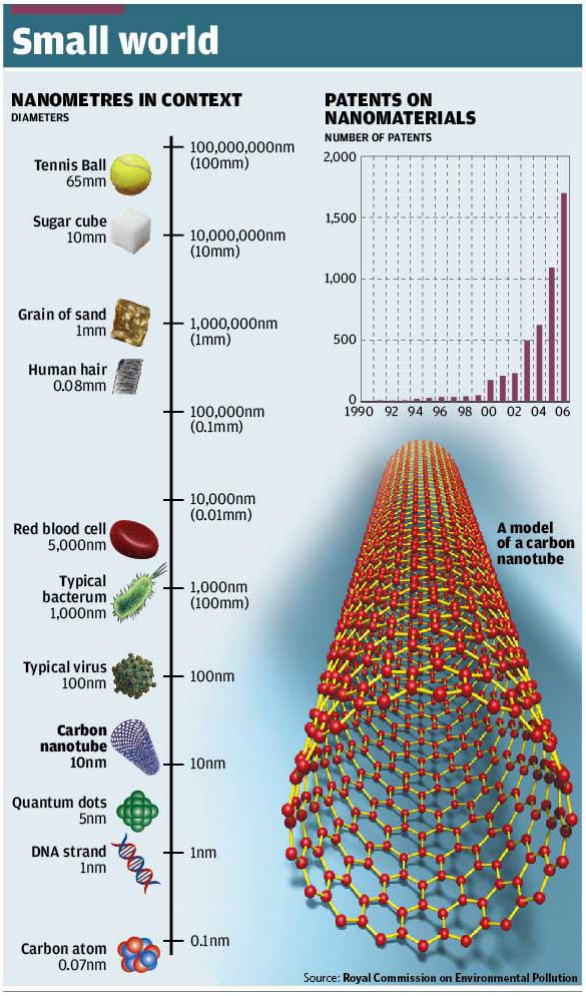
Nanotechnology

Authors: Joke Deschepper, Eléa Ladrouz, Auke Schelstraete, Federico Carta, Martina Margotti and Rachele Modeo
Schools: De Bron and Liceo Gregorio Ricci Curbastro

Contents

What is nanotechnology?

Nanotechnology is science, engineering, and technology conducted at the nanoscale. This scale is about 1 to 100 nanometres. The structures in the nanotechnology are only visible under a super microscope.



SOURCE, *Image*,https://www.independent.co.uk/news/science/big-question-what-nanotechnology-and-do-we-put-world-risk-adopting-it-1015518.html

A part of the nanotechnology concerns the usage of nanoparticles. But what are nanoparticles?
A nanoparticle is a particle with dimensions in the order of 1-100 nanometres. Such particles consist of several to thousands of atoms or molecules. Nanoparticles can be caused by both natural causes (a forest fire or a volcanic eruption) and by human activity. Synthetic nanoparticles are artificially produced particles specifically made for certain properties, such as electrical conductivity or chemical reactivity.
Roughly speaking, nanomaterials can be divided into three categories:

- Naturally occurring materials such as (volcanic) ash, minerals, etc.
- By-products of high-temperature processes such as combustion, industrial processes, welding, etc.
- Synthetic nanomaterials

Nanoparticles can also be classified into different types according to the size, morphology, physical and chemical properties.

- Carbon-Based Nanoparticles
- Ceramic Nanoparticles
- Metal Nanoparticles
- Semiconductor Nanoparticles
- Polymeric Nanoparticles
- Lipid-Based Nanoparticles

All nanoparticles are nanomaterials, but not all nanomaterials are nanoparticles. Nanomaterials can be divided into nanoparticles, nanotubes and nanoplates.
The range of different nanomaterials is considerable and the functionalities for which these nanomaterials are used are large. For example, some products become ultra-strong or extremely economical, others are dirt repellent.
The possible effects of nanotechnology are currently being discussed by scientists. Many new materials and devices with a wide range of applications may potentially be produced by nanotechnology, such as in nanoelectronics, nanomedicine, biomaterial energy production and consumer goods. Nanotechnology, on the other hand, faces many of the same issues as any emerging technology, including questions about the toxicity and environmental effects of nanomaterials and their possible impacts on the global economy. These concerns have led to a

debate between interest groups and governments about whether special regulation of nanotechnology is justified.

