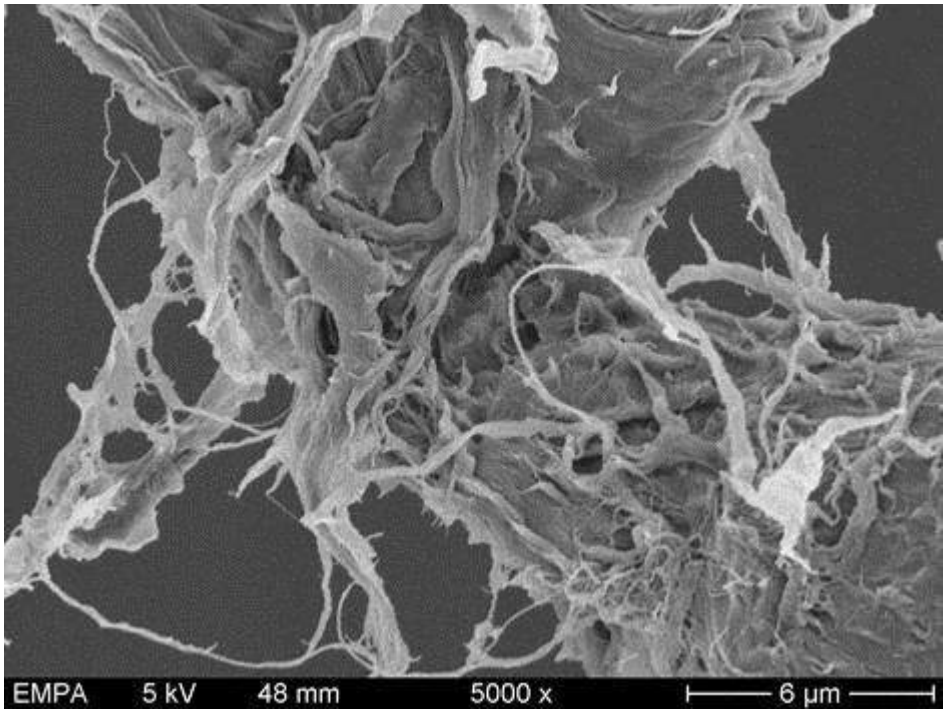
Begbroke Science Park

UNIVERSITY OF OXFORD

An introduction to nanoscience and nanotechnology

Questions to consider

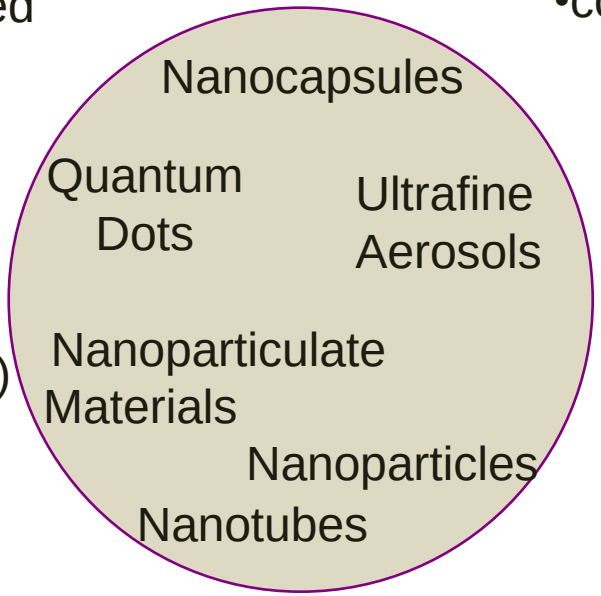
- What is a nanoparticle?
- How big is ‘nano’?
- How big is a nanometre?
- What is a nanoscience?
- Why nano?
- What is a nanotechnology?
- What opportunities are hidden in the nanodimension?
- What techniques are there for characterising nanoparticles?



What is a nanoparticle?

Chemical composition
- metals/metal oxides
- polymers, carbon
- semiconductors
- biomolecules
- compounds . . .

Origin
- natural
- unintentionally released
- manufactured



Dispersed in
- gases (aerosols)
- liquids (e.g. gels, ferrofluids)
- solids (matrix materials)

Shape/structure
- spheres
- needles
- platelets
- tubes

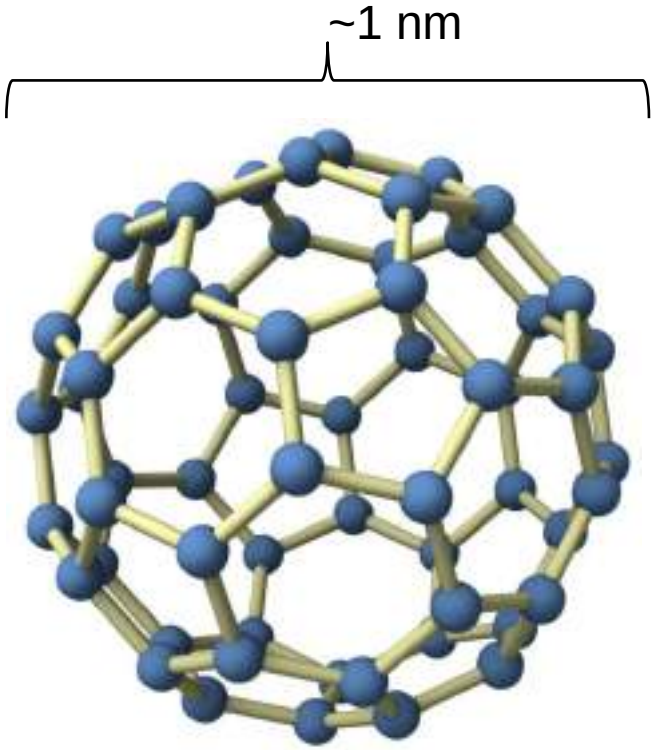
Aggregation state
- single particles
- aggregates
- agglomerates

Surface modification
- Untreated (as obtained in production process)
- Coated (e.g. conjugates, polymer films)
- Core/shell particles (e.g. spheres, capsules)

What is a nanoparticle?

An example is a bucky ball

- a fullerene



- 60 carbon atoms linked together in one unit.

