NANOTECHNOLOGY IN SOCIETY:
ATLAS IN WONDERLAND?

Guest Editors: John V. Stone and Amy Wolfe

Departments

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By John V. Stone and Amy Wolfe

As Alice fell down the rabbit-hole she had plenty of time to wonder what would happen next… She had gotten so much into the way of expecting nothing but out-of-the-way things to happen, that it seemed quite dull and stupid for life to go on in the common way.
            Lewis Carroll, 'Alice's Adventures in Wonderland'

And Atlas, they say, though pre-eminent in strength, moans as he bears on his shoulders the pillars that keep heaven and earth apart.
       Pausanias, 'Description of Greece'

Are we in the early phases of a revolution—a revolution in which nanoscale science and the technologies it produces will have a pervasive reach that will transform science and technology as well as the society in which they are developed and used? This issue of *Practicing Anthropology* is a call to arms of sorts for anthropologists and other social scientists—to engage in, and perhaps help to shape nanotechnology and its impacts on our world. It brings together a collection of articles written by anthropologists and social scientists who are involved in the large and increasingly international network of nano-related research and application.

John Marburger, III, Director of the U.S. Office of Science and Technology Policy, notes that "'Nanotechnology' is not so much a 'field' as a word—a neologism—pressed into service to *symbolize* the status of a very large and important sector of contemporary science." It refers implicitly to "a set of capabilities at the atomic scale that grew steadily throughout the last half of the past century into the basis for a true technology revolution in society"—an observation that has led

John V. Stone

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some to conclude that nanotechnology will be 'socially transformative and revolutionary' (Roco & Bainbridge 2005). Others argue that the present state of nanotechnology is merely an evolutionary extension or cumulative outgrowth of nanoscientific discoveries compiled over the past decade or so, but that *revolutionary* nanotechnolog*ies*, based on fundamentally new science, are very likely to emerge in the near future and with them bring products and societal changes that we cannot presently imagine (Whitesides 2005).

The emerging tale of nanotechnology in society is similarly symbolic, bearing both promise and burden. As Kathleen Brennan so vividly illustrates in our cover artwork, as with *Alice's Adventures in Wonderland*, a trip down the metaphorical rabbit-hole may be transformative indeed, where most anything seems possible if not probable; and yet, the creative and technical capacity to evoke such transformation—almost titanic in its power—bears a similarly heavy burden of responsibility. One hears in the rhetoric surrounding nanotechnology ubiquitous references to 'playing God' and the accordant promise of things both great and grave that accompanies such an endeavor. If one

accepts the claims of nanotechnology's socially transformative potential, then surely the social sciences and anthropology in particular, can be called upon to provide insight on such matters.

How might anthropology contribute to our understanding of the societal dimensions of nanotechnology or actively engage to shape its impacts on society, now as the world plunges competitively if not tentatively down the rabbit-hole? To better understand the nature of our engagement with this topic it is instructive to review the historical development and structure of the federal programs that support it. Attempts to coordinate federal work on the nanoscale began in November 1996, when staff members from several agencies held formal meetings under the auspices of the National Science and Technology Council (NSTC) to develop and coordinate plans in this area. In 2001, the Clinton administration raised nanoscale science and technology to the level of a federal initiative, officially referring to it as the National Nanotechnology Initiative (NNI), which now coordinates the multiagency efforts in nanoscale science, engineering, and technology under the auspices of the "21st Century Nanotechnology Research and Development

Act" (USC PL 108-153). Twenty-three federal agencies presently participate in the NNI, 11 of which have research & development (R&D) budgets for nano-technology. Other federal organizations contribute with studies, applications of the results from those agencies perform-ing R&D, and other collaborations. The "Supplement to the President's 2006 Budget" (NNCO 2005) recommends overall NNI investments for 2005-06 alone in the vicinity of $1.05 billion, with $82 million devoted to "Societal Dimensions" including "Environmen-tal, Health, and Safety R&D" ($38.5 million) and "Education and Ethical, Legal, and Other Societal Issues"h ($42.6 million). As one of the agencies participating in the NNI, the National Science Foundation (NSF) sponsors a number of nano-related priority areas. For example, NSF's Nanoscale Explor-atory Research (NER) Nanoscale Inter-disciplinary Research Teams (NIRT), and Nanoscale Science and Engineering Centers (NSEC) fit within its Nanoscale Science and Engineering initiative. In fiscal year 2005, total funding for these NSF programs exceeded $296 million. Recent government projections suggest that funding for nanotechnology will continue to rise across all sectors, with global expenditures projected to exceed $1 trillion (U.S.) by 2015 (Roco 2003).

NSF is the major source of federal funding for social science research re-lated to nanoscience and nanotechnolo-gies. As part of its NSEC program area, for example, NSF recently funded a net-work of Centers for Nanotechnology in Society (or CNS). Indeed, the submis-sion by Harthorn, McCray, and Satter-field describes the CNS at the Univer-sity of California at Santa Barbara, for which Harthorn (an anthropologist) is Principal Investigator and Co-Director.

Authors of the articles in this issue of *PA* have assembled over the past two years via a series of inaugural nanotechnology sessions convened at the annual meetings of three major anthropological professional associa-tions in North America—the Canadian Sociological and Anthropological Association (CSAA), the Society for Applied Anthropology (SfAA), and the

American Anthropological Association (AAA). These sessions have promoted the emergence of a small but growing network of anthropologists and other social scientists involved in manotech-nology research collaborations. Michael Mehta, a sociologist at the University of Saskatchewan, organized the first ses-sion at the 2004 meetings of the CSAA, under the title "On the Social and Ethical Impacts of Nanotechnology." Fascinating papers were presented at the session by academic sociologists and philosophers, but not anthropologists. Lopez's article derived from that first session at the CSAA. The second ses-sion was convened at the 2005 meetings of the SfAA, under the title "Anthropo-logical Perspectives on Nanotechnol-ogy," with contributors representing anthropology, communications, and sociology across business, industry, academia, government, and the non-profit sectors. Articles by Keating and Jarmon; Mody; Weeks and Boyle; and Wolfe, David, and Sherry grew from the SfAA session. While organizing the session for the SfAA meetings we (the editors) met Chris Toumey, an anthro-pologist with the University of South Carolina NanoCenter (http://www.nano.sc.edu/), who expressed his interest in organizing a similar session for the 2005 AAA meetings. We agreed that the SfAA session could serve as something of a springboard to this effort. The AAA session, titled "Cultural Anthropology and the Future of Nanotechnology," included contributions from European and North American anthropologists. The Stone and Toumey articles were drawn from this most recent nano ses-sion at the AAA. Future sessions on this topic are being planned for upcoming anthropology meetings, with an eye toward developing a broader network of international participants spanning the social sciences and humanities. We can safely state that, with these inaugural sessions in these three flagship organi-zations in anthropology, there is a clear and growing interest in applying and practicing anthropology in the realm of nanotechnology in society.

This special issue of *Practicing Anthropology*, quite possibly the first of
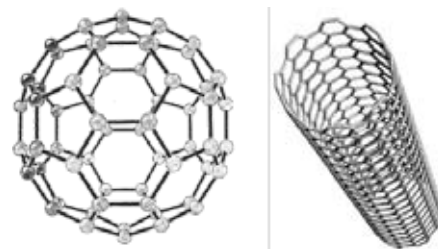
Symbols of Nanotechnology: 'Buckyball' (left) and Carbon Nanotube' (right)

its kind among major North American social science journals, follows on simi-lar special issues devoted to nanotech-nology and society in Philosophy (Baird & Schummer 2004, 2005) and Europe (Jamison 2005). The papers in this issue constitute the first collective representa-tion of anthropological interest in this topic. They are neither intended to be comprehensive with regard to the number of anthropologists involved in nanotech-nology research nor the breadth of po-tential anthropological involvement with this topic. Rather, they are a snapshot of anthropology's initial engagement in this nascent field, an engagement we expect will deepen as the number of anthropolo-gists involved increases. We hope this engagement will generate reflective in-sights into the nature of what 'practicing anthropology' means to the practitioners themselves, to those non-anthropologists with whom they collaborate, and to the agencies and organizations that fund these collaborations.

Just as nanotechnology developers work in academic, private sector, non-profit, and government settings, so do the authors of the articles in this collec-tion. Most of the contributors hail from academia, but Mody and Weeks work for non-profit organizations, Sherry works in the private sector, and Wolfe works at a government R&D laboratory. The authors raise overlapping themes, but from different perspectives. The first three articles present different kinds of overviews of nanotechnologies, and the role of anthropology and other social sciences in relation to emerging nano-technologies and their potential applica-tions. First, Elizabeth Keating and Leslie

.... but God is an overwhelming responsibility

Image by Jeffrey Hammond and Ian Anderson

Jarmon (both from the University of Texas at Austin) focus on communication about nanotechnology in building a common understanding between citizens and scientists. They highlight the language surrounding nanotechnology and the implications of the use of that language in different spheres. For example, Elizabeth and Leslie show us how the linguistic framing of nanotechnology discussions "can very often have the unintended effect of preempting the public's participatory voice." Pris Weeks (Houston Advanced Research Center) and Rachel Boyle (Rice University) take a different perspective, looking towards anthropological and social science insights about, and contributions to, the development of nano-related policies and regulations. They provide examples of the contributions that anthropologists and anthropological methods and approaches can make now, as new regulatory structures and processes are being developed. Pris and Rachel highlight the debate over whether provisions of current regulations, like the Toxic Substances Control

Act, are appropriate and sufficient for nanomaterials in exploring roles anthropology can play through science studies, environmental anthropology, the anthropology of work, and citizen engagement. José López (University of Ottawa) casts a critical eye toward attempts to enroll social scientists in large nanotechnology research projects through the auspices of ELSI (ethical, legal, and social implications) endeavors. He suggests that such involvement by social scientists has become a way of conferring legitimacy on, and promoting the overall success of, nanotechnology research and development initiatives. Moreover, José proposes the idea that social scientists' most important role may be to short-circuit these processes, and not contribute to them.

The next cluster of articles derives from the practice of anthropology related to nanotechnology in different settings. Amy Wolfe (Oak Ridge National Laboratory), Kenneth David (Michigan State University), and John Sherry (Intel Corporation) present views from federal R&D laboratory, university, and private industry perspectives. They describe the organizational settings in which they operate, how they are situated as anthropologists, and the kinds of nanotechnology-related issues of particular interest in their organizational environments. Cyrus Mody (Chemical Heritage Foundation), whose background is in engineering as well as science and technology studies, has studied "instrumentation as a lens for examining the social practice of experimentation."

In discussing his, and his subjects', simultaneous drift toward nanotechnology, Cyrus emphasizes the importance of studying the nanotechnology and nanotechnologists, today, as the field is emerging. He encourages investigation of institutions that both repackage their nano work to reflect their institutions' images and reshape themselves in response to the pressures imposed by the world of nanoscience. Christopher Toumey (University of South Carolina) looks at nanotechnologies from an insider's perspective, specifically as an anthropologist within a large, interdisciplinary program studying societal interactions with nanotechnology. Chris is the primary team member responsible for developing and implementing an outreach program to achieve the team's goal of "moving nanotech into the public sphere." He describes how he brings anthropology to this endeavor, and some of the resulting outreach engagements.

John Stone (Institute for Food & Agricultural Standards, Michigan State University) departs somewhat from the other authors in taking a more introspective assessment of anthropology's contribution to the study of nanotechnology in society. Using his participation in a network of federally funded nanotechnology research projects as his starting point, he asks whether anthropology's engagement with this topic will reveal as much about the cohesiveness of our discipline as it will contribute to a broader understanding of nanotechnology's societal dimensions. He asks, what, if anything, defines our contributions as
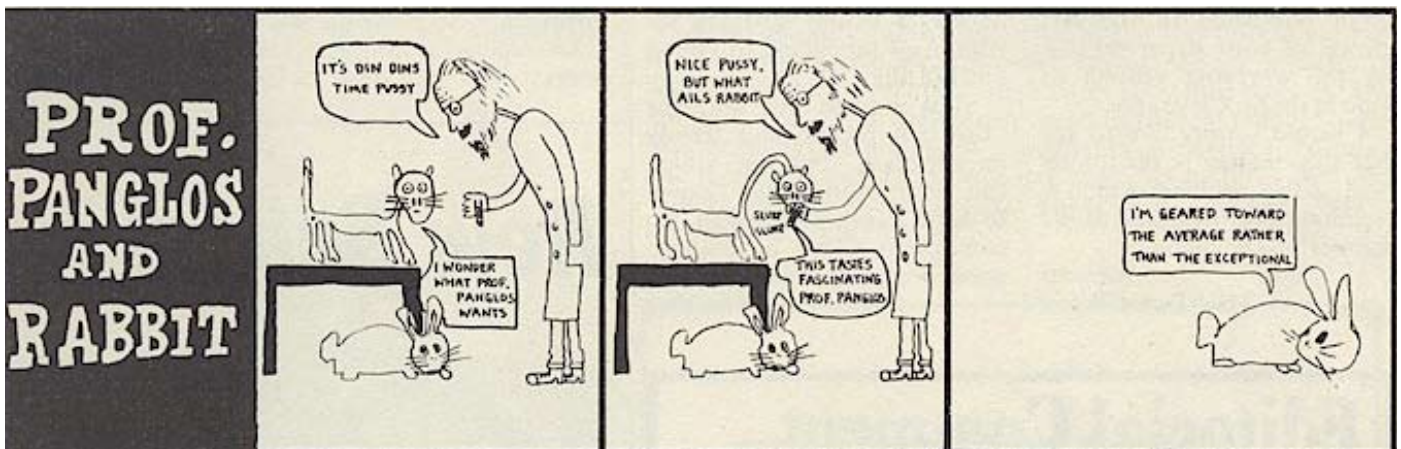

Image by Jeffrey Hammond and Ian Anderson

uniquely anthropological; what distinguishes them from the contributions of practitioners of other disciplines? From this vantage John argues for a more coordinated, holistic and comprehensive four-field approach to the anthropological study of nanotechnology.

We end the collection of articles with the contribution by Barbara Herr Harthorn and Patrick McCray (both at University of California, Santa Barbara), and Terre Satterfield (University of British Columbia). NSF-funded Center for Nanotechnology in Society at the University of California at Santa Barbara. As principal investigator and co-director of the Center, Barbara—an anthropologist—occupies a unique vantage point from which to view and to some extent shape anthropological engagement with this topic. The authors describe opportunities that the Center presents for anthropological research on nanotechnology, both domestic and international, and they identify key entry points for such engagement centering first on ethnographic research with nanoscientists and engineers.

Taken together, this collection of articles demonstrates that anthropologists and social scientists are far from passive or retrospective viewers of the rapid emergence of the nanoscience and nanotechnologies that may change our world. The authors are active participants, and sometimes front and center, in the unfolding nanotechnology revolution. We encourage others to take similarly active roles in the study and practice of anthropology related to nanoscience and nanotechnologies, a realm of tremendous potential and overwhelming burdens.

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WHAT IS NANATECHNOLOGY: NEW PROPERTIES OF WORDS AS TERRITORIES IN A CROSS-DISCIPLINARY, CROSS BORDER FLOW

By Elizabeth Keating and Leslie Jarmon

The cultural impacts of tools and technologies have always been of great interest to anthropologists, cognitive scientists, and developmental psychologists. Humans have a long history of inventing and using tools, both material and symbolic, and these have influenced the development of our societies in crucial ways, both cognitively and in terms of the specialization of social roles and relationships. Perhaps never before have technological innovations emerged at the rapid rate we see today. This rate of technological change has already brought major alterations in daily activities, work and family life, knowledge production and knowledge sharing. The emergence of nanotechnologies, for example, are challenging social scientists, including anthropologists, to synthesize new ways of studying and understanding human societies. Social scientists are being asked to respond to questions from natural scientists and the "general public" about how best to continue to innovate while ensuring public welfare, and how to minimize unintended negative consequences of nanotechnologies. In an era of post-industrial environmental crises and hard won insights about the complexities of generalizing about human cultures, many citizens and scientists are speaking to the issues of relationships between society and technology. The 2005 Session on Nanotechnology in Society, held at the Society for Applied Anthropology annual meeting was a pioneering effort to involve anthropologists in this challenge, and to foster new awareness. The ideas presented here have been shaped by that discussion and by our interest in how culture and particularly

Elizabeth Keating

Leslie Jarmon

language influence the adoption of new technologies.

We feel anthropological and communication perspectives have an enormous amount to contribute to a dialogue between citizens and scientists, an enormous challenge in places such as the U.S. where scientific literacy and understandings of other cultures can be very low and where scientists receive little or no education on cultural impacts of innovations and possible ethical implications of their discoveries. The language that stakeholders use in efforts to communicate about technology can itself create particular realities which obscure understanding and subtly position the discourse and the relationships of those stakeholders to the same social challenges. At the nano panel at the SfAA meetings and also earlier at a convocation to facilitate interdisciplinary research in 2004 sponsored by the National Academies, communication was discussed as a key problem in achieving a public understanding of science. Choices and conventions in terminology, false polarities, ill-considered

metaphors, unexamined belief structures, the linguistic organization of cause and effect relationships, and the *cultural* nature of what we know of as "knowledge of things and processes" all make communication and building shared understanding a daunting process. What the public considers to be 'truth' and legitimate practices can be very different from 'scientific truth' and legitimating practices. Truth "is typically a social matter…not simply because conventions and public criteria are needed for the assessment of truth, but because truth itself becomes an instrument…through which important social work gets done" (Duranti 1993:218). The debate on the truth of "nano," both definitionally (what it means) and in terms of potential societal impacts, as it has emerged so far tends to pit laboratory scientists against an unwary public. This may not be surprising considering that historically inventors and innovators have passed along both benefits

and the potential harmful consequences of their innovations to the public, for example, through the government, policymakers, the courts, and insurance companies. However, rather than reexamining aspects of this historical relationship, the early debate, critique, and counter critique about nano have been constructed along the lines of the power of nano to either save the world or destroy the world. This hyperbole or extravagant exaggeration creates utopic and dystopic views in the growing competition for public attention. In both utopic and dystopic scenarios, language is the principal means for linking cause and effect chains, building worldview and influencing others. Both utopic and dystopic positions reduce the complexity and ambiguity of the very real transformative phenomenon of nano, and this positioning is a risk in itself.

