON 3 ACTIVITY SHEET

NANOTECHNOLOGY AND ENERGY

ACTIVITY 1

The pictures below show people using energy in different ways.

a. Write down the name of the energy source underneath each picture.

i) Energy source: _____

ii) Energy source: _____

iii) Energy source: _____

iv) Energy source: _____

b. For the energy sources that you have identified in pictures (i), (ii) and (iii), explain how the energy originally comes from the sun.

_____

_____

_____

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ACTIVITY 2

Using the table below, divide the different energy sources into renewable and non-renewable energy sources.

Renewable energy	Non-renewable energy

ENERGY SOURCES:

COAL
SOLAR ENERGY
CRUDE OIL
PETROL
DIESEL
WIND POWER
WOOD
ELECTRICITY
HYDROPOWER
PARAFFIN

ACTIVITY 3

Choose the correct words from the word box below to complete the sentences that follow.

carbon	**crude oil**	**batteries**	**nanometres**
electrical	**coal**	**solar**	**micrometers**

1. _____ panels are made up of many layers. Some of these layers are made from _____ nanotubes.
2. Carbon nanotubes are 4 _____ wide.
3. When the carbon nanotubes absorb sunlight, they convert it into _____ energy. This electrical energy can be stored in _____.

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LESSON 3 EXTENSION ACTIVITY SHEET

NANOTECHNOLOGY AND ENERGY

The purpose of this experiment is to test different materials to see which ones are best at converting solar energy into heat energy.

Apparatus:

Three plastic bottles, a white sheet of paper or plastic, a black sheet of paper or plastic, some water, a thermometer (optional).

Procedure:

1. Fill the three bottles with tap water.
2. Roll white paper or plastic around one bottle, black paper or plastic around the second bottle, and foil around the third bottle.
3. Place the three bottles in the sun. Make sure that they are positioned so that they receive a similar amount of sunlight.
4. Leave them in the sun for about half an hour. While they are in the sun, spend some time answering the following questions:
   a. Write a hypothesis for your investigation.
   b. Which variables did you need to control in your investigation? (How did you make it a fair test?)
   c. Which bottle do you think will have the warmer water in it?
   d. Why do you think this will happen?
5. After half an hour, feel the temperature of the water in each bottle. If you have a thermometer, measure the temperature of the water. Write down your observations. How do your observations compare with your predictions?
6. Write a conclusion to your experiment.
7. What other colours or type of materials could you test for their ability to absorb solar energy?

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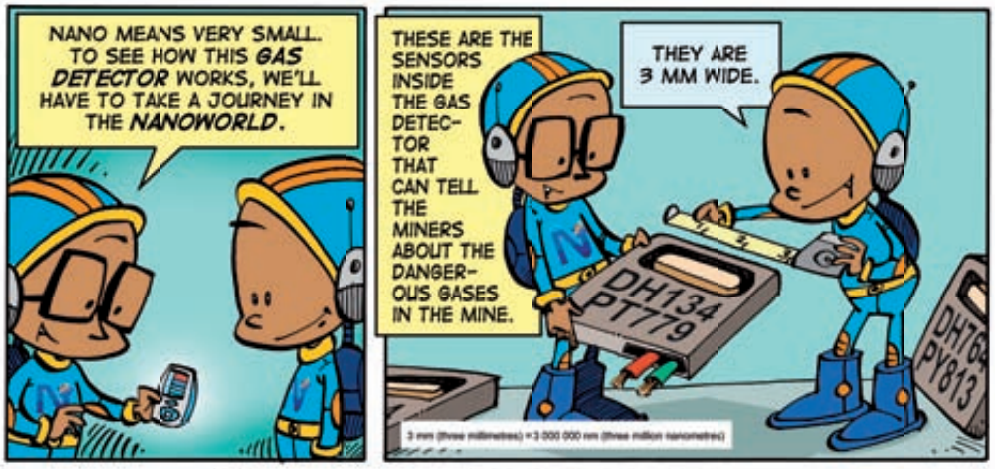
NANOTECHNOLOGY
PUBLIC ENGAGEMENT

