

NANOTECHNOLOGY

What it is and how corporations are using it

Nanotechnology, the manipulation of matter at the scale of atoms and molecules, has been described both as the next industrial revolution and as the operating system for a new era of corporate and state control.

Nanotechnology will fundamentally change the world we live in. It provides a powerful universal tool kit with which to shape and manipulate all matter, living and non-living. It has the potential to radically transform many sectors of industry, from pharmaceuticals to computers, from energy to chemicals, from agriculture to defence.

\$9 billion per year is being invested in nanotechnology by the world's most powerful governments (led by the US, the EU and Japan) and richest corporations (including IBM, DuPont, Syngenta, Exxon, Pfizer, L'Oreal and Kraft).

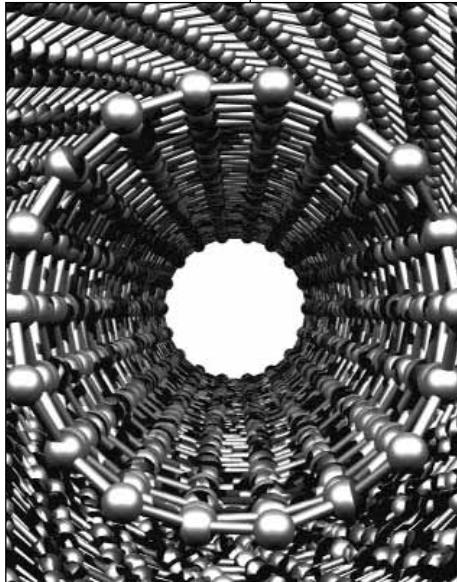
Nanotechnology has the potential to transform and extend corporate power, bringing further corporate concentration and creating new atomic-scale monopolies over life and matter.

Nanotechnology is already happening. The race to secure patents at the nano-scale and to bring nano-products to the market has already started.

As with other revolutionary technologies nanotechnology brings with it the promise of far reaching social and environmental impacts, from novel forms of nano-toxicity to economic disruption caused by nano-commodities, from ethical issues around nano-enabled human 'enhancement' to privacy issues around surveillance from nano-enabled sensors. As yet there is no regulatory framework anywhere in the world to deal adequately with nanotechnology

This briefing is an introduction to the issues around nanotechnology, what it is now, what it may be in the future, how corporations are using it, what is already on the market and what some of the areas of concern are.

This is the first briefing from the new Corporate Watch **Corporate Technologies project**. The project examines how corporations drive forward new technologies to serve the ends of increased corporate profit and power, often at the expense of democracy, equality and the environment.



Atom

<http://en.wikipedia.org/wiki/Atom>

An atom is a microscopic structure found in all ordinary matter around us.

Atoms are the fundamental building blocks of chemistry, and are conserved in chemical reactions. An atom is the smallest particle differentiable as a certain chemical element. Only 91 elements have been identified as occurring naturally on Earth. It is these elements that are recorded in the periodic table, for example carbon, oxygen, gold and lead.

Molecule

<http://en.wikipedia.org/wiki/Molecule>

Atoms are able to bond together into molecules and other types of chemical compounds. Molecules are made up of multiple atoms. A molecule of water is a combination of 2 hydrogen and one oxygen atoms. A molecule is the smallest particle of a pure chemical substance that still retains its chemical composition and properties. It may consist of atoms of the same chemical element, as with oxygen gas (O₂), or of different elements, as with water (H₂O). Examples of molecules are Titanium Dioxide, Carbon Dioxide, and DNA.

1. What is nanotechnology?

When thinking about nanotechnology is it useful to contrast it with another 'revolutionary technology', biotechnology. The 'bio' part of biotechnology refers to what the technology is dealing with, i.e. bios or life, where as with nanotechnology the 'nano' refers not to a thing but to the scale at which the technology takes place.

Put simply nanotechnology is the manipulation of matter at a size so small that it is measured in nanometres (one billionth of a metre), the scale of atoms and molecules.

The nano-scale

It's difficult to grasp quite how small the nano-scale is. To give some reference points one nanometre (nm) is one billionth of a metre, or one millionth of a millimetre. A human hair is 80,000nm thick, a red blood cell is 5,000nm in diameter, a DNA molecule is 2.5nm wide and 10 hydrogen atoms arranged side by side measure 1nm.