The scientific community is more aware than ever that public perception and the use of language can influence policy and research decisions. The European community has had a strong influence in policies which impacted the development and dissemination of genetically engineered food and convincingly demonstrated the strong relationship between culture and technological adoption. In a manner somewhat reflective of problem solving strategies within their own disciplines, some scientists hope to develop a paradigm for managing/controlling such "negative" public perception through specific strategies. At the same time most nanoscientists sincerely want to be *guided* by the public on critical questions, in order to focus research on innovations that will not only be scientifically exciting, but will enable greater "quality" of life, that is, address some social-demand needs. This is no easy task, when even the ways the discussions are linguistically framed by speakers and writers can very often have the unintended effect of preempting the public's participatory voice. For example, when the argument is framed as "social impacts of nanotechnology" (and we ourselves are often forgetful of this), we are locating society in a post-decision,

reactive, even victimized position in relation to decisions made during the developmental phases of nanoscience, decisions made to prioritize nano-research projects, and even earlier funding decisions—frequently using public monies—to prioritize nanoscience and nanotechnology research. Conversely, information about the smallest whims and desires of this same society (not to mention its more basic needs) is a high-dollar commodity when private sector enterprises seek the closest possible fit between their products/services and their consumers. A key challenge is how to foster a collaboration of voices of public interest across typically uncommunicative divides. Innovation is needed in terms of understanding language use and its contribution to building relationships among cultural processes which organize the distributions of power and knowledge within a given community. Science has a long history of disrupting fundamental world views and legitimating systems, and culture has had some disruptive influences on the emergence of science. Discoveries in nano that promise powerful new ways to improve the quality of life for many (health, disease, energy, water supply) using new ways to manipulate materials and the environment have the power to also transform widely held values, beliefs, linguistic and political economies.

Culture and Knowledge Systems

Members of human societies have a well-documented diversity of world views based on cultural belief systems and local ecologies of knowledge. This includes different measures of 'truth' and what counts as knowledge as well as how readily it can be acquired or shared. One recent posting to a weblog of current events, news, and scientific issues refers to the desirability of eliminating the influence "religion" has over "common sense" (http://www.worldchanging.com/archives/003045.html). This illustrates some of the complexity involved in acknowledging and understanding how people organize their knowledge and experience.

There are common processes by which humans regularly equate what is cultural (and locally known) with what is natural (and global or known by all) as has been discussed by anthropologists such as Bourdieu. This can obscure understanding between groups, and can obscure our accurate comprehension of the magnitude of diversity of viewpoints. Ethnocentrism is prevalent across groups and societies. Perspectives learned early in life and reinforced daily can grow habit into "nature" in its own kind of self-replicating, hard to control process. Local charters of legitimacy tacitly and overtly discourage questioning and criticism in some areas, for example, in the case of beliefs in a chartered sacred realm. Because of aspects of the hypothesis testing paradigm in science, many members of post industrial societies have confidence in the "objective" and the objectively-verifiable nature of science, systematic research, measurement, peer review, etc. and are prepared for counter-intuitive results. Concealment of truth is, however, a regular practice, too, prescribed in many cultures as proper behavior, such as some Melanesian and Micronesian cultures described by anthropologists such as Weiner, Strathern, and Keating in order to avoid open conflict, and conserve power. What happens when knowledge produced in one culture confronts knowledge produced in another with different modes of knowledge production, laws, and beliefs about power, nature, cosmology, and the human body?

Beyond possible toxicity/environmental hazards of new materials, and other unintended consequences, the way new technologies and innovations transform our cultures and our ways of thinking must be more widely understood. Anthropologists have extensive experience studying the processes of culture change and culture contact with novel systems, including disruptive effects like the transformation of economic, religious and political systems. How do new types of social behavior arise within individuals or groups in such situations? Innovations which occur "in the hands of" users can affect

society in unpredictable ways, as ideas, information, and technologies move beyond national and local borders. During the period of colonial expansion of the European nations in the 18th and 19th centuries, societies in the Pacific Islands, Africa, and Latin America were rapidly introduced to transformative technological innovations. Major influences on belief systems accompanied the rapid introduction of new principles and applications. Technologies which had developed within European landscapes were adapted to different cultures and environments. Aesthetics and spiritual values, typically outside the purview of scientific innovation, were also in conflict. When the Europeans brought to the Pacific Islands not only new building technologies but also the idea of land as private property both practices were disruptive of indigenous systems. Anthropological research on rapid culture change shows that the attitudes of members of a society are critical in situations of rapid innovation. We know that in times of great cultural change, social movements sometimes arise as alternatives or interesting inversions to newly introduced systems, tools and values. An example is the rise of the cargo cults of New Guinea and Melanesia in the1930s. Members of cargo cults believed that a flood would destroy the European colonists. After the flood ships would come with abundant European goods for the indigenous groups, but without the dominating Europeans. Believers stopped farming and built storehouses for the incoming goods and were encouraged by local leaders to use up their own provisions in preparation for abundance. Examples of similar movements in the U.S. include the Branch Davidians and the People's Temple. Fears held by elites about possible future distribution of wealth can contribute to genocide, enslavement or forced migration.

Territories of Language

Nanotechnology not only reflects a completely new type of science, but science done in new ways across previously impermeable boundaries and conceptual territories that were staked out centuries ago. This has caused confusion in how to define nano. The project of trying to negotiate an agreed upon definition of nanoscience or nanotechnology is one that has received considerable attention. In 94 top newspapers and popular magazines (mostly U.S.), the frequency of nano articles has increased from only one article in 1988 to 305 in 2003 (with 136 of those in the *New York Times*) (Stephens 2004). In the Science, Technology & Society (STS) Program at the University of Texas at Austin we are often asked, "so what is nanotechnology?" One of the roles of academia has been to define fields as well as to legitimate and value certain forms of inquiry. A recent discussion among STS students in engineering, anthropology, information science, communication, and journalism reveals the challenges, however, in managing a new interdisciplinary field.

- Engineer: In order to have fruitful discussions about the societal implications of nanotechnology, we need to determine what we mean by this term. We need a *clear definition*.
- Anthropologist: But we can't dismiss its multiple meanings—not only how scientists define it but also what it implies for different communities.
- Information Scientist: Let's see if we can organize and represent the different meanings using diagrams and other tools.

Across cultural groups this discussion can be even more complex. However, even in science, fields can migrate away from their earlier meanings, as in the case of the meaning of 'organic [living organism] chemistry' which in the latter 19th century came to mean the specific chemistry of carbon and its compounds (http://www.eprairie.com/news/viewnews.asp?newsletterID=4493, July 20, 2005). Meaning making is a collaborative enterprise and meanings are built within other cultural and linguistic structures such as power, authority, aesthetics, and situated knowledges.

Nanotechnology is certainly much more than the prefix 'nano' (from the Greek 'nanos' for 'dwarf') and 'technology' (the application of science). It is more than Taniguchi's definition of "the processing of separation, consolidation, and deformation of materials by one atom or one molecule." Yet engineers and scientists who are familiar with nanotechnology have recently objected that non-specialists have begun to use the term incorrectly. They have responded by advocating a differentiation between a general definition of nanotechnology and molecular manufacturing, a theoretical form of nanotechnology believed to be achievable at some point in the future. The power of those outside of the laboratory to interpret meaning inside the laboratory, and the debate over the "realm" of nanotechnology is reflected in the National Science Foundation's recent interest in efforts to "mute speculative hype" and "dispel some of the unfounded fears that sometimes accompany dramatic advances in scientific understanding" (NSET 280-page report of a workshop on the Societal Implications of Nanoscience and Nanotechnology, September 2000).

The concern with language and terminology is not trivial. Words are well known to have "dangerous" properties. Language is a crucial tool for knowledge functioning not simply as a device for reporting experience but also as a way of defining experience for its speakers, as Sapir noted. Part of its tremendous influence comes from the way it creates sometimes arbitrary relationships between individuals and between individuals and the environment. The event of speaking itself affects our perceptions including our awareness of participant roles, for example, in terms of how various referents are coded into agents or patients in language (Silverstein 1980). Explanations of science to a lay public often involve the appropriation of terminology and analogies from other academic fields and literary genres, including science fiction and popular culture. Metaphors which import vocabulary and concepts from known domains into

unknown ones are powerful means for shaping understanding (see Lakoff and Johnson 1980). Ideas are shaped and reshaped by the environments in which they occur and the cultural expectations of individuals and communities. In addition to definitions of the term nano, debates have arisen about what nano means to the future. In these debates, both utopic and dystopic territories are formulated. Science has frequently been described as both: "our opiate and our joy, our ticket out of whatever ails us into a shining future free of sickness and want" and also "our demon…Three Mile Island, and tides of toxic waste" (Peckerar 2003:24). Fears about nano are discussed in a now famous April 2000 essay in *Wired* magazine titled "Why the Future Doesn't Need Us" by Sun Microsystems cofounder and chief scientist Bill Joy and the 2002 novel *Prey* by Michael Crichton. More people are likely to read *Prey* than read scientific articles.

In nano utopia, the significance of nano is not just its small scale (and small is beautiful in technology), but the way nanoscale materials have powerful qualities and capabilities quite different from their macroscopic counterparts. Nanoparticles are described as having potentials in many applications, and because nanotechnology is interdisciplinary in pioneering ways, advances are expected to contribute to our understanding of biological, environmental, and planetary systems. Nanotech is described as capable of providing affordable products with dramatically improved performance as a result of new understanding of ways to control and manipulate matter. Often cited are new materials to enable new types of health treatments, human-machine interfaces, new types of travel, new ways to solve problems such as clean air, water, and energy, and great portability of technologies. Nanotech is regularly claimed to have the potential to change the way we live fundamentally at least as much as any of the great technological advances of the past five centuries.

The utopic vision of nanotechnology includes economic, social, medical and energy opportunities. Nanotechnology is often itself an agent in these stories; it "offers" better built, longer lasting, cleaner, safer, and smarter products for the home, for communications, for medicine, for transportation, for agriculture, and for industry in general. The word "promise" is regularly used in utopic visions of nanotechnology, a word with positive connotations of trust and responsibility/pledge for the future. We will have the ability to "snap together the fundamental building blocks of nature easily, inexpensively and in most of the ways permitted by the laws of physics" (Merkle 2005). "Leapfrogging" (a term borrowed from a children's game) opportunities (which alter expected trajectories of growth through radical new affordances, for example, the way wireless "leaps" past the necessity to construct a costly infrastructure of land lines) are cited.

On the dystopic side, the term "grey goo" has come to be the metaphor for the potential of nanotechnology to "destroy the world." The phrase grey goo was first used by Drexler to describe a hypothetical situation in which scientists are unable to control self-replicating nano robots, which then consume all life forms (a scenario known as ecophagy, the consumption of an ecosystem). The goo is a large mass of replicating nanomachines. Grey goo doesn't really sound all that scary by itself; it has a childish sound to it and 'goo' can mean 'sentimental tripe.' Utopics argue that objects at the nanoscale are more susceptible to damage from radiation and heat (due to greater surface area-to-volume ratios), and that rather than nanomachines becoming runaway forces, they would quickly fail when exposed to harsh climates and be unable to outcompete other forms of life. Dystopics point out that the very properties of new materials which could make such things as targeted medical cures more efficacious could in fact be harmful to humans by affecting the integrity of cell walls or human immune systems if inhaled or digested. Drexler has retracted the grey goo idea to focus on other possible threats, risks, and mis-

Recap of Experiential Learning with Civic Forum Participants

uses. Containment becomes the newest problem: how can a nano-particle be contained when it is smaller than its would-be container? New topics of concern include the creation of a nano divide, military uses, and enhanced levels of surveillance (nano-panopticism). It is difficult to retract a metaphor which has been widely disseminated to represent a new concept and because nanoscience is regularly referred to as having unprecedented potential to either save the world or destroy it, in any case to transform it, national, international, public and special interest groups are beginning to discuss these possible transformations within frameworks such as education, equality, health, economic planning, and public policy. Important new efforts are emerging to generate innovative forms of dialogue among community members, technologists, natural and social scientists, engineers, and students.

One goal we feel is particularly important is developing broader understanding of how culture can impact decisions made about uses of scientific discoveries as well as how discoveries impact societies. Attention must be paid to how language is used to create "information," and organize ideas about science. Questions must be generated concerning interdependencies, problems with limited individual and corporate vision, and conflicts of interest and perspective among individuals, business and research entities, and society. Anthropologists and communication scholars can help frame the larger

nanotechnology discussion in such a way that it, too, is interdisciplinary, i.e. all stakeholders have an opportunity to participate, learn, and share responsibility. It is clear, however, that there are at present no effective means for generating a truly pluralistic discussion about the future of societies. Not only is the public unaware of what nanoscience "means," but there is a lack of social science models to help guide public understanding and problem-solving about potential cultural and societal impacts. There is a critical need to identify and develop effective models and a language for communication and discussion in order to invite sophisticated and creative solutions to the utopia-dystopia polarities.

Language is extremely important in affecting how people, in the course of daily activities, develop ideas about innovations and sustain culturally based practices and culturally taken-for-granted structures, what counts as reasonableness, and other aspects of shared value systems. This is a time when new understandings of science are being imagined, articulated, and negotiated through language. Potential economic, legal, ethical and other societal implications of science have not usually been talked about by laboratory scientists. At the same time, the internet and other technologies have made possible both global and local information flows on an unprecedented scale, reducing the costs in labor and materials of informing and of organizing efforts by citizens to shape policy. The speed of new technological innovations demands new agility and new models to answer the complex challenges of communicating globally about new global issues.

In January 2005, the STS Program of UT Austin sponsored a "Societal Impacts of Nanotechnology" meeting bringing together Information Technology Industry leaders in Austin, Texas, faculty, and students to discuss societal impacts of nanotechnology and paradigms for understanding social change and prioritize issues of importance. From that event we realized, as did all the participants, that we must create a model for citizens to talk in appropriately complex ways about impacts on human societies of advanced technological processes. We then began planning a large Civic Forum on nanotechnology to pilot new ways to bring scientists, policy makers, students, and "the public" together in a conversation about social change and to create processes which could foster wide participation. We held our first STS Civic Forum on Societal Impacts of Nanotechnology on October 1, 2005. It was the first large-scale event of its kind on societal implications of nanotechnology and designed to create an environment rich in dialog and information sharing from many perspectives. We were impressed that 300 members of the community came on Saturday to learn about nano, and the importance of the event to engage the community in thinking about societal implications of nanoscience was underscored by the attendance of the Mayor and the President of the University. The 300 attendees participated in a variety of learning experiences we designed for them, including a conventional question/answer session with a panel of nanotechnology experts, and an unconventional complex role playing activity where they "became" a member of a fictional community and responded to a series of decisions based on Jarmon's "nano scenarios" (designed around a biotechnology/community health issue). Participants commented afterwards that they did not realize the extent to which developments in nanotechnology could affect daily life, and they were surprised at the number of nano products already on the market or in development. They were excited by potential medical applications of nanotechnology and apprehensive about the power of nano and the fact that the public at large is very unaware of nanotechnology. We are working to refine the 300 participant Civic Forum model and we urge experimentation from others with new ways of practicing anthropology to reach a wider public and engaging in new methodologies for nanosocialscience. We look forward to sharing findings.

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WHAT ANTHROPOLOGY CAN CONTRIBUTE TO THE CONSTRUCTION OF NANOTECHNOLOGY POLICY AND REGULATIONS

By Priscilla Weeks and Rachel Boyle

Introduction

This paper arose from the primary author's participation on the *Nanotechnology and Society* panel hosted by John Stone and Amy Wolfe at the 2005 SfAA meetings in Santa Fe. The issues brought up by both panelists and audience served as a catalyst for further thought by the authors of the role that anthropology can play in the design of regulations for nanotechnology.

Nanotechnology has the potential to radically alter medicine, manufacturing, materials science, telecommunications and agriculture. Some of its adherents predict it will affect every aspect of life in the future and have compared it to the next industrial revolution. Because of the potential for wide ranging impacts, the responsibility for either regulating, or providing information essential to regulation, is spread over several governmental agencies and institutes. These include, but are not limited to, the Food and Drug Administration, Environmental Protection Agency, National Institute of Occupational Safety and Health, National Science Foundation and the National Institute of Environmental Health Sciences. New regulatory structures and processes have not yet been put into place and numerous advisory committees, working groups and inter-agency programs are exploring and debating appropriate regulatory and policy frameworks. Anthropology can contribute to this effort through ethnography, cultural models research, environmental anthropology, social studies of science and more. Below are but a few examples, drawn from work

Priscilla Weeks (left) and Rachel Boyle

on other topics, of the ways in which anthropology can inform the construction of a regulatory framework for nanotechnology.

The basic regulatory task is to determine whether, and in what manner, to control direct and indirect human, animal and environmental exposure to nanomaterials We use the term nanomaterial to refer to consciously constructed nano sized materials, particles and tubes. A lot of scientific work still needs to be done in order to identify exposure routes and assess safe exposure levels before effective regulatory controls can be designed. Therefore, scientific uncertainty drives much of the current regulatory discussion and public controversy over nanotechnology. To date, there are few toxicology studies available on nanomaterials and the results are conflicting, yet nanomaterials are already in a variety of consumer goods. New scientific and technical advancements have unforeseeable and often harmful consequences and there is fear that widespread commercial use of nanotechnology will occur before potential negative consequences have been identified and adequate controls developed.

One point of disagreement is the extent to which the current regulatory

provisions contained in the Toxic Substance Control Act (TSCA) are adequate for nanomaterials. If a chemical is listed on the TCSA inventory, it does not need new approval before being used commercially. If it is not listed, it needs to go through the testing and approval process. Currently, nano-sized versions of chemicals already in the TSCA inventory do not need additional approval before being used in commercial products because they are viewed as existing chemical substances. Environmental organizations such as the National Resources Defense Council, Greenpeace and Sierra Club contend that nano-sized particles are new chemicals and should be treated as such and vetted through the TCSA approval process. Industry groups such as the American Chemical Council disagree, stating that the current TCSA approach is the correct one and that voluntary standards are preferable to regulations.

Science Studies

On one level, the controversy can be viewed as the result of incomplete science, solvable once all the studies and analyses have been completed. Although

researchers, industry and public interest groups agree that more research is needed to answer key questions about how nanomaterials will act in the body and environment, addressing such questions will not guarantee agreement on how nanomaterials should be regulated. Nanotechnology boosters maintain that some of the public fear fueling the controversy is due to lack of correct information and that public education is needed to avoid what they consider to be an 'irrational'

where they get their information about global warming, congressional aides responded with the names of scientists' sharing their world view and with whom they had worked with in the past (Kempton et al. 1995). Additionally, these actors actively searched for scientists and scientific information to fit their political agendas.

A scientist's institutional affiliation will be an important issue in the controversy over nanotechnology. The feeling

affect the way in which new scientific information is understood and accepted. Anthropology can illuminate how nanotechnology will be incorporated into existing cognitive and cultural models and religious and environmental worldviews. Because the processes associated with nanotechnology are so far removed from everyday life, there is not a body of local experiential knowledge that can be drawn upon to understand them. This does not mean, however, that non-experts have no pre-existing frameworks with which to evaluate nanotechnology. In his study of global warming, also impossible to access through local knowledge, Kempton discovered that when local knowledge is not available, people drew upon what they perceived to be relevant experiences to understand new phenomena. When asked about global warming, interviewees referred to changes in weather patterns over the course of their lifetimes to explain why they thought the world was or was not warming (Kempton 1991).

