The Center for Nanotechnology in Society at Arizona State University

NSF #0531194

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Annual Report for the Period
October 1, 2007 to September 30, 2008

This report includes work conducted at nine collaborating universities of NSEC/CNS-ASU: Arizona State University, Georgia Institute of Technology, North Carolina State University, Rutgers, The State University of New Jersey, University of California-Berkeley, University of Colorado-Boulder; University of Georgia, University of New Hampshire, and the University of Wisconsin-Madison.

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Project Summary

The Center for Nanotechnology in Society at Arizona State University (CNS-ASU) is a Nano-scale Science and Engineering Center (NSEC), funded by the National Science Foundation (NSF) in October 2005 as one of two centers in a broader network to investigate the societal dimensions of emerging nanotechnologies. The Center's four-fold mission is to: 1) *research* the societal aspects of nanotechnologies; 2) *train* a community of scholars with new insight into the societal dimensions of nanoscale science & engineering (NSE); 3) *engage* a variety of publics and NSE researchers in dialogues about the goals and implications of NSE; and 4) *partner* with NSE laboratories to introduce greater *reflexiveness* in the R&D process.

CNS-ASU pursues this mission through two kinds of integrated research programs, as well as educational and outreach activities (that are themselves integrated with research). The first research programs comprising "real-time technology assessment" (RTTA) include: RTTA 1, Research and Innovation Systems Assessment; RTTA 2, Public Opinion and Values; RTTA 3, Deliberation and Participation; and RTTA 4, Reflexivity Assessment and Evaluation. The second research programs comprising the thematic research clusters (TRCs) include: TRC 1, Equity and Responsibility; and TRC 2: Human Identity, Enhancement, and Biology. Major achievements include: assembling and mining bibliographic and patent databases to understand the geographic and intellectual contours of NSE (RTTA 1); conducting a national public opinion poll and a poll of leading nano-scienists (RTTA 2); developing new scenario-based methods for stimulating deliberation about NSE and holding the first deliberative citizens' forum of national scope on any science topic in the US (RTTA 3); demonstrating that interactions between NSE researchers and social scientists and humanists can generate productive, reflexive decisions among the former (RTTA 4); generating nuanced findings about the relationship between religious belief and NSE (TRC 1); and exploring views and capacities regarding human nanotechnologies (TRC 2).

As part of its broader impacts, CNS-ASU intends these activities together to begin to allow the *anticipatory governance* of nanotechnologies, that is, the broad-based capacity extending through-out society that can act on a variety of inputs to manage emerging knowledge-based technologies while such management is still possible. Anticipatory governance can be characterized by an ensemble of three kinds of activities: *foresight* or anticipation of plausible futures; *engagement* with various publics; and *integration* of social science and humanities perspectives with scientific and engineering research. Achievements in these areas include: *foresight* through developing an interactive website for the exploration and articulation of NanoFutures; *engagement* ranging from intensive, large-scale deliberation (NCTF) to intensive, small-scale deliberation (Science Cafes) to extensive outreach (NISE Net collaborations); and *interaction* with NSE researchers resulting in identifiable changes in knowledge, identity, and practice.

Education and training activities include not only research training across undergraduate, graduate and post-doctoral levels, but also transdisciplinary curricular innovation, particularly at the undergraduate level, informal science education, and nano-in-society training for in-service high school teachers and NSE researchers.

List of Center Participants, Advisory Boards, and Participating Institutions

2. (a) LIST OF CENTER PARTICIPANTS

Participants receiving Center support:

ASU

Braden Allenby	**Professor**	**Civil and Environmental Engineering**
Philip Bernick	**Assistant Professor**	**English**
Prasad Boradkar	**Associate Professor**	**Industrial Design**
Marilyn P. Carlson	**Professor**	**Mathematics & Statistics**
Elizabeth Corley	**Associate Professor**	**Public Affairs**
Kevin Corley	**Assistant Professor**	**Management**
Tricia Farwell	Professor	Journalism & Mass Communication
Heidi Fischer	**Staff**	**Innovation Space**
David H. Guston	**Professor**	**Political Science**
Ed Hackett	Professor	Human Evolution & Social Change
Jiping He	Professor	Bioengineering
Renata Hejduk	**Assistant Professor**	**Architecture & Landscape Architecture**
Stephen Johnston	**Professor**	**Biodesign Institute**
Stuart Lindsay	**Professor**	**Biodesign Institute**
Gary Marchant	**Professor**	**Law**
Clark A. Miller	**Associate Professor**	**Political Science**
Torin Monahan	Assistant Professor	Justice & Social Inquiry
S. Thomas Picraux	Professor	Materials Research
George Poste	**Director**	**Biodesign Institute**
Paul Privateer	Associate Professor	Film & Media Studies
B. Ramakrishna	Associate Professor	Materials
Wellington Reiter	Dean	College of Design
Jason S. Robert	**Associate Professor**	**Life Sciences**
Daniel R. Sarewitz	**Professor**	**Life Sciences**
Anne Schneider	**Professor**	**Justice & Social Inquiry**
Jameson M. Wetmore	**Assistant Professor**	**Human Evolution & Social Change**
Neal Woodbury	**Professor**	**Chemistry & Biochemistry**
Frederick Zenhausern	**Professor**	**Biodesign Institute**

Collaborators

Barry Bozeman	**Georgia, Professor**	**Public Administration & Policy**
Jennifer Cleary	**Rutgers**	**Senior Project Manager**
Michael Cobb	**NCSU, Associate Professor**	**Political Science**
Susan Cozzens	**Georgia Tech, Professor**	**Public Policy**
Wendy C. Crone	Wisconsin, Professor	Engineering Physics
Terry Devitt	Wisconsin, Science Writer	Science & Technology
Sharon Dunwoody	**Wisconsin, Professor**	**Journalism & Mass Communication**
Aaron Fichtner	**Rutgers, Director**	**Research & Evaluation**
Joan Fujimura	**Wisconsin, Professor**	**Sociology**
Stu Graham	Georgia Tech, Professor	Management
Patrick Hamlett	**NCSU, Associate Professor**	**Science, Technology & Society**
Linda Hogle	**Wisconsin, Associate Professor**	**Medical History & Bioethics**
Maurizio Iacopetta	**Georgia Tech, Assistant Professor**	**Economics**
Helen Ingram	California-Irvine, Professor	Planning, Policy, and Design
Thomas Kelly	**New Hampshire, Officer**	**Office of Sustainability**
Eun-sung Kim	Wisconsin, Assistant Professor	Science & Technology
Daniel Kleinman	**Wisconsin, Professor**	**Rural Sociology**
Frank Laird	**Colorodo, Professor**	**International Studies**
Roop Mahajan	Virginia Tech, Director	Critical Technology & Applied Science

Carl Mitcham	**Colorado School of Mines**	**Liberal Arts & International Studies**
Sheila McNamee	**New Hampshire, Professor**	**Communication**
Mark Philbrick	**California-Berkeley, Asst. Prof.**	**Public Policy**
Roger Pielke, Jr.	Colorado	Environmental Studies
Alan Porter	**Georgia Tech, Professor**	**ISYE & Public Policy**
Scott Reynolds	**Rutgers, Director**	**Workforce Development**
Juan Rogers	**Georgia Tech, Assoc. Professor**	**Public Policy**
Dietram Scheufele	**Wisconsin, Professor**	**Life Sciences Communication**
Jennifer Schneider	**Colorado School of Mines, Prof.**	**Public Policy**
Philip Shapira	**Georgia Tech, Professor**	**Public Policy**
Carl Van Horn	**Rutgers, Professor**	**Planning & Public Policy**
Charyl Yarbrough	**Rutgers, Project Director**	**Workforce Development**
Jan Youtie	**Georgia Tech, Sr. Researcher**	**Enterprise Innovation Institute**
David Winickoff	**California, Berkeley, Professor**	**Political Science**

ASU
Post-Doctoral Scholars

Daniel Barben	**Assistant Research Professor**	**Consortium for Science, Policy, & Outcome**
Ira Bennett	**Research Associate**	**Chemistry**
David Conz	**Lecturer**	**Letters & Sciences**
Erik Fisher	**Assistant Research Professor**	**Consortium for Science, Policy, & Outcomes**
Cynthia Selin	**Assistant Research Professor**	**Consortium for Science, Policy, & Outcomes**
Cathy Slade	**Research Associate**	**Public Policy**

ASU
Graduate Researchers

Parul Agrawal	**Materials Science & Engineering**
Monamie Bhadra	**Science & Technology**
Shannon Conley	**Political Science**
Shannon DiNapoli	**Biology**
Aixa Garca-Mont	**Education**
Manuel Garay Valenzuela	**Education**
Sean Hays	**Political Science**
Nate Hisamura	Mathematics
Taylor Jackson	Biology & Society
Risto Karinen	Political Science
Jason Lappe	**Chemistry**
Shannon Lidberg	**Design**
Christina Nulle	**Global Technology Development**
Azra Panjwani	Mathematics
John Parsi	Political Science
Roxanne Wheelock	**Liberal Studies**
Quinn Spadola	**Physics**
Justin Tosi	Political Science
Walter Valdivia	**Public Administration**

Affiliated
Post-Doctoral Scholars

Eun Syung Kim	Wisconsin	Engineering
Jue Wang	**Georgia Tech**	**Public Policy**

Affiliated Graduate Researchers

Ashley Anderson	**Wisconsin**	**Biomedical Engineering**
Ravtosh Bal	**Georgia Tech, Georgia State**	**Public Policy**
Javiera Barandiaran	**California, Berkeley**	**Environmental Sciences**
Amy Barr	**New Hampshire**	**Sociology**

Noel Benedetti	Wisconsin	Public Policy
Ajay Bhaskarabhatla	Georgia Tech	Public Policy
Stephen Carley	**Georgia Tech**	**Public Policy**
Kajsa Dalrymple	Wisconsin	Public Policy
Jason Delbourne	**Wisconsin**	**Rural Sociology**
Anthony Dudo	**Wisconsin**	**Journalism & Mass Communication**
Andrea Fernandes-Ribas	Georgia Tech	Public Policy
Jason Gallo	Northwestern	Media, Technology & Society
Elliott Hillback	**Wisconsin**	**Journalism & Mass Communication**
Shirley Ho	Wisconsin	Public Policy
Jennifer Jensch	Wisconsin	Public Policy
Luciano Kay	**Georgia Tech**	**Public Policy**
Sujong Kim	Wisconsin	Engineering
Ashley Kirby	**Georgia Tech**	**Public Policy**
Erin Lamos	Georgia Tech	Public Policy
Brice Laurent	Ecole des Mines	Public Policy
Ricky Leung	Wisconsin	Sociology
Pratik Mehta	Georgia Tech	Industrial & Systems Engineering
Charles Luke McCloud	Georgia Tech	Public Policy
Yu Mong	Georgia Tech	Public Policy
Mary Moore	Wisconsin	Computer Science
Christina Ndoh	**NCSU**	**Public Administration**
Jayesh Patil	Georgia Tech	Computing
Sofia Randhawa	**Georgia Tech**	**Quantitative Finance & ISYE**
Lea Shanley	Wisconsin	Environment & Resources
Tsung-Jen Shih	Wisconsin	Journalism
Harmeet Singh	Georgia Tech	Quantitative Finance & ISYE
John Slanina	**Georgia Tech**	**Public Policy**
Li Tang	Georgia Tech	Public Policy
Juin-Yi Tsai	Wisconsin	Public Policy
Rutger van Merkerk	University of Twente	Innovation & Environmental Sciences
Charles Walsh	Georgia Tech	Public Policy
Rosalyna Wijaya	Wisconsin	Public Policy

ASU

Undergrad Interns & Researchers

Kalil Abdullah	Molecular Biotechnology
Derrick Anderson	**Public Policy**
Nidhi Bhalla	Political Science
Josh Choi	Biomedical Engineering & Economics
Rob Davis	Biology
Tara Egnatios	Public Policy
Rebecca Hudson	**Business**
Tobie Milford	**Biology & Society**
Sidra Omer	Journalism & Mass Communication
Zachary Pirtle	**Mechanical Engineering**
David Renolds	**Chemical Engineering**
Lucas Rogers	**Engineering**
Rachel Smith	Biology & Society
Julia Weakley	Global Studies
Brian Young	Biology & Society
Ke Wu	**Biology & Society**

Affiliated Undergrad Interns & Researchers

Brescia Cassellius	Wisconsin	Journalism
Sharyn Finney	Georgia Tech	Public Policy & Economics

Brian Lynch	Georgia Tech	Public Policy
John Garner	Georgia Tech	Public Policy
Clay Karwisch	Georgia Tech	History, Technology & Society
Dave Schoeneck	Georgia Tech	Physics

CNS-ASU Staff

Melissa Cornish	**Biodesign Institute Liaison**
Corrine Dillon	Program Manager
Michelle Iafrat	**Administrative Associate**
Regina Sanborn	**Program Manager**
Joy Trottier	Administrative Associate

Participants affiliated, not receiving CNS-ASU support:

ASU

Alfinio Flores	Curriculum & Instruction	Professor
Antonio Garcia	Hispanic Research Center	Associate Director
Stephen Goodnick	Research & Economic Affairs	Associate Vice President
Joel Greene	Public Policy	Professor
Stuart Hadley	Public Affairs & Foreign Relations	Vice President
Anatoli Korkin	Research and Economic Affairs	Director
Rachel Levinson	Biodesign Insitute	Government Relations Liaison
Jose Lobo	Global Institute of Sustainability	Associate Professor
Vincent Pizziconi	Bioengineering	Professor
RF Shangraw	Research & Economic Affairs	Vice President
Michael Sullivan	Hispanic Research Center	Director
Michael Tracy	Biodesign Institute	Director
Joann Williams	Chemistry & Biochemistry	Professor

Affiliated

Timothy Apenzeller	National Geographic	Editor
David Attis	Policy Studies	Senior Director
David Beck	NISEnet	Staff
Larry Bell	Museum of Science	Staff
Rosalyn Berne	University of Virginia	Professor
Gary Bild	Nanotechnology Industry Liaison	Member
Larry Bock	Board of Visitors	Member
Christopher Bosso	Northeastern University	Professor
Garrett Brown	National Geographic	Editor
Rick Canady	Food & Drug Administration	Staff
Amy Carroll	House Committee	Staff
Lorenzo Cena	University of Iowa	Graduate Student
Jan Cerveny	Department of Energy	Staff
Joshua Chamot	Legislative & Public Affairs	Staff
William Clark	Harvard University	Professor
James Collins	National Science Foundation	Head of Biological Sciences
William Cyrs	University of Iowa	Graduate Student
Michael Dennis	Society & Technology	Staff
Heather Douglas	University of Tennessee, Knoxville	Professor
Kate Duckworth	NISEnet	Staff
Ellen Feigal	TGen	Staff
Elizabeth Farrell	University of New Hampshire	Staff
Guillermo Foladori	Universidad de Zacatecas	Professor
Monica Gaughan	University of Georgia	Professor
Stephen Godwin	National Research Council	Director
David Goldston	Harvard University	Professor
Douglas Goodman	Nanotechnology Industry Liaison	Member
Michael Gorman	University of Virginia	Professor
Herb Goronkin	Nanotechnology Industry Liaison	Member
Richard Gullickson	Lawrence Livermore Lab	Staff
Diana Hicks	Georgia Institute of Technology	Public Policy
Stephen Hilgartner	Cornell University	Science & Technology Studies
Michael Holland	House Science Committee	Staff
Maja Horst	Copenhagen Business School	Associate Professor
John Hughes	Nanotechnology Industry Liaison	Member
Kent Hughes	Teach America	Director
Mary Ingram-Waters	UCSB	Graduate Student
Anil Jain	Michigan State University	Computer Science & Engineering

Sheila Jasanoff	Harvard University	Science & Technologies Studies
Donna Kent	Televerde	Global Studies
Matt Kim	Nanotechnology Industry Liaison	Member
Fred Kronz	University of Texas	Philosophy
Ray Kurzweil	Board of Visitors	Member
Dirk Libaers	Georgia Institute of Technology	Public Policy
Troy Livingston	NISEnet	Staff
Uttam Malani	Georgia Institute of Technology	Public Policy
Benjamin M. Mann	Defense Science Office	Program Manager
Robin Marks	NISEnet	Staff
John McGarity	Nanotechnology Industry Liaison	Member
Celia Merzbacher	Office of Naval Research	Staff
Daniel Metlay	Nuclear Waste Review Board	Staff
Evan Michelson	Rockefeller Foundation	Research Associate
Michael Moffitt	University of Michigan	Associate Professor
Jeff Morris	Environmental Protection Agency	Staff
Daniel Morrison	Vanderbilt University	Professor
Sean Murdock	Nanotechnology Industry Liaison	Member
Richard Nelson	Board of Visitors	Member
Niles Newman	Intelligent Info. Services Group	STIP Associate
Susan Norton	National Geographic	Editor
James Paul	House Committee	Staff
Paul Rabinow	University of California, Berkeley	Professor
Arie Rip	University of Twente	Professor
David Rejeski	Woodrow Wilson Center	Director
Priscilla Regan	Social, Behavioral & Economics	Professor
Mihael Roco	National Science Foundation	Senior Advisor
Marc Rothenberg	Legislative & Public Affairs	Staff
Tind Shepper Ryen	House Committee on Science	Staff
Laura Schiavo	National Building Museum	Curator
Daan Schuurbiers	Delft University	Researcher
Mark Shapiro	Board of Visitors	Member
Gregory Simonson	Science, Technology & Military	Professor
Mitchell Small	Carnegie Mellon University	Professor
Alexa Stephens	Georgia Tech	Public Policy
Albert Teich	AAAS	Director
Joanne Tornow	National Science Foundation	Program Manager
Michiel Van Oudheusden	University of Antwerp	Researcher
Anna Waldron	Cornell	Professor
Fred Weber	Nanotechnology Industry Liaison	Member
James Wilsdon	Lancaster University	Science & Technology
Carly Wobig	University of Illinois	Graduate Student
Gregor Wolbring	University of Calgary	Asst. Prof. Medicine & Community Health

Nanotechnology in Society Network PIs:

Davis Baird	University of South Carolina
Richard Freedman	Harvard University
Barbara Harthorn	UCSB
Lynne Zucker	UCLA

Expert and Oversight Panel for National Citizens' Technology Forum

Roberta M. Berry	Georgia Tech	Professor
Stephen Helms Tillery	ASU	Professor
Maxwell J. Mehlman	Case Western Reserve	Professor
Kristen Kulinowski	Rice	Executive Director
Jason S. Robert	ASU	Assistant Professor

Ida Andersen	Danish Board of Technology	Staff
David Rejeski	Woodrow Wilson Center	Director

2. (b) LIST OF ADVISORY BOARDS

i. Board of Visitors

Larry Bock, Chairman, Luxe Ventures
Diana Hicks, Professor, Department of Public Policy, Georgia Institute of Technology
Stephen Hilgartner, Professor, Department of Science and Technology Studies, Cornell University
Sheila Jasanoff, Professor, Science and Technologies Studies, Harvard University
Ray Kurzweil, Author
Rachel Levinson, Industrial and Government Relations Liaison, ASU Biodesign Institute
Richard Nelson, Professor, Department of Economics, Columbia University
David Rejeski, Director, Woodrow Wilson Center
RF (Rick) Shangraw, Vice President, ASU Research and Economic Affairs
Mark Shapiro, Center for Investigative Journalism
Mitchell Small, Professor, Department of Public Policy, Carnegie Mellon University
Albert Teich, Director, Science and Policy Programs, American Association for the Advancement of Science
James Wilsdon, Professor, Department of Science and Technology, Lancaster University

ii. Executive Committee

Braden Allenby, Professor, ASU Department of Civil and Environmental Engineering
Marilyn Carlson, Professor, ASU Department of Mathematics & Statistics
Elizabeth Corley, Associate Professor, ASU Department of Public Affairs
David H. Guston, Professor, ASU Department of Political Science
Clark Miller, Associate Professor, ASU Department of Political Science
George Poste, Director, ASU Biodesign Institute
Daniel Sarewitz, Director, Consortium for Science, Policy, and Outcomes

iii. Nanotechnology Industry Liaison Committee

Gary Bild
Larry Bock, Chairman, Luxe Ventures
Ellen Feigal, Director of Medical Devices and Imaging, TGen
Douglas Goodman
Herb Goronkin
John Hughes
Anil Jain, Professor, Department of Computer Science & Engineering, Michigan State University
Donna Kent, Senior Vice President of Global Studies, Televerde
Anatoli Korkin, Director, ASU Office of Research and Economic Affairs
John McGarity
Michael Moffitt, Professor, Department of Computer Science and Engineering, University of Michigan
Sean Murdock, Nanotechnology Industry Association
Fred Weber

iv. Expert and Oversight Panel for National Citizens' Technology Forum

Roberta M. Berry, Associate Professor of Public Policy; Director, Law, Science & Technology Program, Georgia Institute of Technology
Stephen Helms Tillery, Assistant Professor, Harrington Department of Bioengineering; Assistant Professor of Kinesiology, Arizona State University
Maxwell J. Mehlman, Arthur E. Petersilge Professor of Law; Professor of Bioethics, School of Medicine; Director of the Law-Medicine Center, Case Western Reserve University
Kristen Kulinowski, Executive Director, Center for Biological and Environmental Nanotechnology, Rice University
Jason S. Robert, Assistant Professor, Department of Basic Medical Sciences, The University of Arizona College of Medicine; Assistant Professor, School of Life Sciences, Arizona State University

Ida Andersen, Danish Board of Technology
David Rejeski, Director, Project on Emerging Nanotechnologies, Woodrow Wilson International Center for Scholars

2. (c) LIST OF PARTICIPATING INSTITUTIONS

i. ASU Academic Participating Institutions

Biodesign Institute
Center for Research on Education in Science, Mathematics, Engineering, and Technology
Center for the Study of Religion and Conflict
College of Design
College of Liberal Arts and Sciences
Consortium for Science, Policy and Outcomes
Decision Theater for a Desert City
Global Institute of Sustainability
Hispanic Research Center
Responsible Conduct of Research Program, School of Life Sciences
Sandra Day O'Connor School of Law
School of Human Evolution and Social Change
Science Policy Assessment and Research on Climate (SPARC)

ii. Academic Participating Institutions Other than at ASU

Carnegie Mellon University
Colorado School of Mines
Columbia University
Copenhagen Business School, Denmark
Cornell University
Delft University, the Netherlands
Ecole des Mines, France
Georgia Institute of Technology
Illinois Institute of Technology
James Martin Institute for Science and Civilization, Oxford University, UK
Lancaster University, UK
Mesa Biotech Academy
Mesa High School
Michigan State University
North Carolina State University
Northeastern University
Northwestern University
NSEC/CNS-University of California, Santa Barbara (UCSB)
Rutgers, The State University of New Jersey
The Center for International Development, Harvard University
UCLA/Harvard/NBER: Collaborative Research; Personnel Exchanges
Universidad de Zacatecas, Mexico
University of Antwerp, Belgium
University of Arizona
University of Calgary, Canada
University of California, Berkeley
University of California, Irvine
University of Colorado, Boulder
University of Georgia
University of Illinois, Chicago
University of Iowa
University of Michigan
University of New Hampshire
University of South Carolina
University of Tennessee, Knoxville
University of Twente, the Netherlands

University of Texas
University of Virginia
University of Wisconsin, Madison
Vanderbilt University
Virginia Tech University

iii. Non-Academic Participating Institutions

American Association for the Advancement of Science
Arizona Nanotechnology Cluster
Arizona Bioindustry Organization
Arizona Science Center
Arizona Technology Council
Bioindustry Organization of Southern Arizona
Center for Responsible Nanotechnology
Department of Energy
Ecological Society of America
Exploratorium, San Francisco
Environmental Protection Agency
Food and Drug Administration
Gordon Research Conference
International Nanotechnology in Society Network (INSN)
Jennings, Strouss, and Salmon PLC
Lawrence Livermore Lab
Luxe Ventures
Museum of Science, Boston
Nanoscale Informal Science Education Network (NISEnet)
National Geographic Society
National Nanotechnology Coordinating Office
National Nanotechnology Infrastructure Network
National Research Council
Nuclear Waste Review Board
Sandia National Laboratory
Spirit of the Senses Salon
Targeted Genetics Corporation (TGen)
Teach America
Tempe Festival of the Arts
Televerde
The Foresight Institute
U.S. DOE/Center for Integrated Nanotechnology (CINT)
Woodrow Wilson International Center

Table 1: Quantifiable Outputs					
	Reporting Year-1	Reporting Year-2	Reporting Year-3	Reporting Year-4	Total
Outputs	2005-2006	2006-2007	2007-2008		
Publications resulted from NSEC Support	24	22	29		75
in Peer Reviewed Journal	8	5	4		17
in Peer Reviewed Conference Proceedings					
in Peer Reviewed Book Chapters	1	5	7		13
Technical Reports	4				4
Working Papers	1	3	3		7
Books			2		2
Theses	3	7	11		21
in Trade Journals		1	2		3
Other Journal Publications	7	1			8
with Multiple Authors	10	11	10		31
co-authored with NSEC faculty	10	11	11		32
NSEC Technology Transfer					
Inventions Disclosed		3	3		6
Patents Filed					
Patents Awarded					
Software Licensed					
Spin-off Companies Started					
Degrees to NSEC Students	6	13	5		24
Bachelors Degrees Granted	3	8	1		12
Masters Degrees Granted	2	4	1		7
Doctoral Degrees Granted	1	1	3		5
NSEC Graduates Hired by					
Industry		1			1
NSEC participating Firms					
Other US Firms		1			1
Government		1			1
Academic Institutions	2	5	3		10
Other		1			1
Unknown	4	4			8
NSEC Influence on Curriculum					
New Courses Based on NSEC Research	3	5	2		10
Courses Modified to Include NSEC Research	2	3	2		7
New Textbooks Based on NSEC Research			1		1
Free-standing Course Modules or Instructional CDs					
New Full Degree Programs			1		1
New Certificate					
Information Dissemation/Educational Outreach					
Workshops, Short Courses to Industry					
Workshops, Short Courses to Others	2	3	2		7
Seminars, Colloquia, etc.	73	88	38		199
World Wide Web courses					
Academic Presentations	49	60	21		130
Industry Presentations	9	10	1		20
Science Cafes	6	8	4		18
Visiting Speakers	8	9	12		29
Community Speaking Engagements	1	1			2
Newsletters	5	4	3		12

Mission and Broader Impacts

The Center's four-fold mission is to: 1) *research* the societal aspects of nanotechnologies; 2) *train* a community of scholars with new insight into the societal dimensions of nanoscale science & engineering (NSE); 3) *engage* various publics and NSE researchers in dialogues about the goals and implications of NSE; and 4) *partner* with NSE laboratories to introduce greater *reflexiveness* in the R&D process. In addition, CNS-ASU intends these activities together to begin to generate a broad-based societal capacity for the *anticipatory governance* of emerging technologies.