"There are three, although I have a feeling that under some future unified theory they will turn out to be just one. The first is, of course, information technology ...the second is biotechnology ...and the third is nanotechnology"

Robert Shapiro (then CEO of Monsanto) when asked what he believed were the world's most promising future technologies

The nano-scale is nothing new. It has always existed, but until recently it has been out of the sight, and reach, of human beings. Unaided, the human eye can't see anything much smaller than a millimetre wide.

Over the last few hundred years optical microscopes have been developed that allow humans to see objects down to the scale of microns (1,000nm things such as bacteria). It is the invention and development of scanning probe microscopes over the last 20 years that has allowed humans to first of all see, and then manipulate matter at the nano-scale.

What is so exciting about the nano-scale?

The nano-scale is special in two ways:

Everything is the same

When viewed at the nano-scale the whole world starts to look the same. Everything on this planet both living and non-living is made up of atoms and molecules, and at the nano-scale that is all you see. The paper this briefing is printed on, the trees you can see from the window, the glass in the window, your cat and you yourself, everything is made up of atoms and molecules arranged in different combinations and different structures.

**Biotech broke the species barrier.
Nanotech breaks the life/
non-life barrier**

Things behave differently

The other important feature of the nano-scale is that substances start to behave very differently when they are very small. Below about 100nm the rules that govern the behaviour of the elements of our known world start to give way to the rules of quantum physics, and everything changes. To take the example of gold, we are all familiar with gold at the 'everyday' macro-scale, for instance, a gold ring is a familiar shiny orange/yellow colour. The same is true of a particle of gold 100nm wide, but, a particle of gold 30nm across is bright red, slightly bigger than that it is purple and going smaller still it is brownish in colour.

Not only colour changes at the nanoscale. Other properties including strength, reactivity, conductivity and electronic properties also change as size decreases.

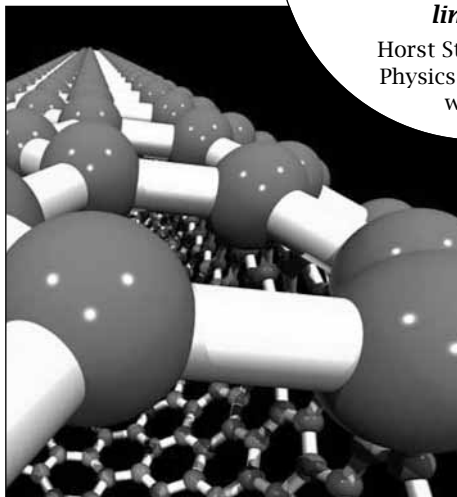
2. What are its potential applications? And why is the nano-scale interesting to corporations?

The basis of nanotechnology is the ability to see, understand and accurately control and manipulate matter atom by atom and molecule by molecule. This ability unlocks a world of new possibilities where the tools and techniques of nanotechnology become a powerful universal tool kit with the potential to shape and manipulate all matter, living and non-living.

For corporations, nanotechnology opens up a whole new world of possible applications and product opportunities across all sectors of the economy: smaller and faster computers; drugs that permeate the body more effectively and can target specific cells; catalysts (used to speed up chemical reactions, including oil-refining processes) can be made more reactive; sensors can monitor everything with much greater precision; materials can be stronger and lighter.

Nanotechnology is not a single technology.

Given the diverse range of applications to which nanotechnology can be put it is more useful to talk of nanotechnology as a technological platform upon which a whole range of nanotechnologies will be based.



What is happening?

We are in the very early days of the commercial applications of nanotechnology. The majority of what could currently be called commercial nanotechnology involves nano-particles. These are new molecules with novel properties created by fine tuning chemical reactions at the nanoscale. These particles are already incorporated into a wide range of products including paints, cosmetics, tennis rackets, clothing, glass and computers. An example of a new nano-particle is titanium dioxide. At the conventional 'macro' scale a particle of titanium dioxide is white in colour and very good at reflecting UV light. It is widely used as the active ingredient of sunblock. However, if manipulated to form particles only 20 nm wide the properties of titanium dioxide change. It keeps its UV light scattering properties, but turns transparent and provides the basis for making see-through sunblock. Other nano-particles include new forms of carbon. Carbon naturally occurs as either diamond or graphite, but nano-scale manipulations have produced new forms of carbon such as 'bucky balls' and 'nano-tubes' involving new arrangements of carbon atoms. These new carbons have radically changed electrical and strength properties and have a huge number of potential commercial applications.

Where next?

Beyond simple nano-particles what's coming next?