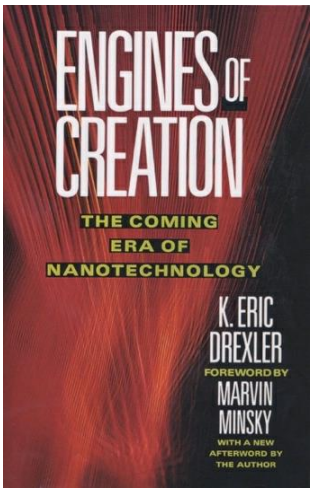
History of Nanotechnology

The history of nanotechnology traces the diffuse on of the concepts and experimental work falling under the broad category of nanotechnology. It is a recent development, but the spread of the core concepts took place over a longer period. In the 1980s there were a few inventions and discoveries such as the invention of the scanning tunneling microscope in 1981 and the discovery of fullerenes in 1985. These were experimental advances. The three most important people in the invention of nanotechnology are: Richard Feynman, Norio Taniguchi, K. Eric Drexler.

SOURCE, *Image*, https://en.wikipedia.org/wiki/Richard_Feynman

In 1959, Richard Feynman gave a lecture for the American Physical Society. He thereby became the founder of microsystems technology and nanotechnology. His lecture is often held to have given inspiration for the field of nanotechnology. Eric Drexler later expanded on this idea in his book Engines of Creation: The Coming Era of Nanotechnology with the concept of minuscule factories that duplicate themselves.

Norio Taniguchi of the Tokyo University of Science first used the term “Nanotechnology” in 1974 to describe semiconductor processes such as thin film deposition and ion beam milling exhibiting characteristic control on the order of a nanometre. His definition was: “ ‘Nanotechnology' consists mainly of the processing, separation, consolidation and deformation of materials by a single atom or molecule." An interesting fact is that no one will use the term Nanotechnology again, until Eric Drexler published his first paper on nanotechnology in 1981. He was unaware of the previous usage of the term by Taniguchi. The nanotechnology vision of Drexler that you can read in his book is also referred to as "Molecular Nanotechnology" (MNT) or "molecular manufacturing." Drexler founded the Foresight Institute in 1986 with the mission "Preparing for nanotechnology."



SOURCE, *Image*, https://www.bol.com/nl/f/engines-of-creation-the-coming-era-of-nanotechnology/30183061/

SOURCE, *Image*, https://en.wikipedia.org/wiki/K._Eric_Drexler

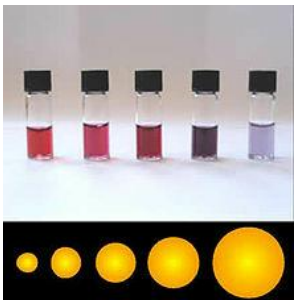
In the next years, many experiments took place and nanotechnology developed more.

Applications in Nanotechnology a small step towards bigger problems: the science in tiny particles

Nanotechnology shaping the future of medical treatment and diagnoses with nanomedicine

What if scientists could design a treatment that only targets cancer cells and leaves healthy cells untouched? Maybe gold is the ultimate solution...

Gold in medicine



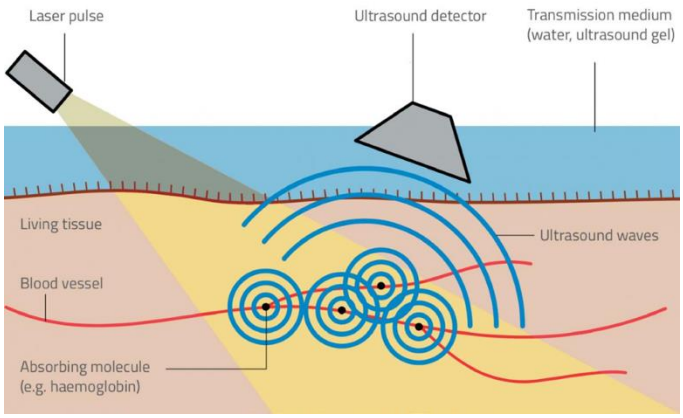
SOURCE, *Image*, https://en.wikipedia.org/wiki/Colloidal_gold

Gold colloids have fascinated scientists for over ages. Immunogold is colloidal gold that consists of gold nanoparticles dissolved in a solution that is usually water. A colloidal solution is a mixture where the solid gold particles of the mixture are tiny, less than 100 µm (micrometer). The emulsion is either an intense red colour (spherical particles less than 100 nm) or blue (for a larger spherical particle or in short nanorods).

