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Documentation
Philip Campbell (Nature) on Nanotechnology

Nanotech, uncertainty and the publics

For some time I've been considering various issues of scientific communication with the public, both from *Nature*'s point of view and more generally. I've been involved in consultations and meetings about life sciences, ethics and society. I've been involved also in discussions about uncertainties in climate change prediction and their implications in communication. It's been a challenge and a contrast to turn specifically to nanoscience and nanotechnology, after I was invited to give this contribution, and to see some similarities and some differences in the controversies. I guess my expertise as an ex-physicist-editor is above all in communication, and that will be the emphasis of my conclusions.

I'll give some opinions. But this contribution aims above all to be factual: to relay genuine rather than bogus concerns - concerns being raised in forums in ways that those engaged in the development of nanotechnology need to be aware of.

Nature is certainly in contact with the public more and more, thanks to the Internet. My talk isn't going to be about *Nature*, but some of our online access statistics illustrate something of what is going on out there. Print circulation is healthy. Over the last three years our online access numbers have increased by about 300%. We now get something like 35 million hits a month across the Nature Publishing Group websites, and Nature gets about 4 million separate visits a month. About 80% of those come through Google and PubMed. Our free news service, Nature Science Update, is not promoted to the public but is rated highly by Google search rankings. I have to admit that our nanotechnology papers do not rank as highly as topics in genetics, but they certainly contribute to our leading position in physical sciences citations.

Both this publishing experience and the other experiences already mentioned point me to the over-riding importance of the Web as a means of communication to all. But as I shall comment at the end, there's a risk that web publishing and communication can fail completely to make the required impact.

In thinking more generally about science and the public, I've come to several general conclusions, and the rest of this talk will amplify those conclusions with particular regard to nanotechnology. So first, my general conclusions:

First, a truism: it's important to know what the real issue is. I know a plant biologist who has gone well beyond the call of duty in sitting on UK regulatory and advisory

Dr. Philip Campbell, editor-in-chief of Nature, has given this talk on June 13, 2003 at a symposium on nanotechnology at ZKM, the Art and Media Museum, Karlsruhe, Germany.

Nature magazine at www.nature.com

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bodies with opponents of GM crops. He has reached the conclusion that, in that issue, although the science is regularly deployed in arguments by both sides, the conclusions of science that health and environmental damage are hard to find are almost irrelevant to the opponents in Europe. They are driven by anti-business or anti-globalization or anti-monopoly or anti-exploitation agendas.

Second, in any discussion about science and the public, you need to define which publics you're talking about, as there are many. One can list at least 20 categories of stakeholders and publics in science, not including journalists nor the catch-all phrase "the general public", which itself can be broken down into social groups. The 20 categories range from various types of technical businesses and suppliers, to government departments, to lobby groups, to retail chains and doctors.

Third, one should never underestimate the interest of some of these publics in the relevant details of science, and their capacity to grasp the key concepts relevant to a debate. Anyone involved in life sciences debates knows the depth of knowledge brought to bear by lobbyists, whether they are technology opponents or beneficiaries like patients' interest groups.

Fourth, one should never underestimate the importance of getting timely information into the public domain.

And finally, one should never underestimate what a group of scientists and technologists can achieve in the face of a sufficient threat. I'll come back to this at the end. So let's start with the issues.

So let's start with the issues.

If you've not read Bill Joy's article in Wired about plagues of nano-replicators, then I urge you to do so. It's a wonderful example of how intelligent and compelling fear-mongering can be. The phrase "fear-mongering" might imply that I am accusing Bill Joy of bad faith. Far from it - I'm sure he believed every word. I am also sure that he is very pro-technology in principle.

Wired magzine at www.wired.com

"Why the future doesn't need us" by Bill Joy in Wired, April 2000
>> pdf document

But the phrase "fear-mongering" does appropriately imply being unduly alarmist, and to describe a technology as bringing us to (I quote) "the cusp of the further perfection of extreme evil… and on to a surprising and terrible empowerment of extreme individuals" is, let's say, questionable. Indeed the title (which may not have been of Joy's choosing) is equally questionable: "Why the future doesn't need us."