The following section briefly summarizes the most significant advances of the Center over the last year in terms of fundamental knowledge, technology (here conceived as applied and/or reflexive knowledge, processes, and capacities, often but not exclusively for internal use).

Fundamental knowledge. Each research program, and most individual research projects, contributed significant advances in fundamental knowledge of the societal aspects of nanotechnology in the last year.

- RTTA 1 RISA: Analyzing extensive global databases of Science Citation Index records, other publication databases, and MicroPatents (covering 1990-mid-2006), CNS-ASU researchers have found:
    - That NSE exhibits a multi-polar structure, combining nodes of disciplinary convergence as well as disciplinary distance in terms of the sharing of knowledge sources, according to research on the cognitive geography of nanotechnologies and locations and knowledge flows of nano-research in the map of science;
    - In an ongoing study of the emergence of regional clusters of NSE activity in the US, that metropolitan areas in the US currently strong in nano publishing and patenting are largely similar to those metropolitan areas strong in previous emerging technologies, lending support to the argument for path dependency in the development of nano-districts. However, some newly emerging nano-districts centered on large government and corporate laboratories and new human capital concentrations are evident.
    - In a study of NSE in China (that included field work in addition to bibliometric and patent analysis), that the quality of Chinese NSE publications is lagging but increasing, the quantity of its patents is lagging significantly (despite a number of commercial firms, mostly SMEs, and a number of nano-products already in consumer markets), commercialization is focused in lower-end applications of nano-materials, and pathways to applications are driven by university research with weak corporate investment.
- RTTA 2 POV: Based on a national public opinion survey (dual frame RDD and listed households CATI survey, N=1015) and a survey of leading U.S. nano-scientists (mail survey, N=363), both conducted May-July 2007, CNS-ASU researchers found that:
    - Public knowledge of nanotechnology has not improved since 2004 baselines;
    - While nano-scientists were generally more optimistic about benefits and less worried about risks than the public, the former interestingly perceive higher

risks of nanotechnologies than the latter in areas of environment and human health (Scheufele et al. 2007);
    - In comparisons with Euro-Barometer findings, the fraction of U.S. respondents who find nanotechnology "morally acceptable" is significantly lower than that fraction of respondents in key European countries (Scheufele 2008).
    - Religiosity moderates the impact of knowledge on attitudes on nanotechnology in the U.S. (Brossard et al. forthcoming).
- RTTA 3 DP: Through deliberative and participatory methods, CNS-ASU researchers have:
    - Designed original mechanisms to vet scenes through bibliometric studies, focus groups, and wiki technologies (Selin 2008).
    - Identified, through Scenario Development activities, "plausibility" as a critical and under-conceptualized issue in foresight and anticipation research.
    - Completed the National Citizens' Technology Forum (NCTF), issued citizen-written reports and conducted pre-and post opinion surveys which are currently being analyzed. The data generated, not yet fully explored, represent the first data from a nation-wide deliberative exercise on nanotechnologies and human enhancement. Early indications are that publics informed in this way are, on one hand, guardedly optimistic about the potential benefits of using nanotechnologies for human therapies and, on the other, increasingly concerned about the moral dimension to using new technologies for human enhancements (Cobb and Hamlett 2008). Current data strongly suggests that consensus formation within the structured NCTF format has successfully avoided the reputational cascades and social effects that sometimes afflict small group deliberations.
- RTTA 4 RAE: Through a set of integrative research and educational activities with NSE researchers, CNS-ASU researchers have found:
    - That such integrative activities can have at least modest effect on NSE researchers' knowledge, identity and practice regarding the societal aspects of their work.
    - That mid-stream modulation of research agendas and research conduct – based on interactions with social scientists – occurs at the level of small groups as well as individual researchers, and at the level of laboratory directors as well as the level of graduate students and trainees.
    - Such interaction has not hampered the NSE research projects and has, in early indications, been found to enhance them.
- TRC 1: Through a workshop on religion and nanotechnologies, CNS-ASU researchers demonstrated that a dialogue between religious thinkers and scientists could productively explore social and ethical issues of nanotechnology; specifically, the workshop identified the role of suffering and its alleviation as a key topic at the interface of nano and religion that has not been addressed significantly in scholarship to date.
- TRC 2: Through the "end-to-end" process in which issues in Human Identity, Enhancement, and Biology are systematically connected with RTTA activities, CNS-ASU researchers have found:

- From RTTA 1 RISA:
  - A substantial and growing research enterprise in the application of NSE to neuroscience and brain research exists and can be mapped onto application areas including cochlear research, biocompatibility, neural networks and artificial intelligence, and neural prosthetics.
  - Publishing in areas of human nanotechnologies does not necessarily map onto claims about interesting potential applications by scientists and others (e.g., a great deal of work on visualizing nano-scale biological structures related to the brain at nanoscales, but not a lot of work on brain implants or neural prosthetics, which has been a principal area of claims of exciting possibilities for research).
- From RTTA 3 NCTF data:
  - Public support for brain implants varies dramatically by proposed functionality and context of application and decreases across functionalities and applications with deliberation.
  - Generally, the highest levels of support are found for functionalities that have the potential to improve health outcomes while the lowest have the potential to negatively impact state-citizen relations.
  - There is a gender split with regard to support for brain implant technologies, with men generally more in favor than women.
- Historical antecedents like cochlear implants and appearances of brain implant technologies in popular entertainment media provide reason to believe that the social and legal aspects of some human nanotechnologies, and especially those relating to cognitive and neural functioning, are likely to be substantial and contested.

<u>Technology (in this case, applied and/or reflexive knowledge, processes, methods and capacities; often these are developed in one part of CNS-ASU and used in another, thus forming the intellectual core of "ensemble-ization")</u>.

- RTTA 1 RISA:
  - Several targeted bibliometric studies supported ongoing CNS-ASU work, especially including RTTA 3/1 Scenario Development activities and TRC 2: HIEB and its "end-to-end" activity.
  - RTTA 1 findings on the size and coherence of US nano-districts led RTTA 1/3 Workforce Development to reassess priorities for research sites and helped it locate additional firms for inclusion in its study of Arizona.
  - RTTA 1 findings of highly cited nano-scientists generated the sample frame for the survey of nano-scientists conducted in RTTA 2/3.
- RTTA 2 POV:
  - Early RTTA 2 public opinion and nano-scientists' survey data was shared in F 07 with RTTA 3/2 InnovationSpace students to help them understand the expectations of researchers and the public vis-à-vis nanotechnologies for human disability therapies and enhancements.
  - The public opinion survey instrument was broadly shared in CNS-ASU to help create the pre- and post-test surveys for RTTA 3/4 National Citizens' Technology Forum.

  - The public opinion survey instrument was also shared with colleagues at CNS-UCSB and with Susanna Priest, now at University of Nevada, Las Vegas to assist their work respective work in creating comparable and not redundant survey instruments.
- RTTA 3 DP:
  - RTTA 3/1 Scenario Development has created a website (http://cns.asu.edu/nanofutures) that is beginning to generate information about how different publics interact with scenes of and create scenarios for "NanoFutures." The scenes created and vetted by CNS-ASU researchers for this website have also been used by:
    - RTTA 3/2 InnovationSpace to help students envision possible nano-products to design (Boradkar and Selin in preparation);
    - RTTA 3/4 NCTF to help deliberating lay-citizens envision potential uses of nanotechnologies in human therapies and enhancements; and
    - ASU law students in "Nanotechnology, Law and Policy" to help imagine potential liability and regulatory issues.
  - RTTA 3/1 SD has also conducted a workshop involving an interdisciplinary team of experts to explore future dimensions of medical diagnostics (Bennett 2008; Selin 2008b).
  - RTTA 3/2 InnovationSpace has created new prospective nano-enabled product designs for three areas of human therapy and is submitting invention disclosures to ASU's technology transfer office based on them.
  - RTTA 3/3 has developed a proto-type toolkit for designers to address societal implications of their work, based on experiences in RTTA 3/2 InnovationSpace (Lidberg 2008).
- RTTA 4 RAE:
  - Public Value Mapping, as a research evaluation method, can have prospective as well as retrospective applications.
  - That anticipation (scenario development) and integration (mid-stream modulation) can be joined for mutually productive activities.
- TRC 1 E&R:
  - Focused and selected public engagement creates information about societal aspects of nanotechnologies that does not arise in other participatory and deliberative forums.
- TRC 2 HIEB/E2E:
  - Creation of databases of publications and grants in the field of applying NSE to neuroscience and brain research.
  - Demonstrated effectiveness of "end-to-end" concept for integrating CNS-ASU research plans and findings.

<u>Education and Training:</u>

- At the undergraduate level, CNS-ASU has consolidated its transdisciplinary undergraduate instructional agenda in the Learning Community and InnovationSpace. It also pioneered a creative new course on "Human Enhancement and Democracy" and supported undergraduate theses, including one on nanotechnologies for the

visually impaired (Silverman 2007), one on a dialogue on religion and nanotechnologies (Milford 2008), and several from Innovation Space.

- At the graduate level, CNS-ASU has partnered with ASU's Professional Master of Science degree in nano-science to include a required nano-in-society course in that graduate program. Also at the graduate level, CNS-ASU graduated five graduate students whose thesis work was supported in whole or part, including its first PhD+ student.
- In informal science education, CNS-ASU drafted and, in partnership with NISE Net, disseminated a discussion of "big ideas" in nano-and-society for museum professionals and other educators (Miller et al. 2007).
- In training for scientists and engineers, CNS-ASU developed, in collaboration with D. Kysar (Yale) and A. Viseu (York U., Toronto), both formerly of Cornell, a user-oriented module on societal aspects of NSE that has been distributed throughout the user facilities of the National Nanotechnology Infrastructure Network (NNIN).

Industrial collaborations. The most significant private-sector relations that CNS-ASU has established in the past year are:

- the completion of the workforce assessment study for the Arizona region, with Jan 08 workshop and supplementary interviews with Agilent Technologies;
- a partnership with Arizona NanoCluster to help plan a portion of their 2009 annual meeting on societal aspects and to encourage a societal aspects component to their student essay contest;
- the inclusion of a number of private sector participants in the Future of Medical Diagnostics, Photon Project, and Religion and Nanotechnologies workshops; and
- the recruitment of Agilent Technologies as a sponsor for CNS-ASU's Science Café series, in collaboration with the Arizona Science Center.

The following section briefly describes the current and potential impacts of CNS-ASU on teaching, training, and learning; outreach to pre-college institutions; broadening the participation of underrepresented groups; enhancement of infrastructure of research and education; dissemination to scientific and technological communities; and benefits to society.

Teaching, training and learning. At any given time, CNS-ASU, including its constituent universities, is training in various capacities approximately one-half dozen junior research faculty and post-doctoral fellows, two dozen graduate students and one dozen undergraduate students in nanotechnology in society. At the constituent universities, most of this training consists of working on the CNS-related research projects under the subcontracts to those universities. At Wisconsin, however, the community of trainees is much larger than that of funded student researchers because the data developed by RTTA 2/1 Public Opinion Poll are too extensive to be analyzed entirely within the project. While CNS-ASU's constituent universities have not yet engaged in unique course development around nanotechnology in society, the CNS-related research they are producing is being incorporated into a number of classroom modules and activities. At ASU, CNS has engaged in extensive training and curriculum development and innovation. In the last year, CNS-ASU has consolidated and expanded its transdisciplinary undergraduate curriculum, expanded its graduate training to include a required class in a professional nano-science master's program, and collaborated

with NISE Net to include nano-in-society ideas in informal science education. ASU is also cultivating a cohort of interdisciplinary junior research scholars (Barben [political science/sociology], Bennett [chemistry], Conz [sociology], Fisher [environmental policy], Selin [knowledge & management], and Wetmore [STS]) who are collaborating in various combinations around the concept of anticipatory governance of nanotechnologies.

Outreach to pre-college institutions. In YR 2, CSN-ASU (Bennett and Pizziconi) developed and taught what we believe to be the nation's only graduate level course for in-service high school teachers in nanotechnology and society. The course was underwritten by the Center for Research in Science, Mathematics, Engineering and Technology (CRESMET), which paid for the credits these in-service high school teachers were taking toward their graduate degrees. In YR 3, we offered the course again, but it was undersubscribed because CRESMET could not continue to pay for student credit-hours and CNS could not take up that burden financially. The course evaluations were extraordinarily good, and the in-service teachers who took the course continue to reach out to Bennett for information, advice, and requests to speak with students and collaborate, etc. (e.g., at Mesa High School and Mesa High's Biotechnology Academy). CNS is therefore actively seeking ways to fund credit-hours on campus, as well as ways to market the syllabus to other training programs. CNS-ASU has also arranged for continuing education credit for in-service teachers for attending its Science Cafes, and to date sixteen teachers have taken advantage of this opportunity.

Broadening participation of under-represented groups. CNS-ASU, including its constituent universities, has had a strong record of including women in key research and leadership positions and recruiting members of under-represented groups into graduate and undergraduate research positions. We have also focused activity (e.g., YR 3 InnovationSpace; Silverman [2007] undergraduate thesis; visit by cochlear implantee M. Chorost) on disability communities as an under-represented population and plan on continuing to do so through the activities of TRC 1 Equity and Responsibility and TRC 2 Human Identity, Enhancement, and Biology. In addition, in YR 3 (Apr 08) and YR 2 (Apr 07), CNS-ASU has, in collaboration with the Hispanic Research Center (HRC) at ASU, organized a small conference nanotechnologies from the perspective of students from under-represented populations. The YR 2 meeting attracted a large number of applicants and six highly qualified ones, around whom we designed the program. The YR 3 meeting, while also attracting a large number of applicants, attracted only one highly qualified one. We have thus decided that our YR 4 activity should be a training activity, akin to the DC Summer Session and other training activities that CNS-ASU has made successful, but targeted for under-represented students. We anticipate holding a winter training session, perhaps adjacent to our YR 4 All-Hands Meeting in January in Tempe, for some one- to two-dozen students from under-represented groups and recruited through HRC's networks as well as our own.

Enhancement of infrastructure for research and education. CNS-ASU maintains a web site (http://cns.asu.edu/) that provides information about its research, education and outreach programs to a general audience. In particular, CNS-ASU has most of its monthly seminars and occasional speakers' presentations available on the web site in audio, video, and PPT versions. The website has several new functional areas, including:

- The NanoFutures site (http://cns.asu.edu/nanofutures), which invites various lay-public and expert groups to help construct and comment on nanotechnological scenarios that CNS-ASU has seeded. This site will continue to expand as users visit and develop new content themselves; and
- An educational clearinghouse (http://cns.asu.edu/educate), which offers the syllabi of all nano-related courses and some co-curricular activities that CNS has developed, as well as some documents from other sources. This site will continue to expand as CNS-ASU develops additional curricular and co-curricular material and gathers material from elsewhere.

CNS is also nearing completion of the "nano-governance wiki," an interactive website through which various public and private groups can describe and publicize their nano-related governance activities, including funding NSE research, funding societal aspects of NSE research, regulation of nano, public participation in nano, and other steering and governance enterprises. CNS has created a backbone and modest descriptions of activities in the US, UK, EU, and Japan, and it is currently attempting to spin the project off to the related International Nanotechnology and Society Network (INSN; www.nanoandsociety.org), founded at ASU in January 2005 and currently including more than one hundred members from more than a dozen nations. Another major resource project underway is "Documenting Environmentally and Socially Integrated Nanotechnologies" (DESIN) project, for which a grant proposal is currently under consideration at the National Collegiate Inventors and Innovators Association to document in creative, web-accessible form the innovation processes in the InnovationSpace course. CNS has also developed for the National Nanotechnology Infrastructure Network a brief PPT presentation on the societal aspects of nanotechnologies that has been distributed throughout the NNIN for use in user training at individual sites.

Dissemination to scientific and technological communities. CNS-ASU has already succeeded in publishing a significant portion of its findings and has much more of its research in the pipeline. We have 60 NSEC-related publications, including 2 books, 14 peer-reviewed journal articles, 11 book chapters, and 13 theses (these numbers do not include manuscripts forthcoming, under review or in preparation). CNS-ASU researchers have also given approximately 130 academic presentations, 21 already in the current year. One publication highlight is the imminent publication of the first volume of the *Yearbook of Nanotechnology in Society* by Springer (Wetmore, Selin, and Fisher, volume editors; Guston, series editor), the world's largest publisher in science, technology, and medicine, with an additional four under contract and three of those already in the planning stages. Guston is also under contract with Sage to edit the first *Encyclopedia of Nanoscience and Society*. Other highlights include:

- a chapter on anticipatory governance of nanotechnology in the new edition of the *Handbook of Science and Technology Studies* (Barben et al. 2008) and two other chapters by CNS-ASU authors in the *Handbook*, commissioned by the Society for Social Studies of Science and published by Sage; and
- publications in *Nature Nanotechnology* (Scheufele et al. 2007) and the *Journal of Nanoparticle Research* (Porter et al. 2007; Youtie et al. 2008).

CNS-ASU also sponsored ten non-affiliated individuals to attend its "All-Hands Meeting," including some from CNS-UCSB and NISE Net.

Benefits to society. In its July 2007 memorandum, NSF describes a set of questions (sub-criteria) related to its broader impacts criterion. Here we articulate the contributions of CNS-ASU for each of these sub-criteria:

- *"How well does the activity advance discovery and understanding while promoting teaching, training, and learning?"* The integration of research, education, and outreach is a particular focus and strength of CNS-ASU, and many of its programs are designed toward this goal from the outset.
    - CNS-ASU has teaching, training, and learning projects at all levels from the pre-college education to post-doctoral training, as well as informal science education projects and training for scientists and engineers.
    - Most of these teaching, training, and learning projects integrate research, education, and outreach, e.g.:
        - students in the Sp 08 Learning Community participated in the NISE Net-sponsored NanoDays by staffing a booth of nano-demonstrations at a local arts festival;
        - undergraduate research in the form of honors theses like Milford (2008) are well-integrated with research programs;
        - undergraduate course development has sprung from research interests ("Human Enhancement and Democracy" Sp 08 by doctoral candidate Hays);
        - graduate course development, particularly "Nano, the Brain, and the Future" (Sp 08; F 08) is driven by research interests;
        - CNS-ASU research activities become case studies for concurrent educational activities, e.g., the Learning Community course at ASU and Wisconson's STS 201 "Where Science Meets Society" both used the National Citizens' Technology Forum as part of a classroom focus on participation and democracy in science.
    - CNS-ASU research and perspectives on nano-in-society (Miller et al. 2007) have been distributed to informal science educators through NISE Net;
    - CNS-ASU partnerships with NSE researchers have enriched its Science Cafes, which local teachers may use for credit;
    - Director Guston has given video lectures for a science policy course at the University of Michigan and for the National Center for Learning and Teaching on CNS-ASU and anticipatory governance;
    - CNS-ASU is currently partnering with ASU's new master of science in nano-science program and with the Biodesign Institute in its development of a doctoral program in Biological Design to incorporate societal aspects of nanotechnologies and emerging technologies into graduate training of scientists and engineers;
    - CNS-ASU trains a small number of CNS-Biodesign Fellows to conduct societal implications research or perform outreach projects around their NSE research;
    - Students have presented CNS-related work in a variety of venues, including at the National Academy of Sciences (Wang) and the upcoming 2008 Gordon Research Conference on Science and Technology Policy on "Governing Emerging Technologies (Garay, Hays, Pirtle, and Valdivia);

- CNS-ASU has tentatively agreed to assist the Arizona NanoCluster in adding a societal component to its student essay competitions;
- Post-doctoral trainee Bennett (chemistry) has been involved in teaching the undergraduate Learning Community, and he and research faculty Selin have been extensively involved in lending expertise to InnovationSpace;
- CNS-ASU has created and will continue to develop a section of its website to serve as a clearinghouse for nano-in-society curricular activities.