> "Nanotechnology has the potential to reduce our environmental footprint by producing stronger and more durable manufactured goods using smaller amounts of materials, enhancing the development of energy efficient fuel cells, hydrogen and solar technologies and reducing the amount of agro-chemicals needed to grow crops."

backlash similar, in their view, to the one generated over biotechnology. Such a view is based on a deficit model of the pubic understanding of science which portrays the public as an empty vessel waiting to be filled with correct scientific information. According to this view, once the correct information is disseminated and accepted, public controversy should dissipate. Anthropological studies of science-based public controversy have revealed that controversy is only partially about incomplete or incorrect interpretations of scientific information. Also important are faith in scientific and governance institutions, cultural models of how the world works and social values.

For example, anthropologists have examined how a scientist's affiliation (industry, environmental organization, government agency) can be an important criteria for judging the credibility of scientific information. When asked

that corporations and governments failed to protect individuals from the perceived harm of biotechnology generated mistrust and fear towards these institutions among biotechnology's critics. Some of the same institutional actors are involved in the promotion of nanotechnology and are therefore at a disadvantage when trying to address the public's concerns. In general, nanotechnology researchers and industries would like significant control over the design of policies and regulations, asserting that experts are best suited to the task of crafting policy given the scientific complexity of the issues and some favor 'soft' regulations such as voluntary standards, self reporting scorecards and ethical codes because they fear too much regulation will hamper the development of the technology.

Although issues of trust are important in the resolution of public based scientific controversy, other social processes also

Ethical frameworks and cultural metaphors will also influence the public understanding and acceptance of nanotechnology. Toumey's (1994) study of creationists illustrates how one issue can encapsulate an entire system of cultural meanings. Toumey found that creationism is not only about evolution, it is an ethical framework by which to understand late 20th century life. In the minds of creationists, evolution was tied to diverse social problems such as rock music, dirty books, inflation and terrorism. This work illustrates how non-scientific attributes become attached to scientific constructs which then are evaluated according to the former. Anthropology reveals that scientific based public controversy is often a critique of larger social issues and to interpret it only in terms of the public's scientific illiteracy is to miss the root cause of disagreement. Anthropology can identify the mental models and cultural metaphors various social groups will use to understand nanotechnology, breaking down stereotypes of the irrational public, facilitating communication across social groups and opening up the regulatory discussion.

Environmental Anthropology

Nanotechnology has the potential to reduce our environmental footprint by producing stronger and more durable manufactured goods using smaller amounts of materials, enhancing the development of energy efficient fuel cells, hydrogen and solar technologies and reducing the amount of agro-chemicals needed to grow crops. Nanomaterials can be used in environmental restoration, moving through soil and rock interstices impenetrable by larger particles to deliver cleaning agents. Two such potential uses are Superfund site remediation and the restoration of water quality. Nanotechnology has also been suggested for use in soil stabilization. In these scenarios, nanomaterials are intentionally released and as such their entrance into the environment mimics genetically engineered food crops. Nanomaterials will also enter the environment in solid, aqueous and gaseous waste streams through manufacturing leakages, wastewater treatment facilities, landfills, etc. In these cases, release to the environment is accidental and mimics standard chemical pollution.

Currently, the regulatory discussion is focused on how nanomaterials will physically enter, and perhaps alter, the environment because the persistence and behavior of nanomaterials in various ecosystems is unknown. Preferring a regulatory philosophy based in the precautionary principle, at least one environmental organization has already called for a moratorium on the use of nanotechnology until some of these scientific issues can be resolved. Others have called for a full life cycle analysis.

Environmental anthropology will contribute to the discussion on the environmental impacts of nanotechnology by analyzing the relationship between ecological and social systems and exposing equity issues related to the allocation of both ecological services (e.g. clean air and water) and environmental pollution (e.g. landfills, waste dumps). Anthropologists have chronicled the physical, economic and social displacement of local communities in the face of ecological degradation. For example,

the Exxon Valdez oil spill killed untold numbers of fish and contaminated fishing grounds, thus decimating the herring roe fishery in Prince William Sound. The material and economic displacement of fishermen led to the weakening of community ties by disrupting long standing social networks formed within the context of fishing (Dyer et al. 1992). Thus, physical contamination of the environment is connected to both economic and social dislocation.

> " The level and type of risk that nanotechnology presents to human health is unknown because nanoscale particles…can have unique chemical, physical and biological properties. "

Nanotechnology's potential to disrupt ecological processes is unknown. There is early evidence that some nanomaterials have bactericidal tendencies. Would nanomaterials released into the soil interrupt bacteria-dependent ecological processes such as decomposition and soil formation? If so, what would be the impact on farmers and foresters? How will nanomaterials used in water remediation impact fish? If nanomaterials bioaccumulate and move up the food chain, 'contaminating' the fish, what happens to fishermen? If the production of nanomaterials follows the trajectory of the production of chemicals, poor and minority communities could suffer disproportionately by virtue of the proximity of their neighborhoods to production facilities and their lack of political power. Anthropology can help identify what social groups are likely to be negatively impacted through nanotechnology, describe the nature of the impact and aid in the formation of policies to mitigate the impact.

Environmentally related social impacts are not always material. Rural and urban landscapes are spaces where identities are formed and maintained.

Because one's relationship to a landscape is a symbol of his or her place in the world, the impacts of environmental degradation must also be understood through social constructs such as sense of place and the cultural meaning of pollution. For example, members of the Southern Paiute tribe conceptualized radioactive waste as an angry spiritual being, embodied by radioactive rock, that blocked the "path to heaven" because it had been removed from its home (Stoffle and Arnold 2003:323). In such a cultural framework, radioactivity puts people at spiritual as well as physical risk. This double threat cannot be dealt with by merely physically decontaminating a polluted area or by using appropriate physical controls to contain the pollution. By unearthing, and showing the importance, of cultural models of pollution, anthropologists can generate more culturally appropriate risk assessments.

The Anthropology of Work

The level and type of risk that nanotechnology presents to human health is unknown because nanoscale particles, even those that are smaller versions of existing chemicals, can have unique chemical, physical and biological properties. For example, there is evidence that nanoparticles might move from one part of the body to another, accreting in organs and pass through the blood brain barrier, becoming permanently lodged in the brain. The inhalation of ultrafine particles is associated with fibrosis in lung tissue, and there is concern that the same will be true for nanoparticles. Workers in nanotechnology facilities

will be especially at risk for high rates of exposure to nanomaterials through skin contact, inhalation and possibly ingestion, but it is unclear whether current safety procedures and equipment are adequate to prevent excess exposure. More information is needed about the circumstances under which workers are exposed in order to design personal protective equipment, safe workspaces and safe work practices and the National Nanotechnology Advisory Panel considers workplace exposure to be a research priority. Workplace and design ethnography can be used to identify specific work practices that expose workers to nanomaterials and design engineered solutions. Workplace ethnography can also identify: how best to organize workers to adopt new safety related routines and/or technology; potential points of resistance to new practices; and the new skills that will be needed to work in the nanotechnology sector. Such studies should inform OSHA certifications and regulations.

Citizen Engagement

Both scientists and industry understand the social similarities between the introduction of biotechnology and nanotechnology. Lack of public disclosure and discussion about biotechnology contributed to its rejection and no one in the nanotechnology community desires a replay of the biotechnology controversy. One way to mitigate controversy would be to have a diverse public including labor activists, health practitioners, environmentalists, animal rights NGOs, consumer groups and others at the table informing the regulatory process. In reality, this would be an almost impossible task. Although such stakeholder groups have been successfully used at the local and regional levels to manage policy issues for which a substantial amount of local knowledge is available, this is not the case for nanotechnology, as discussed above. Also, there is disagreement about who constitutes a stakeholder—i.e. the regulated community, organized interest groups or all potentially affected parties. Surveys of the public's scientific literacy have been used to substantiate claims that the

'general public' is largely uninterested in scientific developments related to nanotechnology. Some have suggested that only that portion the public that has expressed interest in nanotechnology be targeted for involvement in the development of policy and regulations. Lack of knowledge, however, does not exclude members of the 'general public' from being stakeholders because the potentially impacted population includes all consumers. One need not have interest in, or knowledge of, a new technology to be at risk from it and, although difficult, forums for identifying and giving voice to various perspectives need to be designed. A combination of methods that include collaborative learning workshops, discourse analysis, the ethnography of particular social groups, surveys, and citizen advisory panels will be needed in order to give voice to the diverse social groups and individuals that make up the public. Anthropology can contribute to this effort through the identification and analyses of the values, beliefs and ethical perspectives embedded in diverse public discourses articulated in both the informal and formal spheres (See Toumey, and Jarmon and Keating this volume).

Conclusion

In my previous work on fisheries regulations, one thought kept being uttered by both fishermen and agency personnel—that managing fisheries is managing people, not nature. Similarly, regulating nanotechnology is about managing its interface with people— how they use it, how they release it to the environment, how they feel about it and how it impacts them in both the short and long terms. Anthropology has much to say about all of these issues and will thus provide crucial information to the construction of sound, equitable and culturally appropriate regulations and policies.

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[Note: The opinions expressed in this article are those of the authors and do not necessarily reflect the views of the authors' employers.]

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ENROLLING THE SOCIAL SCIENCES IN NANOTECHNOSCIENCE

By José López

Introduction

This article presents a reflection on the challenges and opportunities associated with the now ubiquitous requests inviting social scientists to participate in ELSI (Ethical, Legal and Social Implications)-type frameworks, attached to large science projects such as nanotechnoscience. It elaborates on some ideas presented in a panel discussion titled "On the Social and Ethical Impacts of Nanotechnology" in Winnipeg at the Canadian Sociological and Anthropological Association (CSAA) annual meeting in the spring of 2004. This was the first panel session devoted to nanotechnology in the CSAA. I begin by briefly developing some key ideas from the field of social studies of science in order to draw attention to the fact that scientific activity has always required the mobilisation of a variety of social, political, cultural and economic resources. Nanotechnoscience is no different. What is distinctive, however, is the perceived need to enrol the social sciences in ELSI-type programs as a way securing legitimacy and to contribute to the overall success of these initiatives. I suggest that it is important to attend to the types of discursive spaces and objects of knowledge that are opened up to the social sciences in these ELSI frameworks. In light of work in science studies, the notion that the social implications of the technology can be grasped by simply projecting current trends into the future has to be problematised and treated with great care. I conclude by suggesting that sociology and anthropology's most important contribution might lie not in contributing to the illusion of predictability and control, which nanotechnoscience is currently attempting to foster as a way of securing social, political, ethical and economic legitimacy for its endeavour, but in short-circuiting these processes.

The Hybrid Nature of Science

Scholars working in the field of social studies of science have been advocating, for well over thirty years, the need to conceptualise science as an impure and hybrid practice. Modern representations of the laboratory frequently draw our attention to a clean uncluttered sanctuary of objectivity from which all residues of subjectivity, and traces of political or economic interests, have been scrubbed to allow nature's forces to speak unhindered in a diaphanous voice. Instead, social studies of science scholars, amongst others, have noted the extent to which scientific practices are constituted through complex networks where myriad political, social, economic and cultural goals are mobilized. Indeed, it is argued that it is the elaboration of these networks that makes the highly local and densely contextualised knowledge practices, located in laboratories and other knowledge production sites, mobile. This network-enabled mobility creates the effect of universality, the hallmark of objective knowledge production. The extent to which the mobility of knowledge is a social achievement, rather than the property of "objective" knowledge, is illustrated by the difficulty of moving knowledge from one site to another, e.g., of replicating results, achieving technology transfers, and translating innovations into products.

For science studies, scientific practice is understood as a sociotechnical arrangement in which a variety of constituents, both human and nonhuman, are assigned places and roles in hybrid networks, i.e. mixes of the "social" and the "natural". Thus, it is not by surrounding the laboratory with a "force field" that would disable the effectivity of social, political and economic forces that science has been able to produce its spectacular achievements. It is the constitution of the laboratory as a field in which the

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"natural" and the "social" are locked in complex and heterogeneous mediations that is responsible both for science's failures and successes. Science's stance towards the social world is not one of ascetic retreat but of active engagement.

The emergence of large scale and spectacular science projects, such as the Human Genome Project and now the Nanotechnology and Nanoscience Initiatives, make visible some aspects of the complex sociotechnical arrangements that had remained more obscure in other forms of scientific practice; smaller in scale, contained within disciplinary boundaries, and removed from the limelight, they could more effectively ritually purify their practices. Nanotechnology, on the other hand, necessitates not only significant funding from different sources, and the coordination of a variety of actors across a number sites, but also the alignment of the competing interests contained therein. However, it is not merely a matter of scale; it is also a question of the newness and interdisciplinary nature of the field. Nanotechnoscience melds together a large variety of disciplinary approaches, technologies and practices (e.g. quantum physics, materials science, molecular biology, systems engineering, chemistry,

information science, optical physics) that require new conceptual vocabularies, taxonomies, notations, scopic regimes, research methodologies, instrumentation, collaborative structures and journals, to name but a few.

The articulation of these elements in networks is the product of a variety of social, political, cultural and economic strategies, e.g. access to new sources of funding, the molecularisation of reality, and economic and political rationalities linking knowledge and the economy. Nanotechnoscience does not first emerge followed by these networks whose function is to support its development. Rather, it is the articulation of these networks that simultaneously co-produce nano "things" as scientific objects. Thus, nanotechnoscience provides an ideal site from which to witness the real-time articulation of the fluid sociotechnical dynamics that have yet to become sedimented in tacit routines, and in institutional and organizational structures. It provides an excellent vantage point from which to observe the contingent processes through which polymorphous relations are established between "nature" and "society.

Enrolling the Social Sciences

In addition to the above, because of the level and nature of the funding required, and the types of promissory notes issued to attract such funding, because of the economic and political rationalities used to govern the knowledge economy, because of the claims made, and the level of hype produced, by other large scale science projects— e.g. the biotechnology "revolution" of the 80s, the Human Genome Project in the 90s—nanotechnoscience is forced to promise much. It pledges not only to bring about a revolution in the techno-sciences, but also in society's capacity to achieve a wide spectrum of goals, e.g. wealth, security, health, sustainable development, economic growth and technological progress. As a result, it does not suffice to mobilize the support and resources of scientists, researchers, funders, industry and government. The broad vision, developed by the promot-

ers of nanotechnoscience, also needs to mobilize the hopes and aspirations, and contain the fears and uncertainties of the nation: of its citizens, consumers and patients. The nanotechnology experiment is not containable in remote laboratories or isolated manufacturing facilities; it extends to the entire social fabric. This is true at a practical quotidian level: the vision for nanotechnology is that its products become the widgets of every-day life. It also holds true at the level of social organisation. Indeed, the failure to reconstitute society would be the failure of nanotechnoscience itself because this is precisely what it has promised. It is in this context that the social sciences are enrolled. Yes, but to what end?

In a certain sense, the inclusion of ELSI in nanotechnoscience programs need not be read as evidence that these nano communities, like the promoters of the Human Genome projects, have acquired a new ethical and social sensibility that had been lacking in other scientific endeavours. In fact, it can be seen as performatively expressing the conviction that nanotechnoscience's transformative power will necessarily revolutionise society, hence the need for knowledges and practices to guide this transformation, and help identify the forms of social coordination and the institutional structures that will be required. The question that suggests itself is whether the social sciences can or should be willing to perform this role.

As we all know, the prototype for ELSI was cast in the context of the Human Genome Project. Numerous critics, disillusioned with ELSI's first incarnation, have suggested that it was never really meant to foster critical analysis or promote democratic discussion. Instead, it was conceived as a mechanism for assuaging the fears and concerns raised by the development of biotechnology, in this way contributing to its social acceptability. By circumscribing the object of ELSI's inquiry to a narrow range of actionable issues (e.g. privacy, informed consent, beneficence, risk calculation, individual choice), securely in the hands of a new breed of bioethical experts or *ELSIst*, it deflected the impact of broader ethico-political con-

cerns and curtailed democratic engagement, all the while creating the illusion that the normative questions, associated with biotechnology, had been properly accounted for. So it was with bio-ELSI, so it will be with nano-ELSI!

While there may be some (or much) truth in the above, it would, nonetheless, be wrong to essentialise ELSI as a discursive space that will necessarily legitimize the practices that it is meant to scrutinize and expose to critical debate and study. The current need for science to publicly account for itself, to explicitly open itself up to a broader range of "stakeholders," at the very least, opens up a space where none had existed before. This space can be used, if only to attempt to subvert it. As science and society scholars have shown, objects of knowledge depend on the competing representational practices deployed by different groups. The possibility of incorporating new groups, new modes of representation, and new projects can lead to the rearrangements of existing networks and their practices. So it might yet be possible to reconstitute this ELSI space as a more critical and democratic forum. One need only remember that anthropology and sociology, at their emergence, were part of the colonial apparatus of empire, but this has not prevented them from subsequently mounting powerful critiques of empire and colonialism.

By the same token, it would not do to underestimate the difficulties that are involved. In the US, for instance, the nano-ELSI space has been prospected, demarcated, opened up, and is being financed or exploited by the promoters of nanotechnoscience, and not its critics. Texts such as *Societal Implications of Nanoscience and Nanotechnology (*http://www.wtec.org/ loyola/nano/ NSETSocietal.Implications/nanosi. pdf) and *Converging Technologies for Improving Human Performance* (http:// www.wtec.org/ Converging Technologies/Report/ NBIC_ report.pdf) can be read as crystallising the discursive processes through which attempts are made to align the interests of all the potential participants and beneficiaries of the nano-enterprise. The social sciences and the humanities are represented and

asked to participate. Their role is to help explore the social impacts, enable communication, and mediate between the different actors in nanotechnoscience's field of operation. Whether one accepts, rejects or contests this role, it is important to analyse how it has been produced. In the next section I discuss some of the assumptions that I find most striking. I make no claim that these even come close to exhausting the analysis that might be undertaken. Whether our goal is to enable, reorient or disable nanotechnoscience, I am convinced that this type of reflexive questioning, for which the social sciences have particularly well honed tools at their disposal, must inform our engagement with nanotechnoscience.

Building the Nanoworld

As noted above, the nanotechnoscience endeavour brings together a number of actors with disparate interests, practices, capabilities and goals. The processes through which this coalition of the willing is kept together are complex, but a crucial dimension involves consolidating the diverse fields of actors through a series of linked meanings, which are cohesive enough to give a sense of unity, but sufficiently supple to accommodate local or distinct interests. In discourse analysis, this process is described as the articulation of meanings around a nodal point. Nodal points are capable of stabilising dense networks of meanings and are thus able to produce a certain level of semantic centripetal force. Narratives, organized around themes, tropes, motifs or metaphors, frequently function as nodal points. Metaphors are particularly useful as they provide a great deal of semantic bang for your buck. Why? By establishing the possibility of semantic exchange between two different phenomenological domains, metaphors provide a common interpretive framework. However, and this is crucial, within the common framework, they licence a variety of semantic connections, which are determined contextually. Take the metaphor, "the human genome is the book of life." One could take this as meaning that it is a historical record of the human species,

a book whose meaning is to be decoded, a how-to instruction manual, an assertion of the informational kernel of life, or the human genome as the location of the very essence of life. All of these are distinct and permit different ways of acting on the genome, but they also provide a certain focus, direction and commonality of purpose. Of course, though nodal points stabilise the range of possible meanings, they never entirely succeed in domesticating the field altogether. Thus, unruly readings cannot be excluded. For instance, one can read the abovementioned metaphor as uttering an absolute prohibition against interfering with the genome: "it is the sacred book of life!"