If you go to the Web, you'll easily find plenty of debate about Joy's article. You'll find responses from champions of nanotechnology such as Richard Smalley and Robert Freitas, as well as Freeman Dyson. You'll find plenty of debate from magazines. One important point raised by an online critic:

Joy's article contained no technical analysis of any kind.

But how is the public supposed to form a judgement when experts like Eric Drexler and Richard Smalley totally disagree about the feasibility of nano-robots of the kind envisaged by Joy? You can find that debate on Drexler's Foresight Institute website. So far Drexler has the last word - his latest rebuttal of Smalley was posted on his website in April 2003. (Two month later, in June, he posted an additional letter on his website. -- Ed.) He sticks to physical arguments and shows why Smalley's particular reasons for dismissing molecular assemblers are beside the point. A response from Smalley is awaited.

The Foresight institute at www.foresight.org

As I will discuss later, maybe other voices need to be heard too. But at least any member of the public can see and understand the debate, thanks to the internet and to the fact that some of the participants post their contributions on their own websites.

But these are not urgent issues and I'll say no more about them. There are other concerns which are more pressing and which, whether researchers like it or not, cannot be ignored. Last year, for instance, a meeting held jointly by the European Commission and the US National Science Foundation not only celebrated the opportunities offered by nanoscience and technology but also identified the following as issues of genuine concern for society:

Above all, it was agreed, there will be risks needing monitoring and control in all areas where nanotechnology meets the human body.

Other concerns relate to fairness and technocratic power: lots of infrastructure and know-how is required to make nanotechnology, little is needed to push buttons for good or ill. But, the meeting concluded, information communication and education for literacy are required. There will otherwise be dangers of a lack of public acceptance, and in global terms, a "nanotech divide" - a further concentration of current global divides in resources, wealth and development.

Society needs to focus on fundamental research and inclusion and partnership, preparing workforces and stakeholders for nanotechnology, addressing broad humanitarian goals, and strategies for technological transformation.

Transparency and regulation will be required both nationally - eg to regulate private companies - and internationally to minimize threats from states that are technology paradises but also international threats.

The meeting highlighted the frequent divergence of real risk and perceptions of risk. In reactions to bioscience and biotechnology, there can be an innate gut aversion to tampering with life: the so-called "Yuk" factor. So also, there can be gut aversions to a combination of aspects of

nanotechnology: the invisibility of nano-entities, autonomous locomotion and self-replication. All of these can give rise to aversion. But none of these exists except in science fiction. Consequently, analysis and communication are essential, avoiding or pre-empting the main threat: sensationalism.

Recommendations from the meeting also included the following:

There will need to be improved dialogue with stakeholders. Also, there must be more support for social and economic studies, plus legal on studies of ownership and liabilities.

There is a need for a dedicated advisory group to take the lead.

And finally in this list from the meeting, experts can make nanotech accessible by a variety of hands-on demonstrations and analogies.

I will return to some of these points later. But first it's my task to extend this panorama of concerns. I turn to other people speaking at other events. One event was a hearing by the US Congress held in April 2003, on the societal implications of nanotechnology. The witnesses there are all quite prominent in the world of nanotechnology debates, and all of them also focused on what I'd call the immediate issues rather than the 'grey goo' of Eric Drexler and Bill Joy.

Documentation of the US Congress hearing at www.house.gov (April 9, 2003)

One was **Ray Kurzweil**. A prominent advocate of nanotechnology, his view expressed at the Congress was that existing regulations on the safety of foods, drugs, and other materials are sufficient to deal with the near-term applications of nanotechnology, such as nanoparticles.

Ray Kurzweil's statement at the US Congress hearing >> pdf document

Another, with a contrasting viewpoint, was **Vicki Colvin**, based at the Center for Biological and Environmental Nanotechnology at Rice University in Houston, Texas. She referred to the "wow" factor of nanotechnology excitement and the "yuk" factor of gut aversion already mentioned. Commenting on the experiences of manufacturers of genetically modified crops, she said that a lack of sufficient *public* scientific data on GM organisms, whether positive or negative, was a controlling factor in industry's fall from favour. The mood changed, as she saw it, from Wow to Yuk to Bankrupt.