- *"How well does the proposed activity broaden the participation of underrepresented groups (e.g., gender, ethnicity, disability, geographic, etc.)?"* For CNS-ASU, diversity is not just a matter of inclusion of a diverse research population but making aspects of diversity explicit parts of the research agenda.
  - CNS-ASU fosters research topics that explicitly address issues of underrepresented groups, e.g.:
    - An RTTA 4 research project by ASU master's student Garcia-Mont on Hispanic and Latino/a NSE researchers;
    - An ASU undergraduate honors thesis by Silverman (2007) under the direction of TRC 2 Human Identity, Enhancement and Biology co-leader Robert on nanotechnologies for the visually impaired;
    - A RTTA 3/2 InnovationSpace project on nano-enabled haptic Braille technology for the visually impaired;
    - A RTTA 1/1 Innovations Systems Assessment project, commencing this summer by GA Tech doctoral student Meng on female involvement in nanotechnology patenting;
    - A RTTA 1/2 Public Value Mapping project that includes attention to the differential impacts of minority participation in clinical trials for potential nano-therapeutics;
    - An entire research program area on Equity and Responsibility, which in part addresses ethnic and geographic issues in the distribution of benefits and risks from nanotechnologies;
  - CNS-ASU collaborates with the Hispanic Research Center on the "Whose Nanotechnology?" conference for underrepresented students;
  - RTTA 1 faculty member Youtie gave an invited presentation on nanotechnology and societal assessment to the National Organization for the Professional Advancement of Black Chemists and Chemical Engineers in Nov 07;
  - CNS-ASU post-doctoral trainee Bennett gave an invited lecture to the Central Arizona Chapter of the Association of Women in Science. The talk covered many career options for people with science degrees that would like to work outside of the laboratory, including CNS.
  - CNS-ASU exposes students to underrepresented perspectives in classrooms and co-curricular activities, e.g., inviting mobility-disabled bioethicist Wolbring to the Learning Community and InnovationSpace classes and cochlear implantee and author Michael Chorost to speak on campus;
  - EPSCoR state New Hampshire hosted one of six citizens' panel in RTTA 3/4 National Citizens' Technology Forum;

- *"To what extent will it enhance the infrastructure for research and education, such as facilities, instrumentation, networks, and partnerships?"* CNS-ASU envisions itself as a national and international leader in promoting research, education, and outreach in nano-in-society topics and in integrating those topics into NSE research and education settings.
    - CNS-ASU exists as the largest node of the NSF-instigated nano-in-society network and has taken leadership in the generation of the following networks and collaborations (outside ASU):
        - A Memorandum of Understanding with NISE Net for collaborations centered on enhancing informal science education with expertise from the societal aspects of NSE;
        - A Memorandum of Understanding with the Department of Energy's Center for Integrated Nanotechnologies (CINT) for collaborations centered on training CINT scientists and users in societal aspects of NSE;
        - A Memorandum of Understanding with the National Nanotechnology Infrastructure Network (NNIN) for collaborations centered on training NNIN users in societal aspects of NSE;
        - Leadership in the ASU-created International Nanotechnology and Society Network, currently consisting of more than 100 researchers in more than a dozen nations;
        - Partnering with the first US-India Nano-science and Engineering Institute to add a societal implications component to its program and nano-in-society personnel to its mission.
    - Within ASU, CNS-ASU is a hub for transdisciplinary research and teaching, with specific activities including:
        - Working to enhance graduate education in the Biodesign Institute, the Fulton School of Engineering, the Department of Physics and the Department of Chemistry;
        - Supporting InnovationSpace, which bridges design, engineering, and business;
        - Providing co-curricular opportunities for graduate students in the Fulton School of Engineering;
    - CNS-ASU partners with the Arizona Science Center for the production of monthly Science Cafes during the academic year, sponsored in part by Agilent Technologies;
    - CNS-ASU has already fielded queries about using the NanoFutures site in a number of pre-college teaching and training activities;
- *"Will results be disseminated broadly to enhance scientific and technological understanding?"* CNS-ASU aims to reach a variety of audiences – scholarly, professional, and public – with its research, education, and outreach activities.
    - CNS-ASU's e-mail distribution list reaches nearly 1400 individuals;
    - CNS-ASU targets networks and user facilities for the distribution of nano-in-society training material, e.g.:

        - NISE Net has disseminated the CNS-ASU report on concepts in nano-in-society for education and outreach (Miller et al. 2007) to approximately 100 museums in conjunction with NanoDays;
        - NNIN has disseminated the CNS-ASU led PPT training module throughout its network of user facilities;
    - CNS-ASU conducts monthly Science Cafes – many directly involving CNS personnel – during the academic year, averaging approximately 40 persons in attendance at the Arizona Science Center in the recent year;
    - NanoFutures website information has been distributed to a broad variety of publics, including ASU alumni/ae and NSF-funded NSE researchers;
    - CNS-ASU has a contract with Springer to produce the first five volumes of the *Yearkbook of Nanotechnology in Society* (Guston, series editor), the first of which is to be published imminently (Fisher, Selin and Wetmore 2008) and the next three of which are already in the planning stages;
    - CNS-ASU Director Guston has signed a contract to edit a two-volume *Encyclopedia of Nanoscience and Society* (Sage, forthcoming 2010) that will transmit detailed concepts in nano-in-society to high school and college students;
- *"What may be the concrete and demonstrable benefits of the proposed activity to society?"* The concept of anticipatory governance – comprising foresight, engagement, and integration – provides the intellectual framework for the broader benefits to society that CNS-ASU seeks to generate.
    - Foresight activities, particularly the scenes of plausible nanotechnological products that CNS-ASU has developed and vetted, create through the NanoFutures interactive website an opportunity for diverse publics to encounter, explore, and evaluate nanotechnologies prior to the actual emergence of these technologies;
    - Engagement activities, particularly the large scale and intensive National Citizens' Technology Forum but also the small-scale intensive Science Cafes, create more informed citizens on important topics in nano-in-society;
    - Interaction with NSE researchers, including educational and training activities and workshops as well as laboratory collaborations and interventions, results in identifiable changes in knowledge, identity, and practice. For example:
        - After exposure to CNS-ASU through the DC Summer Session, environmental engineering doctoral student Troy Benn volunteered to become a PhD+ student with the Center, which supported a trip to Washington, DC to visit with Environmental Protection Agency officials to discuss how to fine-tune his ongoing research on nano-silver in the environment to EPA's potential regulatory needs.
        - After serving as a CNS-Biodesign Fellow and organizing the CNS Science Cafes, physics doctoral student Spadola completed her PhD and is planning to continue her education to become a maker of documentary science films.
        - After participating in a scenario development workshop on the future of pre-symptomatic medical diagnostics, Biodesign doctoral student Williams (Chemistry and Biochemistry) decided to change her focus

from Alzheimer's diagnostics to infectious disease diagnostics because she felt the latter would be more congruent with both her and broader societal values.
        - While participating in a workshop on the public values associated with sustainable energy research – part of CNS-ASU's Photon Project – researchers in S. Lindsay's team identified "useful" and even "breakthrough" ideas for pursuing their research in alignment with those public values.
- CNS-ASU has had other informational and educational exchanges with decision makers, including:
    - At the request of Mike Roco, CNS-ASU's RTTA 1 program produced a number of analyses of the national and international distribution of NSE research activities for use by federal R&D managers and decision makers, including those at the President's Council of Advisors for Science and Technology (PCAST);
    - Along with CNS-UCSB Director Harthorn, CNS-ASU Director Guston met with a congressional staffer who supports the Congressional Nanotechnology Caucus to describe nano-in-society research, education, and outreach activities.
    - CNS-ASU Director Guston serves on the Nanotechnology Technology Advisory Group (nTAG) to the US Office of Science and Technology Policy, the White House.
    - CNS-ASU plans a series of research briefings for private sector interests, beginning with one on either nano-districts or nano and public opinion in late May or early June.
    - CNS-ASU's parent organization, the Consortium for Science, Policy and Outcomes, is opening a Washington, DC office that will provide tremendous additional opportunities to directly inform policy makers about nano-in-society activities.

The Center for
Nanotechnology in Society
ARIZONA STATE UNIVERSITY

New Methods in Public Engagement:
A Dialogue on Nanotechnology and Religion

Dr. Jameson Wetmore, Assistant Professor, School of Human Evolution and Social Change, and The Center for Nanotechnology in Society, Arizona State University

Tobie Milford, undergraduate, School of Life Sciences, Arizona State University

To broaden the public engagement process in order to more personally explore the social and ethical implications of nanotechnology, Milford and Wetmore conducted a workshop dialogue that specifically incorporated religious perspective into a discourse on brain-machine interface technologies. Participants included representatives of various religious perspectives as well as scientists who were encouraged to step outside of their customary expertise and engage as "interested citizens."

The dialogue yielded robust ethical reflection, including an atypical discussion of the potentially beneficial role of suffering to the human condition. Participants also discussed the limits of technology with regard to the manipulation of emotional states and the implications of this for community. Dialogues that engage participants at varying levels of identity can open up new lines of questioning and debate that go beyond typical policy considerations.

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The Center for
Nanotechnology in Society
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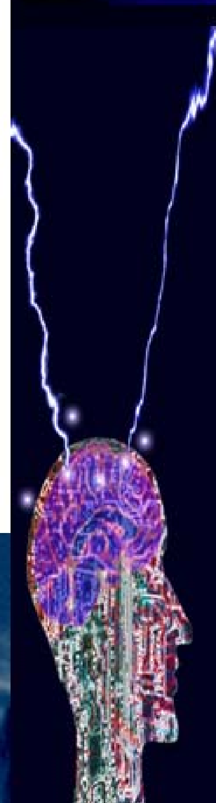
Dr. Clark Miller, Associate Professor,
Science Policy and Political Science,
Arizona State University

End-to-End: Real-Time Technology Assessment of Nanotechnology and the Human Brain

The End-to-End project at CNS-ASU is a real-time technology assessment of the application of nanotechnology to the human brain, in order to systematically assess the convergence of nanotechnology with biotechnology, information technology, cognitive science and neuroscience (NBIC). At the same time that the assessments are done, they are fed back to the innovation process in order to shape NBIC technologies in ways that enhance societal outcomes.

Characterization of nano-neuro research data has identified cochlear implants as the first widespread neural implant where nanotechnology may offer a range of potential applications to improve or enhance the procedure.

Studying the history of cochlear implant technologies offers numerous insights regarding the social meanings that neural implants can give rise to, such as debate over the "disabled" status of deaf culture, or the use of cochlear implants in children.



Manipulating the brain and enhancing cognitive functionality is arguably among the most morally significant emerging technologies likely to impact humans in the next quarter century. The human brain is intimately involved in the creation of human thought, meaning, identity, intelligence and reasoning; the metaphorical and real transformation of the human brain into a biological machine capable of understanding analysis, repair and modification is likely to have enormous ramifications across human societies.

End-to-End explores these themes of human identity, enhancement and biology in a number of real-time technology assessment (RTTA) research projects. These projects include the characterization of nano-neuro research data, the characterization of public and scientist opinions and values, the construction of scenarios to encourage responsible debate about technological futures, and the implementation of nationwide citizen deliberation panels on nano-neural research. End-to-End also incorporates its themes into other CNS-ASU outreach and education activities, e.g., monthly Science Cafés on topics such as the ethics of designing adaptive technology for the central nervous system, and whether robots need a Bill of Rights.

Brain interface technologies have demonstrated the theoretical feasibility (if not yet great practical success) of creating communication pathways between the human brain and computers. Nanotechnology offers one potential route for improving such interfaces through miniaturization, novel nano-bio configurations, new material properties, etc.

Research, education and outreach activities at the Center for Nanotechnology in Society at Arizona State University are supported by the National Science Foundation under cooperative agreement #0531194.

The Center for
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Informal Nanotechnology Education

Nanotechnology is poised to be one of the most significant scientific and industrial transformations of the 21st century. How, then, do you engage the public in a topic they can't see, that requires a science background most people lack, and is so new that many haven't even heard of it? To address this challenge, CNS-ASU provides informal science education through monthly Science Cafés and collaboration with the Nanoscale Informal Science Education Network (NISE Net). The public is also invited to deliberative engagements such as the National Citizens' Technology Forum.

The National Citizens' Technology Forum process was designed to give average citizens ample opportunity to become informed about human enhancement technologies. Participants were provided substantive background reading and participated in two weekends of face-to-face working sessions. They also attended nine, 2-hour Internet discussion forums, in which they learned about nanotechnology from experts as well as citizens at other locations.

NISE network
NANOSCALE INFORMAL SCIENCE EDUCATION

CNS-ASU collaborates with NISE Net to integrate social science research into the museum and outreach projects that NISE Net develops. For example, NISE Net distributed CNS-ASU's white paper on public engagement and education regarding nanotechnology and society to over 100 science museums as part of its Nano Days kits; the paper is also posted on NISE Net's website. Other synergistic CNS-NISE activities include cross-participation in projects, programs and forums.

CNS-ASU sponsors a monthly Science Café at the Arizona Science Center. These are informal discussions that bring together members of the community and university scientists to discuss how science and technology can change the future. A physical scientist is paired with a social scientist, ethicist, or philosopher, in order to bring multiple perspectives to societal concerns.

Research, education and outreach activities at the Center for Nanotechnology in Society at Arizona State University are supported by the National Science Foundation under cooperative agreement #0531194.

The Center for **Nanotechnology in Society**
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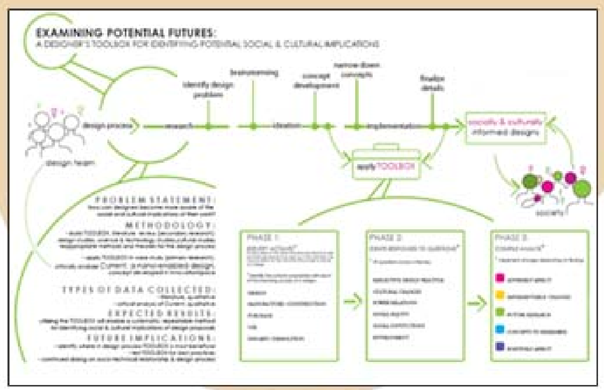
InnovationSpace

InnovationSpace at Arizona State University is a transdisciplinary program in which teams of design, engineering and business students develop "new venture proposals" that include a product design concept, business/marketing assessment, engineering assessment and communication strategy. CNS-ASU sponsors three teams to visualize how futuristic nano-technology product scenes can translate into usable products. Teams must critically examine how people's everyday lives could change because of nanotechnologies; in this process they are supported by CriticalCorps, an interdisciplinary group of researchers and educators who use critical and cultural theory as a means to understand the social significance of the designed environment. Together, InnovationSpace, CriticalCorps and CNS-ASU examine the role that designers and users both play in assimilating nanotechnology into the objects, images, and spaces of everyday life.

In the 2007-2008 academic year, three teams visualized socially beneficial opportunities for nanotechnology in the areas of human health and enhancement. The resulting product ideas were: a hand-held device that can scan text and instantly convert it into Braille on a haptic screen that forms itself into the tactile shapes; a device with a computer screen on which cancer patients can observe their own healing process as nanodevices eradicate malignant cells; and a fusion between a cast and a brace made out of polymer material grafted with "molecular switches" that change rigidity when exposed to a certain wavelength of light controlled by the doctor. These three technologies are so plausible that InnovationSpace has submitted invention disclosures for them.



CNS-CriticalCorps research assistant Shannon Lidberg recently successfully defended her master's thesis, which involved creating a designer's toolbox for identifying potential social and cultural implications of designs.

Prasad Boradkar, Associate Professor of Industrial Design,
College of Design, Arizona State University

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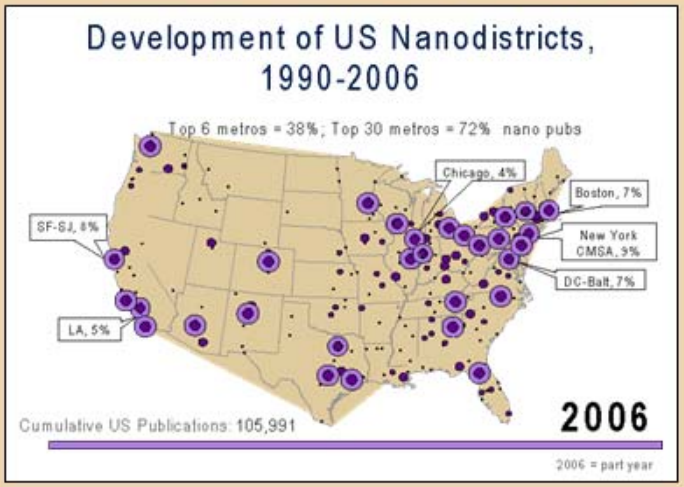
Regional Clusters of Nanoscale Science & Engineering Activity in the United States

Dr. Philip Shapira,
Professor of Public Policy,
Georgia Institute of Technology

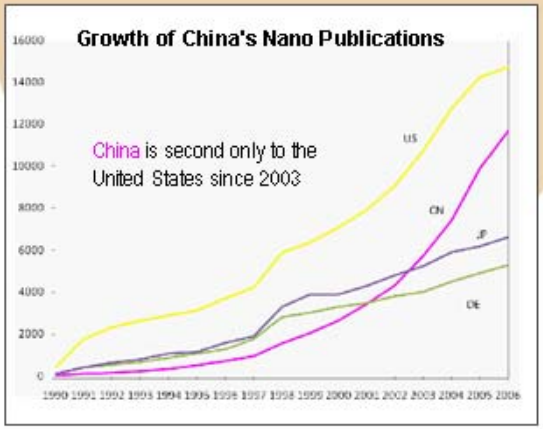
CNS-ASU's research and innovation systems analyses characterize the scope and dynamics of the nanoscience and engineering (NSE) enterprise, public and private, to understand its dynamics, direction, velocity, developing synergies and linkages. Through extensive queries of bibliographic and patent databases, global, national and regional "nano-districts" have been identified that are the focus of publishing and patent activities.

Is Nanotechnology a GPT?

The CNS-ASU research and innovation group is examining whether nanotechnology has the characteristics of a general purpose technology (GPT). Such technologies are widely disseminated across many sectors and can have broad economic and social effects. Early results suggest that NSE appears to be following a pattern of intellectual property more similar to general purpose technologies such as information technology, rather than to more focused technologies like pharmaceuticals.



CNS-ASU research shows that metropolitan areas currently strong in nano publishing and patenting are largely similar to those metropolitan areas strong in previous emerging technologies. This lends support to an argument for path dependency in the development of nanodistricts. However, some newly emerging nanodistricts centered on large government and corporate laboratories, and new human capital concentrations, are evident.



CNS-ASU researchers studied NSE in China through bibliometric and patent analyses as well as fieldwork. They found that the quality of Chinese NSE publications is lagging but increasing, and the quantity of its patents still lags significantly. Commercialization in China is focused in lower-end applications of nano-materials, and pathways to applications are driven by university research, with weak corporate R&D investment.

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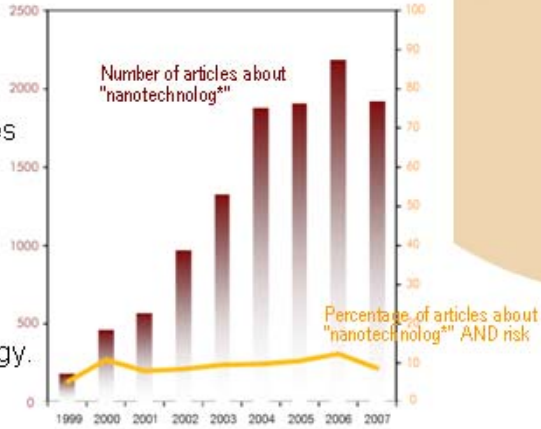
Media Coverage of Nanotechnology – What will Happen Next?

Dr. Dietram A. Scheufele, Professor of Life Sciences Communication and Journalism & Mass Communication, University of Wisconsin, Madison

Dr. Elizabeth Corley, Assistant Professor School of Public Affairs, Arizona State University


The New York Times
May 17, 2006
RISKS
Technology's Future: A Look at the Dark Side

A canvass of print media since 1999 shows that the number of articles about nanotechnology has increased dramatically, while the percentage of those articles that address both nanotechnology *and* risk has remained disproportionately low. This is in keeping with nanotechnology being in the early phase of its "issues cycle," in which media coverage tends to focus on the scientific and economic aspects of a new technology.



Scientists have traditionally been reluctant to talk to journalists about non-scientific aspects of new technologies. Nevertheless, journalists, scientists and policymakers have a key window of opportunity to proactively bridge potential communication disconnects, if they are willing to engage in true dialogue about later issues cycle concerns.

However, as with previous emergent technologies, the issues cycle will progress, and both public discourse and media coverage will eventually reframe around ethical issues and uncertainty.

Our research indicates that citizens use cognitive shortcuts or *heuristics,* such as ideological predispositions or cues from mass media, to form judgments about emergent technologies. Our findings suggest that the influence of new *information* on attitudes toward nanotechnology may be minimal if people rely on strong emotional heuristics to process the information.

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2008 National Citizens' Technology Forum: Public Deliberation about Nanotechnology

Dr. Patrick Hamlett, Principal Investigator
Associate Professor of Science, Technology & Society, and Political Science
North Carolina State University

Locations of the 2008 NCTF citizen panels:

- Tempe, Arizona
- Boulder, Colorado
- Berkeley, California
- Durham, New Hampshire
- Atlanta, Georgia
- Madison, Wisconsin

Citizen reports available online at: http://www4.ncsu.edu/~pwhmds

In March 2008, eighty-six people across six nationwide panels participated in the National Citizens' Technology Forum on "Human Enhancement Through Nanotechnology." These citizens ranged from teens to seniors and had no previous expertise or experience in nanotechnology. They studied background material, met face-to-face, and participated in nine, two-hour Internet discussion forums with scientist experts. During their final meeting, each panel wrote a Citizen's Report that outlines their optimism, concerns and recommendations regarding human enhancement technologies.

The reports address socio-economic, safety, environmental, health and governance issues, as well as regulatory challenges and human identity concerns. This project gives average citizens a voice in the early stages of nano-scale science and engineering research and development. It is noteworthy that every report implores policymakers, research scientists, and the private sector to recognize that real-time citizen input is essential to fully understanding the societal implications of emerging technologies.

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"PhD+" Education in the Societal Dimensions of Nanoscale Science & Engineering

CNS-ASU's "PhD+" Education program helps science & engineering doctoral students to develop insight into the societal dimensions of their research. Graduate students are matched with a social scientist or humanist mentor who also serves on the student's thesis and dissertation committee. Students participate in CNS-related curricular and co-curricular activities that lead to a chapter in their dissertations – or other significant publication – on the societal context of their research.

In 2008, the first student graduated from CNS's PhD+ program: Quinn Spadola, with a PhD in physics. Spadola has contributed greatly through her management of the monthly Science Cafés. From the first few programs at local coffee shops with attendance between 7-12 people, Spadola has developed the cafés into a monthly staple at the Arizona Science Center, with 50-80 attendees.

Spadola's doctoral research concerned inexpensive human genome sequencing technologies, which the National Institutes of Health has described as "the $1000 genome." The government's hope is that cheaply-derived genomic data can both improve health care and reduce per capita health care costs. Spadola's research also addresses the ethical ramifications of "cheap and easy" gene sequencing, such as genetic discrimination, especially if genetic data becomes readily available to employers.

Areas of social implications study for other doctoral students in the PhD+ program include:

- anticipatory explorations of lab-on-a-chip, designer enzymes and directed evolution;
- scientific advisory processes, nanoparticle regulation and water quality;
- sustainability and consumer products.