Nano-technology has given us the tools... to play with the ultimate toy box of nature - atoms and molecules. Everything is made from it... The possibilities to create new things appear limitless

Horst Stormer 1998
Physics Nobel Prize
winner

Nano-encapsulation

Food, pharmaceutical and chemical companies, and the military too, are all working on nano-sized capsules containing flavourings, drugs, pesticides or even chemical/biological weapons designed to break open and release their contents only under certain conditions.

Nano-devices

Nano-devices shrink the size of electronic components and eventually electronic devices to the nanoscale. One example is nano-sensors. Already the US defence research agency as well as corporations are using advances in nanotechnology to develop ever smaller wireless sensors capable of monitoring everything from farms to threats to 'homeland security'.

Nanobiotech

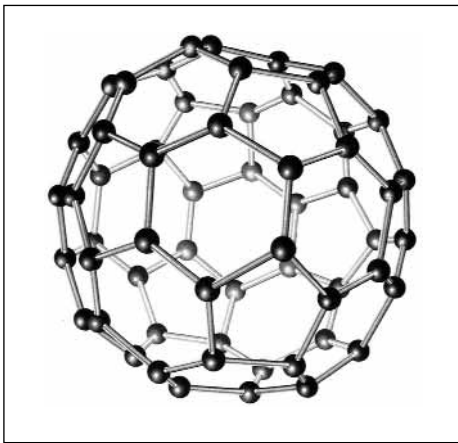
An area of expanding research is nanobiotechnology, the nano-scale mixing of biological and non-biological material. Different approaches to nanobiotechnology being explored include atomically modified seeds, incorporating non-living nano-materials into living organisms, creating new synthetic materials incorporating biological materials, harnessing nature's ability to 'self assemble' to build complex structures from the level of atoms up and treating DNA as a molecule and atomically engineering life atom by atom.

3. What is 'convergence'?

Lots of interest has been generated by the concept of technological convergence at the nanoscale. This stems from the idea that everything is the same at the nano-scale leading to the possible merger of formerly discrete technologies including nanotechnology, biotechnology, information technology and cognitive neuroscience. Known by several acronyms including NBIC (Nano-Bio Info Cogno) and BANG (Bits Atoms Neurons Genes), convergence reaches into a brave new world where human enhancement and machine-mind interfaces become conceivable goals. Although it sounds like the stuff of a bad sci-fi novel, nano-enabled technological convergence is likely to become science fact as it is attracting interest from powerful supporters including major corporations and US defence agencies.

...just as biotech came to dominate the life sciences over the past two decades, ... nano-scale convergence will become the operative strategy for corporate control of commercial food, agriculture and health in the 21st century

ETC Group, The
Big Down



4. Which companies are involved in nanotech?

Big companies

Virtually all of the Fortune Global 500 companies are investing in nanotechnology research. Unlike with the development of biotechnology, big companies have been involved with nanotechnology from the start. They are both developing nanotechnologies for their own products and are using technologies developed by each other and by smaller nano-specialist companies.

Major corporate nano-developers or users include:

computers/electronics: IBM, NEC, Fujitsu, Hitachi, Phillips, Hewlett Packard, Samsung, Motorola, Mitsubishi, General Electric, Microsoft

food: Kraft/Altria, Unilever, Nestle, Heinz, Sara Lee

drugs/healthcare: GlaxoSmithKline, Smith and Nephew, Merck

oil: BP, Exxon, Chevron/Texaco, Shell, Halliburton

clothing: Burlington Industries, Nike, Gap

defence/aerospace: Sandia/Lockheed Martin, Boeing, Qinetiq, Raytheon

cosmetics: L'Oreal, Body Shop, Boots

chemicals: Dupont, Degussa, Dow, Henkel, ICI

agriculture: Syngenta, Monsanto, Bayer

cars/automotive: BMW, Renault, General Motors, Ford, Caterpillar

Small Companies

Nanotechnology has also spawned hundreds of small nano-specialist companies. These are often spin-out companies commercialising the results of university research. Smaller more nano-focused companies include Veeco, Nanosys, Nanophase, Altair, Nanomix, Flamel, Nanogate, Carbon Nano-Technologies, Quantum Dot Corp, Nanoproducts, Nanotex. UK based nano-companies include Oxonica, Thomas Swan and Co, Skyepharma, JR Nanotech and QinetiQ Nanomaterials.