Gold colloids are unified with antibodies. Antibodies are proteins that bind to foreign substances or to diseased cells that need to be annihilated. In this case, the antibodies allow the gold nanoparticles to attach with the tumor cells once they are in the human body. Photoacoustic can be utilized to visualize where the gold particles in the tumor are located in the physical body. Photoacoustic imaging allows the delivery of light energy that is absorbed by tissues causing a thermoelastic expansion. Substantially the expansion generates ultrasound waves (700-800nm) that are detected by the transducer and produce illustrations of optical absorption contrast within tissues. (see the figure)

The gold nanoparticles in the cancer cells can be heated up rapidly with an infrared light laser. Energy transmitted by the laser causes the fluid (around the tumor) to reach temperatures high enough to vaporize the liquid, which causes a swift expansion and annihilation of the cancer cells. This treatment is known as hyperthermia therapy.

There is huge potential for a daily use of gold nanoparticles in cancer therapy. With an enormous global interest in nanotechnology and particularly in nanomedicine. It is more likely that nanomedicine will play an immense role in the future.



Source, *Image,* https://www.scienceinschool.org/content/photoacoustics-seeing-sound

Nanotechnology in the textile industry.

In the apparel industry, nanotechnology with the help of physics has recently brought a lot of changes. The unique features of nanomaterials with their immense benefits and advantages are applied efficiently by engineers and scientists. Nanoparticles (for example of silver and silica) are useful in emergency services such as surgeons, doctors and military forces. As regards the medical field, these materials are used for the administration of drugs and wound healing. Silver nanoparticles include antimicrobial properties, therefore they are added to clothing for their ability to kill fungi and bacteria.

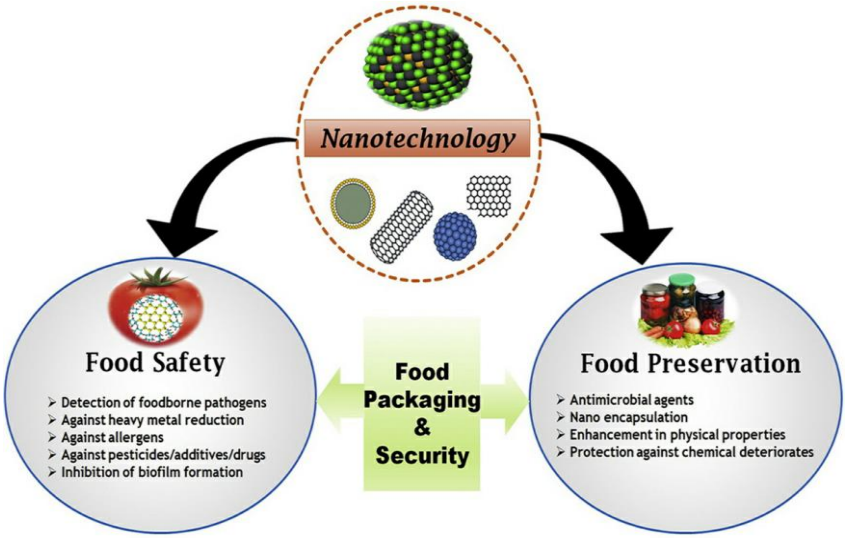
Nanosilver particles emit ions that are positively charged and stop the cells functioning. They are also used in burn-care materials. The garment with the addition of nanosilver particles stays wearable due to their tiny size. Furthermore, these nano-engineered fabrics are used to screen body temperature and heart rate. Nano-based fabrics have other qualities such as water resistance, lightness, anti-ballistic and flame-retardant properties, making this form of fabric suitable for military use. Nanomaterials enable smart sensors which are developed to enhance military intelligence gathering by soldiers directly in the field.