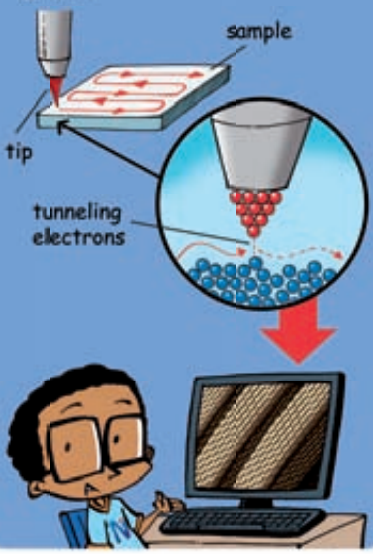
GAS DETECTION IN MINING USING NANOTECHNOLOGY

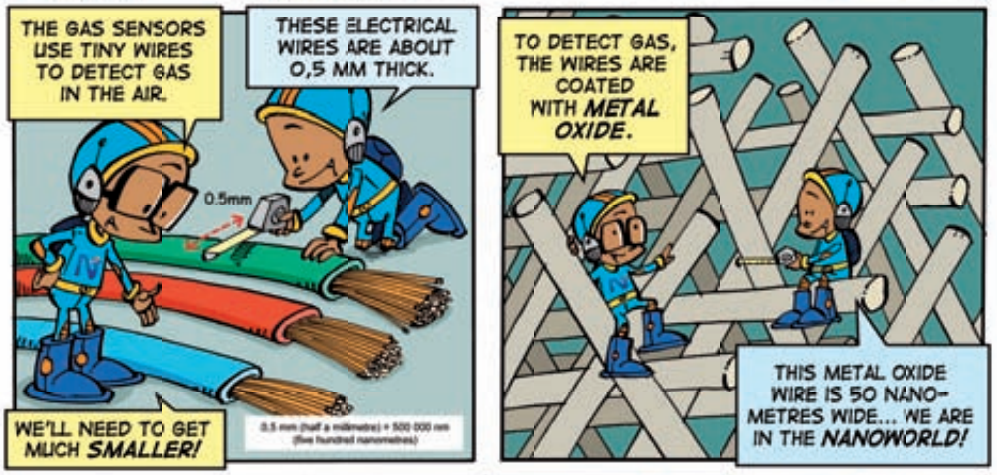


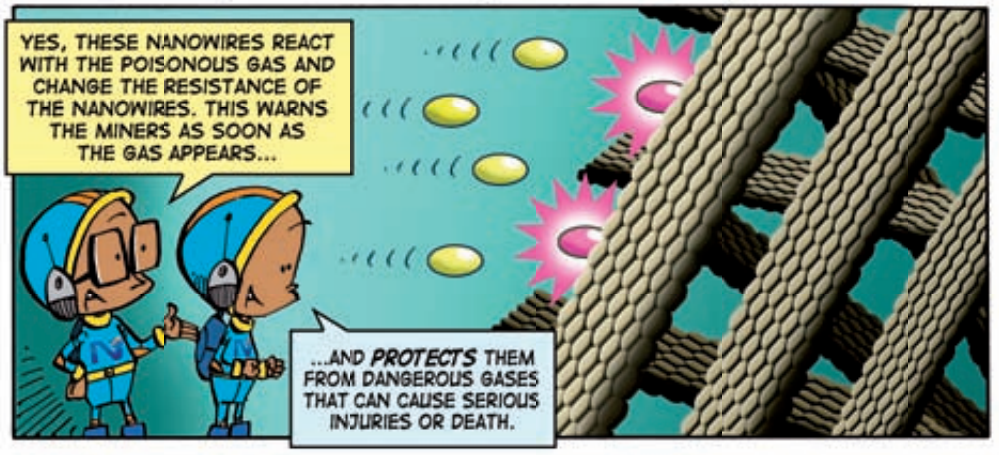
SCANNING TUNNELING MICROSCOPE (STM)

SCIENTISTS USE SPECIAL INSTRUMENTS TO SEE THE NANO WORLD. ONE OF THESE INSTRUMENTS IS THE SCANNING TUNNELING MICROSCOPE:

- The microscope has a tip that travels over the surface of the sample
- Electrons flow from the tip to the surface of the sample
- This forms a signal which is turned into an image and sent to a computer screen.







NANO CAREERS

NANOTECHNOLOGY IS USED IN MANY DIFFERENT BRANCHES OF SCIENCE AND TECHNOLOGY. THERE ARE MANY DIFFERENT CAREERS IN NANOTECHNOLOGY.