Vicki Colvin's statement at the US Congress hearing

She and many others point to the Human Genome Project as a model to follow: it set aside 5% of the total budget for studies on ethics and societal issues, and made all information as available as possible and all aspects of the project as transparent as possible.

Reflecting her particular research interests, Vicki Colvin also highlighted environmental, toxicity and food-chain concerns. And also, she pointed to what one might call

spin-off problems. The manufacture of the Pentium chip has significant energy and waste costs. The manufacture of carbon nanotubes involves toxic solvents and gases. The impacts of such side-effects will need to be minimized by the nanotechnology manufacturing industry.

In contrast to some nanotechnology advocates, she points to specific differences for small nanoparticles compared to inorganic particles. Nanoparticles can enter cells, especially if they are smaller than 50nm - the size of a cold virus. Then what? How will they get distributed in the body? They could cross blood-brain barrier, or leak into fluids between cells. So, says Colvin, they can get to places that your average inorganic particle cannot.

And she has concerns about the pace of development and the lack of safety testing. Nanoparticles used in sunscreen and cosmetics have not been tested, to her knowledge. That doesn't keep her awake, she says, and she uses sunscreens, because the diseases one anticipates come from prolonged acute exposures to particulates. But it would be better to conduct test. She emphasizes that new types of solar cells and treatments for cancer have amazing benefits. But with cosmetics, she says, the risks are less justifiable and there one might want to slow things down.

Another witness was **Langdon Winner**, professor of political sciences in the Department of Science and Technology Studies at Rensselar Polytechnic Institute in Troy New York. He suggested that Congress should create small panels of ordinary disinterested citizens, selected as we now select juries of law, to examine important societal issues about nanotechnology. For example, will proposed paths for military applications make the world safer or not? Would projected uses of nanotechnology in industry tend to create jobs or eliminate them?

Langdon Winner's statement at the US Congress hearing

To the fury of some advocates, Bill Joy in his article advocated that the research community relinquish certain types of research. But Eric Drexler, the founding father of nanotechnology advocacy, himself endorses principles of relinquishment: there should be no development of physical entities that can self-replicate in a natural environment. There should be a ban on self-replicating physical entities that contain their own codes for self-replication. Instead, they'd have to get codes from a centralized server. Maybe, he suggested, even biotechnology could come to use such a centralized coding approach rather than DNA.

In my research for this contribution I came across an article in the Institute of Physics journal Nanotechnology, entitled "Mind the gap - science and ethics in nanotechnology", by bioethicists from Toronto including Abdallah Sadar and Peter Singer. To my mind they commit sins of exaggeration similar to those of fear-mongers, in writing about "a danger of a collision course as in GM crops because of rapid technology development versus call for moratorium on deployment of nanomaterials from lobby groups." **A lack of dialogue, they say, may have devastating consequences.**

They point to yet more genuine issues: privacy and security given the potential invisibility of nano-sensors, and concerns that nanotechnology neuro or other implants may raise questions over whether we are truly human. Their chief conclusion invites cynicism: more funds for bioethics research, please! To be fair, many people interested in these issues are concerned about the lack of funds for investigations of the issues.

Enough about the issues. My second point was about the publics - and in particular, which publics matter? Well, we can note that politicians are getting involved. I mentioned those in the US Congress. In the UK, a recent report of the government's Task Force for Better Regulation identified nanotechnology as a target area.

The European Parliament is also getting involved. Only a year ago, in May 2002, a European Commission spokesperson said that nanotechnology generated the least political controversy of all the thematic programmes of the EU Sixth Framework programme.

