

## Europe Develops an “Integrated and Responsible” Strategy for Nanotechnology

Nanotechnologies offer the tantalizing prospect of engineering at the ultimate precision—the level of atoms and molecules. It is widely recognized that our ability to master these technologies will underpin advances across a wide range of sectors, in particular, materials science. We are already witnessing the first products coming to the market, but these represent just the tip of the iceberg. Many challenges await researchers and engineers, and much research and development (R&D) is needed to realize the most revolutionary applications of nanotechnology. At the same time, however, we are faced with an even greater challenge, namely, ensuring that the general public has confidence in the safety of nanotechnology-based products. It is for this reason that the European Commission (EC) emphasizes the need for an integrated and responsible approach.

So where do we stand? Europe recognized the potential of nanotechnology early; some countries—for example, the United Kingdom—started national R&D programs as far back as 1986. At the European level, collaborative nanotechnology R&D has been part of the EC's 4th Framework Programme (1994–1998) and the 5th Framework Programme (1998–2002), the latter with funding totaling €45 million/year. In the case of the current 6th Framework Programme (2003–2006), nanosciences and nanotechnologies have been identified as a priority with funding of around €250 million/year on average (the figure for 2003 was €350 million). Overall levels of European Union (EU) public R&D investment (i.e., from Member States and the EC combined) has risen from around €200 million in 1997 to the present level of around €1 billion. Less than one-third of this total is from the EC—most of it is coming from a diverse range of national and regional programs. This is different from the situation in the United States where a much greater proportion of public funding comes from centralized federal sources compared to state funding.

The 6th Framework Programme (FP6) supports a wide portfolio of nanotechnology collaborative R&D projects and links teams from across Europe. The consortia vary in size and aim to assemble a “critical mass” of knowledge and resources (often interdisciplinary) that are appropriate to tackle the projects' objectives. Most of these projects are funded in the priority area called “nanotechnologies and nanosciences, knowledge-based multifunctional materials, and new production processes and devices,” where emphasis is placed

upon promoting industrial breakthroughs. Topics range from self-assembly to nanostructured surfaces and the development of multifunctional and “intelligent” materials. The final aim is not to develop nanotechnology *per se*, but to serve the needs and demands of citizens and enhance the EU's industrial competitiveness. In the past, Europe has too often underperformed when it came to turning its excellence in science and technology R&D into wealth-generating products and services—this is a crucial point. An integrated approach is stressed whereby all related aspects are taken into account—for example, metrology, education, training, and societal impact.

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One example of an Integrated Project (IP) that started this year is NAIMO, which brings together 21 organizations from nine countries to focus on the self-organization of matter. It aims to develop new multifunctional materials processed by additive manufacturing (e.g., direct printing) to form components with specific electronic, optical, sensing, and magnetic properties in an environmentally friendly way. The IP comprises a multitude of activities: nanofabrication, theory and modeling, synthesis of self-organizing materials, roadmaps, metrology, and training. A project addressing longer-term R&D is the Network of Excellence NANOQUANTA, which brings together 10 groups to carry out simulations of quantum structures at the nanoscale.

International cooperation is strongly encouraged and possible in virtually all FP6 R&D projects. This is being fostered, for example, by a coordinated EC call for proposals and a “dear colleague” letter from the U.S. National Science Foundation to researchers in the field of computational materials. Participants from the so-called international cooperation, or INCO, countries are eligible for EC funding.

While so many scientific and technical challenges remain, clearly the revolutionary potential of nanotechnology benefits from a holistic approach. In terms of education and training, new paradigms may be required to best prepare young researchers and engineers for the interdisciplinary R&D that nanotechnology demands. New infrastructure that can foster such interdisciplinary collaborations plays a crucial role. Moreover, several other considerations should be taken into

account upfront and from an early stage, as nanotechnology-based products can have implications for society at large, with benefits as well as potential drawbacks for some aspects of production, application, or use. In particular, there is increasing concern about the risks posed by dispersed free nanoparticles. These various aspects are intertwined, and it is clear that we cannot afford to neglect any of them.

An integrated and responsible approach to nanotechnology emerged as one of the recurrent themes of the EuroNanoForum-2003 meeting sponsored by the EC and attended by more than a thousand participants from the five continents (about a thousand students participated in the related Nanotech-Young initiative). Together with advice from numerous experts, discussions at the Forum paved the way for the first EC policy document for nanotechnology, which was adopted and published in May 2004: the communication “Towards a European Strategy for Nanotechnology,” available in 20 languages at Web site [www.cordis.lu/nanotechnology/src/communication.htm](http://www.cordis.lu/nanotechnology/src/communication.htm). In this document, the proposed strategy addresses R&D; infrastructure; human resources; industrial innovation; integration of the social dimension; public health, safety, environmental, and consumer protection; and international cooperation. It is stressed that only through concerted action in all of these dynamics can we secure that the potential of nanotechnology be effectively realized as a benefit to society.

Since the publication of the communication, discussions have been taking place on a political level in the Council of the European Union and are likely to conclude this fall. At the same time, the document has been disseminated widely and received warmly by both the general and specialized press. Views of the wider community have also been gathered by means of an online survey ([www.nanoforum.org](http://www.nanoforum.org)) and dedicated e-mail inbox ([rdt-nano-strategy@cec.eu.int](mailto:rdt-nano-strategy@cec.eu.int)). Taking these views into consideration, the EC intends to prepare an action plan as a follow-up to the communication, together with proposals for the 7th Framework Programme.

RENZO TOMELLINI  
RAYMOND MONK

*Renzo Tomellini is head of the “Nanosciences and Nanotechnologies” unit in the Research Directorate General of the European Commission. Raymond Monk is a program officer within the same unit. This article represents the views of the authors and not necessarily those of the European Commission.*