Giants of the Infinitesimal:

an interactive experience of the Nanoworld

Information for teachers of KS3 and KS2 and activities for pupils

WHAT IS IN THE EXHIBITION?

The Exhibition provides:

- visuals to explain that nano particles are very very tiny
- interactive exhibits which enable children to learn how scientists find out about the nanoworld – including equipment used in real scientific experiments and a large working electron microscope model.
- a fun interactive challenge for children to try to build a nanowire.
- an amazing ball pool which shows how atoms assemble naturally into new structures.
- large screen videos of scientists explaining their discoveries.

The exhibition has links to the National Curriculum:

KS 2 Science - physics and chemistry
KS 3 Science - forces/Brownian motion/electromagnetic waves/chemical bonds

The exhibits – teacher information:

Entering the nano-world. Nano particles cannot be seen with our eyes so highly specialised scientific techniques are required.

Exhibit 1a Investigation chamber – using X-rays to find which elements are in a sample. You can track the beams.

Exhibit 1b Investigation chamber – using Infra-red light to determine the chemical bonds in a sample. Can you spot the elements present?

Exhibit 2 Electron microscope – using electrons to image. Challenge: what is it?

Exhibit 3 SPM - nano-particles can be positioned individually. Challenge: make a nanowire before it gets too hot!

Exhibit 4 Self-Assembly Pool – watch particles form completely new structures.

Exhibit 5 Amazing structures of the nano-world – including a Graphene kinetic sculpture

ACTIVITIES FOLLOW on Pages 2 to 4 with answers on Page 5.

WORKSHEETS for KS3 and KS2

AS YOU MOVE ROUND THE EXHIBITION, DO READ THE INFORMATION PANELS.

Entering the Nanoworld.

A nanometre is a very, very, very tiny distance.

Look at the edge of a sheet of paper. It is about 100,000 nanometres thick.
One of the letters on this page is about 1 millimetre wide. There are about one million nanometres between the sides of this letter o.

A. Your hair grows one nanometre each second. Can you see it growing? **YES / NO**

B. Everything is made of atoms. The diameter of a large atom is about half a nanometre.
Do you think it is possible to see atoms using your eyes? **YES / NO**

C. Which of the following is true?
   i. When we see a flame the visible light from the candle enters our eyes. **TRUE / FALSE**
   ii. We see a ruler when our eyes send out visible light to the ruler. **TRUE / FALSE**
   iii. We see a pen when visible light is reflected (bounces) from the pen and travels to our eyes. **TRUE / FALSE**

Visible light travels like a wave with a wavelength about 1000 times longer than an atom.

D. Trying to see atoms with visible light is like using a) a dumper truck to find a pea
b) a spade to find a pea
c) a spoon to find a pea. *(Which answer is best?)*

Scientists have developed highly specialised techniques to 'see' nanoparticles.

Exhibit 1a: The investigation Chamber – using X-rays to find what a sample is made of.
(Real scientific equipment converted to form an exhibit.)

X-rays are like light waves or radio waves but they carry a lot of energy.
When X-rays hit a surface (like the ring) they knock off electrons. Electrons are incredibly small particles. They are about 1 millionth the size of an atom.
Note: When scientists do experiments with an investigation chamber there is a high vacuum inside the chamber so that the electrons are not absorbed by air molecules.

- **Press the button on the Investigation Chamber**. The path of the X-rays and electrons appear as a bright yellow line.
- **You can track the path if you look through the windows in the exhibit.**
- **Can you find the curved tracks through the large dome?** The electron path curves because they pass through an electric field. The electrons have different energies so they follow different paths.
- The scientists can measure how many electrons pass into the analyser with each energy.
- Then the scientists can work out what the sample is made of from their results.

Exhibit 1b: The investigation Chamber – using infra-red light to discover what is on the surface of a sample by finding out about the chemical bonds in the molecules.
The infra-red light is not used to see the sample. Light carries energy. You know that because on a sunny day, you can feel the sunlight warming you. (Another name for infra-red is heat.)
The energy carried by infra-red is just right to cause the molecules in the sample to vibrate.