How big is ‘nano’?

ratio
earth / football

=

ratio
football / fullerene

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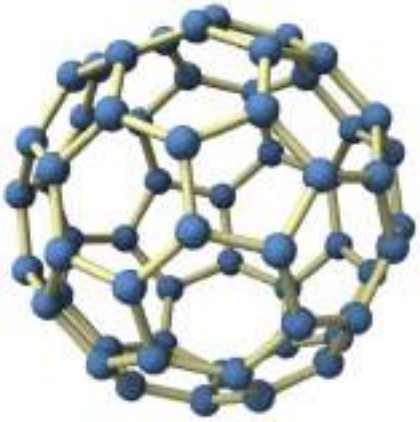
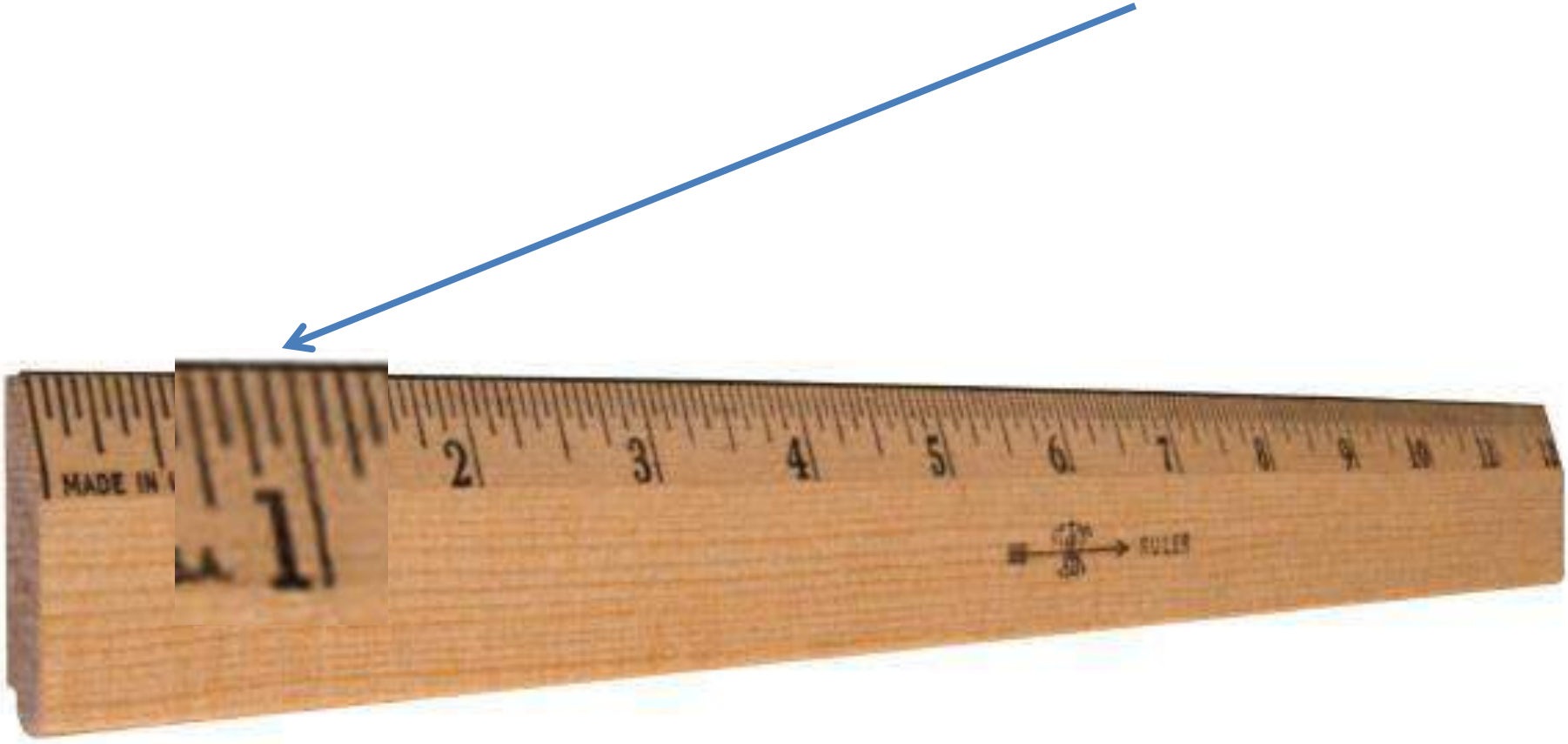


nanotechnologyuniverse.com

How big is a nanometre?

It is a million times smaller than the smallest measurement you can see on a ruler!