In the mean time the Canadian based ETC group has entered the playing field in Europe. ETC is the Action Group on Erosion, Technology and Concentration. They have published reports on several of the issues I have already mentioned. The ETC group and associated Members of the European Parliament, as well as NGO's such as Greenpeace are now campaigning. They are a group that is achieving an impact out of all proportion to their tiny size - just a few people. They are demanding a moratorium on the deployment of nanoparticles until the health and safety effects have been properly investigated; and for an International Convention for the Evaluation of New Technologies. In the mean time, they organised a debate at the European Parliament.

ETC group at www.etcgroup.org

In order to present appreciate the arguments adopted by these pressure groups, I quote from recent documents supplied for this debate. For example:

"Nanotechnology, the manipulation of atoms and molecules, is set to become the defining technology of the new century. By rebuilding nature atom by atom and exploiting the properties of quantum physics, scientists are engineering novel materials and biomechanical devices placing unprecedented industrial power in the hands of some of the worlds largest companies and the military. Current global spending on nanotech (public and private) is in excess of US$4 billion and rising. Over 30 national governments have now launched nanoscience initiatives, with Europe, USA and Japan competing for the lead. An estimated five hundred nanotech companies are active throughout Europe, North America and Asia including leading transnationals such as BASF, L'Oreal, Bayer, Exxon, IBM and Hewlett Packard. Their nanotech particles are already used in cosmetics, clothing, windows, sports goods and amunitions. By 2015 global nanotech-related sales are predicted to exceed $1 trillion per year (US National

Science Foundation) with all sectors of the economy being affected - from electronics and computing, defence and weaponry to energy, agriculture, pharmaceuticals, fabrics and cosmetics. Like nuclear power, computing and genetic engineering before it, the ability to atomically modify matter - both living and non-living - will alter our societies, our economies and even our sense of ourselves. The nanotech revolution, however, is currently evolving quietly beneath the radar screens of government regulators and the public alike. No regulatory body has taken the lead to ensure that nanotech applications are safe and many of the hard questions have not yet been asked: **Who will control** nanotechnology? Who will determine the research agenda and who will benefit from nano-scale technologies? **What mischief** can synthetic nanoparticles create floating around in our ecosystem, our food supply and in our bodies? **What happens when** human-made nanoparticles are small enough to slip past our immune systems and enter living cells? What might be the socioeconomic impacts of this new industrial revolution? How will countries in the South be affected? **How will the poor,** excluded and disabled be affected? Should governments apply the Precautionary Principle?"

This discussion was sponsored by ETC Group, Greenpeace, Dag Hammarskjold Foundation, Genewatch UK, Clean Production Action and The Greens in the European Parliament. It included a panel discussion involving MEPs very active in such debates, several very supportive of science and technology. This is not a fringe discussion. My spies tell me that very few non-green MPs attended, and that ETC made less impact than they might have by not focusing exclusively on nanotechnology but talking more generally about the environment, globalization and so on - their principal concerns.

In June 2003 these groups followed up with an internal meeting, planning further actions, to focus on disability rights, peace, disarmament and security, social justice, environmental protection, privacy invasion, corporate control and industrialization of health and agriculture, consumer rights, workers rights, health and safety concerns and questions of Democracy and Governance.

A search of the websites will reveal other discussion in recent years, but this is enough to show that there is high-level attention to nanotechnology and that there is a broad consensus that issues need to be discussed in society.

Now we shall recapitulate my general principles:

First it's important to know what the real issue is. You'll recall that I said that in GM, the issues are much more anti-business than science. In nanotech, that isn't the case. Concerns about corporate dominance over other interests are there, but so too is a serious lack of understanding about what might be technologically and scientifically around the corner.

Second, in any discussion about science and the public, you need to define which publics that you're talking about, as there are many. I think I've done enough to show that there are key publics out there who are interested at a serious level.

Of course, we cannot forget the media. Here there is some slightly encouraging news. In 1999, the UK media went crazy about GM crop fears, spurred on partly by a certain member of the British Royal Family. Recently he spoke of fears about grey goo. This time the media response was very different. The science correspondents piled in and all said very much the same: such fears were huge exaggerations and distortions of reality. Note a key difference compared to the GM crops issue: then, there was (and still is) Monsanto. There's no easily identifiable nanotechnology corporate 'monster'.