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Science & Engineer Practitioner Training about Societal & Ethical Dimensions of Nano

CNS-ASU has developed training modules on the social and ethical dimensions of nanotechnology that are designed for science and engineering practitioners at major user facilities. These modules have been deployed at the Department of Energy's Center for Integrated Nanotechnologies (CINT) as well as at the National Nanotechnology Infrastructure Network (NNIN).

The CNS-CINT training program consists of four sessions, each of which includes background reading materials, briefing packets, lectures and discussions. Topics addressed include nanotechnology and public policy, environment, health and safety, ethical and societal implications, and social science research. The roundtable discussions compare existing and emerging methods of integrating science and society into the laboratory.

NNIN National Nanotechnology Infrastructure Network
Serving Nanoscale Science, Engineering & Technology

The NNIN training module has been posted on the NNIN Societal and Ethical Issues website for use in all NNIN facilities.

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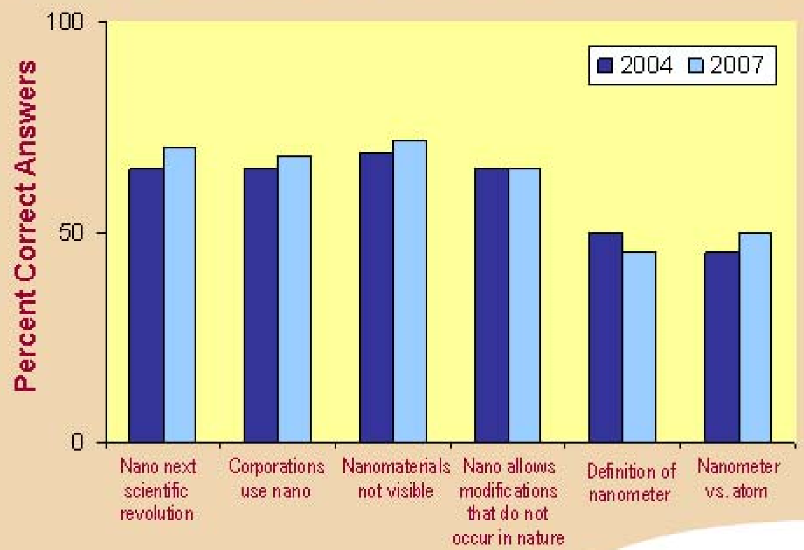
Lack of Knowledge Doesn't Stop Americans from Having Opinions about Nanotechnology

A 2007 national survey of American households finds that levels of knowledge about nanotechnology are relatively low, and these levels have not changed significantly since 2004.



Furthermore, comparisons with identically-worded questions from a 2006 European survey show that significantly fewer Americans agree that "nanotechnology is morally acceptable" than respondents in many European countries. These findings have critical implications for how experts explain nanotechnology and its applications. The scientific community needs to do a far better job of placing the technology in context and in understanding the attitudes of the American public.

Dr. Elizabeth Corley, Assistant Professor of Public Affairs, Arizona State University | Dr. Dietram A. Scheufele, Professor of Life Sciences Communication, and Journalism & Mass Communication, University of Wisconsin, Madison

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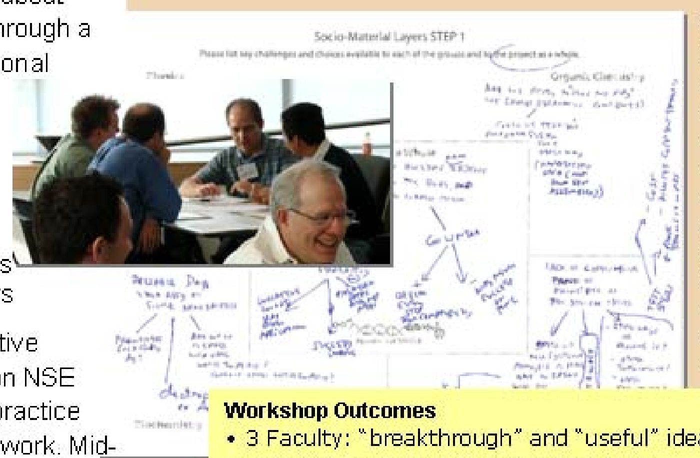
Integration and Reflexivity in Nanoscience and Engineering

Greater reflexive capacity increases the opportunity for informed deliberation and conscious choice. CNS-ASU programs therefore strive to help nanoscale science and engineering (NSE) researchers develop a greater capacity to understand where scientific and social values come from, what they mean, and how they are related to decisions about their research. This is accomplished through a set of integrative research and educational programs that include:

- workshops
- laboratory studies;
- interviews with NSE researchers;
- functionally interdependent activities between CNS and SNE researchers

CNS-ASU has found that such integrative activities have at least modest effect on NSE researchers' knowledge, identity and practice regarding the societal aspects of their work. Mid-stream modulation of research agendas and conduct occurs at all levels of the NSE enterprise, up to and including laboratory directors. Interactions with social scientists do not hamper NSE research projects, but rather have been found to enhance them.

"Tubes in the Desert" is a large-scale research partnership between the Biodesign Institute at ASU and British Petroleum, where specially optimized photosynthetic bacterium will be used to produce biodiesel. Embedded in the project organization, CNS-ASU will mediate between research and societal outcomes through process interventions that include a "societal dimensions workshop" with project personnel. CNS will evaluate its ability to influence the project through ongoing comparison to a control project at the ASU Polytechnic campus where CNS is not involved.



"Public Value of Organic Solar Cell Research" is a CNS-ASU integration into a Biodesign Institute project that is investigating how to break through current technological hurdles of solar energy to make it a more viable energy source. "Embedded humanist" Erik Fisher will conduct real-time public value mapping and participate in the project as a team member, observer and facilitator. Fisher conducted an initial workshop that asked project members to consider how public values affect the direction of laboratory research. Workshop attendees reported that the process-oriented activities helped them shift their paradigms of how their own innovation and decision-making are framed, and asked for additional similar activities in the future.

Workshop Outcomes

- 3 Faculty: "breakthrough" and "useful" ideas
- 2 Grads: new perspectives on project

Future Workshops

- We should have "more meetings like this"
- Commitment to engage "quarterly"

Dr. Erik Fisher, Assistant Research Professor, The Center for Nanotechnology in Society at Arizona State University

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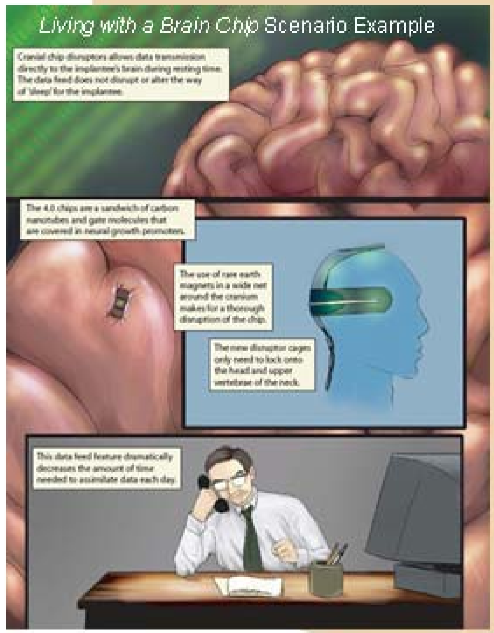
Using Scenarios to Encourage Responsible Debate about the Social Implications of Nanotechnology

Dr. Cynthia Selin, Assistant Research Professor,
The Center for Nanotechnology in Society at
Arizona State University

As an experiment in creating social engagement around anticipatory governance of nanotechnology, CNS-ASU developed six futuristic scenes of products that utilize nanotechnology. Based on documented claims in published scientific literature, the scenes project these claims into possible short-, medium- and long-term future product applications. In order to establish their plausibility, the scenes have gone through a rigorous vetting process involving scientists with relevant expertise.

These scenes have been used to facilitate discussion of the larger social, political, economic and ethical implications of nanotechnology in a variety of settings, including college courses and in nationwide citizens' technology deliberation panels.

The scenes have also been published on the web, at http://cns.asu.edu/nanofutures. At this website, any visitor can read about the project, respond to the scenes in a discussion forum, and even revise them into full scenarios that explore the wider implications and dilemmas of nanotechnology.



The scenes address products such as synthetically-engineered tissues, brain chips that allow data to be fed directly into the brain during sleep, bionic eyes that enable magnification and night-vision, and a "doc-in-a-box" that can detect disease years before a person manifests any symptoms.

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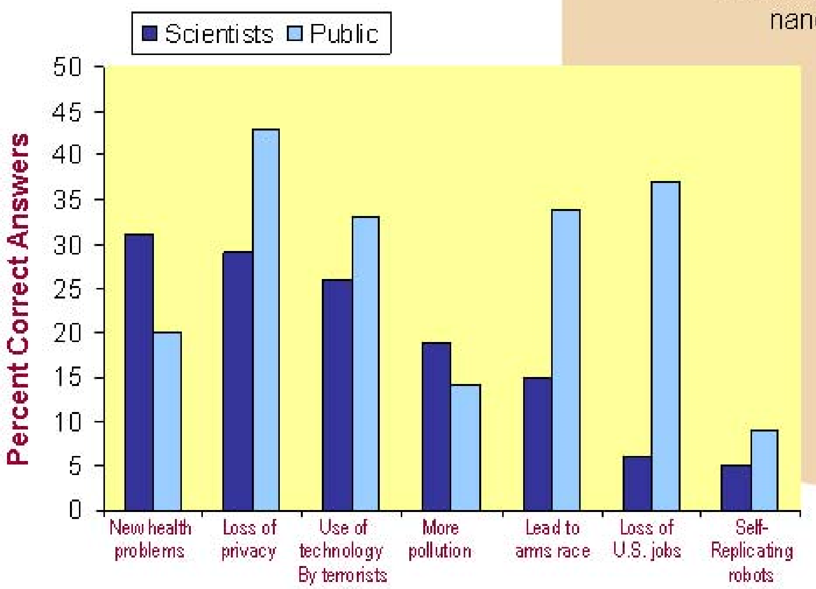
Scientists Worry about Nanotechnology's Health & Environmental Impacts

Dr. Dietram A. Scheufele, Professor of Life Sciences Communication, and Journalism & Mass Communication, University of Wisconsin, Madison

In spring 2007, two surveys compared the public's and scientists' perceptions of the risks and benefits of nanotechnology.



The results indicate that scientists are more optimistic about the potential benefits of nanotechnology than is the public; however, the unknown human health and environmental impacts are a bigger worry for scientists than for the public. The study reveals that those scientists with the most insight into nanotechnology's potential are nevertheless unsure what health and environmental problems it might pose.

Finally, less than ten percent of either group was concerned about the risks associated with "self-replicating robots," a suggested outcome of nanotechnology that has received media attention in the past.

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Workforce Assessment in Nanotechnology Industries

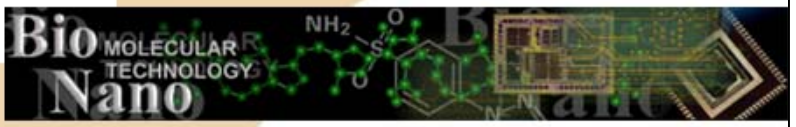
An ongoing workforce assessment of more than 30 companies and educators in Phoenix and Tucson, Arizona, has found that in three key industries that could be affected by advances in nanotechnology (aerospace, semiconductor and biotechnology), it is difficult for companies to assess their gross demand for nanotechnology workers. Although companies anticipate further research in nanotechnology, they cannot be more specific. Employers nevertheless consistently mention *interdisciplinary skills* as important for nanotechnology workers, so that employees with a background in a traditional discipline can understand applications of nanotechnology in other disciplines.

IGA
interdisciplinary graduate academy

Bringing the World to ASU

ASU

Educational institutions are beginning to create "nanotechnology degree programs," such as an interdisciplinary Ph.D. in science and engineering manufacturing operations at Arizona State University. Furthermore, educational institutions are creating research centers and institutes with some focus on nanotechnology, such as the University of Arizona's NanoBiomolecular Engineering, Sciences and Technology Program.



Dr. Aaron R. Fichtner, Director of Research and Evaluation, John J. Heldrich Center for Workforce Development, Edward J. Bloustein School of Planning and Public Policy, Rutgers, the State University of New Jersey

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Strategic Research Plan

The long-term research goals of CNS-ASU are to demonstrate the ability to engage in real-time technology assessment (Guston and Sarewitz 2002) and, in doing so, help build capacities for the anticipatory governance of nanotechnologies and reflexivity in the NSE enterprise. By "anticipatory governance" we mean a broad-based capacity that extends through-out society that can collect, analyze, synthesize and interpret a wide range of information to manage emerging knowledge-based technologies while such management is still possible. By "reflexivity" we mean a capacity for social learning – by individuals, groups, institutions, and publics – in the NSE enterprise narrowly and society more broadly that expands the domain of and informs the available choices in decision making about nanotechnologies.

The concept of anticipatory governance is elaborated in a variety of Center publications, including Karinen and Guston (under review), which locates it at an under-explored nexus of incrementalist, futurist, and public management literatures, and Guston (2007), which explores it as an over-arching theme of the Center for a more general readership. The most important elaboration is Barben et al. (2008), which delineates anticipatory governance into three distinct research capabilities: *foresight*, *engagement*, and *integration*.

Foresight embodies a number of different approaches to anticipating nanotechnological futures, including, e.g., the identification and analysis of research trends, scenario development, science fiction, etc. Key to recognizing the role of foresight in anticipatory governance is understanding that it is not about prediction but rather about intellectual and societal preparation: In much the same way that physical exercise prepares one for the rigors of life in expectation of achieving greater health, anticipatory governance helps prepare society for the rigors of its technological future, regardless of which precise future emerges. Research activities involving foresight at CNS-ASU include:

- RTTA 1/1, Research and Innovations System Assessment, which has provided empirical basis to the expectation that nanotechnologies will emerge as a general purpose technology (Youtie et al. 2007), has demonstrated that the regional and national interests aggregating around nanotechnologies are subtly different from those in other emerging technologies (Shapira and Youtie 2008), and has generally provided a significant body of evidence for identifying and analyzing trends in NSE research;
- RTTA 1/3, Workforce Assessment, which has elaborated, for the regional nano labor market in the Phoenix-Tucson area, expectations about the supply and demand of nano researchers;
- RTTA 2/1, Public Opinion and Values, which has elicited expectations about the potential risks and benefits of nanotechnologies from a large random sample of the US population (e.g., Scheufele et al. 2007) and also assesses perceptions of long-term risks among nano-scientists;
- RTTA 3/1, the NanoFutures project, which has developed and vetted naïve product descriptions ("scenes") of nanotechnologies and has made them available for comment and elaboration on an interactive (wiki and blog) web site (http://cns.asu.edu/nanofutures/), and which has also conducted one scenario

development workshop on "doc-in-the-box" technologies, which are among the most provocative potential nano-enabled therapeutic technologies being discussed (Selin 2008; Selin 2008b). NanoFutures is also planning two additional workshops involving cancer vaccines);

- RTTA 3/2, InnovationSpace, a transdisciplinary undergraduate educational laboratory which develops conceptual engineering models, marketing plans, and product designs for prospective nanotechnologies;
- RTTA 3/4, National Citizens' Technology Forum, which has elicited both general perspectives on nano risks and benefits, as well as specific expectations about human nanotechnologies (enhancements) from small sets of lay citizens in the context of a highly coordinated deliberative exercise;
- RTTA 4, Photon Project, in conjunction with RTTA 1/2 Public Value Mapping, on the development of PVM as a prospective tool at the laboratory level of analysis; and
- The first volume of the *Yearbook of Nanotechnology in Society* (Fisher, Selin and Wetmore 2008; series editor, Guston), which focuses on "Presenting Futures" of nanotechnologies.

Engagement, likewise, comprises a number of distinct activities that involve various segments of the public in multi-faced and bi-directional communication of the facts of nanotechnologies and their societal aspects. CNS-ASU does not believe that there is one best way to "engage the public," and it therefore supports a variety of activities, each with a specific combination of research, education, and outreach goals that is designed to be complementary to the others. Examples include:

- RTTA 3/1, NanoFutures, which is using interactive wiki and blog tools to engage the perspectives of various publics (science policy types, science studies types, nano enthusiasts, ASU alums, etc.) to elaborate a variety of "scenes" of nanotechnological futures;
- RTTA 3/4, National Citizens' Technology Forum, which enabled the first-of-its-kind, independent and joint deliberation of six groups of locally representative lay citizens from across the US on issues in human nanotechnologies and enhancement;
- TRC 1, Equity and Responsibility, which has conducted the first (Milford 2008) of a series of workshops engaging scientists and non-scientists from a variety of denominations to discuss religion and nanotechnologies;
- RTTA 2, Public Opinion and Values, which is using national public opinion surveys to segment the population, identify core values, beliefs and information seeking behavior for each segment, and explore modes of communication to successfully reach each segment (e.g., Scheufele and Corley, 2008);
- The Science Cafes, informal meetings held monthly at the Arizona Science Center that bring ASU-based researchers from both NSE research and societal implications research into discussion with the museum-going public; and
- Interactions with the Nano-scale Informal Science Education Network (NISE Net), coordinated under a memorandum of understanding, that include a background document (Miller et al. 2007) on societal aspects of nanotechnologies circulated by NISE Net with their NanoDays materials, technical assistance in the NanoFutures web

site, and ongoing discussions of ways to communicate the innovation process used by InnovationSpace to on-line publics.

Finally, *integration* includes a set of activities whose primary purposes are not only to provide opportunities for social scientists and humanists to work in close proximity with NSE researchers (e.g., ethnographic observation of NSE research), but also to afford opportunities for collaborative work and create the conditions for (and document) early, or upstream, changes in research foci, decision making, etc., based on these interactions. Integrative activities at CNS-ASU involve many research, education, and outreach functions, often with shared funding from the scientific partner, including:

- RTTA 3/1, NanoFutures, which has collaborated with NSE researchers to vet its "scenes" (including the generation of mini-road maps) and has completed one scenario development workshop (and is planning another) that brings together NSE researchers, CNS-ASU researchers, and outside experts from across sectors to explore future technologies like "doc-in-a-box" and cancer vaccines;
- RTTA 4, Photon Project, which involves close day-to-day interaction as well as interviews and workshops between a CNS researcher and a nano-photovoltaics research group over the public values (see also RTTA 1/2 Public Value Mapping) implicated in their work;
- RTTA 4 Tubes in the Desert, in which a small CNS research team works as part of a much larger, industrially-funded research and demonstration project at the Biodesign Institute to explore and enhance decision-making about a project with a potentially large and controversial public impact;
- Graduate-level education initiatives, including the PhD+, the DC Summer Session, and International Perspectives on Nanotechnology and Society, that provide STS and science policy training and research experience for NSE doctoral students at ASU; and
- Undergraduate Learning Community and InnovationSpace, which draw on cross-disciplinary teams of faculty to educate undergraduates in both technical and societal aspects of nanotechnologies.

Barben et al. (2008) argue that these research capabilities must also occur *ensemble* for the fullest potential of anticipatory governance to be realized. Although many projects and programs in the US and Europe partake of one or two of these activities, CNS-ASU is one of the few places, if not the only place, where such an ensemble of foresight, engagement, and integration exists. CNS-ASU orchestrates these ensembles through such activities as:

- The provision by RTTA 1/1 Research & Innovation Systems Assessment of targeted bibliometric profiles for scene development, based on key words provided through the vetting process;
- Interactions between RTTA 1/2 Public Value Mapping and RTTA 4 Photon Project on developing PVM as a prospective methodology at the laboratory level;
- Interactions between RTTA 1/3 Workforce Assessment and RTTA 1/1 Research & Innovation Systems Assessment that helped set the empirical agenda for RTTA 1/3, and findings that are feeding into educational planning and potentially into industrial outreach;

- The central, and centripetal, role of RTTA 3/4 National Citizens Technology Forum, which incorporated expertise from across CNS-ASU into its background documents and overall process, including using scenes from RTTA 3/1 NanoFutures, material for pre/post-test uses input from both TRCs, developing data-gathering strategies and details with RTTA 2/1 Public Opinion Survey, returning re/post-test data, qualitative data, and other information to the TRCs, and generating a background document for multiple uses within the Center and beyond; and
- The "End-to-End" Assessment, which interweaves TRC 2 Human Identity, Enhancement, and Biology with almost every segment of the Center to proto-type the "ensemble-ization' required for real-time technology assessment and anticipatory governance applied to one particular technical area, for example:
    - Drawing on RTTA 1/1 and 2/2 for bibliometric and news article guidance, respectively, to research work in the thematic area of human enhancement;
    - Providing questions and framings and receiving data from pre/post-tests for RTTA 3/4 NCTF;
    - Providing similar material for RTTA 2/1 public opinion poll; and
    - Creating a 1-credit course in Sp 08 and a 3-credit in F & Sp 08-09 to contribute to the educational program.

In the remaining twenty-eight months of the sixty-month collaborative agreement, CNS-ASU will continue to engage in the development of the RTTA programs as foundational tools for anticipatory governance. In some instances, this development will mean bringing fully on-line projects, e.g., RTTA 2/2 Media Influence and RTTA 3/3 CriticalCorps, that had not been budgeted for full activity until YR 4. In others, it will mean an updating and reiteration of well-grounded activities. For example, RTTA 1 bibliometric and patent analysis will continue in the same general directions, but CNS-ASU will update the databases from the middle of 2006 to be current to at least the middle of 2008. Similarly, RTTA 2 will plan not only a smaller, focused study on nano-related human enhancement and equity issues later in YR 3 (Summer 2008) and a second scientists' survey (specific time to be determined), but it will return to a more general survey in YR 5 to create additional perspectives for longitudinal analysis with earlier CNS-ASU work and comparative analysis with ongoing EuroBarometer work. RTTA 4 activities, particularly the Photon project (Fisher in Lindsay's lab) and the Tubes project (Conz and Bhadra with the "Tubes in the Desert" Biodesign-British Petroleum collaboration) will explore the nature of NSE-social science integration more intensively and extensively.

In still other instances, continued RTTA program development means taking advantage of the data we have already created for analysis and dissemination. The surveys have more data than the faculty and student researchers employed by CNS at Wisconsin can analyze efficiently, and RTTA 2 co-leader Scheufele is both attempting to design incentives for other students to use the data as well exploring ways of posting at least sets of the data on a website for more general use. Similarly, RTTA 3/1 Scenario Development has created the NanoFutures site, which went live at the end of Apr 08 and is beginning to generate data through a variety of users. RTTA 3 researchers will need to analyze the interactions of these users with the site. RTTA 3/4 National Citizens' Technology Forum has also generated large volumes of data – not only the relatively brief reports from the six citizens' panels and the

fairly extensive pre- and post-test surveys, but also the video recordings of the face-to-face meetings and the transcripts of the keyboard-to-keyboard meetings. As with the surveys, NCTF personnel are considering ways of making such extensive data available beyond CNS-ASU.

RTTAs will also take advantage of opportunities of mutual and thematic interest that offer themselves. RTTA 1 is exploring the emergence of China as a fast-rising player in NSE research and development, as well as the NSE activities of other developing countries. RTTA 2 has been interested in comparative perspectives on public and scientific opinions regarding nanotechnology. RTTA team co-leader Scheufele has been approached about a possible project on public and scientists' opinion in China and other Asian countries, and RTTA 1 and RTTA 2 are currently marshalling resources to see if they could pursue such a project.