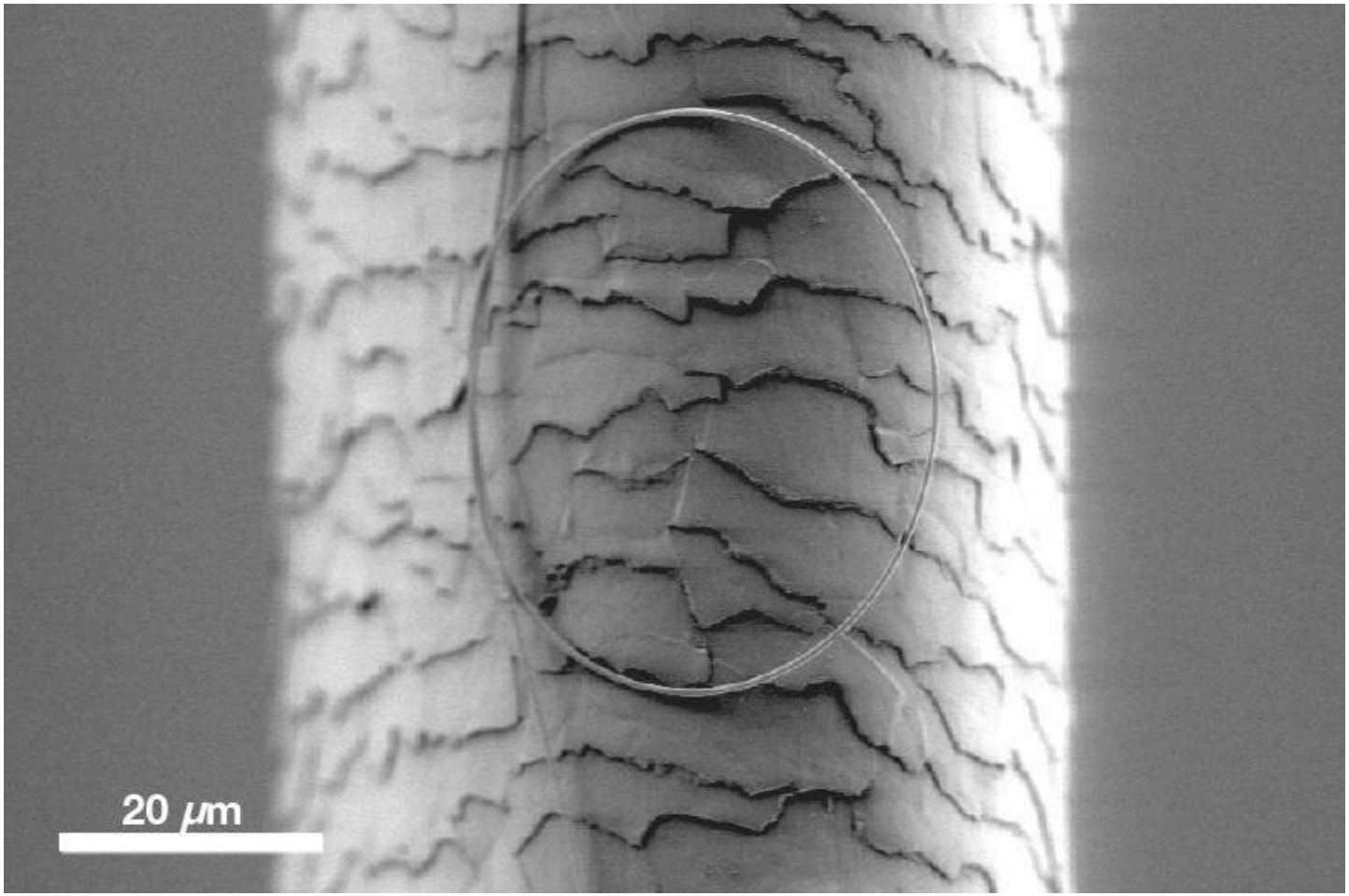


It is a millionth of a millimetre or a billionth of a metre

A human fingernail grows
1 nanometre every second.

A man’s beard grows
5 nanometres every second.

This is a silver nanowire resting on a human hair.
Look at a strand of your own hair and imagine how small that is…



What is nanoscience?

The study and manipulation of materials at the nanoscale

Why nano?

At the nanoscale, strange things happen to materials – their **properties can change**.

Reactivity - As particles get smaller they tend to react differently with their environment than larger particles.

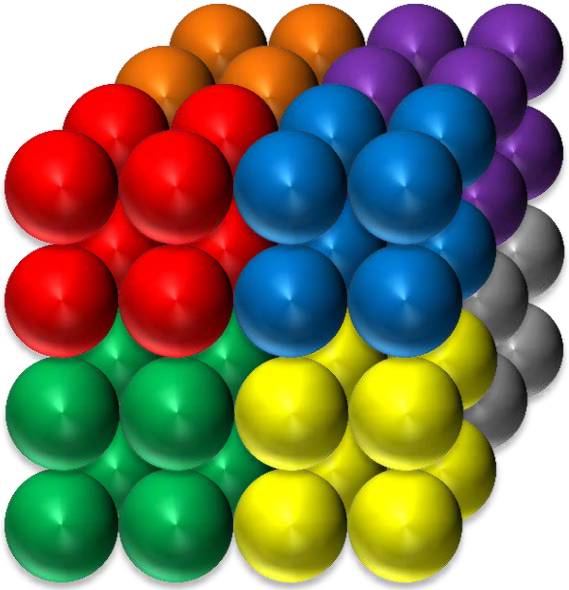
Size - Smaller particles can have different optical properties: their colours change because different sizes of particle reflect and absorb light differently.

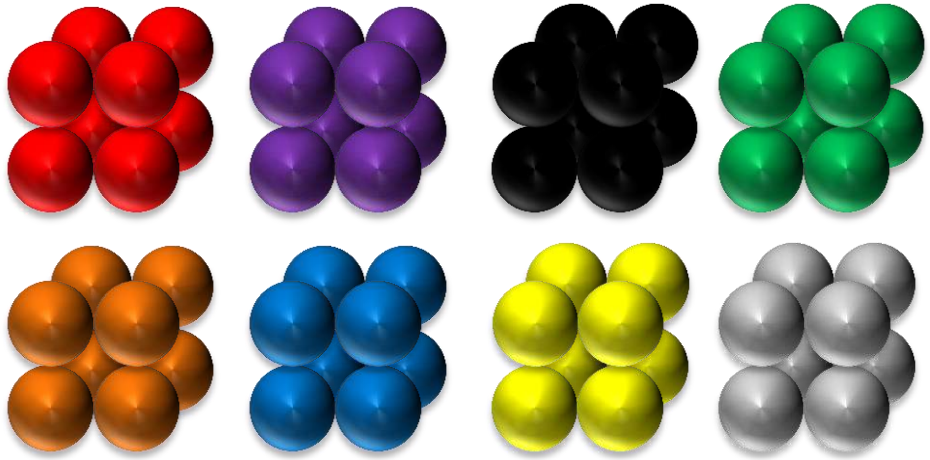
Magnetism - Smaller particles can have different magnetic properties than larger.

Reactivity

Necessary understanding:

- What an atom, a molecule, a nanoparticle and a chemical reaction is.
- How the surface of a cube is calculated.
- How the volume of a cube is calculated.