Third, one should never underestimate the interest of some of these publics in the relevant details of science, and their capacity to grasp the key concepts relevant to a debate. This applies to lobby groups and to stakeholders. But who, other than industry and scientists, are the stakeholder beneficiaries of nanotechnology? Is it too soon to mobilize patients' groups? Whether or not that is the case, scientists should assume that even quite specialized information will be taken on board by some of the influential sectors of public opinion.

My fourth principle: one should never underestimate the importance of getting timely information into the public domain.
And finally, one should never underestimate what a group of scientists and technologists can achieve in the face of a sufficient threat.

This brings me to my bottom line. As I described, some politicians want public discussion groups to be convened by Congress, and other public dialogues to be pursued. In Scandinavia and elsewhere, consensus conferences are readily accepted as a way of giving public temporary control of the issue, in order to establish key questions and hint at possible answers about regulation.

Even though there is little sign of debate spinning out of control, all of this amounts to a serious level of public concern. **It is essential that the nanotechnology community engage.** And in particular, websites should be developed, easily findable by Google, and promoted to journalists and others with influence. These websites should contain explanations of nanotechnology concepts, and of possible applications, and should address head-on some of the concerns I have mentioned. But they should not be dismissive. It is not good enough to always minimise consideration of risks.

Above all these should be responsive to public debates, and be responsive very promptly. My best example of this is a new organisation in the UK, the Science Media Centre in

The British Science and Media Centre at www.scienceand

London. Sponsored by many organisations to a maximum of 5% of the total, so that no sponsor can overly influence it, it employs three people whose sole task is to respond within a few hours to headline news stories about any area of science, and to ensure that journalists have access to a range of scientific opinion. If a debate is long lasting, it organises seminars to allow journalists and scientists to meet and air their views, to discuss not only the science but also the way the media can best approach the many sides of such debates. It faced much scepticism from journalists at its launch but is now widely respected.

All of that engagement is unfamiliar ground to most scientists. And learned societies find these debates difficult, while industry voices will get discounted. But there are precedents for researchers to take a stand. They can spontaneously form lobby groups, as, for example, when scientists in Switzerland banded together in 1998 to resist a referendum banning GM organisms from their country. Even if one temporarily loses control of a debate because of unanticipated events or scientific discoveries that spark major concerns, perseverance and good contacts can moderate the impact of unbalanced discussions, and restore a balance.

So if I look around the landscape of nanotechnology champions, are there ready candidates to fulfil this highly responsive and responsible role in relation to key publics?

On the surface there is no shortage. One can find the following organisations with websites who state that they represent and communicate nanotechnology: the European Society for Precision Engineering and Nanotechnology, Nanoforum.Org - a European nanotechnology gateway sponsored by the European Commission, a related organisation CMP Cientifica, and national and regional organisations like the Institute of Nanotechnology in the UK, Minatec in France, the German engineering association the VDI, and Nordic Nanotech.

Some of these are clearly geared towards not only professional and investment communication but also public communication. **But none of them** show serious engagement with the issues and public discussions I've described in this talk. I cannot say whether these would be appropriate bodies to do more or whether, like the Swiss, a few scientists need to demonstrate a distinct initiative.

Individual labs can do something. In and around Karlsruhe, Germany, for instance there is some outstanding work on optical and electromagnetic functional nanotechnology going on. None of this needs to be affected by the debates I've mentioned, because it happens to be remote from the specific concerns I've described. If every lab puts a complementary highly readable summary of its main points for an even wider audience on their website, while also giving more public presentations, you are taking useful steps to minimize the chances of being tarred with lobby groups' anti-nanotech brush and to reassure the public.

I have concentrated on saying what is happening rather than analysing and criticising the concerns being raised. But the concerns I've described won't go away, and nor will the NGOs who agitate about them. I hope I've shown that more responsiveness by scientists and nanotechnologists to such concerns is both possible and advisable.

Feedback

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