It is not uncommon for nanostructures to be represented as the fundamental building blocks of matter. This is due to the fact that it is from the nano-scale that important material properties and functionalities arise. Consequently, in nano-discourse, nanotechnologist and scientists are frequently cast in the role of "master builders" because they are enabled, through a suite of innovative tools and technologies, to intervene at this fundamental level. That this role is not merely an implicit conceit is suggested by the title of the National Science and Technology Council brochure on nanotechnology (NSTC) —*Nanotechnology: Shaping the World Atom by Atom* (http://www.wtec.org/loyola/nano/ IWGN. Public. Brochure/ IWGN. Nanotechnology. Brochure.pdf). In the pamphlet, Nobel laureate nanotechnoscientist Richard Smalley claims that "nanotechnology is the builder's ultimate frontier." The interlinking of these metaphors—i.e. building blocks, ultimate toolbox, builders, fundamental building structures, world building — creates a dense and powerful semantic network that sustains a nanotechnoscience-as-world-building narrative. This narrative, in turn, acts as a powerful nodal point for framing and linking together a wide range of practices, e.g. building stronger materials, efficient economies, more resilient bodies, faster processors, more effective defence networks and more intelligent machines.

Moreover, because everything that exists in the world is understood as

doing so through some form of material embodiment, every existing thing can potentially be understood at the nano-level and is open to the world-building potential associated with nanotechnoscience. Indeed, in the publication, cited above, *Converging Technologies for Improving Human Performance*, the editors identify the nano scale as the point of translation and convergence between Nanoscience and technology, Biology, Information and Cognitive sciences (NBIC). What is outlined in the text is a dramatically nano-reductionist program that envisages that the synergies created around the convergence of these technologies will enable the "building" of a radically new world. In this world, NBIC-enabled technologies and individuals will facilitate new forms of social communication and coordination that could very well lead to the evolution of human societies and culture.

Any avid reader of science fiction will no doubt recognize in this world-building metaphor, a narrative trope known more formally amongst science fiction scholars and critics as the *novum*. One of the exigencies that the science fiction genre faces is the need to construct radically alternative but plausible worlds, whether in the past, future or in a parallel universe. These worlds need to be coherent and sufficiently credible to encompass the actions of characters and the unfolding of plots. The *novum* is essentially a "What if?" question. What if we were visited by extra-terrestrials? What if time travel were possible? What if space travel were possible? This interruption to the normal flow of things is then used to build the new or alternative world. The important thing to keep in mind is that all of the dimensions of this alternative world can be traced back to the introduction of the change (e.g. because we were visited by extra-terrestrials, we got access to a new technology, because we got access to this new technology, new cleavages were formed, and so forth). The *novum* acts like a seed in which the new word is preformed. This produces a one-dimensional world—this is not the same as saying that science fiction is one-dimensional—that remains plausible and coherent because it is organised

by one principle; it can be traced back to one event.

When the *novum* used in science fiction is a scientific or technological one, the world that it generates is a technologically determined one. This is not a problem because the function of science fiction is not to predict the future. It is to use the effect of the future as a dramatic device for some other purpose (e.g. entertainment, critical reflection, story narration, aesthetic experimentation). However, when the promoters of nanotechnoscience or NBIC draw on the world-building connotations of the metaphors that I identified above to extrapolate the future, there is a problem. The ability to narratively create a one-dimensional future is being confused with foresight.

Short-Circuiting Nanotechnoscience

The alleged social implications (wealth, health, security, increased competitiveness, efficiency), which are extrapolated in *Societal Implications of Nanoscience and Nanotechnology* and *Converging Technologies for Improving Human Performance*, and which the promoters of nanoscience would like social scientists to help finesse, reveal a profound technological determinist logic. Because technological determinism understands social, cultural, political and economic changes in terms of technological causes, it fails to capture the complex mediations, the non-linear trajectories, the punctuated equilibria and the contingent, and frequently fragile sociotechnical assemblages that make scientific and technological practices possible. It is important to be clear that the sensitivity towards the existence of these interrelationships and/or the ability to analyse them does not provide the social sciences with any privileged claim on the future. Predicting the future is not what we do! As a result of the necessarily open-ended nature of sociotechnical processes, the role of the social sciences must not be to support the development of what Sheila Jasanoff calls, with her inimitable eloquence, "technologies of hubris."

Given the radical unknowability of our sociotechnical futures, rather than mobilise public legitimacy by staging the illusion of control, we should contribute to the development of decision-making processes anchored in "technologies of humility", which according to Jasanoff need to be grounded around the importance of "framing, vulnerability, distribution and learning" (Jasanoff, S. Technologies of Humility: Citizen Participation in Governing Science. *Minerva* 31(3): 223-44. 2003). Just how the current nanotechnology and science initiative, and the ELSI space it is in the process of articulating, would receive this type of social science contribution is not clear, but its world-building metaphors suggests that any hubris we could contribute as social scientists, and I am sure we could, would be redundant.

Paradoxically, it would appear that, as social scientists, one of our most significant contributions to the development of the nanoworld might be to short-circuit it. I am not by any stretch of the imagination advocating a Luddite stance towards nanotechnoscience. By short-circuiting, I mean that we puncture the illusion that the parameters of nanotechnoscience are strictly technical and that given sufficient knowledge we will be able to effectively steer this endeavour. In the last twenty years or so, technoscientific practices have found themselves in a situation whereby their own "internal" practices and the knowledges that they produce no longer suffice to guarantee the legitimacy of their enterprise. One of the responses to this situation has been to incorporate other knowledges—ethics, bioethics, social sciences—in the hopes that they will "externally" validate their scientific projects. However, if the role of the social sciences is to draw attention to the contingency and radical unpredictability of the development of sociotechnical devices and processes, then it should be clear that we cannot provide the suture that the nanotechnoscience community seeks.

Indeed, I would argue that it is crucial that we not allow the tear in science's social legitimacy to be closed. This would allow us to focus attention on the fact that things like the Nano-

technology and Nanoscience Initiatives are political projects. They seek to mobilise science in the pursuit of political goals such as economic well being, health, security and justice. It is important, then, that the debate not be merely focused on acceptable levels of risks, on the conflict of values between nanotechnoscience and society, or on ways of facilitating social communication to optimise the development of nanotechnoscience. In addition, nanotechnoscience, as a political project, needs to be tested against other political imaginaries. Could improved health for the nation be pursued through a more equitable distribution of resources rather than through nano-medicine? Could national security be achieved through diplomacy rather than high-tech military imperialism? No amount of technical or scientific knowledge will provide the legitimate responses. They remain political questions that need to be tackled democratically, and yes, with humility.

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IT DEPENDS ON WHERE YOU SIT: ANTHROPOLOGISTS' INVOLVEMENT WITH NANOTECHNOLOGY IN GOVERNMENT, UNIVERSITY, AND INDUSTRY SETTINGS

*By Amy K. Wolfe,
Kenneth David, and
John Sherry*

This paper emerged from discussions during and after the spring 2005 SfAA session on anthropology and nanotechnology. The three authors have worked for many years in substantially different institutional settings. Wolfe has worked at Oak Ridge National Laboratory (ORNL), owned by the U.S. Department of Energy and currently managed by UT-Battelle, LLC, for a generation. David has resided at Michigan State University's anthropology department for even longer. Sherry is the relative newcomer, having worked at Intel for 9 years (after 2 years at Microsoft). When talking about the nanotechnology-related work we are, are endeavoring to, or are interested in pursuing, it became clear that our institutionally grounded perspectives varied substantially. Moreover, despite some commonalities, the ways in which we do or would engage in nanotechnology research also diverge. This article is a formalized expression of those commonalities and differences, and is indicative of the range of ways in which anthropologists may participate in research surrounding this potentially revolutionary set of technologies.

A View from a Federally Funded Research Laboratory

ORNL is a science and technology research and development institution with a staff of approximately 3800, located in Oak Ridge, Tennessee. About two dozen of ORNL's 1500 scientists and engineers are social scientists. Of the social scientists, nearly half are economists, followed by geographers,

Kenneth David

planners, sociologists, and one anthropologist. Most research staff members are on "soft" money, and must secure full funding (in a lead or supporting role) from outside sources or highly limited internal sources. Traditionally, the U.S. Department of Energy (DOE) has been the primary source of funding, but increasingly funding is obtained from other federal agencies and, to a lesser extent, through cooperative research and development agreements (CRADAs) with industry. Virtually all projects are team efforts. As the lone anthropologist, I [Wolfe] work in interdisciplinary teams, typically with other social scientists (especially economists), but also with ecologists, life scientists, and engineers, among others. It can be challenging and frustrating to work with people who may not consider social science a science, or who view anthropology as exotic and undisciplined, whose data are un-interpretable, non-generalizable "just so" stories. Nevertheless, I believe this teamwork is essential in addressing issues that no single disci-

John Sherry

pline can resolve. My research interests center on decision making about science, technology, and environmental issues.

Despite these interests, only rarely does my work deal directly with the varied science and technology research and development activities taking place at ORNL. So, for example, although ORNL is the home of one of DOE's five nanocenters, the Center for Nanophase Material Sciences, and a diverse suite of nanoscale research and development activities take place there, my social science colleagues and I are not (yet?) engaged in them in a funded or insider way.

I became interested in nanoscience and nanotechnologies largely as an outgrowth of my previous work, especially on the societal acceptability of novel or controversial technologies. We (David Bjornstad, an economist, and I) situate technology acceptability as a social decision-making process that is technology-oriented but not technology-driven, in which acceptability is conditional and negotiated formally and informally over time. These perspectives may be commonplace among anthropologists, but are atypical for the audiences we typically address (e.g., federal agency staff, scientists, engineers).

Themes from my previous work apply to nanoscience and nanotechnologies. Examples include decision making about technologies of future, where uncertainties are amplified by unknowable

questions and responses; risk and risk (or technology-related) communication; public involvement and participation; and environmental justice. The application of nanotechnologies may become so ubiquitous that the range and number of potential research questions that social scientists and anthropologists can pose are overwhelming. As a staff member of a DOE-owned national laboratory, one way to reign in these questions is to focus on the agency's interests in nanoscience and nanotechnologies. This bounding process excludes such applications as clothing and cosmetics. It limits attention within spheres such as agriculture to crops that could be used to create biofuels, and to the processes and technologies associated with such bioconversion.

Overall, DOE seeks to study and develop nanotechnologies that align with its goals of:

> …advancing the energy, economic and national security of the United States, promoting scientific and technological innovation and ensuring environmental cleanup of the national nuclear weapons complex…

For example, nanoscale synthesis and assembly methods will result in:

- significant improvements in solar energy conversion; more energy-efficient lighting;
- stronger, lighter materials to improve efficiency in transportation;
- greatly improved chemical and biological sensing;
- low-energy catalytic pathways for fuel and chemical production and to break down toxic substances for environmental restoration;
- better sensors and controls to increase efficiency in manufacturing; and
- many advanced systems for stockpile stewardship. (http://www.science.doe.gov/Sub/Newsroom/News_Releases/DOE-SC/2006/nano/DOEs%20Missions.htm)

I find many possible avenues of research associated with DOE-relevant development and deployment of nanoscience and nanotechnologies that could be intriguing and fruitful. Thinking within the context of social systems, however, three overarching questions emerge that can be addressed with regard to a subset of nanotechnologies or applications, or across those technologies and applications. First, what are the likely *implications*, over time, of these technologies/applications on social institutions and systems if they "work" as anticipated, and if they do not? Second, how are individuals, organizations, and institutions likely to *respond* to the technologies/applications and the changes integral to their deployment and use over time? Third, what *actions or interventions* (e.g., regulations) associated with the technologies/applications and their use/deployment likely will, or should, be taken at local, regional, and national levels over time to promote their socially defined benefits and to avoid, minimize, or mitigate any adverse impacts?

A University Perspective

Nanotechnology as Variably Controversial

From a university perspective, it is essential to communicate about nanotechnology (NT) in terms an intelligent 12 year old can understand. Said again, whether communicating with university colleagues or with people from profit or non-profit organizations, I [David] follow the rule that although the audience is not stupid, it is also not specifically informed about this topic. With this level of discourse in mind, I get across the point that NT devices are *variably* controversial with several contrast cases.

First, what are the *properties and impacts* of nanotechnologies?

- Are NT devices small, but stable and helpful? Picture IBM's on-demand Business Help Desk commercial popularly known as "Maybe the boxes should drive." A truck screeches to a halt in front of a desk in the middle of a deserted road. When the driver asks why she is there, the professionally suited woman tells the driver that she is at the Help Desk and that

they are lost. The driver asks how she knows. She replies that the boxes have Radio Frequency Identification [RFID] tracking chips. The driver's buddy then dryly remarks, "Maybe the boxes should drive." This scenario suggests that humans can now attain a degree of information precision never previously attained as well as the possibility of a new organizational structure—a very flat organization capable of controlling and coordinating activities.

- Are NT devices a self-organizing complex structure with a tipping point beyond which they become madly out of control? Grey goo is portrayed by Michael Crichton as an evolving swarm of self-replicating nano-robots. For a rebuttal, see http://www.nanotech-now.com/Chris-Phoenix/prey-critique.htm. The rebuttal does not totally refute an underlying fear—the suggestion that, having partially tamed or technologized Nature over the last centuries, we are creating a new, uncontrollable Nature such as it was perceived at the time of the Bubonic Plague in the 1400s.

Second, what are *social, legal, and ethical impacts* of a controversial set of technologies? Invasion of privacy is a good example.

- Smart Carts, shopping carts using scanning devices based on RFIDs, are ethically dubious. You walk through a supermarket. Each time you place an item in the cart, it is scanned. Are you happy? Then you approach the exit and find out that the cart has already read the credit card in your wallet. Are you still happy? Perceived threats to privacy have already stirred protest by a group called CASPIAN, that is, Consumers Against Supermarket Privacy Invasion and Numbering (www.nocards.org/).
- Mad cow disease detection via RFIDs stirs no protest. Individual cows are already tracked via implanted RFIDs so that the incidence of *bovine spongiform encephalopathy (BSE)* can be revealed and countered. To my knowledge, Dr. Seuss's

Lorax has yet to appear to speak for the cows and against bovine privacy invasion.

Apparently, the advent of nanotechnologies has mobilized proponents and opponents; some recognize benefits; others perceive fears. Social and ethical considerations vary for public acceptability (in Amy Wolfe's meaning above) as well as public acceptance. Invasions of human privacy stir public wrath; invasions of bovine privacy stir benign neglect.

The previous account also indicates that my prime research interests are the mobilization of proponency and opponency to this controversial technology, marketing and de-marketing of the application of NTs and organizational implications of NTs.

Future inter-disciplinary research is now being planned for understanding the impact of multiple technologies: what happens when RFID tags are combined with Global Positioning Systems devices, Global Information Sciences tracking? Will a combination of these technologies incite profound changes on 1) organizational structure and processes within a firm and 2) processes of coordination and control in relationships among firms? A current example is the controlling role of Walmart on the numerous firms that supply products to Walmart.

Influence of the University Context

Now, what university conditions facilitate or hinder research into a controversial set of technologies?

First, like the government lab, university faculty produce two deliverables: knowledge and revenue (as in administrative overhead from grants). Both deliverables require allocation of time, energy, and professional attention. Research grants are a source of financial gain. Researchers must market their skills/backgrounds to the grant-giving agencies to get funding

Second, effective research collaboration is forwarded when (1) there is dual emphasis on practical as well as theoretical deliverables and (2) engagement in inter-disciplinary and international collaborations is encouraged at university, departmental, and subfield levels.

- Michigan State University (MSU) is a large (43,000 students; 2500 faculty) multi-college university. Its mission is to produce a balance of theoretical knowledge and practical applications of knowledge for practitioners—from farmers to engineers. Persons interested in nanotechnology are found in various colleges and are organized in a collectivity called Nanofolks.
- Work at MSU on nanotechnology is also inherently interdisciplinary and international. The team working on our NSF-funded research project (Social and Ethical Capabilities for Agrifood-Nanotechnology) includes two anthropologists (John Stone is the other), a philosopher, several sociologists, and faculty from packaging, nutrition, and agricultural development. Inter-disciplinary collaboration poses opportunities as well as challenges. The opportunity is to pool your competence with other people's competence. The challenge is to work collaboratively and avoid the *foregrounding* and *backgrounding* of knowledge by associated scholars.
- MSU's Anthropology Department has 22 faculty persons, many of whom have lasting inter-disciplinary connections with other departments, other colleges, and other countries. The department's subfields focus on particular research and teaching areas: *Socio-cultural* on culture, resources, and power (CRP); *Archeology* on Great Lakes ethnohistory; *Medical* on critical medical anthropology and bioethics; *Physical* on the effects of human actions on skeletal anatomy both during life and after death. See http://www.ssc.msu.edu/~anp/ for more details.
- My subfield, CRP, involves faculty and students in socio-cultural and linguistic anthropology. The program links theory and practice in anthropology and prepares students to contribute to policy formation and implementation. CRP graduates take positions in both private and public sectors, within and outside of academia.

To sum up, David's particular focus is a counterpoint between practical and theoretical sides of Anthropology. Organizational anthropology can contribute to strategic management and communications studies by highlighting cultural and power issues.

Professional applications of anthropology aim to further educate professionals in various fields who receive thorough technical training but are not taught the capabilities to deal with cultural, power, and multi-media communications issues that are part of daily practice in engineering and medicine.

Looking within Industry

To understand this particular "industry perspective," it is important to describe the type of firm in which I [Sherry] operate. For roughly two decades, Intel Corporation has been the world's leader in the design and manufacturing of microprocessors, the so-called "brains of the personal computer." This leadership derives directly from Intel's ability to manufacture products of exceptional quality at the nano-scale. (For instance, Intel's next generation manufacturing process will involve the creation of transistors on the scale of 45 microns.) This leadership and manufacturing ability has had a couple of important implications.

- First, intimately tied with this success is the fact that the company's policies, perspectives and interests have been greatly shaped by its manufacturing prowess. Through the 1990s, as global demand for microprocessors continued to rise, Intel had developed a manufacturing philosophy known as "copy exactly." This philosophy entailed the development of a manufacturing process at one site, followed by its (allegedly) exact duplication at manufacturing facilities elsewhere in the world. The "copy exactly" mentality, and the apparently deterministic pace with which new products and new manufacturing techniques were routinely developed, created the tacit assumption among many engineers and decision makers that human adoption would remain similarly predictable. It was as if the

world followed a single trajectory of technology adoption, on which the affluent households and offices of the United States were the clear leaders.

