

## **From Laboratory to Society: Developing an Informed Approach to Nanoscale Science and Technology**

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**PI: Davis W. Baird**

University of South Carolina

Nanoscale science and engineering presents new challenges and opportunities not only to the scientific research community but also to all those who shape its public understanding. The assumption underlying our approach is that, only when we have a broad-based dialogue concerning how understanding and control of nanoscale phenomena is achieved in the laboratory and communicated beyond it, will we be in a position to engage in a fruitful examination of the societal implications of nanotechnology. This assumption drives the two objectives of our project. First, we are creating a variety of opportunities to bring about a broadly inclusive interdisciplinary dialogue on nanoscale science and technology. Second, within this model, we are pursuing an integrated multidisciplinary collection of four research projects (“Task Areas”) each intended to establish an informed understanding of nanoscale science and technology. The result we aim to achieve is an active and transforming line of communication between the scientists and engineers that are bringing nanotechnologies into the world, and the broader publics that these technologies will serve.

The team’s first objective is to create an integrated and participatory model to facilitate public understanding of nanoscale science and technology. We start by engaging the faculty members of the NanoCenter at the University of South Carolina. As the investigators explore the properties and possibilities of the nanoscale, a larger academic and non-academic public can participate in their discussions. Through workshops, colloquia, conferences, an interactive listserv, publications, courses, etc. our interdisciplinary research team invites bench scientists, humanities scholars, legal thinkers, students, teachers, and citizens to join together in its investigations.

The pursuit of this first objective allows for the achievement of the second objective, namely to conceptualize nanoscale research at an informed middle ground between hype and fear. Our research team focuses on the concepts of *understanding* and *control*, concepts that are central to a judicious assessment of opportunities and risks. We examine these concepts in four Task Areas that bring understanding and control of nanotechnology out from the laboratory, first to a wider audience within both this university and the academy at large, and then to its ultimate integration into our democratic society.

### **Research Projects**

Our Task Area 1 (Ideas of Stability and Control in the Theory and Practice of Nanoscale Research) is concerned with a systematic philosophical examination of nanoscale research, focusing particularly on the interdisciplinary research space in which nanotechnology is developing. Task Area 1 ran one conference in Darmstadt, Germany, “Discovering the Nanoscale II” (October 2003) a follow-up conference to the project’s first conference, “Discovering the Nanoscale” (Columbia, March, 2003). Further information on this conference is available at <http://www.ifs.tu-darmstadt.de/phil/nano>. In addition, D. Baird, A. Nordmann, and J. Schummer recently published an edited volume of essays inspired by this pair of conferences, *Discovering the Nanoscale* (Amsterdam: IOS Press, 2004). The next event for this TA is a

conference in the early stages of planning on the influences and computational legacy of physicist John von Neumann in nanotechnology, being planned by O. Bueno and A. Johnson for fall 2005.

Task Area 2 (Imaging and Imagining the Nanoscale: From Atomic Force Microscopic Topographies to Science Fiction Utopias and Dystopias) aims at developing a comprehensive understanding of how images and imaginings of the nanoscale work, and how they might work better. How we see the nanoscale, both with our (aided) eyes and in our mind's eye, has a powerful impact both on the science and technology of the nanoscale and on the public reception to nanoscale research and its fruits. The main product of TA2 during 2003/04 was the "Imaging and Imagining" conference. The conference brought together for the first time the full spectrum of experts that deal with imaging and imagining nanoscience and engineering, including microscopists, experts in computer modeling, leaders in the nanotechnology business, visionaries, science-fiction authors, artists and historians and philosophers of science, including Phillip Russell, Julio Ottino, James Von Ehr, Eric Heller and Kathleen Ann Goonan. The conference was well attended, bringing 80 registrants from seven different countries, along with a large number of local participants (who did not have to register). Another follow-up conference in Germany is planned for May 2005. In addition Task Area members collaborated to create a poster presentation, "Visual Images in Nano Science/Technology" that was presented as part of the USC NanoCenter's "Symposium V: Molecular Electronics."