- ROBOTICS
- NATIONAL SECURITY
- SPACE EXPLORATION

science & technology
Department: Science and Technology
REPUBLIC OF SOUTH AFRICA
NRF National Research Foundation
SAASTA South African Agency for Science and Technology Advancement

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LESSON 4

NANOTECHNOLOGY AND MINING

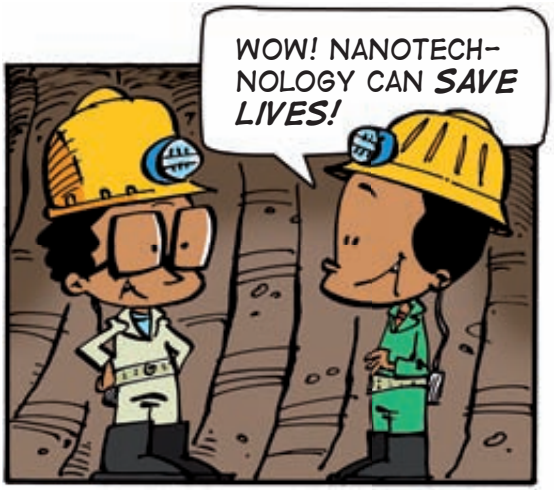
What will you learn in this lesson?

- What is nanotechnology?
- What mining is done in South Africa?
- What are the dangers of mining?
- How is nanotechnology being used to make mining safer?

1. WHAT IS NANOTECHNOLOGY?

Nanotechnology is about **the science of very small objects.**

Particles that are designed and used by nanotechnology scientists are so small that they can be used in new and powerful ways to solve problems that we've never been able to solve before. For example, nanotechnology can be used to make mining safer, and can even save the lives of miners. In this lesson you will learn about mining in South Africa, and you will find out about how nanotechnology is used to improve the safety of mines.



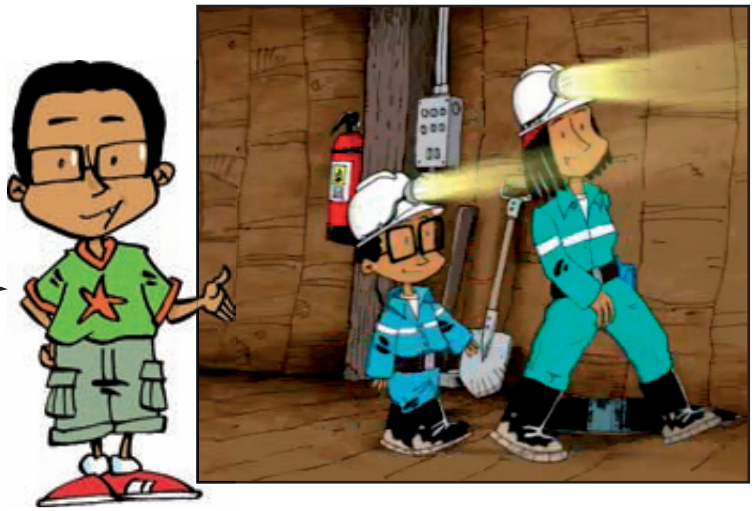
2. WHAT MINING IS DONE IN SOUTH AFRICA?

Ask yourself: What do you know about mining in South Africa? Have you visited any mines? Discuss your ideas and experiences with the class.

South Africa is a country that is rich in minerals, and mining in South Africa has been an important part of the development of the country's economy. The main minerals that are mined are gold and diamonds, but there are many other minerals that are also mined in South Africa. In fact South Africa is the world's largest producer of some very important minerals.

DID YOU KNOW?

SOUTH AFRICA IS THE WORLD'S LARGEST PRODUCER OF CHROME, MANGANESE, PLATINUM, VANADIUM AND VERMICULITE, AND IS THE SECOND LARGEST PRODUCER OF ILMENITE, PALLADIUM, RUTILE AND ZIRCONIUM.



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Gold mining

Gold is a beautiful and shiny material, and so for thousands of years it has been used in jewellery and for other decoration. Gold also has other properties which make it a very useful material in industry. For example, gold is a very good conductor of electricity, and does not become tarnished (dull or dirty). It is very easy to work with and can be hammered into very thin sheets or drawn into long pieces of wire, and can be melted and reformed into very detailed shapes. Because of its many uses, gold is a very important and valuable mineral.

http://www.fotopedia.com/items/flickr-442965594

Most modern gold mining is done by digging for the gold underneath the earth's surface. These are called **underground** mines. The gold is found in gold-bearing rock called ore, and this has to be dug out of the ground. Deep shafts are built for this purpose, some of them as deep as 4km below the ground. Once the gold ore has been brought up to the surface, it is crushed to get the gold out of it. The gold is then separated from this crushed ore and melted into bars.