As has been the case, the TRCs will continue to evolve and focus on bringing various RTTA programs together *ensemble*. TRC 2 Human Identity, Enhancement and Biology will in the next year complete its "End-to-End" (E2E) experience, which will then serve as a template for a similar "ensemble-ization" of TRC 1 Equity and Responsibility. This activity will include the completion of volume 2 of the *Yearbook of Nanotechnology in Society*, on "Nanotechnology, the Brain and the Future" (Robert, ed.). Assisting TRC 1's E2E work in grant year 4 will be a pair of workshops that will lead to volume 3 of the *Yearbook of Nanotechnology in Society* on "Nanotechnology, Equity, and Equality." Further assisting in this work will be a new post-doctoral trainee to be hired by CNS-ASU. This trainee will focus on creating a smooth transition from E2E applied to TRC 2 to E2E applied to TRC 1. The trainee will also conduct independent research and collaborate with TRC 1 on various aspects of the Equity and Responsibility agenda.

CNS-ASU also plans to nurture and develop some emerging themes that promise to enrich the RTTA and anticipatory governance frameworks. One is "plausibility," which has surfaced through the RTTA 3/1 Scenario Development activities as a key, under-explored concept in the *anticipation* agenda. The issue first arose as a challenge for mutual comprehension in the YR 2 site visit, but brief discussions with colleagues outside CNS-ASU – including P. Rabinow (Berkeley), J.P. Dupuy (Stanford), and A. Wilkinson (Oxford) – suggest that a project focusing on plausibility in contrast to such more developed but related topics as "accuracy," "risk" and "probability" would be a compelling one for foresight activities and anticipatory governance more generally. Assistant research professor and RTTA 3/1 activity leader Selin is currently planning a workshop and proposals for funding to explore plausibility.

A second developing project is to focus the *participation* agenda onto specific groups. In Fa 08, Robert and Bennett will pilot a novel suite of methods (the "techno-speakeasy") for public deliberation about emerging technologies, in the service of upstream technology assessment and anticipatory governance. Techno-speakeasies are designed (1) to empower ordinary citizens to engage in rational reflection on the processes of technological innovation, (2) to make explicit their individual and societal values, and (3) to probe those values in relation to particular visions of innovative technologies under development. The piloting of techno-speakeasies will involve both scenes as developed within RTTA 3, as well as novel scenarios

generated through the TRC 2 E2E project and through TRC 2 itself. The methods employed within techno-speakeasies are interdisciplinary: in addition to a range of methods used to devise scenes and scenarios, (1) involves the use of history to contextualize technological innovation, (2) requires qualitative social science methods to expose values, and (3) necessitates humanistic (and particularly philosophical and ethical) methods to scrutinize values and foster public deliberation. During the prohibition era in the United States, speakeasies were underground joints where, as long as they were quiet (and so spoke 'easy'), people could engage in illicit behavior – notably, the consumption of alcohol. Our focus is another illicit behavior: mooting the role of regular folks in deliberating substantively about values and interests as they inform scientific and technological research and development. Accordingly, the metaphor of the "speakeasy" is intended to invoke a literal and figurative space in which people can be brought to speak their minds without fear of reproach – it is a safe, semi-public gathering place for undertaking the subversive work of the applied humanities and social sciences in deliberative democracy.

A third project that CNS-ASU is nurturing is the development and dissemination of assistant research professor E. Fisher's concept of "mid-stream modulation," initially explored in Fisher's dissertation (2006) supported by CNS at Colorado-Boulder. In the past year, Fisher planned, coordinated and submitted a complex and ambitious grant proposal to scale mid-stream modulation up from the single laboratory in his dissertation to a multi-site, internationally and technically comparative intervention-oriented ethnographic study. The proposal, which would significantly advance the *integration* agenda, received sound review (E, VG, VG, VG) but was not funded. Fisher will revise and resubmit the proposal in August and, in the meantime, CNS-ASU will attempt to find ways to keep communication and coordination going among the network of potential collaborators across several nations that Fisher identified.

CNS-ASU will also engage in an activity at the beginning of YR 4 that will advance the "ensemble-ization" agenda of anticipatory governance as well as turn reflexive scrutiny onto our research. CNS-ASU is planning a "Visioning Workshop for Anticipatory Governance" in Oct 08 that will bring together the Center's research, education, and outreach leadership – along with several of our collaborating NSE researchers and likely a select number of non-CNS participants. This day-and-a-half workshop will consider anticipatory governance as a technology to be imagined in its future capacities (*a la* scenario development) and attempt to establish milestones for its more complete and socially positive development (*a la* roadmapping). Not intended to necessarily tie in to CNS-ASU's upcoming renewal process, the visioning workshop is instead intended to address the need for reflexivity (identified in Barben et al. 2008) with which CNS-ASU and others approach the anticipatory governance agenda. This workshop will also address the lack of substantive progress that the social sciences in general and technology assessment in particular have made in comparison the natural sciences and engineering (identified in Karinen and Guston under review) in creating concrete plans of action, if not in actual capacity-building.

Finally, CNS-ASU will be able to take advantage of a new Washington, DC-based office to be opened 1 Jul 08 by its parent center, the Consortium for Science, Policy and Outcomes. CSPO-DC will be linked through video technology with CSPO-AZ, and the two sites will

share research, education, and outreach programs. With the new CSPO-DC location, CNS-ASU will be able to more easily and cost-efficiently hold briefings and educational activities for policy makers and non-governmental organizations in DC, and pod-cast these activities back to a broader audience.

Research Program, Accomplishments, and Plans

As described briefly above, CSN-ASU research programs are divided into two types: the Real-Time Technology Assessment programs with a more use-inspired agenda, and the cross-cutting Thematic Research Clusters with a more curiosity-driven agenda. Key to the success of the Center is the interaction among these programs and their accord with the strategic research plan, and so we present with the program accomplishments and plans below comments on how each program contributes to the agendas for anticipatory governance (anticipation, engagement, and integration) and ensemble-ization, and to education, training, and outreach. In addition to the formal research programs, this section also contains material about CNS-ASU's international research activities.

Real-time Technology Assessment (RTTA) Programs

RTTA 1: Research and Innovation Systems Analysis (RISA)

Personnel – faculty and senior participants

Philip Shapira, RTTA 1 leader (GA Tech, professor, Public Policy)
Barry Bozeman (University of Georgia, professor, Public Administration)
Aaron Fichtner (Rutgers, research director, Heldrich Center for Workforce Development)
Erik Fisher (ASU, assistant research professor, CSPO)
Maurizio Iacopetta (GA Tech, Economics)
Alan Porter (GA Tech, professor emeritus, ISYE and Public Policy)
Juan Rogers (GA Tech, associate professor, Public Policy)
Carl Van Horn (Rutgers, professor, Public Policy and Heldrich Center for Workforce Development)
Jan Youtie (GA Tech, senior researcher, Enterprise Innovation Institute and adjunct associate professor of Public Policy)

Personnel – graduate students (11), undergraduate students (3), post-doc (2)

Ravtosh Bal (GA Tech, doctoral student, Public Policy GT-GSU)
Stephen Carley (GA Tech, doctoral student, Public Policy)
John Garner (GA Tech, undergraduate student, Computing)
Clay Karwisch (GA Tech, undergraduate student, History, Technology & Society)
Luciano Kay (GA Tech, doctoral student, Public Policy)
Ashley Kirby (GA Tech, graduate student, Public Policy)
Beth Leach (University of Georgia, graduate student, Public Affairs)
Bryan Lynch (GA Tech, undergraduate graduate student, Public Policy)
Pratik Mehta Mehta (GA Tech, graduate student, Quantitative Finance & ISYE)
Yu Meng (GA Tech, doctoral student, Public Policy)
Sofia Randhawa (GA Tech, graduate student, Quantitative Finance & ISYE)
Harmeet Singh (GA Tech, graduate student, Quantitative Finance & ISYE)
Cathy Slade (University of Georgia/ASU, post-doctoral trainee)
Li Tang (GA Tech, doctoral student, Public Policy)

Jue Wang (GA Tech, post-doctoral trainee, Public Policy)
Walter Valdivia (AU, doctoral student, Public Affairs)

Goals. The overarching goal of RTTA 1/RISA is to characterize the technical scope and dynamics of the NSE enterprise and the linkages between it and a variety of public values and outcomes. The major research theme – RTTA 1/1: Research Program Assessment – characterizes the NSE enterprise and its dynamics through data-mining techniques such as bibliometric and patent analysis, as well as through text-mining, interviews, and other methods. The smaller research themes are: RTTA 1/2: Public Value Mapping, which explores the connections between claims of contributions to public values made on behalf of a research activity like nanotechnology and empirically identifiable outcomes associated with those values; and RTTA 1/3: Workforce Assessment, which identifies one such public value, an appropriately educated nano-workforce and assesses the supply and demand characteristics for such a workforce in a regional labor market.

Research Accomplishments and Plans. RTTA 1/1 has successfully built a large-scale set of global databases of nanotechnology research publication records (1.1 million articles, of which 406,000 from SCI) and 61,000 nanotechnology patents (from 70 patent offices worldwide, including USPTO, EPO, WIPO, and the Chinese State Patent Office) covering the period 1990-2006 (mid). A two-stage bibliometric search method was developed. This method has been published (Porter et al. 2007) and is emerging as a public tool that other research groups are using or adapting. Additional databases of US nanotechnology-based firms and patent citations have been developed. The datasets are being exploited to assess nanotechnology research and innovation implications, resulting to date in 16 publications and working papers.

Findings from this research include:

- patent citation analysis indicates that nanotechnology has the characteristics of a General Purpose Technology (Youtie et al. 2007);
- China and other Asian countries are fast expanding their quantity of publications, but the US and Europe maintain an edge in quality (Youtie et al. 2008); and
- established technology regions lead in nanotechnology research and innovation in the US, but some new regions are entering (Shapira and Youtie forthcoming).

Several new research papers are in the pipeline, including:

- an updated analysis of nanotechnology as a general purpose technology (19,800 patents in 255 fields are analyzed to probe the spread of nanotechnology-related knowledge) (Iacoppeta and Graham);
- the cognitive geography of nanotechnologies and knowledge flows (Porter and colleagues);
- research centers as a policy tool in the US National Nanotechnology Initiative (Rogers);
- an analysis of emerging nanodistricts in the US and Europe (Shapira, Youtie, Carley);
- the engagement of social science with nanotechnology (Shapira, Youtie, Porter); and
- the role of women in nanotechnology patenting (Meng).

These projects draw on our global nano databases or other large-scale databases that are available to us.

In year 4, RTTA1 will update the core nano database of publications through to 2008; we will also add a new patent dataset (PATSTAT) which will provide updated patent records for the US and on a worldwide basis through to 2008. RTTA1 will continue to mine these datasets and develop collaborations inside and outside of CNS-ASU, and in new work will focus on metrics and maps to gauge nanotechnology R&D networking, coherence, knowledge transfer, how institutions and organizations in emerging nanodistricts influence research and technologies produced; and explore the trajectories of likely emerging nanotechnologies technologies warranting impact assessment.

RTTA 1/2 Public Value Mapping explores the connections between claims of contributions to public values made on behalf of a research activity like nanotechnology and empirically identifiable outcomes associated with those values. Based on a model articulated by Bozeman and others, RTTA 1/2 is collaborating with a separately funded project (NSF SBE-0738203; Sarewitz, PI; Bozeman, co-PI) to elaborate PVM across a number of case studies, several of which involve nanotechnologies. PVM attempts to provide a model of innovation and major intellectual advances based on widely shared and non-economic, i.e., public, values. As there are potential market failures, there are likewise potential public values failures, including: interest articulation or aggregation, imperfect monopolies, benefit hoarding, scarcity of providers, short time horizon, conservation of resources, and threats to human dignity and subsistence.

The nano-related cases under development include:

- Cancer health disparities, being developed by post-doctoral trainee Slade and investigating the extent to which novel nano-based therapies for cancer might or might not contribute to exacerbating health disparities among sub-populations;
- The use of nanotechnologies to improve water quality, being developed by graduate student Leach at University of Georgia;
- The role of university centers and university-industry partnerships in promoting public values in nanotechnologies, to be developed by incoming ASU graduate student Schwartz;
- Technology transfer policy and its implementation by universities for public values, with cases in nanotechnologies, being developed by ASU graduate student Valdivia; and
- The potential prospective use of the PVM framework in energy nanotechnologies, under development by ASU researcher Fisher.

The project has formulated a standard approach for each of the cases, involving narrative descriptions of the social problems and stakes involved in the case, the imputed public values and policy statements articulated, the case content, the state of the knowledge value and user communities, an assessment of the public values failures involved, an assessment of the market values involved, an analysis of the values chain that links articulated public values to outcomes, and recommendations.

Work to date by Slade on nanotechnologies and cancer health disparities begins with the following observations about the social problems and stakes involved:

- Racial disparities in cancer survival continue to grow.
- Nanomedicine is supposed to be the new cancer nemesis.
- Cancer cures are identified through clinical trials.
- Minority participation in clinical trials continues to decline.
- How can it be ensured that minorities benefit from nanomedicine advances?

Slade has also made a preliminary assessment of the public values failures involved:

- Interest articulation or aggregation: NIH requirements for minority participation in sponsored research dating back to 1993 have been largely ineffective in increasing proportion of minorities in trials.
- Imperfect monopolies: Minorities, especially low income persons in minority groups tend to receive their health care in private community settings least likely to have physicians with access to or an interest in participation in clinical trials.
- Benefit hoarding: Lack of diversity in potential study populations (those with access to participating physicians or centers) results in inequitable distribution of clinical trials (often life-saving) resources. Most trials limit co-morbid conditions that are more prevalent in minority populations.
- Scarcity of providers: Lack of minority physicians in general with only 3 to 4% of board-certified minority physicians participate in clinical trials (compared to several times that for white physicians).
- Short time horizon: Healthy People 2010 and 2020 short term goals for cures for cancer and elimination of health disparities inconsistent with timeframes for nanomedicine development.
- Conservation of resources: No replacement for cultural diversity yet health policies often ignore the benefits and treat minority populations as expendable.
- Threats to human dignity and subsistence: Results of clinical trials often have limited generalizability to population as a whole, with even less generalizability to minority groups that may experience different biological responses to drugs and devices than most study participants. The result could be greater risk to minorities of the "unintended consequences" of nanotechnology.

Similarly, work by Leach on nanotechnologies and water quality begins with the following observations about the social problems and stakes involved:

- Clean drinking water is essential to human survival, and there is an increasing demand for clean water especially in developed countries.
- Nanotechnologies can, and have been touted as being able to, address several water quality problems including remediation and desalination.
- Nanotechnologies have been implicated in potential environmental health and safety concerns.
- Do the short term benefits of nanotechnologies for water purification outweigh the long-term hazards of potential nanoparticle contamination?

Leach has made a preliminary assessment of the public value failures involved:

- Interest articulation or aggregation: The public generally takes clean drinking water for granted until there is a problem. Prior problems have been of relatively small scale or duration. This produces complacency.

- Imperfect monopolies: This failure is less relevant for this study. Most water systems public, though some systems have more political and economic clout than others.
- Benefit hoarding: Water distribution systems allow negotiation between providers that could result in inequitable access to cleaner water. More affluent communities could have earlier and greater access to new technologies.
- Scarcity of providers: Scarcity of technical expertise in nanotechnology for local water agencies. Cost of new water quality systems coupled with existing aging infrastructure predicts maldistribution of new systems.
- Short time horizon: Long-term effects of nanoparticles as water contaminants unknown. Less is known about the combination of new nanotechnology and aging water quality infrastructure (most tests in laboratory settings).
- Conservation of resources: There is no substitute to water – once contaminated its often too late to recover without significant cost. Once water systems retrofitted for nano – if failure, alternatives are few and costly.
- Threats to human dignity and subsistence: Clean water is necessary for survival.

Other cases anticipate preliminary results by F 08 and conference presentations in Sp 09.

RTTA 1/3 Workforce Assessment

In YR 3, the RTTA 1/3 team, led by Van Horn and Fichtner at Rutgers' Heldrich Center for Workforce Development, continued its field work in Arizona on the supply and demand of nanotechnology workers in the Phoenix-Tucson region. In Feb 08, the team held a "Progressive Dialogue" at ASU with attendees from the university, local and state government, and regional nano-industries to reflect preliminary findings of the research and gather any additional data. At the Progressive Dialogue, it was agreed that the RTTA 1/3 team would extend its Arizona regional research by conducting an in-depth case study with Agilent Technologies, including interviews with multiple individuals from human resources, research, and senior management, and craft a report on Agilent as an addendum to its Arizona Nanotechnology Workforce Assessment Report.

Preliminary findings, to be finalized in the report, are based on input from more than 30 companies, educators, and other stakeholders in the Phoenix and Tucson regions, including: responses to an on-line inquiry, in-depth interviews with more than 20 individuals, and interactions during and following the Progressive Dialogue. Companies providing input included Motorola, FreeScale, Raytheon, and General Dynamics.

Characterizing the regional nano-cluster, the RTTA 1/3 team found that Arizona is home to three key industries that could be affected by advances in nanotechnology – aerospace, semi-conductors, and biotechnology. Companies currently using nanotechnology include:

- Start-up companies (often with small numbers of employees) that often have close connections to the state's educational institutions;
- A limited number of medium-sized companies focused almost entirely on nanotechnology; and
- Research labs of larger companies across the three primary industries.

While the researchers found that companies anticipate further research in nanotechnology, they also found that companies were uncertain about the gross demand for future nanotechnology workers. Companies also diversely reported that existing disciplinary skills might suffice and that nano-specific skills might be learned on the job, but that some nano-specific knowledge and concepts (effects at scale, e.g., quantum effects) were important to have. Companies most consistently reported that interdisciplinary skills were important for nanotechnology researchers to have.

Thus, while the researchers note that some educational institutions are now bringing new nanotechnology-related degrees to market – including ASU's own interdisciplinary PhD in science and engineering manufacturing operations, its master's degree in semiconductor processing and manufacturing, and its professional master of science in nanoscience – these developments are occurring in a relative absence of knowledge of what commercial needs exist.

To this end, RTTA 1/3 plans for YR 4 have shifted to include mapping the nanotechnology educational landscape. RTTA 1/3 will identify degree programs across the country focused solely on nanotechnology, as well as those that have been modified to include a significant focus on nanotechnology. It will create a database of such programs, with information on when the program was established, a brief description of it, the disciplines involved, curricular requirements, student and alumni/ae information where available, and sources of funding if available). Data-gathering will occur through web-based searches, a review of NSF funding, and a web-based survey of colleges and universities (with the assistance of organizations like the Association of American Universities and the American Association of Community Colleges). RTTA 1/3 personnel will also conduct interviews at as many as one dozen colleges and universities with significant academic focus on nanotechnology. The target date for completion of the database and a report on findings is Feb 09.

The RTTA 1/3 team will also conduct a second regional study, located in the use of nanotechnology among the New Jersey biotechnology and pharmaceutical complex. (Earlier discussion, in part involving data and advice from RTTA 1/1, suggested that any additional regional workforce assessments take place in a more coherent and larger nano-cluster, and neither Atlanta nor Madison fit the bill.) The study will make use of in-depth case studies, akin to the one developed for Agilent Technologies, with assistance from RTTA 1/1 and from long-standing contacts in industrial organizations like BioNJ and HealthCare Institute of New Jersey to identify appropriate firms to study. Interviews with human resources staff, research scientists, and senior manages will focus on the current and future demand for individuals with nanotechnology-related skills and knowledge, the characteristics of such skills and knowledge, the hiring practices for such individuals, the efforts of firms to upgrade the skills and knowledge of current staff, the preferences of firms for educational preparation of new hires, and the nature of their collaborations with institutions of higher education.

<u>Connection to Anticipation, Engagement, and/or Integration</u>.

RTTA 1 activities help condition anticipation by:

- establishing trajectories, through bibliometrics and patent analysis, for scientific and technological developments within NSE;
- examining expectations, through PVM, for what NSE innovation might bring; and
- attempting to understand what future workforce needs might be.

Contribution to E2E, "ensemble-ization" or other center-wide activities.

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RTTA1/1 has developed an extensive array of linkages with other components of CNS-ASU, including:

- working with RTTA 2 to identify active US nano researchers for polling of scientists perspectives;
- collaborating with RTTA 2 to expand such a survey to Chinese nano scientists;
- bibliometric nanotechnology profiles have been developed for RTTA 3/1 to aid scenarios (e.g. doc-in-a-box, nano drug delivery) and TRC 2 (on nano-neuro interfaces)
- Working with TRC2 and the E2E project to create several databases (bibliometric, grants, newspaper articles) and develop an analytic framework for research examining the emergence and temporal dynamics of NSE research applying nanotechnology to neuroscience and brain research.

Connection to Education, Training, and Outreach.

RTTA 1/1 training has occurred primarily through providing hands-on research opportunities to graduate and undergraduate research assistants. In addition to the core complement of 5 graduate students, 2 undergraduate students, and 1 post-doc, RTTA 1/1 has opened up access to data to other student research at CNS.

RTTA 1/2 research is conducted largely by a group of doctoral students and post-doctoral trainees led by Bozeman.

RTTA 1/1 has engaged in extensive outreach activities, including:

- presenting analyses and other CNS-ASU perspectives by Shapira to the Beijing Institute of Economic Management and the Institute of Policy and Management at the Chinese Academy of Sciences (Jun 07);
- sharing of patent data on quantum dots, 1990-2006, with Chris Newfield at CNS-UCSB (Aug 07);
- developing count and citation data by country and country group in support of request from Mihail Roco at NSF for PCAST (Sep 07);
- meeting by Porter (GA Tech) with North Carolina State University nano project to pursue collaborative projects (Sep 07);
- meeting by Porter with investigators at CNS-UCSB to follow up on data sharing on quantum dots (Nov 07);
- developing profiles of nanotechnology in India for Professor Ramanath of the RPI NSEC for the January 2008 mission to India (Dec 07);
- meeting with Atlanta-area startup companie by Shapira, Porter, Youtie, Wang, and Kay: iNano Capital Markets (Dec 07; Feb 08) and Spark IP (Dec 07);

- presenting information about publication and patents in Georgia to the Enterprise Innovation Institute Strategic Partners group responsible for working with Georgia Tech's Nanotechnology Research Center by Youtie (Feb 08); and
- posting animation depicting growth of nanodistricts in the US, 1990-2006, to Youtube (http://www.youtube.com/watch?v=tpBxLGcFjug).