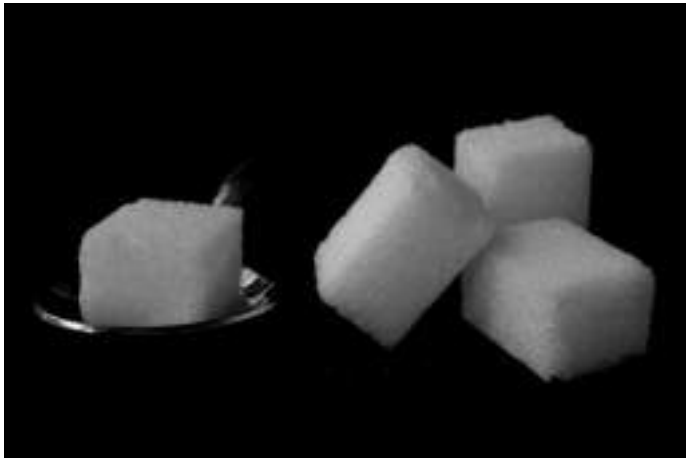




Example:

Which dissolves faster in water?

granulated sugar



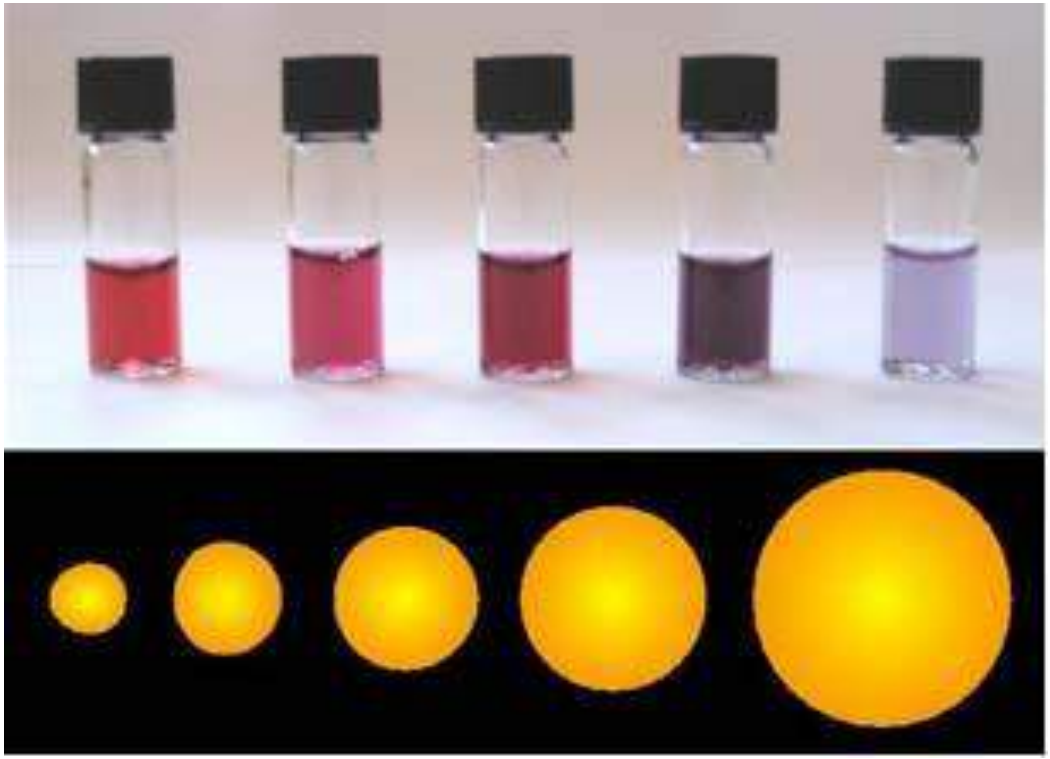
sugar cubes

Size

Which of these is Gold?

The colour of gold can range from purple to red depending on the size of the atom clusters.

Different sizes of particles reflect and absorb light differently.



Hundreds of years ago it was known as art

Red stained glass gets its colour from nanoparticles of gold that are only 20 nanometres across.

Orange glass gets its colour from gold nanoparticles that are 80 nanometres across.

Now we call it nanotechnology

What is Nanotechnology?