- Second, none of the social science research carried out at Intel to date (we have had some such capability since 1995) has concerned itself with what happens at the nano-scale. Most ordinary folk don't directly interact with the microprocessor. Rather, all social science research has been focused on a much more macro-scale, namely, what people do with that processing power, as it hums silently (but increasingly warmly) inside the humble beige desktop PC or sleek laptop.

Yet both of these conditions have been (and continue to be) changing rapidly. MP3 players and countless other devices have proven the "single trajectory" assumption wrong. In different parts of the world, people are accessing each other, the internet, and other dimensions of the digital world through devices other than personal computers with astonishing alacrity. Technology adoption trajectories are multiple and difficult to understand sometimes even in retrospect, let alone to predict. In light of this difficulty, Intel has shifted its perspective considerably: social scientists, in concert with market research, engineers, and designers have been tasked with understanding the complexities of human needs, desires and practices, and how they affect the attitudes towards and uses of technologies. Our purpose is to help our company better address these values and attitudes in the creation not just of microprocessors, but "platforms," constellations of technology that are more closely matched to real human needs and practices—for instance, uses associated with mobile technology use, or, more recently, uses associated with home entertainment and media consumption, or, in the case of my own research group, uses associated with the maintenance or recovery of health.

The second "fact," that the appropriate social scientific inquiry is best focused at the macro-scale, seems likely to change in the very near future as well. Increasing research and development

throughout the high-tech industry has begun to focus on the very small not just in terms of transistors, but in terms of fluid manipulation for biological assessment, of implantable (or ingestible) devices, or, perhaps less dramatically, in terms of fabrics into which are woven radio antennae, memory, storage, or simple processors or the kinds of RFID tags referenced above by Dr. David. Technology research in our own corporation challenges what were once easy boundaries between the "person" and the "computer" in both exciting and potentially disturbing ways. By providing scaffolding or supplemental capabilities to those who have suffered cognitive or physical loss, for instance, new technologies might increase personal fulfillment or productivity. By radically reducing the cost of moving information, new health care "professionals" in parts of the world that lack physicians or nurses might be able to provide simple diagnoses to some of the world's three billion people who lack adequate access to health services.

As such capabilities spread throughout a population, even in the most benign scenarios, what might the emergent effects be on families, communities, or nations? Wellman (1999), among others, has suggested that new technologies have made our society into one of "networked individuals," enabling greater personal freedoms, but weakened social network ties. As the cohort of aging baby-boomers takes its place atop the world's changing demographic pyramid, what broader effects will be wrought by the presence of technologies that allow (require?) aging adults to be productive into their seventies, or beyond. What might be the broader consequences of the creation of rapid, in-home blood tests or medical-imaging technologies? How will individuals and families who suddenly realize that they carry risk factors for conditions that threaten their insurance status or employability react on both a personal and societal scale? We can't hope to answer all these questions, but only to raise them, explore them, and continue to advocate for a human-centered perspective in the imagination, development and deployment of these new capabilities.

It Depends on Where You Sit

The three of us are among the growing number of anthropologists whose practice involves or focuses on nano-technologies. Our pursuits, of course, are influenced by the contexts in which we work—federal laboratory, university, and private industry. These institutions have been, and will continue, to pursue nanotechnology research, development, and deployment, with or without the involvement of anthropologists. We believe that anthropologists can and should play a role in raising questions that may not otherwise be considered, and in using our theories and methods to help address those questions—no matter whether the products of interest are biofuels; RFIDs or other devices that can be implanted or ingested into living beings or incorporated into materials; nano-scale sensors; or nano-processors.

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Amy K. Wolfe is profiled on page 5.

Kenneth David, <davidk@msu.edu>, *specializes in boundary-spanning project studies and organizational studies—an anthropological commentary and critique of management and communications studies. He equally works in Professional Applications of Anthropology. His MA and PhD in Social Anthropology are from the University of Chicago. His MBA in International Business is from Michigan State University.*

John Sherry, <john.sherry@intel.com>, *is director of social science research in the Digital Health Group at Intel Corporation. The team is comprised of anthropologists, psychologists, and designers whose collective goal is to drive both product and business innovation from a deep understanding of human practice and human systems. Dr. Sherry holds a PhD in anthropology from the University of Arizona.* ■

NANOTECHNOLOGY AND THE MODERN UNIVERSITY

By Cyrus C.M. Mody

The novelty of nanotechnology presents social scientists with an interesting dilemma. On the one hand, the scientists and engineers doing nano research have been at it for such a brief time, and are performing such a diffuse array of activities, that it is very difficult to see *what* social scientists should be studying, much less *how* they should go about it. On the other hand, social scientists who study science and engineering have (at least over the past decade) focused largely on disciplines that are relatively marginal to nano—computing-information technology, genomics-biotech, psychology-cognitive science, economics, and medicine (this gross generalization is based on looking through the program of the annual Society for Social Studies of Science meeting for the past few years). There is very little sociology or anthropology of the core fields of nano (materials science, chemistry, applied and/or condensed matter physics, electrical and mechanical engineering)—though the exceptions are some of the best representatives of social studies of science (e.g. Hugh Gusterson, Laura McNamara, Bart Simon, Harry Collins). Obviously, some lessons from ethnographies or recent histories of biotech, economics, etc. will translate well to the study of nanotechnology; but we should also accept that it will probably take as long for social scientists to develop a methodology *for* nanotechnology as it will take scientists and engineers to develop a practice *of* nanotechnology.

My own path to studying nanotechnology gives a sense of the mutual development of technical and social scientific approaches to the field. I have an undergraduate degree in mechanical and materials engineering, though even in college the questions that interested me concerned engineering's connections to the wider world—how and why

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does knowledge of materials get made? How do new materials find their way into general use? What is the relationship between the engineering fields' knowledge and practices and those of other communities? To move closer to those questions I began my graduate work in Science and Technology Studies at Cornell by conducting ethnographic research with a group of Cornell materials scientists. Over time, I added an historical dimension to this study and began focusing on instrumentation as a lens for examining the social practice of experimentation—how do communities develop around new instruments? How do those communities relate to the institutions and disciplines of science? How do organizations (e.g. instrument manufacturers or national metrology

laboratories) bring widely-dispersed communities into contact with new instruments?

The instruments I chose to study were those used regularly by my informants at Cornell—the atomic force microscope and the scanning tunneling microscope. Today, these instruments are regularly invoked as the breakthrough enablers of nanotechnology. Yet when I began my study in the late '90s, the materials scientists I was working with had barely heard of nanotechnology—the AFM was a tool for "characterizing surfaces" or "studying materials," not for "doing nanotechnology". Yet a few years later, once the National Nanotechnology Initiative became a reality, "doing nanotechnology" was a nearly unavoidable part of being a

materials scientist at Cornell. For my part, it very quickly became impossible to understand the social practice of instrumentation and materials science without examining why people would want to call themselves nanotechnologists—i.e., I quickly needed to learn some techniques for studying nano, and I needed to find other people interested in bringing social science into nano. Fortunately, this "nano-studies" community is now taking shape, particularly through a series of panels at various professional society meetings (the Society for Applied Anthropology, the American Anthropological Association, the Society for Social Studies of Science), dedicated conferences at (among others) the University of South Carolina and the Chemical Heritage Foundation, and the new NSF-funded Centers for Nanotechnology in Society at Arizona State and UC Santa Barbara.

For my own research, I've tried to draw some lessons from my drift (alongside my informants) toward nanotechnology. First, this drifting into nano implies that we need to understand the field's novelty as a social construct. There was plenty of "nano" going on well before that label was applied. We need to understand what values, practices, and social organization were carried through into nano by these fields, and what difference nano makes within and between these "constituent communities." Second, the importance of these constituent communities points to the need to bring historical perspectives to bear on ethnographic data and vice versa. Contemporary approaches alone risk being credulous about nanotechnology's novelty; historical approaches alone risk insularly reifying the communities they study without noticing the nascent connections that link those communities via the nano umbrella. Finally, we need to pay attention to the sites where nanotechnology qua nanotechnology is *presently* and *currently* changing people's lives. The public face of nano—like any emerging technology—is rife with grand pronouncements about how nano *will* change the world, how it *will* be the next industrial revolution. Social science approaches to

nano—particularly ethnographies—must put such pronouncements in context by looking at how communities manufacture nano today, rather than setting up outposts in some future world on the assumption that nano *will* be X or Y.

This might seem like a call for an internalist approach to nano—let's study the practices of nanoscientists today, and then follow the products of their work as they diffuse out into the wider world. And, indeed, I think the emergence of nanotechnology (and nano-studies) is a golden opportunity to revitalize laboratory ethnographies—such as the excellent clean room studies being done by Ana Viseu at Cornell and Mikael Johansson at Göteburg. I'd like to spend the rest of this article, though, outlining some ways to broaden this preoccupation with present practice so that it blurs the internal-external distinction while placing nano's grand pronouncements in context.

Let's take, for instance, some of the most well-known corporate manifestations of nanotechnology. Two to three years ago, there were certain times of the week and year (Sunday mornings and afternoons in the spring and summer) when it was difficult to avoid seeing nanotech-themed commercials for Hewlett-Packard and General Electric on network television. Since then, it has become difficult to avoid seeing articles on corporate nano-luminaries such as Phaedon Avouris (of IBM) and Stan Williams (of HP) in certain kinds of publications—*Forbes*, *The Economist*, *Business Week*, *Red Herring*, the *New York Times*, the *Wall Street Journal*, etc. In the past year or so, the high-tech promises about nano in these publications have been matched by the advent of overtly nano-derived consumer goods—golf balls, tennis balls and rackets, invisible sunscreen, stain-resistant chinos.

Obviously, then, nanotechnology *qua* nanotechnology means something for people working at certain companies. IBM, for instance, clearly sees "nanotechnology" as a way to organize its chemists, electrical engineers, materials scientists, and applied physicists to help them offer a compellingly radical

alternative to the dominant technological pathways in the microelectronics industry—the linkages, materials, and concepts binding nanotechnology together are exactly what IBM needs in its fight to shift Moore's Law of miniaturization away from traditional silicon. Thus, nanotechnology plays a very specific role in solving these corporations' particular problems; yet it also plays a generic role in the presentation of corporate self. It is no coincidence, I believe, that HP and GE's nano-themed commercials aired during the Sunday political talk shows and golf tournaments (alongside commercials for other blue chip companies like Siemens and ADM), or that nano is such a popular topic in the business press, or that the consumer goods that most loudly trumpet their nano-contents are those such as tennis rackets, golf balls, and chinos that marketers might associate with the same investing class that reads *Business Week* and watches *Meet the Press*, or that nanotechnology became an institutional bandwagon just at the height of the dot.com frenzy in 1999-2000. Nano, in this generic sense, is part of firms' attempt to appeal to investors—a module pulled off the shelf to demonstrate that the company is innovative, dynamic, and *au courant* with the forefront of research.

If social scientists are to understand nano, then, they must confront both these particular and generic aspects. Nano is, on the one hand, a way of tying together pre-existing research traditions in order to yield new solutions to the specific problems of particular institutions—how to make transistors smaller, how to make electronic ink, how to diagnose and cure cancer, etc. On the other hand, it is also *not* novel precisely because it is plugged into a long-standing *discourse* of novelty—another new science for the New Economy. This is not to say that the generic manifestation of nano is simply cynical spin—rather, the construction of narratives of innovation and fore-front research is its own concrete practice, and nano is a new instrument in that practice. Social scientists would do well to study the communities associated with that

practice if they want to understand the networks surrounding nanotechnology. I particularly have in mind here the need for a history and/or ethnography of the futurist community—people like Eric Drexler, Marvin Minsky, Stewart Brand, Bill Joy—and the permeability between that community and the world of business forecasting and reporting. Thomas Frank and Fred Turner have given us part of this equation, but a study that extends their ideas to nanotechnology would be wonderful.

As important as corporations are to nano, though, social scientist would (I believe) do well (for the moment) to look more to universities than corporations. Campuses are where nanotechnology is most visibly a *current* and *compelling* practice—again, in both a generic and a particular sense. Corporate researchers have a product line to contribute to, and if nano helps them do that they will associate with it; but universities have a more diffuse objective (Training students? Producing knowledge? Leading culture? Cooperating with nation and industry?) that nano is helping to bring in focus. The flow of investors' money into nano continues to be relatively slight; but the flow of donors' and taxpayers' money in and around universities earmarked specifically for nanotechnology research has been (relatively, of course) quite large. It would be hard to measure this, but my impression is that a large majority of the people who are *changing* their beliefs, practices, networks, etc. specifically because they see themselves as part of the nanotechnology enterprise work for or around universities. This includes a diverse array of people, from academic scientists and administrators, to the architects and construction workers building dozens of new nano centers, to the federal grant officers whose primary job is to fund and coordinate academic research, all of whom *ought* to be at the center of social science approaches to nano, but have been nearly invisible thus far.

Very few—if any—American research universities have allowed talk about nanotechnology to go unnoticed; many have built or are building

Photo by Cyrus C.M. Mody

Magazines Addressing Nanotechnology

their own nano centers or institutes or laboratories. A few have gotten NSF funding to call their local nano centers "national" nanofacilities. Nano is trickling slowly into the undergraduate curriculum in chemistry, physics, materials science, electrical engineering, and biology; and at the graduate level, it's providing the platform for new kinds of training and research, and new outlets for partnerships with government and industry. So here we have a set of institutions where nanotechnology means something fairly definite and far-reaching, where nano funding could profoundly reshape the institution, perhaps reinforcing its traditional values or perhaps moving it away from its heritage. There is also a large, semi-public community of people—the university's alumni, donors, and local residents—who are interested in the fate of the institution and can, therefore, be consumers of academic nanotechnology's generic face. Between the institution and this semi-public sphere, then, there is a substantial body of people working in and around universities who construct and disseminate this generic manifestation.

These mediators will be key to the development of nanotechnology and should, therefore, play an important part in social scientific analysis of the field. There is, for the moment, *no* public sphere for nanotechnology that social scientists can poll, prod, or interrogate to find out whether "they" are ready for, skeptical about, or scared of nano. There are, however, a number of these semi-public spheres, porously defined by attachment to some institution, and a large number of mediators who help define the meaning of nano within their particular sphere. Social scientists will, I believe, learn much more about how nanotechnology will or will not be accepted in the general public sphere by working with these mediators than by simply approaching the public *en masse*.

To get a sense of what I mean here, I decided to take a look at one of the quintessential products of these academic semi-public spheres—the university alumni magazine—in preparation for a talk at the Society for Social Studies of Science annual meeting. I'd been interested in how universities use nanotechnology to navigate internal and external institutional pressures for a while; but the immediate trigger for looking at alumni magazines was seeing two feature articles (one from my own

alma mater and one from a friend's) in the space of a week. Cursory digging then turned up more than a dozen other pieces from the past few years. This was a very brief study, and the observations below are merely a first glance at some obvious patterns. An in-depth of ethnography of how university PR and administrative offices deal with science would be a wonderful thing (as Daniel Lee Kleinman and Jason Owen-Smith have demonstrated); but this article is not that. Instead, I compiled a small archive of alumni magazines related to nanotechnology, tried to read a few articles from those magazines on other new sciences (especially biotech), and then conducted half-hour phone interviews with a half-dozen authors—some freelancers, some university employees.

Interestingly, this methodology is quite similar to that used by my informants themselves. Each of these authors drew on interviews with leading nano scientists and engineers (and a few social scientists or philosophers) on campus, plus the usual tour of labs and clean rooms (which I too have done). I think this paralleling of actors' and analysts' methodologies—what George Marcus calls "paraethnography"—is a good place for social scientists' to start in looking at nano for two reasons. First, the kinds of mediators I talked with for this study are playing a similar role to that of the social scientist—crafting both a particular story and a generic representation (or, for social scientists, a generic theory). These people will have insights about method and content that are worth drawing on. At the same time, this similarity of purpose should be cautionary as well. These authors are constructing representations of nanotechnology to buttress particular ideologies and institutions. Critique of their constructions should help us, as social scientists, to be skeptical about our own aims and claims.

For instance, like *Forbes* or *The Economist*, these magazines are, in some sense, pitched to an investing class—some are filled with ads for Italian sports cars, high-end hedge funds, and classifieds for chateaux in Provence—and, therefore, they similarly construct nano-

technology as an investor-class science. But unlike these general, business-oriented publications, alumni magazines reach out to a rather well-defined (though certainly not monolithic) audience, partly to encourage investment (in the university, rather than any business) but also to generate good will and strengthen community. Thus, only when the institution at the heart of that community—the university—undergoes significant, nano-related changes, do alumni magazines take notice. Thus, in the past couple years, where there are nanocenters being built, articles have appeared—in (among others), *Stanford Magazine,* the *Pennsylvania Gazette*, *On Wisconsin*, and *Harvard Magazine*, MIT's *Technology Review*, and Caltech's *Engineering and Science.*

These articles mediate the generic and particular versions of nanotechnology in very interesting ways. Almost all of them narrate a roll call of the scientists and engineers (and sometimes social scientists or philosophers) doing nanotechnology at the university—often accompanied by images of the most photogenic nano researchers and nanomaterials. Notably, the technical content of what these researchers are doing is simultaneously crucial and peripheral to these articles. The authors go into sometimes excruciating detail about dozens and dozens of rather arcane experiments; and yet, that detail is important less as content to be transmitted to the public than as a means for amplifying and reaffirming (or perhaps reshaping) a core message about the institutions to which science is coupled. Nanotech is, in most of these articles, a fairly unmemorable text that carries with it *the* crucial subtext—our campus is X and Y, everything you remember it being, and yet so much more as well, and here are some stories about nanotechnology that reinforce that message.

What you see, then, is nanotech repackaged to exemplify core positive values—even stereotypes—of the university, while minimizing its less attractive features and demonstrating its worthiness for the new century. Each of these articles—sometimes subtly, sometime not—plays to an entrenched image

of the particular university. Sometimes this is deliberate—some authors are recruited from within the campus PR machine and know exactly what to emphasize. So, for instance, the Harvard article is long, rather labored, rather insistently educative and edifying, plodding through a half dozen experiments in glorious, nerdy detail—and, as the author (who is also the magazine's managing editor) told me, the overt mission of the magazine is not to be a mouthpiece of the university (indeed, it's an independent entity), but to be a vehicle of continuing education (and yet, one needs only see the advertising to understand that all this educative text carries a subtext of endowment-building). So in the frame of the article, nanotech exists at Harvard not to make money or promote national security or any of the things it is associated with in other universities' semi-public spheres; rather, for Harvard alumni, nano is there simply to ensure that both current and former students continue to get the insistently edifying and rather arcane educations to which they've become accustomed.