RTTA 2: Public Opinion and Values (POV)

Personnel – faculty and senior participants

Dietram Scheufele, RTTA 2 co-leader (Wisconsin, professor, School of Journalism and Mass Communication)
Elizabeth Corley, RTTA 2 co-leader (ASU, associate professor, School of Public Affairs)
Dominique Brossard (Wisconsin, assistant professor, School of Journalism and Mass Communication)
Sharon Dunwoody (Wisconsin, professor, School of Journalism and Mass Communication)

Personnel – graduate students (5), undergraduate students (0), post-docs (0)

Kajsa Dalrymple (Wisconsin, doctoral student, Journalism and Mass Communication)
Anthony Dudo (Wisconsin, doctoral student, Journalism and Mass Communication)
Elliott Hillback (Wisconsin, doctoral student, Journalism and Mass Communication)
Shirley Ho (Wisconsin, doctoral student, Journalism and Mass Communication)
Tsung-Jen Shih (Wisconsin, doctoral student, Journalism and Mass Communication)

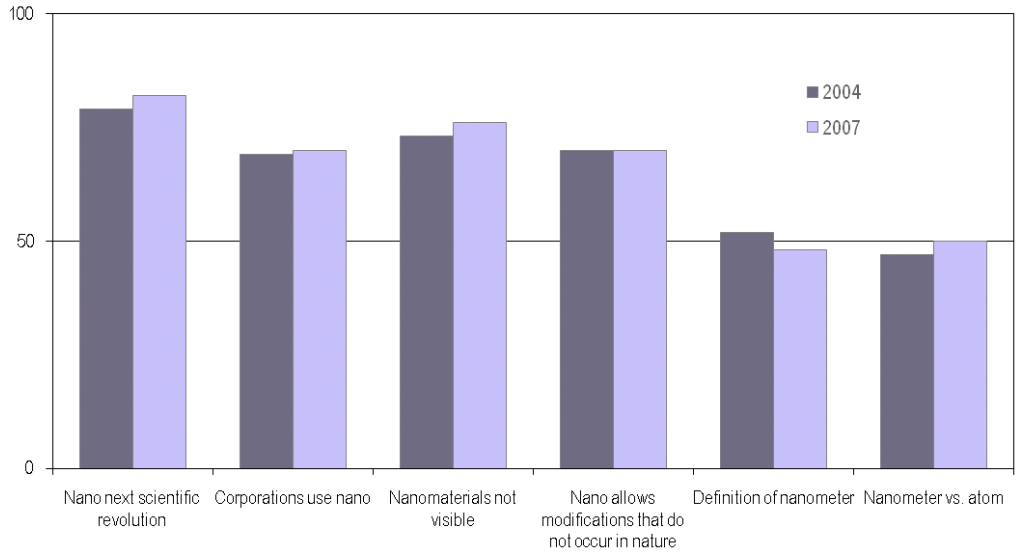
Goals. The overall goal of RTTA 2 POV is to monitor, among both the public and scientists, the understanding of and values relating to NSE and its potential societal outcomes, track these variables over time, and examine the role of the media in reflecting and influencing them. POV comprises a set of inter-related research themes around the public, NSE researchers, and the media. RTTA 2/1 Public Opinion Polling is a major theme conducts nation-wide public opinion polls to understand at an aggregate level the public's knowledge of and values regarding nanotechnologies. RTTA 2/2 Media Influence is a research theme that tracks media stories of nanotechnologies and, using a quasi-experimental design, attempts to understand how various media frames for nanotechnology stories can influence the knowledge and opinions of the public. RTTA 2/3 Scientists' Opinion is a major research theme that conducts polls of NSE researchers to understand their values regarding nanotechnologies.

Research Accomplishments and Plans. RTTA 2/1 completed its public opinion survey in Jul 07, just after the YR 2 site visit at which Scheufele presented very preliminary data. The survey was a CATI survey with a combined RDD and listed household sample conducted May – Jul 07 (N=1015; AAPOR RR-3 30.6%; margin of error, +/- 3%). Questions in the survey were specifically designed or chosen to enable comparisons with a 2004 US nanotechnology survey as a baseline and with the 2006 EuroBarometer for international comparative data (the 2008 pre- and post-test surveys for the National Citizens' Technology Forum were crafted to correspond with this survey as well). The survey's content included questions about communication and information environment, strategies for processing scientific information, attitudes and values, nano literacy, perceptions of scientists, policy makers and the need for regulation, and perceptions of the risks and benefits and future developments of nanotechnologies. Comparisons with the baseline will be discussed in this section; comparisons with RTTA 2/3 Scientists' Survey will be discussed below in that section.

The 2007 survey shows little if any change from 2004 in knowledge about nanotechnology:

- About 25 percent (2004: 25 percent) of all respondents reported never having heard of the issue, even if it was explained to them by the interviewer
- Only about 11.7 percent (2004: 16 percent) of all respondents felt at least "somewhat informed" about nanotechnology.

Similarly, little or no change is observable with respect to with knowledge about nanotechnology, which for the two most specific questions is indistinguishable from coin flipping:



Similarly, responses to questions about perceived risks and benefits asked in both 2004 and 2007 are statistically indistinguishable.

The 2007 survey also compares the perspectives of respondents who are aware and unaware of nanotechnology. There is no consistent pattern with respect to risks, as respondents who are aware of nanotechnology perceive higher risks for loss of privacy, risk of arms race and terrorism, while those who are unaware of nanotechnology perceive higher risks for loss of jobs, self-replicating nano-bots, pollution and new health problems. More of those who are aware of nanotechnology, however, perceive benefits across the board than those who are not aware of it.

The data suggest that nano continues to be an "ambiguous stimulus" and that audiences process frames through their own perceptual filters, i.e., audiences use religious beliefs, moral schema, trust, etc., to process new frames or information like nano. As a result, any given frame may mean different things to different people (Scheufele 2006). One of the important perceptual filters that American's use is religion. Religiosity appears to moderate the perception of benefits from nanotechnology; among those who perceive high benefits, those who report a low religiosity perceive those benefits to be still higher than those who report a high religiosity (this relationship does not hold true for those who perceive low benefits) (Brossard et al. forthcoming). Furthermore, compared to Europe, fewer Americans find nanotechnology "morally acceptable," and among the US and many European countries there is a strong correlation between perceptions of its moral acceptability and measures of religiosity.

(At the All-Hands Meeting, participants had an intense discussion about religion and nanotechnology, featuring these findings, those of TRC 1's Dialogue on Nanotechnology and Religion, and other perspectives. The discussion led to some refinement of ideas that can be further explored in the contexts of both opinion surveys and focus groups.)

In Su 08, RTTA 2/1 will field a second national survey, smaller in scope (N approximately equal to 600), that will focus on issues related to the E2E assessment of TRC 2 Human Identity, Enhancement and Biology and some concerns from TRC 1 Equity and Responsibility. The protocol for that survey has just been delivered to the survey center at Wisconsin for programming. Questions on the survey are designed to explore hypotheses derived from the data in the NCTF pre- and post-tests, as well as from other ongoing research of TRC 1 and TRC 2. Many of the questions from the first survey will not be repeated because of the lack of perceptible change over time since the 2004 baseline.

Late in YR 4 or early in YR 5, RTTA 2/1 will field its third national survey, akin in size to the first survey and returning to questions that highlight the longitudinal and comparative opportunities in that survey. RTTA 2 is also investigating the possibility of obtaining a supplement to perform public opinion and scientists' opinion work in China.

RTTA 2/2 has conducted a variety of analyses of nanotechnologies in the media but – because of entirely planned budget allocations – has only just begun constructing its quasi-experimental framework for assessing media influence. "Understanding Message Impacts: Nano Stories on the WWW" is currently engaging in conceptualization and design processes. The projects to date involve three faculty (Dunwoody, Brossard, and Scheufele) and 8 graduate students from the School of Journalism and Mass Communication at Wisconsin. One of the students is a paid participant in CNS-ASU, while the rest are working on a volunteer basis.

The goal of this RTTA 2 project is to explore the ways in which public narratives about nanotechnologies might influence lay audiences' perceptions of, the extent of learning about, and their judgment about the possible risks presented by nanotechnologies. Research will focus on Web narratives in part because of the growing salience of this channel as a deliverer of science information. The group will conduct a series of experiments that will manipulate a

subset of factors that it hypothesizes may influence such dependent variables as: 1) the extent to which individuals choose to process information about nanotechnologies carefully and effortfully; 2) knowledge gain; and 3) personal risk judgment.

Prominent among those predictive factors may be:

- Cognitive overload: The extent to which the rigors of negotiating an information channel trump learning. This is a continuing concern for the Internet, as individuals often confront novel home page designs and confusing technology.
- Interactivity: The extent to which a truly interactive message will influence learning. Much literature touts the ability of interactive messages to enhance learning; we would like to test that within a nano framework.
- The role of emotion in riveting readers' attention, getting them to invest in learning, and influencing such things as their risk judgments. "Affect" is the variable du jour for risk communication studies, in part because it has proven itself to be a powerful predictor of both knowledge gain and behavioral change. Since perception of the possible health risks of nano are barely on the radar screen among lay publics, we want to explore the extent to which narrative devices that generate emotional reactions will also influence those risk perceptions.
- Visualizing nano: To what extent do visual images intended to represent nanotechnologies influence knowledge gain or, in some cases, emotional response? In contrast to their apparent power, images are a neglected area of study. Since the scale of NSE makes the employment of such images almost irresistible, we want to better understand how they convey meaning.

RTTA 2/3 completed its survey of the opinions of NSE researchers in Jul 07, in parallel to RTTA 2/1, and Corley similarly presented very preliminary data at the YR 2 site visit. The survey of NSE researchers was based on a sample of highly cited, US-based non-graduate student authors located in the bibliographic database compiled by RTTA 1/1. A mail survey following Dillman's Total Design Method received 363 responses (AAPOR RR-3 39.5%).

The survey's content included questions on the communication and information environment, scientists' perceptions of media communication for science in general and nano in particular, their perceptions of the risks and benefits of nano and the need for different types of regulation, their perceptions of the relationship between science and the public and public support for nanotechnology research, and their perspectives on which groups should play a formal role in communicating nano risks and benefits to the public and which groups that have the expertise to communicate nano risks and benefits to the public.

The most important findings from RTTA 2/3 are derived from comparisons with RTTA 2/1 on perceptions of risks from nanotechnologies. In particular, a comparison between the two suggests that for nano, perhaps unique among emerging technologies, experts perceive more risk in certain areas – namely new health problems and pollution – than the public does (scientists nevertheless perceive more benefits across the board) (Scheufele et al. 2007).

In YR 4 or 5, RTTA 2/3 will field a second survey of NSE researchers. It will attempt to expand its sample to include more industrial NSE researchers by tapping the RTTA 1/1 patent databases for individual NSE researchers as well as the bibliometric databases. It may also attempt to apply for a supplement to expand its study of NSE researchers to China, in parallel to the possible RTTA 2/1 plans there.

Connection to Anticipation, Engagement, and/or Integration.

RTTA 2 studies help establish the background conditions of public understanding and values against which nanotechnologies will emerge, thus contributing to anticipation. While not as intensive as other public engagement activities, the extensiveness of the public opinion survey is a contribution to engagement. Similarly, the scientists' survey is a contribution to integration by providing empirical data and analyses about NSE researchers' understanding of the environment in which their research exists.

Contribution to E2E, "ensemble-ization" or other center-wide activities.

RTTA 2 collaborates has shared instruments and findings and has collaborated with researchers in a number of other RTTAs and TRCs. RTTA 2 members have also begun collaborations with members of CNS-UCSB on a potential expansion of our survey work to Asia.

- Working with TRC2 and the E2E project to develop a database of news media coverage of NSE research applying nanotechnology to neuroscience and a framework for analyzing this data.
- Working with TRC1, TRC2, RTTA 3, and the E2E project to develop a survey instrument for the next national survey of nanotechnology and developing the protocols for the Wisconsin Survey Center to field the survey in spring/summer 2008.

Connection to Education, Training, and Outreach.

RTTA 2 currently has 5 doctoral students who are in the process of completing dissertations using various data sources collected with support from CNS-ASU.

RTTA 2 faculty have given many academic talks in venues on their own campuses as well as at conferences like the American Association for the Advancement of Science, the Society for the Social Studies of Science, etc.

Media coverage of RTTA 2 findings include: ABCnews.com. *BusinessWeek*, the *Los Angeles Times*, the *Wall Street Journal*, the *Capital Times*, *Wired*, and *SmallTimes* in the U.S. Internationally, RTTA 2 work has been covered in the *Daily Telegraph* and *The Times* (UK), *Die Welt* and *Frankfurter Allgemeine Zeitung* (Germany), *AFP* (France), and *COSMOS* magazine (Australia).

RTTA 3: Deliberation and Participation

Personnel – faculty and senior participants

Daniel Sarewitz, RTTA 3 co-leader (ASU, Life Sciences)
Patrick Hamlett, RTTA 3 co-leader (NC State U., Political Science)
Philip Bernick (ASU, assistant professor, English)
Prasad Boradkar (ASU, associate professor, Industrial Design)
Michael Cobb (NC State U., Political Science)
Susan Cozzens (GA Tech, professor, Public Policy)
David H. Guston (ASU, professor, CSPO)
Renata Hejduk (ASU, assistant professor, Architecture and Landscape)
Tom Kelly (University of New Hampshire, professor)
Daniel Lee Kleinman (Wisconsin, professor, Rural Sociology)
Carl Mitcham (CO School of Mines/UC-Boulder, professor, Liberal Arts and International Studies)
Jennifer Schneider (CO School of Mines, assistant professor, Public Policy)
Cynthia Selin (ASU, CSPO, assistant research professor)
David Winikoff (UC-Berkeley, assistant professor)

Personnel – graduate students (7), undergraduate students (1), post-docs (2)

Ravtosh Bal (Georgia/GA Tech, doctoral student, Public Policy)
Javiera Barandiaran (UC-Berkeley, doctoral student, MCESD-ESPM)
Amy Barr (University of New Hampshire, doctoral student, Sociology)
Ira Bennett (ASU, post-doctoral trainee, CSPO)
Jason Delborne (Wisconsin, post-doctoral trainee, Holz Center for STS)
Shannon DiNapoli (ASU, master's student, Biology & Society)
Andrew Gaddis (ASU, undergraduate intern, Industrial Engineering)
Sean Hays (ASU, doctoral student, Political Science)
Shannon Lidberg (ASU, master's student, School of Design)
Christina Ndoh (North Carolina State U., doctoral student, Public Administration)
Roxanne Wheelock (ASU, master's student, Liberal Studies)

Goals. The central goals of RTTA 3 are to develop multiple, plausible visions nanotechnology-enabled futures, elucidate public preferences for various alternatives and, using such preferences, help further refine future visions and enhance contextual awareness. RTTA 3 consists of four tightly integrated themes that cover research, education, and outreach. RTTA 3/1 Scenario Development creates, vets, and disseminates plausible nanotechnological "scenes" for further development and deliberation by a variety of publics. RTTA 3/2 InnovationSpace is a collaborative undergraduate design course among ASU's Schools of Design, Engineering, and Business in which transdisciplinary teams of students create product designs, marketing plans, and engineering models of potential products within a framework of responsible innovation. RTTA 3/3 CriticalCorps uses the methods of cultural studies and design to elaborate on the socio-cultural significance of the scenes developed and products imagined by the other RTTA 3 programs. RTTA 3/4 National Citizens' Technology

Forum is the first-of-its-kind, independent and joint deliberation of six groups of locally representative lay citizens from across the US on issues in human nanotechnologies and enhancement.

Research Accomplishments and Plans.

RTTA 3/1 Scenario Development has four main areas of activity:

1. *Scene Development* constructed short vignettes of possible nanotechnological futures (which we call "scenes") relevant to CNS-ASU activities.
2. *Vetting* established the technical plausibility of the scenes through multi-method investigations in collaboration with NSE researchers in Biodesign, the Fulton School of Engineering, and Georgia Tech, as well as with the TRCs and their contacts;
3. *Evaluation and Elaboration* is evaluating the developed and vetted scenes through a web site by targeted audiences and their consequent elaboration into scenarios; and
4. *Outreach and Use* is the ongoing use of the vetted scenes and elaborated scenarios by CNS-ASU and other activities, e.g., InnovationSpace, National Citizens' Technology Forum, NISE Net, etc.

In the last year, CNS-ASU completed scene development and the face-to-face (i.e., focus group) vetting and constructed a user-friendly web site (http://cns.asu.edu/nanofutures) through which various communities have been invited to read, edit, and comment on the scenes.

Scene Development. CNS originally developed ten different "naïve product scenes." These scenes are short vignettes that describe in technical detail, much like technical sales literature, nano-enabled products of the future that span a range of different application areas. We adopted this strategy not only because the "societal implications of nanotechnology" is too vague a starting point, but also because public deliberation often needs to focus on specific applications rather than the underlying technical processes in order to gain traction. We thus need a specification and grounding of particular, potential applications of nanotechnologies in order to inquire into the implications of nanotechnology. Scenes are written to assist deliberation and anticipation, and not to signal any forecast of future technologies.

We drew inspiration for scenes from the academic science literature, the popular science literature, and the science fiction literature. RTTA 3 researchers selected application areas that suggest a reasonable mix between short, medium and long term developments (which the vetting seems to support). We now call these starting points "scenes" to distinguish them from full-blown "scenarios" and to evoke the sense of setting a scene for further elaboration. As a starting point for Vetting, Deliberation, and Outreach, the scenes are intentionally unencumbered with explicit illustrations of the social, political, economic and ethical implications of such products. It is then the role of various publics and professionals to elaborate such implications in the NanoFutures site as described below.

Because nanotechnology has a platform or general purpose character (Youtie et al. 2008), we needed to narrow the field of applications; we chose application areas relevant to TRC 2

Human, Identity, Enhancement, and Biology, which is also a larger theme for the Center in 07-08, including the NCTF. This application area includes nanotechnologies that draw on information technology, cognitive science, and biology.

Vetting. Of critical importance to CNS is that scenes are technically plausible and, hence, a substantial vetting effort has been made prior to the evaluation and elaboration stage, as well as outreach and use. With vetting, we mean to counter a frequent lack of realism attending much of the popular discourse surrounding nanotechnologies, as well as the habit in dialogue to dismiss deliberation because "the technology isn't there yet" or "that application will never happen." The vetting process provides a solid but not definitive rebuttal to these objections. Once scenes were written, the vetting process followed three main lines of approach:

1. focus groups with scientists with relevant expertise including
2. roadmapping; and followed by
3. bibliometric analysis of keywords.

We chose participating scientists based on how pertinent their scientific or technical expertise was to the scene. We chose only scientists working either on the nanoscale or with a disciplinary expertise relevant to the scenes. We asked scientists participating in the focus groups for their evaluation of the plausibility, timeliness, and relevance of the scenes, specifically:

- Technical validation: Is the scene within the realm of current understanding? Is this technology possible? Are the descriptions technically complete and accurate?
- Relevance: Does the scene capture what is interesting about this technological trajectory?
- Alternatives: Is there a more elegant or effective way of arriving at a similar function?
- Revisions: What changes should be made to the scene that makes it more plausible?

In addition to the vetting criteria, the participants were asked about the kind of technological achievements that were necessary in order to achieve the capability described in the scene in the effort to produce a "mini-roadmap" for the scene. Generally, a technology roadmap is an exercise in reverse engineering that:

- outlines and references current research;
- specifies directions of research threads relevant to the sought-after product;
- notes the technological obstacles that need to be overcome; and
- estimates the dates for solutions/breakthroughs along the way.

The outcome is a list of scientific problems and technical challenges with milestones in 2, 5, and 10 years that would be necessary to meet for the product to emerge. The roadmap measure serves as another means to frame conversation beyond "is this possible" and asks researchers to specify their views with somewhat greater precision. This structuring into time enables the focus group to specify in more detail the technical hurdles. In some instances, the construction of the roadmap has led to other pathways of developing more elegantly the same product, thus revising the scene. We emphasize that both the scenes and roadmaps are meant to be neither authoritative nor predictive but defensible and plausible.

We also asked the scientists in the focus groups to suggest five bibliographic search or index terms for the state of the art in the area of the scene. We then sent those key words to the RTTA 1/1 group, which used them to search some 4700 publications pulled from the Web of Science and other sources. The search generated reports of top key words, relevant publications, top research institutions, lead authors, and countries. The intent is to assess the extent to which these technically validated scenes also fall within current NSE research activities. In this way, the scenes are also connected to published research and ongoing research activities in real time.

Of the original ten scenes, only six remain to be developed in the current activity; four scenes were excluded for at least one of the following reasons:

- the scene was not sufficiently relevant to TRC 2;
- the scene did not contribute to a well-balanced presentation of nanotechnologies associated with information technology, cognitive science, and biology;
- the scene was not sufficiently plausible technologically.

The goal of the Evaluation and Elaboration and the Outreach and Use phases of the RTTA 3/1 Scenario Development activities is to co-produce with broader audiences clear thinking around some of the trickier issues that nanotechnologies could introduce and thus open the future to more critical reflection. Invited communities flesh out product scenes online to address questions of governance and control, ethics and religion, cultural, economic, and legal change, and issues specific to human identity and enhancement. Our hope is that the invited participants will critique the scenes and elaborate on them in ways that add to their social context and complexity.

In order for the scenes to be widely interrogated, they are housed on an interactive website (http://cns.asu.edu/nanofutures) produced jointly by CNS and the San Francisco Exploratorium's NISE Net project. The site is designed to enable diverse communities to further elaborate on the scenes and to modify them by adding on content. We make clear that these scenes do not represent any prediction of what nanotechnologies will actually do in the future. There is a main portal that enables users to select in which way they would like to interact with the scenes:

From the portal, users can choose to go to 1) the Wiki; 2) the Discussion Forum; 3) About this Project.

1. The NanoFutures Wiki is an open source-like portion of the site where the scenes can be modified in a collaborative fashion. While the original (i.e. unedited) CNS scenes are available elsewhere on the site, the wiki portion enables the users to modify or add to the scene. In this way, each user can see other contributions in real time, thus in principle allowing an ongoing assessment and development of the nano-enabled product.
2. The Discussion Forum is the place where users can express their views and opinion in a more unstructured fashion. Using a simple blog platform, the forums are moderated on a weekly basis to control for abuse.
3. About this Project is an area on the site where users learn more about the project and the development, vetting and use of the scenes.

CNS has solicited input from a variety of publics:

- Social scientists – members of the Society for Social Studies of Science;
- General publics – ASU alumni/ae and NCTF participants;
- Nano-interested people – Foresight Institute members; Center for Responsible Nanotechnology community; CNS-ASU external mailing list; International Nanotechnology and Society mailing list;
- Science policy professionals – mailing list of the Consortium for Science, Policy and Outcomes;
- NGOs engaged with nanotechnology – identified through internet research; and
- NSE scientists and engineers – awarded grants through NSF.

While there are obvious shortcomings with selecting these communities, we feel they will offer a reasonable range of perspectives. Of note is that we are limiting our project to individuals with the internet, thus excluding those sections of people without access. In defiance of the notion of "the public" as broadly unspecified mass, our "publics" are not meant to be representative of the general population (we have survey work for that slice of public-ness), but rather groups ranging from ASU alumni, who we expect to have limited prior knowledge of nanotechnology, to nano professionals, who we expect of course to have more knowledge.

NanoFutures has met with much enthusiasm from academics as well as foresight practitioners. In the days following the launch of the site (29 Apr to 4 May 08), CNS received several emails in support of the project and inquires regarding further collaborations, including:

- Teresa Ribeiro, Head of Scenarios, Instruments & Challenges, European Environmental Agency says, "[I have been] disseminating your website in several occasions - including for a scenario project that is being developed in Novoenzimes A/S a biotech company."
- Martha R. Atwater, Deputy Director, Center for Nanoscale Chemical-Electrical-Mechanical Manufacturing Systems, University of Illinois at Urbana-Champaign, Department of Mechanical Science & Engineering writes: "I am reading your work with great interest…Would you be interested in [our large teachers program] reactions and perhaps a long-term collaboration with the teachers and students who use the materials? We also work throughout the year with thousands of high school students who could be a test bed for your work. We have independent evaluators who could provide data on the effectiveness of the materials with varying audiences. We're always looking for interesting new content, and perhaps our many education programs could provide some new opportunities for you to reach some different audiences."
- Guillermo Foladori, Universidad Autónoma de Zacatecas, Mexico, has researched and written extensively on nanotechnology and is the coordinator of the RELANS Latin American Network for Nanotechnology and Society, writes: "Of course it would be excellent to have it in Spanish….The scenarios could be used in workshops, and also extend to cover some other societal issues (i.e. impacts on employment, on wealth concentration, etc.)…I will test one or two in a workshop we will have in July with workers from trade unions."