The development of materials and devices by exploiting

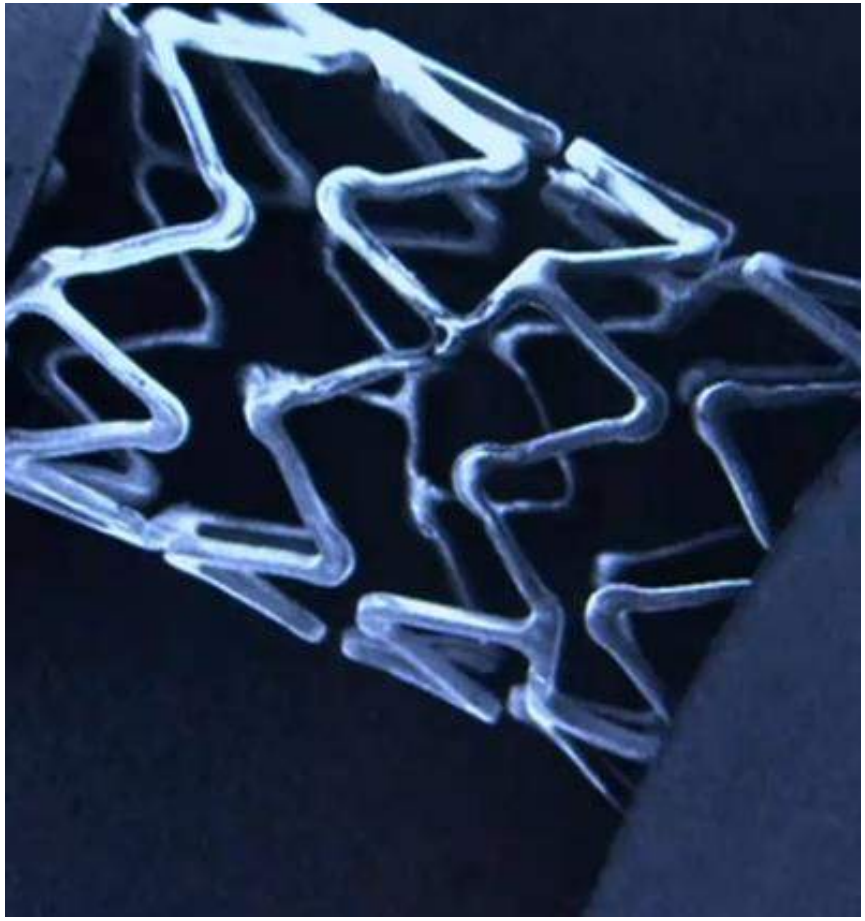
the characteristics of particles

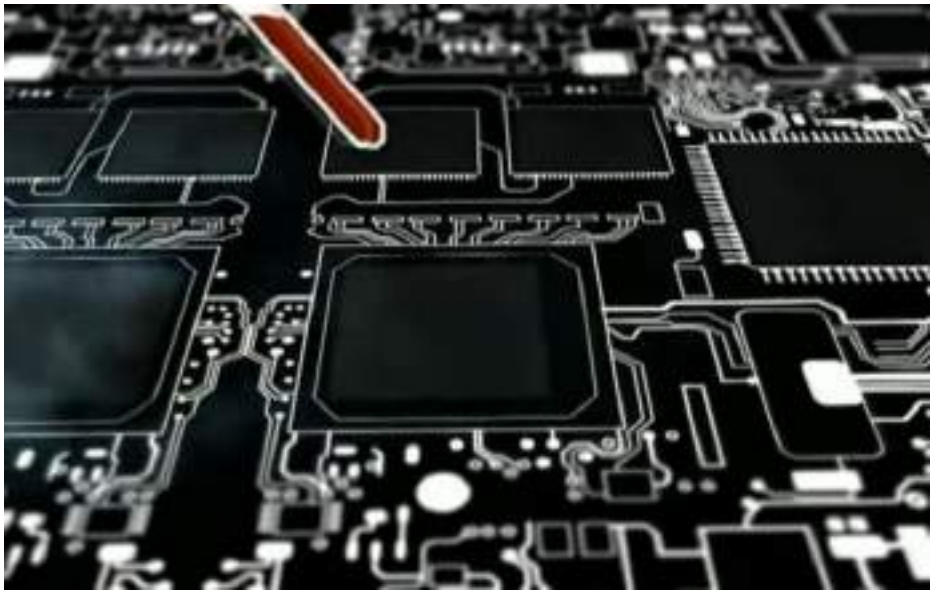
on the nano-scale

(by humans).

Potential impacts of nanotechnology

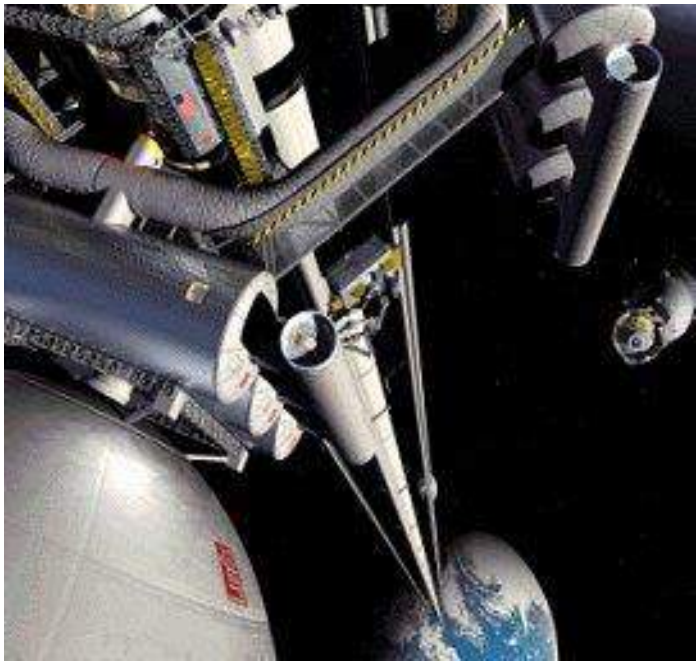
Health:
Diagnostics, Cancer treatment and targeted drug delivery.





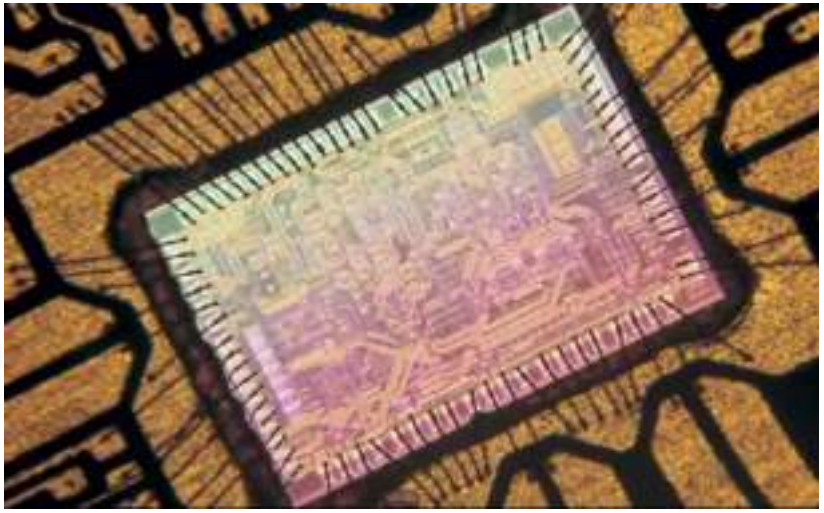
Potential impacts of nanotechnology

Materials:
Sports industry, cosmetics, clothing and space elevators.



Potential impacts of nanotechnology

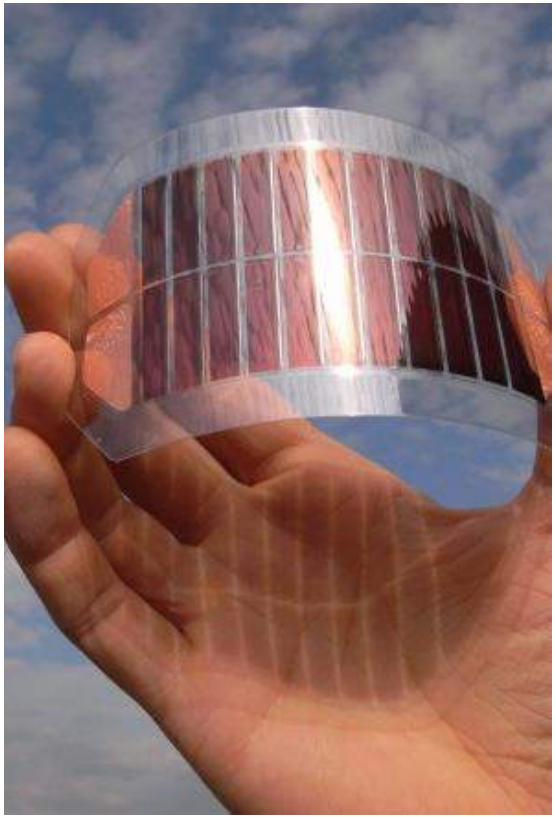
Technology:
Faster processing, morphing computers and smaller, more powerful mobile devices.