Contrast this with the Berkeley magazine's view of nano, where a different but not unexpected set of campus images is served: first, profiles of the Third World childhoods of, and continuing international humanitarian work done by, Berkeley nanotechnologists; and, second, a *mea culpa* that past research at Berkeley—particularly in biotechnology—has cuddled too close to the military or corporations like Novartis, but that nanotechnology (while bringing sensible gains to economic growth and national security) will be constrained by new safeguards that ensure Cal's progressive tradition is not suborned. The contrast here is quite stark—the Harvard article contains no mention of commerce or the military, indeed almost no mention of societal benefits of the research; nor does it contain any mention of the personal backgrounds of its scientists.

So these articles take the local details of nano and recraft them in ways that are both generic (any science would do for the purpose) and specific to that

university (nano must reinforce that which makes *this* university different and special). Even when the authors are freelancers with no particular connection to the institution, the same message gets out, largely through the work of editors and the voices of interviewees. So, even though the author of the *Penn Gazette* article isn't associated with Penn and isn't particularly familiar with the university, the message he got from editors and interviewees relayed a Penn-centric view of the world that should be familiar to those who know the university—we're doing "pure" or "fundamental" science, we're not interested in commerce, we're making basic discoveries that will enable other people to cash in rather than developing new technologies ourselves. The *Stanford Magazine* piece, also written by an outsider, flips this around for a typically Stanford message—nano research at Stanford "isn't just an academic exercise. It paves the way": for beating Moore's law, for new modes of manufacturing, for new partnerships with commerce, especially in Silicon Valley—all the things research at Stanford has a self-conscious tradition of doing.

Of course, everywhere there's a norm to reinforce, there's a counternorm to invoke. Everywhere these schools are giving the old college try, they're also packaging nano as a way to shake off musty old values—we hear, for instance, that Northwestern is out there patenting research and encouraging professorial start-ups because "Chicago and the Midwest missed the information technology boom and largely missed biotechnology, but we are not going to miss nanotechnology." Or a *Tech Review* piece on Eric Drexler—"Moses of the Nanoworld"—takes the line that, yes, MIT trained Drexler, but the Institute's association with far-out futurism is so 1970s; nowadays, MIT is much more interested in what real nanotechnologists like Whitesides and Smalley have to say than dreamers like Drexler. From ethnographic work I've done at scientific trade shows, I've seen this same technique used quite widely in universities' and regions' representations

to technical communities. That is, positive connotations are continually and unironically embraced, while negative stereotypes are commented on as yesterday's news. For instance, the Massachusetts pavilion at the 2005 Biotechnology Industry Organization show presented a number of variations on this theme: Massachusetts has a four century tradition of commitment to higher education (*ergo* heritage dictates that our workforce is well-suited to laboratory work); but anything you may have heard about the power of labor unions in the Bay State is no longer true (i.e., our workers have updated themselves by casting off bad traditions of labor activism).

And yet, for all that these magazines evoke particular associations between nanotechnology and the specific attributes of their university, there's a remarkable consistency among these articles. We see the same tropes over and over and over again. Even the titles—especially the titles—are tremendously repetitive: "Small Science;" "Nanotechnology: Big Ideas in Small Packages;" "Small Is Big;" "Smallville;" "Small Technology, Big Promise;" "Thinking Small;" "Small Wonders." Yet it's not just lack of imagination at work here; the same themes continually get evoked precisely because nanotechnology helps alleviate some of the institutional pressures that face all universities (certainly all American research universities—it would be an interesting extension of this study to look at smaller schools, community colleges, or universities in other regions). Campus nano is almost always represented as: (1) interdisciplinary—this gets hammered home continually as an issue of "we're all playing in each other's sandbox for the good of the world"—it's not too much of a stretch, I'd say, to see in this a reflex of American universities' obsession with diversity. (2) Campus nano is commercial—in a climate where universities are scrambling for funding and adjusting to a society that seems more oriented to the market than ever, magazines present nano as yet another tool for the institution to make itself leaner and more corporate. And (3) campus nano is solving *your* problems as a citizen and

a member of the investor class—in a world where many deans and chancellors feel themselves on the front lines of the culture wars, nano is presented as the university's answer to its nation's call.

This is, I'd say, the real story about nanotechnology—that wherever we find nano, we see it balanced between the local and the global. These alumni magazine articles balance two sets of family resemblances—on the one hand, nano looks like everything else that a particular university does, a comforting reminder to alumni about what makes their *alma mater* special and how it's still what it was, but better; and on the other hand, nano here looks a little like nano everywhere—this university answers to many of the same pressures as all the others. If we want to understand nanotechnology, we won't get much from the big picture, the pronouncements of Mike Roco or Rick Smalley or Eric Drexler—we have to look at this middle level instead, where a sphere is being created for nano that is neither strictly private nor wholly public. We have to understand why particular institutions respond to the call of nano, and how they repackage it to exemplify what those institutions purport to be about—and yet, we have to recognize the encompassing environment those institutions face that shapes nanotechnology at all points.

NANOTECHNOLOGY OUTREACH BY AN ANTHROPOLOGIST

By Chris Toumey

My background in cultural anthropology has brought me to a situation where I work with an interdisciplinary research team studying societal interactions with nanotechnology. Our work benefits from the distinctive disciplinary backgrounds of its members, but it is seldom necessary to credit a particular idea or project to one traditional discipline or another. We borrow freely from each other's backgrounds, and this kind of synergy contributes greatly to the success of our work. Much of what I do, for example, is not specific to anthropology. In fact I sometimes find that people who read my articles on nanotechnology are surprised to find that I am an anthropologist.

Even though I rarely need to highlight my own disciplinary origins, I am nevertheless very conscious that some of my work is firmly grounded in cultural anthropology. I'd like to comment briefly on how cultural anthropology brought me to the study of societal interactions with nanotechnology, and then explain how it influences one of my primary responsibilities, namely, an outreach program which serves nonexperts who are curious about nanotech.

Since the time of my dissertation research, most of my work has been devoted to studying public scientific controversies as hermeneutic problems, that is, the deployment and manipulation of the symbols and meanings of science. I have pursued this question in my writing about creationism, fluoridation, cold fusion, and other topics.

I frequently stress two particular insights that come from repeated ethnographic observations, both by myself and others. First, the social actors in public scientific controversies have a broad spectrum of scientific expertise or lack thereof, including scientists, engineers, technicians, would-be scientists, and wouldn't-be scientists, plus people with no scientific expertise at all, including some who may have no desire to possess any scientific expertise.

Secondly, I use the paradigm of interpretive anthropology to make sense of the meanings and symbols that circulate in a public scientific controversy. This approach keeps meanings very prominent in my analysis: good empirical scientific knowledge is always valuable, but it is set within a context of pre-existing values, beliefs, worldviews, and other sorts of understandings. A scientist might object to some views of the lay public by saying that values without good science make bad science policy. Indeed this is true, but so is the reverse: good science that ignores peoples' values and beliefs will not become science policy. The processes for making science and technology policy in American society include numerous mechanisms by which nonexperts (and experts) inject their values and meanings into policy, e.g., lobbying, litigation, legislation, referendums, appropriations, local public health policy, local environmental regulations, and so on.

One can see these two observations in such controversies as creationism-versus-evolution, fluoridation, cold fusion, and AIDS/HIV disputes, to name but four.

That way of thinking had shaped my anthropology by the time I met my South Carolina colleagues who are studying societal interactions with nanotechnology. These faculty had plenty of talent before I joined them, but I filled an unoccupied niche as an ethnographer of public understandings of science, and I had a reliable paradigm for studying public understandings of nanotechnology. I was asked to join the team for the purpose of adding my anthropology-of-science perspective, and I was happy to do so.

In December 2003, four people from the USC team, including myself, attended a National Science Foundation

Chris Toumey

workshop on societal implications of nanotechnology, where three troubling themes were expressed repeatedly by experts from academia, government, and business:

1. Public understandings of nanotechnology were almost nonexistent at that time;
2. Some polarizing visions of nanotech, framed in vivid hyperbole, were circulating, and were likely to dominate the ideological landscape in lieu of more balanced or centrist public understandings;
3. The process of building public understandings must not be a one-way communication from active experts to passive laypersons. On the contrary, it must include ways for laypersons to express their questions, their concerns, and their values, and for them to receive responses from experts.

One of the explicit goals of our team is moving nanotech into the public sphere, as we call it: to investigate how nonexperts will understand (or misunderstand) nanotech, and, we hope, to identify good ways for the lay public to participate in nanotech policy. The seriousness of the three NSF workshop themes motivated us to devise an outreach program that we called the South Carolina Citizens' School of Nanotechnology (SCCSN). I was primarily responsible for this project.

We began by looking to the idea of a mini-medical school, that is, a series of lectures which introduce the public to some of a medical school's research. This is not a microcosm of the medical student's experience, but rather a window into ideas that challenge the medical school faculty. By responding to peoples' curiosity about medical topics, a mini-medical school demystifies the role of the med school and enhances public appreciation of the school. It is extremely important that the faculty who participate are capable of talking about their work to nonexperts and are comfortable with that task.

We also realized that mini-medical schools draw very large audiences. Sessions tend to be one-way communications between the expert and a passive audience, with little opportunity for questions, and no possibility of general discussion.

We modified three features of the mini-medical school model for the SCCSN:

1. Each session would be supported by some background readings that are readable for nonexperts, which the participants would ideally read prior to each session, so they could acquire some confidence before hearing a particular presentation;
2. We would keep the sessions to a size that was small enough, and friendly enough, to permit questions, discussions, and other comments from the participants;
3. In addition to questions and comments during each presentation,

there would be time after each presentation for participants to discuss that evening's topic with the presenter; participants could continue such discussions face-to-face with the presenter after the formal part of program was finished; and participants could contact the presenters at a later time to raise more questions and express their concerns.

The first round (SCCSN.1) consisted of six sessions on consecutive Wednesday evenings in March and April 2004. Forty-four people enrolled, and average attendance was about 35. The speakers were USC faculty from Philosophy, Chemistry, the School of Medicine, English, and the NanoCenter. Participants included social workers, physicians, attorneys, students, clergy, nurses, machinists, venture capitalists, and other occupations.

Between the first and final sessions SCCSN.1, we saw a distinct increase in the participants' confidence in understanding scientific and societal features of nanotechnology. The package of readings was especially appreciated, both for the breadth of its substance and for its readability.

At the final session, the participants filled out evaluations which caused us to revise some parts of the program for the second round, which occurred in Fall 2004. Participants wanted more knowledge about societal interactions with nano, so we added another presentation, supported by several articles. Another set of comments concerned the instruments that make nanotech possible, i.e., the scanning tunneling microscope (STM) and similar machines. The participants were extremely curious to see these machines in operation, and so suggested adding a lab tour. This was done in he second round: the group visited both the USC Electron Microscopy Center and a Chemistry lab with an STM. They saw the imaging of nanoscale materials and surfaces (ranging from 30 to 0.27 nm) in real time. The faculty explained the instruments and the images and answered questions.

Those who attended the lab tour said that this was a rare and exciting insight into the workings of nanotechnology. I don't mind adding that seeing individual atoms and molecules imaged in real time is one of the coolest things one can experience in the study of nanotechnology.

SCCSN.2 was particularly successful at creating dialogues between experts and nonexperts, which of course was at the heart of its purpose. Two incidents are worth relating. In the first, Robert Best of the USC School of Medicine spoke on the topic of nanomedicine, as he had done in the first round. He had a well-developed powerpoint presentation which led audiences through the topic of nanomedicine in a clear linear order. On the evening of 20 October he brought his presentation on a flash drive and planned to use the computer in the classroom, which was networked to the powerpoint projector. We were unable to get into that computer, however, because I could not find the password. So Dr. Best delayed his formal presentation while I tried unsuccessfully to get the password, and he began by soliciting questions about nanomedicine from the participants. This had an excellent effect: it was clear that the evening would be driven by their concerns, not his conclusions. Then when he switched from informal question-and-answer to his presentation, he proceeded without the benefit of his powerpoint slides, which reinforced the informality of the session and further encouraged participants to interject comments and questions. So his talk had a structure which moved from topic to topic, but it was also flexible and very participant-friendly. Perhaps a speaker who was less confident with his or her presentation might not have been able to do this, but I must say that the dialogue between concerned participants and a knowledgeable expert was ideal on that occasion.

A similar thing happened when Steve Lynn spoke on nanotech in science fiction. Dr. Lynn had done this in SCCSN.1 in April, and had also delivered variations on this talk at other venues since then. His presentation

gave a typology of science fiction styles (predicting the future; moral/social commentary; evils of science), and then related nanotech to each of those styles, which is to say that, like Robert Best's talk on nanomedicine, it had a logical structure. But Lynn tended not to be bound to structure: he liked to be able to digress when appropriate. On this occasion, he was clearly even more relaxed than he had been in April, and so he entertained even more questions and comments than usual, which is saying a lot. This was important because his plan of putting nanotech into his typology of science fiction styles evoked numerous sharp comments about the societal and ethical implications of nanotech. Again, a robust two-way interaction between expert and nonexpert helped realize the ethos of the SCCSN.

The third round was held in April 2005, and the fourth in Fall 2005. We are still open to new ways to improve and revise the SCCSN, and we consider each round to be an opportunity for further experimentation and innovation, especially the participants' suggestions. Meanwhile, our experiences with four rounds have given us the confidence that the SCCSN is worth continuing, and we expect to offer it twice a year for the foreseeable future.

What, then, is the anthropological grounding of this work? Two features stand out. First, the ethos and the execution of the SCCSN deviate from the standard literature on the public understanding of science. Notice that "understanding" is singular, implying an undifferentiated public which ought to receive the public understanding of science. This kind of thinking leads to a simplistic binary scenario of scientists versus the public, with no one in between, and it also encourages linear deliveries of scientific knowledge from active experts to passive laypersons. But my ethnographic experiences in public science controversies have convinced me that public understandings are truly plural in the sense that they are socially stratified and otherwise fragmented along dimensions of socio-

economic status, gender, religion, and other factors. An outreach program like the SCCSN must realize that its audience possesses a spectrum of scientific expertise.

Presentations or readings that are aimed at a supposedly homogeneous passive audience are misguided. The alternative is to recognize the plurality of public understandings and work with them. And so one of the reasons why the South Carolina Citizens' School of Nanotechnology evokes questions, comments, and discussion from the participants is so that everyone involved—presenters, participants, and coordinator—can see that different people understand science and technology differently. This will also be true, of course, for their understandings of nanotechnology.

Here I am not implying a nihilistic relativism in which all opinions have equal scientific validity. I recognize a normative universe in which some claims about nanotechnology are more realistic than others, and should be seen as such, and some understandings are more sensible than others. But the process of building sensible public understandings of nanotechnology is a social process that begins with social reality, and that reality includes the social stratification and fragmentation of understandings of science and technology.

Secondly, interpretive anthropology makes meanings and values just as prominent as empirical facts. SCCSN evokes participants' values and concerns, and makes them as important as the delivery of scientific knowledge. I like to think of the South Carolina Citizens' School of Nanotechnology as an exchange of scientific knowledge and cultural meanings. Both are intensely important. No one has a magic formula for weighing the two, but when the SCCSN works the way I want it to, the participants' understandings of nanotech are infused with good science and articulate expressions of critical concern about the future of nanotechnology.

Studies of scientific literacy of science are pretty grim. Decade after

decade, they reveal that few adult Americans have the knowledge or the skills to make informed decisions about science and technology policy. Measures of science education complement that by showing that American children perform very poorly on comparative international studies of science and math.   One could summarize all this and arrive at total despair. Alternatively, one could see this as a great opportunity to do applied anthropology by experimenting with new ways to nurture public understandings of science and technology. The status quo is so bad that it would be extraordinarily difficult to make it any worse; the near-future potential of nanotechnology is so powerful that it is likely to change our material and social world; nanotech policy will not to be made exclusively by experts, nor should it; the literature on public understandings of science suggests that new forms of informal science education are worth discovering and developing. Now the responsible thing to do is to nurture public understandings of nanotech with a trial-and-error approach that includes good ideas from cultural anthropology and other disciplines. That leads one to outreach programs like the South Carolina Citizens' School of Nanotechnology.

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ROOTS TO BRANCHES: ANTHROPOLOGY AND THE HUMAN DIMENSIONS OF NANOTECHNOLOGY

By John V. Stone

Introduction

From its broadest perspective the history of human culture is the story of technological change that, interwoven with biological modifications, has produced modern *homo sapiens*. Traditionally, anthropologists retrospectively studied the human effects of new technology (Spicer 1952), but in recent years they have assessed human effects before technology intervention occurs (Goldman 2000). Such interest forms the basis for this article, which builds upon nanotechnology sessions convened at the 2005 annual meetings of the Society for Applied Anthropology (SfAA) and the American Anthropological Association (AAA). The goal of these sessions and indeed this article is to generate questions to spur further debate on the nature of anthropological contribution to studies of nanotechnology in society.

Nanotechnology—broadly, the ability to control or manipulate at the atomic scale—is a product of, and may transform, social structures and processes. Scientific and policy institutions are exploring the social and ethical dimensions of nanotechnological interventions, and anthropologists are contributing both conceptually and methodologically to this endeavor. Yet, the discipline of anthropology presents an holistic, bio-cultural, historical and comparative perspective that may help to integrate exclusively social and ethical considerations within a broader more comprehensive framework. If, as nanotechnology proponents envision, this new technology will be 'socially revolutionary and transformative' (Rocco & Bainbridge 2005) then we sit as a discipline on the brink of opportunity to frame the human dimensions of nanotechnology in uniquely anthropological

terms. But will we? Are we doing so now? What constitutes an 'anthropological approach,' and how will we know when it has been contributed? To borrow from Urciuoli (2005), what will count as 'anthropological knowledge' in studies of nanotechnology in society?

> " Nanotechnology—broadly, the ability to control or manipulate at the atomic scale—is a product of, and may transform, social structures and processes. Scientific and policy institutions are exploring the social and ethical dimensions of nanotechnological interventions…. the discipline of anthropology presents an holistic, bio-cultural, historical and comparative perspective that may help to integrate exclusively social and ethical considerations within a broader more comprehensive framework. "

The dialogue surrounding such questions provides anthropologists with a venue to reconsider Brown's & Yoffee's (1992) "Is Fission the Future of Anthropology?,' wherein the authors trace anthropology's historical divergence from a central 'anthropological perspective' and into numerous specializations within each of its four major subfields. They consider whether ever greater specialization within anthropology, in the absence of continued grounding in its core tenets, will render the discipline irrelevant. It's worth noting further that this issue maintains relevancy within the discipline, as *Anthropology News*

has recently taken up the question 'To Split or Not to Split?' in its 'In Focus' section (Shenk et al., 2006). Whereas these articles address the 'fission' issue in terms of the constitution of academic anthropology programs, the same questions may be asked—indeed

have been asked previously (Brenneis 2004)—of anthropological engagement with the organizations that fund social science research and practice. For example, consider this quote from an article titled "Too Little Too Late," by Ira Bennett and Daniel Sarewitz (2006), forthcoming in the journal 'Science & Culture:' "Social science communities have engaged with the challenges of nanotechnology only when stimulated by the appearance of federal research funding starting in about 2001. Thus, they did not materially participate in the framing of public discourse about nanotechnology, or in the design of
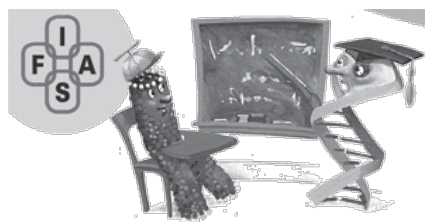
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What Can Nano Learn from Bio?
Lessons from the Debate over Agrifood Biotechnology and GMOs

Image by MSU Agrifood Nanotechnology Project

Conference Masthead

research programs to study the social implications of nanotechnology." One is compelled to question how these issues might apply more specifically to the discipline of anthropology. That is, to what extent have anthropologists 'materially participated' in the design of research programs to study the human dimensions of nanotechnology, and has that participation been primarily in the form of anthropological 'fusion' or 'fission?' When one surveys the field of currently-funded anthropological research on nanotechnology, does one find evidence of increasing integration or fragmentation among our disciplinary specializations? And does it matter one way or the other? Applying anthropology to studies of nanotechnology in society may reveal as much about our discipline as it does the human dimensions of nanotechnology.