Coal mining

Coal originally comes from plants that have been buried underground, and have slowly turned into coal over millions of years. Coal is an important energy source, and is used to make electricity and other energy products.

Some coal is found deep underground, and is mined using underground mines, similar to gold mines. Some coal is nearer the Earth's surface, and is mined in **open-pit** mines. In this process the coal-bearing ore is dug out of an open pit. The coal-bearing ore is separated from the surrounding rock and is crushed to enable the coal to be removed.

http://www.geograph.org.uk/photo/982978

Diamond mining

Natural diamonds have been formed from carbon-containing objects like wood and coal that have experienced high pressures and temperatures over millions of years. Diamond is a very pure, tough mineral, and so it has very important uses in industry. It is also sparkly and beautiful, and has been used to make jewellery.

Diamonds can be mined in underground mines, in open-pit mines, and also in river beds. This river mining is called **alluvial** mining. Here the sand and stones along river beds are sifted, and the diamonds are found and separated from the other material.

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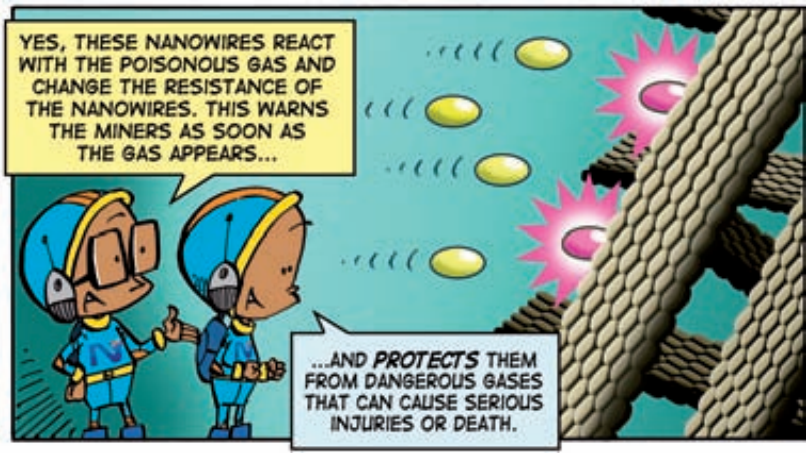
3. WHAT ARE THE DANGERS OF MINING?

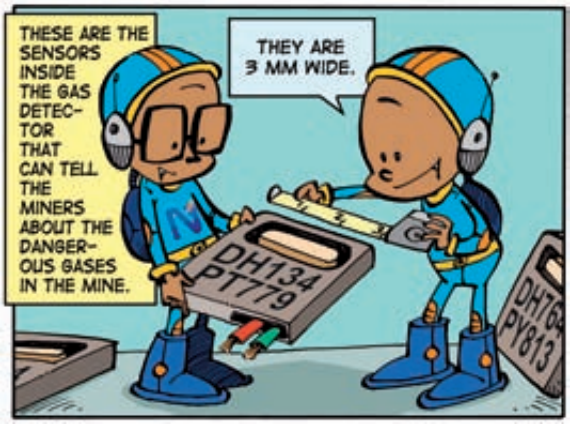
Mining can be very dangerous, especially underground mining. Miners can fall through the floor of an underground tunnel if it is weak in some place. Mines can collapse, leaving the miners crushed or trapped underground. In some mines there are small dams of water, and miners can slip and fall into these dams, and can even drown. Sometimes the air in mines can have flammable or poisonous gases in it. Flammable gases can easily catch fire, and can even explode. If miners breathe the poisonous gas they can suffocate, or become sick and even die.

4. HOW IS NANOTECHNOLOGY BEING USED TO MAKE MINING SAFER?

One of the ways that scientists are using nanotechnology to make mining safer is by building gas detectors that can pick up dangerous gases. These detectors are like small noses that can pick up exactly what gases are in the air, and how much of these gases there are.