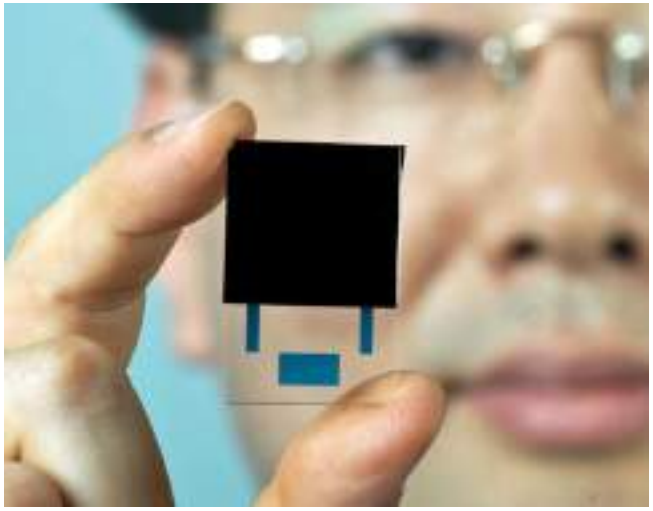


Potential impacts of nanotechnology

Environment

Cleaner energy, better energy storage and treatment of water.

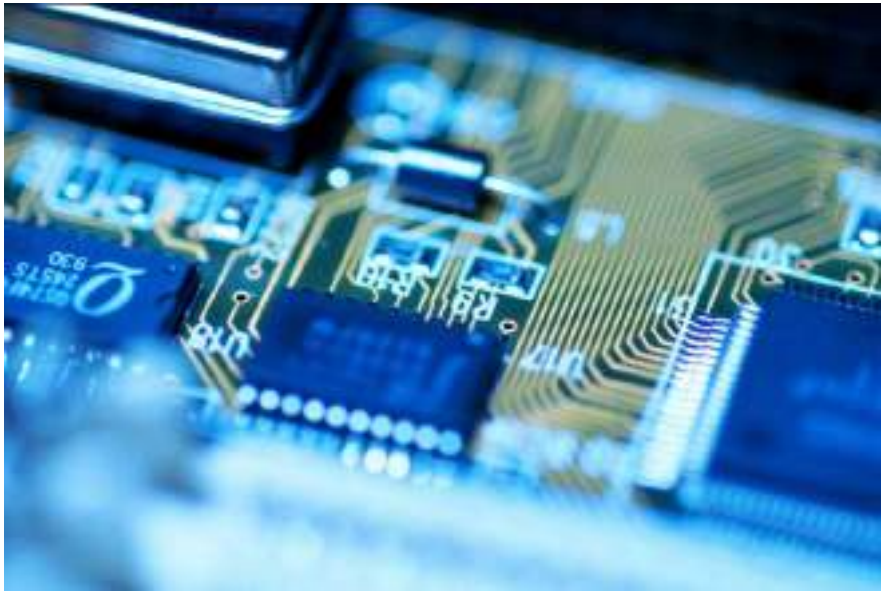


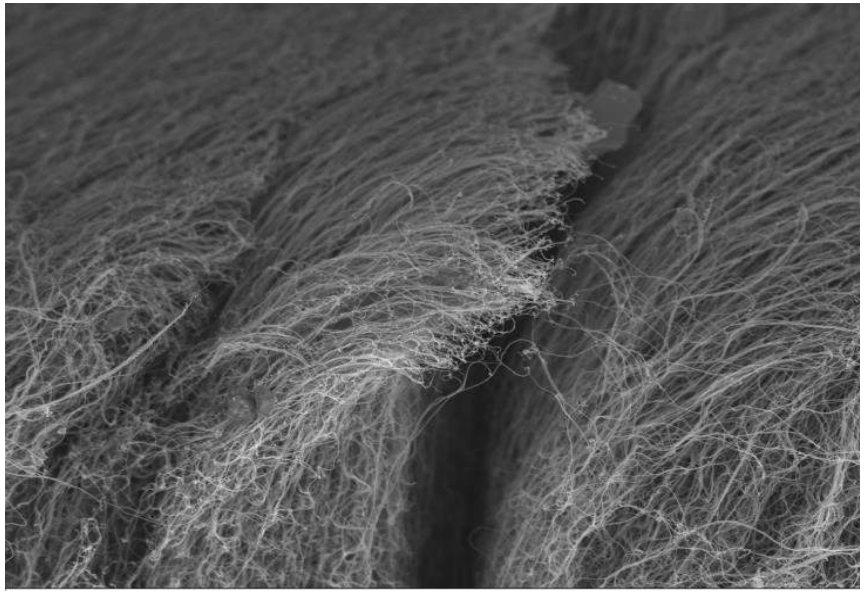


How do we build small things?

Computer chips can be made **“Top-down”**– building something by starting with a larger component and carving away material (e.g. like a sculpture).