Nanotechnology and the Human Dimensions of Anthropology

Following Brenneis' lead, I address these issues from my viewpoint as an applied anthropologist working with a multidisciplinary research team on an NSF-funded project (grant #0403847; http://www.msu.edu/user/ifas/key-projects.htm) to study the societal dimensions of nanotechnology in food and agriculture, and from this vantage inquire as to the value and insight our discipline may provide in future nanotechnology research programs. Our project responds in part to funding and policy agency calls for multidisciplinary collaboration and interdisciplinary synthesis (Rocco & Bainbridge 2005;

National Academies 2004, 2002), as our project team includes anthropologists, engineers, sociologists, chemists, philosophers, economists, and food and nutrition scientists. A significant portion of our project activity centers on developing a hybrid language or set of principles for facilitating our research—that is, 'building capacity' to move from multi-disciplinary assemblage to interdisciplinary synthesis. Our methods of research are multiple and involve interviews, content analysis, web fora, and philosophical deliberation. Findings from these activities are being integrated through team meetings and the conduct of public symposia and workshops addressing lessons from agrifood biotechnology, the emerging shape of agrifood nanotechnology, and emerging standards for food safety and product quality associated with agrifood nanotechnology.

Through this project I became involved with a sequence of nanotechnology sessions which, as noted in the introductory article, have been convened over the past year at the annual meetings of the CSAA, SfAA, and AAA. These inaugural sessions in three of anthropology's flagship organizations demonstrate a clear and present disciplinary interest in nanotechnology. These sessions have supported the emergence of a small but growing network of anthropologists involved in nanotechnology research collaborations. Chris Toumey (University of South Carolina) is presently compiling a directory of these people, and I, too, have been attempting to identify others who may be working on nanotechnology but who are

not currently identified with this group. Part of this effort includes informal conversations I have had with the heads of various anthropology-related programs at several large national science funding and policy agencies. Suffice it to say, there aren't many of us at this point— roughly 22 at my last count—and judging by conversations I have had with most of them, I would describe the vast majority as 'cultural' anthropologists to varying degrees. Indeed, the recent AAA session on nanotechnology was titled 'Cultural Anthropology and the Future of Nanotechnology.' I applaud these efforts and count myself among them; however, given the richness, breadth, and diversity of our discipline, my concern is that we currently represent a disproportionately narrow slice of potential anthropological contribution to national nanotechnology initiatives. I can't help but wonder whether 'we'—in the rhetorical sense—are going far enough. It seems anthropology has more to offer in this endeavor.

Wolf (1964) notes that anthropology is the most scientific of the humanities and the most humanistic of the sciences. Reck (1996) observes further that anthropology's uniqueness resides in this paradoxically comfortable and uneasy location between the sciences and the humanities, and that anthropological understanding is best obtained through 'multiple routes' of inquiry. It is in this vein that I paraphrase earlier discussions of core perspectives and interests in anthropology (Brown & Yoffee 1992; Shenk et al., 2006) and ask to what extent these are present in our current research efforts on nanotechnology, and how they might be factored more explicitly into our future engagement with national nanotechnology research initiatives. Each of anthropology's four major subfields builds to some degree upon its own body of theory and method, and in this regard may be considered separate from the others. And indeed specialists and 'subspecialists' may be found within each, which further serve such distinctions. These authors consider in the context of academic anthropology programs whether such distinctions

have ingrained themselves to the point at which the specialists in any of the subfields actually bear more in common with their non-anthropologist collaborators than they do with fellow anthropologists specializing in other subfields. And if this is the case, then it raises the question of what it means to be an anthropologist, indeed 'what is anthropology.' Brenneis (2004) and Urciuoli (2005), on the other hand, focus more explicitly on anthropological engagement with programs conceived by research funding agencies, and this approach may be particularly revealing with regard to the role of the social sciences in the NNI, wherein, as noted previously, explicit calls for 'interdisciplinary collaboration' are being made.

Depending on the nature of the question being addressed, relative degrees of mutual inclusion may be found among both the scientific and humanistic dimensions of anthropology's four subfields. But it is typically understood that what holds these interests together, even in light of the most exclusive or divergent research questions, is a long-standing anthropological emphasis on 'holism,'—the idea that the human dimension encompasses an interplay among cultural, biological, ecological, communicative, and historical aspects that must be investigated from a broad, comparative perspective (Brown & Yoffee 1992). In this view, as well as from my vantage point as an anthropologist involved in this work, the anthropological difference in research on the human dimensions of nanotechnology lies, at least in part, in the degree to which anthropologists—regardless of their respective subfield specializations—are able to frame their collaboration in distinctly holistic or '*intra*-disciplinary' terms. Indeed, Schiffer (2001) suggests technology studies generally as one possible mechanism for reintegrating an increasingly fragmented field. Others argue that a more generalizable anthropological 'value-added' lies not in holistic synthesis but rather as "interpretive social science grounded in both fine-grained ethnographic research and the foregrounding of contingency

by means of wide-ranging comparison across cultures and epochs" (see, e.g., Shenk et al., 2006).

Toward an Intra-Disciplinary Anthropology of Nanotechnology

So how might an intra-disciplinary 'anthropological difference' be reflected in future research on the human dimensions of nanotechnology? Although I'm not in a position in this article to fully address this question, through my vantage as an anthropologist involved in various aspects of this work I am able to provide a few brief examples of potential four-field applications in this area. Certainly, these represent only a narrow slice of what I think should be a much more robust and comprehensive disciplinary engagement with this topic. They are offered here simply to underscore both the conceptual breadth and topical specialization that anthropology can bring to bear on such matters.

One needn't look far for examples of cultural anthropology in nanotechnology research, as the articles comprising this special issue can attest. To this I would like to add my own experience framing ethnographic research among organizations that facilitate and set

nanotechnology standards. Our project is especially concerned with the potential impacts that such standards may have as they are integrated within extant agrifood standards regimes. If one thinks of 'power' as the ability to set the rules that others have to follow, then 'standards' represent a form of codified social power reflecting the interests of those groups having the greatest social access to standards-setting processes. By virtue of this project, we have an appointed seat on the Nanotechnology Standards Panel of the American National Standards Institute (ANSI-NSP), and this provides a unique opportunity for participant-observation and ethnographic description. Perhaps most interesting to me during these early phases of this effort is the emerging relationship between perceived risk and social representation and action on the NSP, a topic with which anthropologists have a longstanding interest. Although we are far too early in our research to discuss 'findings' per se, it's clear that differential social access to participatory processes will plague the standards sphere, much as it has environmental decision-making (Stone 2001a,b). Our group is presently considering research into this area, to promote participatory
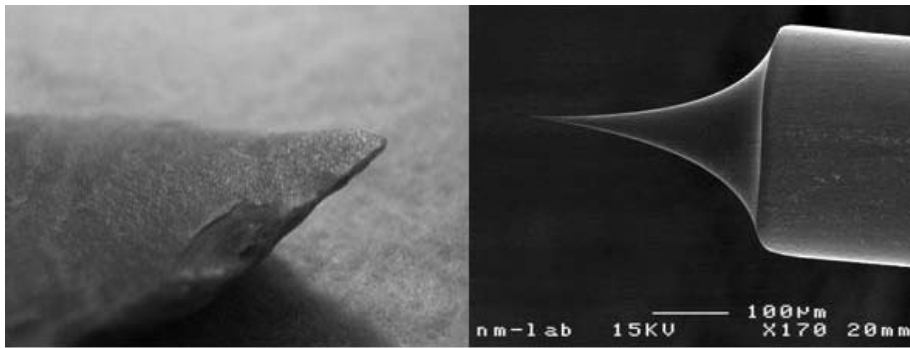
Image Credits: Pastpieces (neolithic); Magnus Larsson (nanolithic); John Stone (arrangement)

Neolithic to Nanolithic: Neolithic Flint Piercing and Grooving Tool (left); Nanoscale Tungsten Tip for Scanning Tunneling Nicroscope (right)

equity in nanotechnology standards development and integration.

Anthropological linguistics might also be applied to NSP activities. The Panel's first task is to establish a standard nomenclature and terminology for nanotechnology. This interest was precipitated by the fact that scientists in different fields were making similar nanoscale discoveries and devices but were describing them in terms specific to their respective fields. Not surprisingly, this presented problems, for example, for the US Patent and Trademark Office, which maintains an interest in *not* granting multiple patents for the same item differently described. The decision facing the NSP is whether to create a new hybrid nomenclature reflecting input and negotiation among the major disciplinary interests (e.g., chemistry, physics, biology, engineering), or to adopt a lingua-franca, of sorts, where one discipline's nomenclature becomes standardized as *the* nomenclature of nanotechnology, to which new hybridized terms would be added as the field advances. The Panel is leaning toward the former, with the rationale being that the latter would confer unfair access to grants, patents, and publications for those whose primary 'language' is that of the chosen speech community, or discipline. Yet a componential analysis of speech terms and meanings could potentially reveal the same kinds of issues in a hybridized nomenclature; that is, by assessing where in the standard social power resides via the relative prevalence of semantic components of contributing speech communities. I don't consider myself to be a specialist in anthropological linguistics—knowing only enough to be dangerous—and this example may not be particularly representative of the full conceptual weight that anthropological linguistics could bring to bear on this topic. My intention here is simply to suggest that there is ample room in this domain, and certainly anthropological linguistics has much to contribute.

The same may be said of archaeology, which has a longstanding association with the material and behavioral aspects of culture and technological change (Schiffer 2001). I noted in the opening to this article that traditionally, anthropologists retrospectively studied the human effects of new technologies. Current interest in the human dimensions of nanotechnology presents the opportunity to frame these same issues prospectively; that is, to look forward by first looking back. As Schiffer observes, archaeologists have recorded variability and change in technology through time and across cultures—"from the australopithecines' first flakes to yesterday's lunch." This historical/comparative perspective provides the basis for insight concerning potential social impacts—not just of nanotechnology itself, but of the very tool-making technologies that are enabling the so-called 'nanotechnological revolution.' Entire cultural traditions are defined by such revolutionary techniques—e.g., Acheulean, Levallois, Mousterian, 'Transhumanist(?)'—the archaeological records of which reveal much about social diffusion and displacement, intensification and cultural transformation. Perhaps the tungsten-tipped scanning tunneling microscope is our flint piercing and grooving tool, the nanotechnology 'clean room' our 'steel axe.' What kinds of questions might an archaeologist ask if s/he were present at the first stone flakings? Might such questions shed prospective light on the potential societal implications of nanotechnology? Who better than archaeologists to raise them?

The human dimensions of nanotechnology are similarly well-addressed from a bio-cultural perspective—essentially, that in *Homo sapiens* nature and nurture are inextricably intertwined, thus are the physiological and socio-cultural dimensions of nanotechnology. Popular literature such as Garreau's 'Radical Evolution' (2005) is focusing public attention on what it means to be human: 'we are engineering the next stage of human evolution… through converging advances in genetics, robotics, information, and nanotechnologies.' Prominent academic institutions are taking such claims quite seriously, for example, the James Martin Institute at Oxford University is convening an international forum to address 'Tomorrow's People: The Challenges of Technologies for Life Extension and Enhancement' (see, e.g., http://www.martininstitute.ox.ac.uk/jmi/forum2006/). Human sustenance is one area of considerable interest. For example, the convergence of nanotechnology and genomic information has led to speculation that human diets can and indeed will be engineered to meet population-specific health needs through so-called 'functional foods' and 'nutriceuticals' targeted to particular communities. Such capability would add a new twist to the meaning of 'ethnic food,' potentially changing its connotation from 'of' a people to 'for' a people. Aside from related issues pertaining to the redefinition of social groups by their genetic predispositions to particular diseases (and hence dietary proscription), one might ask on

what scientific grounds such claims are being made. Perhaps a clinal critique is in order here? Certainly, biological anthropologists have a longstanding association with the topic (Sauer 1993). Knowing that genetic traits are continually variable over space and that so-called biological races represent only central tendencies, how is it that diets can be engineered—nano or otherwise—to address the range of health issues facing any particular population? Such critique has recently been brought to bear on similar claims surrounding the heart drug 'BiDil,' supposedly engineered for the African-American population (Jones & Goodman 2005). Sadly, the BiDil claim centers less on biological evidence and more on clever marketing to secure patents and FDA approval (Kahn 2004), so perhaps our species' 'radical evolution' will reflect not only the convergence of new technologies and human biology but also their social production and cumulative marketing through time. In either case, biological anthropology provides much needed insight into such matters, and I encourage biological anthropologists to further engage the human dimensions of nanotechnology.

Discussion

If one accepts the claims of nanotechnology's transformative potential, then surely the social sciences and anthropology in particular, can be called upon to provide insight on such matters. And, as noted previously, calls for multidisciplinary collaboration and interdisciplinary synthesis continue to be made by US science policy and funding organizations. Such calls beg the question of what it is about particular disciplines— in this case anthropology—that makes their inclusion so desirable. What, if anything, defines our contributions as uniquely anthropological; what distinguishes them from the contributions of practitioners of other disciplines? Does such distinction matter? If not—if we're just one community of conceptually and methodologically sharing scientists and humanitarians, then why the calls for multidisciplinary collaboration and

interdisciplinary synthesis? The fact that multidisciplinary collaboration carries such import with nanotechnology funding and policy agencies is, in my view, our occasion to re-examine anthropology from roots to branches, to seek prospective clarity in our anthropological 'value-added,' and to think about ways in which we might retrospectively

> " So the question remains: will anthropology—as a member of the 'social science community'—'materially participate' in the design of future federal research programs on nanotechnology in society, and specifically in framing the overarching research questions that such programs address? …what will (or *should*) be the 'anthropological difference' at this institutional level—roots to branches, fusion or fission? "

evaluate our contributions to nanotechnology research so as to better determine whether and/or to what degree we have actually contributed 'anthropological insight' to our topical engagement and interdisciplinary syntheses.

The examples presented above of potential four-field anthropological application to nanotechnology research, while admittedly narrow in scope, are intended to illustrate the conceptual breadth and topical specialization that anthropology can bring to bear on such matters. For me, these qualities taken together, and grounded in holistic and bio-cultural perspective, constitute anthropology's unique contribution. I'm not suggesting therefore that anthropology 'go it alone' but rather that our collaboration be deliberately inclusive of our disciplinary subfields, with an eye toward the core perspectives that link us in common *intra*-disciplinary

community. Early indications are that anthropological contributions are less 'intra-disciplinary' than they might be; the good news being that there is ample room for both a more diverse *and* integrated anthropological engagement with this topic.

In harkening back to Bennett's and Sarewitz' observation that "Social science communities…did not materially participate in…the design of research programs to study the [human dimensions] of nanotechnology," it's worth noting that the Environment and Technology Section of the American Sociological Association (ASA) has recently formed an advisory committee to inform the nanoscience community regarding potential symbioses between nanotechnology and the social sciences. Although designed primarily to address nanotechnology applications in social science, it is clear that such disciplinary engagement creates opportunities to help the nanoscience community frame research questions concerning the human dimensions of nanotechnology. I think this is an important point because the nature of our future multidisciplinary collaborations on this topic will depend largely on how such questions are framed among funding organizations

- Where does the discipline of anthropology stand in relation to national nanotechnology research, specifically with regard to funding agency calls for multidisciplinary collaboration and interdisciplinary synthesis?

- Should there be a coordinated anthropological approach to nanotechnology research? Or should this emerge through the involvement of individual practitioners?

- What do we contribute as individual anthropologists engaged in various nanotechnology projects? Do (or will) applied anthropologists apply anthropology in nanotechnology research?

- Is an 'anthropological difference' even necessary in our collaborations? If not, then is anthropology per se necessarily relevant in this context?

- If anthropological contributions are relevant in nanotechnology research initiatives, then how do we evaluate the 'anthropological difference' of our collaboration? Is such evaluation even necessary?

- What does 'multidisciplinary collaboration' mean in nanotechnology research? Does it connote multiple disciplinary conceptualizations of nanotechnology in society, or the sum involvement of practitioners of specific disciplines (i.e., per their degree) through which multiple disciplinary conceptualizations are assumed to emerge? What are the implications for anthropology (or any discipline) of either of these connotations?

Table 1. Points for Anthropologists to Ponder in Nanotechnology Research Collaboration

that design the research programs that support our work. In general, the more holistic the questions the greater the search for interrelationships among systems at varying levels of integration, and thus the greater the likelihood for comprehensive four-field collaboration. By contrast, more particularistic questions will, in my estimation, place less emphasis on systems integration and will thus tend to favor specialistic collaboration. As noted previously, depending on the nature of the question being addressed, relative degrees of mutual inclusion may be found among both the scientific and humanistic dimensions of anthropology's four subfields.

So the question remains: will anthropology—as a member of the 'social science community'—'materially participate' in the design of future federal research programs on nanotechnology in society, and specifically in framing the overarching research questions

that such programs address? And if so, will—or perhaps more importantly *should*—the contribution be modeled upon a comprehensive four-field approach to framing 'human dimensions' broadly, or will it reflect an exclusive assemblage of complementary albeit disconnected specializations? In short, what will (or *should*) be the 'anthropological difference' at this institutional level—roots to branches, fusion or fission? And regardless of the conceptual constitution of federal nanotechnology research agendae, how shall we engage the system as institutionally embedded anthropological practitioners? Some may engage as specialists addressing a particular component of a larger research agenda—those with an eye toward a more holistic understanding of the topic, others with little if any real need to relate their work to anthropology. On the other hand, although there aren't too many four-field generalists

these days, certainly none that I know of working yet in nanotechnology, it's not unreasonable to envision teams of four-field specialists mutually framing an intra-disciplinary nanotechnology research agenda. To date, however, I am not aware of any such initiative, neither among individual practitioners nor at the broader disciplinary level.