5. What products are already on the market in the UK?

Glass: 'Activ' self cleaning glass by Pilkington

Sunblock: see through sunblocks by Boots, Body Shop, Green People and others

Wound dressings: Smith&Nephew 'Anticoat' wound dressings

Fuel additives: Oxonica/Cerulean International 'Envirox' fuel additive (in the process of being rolled out to the entire Stagecoach UK bus fleet)

Cosmetics: L'Oreal 'Plenitude Revitalift' anti-wrinkle cream

Printer paper: Kodak 'ColorLast' inkjet printer paper

Clothing: Stain resistant and wrinkle resistant fabric by Nanotex used in some clothing lines by Levis, Regatta, Marks and Spencer, Eddie Bauer, GAP, Lee, and Kathmandu. Solefresh anti odour nano-silver socks from JR Nanotech

Sports equipment: Carbon nanotube reinforced tennis rackets from Babolat. Tennis balls from Wilson Double Core

And what's coming next?

Fuel cells: NEC laptops powered by nano-tube fuel cell batteries

Flat screen displays: nano-particle screens from Ntera, carbon nanotube screens from Motorola

6. What are the problems?

Toxicity

Just as the nano-scale has opened a whole world of potential commercial applications, it has also opened a new world of risk. Profit motivated corporations have rushed into commercialising the first generation of nanotechnology based products (nano-particles) before adequate safety testing procedures, let alone regulations, are in place to deal with them. Given that nano-particle products including cosmetics and wound dressings are already on the market, and food and environmental remediation applications are not far off this should be ringing alarm bells.

"There is evidence that UFPs [Ultra Fine Particles or nano-particles] can gain entry to the body by a number of routes, including inhalation, ingestion and across the skin. There is considerable evidence that UFPs are toxic and therefore potentially hazardous. The basis of this toxicity is not fully established but a prime candidate for consideration is the increased reactivity associated with very small size."

Dr Vyvyan Howard,
toxicologist

The main reason for developing nano-particles has been to take advantage of the fact that everything is different at the nanoscale. Simply by reducing the size of particles to the nano-scale their properties change and interesting new applications become possible. However, it seems that the dazzling array of potential applications has blinded researchers from asking more searching questions about what new risks emerge in a world where everything is different.

There is a growing body of scientific opinion which claims that a unique set of problems are associated with the toxicity of manufactured nano-particles.

The concern is two fold: Firstly that by being reduced to the nano-scale materials become more reactive and therefore potentially more toxic. Secondly, our bodies have not evolved to recognise nano-particles. Prior to their deliberate manufacture as nano-particles relatively few particles of this size existed in the world. As a result our bodies' protective filters, from the skin to the lining of the lungs to the blood/brain barrier, do not recognise and filter out nano-particles. Nano-foreign bodies therefore have the ability to reach the places other foreign bodies can't reach with, potentially dangerous effects.

Despite nano-particle-based products already being on the market there are very few studies on the toxicology of nano-particles. Those studies that have happened have shown problems, for example fish exposed to carbon nano-particles quickly developed brain damage.

Even the traditionally pro-technology Royal Society has urged caution about the use of nanotechnology, especially nano-particles, and has stressed the need for tight regulation of nano-particles to be put in place.

We are only dealing with the first generation of relatively simple nanotechnology based products and there are already significant safety issues. As the scope of commercial nanotechnology increases we can expect further safety problems to arise. For example, what will the bio-safety implications of nanobiotechnology be?

At present there are no regulatory frameworks designed specifically to deal with nanotechnology anywhere in the world.

Corporate control is increased

Colonisation of the nano-scale

Just as colonial explorers hoisted the flag of their home country to lay claim to their new-found colonies, so too corporations have used corporate logos to lay claim to their stake in the new world of the nanoscale. In 1989 scientists working for IBM announced to the world their ability to manipulate matter atom by atom by using a scanning tunnelling microscope (IBM's own patented technology) to rearrange 35 xenon atoms to spell out the letters I-B-M on the surface of a nickel crystal.