- **Press the button on the Investigation chamber.** The path of the infra-red appears as a bright red line.
- **You can track the path if you look through the windows in the exhibit.**
- Some of the infra-red is absorbed by the sample. The remainder travels on to the detector.
- **Look at the screens on the exhibit to find out more.**

Note *that the Investigation chamber is a real piece of scientific equipment that has been modified so that you can see how it works.*

Exhibit 2: The Electron Microscope

An optical microscope uses visible light which is passed through a series of lenses. An electron microscope uses a beam of electrons to scan very very small objects and build up an image.

- **Press the blue button to start.**
- **Move the joy stick backwards and forwards as well as up and down.** .An image of the object slowly builds up.
- **You have one minute to work out what it is.**
- The list of objects is on the back of the exhibit.
- **You can choose a different one and have a second try.**
- It is often difficult for scientists to recognise the nano-size particles that they scan.

Exhibit 3: The Scanning Probe Microscope SPM

The magnification produced by an SPM is so huge scientists can ‘see’ and move individual atoms with its probe.

An SPM is a microscope for ultra-high magnification. It uses an ultrafine ‘tip’ to scan over a surface and image individual atoms. However, this is not easy because atoms and molecules move continuously and randomly. At very cold temperatures, near absolute zero, (blue lights) it is much easier to manipulate the particles to complete the wire because at these temperatures the atoms almost stop moving.

In this model of a SPM the balls represent atoms.

- **Challenge – you have five minutes to complete the nanowire before the temperature rises!**
- **Use the green button to lift the probe.**
- **Use the yellow buttons to move the probe over a ball (which represents an atom).**
- **Use a green button to lower the probe to pick up an 'atom' by a red dot.**
- **Use the yellow buttons to move the probe and ball in line with the nanowire.**
- **Then the other green button to lower the ball onto one of the contacts.**
- **Use either the red or blue button to release the 'atom'. Find which one is needed!**
- **Repeat this until the wire is complete – all the orange lights will flash!**

When the blue lights turn pink, the temperature is rising and the 'atoms' begin to vibrate.
Is it easy to manipulate the 'atoms' now?
When the lights turn red, this represents the temperature becoming hot and it is impossible to make the nanowire.

Exhibit 4: **The Self-Assembly Pool** - nanoparticles can form completely new structures.

The balance of attraction and repulsion between the electrons in different atoms decides which particular shapes and structures can be formed via self-assembly. The forces between atoms are continually changing because of the vibration of atoms and molecules due to energy in the form of heat. At first this movement appears to be just a nuisance but is essential for the process of self-assembly – it allows atoms to find their most stable position in a structure.

Complex molecular structures have developed over millions of years. Some are vital for life itself.

Watch carefully and list the different structures you spot. (e.g. rings)

Exhibit 5 **Visualising the amazing complexity of the nanoworld. (More on this website)**

The artists in the Giants of the Infinitesimal team have created sculptures to represent nanoscale structures which are fascinating yet beautiful.

The structure of **graphene** is a lattice made up of carbon atoms and is only one atom thick. Watch the graphene exhibit as it vibrates and changes shape.

See also the interactive graphene sheet at http://www.giantsoftheinfinitesimal.com/digital-graphene.htm. Move your mouse over the lattice and watch it flex amazingly! You can vary the elasticity, the number of atoms and make other changes. You can even switch off the lines drawn to represent the bonds.

The future: Controlling nanocomponents may solve many world problems such as providing new clean energy sources and computers 1000 times smaller and faster.

ANSWERS

A. Your hair grows one nanometre each second. Can you see it growing? **NO**

B. Do you think it is possible to see atoms using your eyes? **NO**

C. Which of the following is true?

i. When we see a flame the visible light from the candle enters our eyes. **TRUE**

ii. We see a ruler when our eyes send out visible light to the ruler. **FALSE**

iii. We see a pen when visible light is reflected (bounces) from the pen and travels to our eyes. **TRUE**

D. Choice c) - a dumper truck!

Find out more at the Giants of the Infinitesimal website - http://www.giantsoftheinfinitesimal.com/

Contact giants@liv.ac.uk with your queries