- Bruce Goldstein, Department of Urban Affairs and Planning, Virginia Tech writes: "I would like to invite you to a symposium this November at Virginia Tech, considering how collaborative and networked forms of planning and policymaking can contribute to enhancing societal resilience. Your Nano Futures project is just the kind of thing that we would like to see presented and discussed…"

Such requests for further collaboration are being pursued.

The vetted scenes, without representation through the NanoFutures site, have also been used by CNS-ASU in other activities, e.g., InnovationSpace, National Citizens' Technology Forum, a course in Nanotechnology, Law, and Policy at ASU's O'Connor School of Law, NISE Net's museum audiences, public presentations by CNS-ASU scholars, etc.

RTTA 3/2 InnovationSpace: See Education Section.

RTTA 3/3 CriticalCorps

CriticalCorps uses the methods of cultural studies and design to elaborate on the socio-cultural significance of the scenes developed and products imagined by the other RTTA 3 programs. Since it is dependent and sequential with these other activities, CriticalCorps work is has only been underway in the current reporting year, and then only modestly, as planned.

The central activity in the reporting year has been a master's thesis by Lidberg (2008), under the direction of Boradkar, Hejduk, and Wetmore. In the thesis, Lidberg develops a "toolbox" for designers to use to improve the societal implications of their designs, and she draws on RTTA 3/2 InnovationSpace designs for CNS-ASU from YR 2 as case examples. Lidberg's thesis presumes that the production and consumption of designed goods make a vital contribution to the larger social fabric within which we live, and that design is both a significant component of production that heavily influences practices of consumption, and also a crucial giver of form to emerging technologies by delivering them to the market through commercial applications.

She argues that the analysis of products, graphics, spaces, and services within a society can reveal beliefs, values, or general way of life, and as contributors to the complex relationship between society and technology, designers can play an important role in identifying potential social and cultural implications of their work. For instance, through reflexive and critical analysis of their work, designers can anticipate social changes to systems such as education, economics, politics, or healthcare, and cultural changes such as practices, attitudes, behaviors, or beliefs of people. Critically examining design proposals in this way can steer the development of new technologies towards more socially beneficent outcomes, and create more socially and culturally conscientious, and potentially superior, end products.

This thesis begins development on a critical, analytical toolbox for designers to utilize during the creative process that will help them envision the social and cultural implications of their work, whether it is the design of buildings, spaces, graphics or products. The toolbox is based on a literature review of three key subjects: design studies, science and technology studies,

and material culture studies. After compiling the toolbox, Lidberg applies it to one nano-enabled design proposal created by an InnovationSpace design team. The thesis finds the practicality and potential utility of the development of a robust method for identifying and examining potential social and cultural implications of the designed environment. The critical examination of design and the reflexive analysis of design practitioners can enable designers to become more aware of the ways in which they affect society.

RTTA 3/4 National Citizens' Technology Forum.

In Mar 08, CNS-ASU held its National Citizens' Technology Forum (NCTF) on nanotechnology and human enhancement technologies. The NCTF is a product of the convergence of several forces, including the belief of many people in government, business, academia, and advocacy that informed citizen input in the shaping of public policies about modern science and technology is an increasing necessity. With numerous examples of the entanglement of major technologies – nuclear energy and genetically modified foods come to mind – in deeply polarized political conflict and legal action. decision makers are eager to find ways to elicit and integrate public concerns and values in the technology development process. The authorizing legislation for the National Nanotechnology Initiative, and its accompanying reports, are one expression of such belief (Fisher and Mahajan 2006). But other forces include ongoing, theory-driven research on public deliberation and the implementation and evaluation of deliberative exercises meant to enhance both decision making and democratic politics.

With this background, CNS-ASU designed a national citizens' technology forum, patterned after the Danish consensus conference, which provides through its Board on Technology the Danish Parliament with informed, deliberative public opinion about science and technology policies. The Danish consensus conference involves recruiting ordinary Danish citizens from all walks of life, providing them with background information and access to experts, and assisting them as they deliberate to a set of common policy recommendations about how the Parliament ought to manage the particular technology under investigation

Over the past ten years, the Citizens' Technology Forum (CTF) has been developed for use in the American context – which offers the particular challenge of deliberation across a democracy the size of a continent rather than a city-state. The CTF process adds to the original model the use of the Internet, mixing Internet elements and face-to-face elements, and deliberations involving multiple sites.

We applied the NCTF framework to a new, emerging area of scientific and technological change has come to the attention of decision makers around the globe: the "converging technologies" of nanotechnology, biotechnology, information technologies, and cognitive science (NBIC). Many observers anticipate radical and pervasive changes as NBIC developments, which "converge" at the scale of nanometers where biological, mechanical, and electrical systems can all interact, are applied to enhancing human abilities. They also anticipate significant social change as these technologies deploy throughout society, and they are very concerned about public reactions to these developments.

The NCTF organized by CNS-ASU on nanotechnologies and human enhancement involved the full participation of seventy-four ordinary citizens in six locales across the country. Those locales were: the University of New Hampshire (Durham), Georgia Institute of Technology (Atlanta), the University of Wisconsin (Madison), the Colorado School of Mines (Golden), Arizona State University (Tempe), and the University of California (Berkeley). This organization provided citizens' panels from one site in New England, one in the Southeast, one site in the Midwest, one in the Mountain West, one site in the Southwest, and one on the West coast. The study thus represents not one sector of the country but rather a truly national scope.

Panelists were recruited in each locale, using newspaper and internet advertising. Sites attracted varying numbers of volunteers, each of whom was offered $500 if they completed all elements of the NCTF, and CNS took significant care to create panels that were broadly representative of the communities from which they were drawn. The overall demographics are strongly suggestive of the nation's diversity if not fully statistically representative of it.

CNS-ASU prepared a 61-page background document, delivered to each panelist prior to the first face-to-face (F2F) meetings. The document describes the emergence of NBIC technologies and current debates about their possible social impacts. Authored and vetted by CNS researchers, the background document was also vetted by outside overseers Ida Andersen of the Danish Board on Technology and David Rejeski, director of the Project on Emerging Technologies at the Woodrow Wilson International Center.

During the first weekend of the project, citizens gathered in each locale for face-to-face (F2F) discussions that facilitators from each of the campuses led. These discussions were all video taped. The panelists discussed the background materials, the structure and goals of the project, and began to raise whatever concerns or issues they found significant. In this sense, the panelists had control of the agenda.

After the first weekend, the citizens from all six sites joined together for nine two-hour, synchronous online discussion sessions (which replaced the traditional "middle weekend" of the Danish practice). During these Internet, or keyboard to keyboard (K2K) sessions, therefore, citizens from each site were exposed to the concerns, interests, values, and perspectives of their counterparts at all the other sites. In addition, five content experts joined in online sessions to respond to questions developed by the citizens. The content experts were:

- Roberta M. Berry, J.D., Ph.D., Associate Professor of Public Policy and Director, Law, Science and Technology Program, Georgia Institute of Technology
- Stephen Helms Tillery, Assistant Professor, Harrington Department of Bioengineering and Assistant Professor of Kinesiology, Arizona State University
- Maxwell J Mehlman, Arthur E. Petersilge Professor of Law and Professor of Bioethics, School of Medicine; Director of the Law-Medicine Center, Case Western Reserve University
- Kristen Kulinowski, Executive Director, Center for Biological and Environmental Nanotechnology, Rice University

- Jason Scott Robert, Ph.D., Assistant Professor, Department of Basic Medical Sciences, The University of Arizona College of Medicine and Assistant Professor, School of Life Sciences, Arizona State University

The citizens gathered for a second F2F weekend, during which they reconsidered the issues, problems, and concerns they had expressed during the first weekend in the light of the additional information and discussions provided by the Internet sessions. Working with a facilitator, they then deliberated to a set of policy recommendations that they all felt comfortable endorsing and including in their site's final report.

While the panelists at each site had been exposed to the concerns and issues panelists at the other sites thought were important, there was no effort to reach a single consensus across sites; thus, each site worked independently in reaching its recommendations and in writing its final report. Nevertheless, when we compare the final reports, we find significant overlap among all six sites in the areas they thought were of particular concern, including:

- Regulatory adequacy (6 out of 6 sites); Panelists at all six sites expressed significant concern about effective regulation of these new technologies. Some sites recommended creating a new regulatory agency charged with managing these technologies, while others recommended strengthening the US Food and Drug Administration.
- All six sites strongly endorsed programs intended to keep the public informed about human enhancement technology developments, including more deliberative panels and enhanced high school and K-12 education.
- Access & equity (5 out of 6 sites); Nearly all the sites include recommendations that enhancement technologies be made available on an equitable basis to those who need them most.
- Funding accountability (5 out of 6 sites); Nearly all the sites recommended that funding be directed primarily at the treatment of disease before enhancements, and that stakeholders should have a say in research decisions.
- Safety (5 out of 6 sites); Nearly all the sites included recommendations for the careful monitoring of enhancement technologies, and for the development of international safety standards for these technologies.
- Entrepreneurship & development (5 out of 6 sites); Nearly all the sites included recommendations that the development of these technologies should maximize their benefit, and that both public and private investment in these technologies is critical.
- Ethical consideration (4 out of 6 sites); A majority of the sites recommended that ethicists and ethical considerations should be a formal part of decision-making about these technologies.
- Privacy (4 out of 6 sites); A majority of the sites recommended that individual privacy be carefully protected in the development and deployment of enhancement technologies.
- Health insurance (4 out of 6 sites); A majority of sites recommended that health policies should cover enhancements and remediation that are deemed medically necessary, and that physicians should provide information on alternatives to enhancement technologies.
- Military uses (3 out of 6 sites); Half the sites expressed concerns that enhancement

technologies might become tools for terrorists, or might be imposed on military personnel without their consent.
- Environmental impacts (3 out of 6 sites); Half the sites included recommendations that enhancement technologies be carefully tested for environmental impact, toxicity, and stress on planetary resources.
- Rights (3 out of 6 sites); Half the sites included recommendations that human enhancement technologies not violate civil liberties or the rights of individuals to refuse their use.

In addition to the reports, the NCTF generated a large amount of pre- and post-test data. Available analyses suggest the following findings:
- Participants strongly supported the findings of their groups, with only one person disagreeing "that the recommendations contained in the final report accurately reflect my individual preferences;" and only two "objecting to many of the major points in the report;"
- The main effect of deliberation was that it produced (informed) opinions (i.e., greater % holding an opinion).
- Deliberation sometimes failed to alter attitudes, but it resulted in polarizing divergent emotions, e.g., after the NCTF, 67% of respondents were worried "only a little" about nanotechnology, while 54% were "very hopeful" about nanotechnology.
- Opinion change after deliberation was often, but not always, in the direction of increased risk perceptions.
- Deliberation led to more reserved policy preferences.
- While both F2F and K2K deliberations were unfamiliar to participants, they did find F2F preferable in the post-test.
- Overall, women were less inclined to support human enhancement, and deliberation increased the difference between men and women in terms of support for human enhancement.
- After the NCTF, 28% of respondents felt the risks of nanotechnology would outweigh the benefits, 23% felt the risks and benefits would be about the same, and 46% felt the benefits would outweigh the risks.
- After the NCTF, respondents did not feel particularly confident that either the government or the private sector was capable of protecting them from the risks of nanotechnology, although they had somewhat greater confidence in the government.
- Overall, both before and after the NCTF, respondents disagreed significantly with the statements "I can contribute to science and technology policy decisions"; "Scientists understand my values"; and "Scientists would treat me with respect". After the NCTF, respondents were, overall, a bit more favorable regarding scientists treating them with respect, but even less confident that they could contribute to science and technology policy decisions.

The NCTF team, led by Hamlett, is currently composing its summary report, and Cobb and various team members at the participating institutions are engaged in data analysis.

Connection to Anticipation, Engagement, and/or Integration.

RTTA 3/1 Scenario Development, through the NanoFutures site as well as through scenario development workshops highlighted in RTTA 4 activities, is the primary anticipatory activity at CNS. InnovationSpace also contributes to the goal of anticipation by imagining and then rendering as concrete as possible – in the form of disclosable inventions – visions of nanotechologies. Like the RTTA 2 surveys but in a more intensive fashion, the RTTA 3/4 NCTF contributes to anticipation by contributing an empirical understanding of what citizens understand, feel, and expect of nanotechnologies in preparation for any particular ones that might develop.

RTTA 3/4 NCTF is the primary engagement activity of the Center, but RTTA 3/1 and 3/2 have important engagement activities. NanoFutures reaches out to involve many different publics, including a generalized one of ASU alumni/ae, to involve them in thinking about nanotechnologies. InnovationSpace has, as part of its research methodology, intensive contact with potential users of its technologies.

RTTA 3/1 Scenario Development contributes to integration through the necessary collaboration of social scientists and NSE researchers in the vetting process of the scenes.

Contribution to E2E, "ensemble-ization" or other center-wide activities.

RTTA 3/1 worked with TRC 2 to develop and validate scenes related to human enhancement, identity, and biology research.

RTTA 3/4 worked with TRC 2 and the E2E project to incorporate questions into the pre-test and post-test for the NCTF regarding the application of NSE research to neuroscience and brain research and to analyze the resulting data for inclusion into the E2E project.

RTTA 3/2 worked with TRC 2 and the E2E project to developed a number of projects addressing themes of human enhancement, identity, and biology and, more specifically, the application of NSE research to the brain.

Connection to Education, Training, and Outreach.

Research in RTTA 3 is contributing to the development of a number of graduate theses, including Lidberg (2008; CriticalCorps), DiNapoli (NCTF), and Hays (NCTF).

RTTA 3/4 NCTF succeeded in transferring expertise from Hamlett to a set of facilitators and researchers in six sites in the details of conducting such forums.

The scenarios developed in RTTA 3/1 are the locus of a great deal of outreach and educational experiences, from their integration into a number of courses at ASU to the activity generated on the NanoFutures site, to the second level of interest generated by the invitations to the site themselves. Among other interactions, Selin met, in Sep 07, with the Exploratorium's Veronica Garcia-Luiz, who was interested in the procedures CNS used to vet

its scenes and how to sustain methodological integrity when creating and presenting scenarios, which NISE Net uses to frame the conversations and instigate debate in its public "Forums." Selin had follow-up conversations about integrating vetting procedures into the Forum in November 2007 with Troy Livingston, Vice President for Innovation and Learning Museum of Life and Science in Durham, NC, who is also a project lead on the Forums project. Livingston has also expressed interest in using CNS as a sparring partner and using the NanoFutures scenes in their nationwide Forums.

RTTA 4: Reflexivity Assessment and Evaluation

Personnel – faculty and senior participants

Erik Fisher, RTTA 4 leader (ASU, assistant research professor, CSPO)
Elizabeth Corley (ASU, associate professor, Public Affairs)
Kevin Corley (ASU, assistant professor, Carey School of Business)
Dave Conz (ASU, assistant research professor and lecturer, CSPO and Bachelor of Interdisciplinary Studies)
Anne Schneider (ASU, professor, Political Science)
Cynthia Selin (ASU, assistant research professor, CSPO)
Jameson Wetmore (ASU, assistant professor, School of Human Evolution and Social Change)

Personnel – graduate students (3), undergraduate students (2), post-docs (1)

Derrick Anderson (ASU, management intern, CSPO)
Ira Bennett (ASU, post-doctoral trainee, CSPO)
Monamie Bhadra (ASU, doctoral student, Political Science)
Manuel Garay (ASU, doctoral student, Education)
Aixa Garcia-Mont (ASU, master's student, Education)
David Renolds (ASU, undergraduate, Chemical Engineering)

Goals. RTTA 4 attempts to understand how the knowledge generated by CNS-ASU influences the values and choices made by NSE researchers and others, and to assess and evaluate the impact of CNS-ASU activities more generally. Its focus is the integrative activity that CNS-ASU performs with NSE researchers. Projects under the RTTA 4 rubric include: annual interviews with collaborating NSE researchers, exit interviews with graduating affiliates, and qualitative evaluations of co-curricular and workshop activities involving integration and reflexivity as key goals; laboratory studies and engagements, including the Photon project, the Tubes in the Desert project, and scenario development projects; co-curricular activities including the DC Summer Session; and a small number of other projects about the role of societal aspects of nanotechnologies and reflexive knowledge more generally.

Research Accomplishments and Plans.

In order to assess the influence of the Center's activities on the NSE researchers with whom we collaborate, we implement an interview protocol annually each May/June. This protocol

has focused on the knowledge, identity, and practices of our collaborating scientists, particularly around their understanding of the societal aspects of their work. We conducted baseline research in Sp 06 and the first subsequent round in Sp 07. The Sp 08 interviews are currently being scheduled.

Findings from the Sp 07 include reports of higher familiarity and involvement with CNS-ASU among senior faculty and graduate students, but less on both dimensions among junior faculty and post-doctoral trainees. For both senior faculty and graduate students, the high levels of familiarity and involvement are associated with noted changes in knowledge and emergent changes in practice. Interviews are also conducted before and after co-curricular activities like the DC Summer Session organized for NSE graduate students in the Biodesign Institute and the Fulton School of Engineering in Jun 08. These interviews indicate students involved become more comfortable and sophisticated in talking about the societal aspects of their work after the activity.

CNS-ASU has created a set of laboratory studies and engagements. These studies are not traditional laboratory ethnographies, but rather efforts to integrate social science and humanities with NSE research. In previous years, we reported on efforts of Wetmore and McGregor in the Woodbury lab, and of Fisher in the Center for Integrated Nanotechnologies (CINT) in the Department of Energy's Sandia and Los Alamos National Laboratories.

In the current reporting year, the integrative lab studies and engagements include:

- The Photon project, in the Lindsay lab;
- Tubes in the Desert, in Biodesign;
- Medical Diagnostics, with the Johnston lab in Biodesign; and
- International comparisons planned for the future.

In the Photon project, CNS-ASU collaborates with the Center for Single Molecule Biophysics, directed by Lindsay, on a $1.1 M NIRT award that asks if DNA can be used to self-assemble complex photonic and electronic structures? In this study, Fisher fulfills roles as an observer, facilitator and member. He attends lab meetings and interacts with the four co-PIs and 14 other group members who cover a wide interdisciplinary space. A significant part of the project's framing is derived from RTTA 1/2 Public Value Mapping, and from Fisher's on-going work about the possibility of mid-stream modulation of research practice. Fisher organized a workshop in Apr 08 meant specifically to explore the relation of public values to the Lindsay group's research. The workshop brought the lab members in contact with several experts in energy, policy, and values. Preliminary results from the workshop include observations by the NSE faculty involved that it led to "breakthrough" and "useful" ideas and by the graduate students involved that it provided new perspectives on the potential value of their work for practical applications beyond the laboratory. The lab participants desired more such interactions, expressing a desire to meet quarterly on the public values agenda. Graduate students repeatedly expressed an interest in hearing their professors discuss the broader dimensions of the research projects to which they contribute.

In the Tubes in the Desert project, CNS-ASU collaborates with a major use-inspired research project in the Biodesign Institute, performed in collaboration with British Petroleum. The

purpose of the Tubes in the Desert project is to pilot a system for producing biofuels that uses genetically modified cyanobacteria. The project is currently staged into a roof-top demonstration (in process) and a large-scale implementation. CNS-ASU's role is co-funding Conz and Bhadra to observe the project, interact with project members on relevant societal aspects, and perform research on aspects of the project including potentially conflicting goals between Biodesign and BP and comparisons with similar projects at ASU's Polytechnic campus. To date, Conz and Bhadra have successfully embedded themselves in the project (including representation on the overall project organization chart), conducted a number of interviews with principals in the project, attended project meetings, and planned research and intervention activities including a survey of public attitudes, comparative case analysis with the Polytechnic project, and a societal implications workshop with Biodesign personnel.

The Medical Diagnostics project, run by Selin, is also affiliated with RTTA 3/1 Scenario Development. In this project, CNS-ASU collaborated with Stephen Johnston and other colleagues at the Biodesign Institute in a two-day scenario development workshop held in Nov 07 that identified and explored four future visions for the "doc-in-a-box" pre-symptomatic medical diagnostic technology that Johnston's lab works on. Workshop participants identified a large number of potential issues involved, including issues of privacy and security, affordability and access, the location of decision-making, new taxonomies of health and wellness, the importance of first applications and path dependence, and the outstripping of treatment capacity by diagnostic capacity. In addition to the production of the scenarios themselves and a report (Selin 2008), outcomes of the workshop included:

- One graduate student who participated in the workshop who took the dilemma of detecting diseases without offering cures so seriously that she changed her research from diagnosing an exotic disease to a more common infectious one.
- Insights by scientists involved into
    - the "political implications and social backlash" of use of the technology;
    - the importance of looking "at the impact of the technology early in the development;"
    - the role that stories had in helping elucidate "the connections between decisions made early in the development process and outcomes."

Nearly all the participants valued the "unique variety of perspectives" and the way a "diversity of participants" could sustain a rich dialogue. Selin and Johnston plan additional scenario workshops around the topic of cancer vaccines in the coming year.

As part of future plans for RTTA 4, Fisher has submitted a proposal on "Socio-Technical Integration in Research" to NSF. It received a strong revise and resubmit (E/VG/VG/VG) and he will be resubmitting it for the 1 August deadline. The proposal would fund a set of comparative, international, interventionist-oriented ethnographies between ASU and laboratories in the Netherlands, Spain, India, and Chile.

RTTA 4 is involved in the development of co-curricular activities meant to integrate societal aspects of nanotechnology into the education of NSE research students. The principal activity in the reporting year was the DC Summer Session "Science Outside the Lab: A Policy Dis-Orientation," reported on in the Education section.

RTTA 4 also involves a set of additional research projects that investigate the role of societal aspects of nanotechnologies and reflexive knowledge more generally, including:

- research by Garay, under the supervision of Fisher, on the nature of societal aspects of nanotechnology research and integration at the Nano-scale Science and Engineering Centers (NSECs), leading to a poster at the upcoming Gordon Research Conference on Science and Technology Policy;
- research by Garcia-Mont, under the supervision of Conz, on the knowledge, practice, and identity of Hispanic and Latino/a NSE researchers, leading to a journal manuscript in preparation;
- research by Schneider on the content of "criterion two" justifications in NSE proposals to NSF, still underway.

Connection to Anticipation, Engagement, and/or Integration.

The RTTA 4 activities of laboratory engagement and scenario development projects, and co-curricular activities all fall under the rubric of integration in that they (1) seek to introduce nanoscale scientists and engineers to explicitly normative concepts, discourse, and deliberations; and (2) seek to assist in their assimilation into NSE research practices and education. Several of these activities, including the Photon workshop, Medical Diagnostics workshop, and aspects of the IPNS program used anticipatory concepts and techniques, including scenario development, multi-path road mapping, and science fiction writing. Several combined aspects of engagement as well: the Photon workshop included the participation of Rahi Khan from the Loka institute, who described the potential interest and roles of citizens with respect to decisions about science.

The Medical Diagnostics workshop built upon the NanoFutures project by utilizing a technical scene as the object of deliberation and focus of scenario development.

Contribution to E2E, "ensemble-ization" or other center-wide activities.

RTTA 4 works with TRC 2 and the E2E project to find effective means of building communication between E2E and scientists and users working to apply NSE research to neuroscience and the brain.

In addition to providing a means to showcase the Center's intellectual and bridging capacities, the Medical Diagnostics workshop's utilization of foresight methodologies, coupled with the purpose to integrate social science research into the lab, utilized the unique competences of the Center as an integrative whole.