The sensors are built from tiny wires, called nanowires. These nanowires are made out of materials called metal oxides. When the wires made from metal oxides come into contact with different gases, this changes the resistance of the wires. This means that their ability to conduct electricity changes. This change in electrical conduction is picked up by a detector, which gives a warning to the miners about the kind of gas that has been detected.





Because nanotechnology uses very small amounts of material, the gas sensors can be made very small, so that they can easily be carried around by miners.

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LESSON 4 ACTIVITY SHEET

NANOTECHNOLOGY AND MINING

ACTIVITY 1

Choose the words from the word box to fill in the missing words in the paragraph below:

open-pit	**poor**	**underground**	**ore**
alluvial	**tarnished**	**good**	**energy**

1. Gold is a very _____ conductor of electricity, and does not become _____ (dull or dirty).
2. Gold is mined in South Africa in _____ mines. Here gold is found in rocks called _____.
3. Coal is an important _____ source.
4. Coal that is near the Earth's surface is mined in _____ mines.
5. The process of mining diamonds from river beds is called _____ mining.

ACTIVITY 2

Describe the mining dangers that are shown in the picture below.

_____

_____

_____

_____

_____

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ACTIVITY 3

In a group of 5 or 6 learners, design and draw a poster showing how nanotechnology is being used to build gas sensors for mines.

Make your poster as clear and colourful as possible. Your teacher will assess your work using the following criteria:

Poster is colourful and creative	2 marks
Poster shows original ideas	2 marks
Poster is clearly presented	2 marks
Information on poster is informative	2 marks
Groupwork - All learners were included	2 marks
TOTAL	**10 marks**

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LESSON 4 EXTENSION ACTIVITY SHEET

NANOTECHNOLOGY AND MINING

In gas detectors that are used in mines, metal oxide nanowires are used. When these wires come into contact with a poisonous gas, their resistance changes, which changes the electrical current that they can conduct. In this investigation you will test the effect of changing resistance on the current in a circuit.

APPARATUS:

A torch bulb, a battery holder with two batteries in it, three electrical leads or wires, a length of pencil lead.

INVESTIGATION:

Pencil lead is an electrical resistor. The longer the length of the pencil lead, the higher its resistance.

1. Write an investigation question

Write down the question that you will be investigating.

2. Write a hypothesis for your investigation

A hypothesis is a best guess at the answer to your investigation question. Write a hypothesis for your investigation.

3. Procedure for the investigation

Make sure that your hypothesis gives a clear idea of the steps you need to do to find the answer. What variables do you need to control in your investigation?

Follow the experimental steps below:

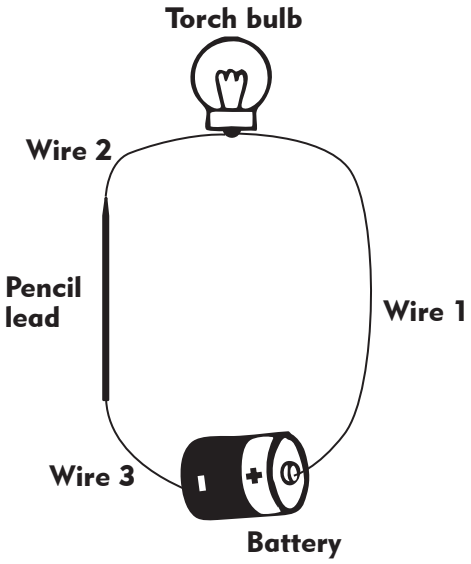
a. Connect your equipment so that you have built the circuit shown in the diagram.

b. Begin by including as much of the pencil lead as you can in your circuit.

c. Once you have completed the circuit, observe the brightness of the lightbulb.

d. Now change the length of the pencil lead that has been included in your circuit by moving the end of wire 2 so that it is nearer the middle of the pencil lead.

e. Observe the brightness of the lightbulb with this shorter length of pencil lead.



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f. Now decrease the length of the pencil lead that has been included in your circuit once more.

g. Observe the brightness of the lightbulb with this shorter length of pencil lead.

h. Record your observations carefully.

4. Analyse your data

Assume that the brightness of the light bulb tells you the strength of the current that is flowing in the circuit.

What relationship between current and resistance do you notice from your observations?

5. Write a conclusion

Write a clear conclusion to your investigation.

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NOTES:

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Thank you!

Please return this form to
Fax no. 012 320 7803
Email: mthuthuzeli@saasta.ac.za

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