

If you thought studying science at university was dull, you've never heard of nanotechnology, says **PAUL REDMOND** as he goes on a microscopic journey to explore the hottest science of the 21st century

# Technology on a teeny scale

**T**hirty years ago, the movie "Fantastic Voyage" first appeared on cinema screens. Based on a novel by science-fiction writer Isaac Asimov, the story tells of a group of scientists who use lasers to shrink their spaceship to microscopic size before injecting it into a man's body to cure him of an inoperable blood clot. Before resuming normal size, they battle with ferocious white blood cells and come under attack from millions of killer bacteria.

Leap forward 30 years and another tiny vessel, 1,000 times smaller than the diameter of a human hair, once again tumbles through a patient's bloodstream, hunting down diseased cells and penetrating membranes to deliver precise doses of medicines. Only this isn't Hollywood. This is real science, and it will shortly be coming to a hospital near you.

## Nanotechnology

"Imagine a box no larger than a sugar cube that contains the entire contents of the Library of Congress. Or materials much lighter than steel that possess ten times as much strength" – US National Science Foundation.

In 1987, K Eric Drexler coined the term "nanotechnology" (a "nanometre" being a measurement of one billionth of a metre) in his book, *The Engines of Creation*. Drexler talked about building machines on the scale of molecules, a few nanometers wide – motors, robots –

**'Progress in the field of nanotechnology has moved at a mind-blowing pace'**

even whole computers all smaller than the size of a cell. Drexler then spent the next decade fending off accusations of science fiction. Since then, progress in



the field has moved at mind-blowing pace. Soon, the world's smallest and densest computers will be powering the first walking silicon chips.

These computers will be so small that 400 of them could fit on to the surface of a grain of salt. Nanotechniques have already given rise to single-molecule transistors, enzyme-powered bimolecular motors capable of travelling from the blood into the brain to deliver tumour-fighting chemicals, and the appearance of nano-robots ("nanobots") the size of houseflies. Scientists are even claiming that nanoparticles will eventually allow

for the early detection of diseases such as HIV, cancer, BSE and Alzheimer's.

## Commercial sector

But it is in the commercial sector where some of the biggest breakthroughs in nanotechnology are starting to emerge. The commercial value of nanotechnology derives from the simple fact that at the molecular level, the laws of physics don't apply (stand by as more physics text books are consigned to the dustbin). Instead, quantum physics kicks in, meaning that the properties of materials begin to change. This knowledge has

already led to the manufacturing of startling new products, such as “intelligent” sunscreens, stain-resistant fabrics, self-cleaning window glass, and a clear, tasteless drink containing nanoparticles that can be activated in a microwave to produce whatever taste the consumer desires.

One of the biggest players in the nano-field is cosmetics giant L’Oreal. With a research budget of £350m – the financial equivalent of 10 universities – L’Oreal employs upwards of 3,000 scientists to work on nano-related projects. Other firms are not far behind. IBM, Fujitsu and Intel are all pouring money into nano-research. Indeed, over the next decade, global funding for nanotechnology is set to exceed \$10bn, with some analysts

**‘All branches of science have their dark sides, unfortunate outcomes, unforeseen accidents’**

putting the figure as high as \$1trillion.

But big businesses are not the only ones desperate to get in on the nano-craze. In the past two years, the US government has spent \$1bn on nanotechnology, while in Europe spending has grown from £79m to £219m. This is pocket money compared to Japan, where investment in nanotechnology has rocketed from £75m to £470m.

### Nano-fears

“21st century technologies – genetics, nanotechnology and robotics – are so powerful they can spawn whole new classes of accidents and abuses” - Bill Joy (2000). All branches of science have their dark sides – unintended consequences, unfortunate outcomes, unforeseen accidents. (Pointing this out made Mary Shelley world famous). Nanotechnology is no exception. While its supporters claim that it offers the prospect of clean environments, disease-free humanity, and enough material abundance to make poverty a thing of the past, critics, such as Prince Charles and the chief scientist at Sun Microsystems, Bill Joy, take a different view. Sceptic-in-Chief is Eric Drexler himself, who in recent years has voiced concerns over the future direction of nanotechnology:

“There are many people, including myself, who are quite queasy about the consequences of this technology for the future. We are talking about changing so many things that the risk of society handling it poorly through lack of preparation is very large.”

Coming from Drexler, this is an amazing admission – the scientific



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equivalent of Henry Ford expressing fears over the environmental impact of the motorcar, or the MacDonald brothers going public about the unhealthy fat content of hamburgers. So what exactly is it that Drexler and co are so afraid of?

First, there is the issue of who controls nanotechnology. Other scientific breakthroughs have often been managed or paid for by governments. Not so nanotechnology. The threat of designer-made nano-diseases, or biologically-engineered viruses falling into criminal hands – “nano-terrorism” – needs to be taken seriously.

Second, there’s the famous “grey goo” issue. Scientists have warned that nanotechnology, if left unchecked, could lead to the “accidental” creation of self-replicating, “artificial” substances (hence, “grey goo”), which could eat their way through various life forms – one of them being us. Far-fetched? Perhaps. Yet, the same futuristic “sci-fi” spectre that haunted Michael Crichton’s 2003 nano-novel, *Prey*, finds echoes in the words of Professor Stephen Hawking, who has warned of “tough, omnivorous bacteria” spreading like blowing pollen, reducing the biosphere to “dust, in a matter of days”.

### New breakthroughs

Some scientists argue that nanotechnology represents the next stage in evolution – man-made evolution; that eventually such new sciences will blur the boundaries between organic and inorganic, humans and machines. Nanotechnology certainly offers a fascinating new era of possibilities and breakthroughs. And, as with all new

breakthroughs, separating the hype from the reality is far from easy – particularly when the “reality” in question measures less than 1/800th of a millimetre. Yet while scientists might disagree on the extent to which nanotechnology deserves its “dubious reputation” for being the science that will save or destroy the world, none can argue that the future of nanotechnology will never be dull!

### Scientific thinking

Nanotechnology calls for a radical interdisciplinary approach to science education. One reason why the subject is so exciting is that it offers an entirely new way of thinking about science subjects. Rather than representing one specific academic discipline, nanotechnology operates at a fast-changing intersection between old “19th century subjects”, such as physics, biology, and chemistry. The challenge is one that more and more universities are eager to respond to. As Christopher Edwards, vice-chancellor of Newcastle University said recently, “Our vision is that in the 21st century, new industries based on developments in nanotechnology, bioscience and molecular engineering will become as powerful as coal and shipbuilding were in the 19th century.”

Coals to Newcastle? Only if they measure one billionth of a metre.

*Dr Paul Redmond is head of Career Development at Liverpool Hope University. A full version of this feature, including a detailed list of sources, can be downloaded at [www.careerscope.info/nanofuture](http://www.careerscope.info/nanofuture).*