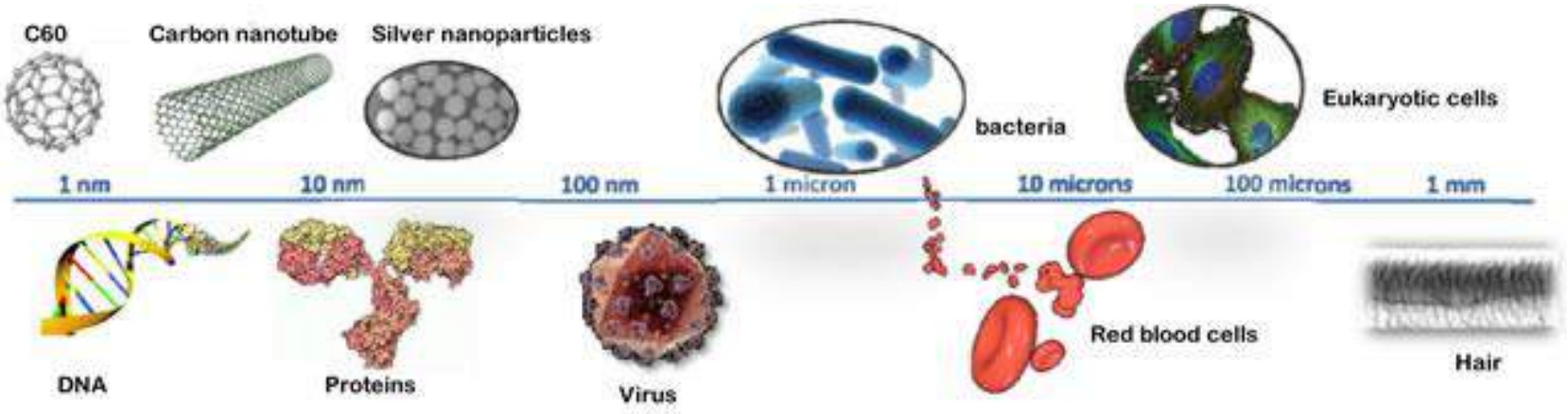
Metal nanowires are made “**Bottom-up**”– building something by assembling smaller components (e.g. like building a car engine or Lego).





It's a question of size . . . .

macro, micro and nano

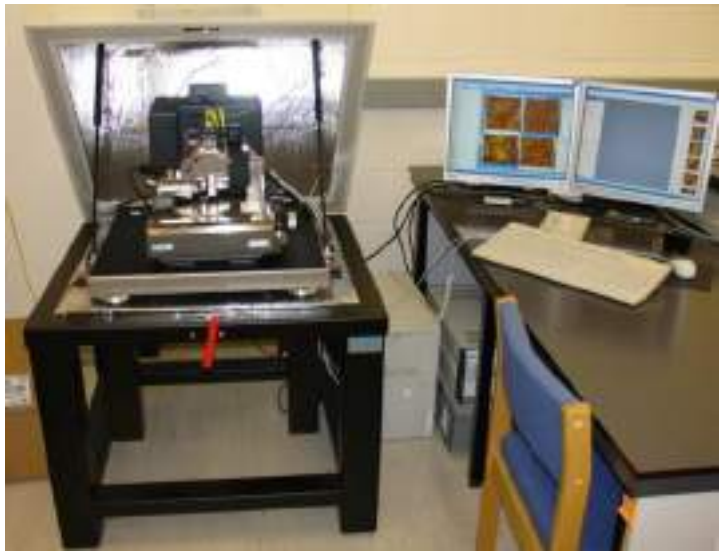


What we want to see dictates what instruments we use:

Beyond the magnifying glass

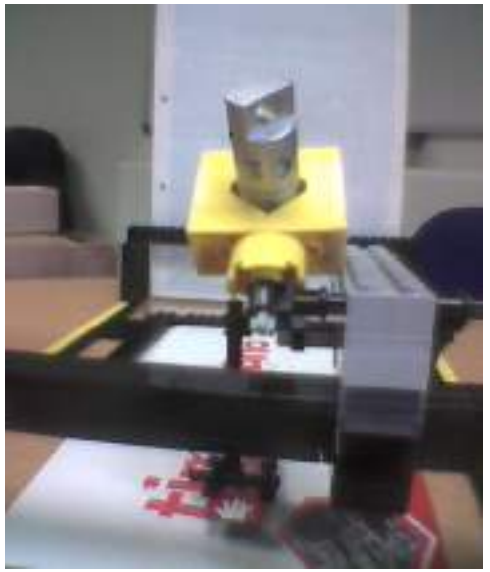
- Optical microscopes
- Electron microscopes
- Surface analysis
- Elemental analysis
- and more…….