New enclosures/new monopolies

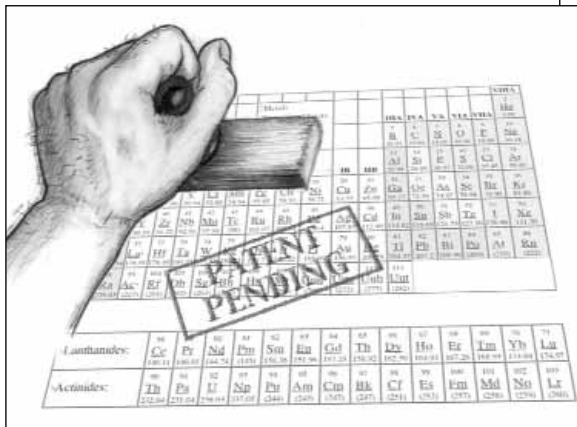
Nanotechnology opens a new world of ownership and corporate control. Just as biotechnology's ability to manipulate genes went hand in hand with the patenting of life, so too nanotechnology's ability to manipulate molecules has led to the patenting of matter. The last few years has seen a gold rush to claim patents at the nanoscale. Over 800 nano-related patents were granted in 2003, and the numbers are increasing year on year. Corporations are already taking out broad ranging monopoly patents on nano-scale discoveries and inventions. For example, two corporations, NEC and IBM, hold the basic patents on carbon nanotubes, one of the current cornerstones of nanotechnology. Carbon nanotubes have a wide range of uses, and look set to become crucial to several industries from electronics and computers, to strengthened materials to drug delivery and diagnostics. Carbon nanotubes are poised to become a major traded commodity with the potential to replace major conventional raw materials. However, as their use expands, anyone seeking to manufacture or sell carbon nanotubes, no matter what the application, must first buy a license from NEC or IBM.

Changing the size and shape of corporations

If nanotechnology opens up a whole new world of technological possibilities, it also gives rise to a new world of corporations. Just as the biotechnology revolution resulted in the lifesciences company (in which chemicals, pharmaceuticals, seeds and materials interests were merged together) nanotechnology is likely to result in companies with traditionally very different areas of operation working together, merging or buying each other due to their similarities at the nano-scale. The beginnings of this are already happening albeit at a small scale. For example, Bridgestone Corporation is finding that its nano-applications, initially developed for tyres, are equally useful in making flat screens and is about to go into production. Given the diverse range of companies embraced by a nano-enabled technological convergence, what are the corporate mergers of the future going to look like? How powerful will those companies be and what priorities will they be governed by?

Nano-disruption

Another major problem with nanotechnology is its potential to cause huge economic and social disruption. There are plenty of examples in history, from the mechanisation of cotton weaving in 19th century England to the introduction of GM soya to Argentina in the last ten years, of how the introduction of new technologies leads to massive social and economic disruption, felt hardest by the poorest, most marginalised sectors of society.



As nanomaterials become widely used there is the potential for major traded commodities, from iron and copper to rubber and cotton, to be replaced by nanotech based equivalents. For example, the use of carbon nanotubes in the electronics industry looks set to make a sizeable dent in the copper extraction industry. The hardest impacts of these changes in commodity flows will be felt not by large corporations dealing in copper (who will simply relocate or diversify their business) but by local communities who have been made reliant on extractive industries such as copper mining.

"Just as the British industrial revolution knocked hand-spinners and hand weavers out of business, nanotechnology will disrupt a slew of multi billion dollar companies and industries"

Lux Nanotech Report
2004

Further reading

Nano-background reading

The Big Down and *A Tiny Primer on Nano-scale Technologies* and *The Little Big Down* by the ETC Group available online at www.etcgroup.org

May 2003 edition of the *Ecologist* Nanotechnology Special Report

Nano-food and agriculture

Down On The Farm by the ETC Group available online at www.etcgroup.org

Nano-toxicity

Size Matters by the ETC Group available online at www.etcgroup.org

Nano-patents

Nanotech's "Second Nature" Patents by the ETC Group available online www.etcgroup.org

Technological Convergence

The Little Bang Theory by the ETC Group available online at www.etcgroup.org

Nano-Regulation

Nanotech Report Raises Red Flags and Government commissions and ignores nanotech report in *Corporate Watch* newsletter available online at www.corporatewatch.org.uk

Nanoscience and Nanotechnologies: Opportunities and Uncertainties by the Royal Society and Royal Academy of Engineering www.nano.org.uk

Technology / democracy

TECHNE - an email list for discussion, activism and organising around technology and democracy issues. Subscribe at : <http://lists.riseup.net/www/info/techne>

Wikipedia - online encyclopedia pages on technology democracy http://en.wikipedia.org/wiki/Technology_Democracy

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Nano-tube illustration by **Chris Ewels**
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Periodic table illustration by **Rey Page**
taken from www.etcgroup.org/article.asp?newsid=509

www.corporatewatch.org.uk



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