The nanoparticles can also be used in general uses of fabrics. The first example that comes to mind is the "odour-free fabric". To avoid the unpleasant smell created by microbial activity, nanosilver particles are used. Many companies are already employing fabrics coated with nanoparticles to reduce unpleasant smells in stockings, socks and undergarments. Nanoparticles are applied in waterproof and stain-resistant fabrics as well. Very small particles of silica are incorporated into the weave of a fabric or sprayed onto the surface which makes the cloth repel liquids. The silica coating produces adequate surface tension to ensure that liquids from tiny beads that roll off the fabric rather than soaking into it.

SOURCE, *Image*, https://www.nanowerk.com/spotlight/spotid=42713.php

Nanotechnology in the food industry

The food industry has been revolutionized by recent advances in nanotechnology. Nanoparticles, whose properties follow quantum mechanics, are indeed widely used both during the food process, and in order to improve its shelf life. As we can see in the following image, nanotechnology guarantees a better food quality thus ensuring many advantages.



SOURCE, image, https://www.sciencedirect.com/science/article/pii/S1021949818301169

Moreover, the mechanical strength of nanoparticles and their ability to alert the costumers about the status of food is very interesting. Consequently, the demand for nanoparticle-based materials in this field has increased.

We can also talk about nanostructured ingredients, which are employed as additives in order to enhance flavor, texture and, in parallel, they improve the physical properties, so the durability, of packaging materials.

Focusing on the nutritional value, nanoparticles are developed as a supply of vitamins and micronutrients with the aim of providing all health benefits.

Despite many benefits, nanomaterials-related safety problems should not be ignored. Someone claims that nanoparticles are likely to move from packaging materials to food, so this will not be good for the health of the consumer. However, regulatory authorities must establish rules for goods to ensure the product's health and safety.

To sum up, nanotechnology provides full food solutions and it makes a great difference in the food industry, so researches in physics drive the development of this field. In any case, its validity is a priority and the testing of nano foods is crucial.

The risks of nanotechnology

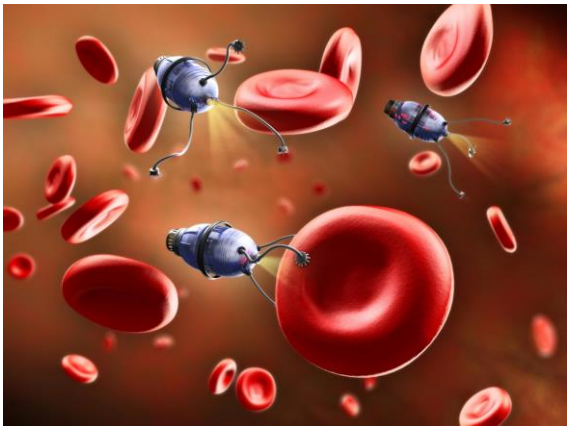
Cause of the small size of nanomaterials and the way their surfaces are modified to increase the ease with which they can interact with biological systems, makes nanomaterials potentially damaging for humans and the environment.

For example, the nanoparticles may damage the lungs. The lung-damaging nanoparticles are produced in diesel machines, power plants and incinerators. The nanoparticles are dangerous because they can get deep into the lungs and carry other chemicals with them including metals and hydrocarbons. The particles get into the body through the skin, digestive system and they can mutate the DNA. When nanoparticles arrive in the bloodstream they can travel further into the brain. This can be hazardous.

Several studies have shown that carbon nanotubes cause mesothelioma in the lungs of rats, a type of cancer that develops from the thin layer of tissue that covers many of the internal organs (known as the mesothelium). Other nanoparticles have also shown that they can cause brain damage in fish and dogs.

Is this the only danger? Well, nanoparticles could be dangerous in clothing. For the studies done in the laboratories of Natalie von Goetz from the Swiss University of Zürich, no nanoparticles with titanium dioxide were found in the fabric clothing. However, Rickard Arvidsson from the University of Technology in Gothenburg, Sweden, thinks that even though silver nanoparticles are non-toxic to human beings, it could be poisonous to aquatic animals. In fact, his research proposed that the enormous use of silver nanomaterials in clothing can lead to high concentrations of silver in the sludge from wastewater treatment plants that could ultimately have negative effects on aquatic animals.

We can conclude that the nanotechnology is revolutionary. But it is also important to consider the risks and to investigate them in parallel with the development of new nano-products.



SOURCE, image, http://www.justscience.in/articles/risks-development-nanotechnology-medicine/2017/12/13

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