

Nanotechnology — the ability to arrange matter at the scale of individual atoms and molecules — has the potential to transform medicine, computing and energy production, and offers the prospect of reducing the quantity of raw materials required for the manufacture of goods. Today, nanotechnology is only in its infancy. To benefit fully from its potential, Europe must mobilise and develop its considerable capacity for fundamental science in a massive, long-term programme of coordinated research.

Nanotechnology is based on the science of the very, very small. One nanometre (1 nm or 10^{-9} m) is a millionth of a millimetre — about eight times the radius of

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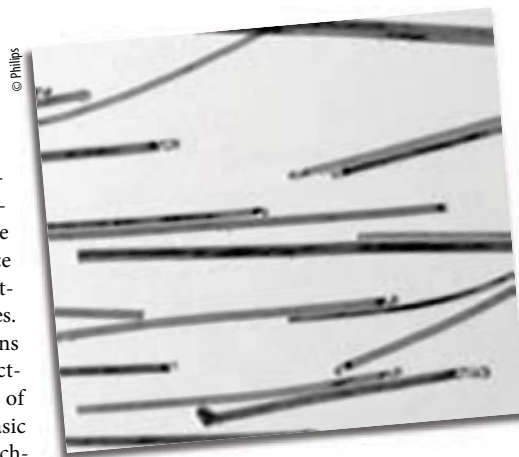
an atom, and a hundred times smaller than a bacterial cell. At this scale, matter behaves differently. It often becomes more reactive, and quantum effects can produce surprising results. A material's electrical conductivity, strength and melting point may all change, for example.

Since the invention of the scanning tunnelling microscope (STM) in the 1980s, researchers have developed increasingly powerful techniques for seeing and manipulating surfaces

at the nanoscale. This has led to the development of new materials, and even to the conceptual design of molecular pumps and motors.

A number of commercial applications have already reached the market. These include biocompatible medical implants, high-performance computer hard drives, scratch-resistant paints and self-sterilising surfaces. Many of these important applications have been realised through unexpected discoveries made in the course of fundamental research. Yet, much basic science remains to be done if nanotechnology's full social and economic benefits are to be realised. The private sector will normally fund only research that promises a commercial payback. But developing the building-blocks of knowledge that underpin industrial research, and the tools required to carry it out, still demands long-term publicly funded research.

Learning to predict accurately how material will behave at the nanoscale requires extensive theoretical and modelling work. Much research has centred on 'top-down' approaches that further miniaturise existing fabrication technologies. In the long term, 'bottom-up' self-assembly — perhaps using processes of biochemical synthesis similar



to those employed by nature itself — may have even greater potential.

Despite rapid current progress, science has still only scratched the surface of what nanotechnology can offer. Without continuing public support for basic research, atom-by-atom nano-assembly, quantum computing and many other anticipated technologies may be developed with considerable delay, or may indeed never be realised at all. The EU framework programmes will continue to play a critical role in the years ahead. The projects presented in this section illustrate some of the fundamental research carried out with their support.

EU funding to help establish European nanoscience facility

In order to promote increased collaboration between nanoscience researchers in Europe, the EU is to part-finance the creation of a European Theoretical Spectroscopy Facility (ETSF) along the lines of existing European synchrotron laboratories.

The ETSF is an initiative put forward by the Nanoquanta NoE, funded under the nanotechnologies strand of FP6, with additional resources provided by national research funding organisations. The countries represented in the network are Belgium, France, Germany, Italy, Spain and the UK.

The project builds on 15 years of successful collaboration between leading condensed matter theory groups in Europe, whose work focuses on the properties of electronic excited states in matter, particularly nanostructures.

According to Lucia Reining, research director at the *École Polytechnique* in Paris: 'Over the last two decades, European research and training networks have increasingly contributed to the development of scientific communities. In order to share this benefit more widely between scientists and with society, we have to find new forms of working to-

gether. The ETSF will be a major help for us to answer this challenge.'

The main objective of the ETSF, as announced in a press release in May 2005, will be to bring a deeper theoretical understanding of the science that underlies nanotechnologies to the wider scientific community. 'Until now,' the network stated, 'support for such work by the EU and national organisations has concentrated on self-contained, fixed-term research projects and networks with no permanent opportunity for other researchers to benefit from the new theoretical and computational developments.'

In a similar way to existing synchrotron facilities, the ETSF will act as a professionally managed knowledge centre whose expertise, theory and associated software can be employed differently according to the needs and interests of its various users. At its core will be a number of collaborating

research groups specialising in the theory of nanosciences or associated software developments, while users of the facility will be drawn from a much wider community, comprising researchers from both the public and private sector that wish to benefit from the latest developments in the field.

Such outreach initiatives will include the dissemination of theories, algorithms and computer programmes through publications, events and training sessions, as well as hosting visiting research teams from universities, research institutes and other organisations. The ETSF will also provide long-term training for users and doctoral students, as well as modules for Masters-level students.

Martin Stankovski, a doctoral student at the University of York which is coordinating the Nanoquanta network, concludes: 'Nanotechnology has enormous potential for the industry, but deeper theoretical knowledge of the science involved is often missing in the broader research communities, especially in the private sector. With the ETSF we have the opportunity to get the experience and knowledge of our research out where it will be of direct use.'

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