Although my personal preference is for a more coordinated intra-disciplinary engagement (noting my own professional involvement falls short of this), my primary purpose here is less about advocating that approach (although it is that, too) than it is about generating questions to spur further debate on the nature of anthropological collaboration with and conceptual contributions to national nanotechnology research initiatives. Table 1 presents a sample of these questions that emerged through the SfAA and AAA nanotechnology sessions. Regardless of our institutional situation, when called upon to contribute as *anthropologists* to 'multidisciplinary collaboration' and 'interdisciplinary synthesis' in nanotechnology research programs, I would encourage us to clarify to the greatest extent possible the expected 'anthropological difference' of our collaboration. Doing so will provide a basis for retrospectively evaluating at both disciplinary and personal levels whether and/or to what degree we have actually contributed 'anthropological insight' to these programs, and will help clarify our subsequent collaborations by focusing our attention on the value such insight can bring to these efforts.

Summary and Conclusion

I have raised in this article the prospect that anthropological engagement with national nanotechnology research initiatives may reveal as much about the nature of our discipline as it does the human dimensions of nanotechnology. In this way nanotechnology serves as a lens through which anthropologists may interrogate the broadly human dimensions of their discipline. I have used my position within a federally funded network of anthropologists (and other

social scientists) as the basis for my own interrogation, and from this vantage I see a largely cultural anthropological bias in our present disciplinary engagement with this topic—a bias that I fear is overly present in my own application as well. This 'bias'—if I can use that word here—is, as reflected in the literature, partly a function of the way in which programmatic research questions have been framed among the leading science funding organizations that support this work, and partly a function of our own inability to conceive a more broadly comprehensive—what I have called 'intra-disciplinary'—anthropological strategy to engage the programmatic research questions that have been framed. To this end I have outlined a few examples of potential application across anthropology's four major subfields and have suggested, as have others, that these multiple routes of inquiry, linked in holistic and bio-cultural perspective, constitute a uniquely anthropological contribution to national nanotechnology research initiatives. However, not all or even most anthropologists would necessarily agree with this assessment, and so in respecting the richness and diversity of their opinions, I have also sought in this article to generate questions to spur further debate on the nature of our disciplinary contribution to this topic. Amidst continuing calls for 'multidisciplinary collaboration' and 'interdisciplinary syntheses' in nanotechnology research, such debate will help clarify at both disciplinary and practitioner levels the nature of our contribution and, indeed, the 'anthropological difference.'

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John V. Stone is profiled on page 5. ∎

ANTHROPOLOGICAL RESEARCH AT THE UCSB CENTER FOR NANOTECHNOLOGY IN SOCIETY

By Barbara Herr Harthorn, W. Patrick McCray, and Terre Satterfield

On Oct 6, 2005, the National Science Foundation announced it Note: The authors gratefully acknowledge the support of NSF grant #051184 for the work on which this article is based. The opinions expressed are those of the authors and do not necessarily reflect the views of the NSF, nor of the authors' employers or collaborators. s new awards under the Nanotechnology in Society initiative. Their banner headline read "New Grants Are Awarded to Inform the Public and Explore the Implications of Nanotechnology", in an effort to "…greatly expand efforts to inform the general public about nanotechnology, and to explore the implications of that fast-moving field for society as a whole" (NSF 2005). Two new Nanoscale Science and Engineering Centers (NSEC), each designated a national Center for Nanotechnology in Society (CNS), were funded, the first ever to be dedicated entirely to societal issues concerning nanotechnology.

Medical anthropologist, Barbara Herr Harthorn, is Principal Investigator and Co-Director of the CNS at University of California at Santa Barbara. The other new Center will be housed at Arizona State University, led by political scientist Dave Guston with a large team of collaborators Historian Patrick McCray (doctoral minor in anthropology) is Co-Director and Co-PI with Harthorn of the CNS-UCSB and will lead a research group tracing and documenting the history of the nano-enterprise. Harthorn will lead the CNS interdisciplinary research group focused on Risk Perception and Social Response to Nanotechnologies along with anthropologist Terre Satterfield, University of British Columbia (Vancouver) and social

Barbara Herr Harthorn

W. Patrick McCray

Terre Satterfield

psychologist Nick Pidegon, University of Wales-Cardiff (UK). Anthropologists Francesca Bray, University of Edinburgh, and Susan Stonich, UCSB, are also collaborators. Although the work of the new center is explicitly interdisciplinary and developed around mixed methods approaches, its research efforts will draw on anthropological theory and practice in almost all phases of work.

The range in new particles, structures, materials, and systems anticipated to result from nanoscale research is enormous, and the potential social issues around their creation, development, production, consumption, and disposal across transnational space are similarly diverse. A national center devoted to the social scientific study of nanotechnologies must anticipate where the most important social and ethical issues will arise, collect sufficient baseline data before public awareness and debate escalates, and be poised to respond to emerging issues—a rapid response team, if you will, with a ready

toolkit and the expertise to implement and build a strong research program. Anthropological fieldwork, with its daily challenges and ever fluctuating parameters, should provide an excellent background for the uncertainties ahead.

Opportunities for Anthropological Research in Nanotechnology

One of the obvious entry points for anthropologists into the world and work of nanoscience is through *ethnographic research with nanoscientists and engineers*. In undertaking this research, anthropologists are fortunate to have a large body of earlier studies that explore such critical issues as laboratory practices, pedagogy, and initiation rites, to name just a few. The literature pertaining to the anthropological study of science and technology is too large to effectively cite here. A few examples of previous work, however, are especially salient: Traweek (1988) provides a classic example of how an anthropological study of the laboratory can produce insights that might otherwise be unobtainable via other methodologies. Mody (2001) presents a more recent study of how ethnography can shed insight into the tacit rules and behaviors of the laboratory environment. Elsewhere in this issue, Mody discusses other loci in which anthropology, perhaps combined with methodologies from history or other fields, can yield especially valuable results.

These works can provide assistance in the design of research programs to explore the nano-enterprise; they also offer the possibility of fruitful comparative studies. How is nano-research alike or different from research in biotechnology, stem cells, or other areas of science which arouse public hopes and fears? Ethnographically-based studies can also help scholars begin to address issues such as the degree to which nano-research is interdisciplinary, the training of students, and the interplay between researchers engaged in basic research with their more theoretical-oriented colleagues.

Unlike more esoteric arenas of scientific study such as particle physics, the societal implications of nanotechnologies may directly affect a far greater fraction of the earth's population. For this reason, ethnographic studies of the nano-enterprise that go beyond or, ideally, connect the laboratory with other social organizations may provide especially rich insights. Examining the interfaces of the laboratory with the worlds of venture capitalists, technology transfer offices, social activists, and policy makers will provide researchers with a broader understanding of groups and organizations involved in promoting or resisting the nano-revolution.

CNS-UCSB researchers, including the co-authors, will be engaged in ethnographic research in nanoscale research laboratories at UCSB, in private laboratories in the US, and in comparative laboratory settings in the UK and China. We are particularly interested in understanding how disciplinary differences among nanoscientists may be associated with different understandings and expectations about societal interface, how different lab cultures or ethos may produce different opportunities for innovation and creativity (among other effects), how nanoscientists view the regulatory processes in the US and abroad around safety, environment, and health issues, and whether they believe nanotechnologies will challenge existing structures, formats, and approaches in new ways. The social and ethical construction of "responsible science" is thus a core interest of our research.

Social and Cultural Construction of Risk and Risk Perception

Satterfield and Harthorn have led panels at the SFAA for the past several years on anthropology's potential contribution to the interdisciplinary field of risk studies and on the cultural construction of risk (see Harthorn and Oaks 2003). Our particular aims have been to explore social and cultural construction of risk in health and environment, to move beyond limited, dichotomous 'David and Goliath' analyses of expert/public judgments about risks to a multiple party approach, and to explore cultural and psychological processes in both social amplification and social attenuation of risk perception as research and policy issues.

Societal response to and engagement with emerging nanotechnologies offer an unprecedented opportunity to exercise these interests. We will be conducting interview research asking questions about nanoscientists' and nanotoxicologists' ethno-scientific understandings of personal and societal risk, focus group work on public and NGO's views in the US and comparing these with data from the UK, national survey research and spatial analysis of perception of risk, and comparative local ethnographic research with particular communities of risk perception. Issues we plan to explore include personal and group values and beliefs regarding particular kinds of technologies, technological change, social intelligence about issues of development and precaution, and the affective and cognitive responses to images, among others. Public awareness of nanotechnology in the US is still quite low, and so far, as with response to other technological change, the US public has responded more enthusiastically than UK or EU citizens about technological advancement in general, the degree to which people think they will personally benefit from nanotech development, and their level of trust in government to regulate and control safe production and use of such new products. Our research will aim to explore such responses in more detail and to understand how very different kinds of products and applications may be perceived differently among different subsets of the US public and over time. Anthropological theory and methods for studying meaning systems will be invaluable in this research, and comparative analysis will enable us to contextualize diverse US publics in a global context.

Public Participation, NGOs, and Social Movements

Nanotechnologies have already been the focus of some debate and public deliberation in the UK (e.g., see UK Royal Society study report at http://www.nanotec.org.uk/; Demos/Lancaster Univ. publications and links available at http://www.demos.co.uk; or the Nano Jury UK project at www.nanjury.org), but such efforts are mostly behind closed doors or still at the discussion

point in the US. We do know more from analysis of public acceptability of other technologies, and educated predictions will need to be based on past analyses and current empirical work. What will work for effective public deliberation processes in the US, for particular populations, locations, and different nanotechnologies is a research question anthropological efforts can help to address. We plan to conduct a selective, comparative meta-analysis of noteworthy deliberation efforts, pilot modest comparative sessions to investigate the ways that the US publics will respond

by anthropologists on global social movements in response to biotechnology, nuclear power, and others.

These are just a few of the possible dimensions for anthropological involvement with nanotechnologies and their numerous issues related to health, environment, social, and ethical/moral domains. In this new center, anthropologists are in a unique position to positively influence research engagement and critical analysis of social and scientific innovations and the rapid social transformation that may accompany their development.

Cambridge: Harvard University Press.

> " …anthropologists are in a unique position to positively influence research engagement and critical analysis of social and scientific innovations and the rapid social transformation that may accompany their development. "

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in comparison to their UK counterparts who have been more thoroughly researched. These efforts will enable us to develop more effective survey instruments and outreach and education materials.

We also plan analysis of emergent "citizen networks" and social movements in response to nanotechnology. The networks of interest will include some traditional advocacy groups, newer online groups dedicated to monitoring, discussion, and mobilization, and in some cases perhaps "personal media" users who employ blogs, podcasts, and other media to engage with others, shape public opinion, and organize collective action, both in support of or opposition to specific nanotechnologies. This work draws from contemporary US technology and society studies but adds a global comparative dimension, drawing on work

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'TEACHING' PRACTICING

By Alice Wright

As an undergraduate at a relatively small liberal arts university, I admit that before reading this collection of articles, I had no idea what nanotechnology was. Furthermore, once I had read the issue, I had even more questions about nanotechnology than when I started!

With this in mind, it seems to me that these articles provide a unique chance to teach anthropology. Questions are inherent to any discussion about nanotechnology, concerning topics as varied as the implications of nanotechnology itself, the practical approaches to studying it, the ethical considerations involved in this new science, and place of the anthropologists in this research. What is really interesting, though, from a student's point of view, is that all of these questions have yet to be fully answered. Nanotechnology is a new science, and the social scientific study of it an even more recent development. The resulting unknowns let students – not to mention many teachers, to whom I'm sure this topic is equally unfamiliar – actively participate in the nanotech debate. Our perspective and insights might *actually matter*, especially considering that so much of what nanotechnologists are now concerned with is its public perception. Who better to ask how to educate people about nanotechnology than actual students?

Additionally, the inter-disciplinary nature of nanotechnology studies seems tailor-made for today's university classroom, particularly at schools where taking courses in several different departments is encouraged or required. I, for instance, need to take classes in hard sciences, politics, philosophy, anthropology, and communications to graduate. Even such a cursory background in these subjects could greatly add to discussions about nanotechnology in anthropology classes, allowing students to respond to questions by considering several disciplinary perspectives.

Any attempt to teach and learn about nanotechnology thus exemplifies the notion of "practicing anthropology." Classroom debates and responses might offer contributions to this new field, which will surely involve many current students of anthropology both professionally and personally as it develops. I encourage you to use the following questions as a springboard for initiating classroom involvement to this ongoing discussion.

Questions

- What is meant by the statement "regulating nanotechnology is about managing its interface with people?"
- How will people's values and worldviews frame their understanding of the potential consequences (positive and negative) of nanotechnology?
- What innovative metaphors can you imagine might be used in dialogues among diverse stakeholders to generate greater


Alice Wright

interdisciplinary or multi-perspective understanding by reframing the issue at hand?
- What are the obstacles that impede the democratization of decision-making in the field of nanoscience and technology?
- Do you see any problems in the claim that there is currently no general public sphere for nanotechnology, only a variety of institutionally-affiliated semi-public spheres? Mody discusses business journals and alumni magazines – what other kinds of texts and organizations might be building semi-public spheres around nanotechnology? What methods might be best for understanding such semi-public spheres?
- We see how certain lessons from cultural anthropology have shaped the organization and style of an outreach program, the SCCSN. Now let us ask a critical question: how might the SCCSN be a better program if it was guided by different lessons or principles? How do Toumey's anthropological lessons limit the value of the SCCSN?

Alice Wright *is the Editorial Assistant at* Practicing Anthropology *and is currently working on her B.A. in Anthropology and English at Wake Forest University. She anticipates future graduate study in archaeology and European prehistory.* ∎
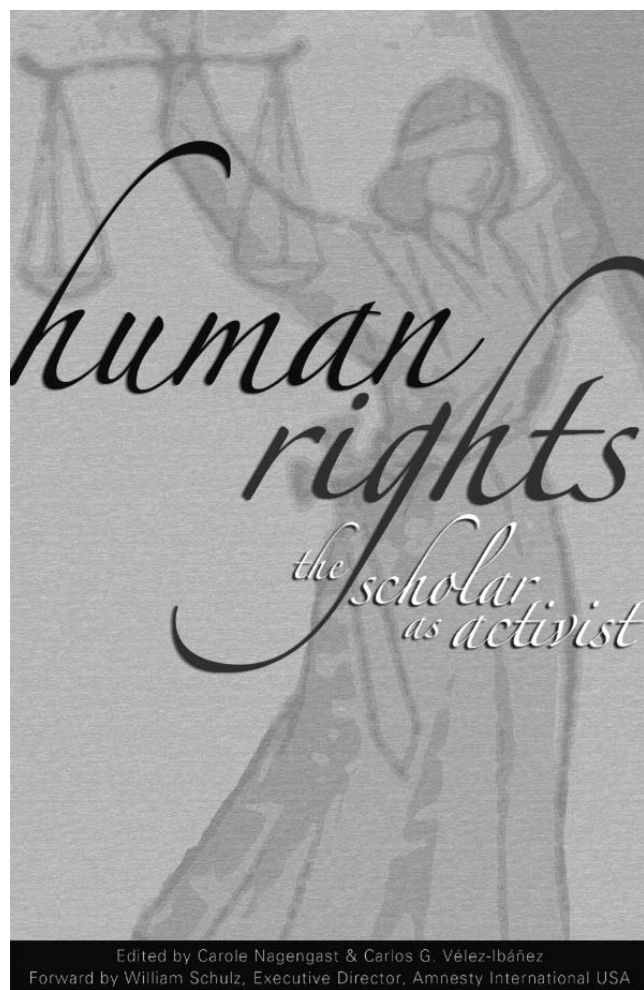
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The Dynamics of Applied Anthropology in the Twentieth Century:
The Malinowski Award Papers
Thomas Weaver, Editor and Contributor of Introductory Materials

The Malinowski Award has been presented annually since 1973 by the Society for Applied Anthropology in recognition of efforts to understand and serve the needs of the world's society through social science. Bronislaw Malinowski (1884-1942) was a leading figure during the 1920s and 1930s in the nascent but growing discipline of anthropology. While best known for his contribution to fieldwork methods and anthropological theory, he also promoted the practical use of anthropology. Anthropologists, he argued, must advocate for native populations, involve themselves in policy matters and politics, and research contemporary social issues. The careers of the twenty-eight persons who had received the award by 1999 illustrate major themes in the development of applied anthropology in the twentieth century, and their Malinowski Award addresses provide an interesting reflection on issues and events of this era. This collection presents all the Malinowski Award addresses that exist in written form, as well as a biographical essay on each recipient and on Bronislaw Malinowski.

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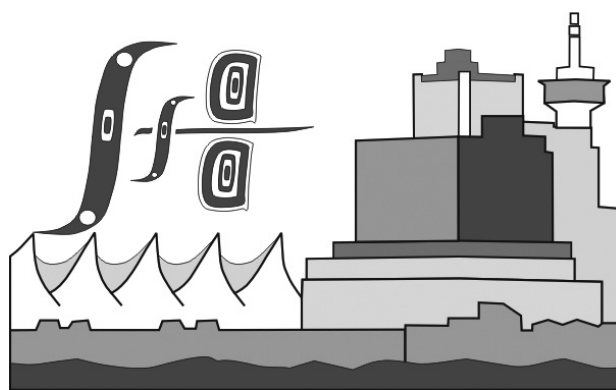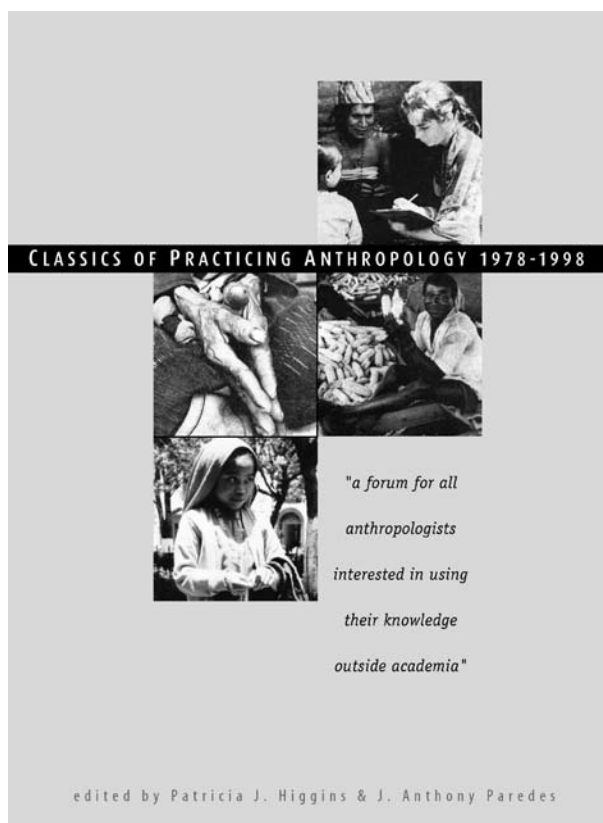
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