THE FOUNDATION FOR SCIENCE AND TECHNOLOGY

DINNER/DISCUSSION SUMMARY

Opportunities and threats from nanotechnology

Held at The Royal Society on Tuesday 18th November 2003

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In the Chair: **The Rt Hon The Lord Jenkin of Roding**

Speakers: **The Lord Sainsbury of Turville**
Minister for Science and Innovation, Department of Trade and Industry
Professor Sam Stupp
Director, Institute for Bioengineering and Nanoscience in Advanced Materials, and Professor of Materials Science, Chemistry and Medicine, Northwestern University, USA
Professor Stephen Holgate FMedSci
MRC Clinical Professor of Immunopharmacology, School of Medicine, University of Southampton
Professor Ann Dowling CBE FRS FREng
Chairman, Royal Society and Royal Academy of Engineering Study of Nanotechnology

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The invited speakers reviewed progress and issues in nanotechnology, largely with reference to nanoparticles and nanotubes. In discussion it was observed that small structures such as those buried in lasers should not be forgotten. Much of nanotechnology concerned the control of structure on a microscopic scale, and materials scientists asking about the effect of structure on properties had been the first nanotechnologists. Toxicology too needed to spread its wings and look at the effects of structures on this scale.

Professor Holgate's talk explained how small particles entered the body through the lungs and how they affected it. In discussion attention was drawn to the importance of smoking in promoting the inhalation of air pollutants in the form of very small particles with highly reactive substances on their surface. The effects were not always obvious. The size of particle and its lifetime were both relevant, with some of the larger particles from car exhaust persisting in the environment for as long as 30 days. On the other hand it was claimed that additives to make fuel burn cleaner reduced particle emissions without themselves appearing in the exhaust. It was also said that useful medical particles were likely to be biodegradable.

The impact of small particles on health was both chemical and physical, and there was a synergy between the two effects. Particles could contain active substances, but even chemically inert particles could be highly active biologically by reason of their very large surface area. They could damage mitochondria and provoke the creation of reactive oxygen species. It could not be assumed that nanoparticles made from a material which was safe in bulk would themselves be safe.

A manufacturer of nanotubes who already took sensible precautions wondered whether any lessons could be learned from blue asbestos. In reply it was said that the toxicology of that substance was still a mystery. The damage that it did seemed to relate not only to the needle-like shape of the particles but also to their surface chemistry. The surface chemistry of nanotubes needed to be investigated.

Figures quoted by Professor Stupp for expenditure on research and development in nanotechnology prompted the question whether people were rushing ahead without regard to safety. One answer to that was "yes". There was much reliance on small animal studies to model the effects of nanoparticles on human health, but rats and mice were adapted to living in drains and breathing toxic particles. Human airway epithelia were much more sensitive than the corresponding animal cells, and studies using human cell cultures were needed.

Against this it was argued that it was premature to worry too much. It was not yet clear what the most important nanomaterials would be and so it was too soon to do much work on safety. There was a danger of damping down enthusiasm and discouraging young people if too much emphasis was placed on possible hazards. The studies should be done but not made the centrepiece. No-one was about to paint walls with nanotubes.

Other speakers thought it important to address safety at an early stage. If the first thing people heard about a new development was bad this would stick, and it would be a mistake to wait until nanotechnology impacted on people through products. Certainly it would be wrong to focus on safety issues while forgetting the potential benefits, and a scientific debate in which there was no consensus would cause alarm, but the public would expect scientists to be looking at possible health effects.

There was a danger that in ten years time people would throw up their hands, as they had over genetically modified food. The language used to talk about nanotechnology should be carefully chosen: for instance talking about "disrupters" could cause misunderstanding. The right language could create excitement, and analogies could go a long way. Thus a Swiss scientist forecasting developments in pharmacology had described how it moved from describing effects in human, then chemical, then biological terms, and foresaw that the next step would be to combine biological and mechanical devices.

There was a question how best to consult the public at a stage when the technology had great promise but little immediate application. Asking people whether they had heard of it, and whether they approved, would invite the answers "no" and "no", but a more intelligent approach than that ought to be possible.

A speaker wondered why people identified ethical issues in nanotechnology, as distinct from practical questions like how to avoid damage to health. The evening's debate had identified issues over health and safety but not questions of ethics. It was observed that if the hyped claims for achieving immortality through nanotechnology came true there would be big issues, but the main current questions were practical. The technology might make possible some worrying applications, for instance a greater capability for remote sensing, and the interdisciplinary nature of the science meant that physicists and engineers would have to learn to cope with ethics committees. As yet, though, it was suggested that nanotechnology did not raise any ethical points which had not come up already in the context of other areas of innovation.

To the extent that ethical questions did arise, something could be learned from contrasting public attitudes to stem cells and GM food. Research on stem cells had been accepted because a legal framework had been put in place at an early stage and the scientists were seen to be under control.

A speaker raised the question of education. Nanoscience had been around for 100 years, but as yet there was very little production using nanotechnology apart from paints, pigments and catalysts. There was probably a five to ten year gap in which problems could be addressed before manufacturing really took off. Educational needs should be looked at for the next 20 to 50 years. People needed to understand the language. Once nanotechnology was properly established the prefix "nano" could be dropped, because it would be part of the mainstream.

Other participants stressed the importance of building interdisciplinary teams of multi skilled scientists. There was an exciting opportunity for young people thinking of becoming scientists to decide to work together, to cluster with other scientists. In America federal agencies funding research were being urged to talk to each other. The National Institutes of Health commanded huge resources, because health won elections, but were not doing much about nanotechnology, while the National Science Foundation had a tiny budget. They needed to co-operate with each other and with relevant Government departments and set up joint programmes of research funding. There were signs of progress: the director of the NIH now talked about nanotechnology in speeches and there were interdisciplinary panels to judge applications for research grants.

In the UK it was said that the most popular doctoral programme at Oxford University was for physical scientists moving into biology. The enthusiasm started before university. The pupils at one school in Cambridge had their own nanotechnology web page. Attitudes needed to change. A lot of schoolchildren opted to study double science rather than physics and biology, and it was argued that the established scientific community ought to support this rather than complaining about weaknesses in basic sciences. Similarly in the universities the traditional disciplines were still dominant, and it was said that in the US decisions on tenure for academic staff were influenced by the concentration on what was seen as solid science. In the UK one speaker saw a need to introduce interdisciplinary studies throughout the secondary and university systems and urged that they should be "given a good shake". It might be time to look again at moving to a baccalaureat.

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