Task Area 3 (Problems of Self-replication, Risk, and Cascading Effects in Nanotechnology: Analogies between Biological Systems and Nanoengineering) is concerned with an examination of the potential risks posed by nanotechnology, with particular emphasis on trying to understand "cascading effects." To do so, G. Khushf and E. Munn are currently soliciting abstracts and organizing a conference for March 2005 on the ethical and legal issues raised by nanotechnology and the larger convergence of technologies. Because developments in nanotechnology provide the basis for a convergence of the physical and life sciences, virtually all areas of human life may be transformed by these new technologies. These transformations will likely involve both great benefit and great risk. In addition, Khushf and M. Roco are editing a special issue of the *Journal of Medicine and Philosophy* on converging technologies.

Task Area 4 (Moving Nanotechnology into the Public Sphere) focuses on the communication about nanoscale science and technology as it engages the public sphere, including the public at large and our legal and political systems. Informed and engaged communication between the scientists and engineers that pursue nanotechnology and the people involved in the several dimensions of the public sphere is imperative if a broad-based understanding is to guide our democratic society as it deliberates over our control of nanoscale research and technology. At the end of the day, all the advances in our understanding of nanotechnology from Task Areas 1-3 will be of little value if they are not integrated into the public, political and legal discussions of nanotechnology. Task Area 4 is concerned both with developing models for how to accomplish this, and with bringing the insights from all Task Areas to the public sphere, drawing on the collaborative infrastructure established by our project. Several lines of research are being pursued on an individual level, resulting in articles and a book to be published in 2005 (D. Berube's *Nanohype* aimed at a broad audience). Several collaborations have also begun--including efforts by Baird, Berube, Best, Munn and Toumey to develop citizen deliberation panels and polling studies to assess public attitudes about nanotechnology. TA 4 also is

beginning to plan for a major international congress on ethics and regulation of nanotechnology for spring 2006.

### **Education and Outreach**

A main goal of our NIRT is to create a “nano-literate” campus. Our aim is to make an appropriate level of information available to a broad segment of the campus. Our contention is that awareness of nanotechnology—what it is now and what it promises for the future—should extend well beyond those preparing for careers in science and engineering at the nanoscale. During the first year of the project, we took two important steps in the direction of the nano-literate campus: (1) three courses were taught; (2) eight undergraduates were engaged in supervised research on various aspects of the societal and ethical implications of nanotechnology. Two undergraduate courses—“Enhancing Humans” (Khushf) and “Nanotech Implications” (Munn)—introduced various aspects of nanotechnology to a broad undergraduate audience that drew from students majoring in the sciences to students majoring in the humanities. Currently, registration is underway for our spring 2005 “Nano Semester,” a cluster of six courses focusing on different aspects of nanotechnology, including societal interactions, and several other events designed to bring the students in the different courses together for combined experiences. The March 2005 ethics conference will be one such event. But we also aim to bring several notable nano researchers to campus for lectures. Most importantly this cluster of classes provides an intellectual space for students from the humanities, social sciences, arts, to interact with students in science and engineering over a common interest in nanotechnology. This space is also vital to the undergraduate research projects, such as Ashley Shew’s investigation of the differences between professional ethics codes in science and engineering and the need for a nanotechnology code of ethics which bridges those differences, respecting the interstitial disciplinary space in which nanotechnology develops.

A major effort in reaching out beyond the campus was the South Carolina Citizens’ School of Nanotechnology. This “School” consisted of a sequence of six meetings, each led by a different member of the USC NanoCenter, coordinated by NIRT member, Chris Toumey. Approximately 45 Columbia-area citizens attended. The school was repeated this fall, and plans are underway to travel the school to other parts of the state.

At an administrative/institutional level, the NanoCenter has been very supportive of our project and of working to develop closer ties between NanoCenter scientists and engineers and NIRT personnel. Davis Baird was appointed Associate Director for Societal Implications of the NanoCenter in fall 2004. He now has a voice in NanoCenter planning. The NanoCenter has provided a significant amount of space (four offices) for project personnel. This provides an opportunity for informal “in-the-hallways” discussions between NIRT personnel and the scientists and engineers in the NanoCenter. In addition, many project events occur in NanoCenter facilities. For this reason, the NanoCulture seminar series has brought scientist and engineering members of the NanoCenter into discussion with other project personnel.

In short, USC’s NIRT has achieved a variety of objectives: an array of collaborative research projects; establishing a nano-literate campus; taking nano-literacy beyond USC; and working toward the co-evolution of our understanding of the societal and ethical implications of nanotechnology with the science and engineering of the nanoscale.