timefornano

1

instructions

# how tall are you in nanometres?

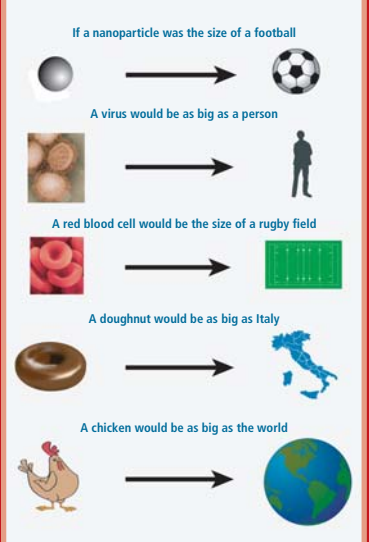
## What happens in this experiment?

For most of us it is very difficult to have an idea of how different the scale of the nanoworld is from our daily macroscopic scale (that is, larger than about 1 mm). The goal of these two activities is to help you understand how different these two scales are.

The naked eye is not able to see objects smaller than about ten micrometres (10 μm = 0.01 mm). But atoms or viruses are much smaller than 10 μm. The most convenient unit to measure such small things is the nanometre. 1 nm = 0.000 000 001 m, or one billionth of a metre. Despite being so small, modern science and technology can investigate and manipulate nanometre-sized objects.

Science and technology can investigate and manipulate objects as small as a few nanometres (nano-objects). Special tools and equipment, such as scanning probe microscopes (SPM), are needed to work with these objects. These particular tools are able to investigate different properties of nano surfaces and show different images of the nanoworld. More information about such microscopes can be found in the activity 'Magnetic probe'.

At the nanoscale many common materials exhibit unusual physical or chemical properties. In fact, nano objects can demonstrate behaviours that would be completely unexpected at the microscopic or macroscopic scales. For example, silver and gold nanoparticles have size-dependent properties: their different colours depend on the size and shape of each particle. This was used in the Middle Ages by the makers of stained glass. These clever craftsmen were using nanotechnology without knowing it!




There are two ways of creating nano-objects:

- The first one is top-down nanofabrication in which scientists use bigger objects that are processed with a nanotool to shape them into smaller objects. Similar to the way an artist creates a sculpture from a block of marble.
- The second one is bottom-up nanofabrication in which individual atoms are assembled to build bigger structures. In theory, if a drop of water has around $10^{21}$ atoms (that's a 1 followed by 21 zeros!) and it takes one second for a scientist to manipulate a single atom, it would take 300 million million years to make this single drop. Scientists therefore need to study so-called 'self-assembly' processes, which build structures without having to manipulate each individual atom. Although less developed, this method holds great promise for the future.

## Applications

Nanotechnologies can potentially be applied in many different scientific fields. In the near future a lot of scientific developments are expected as a result of these technologies.

- **Health:** Nanoparticles can be used as miniaturised diagnosis labs (called 'a lab on a chip'). These could help to discover illnesses earlier and find the best treatment method. Nanoparticles could also be used as medicines that specifically target diseased tissues such as cancer cells.
- **Environment:** Nanoparticles could be used as filters to clean up polluted land or water. Scientists also think that nanotechnology will improve the efficiency of solar panels.
- **Materials science:** Nanotubes of carbon are already used in sports such as tennis and sailing. A nanotube of carbon is 100 times stronger and six times lighter than steel. Some experts even estimate that a nanotube narrower than a human hair might be able to suspend a lorry trailer, although a nanotube that big has not yet been made to test this!
- **Computer science:** With nanoprocessors we would be able to make an electronic device as small as a credit card that could also be a cell phone, a video recorder, a camera, a GPS locater and even a credit card all in one.

These are only a few examples of what we hope will be possible with nanotechnologies and nanosciences. Many more applications are expected soon.

## Ideas for conducting the activity or discussion

Here are a few numbers that you can discuss with the students:

- A human hair is between 50 000 and 100 000 nm wide.
- A red blood cell is around 7 000 nm in diameter.
- A typical bacteria measures around 1000 nm.
- Most viruses are between 10 nm and 250 nm in size.
- The DNA double-helix is approximately 2 nm wide.
- The typical diameter of an atom is between 0.1 and 0.5 nm.

You can also discuss of the other scales used for measuring distances such as kilometres and millimetres.

## Learning objectives or school curriculae

- To understand how small a nanometre is through comparisons to everyday measurements such as height.
- To introduce the world of nanosciences and nanotechnologies.
- To understand the different prefixes used before a measure unit.