Beyond the magnifying glass

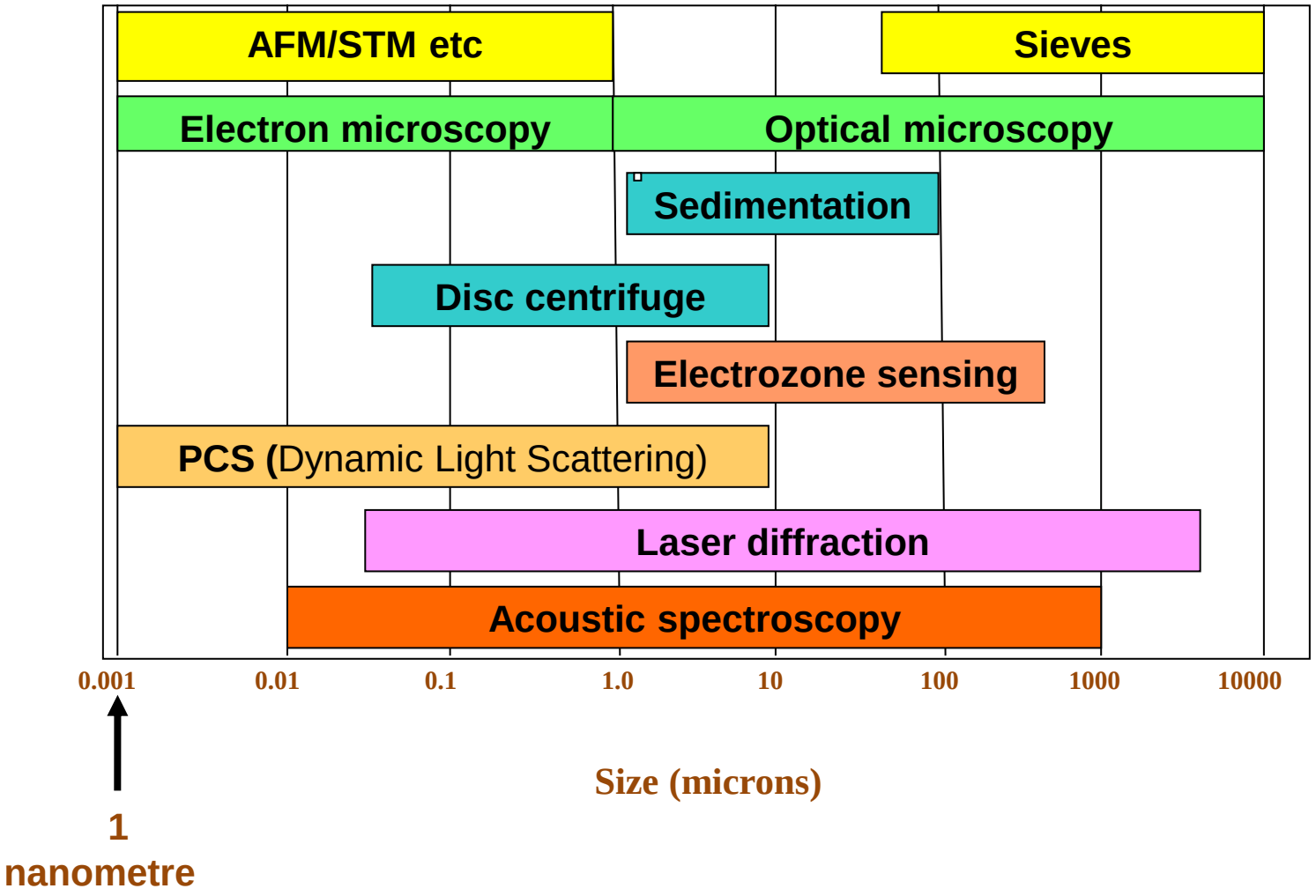


Atomic Force Microscope

Which can be modelled and demonstrated in class with Lego^{R}



Techniques for measuring the size of nanoparticles



Compared with the number of techniques for measuring the size of a particle greater than 1 micron, there are very few techniques that are able to accurately measure the size of small particles, particularly those less than 10 nanometres.

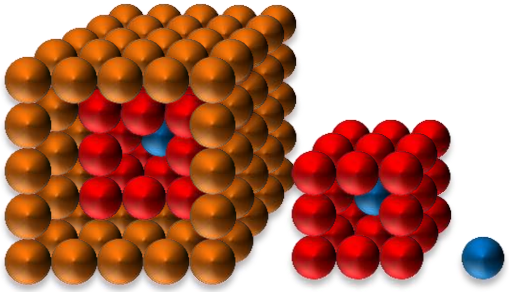
Nano Teachers' Day

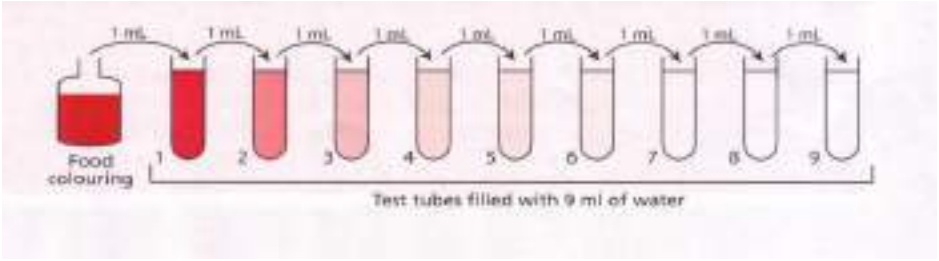
Experimental sessions:

- **Session 1**: What is nano?
- **Session 2**: Carbon nanotubes and buckyballs.
- **Session 3**: Colourful nanoworld –
  making gold and silver nanoparticles.
- **Session 4**: Make your own solar cells.

Session 1:

These activities are aimed at finding ways of experiencing the nano world and gaining confidence in using numbers to explain what we can't see.

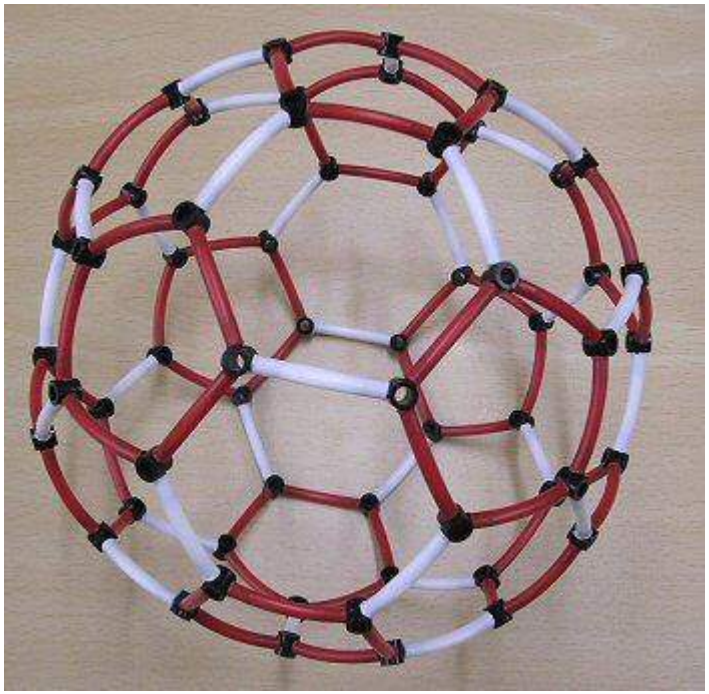




Nano is natural as well as manufactured.

Session 2: Carbon nanotubes and buckyballs.

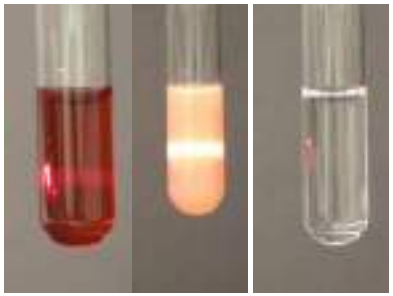
Nanotubes are extended Bucky balls. They can be natural and manufactured.



This activity shows bonding and crystal structure. The curved ends of the nanotube contain pentagons, the walls are the normal hexagonal structure.

Session 3:

Colourful nanoworld – making gold and silver nanoparticles.



Left to right

Tyndall effect

gold, silver, plain water

In Blue Peter fashion this works for y5 to y13.

Session 4:

Make and test your own solar cells.

Any Questions?