Connection to Education, Training, and Outreach.

The co-curricular activities and workshops used as methods in RTTA 4 are important aspects of education and outreach.

The integrative activities also contribute to the education and training of NSE students as potentially more reflexive researchers.

Thematic Research Cluster (TRC) Programs

TRC 1: Equity and Responsibility

Personnel – faculty and senior participants

Susan Cozzens, TRC 1 co-leader (GA Tech, Public Policy)
Jameson Wetmore, TRC 1 co-leader (ASU, Human Evolution and Social Change)

Personnel – graduate students (1), undergraduate students (1), post-docs (0)
Walter Valdivia (ASU, Public Affairs)
Tobie Milford (ASU, Biology & Society/Religious Studies/Barrett Honors College)

Personnel – post-doctoral trainees

Goals. The goals of TRC 1 Equity and Responsibility are research ways that the concepts of equity and responsibility are being applied in the context of the development of NSE and to explore ways to ensure that NSE can contribute to equity and responsibility as public values. These concepts include concerns about equity in the distribution of the conduct of NSE research as well as in the distribution of risks and benefits from consequent innovations, both domestically and internationally. They also include concerns about NSE researchers can behave responsibly toward such concerns.

Research Accomplishments and Plans

The Thematic Research Cluster (TRC 1) on Equity and Responsibility began its own work in Su 07 and has simultaneously ramped up its efforts to integrate with other CNS activities. Led by Cozzens (GA Tech) and Wetmore (ASU), TRC 1 has begun two major projects that are already generating results and beginning to interact with other projects.

The first major project is the beginning of a series of dialogues among religious thinkers and nano-scientists hosted at ASU in Sp 08. A minefield of theoretical and practical challenges exists to creating a productive dialogue among representatives from these two groups, TRC 1 prepared for these workshops by through a number of preparatory meetings that tapped other expertise at CNS to help identify and navigate through these issues. Data generated in other areas of CNS, e.g., the polling data from RTTA 2 and several of the RTTA 3 scenes as well as the background document from the National Citizens' Technology Forum, were used to inform the first of these dialogues. Milford (2008) derived his undergraduate honors thesis from the workshop, arguing that other kinds of attempts at public engagement over nanotechnologies, including NanoJury UK, are often rather "flat" in their approach to issues, lacking both focus and diversity in their attempts to get at representativeness and, to some extent, credibility. They also are overwhelming concerned with more practical issues of environmental health and safety and less concerned with issues more closely associated with ethics and morality. The new model for nano-engagement thus established in the dialogue on nano and religion a situation in which: religion and nano were provided an equal footing, a specific area (of brain-machine interfaces) became the focus within nano; and scientists were

treated as concerned citizens and participants and not as expert panelists. Participation by individuals included: a religiously unaffiliated bioengineer/neuroscientist, a Lutheran physicist, an unaffiliated retired neurosurgeon, a Latter-day Saints biophysicist, a Catholic undergraduate, a Muslim-raised philosopher, a Christian chemistry graduate student, and a Buddhist-raised CSPO graduate student. The dialogue that emerged encouraged the expression of both religious and non-religious views and values, enabling the expression of a diversity of opinions and of ethics, values and societal outcomes as well as of risks and safety issues. Most importantly, the dialogue identified two areas of interest that have not received much attention from other forums: first, the notion of suffering, its role, and its alleviation (or not) as a central concept for some religious perspectives; and second, the role of ritual as a social technology and the role of technology in simulating religious ritual and experience. While there are difficulties in this model of engagement, notably in its interaction with a policy environment that often demands representativeness and statistical power as the coin of the realm, the role of such dialogues in creating wisdom and setting agendas may be important to an anticipatory governance agenda.

The second major project is planning a pair of workshops to be held in AY 08-09 and the consequent third volume *Yearbook of Nanotechnology in Society*. In its very early stages, the project will use the workshops to help scholars throughout CNS reflect on the variety of equity issues that nanotechnologies raise. The workshops will host a dozen or speakers who work in science, technology, and equity, ask them to present their latest research findings, and help us think through the new challenges that nanotechnologies raise.

Graduate student Valdivia, advised by Guston, is conducting research for a doctoral dissertation that straddles several programs but is motivated by the questions of equity that are central to TRC 1. His research begins with the observation that the last three decades of innovation policy in the US, which aims to boost the competitiveness of national industry, rests on at least three assumptions: The first assumption is that investments in research and development lead to technological innovation. The second assumption is that technological innovation is the only source of long-term productivity gains for high-income economies. The third is that the economic growth induced by increasing productivity trickles down to all sectors of the economy increasing overall industrial competitiveness. Valdivia's study reviews the literature that has defended the plausibility of the two former assumptions, the social contract for science and the endogenous growth model respectively. The research then turns to the empirical evidence that challenges those two assumptions, explaining the rupture of the social contract for science and the slow growth of high-income economies despite investments in R&D. This line of argument leads to a theoretical argument that takes issue at the third assumption, showing that sectoral disparities of productivity gains induced by innovation tend to perpetuate themselves as opposed to spilling over across productive sectors. The research further discusses how these uneven productivity gains induce wage differentials across sectors and within sectors. Finally, the research considers policy implications and examines some evidence of such implication from technology transfer policy and the governance of nanotechnologies and biotechnologies.

Connection to Anticipation, Engagement, and/or Integration.

The Dialogue on Nanotechnologies and Religion is an exemplar activity for cutting across the areas of *anticipation*, *engagement*, and *integration*. By involving lay-citizens and scientists deliberating together, it serves both the engagement and integration agendas well. By locating areas of interest that other public engagement activities have overlooked, e.g., the role of suffering, it serves the anticipatory goal of providing a perspective on an emerging issue that may help a variety of decision makers understand public reactions when, or before, they occur.

Contribution to E2E, "ensemble-ization" or other center-wide activities.

TRC 1 team has been developing a number of additional activities with other CNS members and groups. Specifically, the TRC 1 group:

- Developed two vetted scenes from RTTA 3 to help bring focus to issues of equity that might otherwise be missed into discussions. These elaborated scenes were being reviewed by TRC 1 and RTTA 3 personnel prior to their use in the background material for the NCTF. (Valdivia had been planning to use them to engage with NSE researchers during the Jan 08 US-India Institute, but his time was cut short there by organizational difficulties beyond his control and he was not able to use them.)
- Coordinated with Scheufele and Corley the introduction of questions that pertain to equity in the upcoming public opinion survey (RTTA 2/1). The TRC 1 team will initiate exploratory research into the perceptions of inequalities (descriptive) and equity (normative) as the various publics surveyed react to advances and commercialization of nanotechnologies. These questions are being prepared to fit the broader research designs of RTTA 2 and TRC 1 itself.
- Worked with TRC2, RTTA 2, RTTA 3, and the E2E project to develop and analyze questions for the NCTF and develop questions for the second national survey instrument to be fielded in 2008 regarding the equity implications of human enhancement.
- Plans to use the survey questions and elaborated scenes to probe reactions from nano-scale scientists engineers. More specifically, the TRC 1 team will discuss with RTTA 4 the possibility of amending its interview protocol to include reference to these questions and scenes for comparison to the surveys.
- Through graduate student Valdivia is participating in two projects that span RTTA 1 activities. The first one corresponds to RTTA 1/2 Public Value Mapping. In collaboration with RTTA 1/2 leader Bozeman and a larger group of researchers on PVM not involving CNS, Valdivia is examining US technology transfer policy to establish the degree of correspondence between the public values predicated by the policy and those effectively advanced by it. Under the TRC 1 frame of equity, the focus on public values focus of this study includes market concentration and knowledge diffusion. This study will closely examine two technologies patented in the last 10 years, in order to shed further light into the soon to be patented nanotechnologies. The second project relates to RTTA 1/3 Workforce Assessment. In collaboration with Cozzens, the study will build upon ongoing research regarding excess demand of the NSE labor market. Instead of the regional focus of RTTA 1/3,

this paper will examine trends and general mechanisms by means of which social inequalities are generated under these conditions in the labor market.

Connection to Education, Training, and Outreach.

- TRC 1 was centrally involved in guiding the undergraduate honors thesis of Milford (2008) and in planning the doctoral dissertation of Valdivia (in progress).
- TRC 1 is working to assure that issues of equity and responsibility are integrated into other education projects sponsored by CNS-ASU, e.g., the Jun 07 "Policy Disorientation" summer session featured ethicist Rosalyn Berne for a day and a half and discussed issues of equity on a number of occasions. Equity and nanotechnology has also been by introduced using the debate between Salamanca-Buentello et al. and Invernizzi and Foladori in POS 598 Science, Technology & Societal Outcomes; ASB 394 Technology and Society; and the Sp 08 Learning Community. The debate is also included in Wetmore (2008).

TRC 2: Human Identity, Enhancement, and Biology

Personnel – faculty and senior participants

Jason Robert, TRC 2 co-leader (ASU, associate professor, School of Life Sciences)
Linda Hogle, TRC 2 co-leader (out-going) (Wisconsin, associate professor, Medical History and Bioethics)
Joan Fujimura, TRC 2 co-leader (in-coming) (Wisconsin, professor, Sociology)
Clark Miller (ASU, associate professor, Political Science)

Personnel – graduate students (4), undergraduate students (6)

Parul Agrawal (ASU, master's student, Materials Science and Engineering)
Shannon Conley (ASU, doctoral student, Political Science)
Sean Hays (ASU, doctoral student, Political Science)
Natalie Porter (Wisconsin, master's student, Anthropology)
Derrick Anderson (ASU, management intern, Political Science)
Rehman Anjum, (ASU, undergraduate, Biology)
Nejra Dobric (ASU, undergraduate, Biology)
Tobie Milford (ASU, undergraduate, Biology & Society/Religious Studies)
Erica Spiro (ASU, undergraduate, Biology)
Ania Zwolinski (ASU, undergraduate student, Political Science)

Goals. The goal of TRC 2 Human Identity, Enhancement and Biology is to investigate the historical, philosophical, cultural, and political dimensions of the interactions between human biology and human values in the context of new nanotechnologies.

Research Accomplishments and Plans.

In May 2007, under the leadership of Robert, co-leader of TRC2, and Miller, co-PI and Associate Director of Education and Outreach, CNS-ASU launched its first center-wide "End-to-End" (E2E) initiative, focused on the application of nanoscale science and engineering to neuroscience and the human brain. The objective of the E2E initiative is to pilot test the full scope of real-time technology assessment as a research tool for anticipatory governance of new and emerging technologies. E2E involves research and researchers from all aspects of the center, including all four RTTA projects and both TRCs. The initiative will prepare a synthesis report by summer 2009, as well as peer-reviewed journal articles.

The E2E project addresses core questions of human identity, enhancement, and biology central to TRC 2, using data and analyses produced by each of the RTTA projects of the Center. The work proceeds from the prior interest and research of Robert in neural prosthetics research, where advances in micro-scale devices allow for signal exchange and neuron stimulation between mechanical-electrical prosthetics and brain functioning. This emphasis offers a number of unique advantages for the E2E project.

- NSE is increasingly emphasized as a potential research tool to create advanced neural prosthetics.

- NSE also has potential application to further advancement of neuroscience in brain imaging, neural functioning, and mental health therapies.
- The relatively early stage of NSE application to neuroscience will enable the development of RTTA capabilities in parallel with the emergence of new research directions – a key element of anticipatory research.
- Perhaps most importantly, NSE application to the human brain – leading to treatments for debilitating diseases or to cognitive enhancement – has a high probability of significant, long-term moral, ethical, and societal implications that call for substantive social science research.

The E2E project has made substantial progress since its inception, including:

- With RTTA 1, the creation and preliminary analysis of a database of 1739 nano-neural research publications in the period 1990-2006 from Web of Science, Compendex, and INSPEC.
- With RTTA 1, E2E has also identified, generated, and analyzed subsets of records within this database focused on aspects of nano-neural research of interest to TRC 2, including publications on cochlear research, biocompatibility, neuroscience, and neural nets and artificial intelligence (which was completely unexpected by TRC 2 but of considerable interest to Hays, a graduate student researcher pursuing his PhD dissertation on the political theory of human enhancement and artificial intelligence).
- With RTTA 2, the creation and preliminary analysis of a database of 850 news and media articles covering the period 1990-2007 from Lexis/Nexis, including potentially valuable press releases that offer earlier indications of research trends than publication data.
- With RTTA 3, two substantive deliberative exercises – the National Citizens Technology Forum and the Nanotechnology and Religion Dialogue – each of which produced significant data on public perceptions of NSE application to neuroscience and the brain that has been preliminarily analyzed. In addition, RTTA 3 sponsored three Science Cafés on neural prosthetics and will sponsor a fourth in Fall 2008.
- With RTTA 4, initial collaboration regarding the integration of E2E work and NSE research, including hosting meetings with relevant NSE and neuroscience researchers and research subjects and the involvement of NSE researchers in E2E projects.
- With RTTA 2, RTTA 3, and TRC 1, the development of a national public opinion survey instrument that will be fielded in late spring / early summer 2008.
- Working with TRC 2 researchers and scientists at Biodesign, RTTA3 developed and vetted a scene for a nano-neural interface technology entitled “Sleep,” which was subsequently used in the National Citizens Technology Forum, Innovation Space, and the Nano Futures project, and is being considered for inclusion on the website of the Nanoscale Informal Science Education Network (NISE Net).
- The creation of a database of NSF research grants on NSE application to neuroscience and brain research.
- A historical analysis of the development of cochlear implant technologies and the ethical, legal, and societal implications that have accompanied their use to cure deafness – as well as a detailed analysis of NSE research applied to cochlear research.
- A preliminary literature review of the application of NSE for delivery of drugs across the blood brain barrier.

- A preliminary analysis of the current state of NSE application to neural prosthetics research.

Plans for the second year of E2E research include:

- With RTTA 1, refining of NSE-Neuroscience publication database based on an expanded list of appropriate search terms; full-scope analysis of the refined database to fully specify the research and innovation activity occurring in the application of NSE to neuroscience and brain research; and additional targeted identification and analysis of relevant subsets of NSE-Neuroscience research.
- With RTTA 2, full-scope analysis of media database and fielding of national public opinion survey (N=600) and analysis of survey data.
- With RTTA 3, full-scope analysis of public deliberation data from the National Citizens Technology Forum (NCTF), as well as the design of deliberative focus groups to explore questions raised by the NCTF data regarding public attitudes about brain implant technologies.
- With RTTA 4, further integration of science and engineering researchers into E2E activities, as well as the development of methods and approaches for assessing the long-term impact of E2E research.
- Compilation of a substantial report reflecting an initial, integrated RTTA of the application of NSE to neuroscience and brain research.

In a separately organized TRC 2 project, graduate student Porter – under the direction of co-leader Hogle at Wisconsin, completed a project entitled "Nanotechnology as a Response to Viral Infectious Outbreaks: Reconceptualizing Risk, Infection and Public Health Responses." In accord with TRC 2's goal of investigating the institutional and political dimensions of the interactions between human biology and human values in the context of new nanotechnologies, Hogle and her trainees have examined emerging institutions and practices as scientists, politicians, engineers, clinicians, public health providers, business executives, users and others create new networks of activity around various nanotechnology applications. Porter has contributed to this theme by examining the way public health institutions – both global and local – may be transformed with the advent of nanomedicine. Specifically, she chose three technologies: nanoscale vaccines, nanoviricides, and point-of-care diagnostics and the threat of pandemics. She focused on avian flu to illustrate the issues because of the potential scale of both risks and interventions, and the extent to which it stimulated intensive activities within both public health institutions and entrepreneurial nanotechnology organizations.

Porter was able to interview key personnel in several agencies and companies, and she compiled a significant bibliography. Her findings describes the ways that concepts of risk, infectivity, and appropriate infection control by various public health authorities are intimately connected to the assumptions upon which nanotechnological approaches to infection are based. Moreover, plans for distribution, management, and networking of transnational health organizations will very likely be impacted by the advent of nanotechnologies. In particular, the delivery methods that nanotechnologies may make possible will dramatically change the way resource-poor countries manage programs for treatment and prevention, and the possibility of point-of-care diagnostics creates a new

scenario for the sensing of not only viral agents like avian flu, but also a range of biological toxins and infective agents as well.

Connection to Anticipation, Engagement, and/or Integration.
The E2E initiative is a prototype for the design of an integrated suite of RTTA capacities that can provide anticipatory insights into the development and societal implications of new and emerging technologies. E2E has developed, to date, preliminary insights into:

- Research and innovation developments in NSE application to neuroscience and brain research, including the scale and scope of research, publication, and grant activity in the field, as well as projections of scientific aspirations and detailed insights into specific sub-areas of research.
- Public attitudes regarding NSE application to neuroscience and brain research, as well as the character and impacts of public deliberation on this topic.
- Media coverage of NSE application to neuroscience and brain research.
- Potential analogous societal implications and concerns that may arise from neural prosthetics research.

The E2E project has also been integral to a range of engagement and integration activities in CNS-ASU:

- Human identity, enhancement, and biology was the central focus of the NCTF project, led by RTTA 3, and numerous aspects of NSE application to neuroscience and brain research were highlighted in the NCTF background document and process, including the participation of TRC 2 co-leader Jason Robert and ASU neuroscientist and bioengineer Steve Helms Tillery. E2E will continue its public engagement efforts in its second year.
- TRC2 and E2E have worked with Steve Helms Tillery and George Poste to begin integration of social and natural science research and plan to expand these efforts in the second year of the project. Three undergraduate students and one graduate student from the sciences and engineering participated actively in E2E research in the first year of the project.

Contribution to E2E, “ensemble-ization” or other center-wide activities.
The E2E project has served as a principal instrument of “ensemble-ization” of CNS-ASU activities across a broad range of center activities. Arguably, it is the first and largest center-wide activity undertaken to date and will serve as a model for additional center-wide “end-to-end” RTTA projects in the future. CNS-ASU participants in the E2E project from outside TRC 2 included: Cynthia Selin, Sean Hays, Michael Cobb, Patrick Hamlett, Alan Porter, Jan Youtie, Clay Karwisch, Dietram Scheufele, Elliott Hillback, Elizabeth Corley, and Jameson Wetmore.

Connection to Education, Training, and Outreach.
A key element of E2E has been the creation of an ongoing research seminar on *Nanotechnology, the Brain, and the Future* that has operated as a focal point for the training of both undergraduate and graduate researchers involved in the E2E project. This seminar met first in Spring 2008 and will continue throughout the 2008-09 school year. The seminar is taught by Jason Robert and Clark Miller and provides learning opportunities in the subject of

NSE applications to neuroscience, research methods in RTTA data collection and analysis, and research presentation and writing skills.

International Research and Collaboration

Personnel (Su 07):

Philip Shapira (GA Tech, Public Policy, faculty)
Jue Wang (GA Tech, Public Policy, doctoral student)
Li Tang (GA Tech, Public Policy, doctoral student)
Genevieve Maricle (Colorado, Environmental Policy, doctoral student)
Erik Fisher (ASU, CSPO, post-doctoral trainee)
Cynthia Selin (ASU, CSPO, post-doctoral trainee)
Walter Valdivia (ASU, Public Affairs, doctoral student)

Personnel (Su 08):

Philip Shapira (GA Tech, Public Policy, faculty)
Jue Wang (GA Tech, Public Policy, post-doctoral trainee)
Li Tang (GA Tech, Public Policy, doctoral student)
Erik Fisher (ASU, CSPO, assistant research professor)
Cynthia Selin (ASU, CSPO, assistant research professor)
Shannon Lidberg (ASU, Human and Social Dimensions of S&T, doctoral student)

Goals. Through an initial supplement from NSF's Office of International Science and Engineering (OISE), CNS-ASU has sponsored a number of research trips abroad, with priority going specifically to students and junior scholars. CNS-ASU has also hosted a number of international scholars. This section describes such international research and collaboration for the previous year and reports plans for the upcoming year.

Research Accomplishments and Plans.

RTTA 1 leader P. Shapira led GA Tech doctoral students J. Wang and L. Tang on a research trip to China in Su 07 to supplement the bibliometric and patent analysis performed in that program. One theme of this research, led by L. Tang, examines the patterns of scientific development in NSE in China and explores the role of research collaboration in facilitating China's emergence as a major international player in NSE research. A second connected theme, led by J. Wang, explores the relationships between NSE research and early commercial development in China. The research included twenty-four in-depth interviews with NSE researchers across sectors in Beijing, Shanghai, and Tianjin. Li Tang was invited to participate in the European PRIME winter nanotechnology workshop in France (Jan 08), and Shapira is engaged in planning an international colloquium on nanotechnology research and innovation in the UK for Fall 09.

University of Colorado doctoral student G. Maricle conducted a research trip to the United Kingdom to interview scholars and decision makers about the development of NSE research portfolios as part of a larger project to understand the role that scholarship in the social studies of science and technology plays in UK policy making. She interviewed scholars at Lancaster University, the University of Sussex, and Oxford University, members of the think tank

Demos, and policy makers in the UK Economic and Social Research Council and the Department for Environment, Food, and Rural Affairs. She also met with scholars at Oxford's James Martin Institute on Science and Civilization and participated in discussions on scenario planning and risk governance for nanotechnologies and other converging technologies.

ASU post-doctoral trainee E. Fisher traveled to Norway, Germany, the Netherlands, and Belgium to meet with colleagues who pursue agendas in the constructive technology assessment of nanotechnologies (CTA is the European analogue to RTTA). In Norway, Fisher participated in two workshops at the University of Bergen. In Karlsruhe, Germany, Fisher (2007) made a research presentation and acquired (through conversations and interviews with Ulrich Fiedeler, Joachim Schummer, Michael Dekker, Thorstein Fleischer., and others) a rudimentary comparative history of nanotechnology policy in Germany and the nature of technology assessment practiced by the Institute for Technology Assessment and Systems Analysis (ITAS). His presence encouraged two ITAS colleagues to visit CNS-ASU in 2007. He also provided Ulrich Fiedeler with editorial comments and guidance for a chapter in the *Yearbook of Nanotechnology in Society* (Fisher, Selin and Wetmore 2008). In Bielefeld, Germany, Fisher (2007) made a research presentation. He also had conversations with several scholars – including Wolfgang Krohn, Peter Weingart, Alfred Nordmann, and Hans Glimmel – about one of his papers [more specs?]. In Enschede, The Netherlands, Fisher worked with Arie Rip at the University of Twente on several publications, including a study of laboratory studies (Fisher and Rip in preparation) and a chapter (Rip & te Kulve 2008) for the *Yearbook of Nanotechnology in Society* (Fisher, Selin and Wetmore, 2008). In Den Haag, The Netherlands, Fisher (2007) presented his research. He also interviewed Rinie van Est, Anouschka Versleijen, Bart Walhout, and others about the history of nanotechnology policy in The Netherlands and the nature of technology assessment at the Rathenau Institute. He also met with Daan Schuurbiers, which directly led to Schuurbiers directly incorporating Fisher's method of midstream modulation into his PhD thesis (Schuurbiers forthcoming); Schuurbiers subsequently received a grant from the Netherlands to spend six weeks at CNS-ASU to study with Fisher and refine this work. In Leuven, Belgium Fisher (2007) presented his research. He also worked with Michiel van Oudheusden, Johan Evers, and Lieve Goorden on their chapter for the *Yearbook of Nanotechnology in Society*. The meeting led to a visit from van Oudheusden to the CNS-ASU in 2007 and to a paper by van Oudheusden and Evers for a special issue of *Science and Engineering Ethics* (Fisher and Bird in preparation). Fisher met with Tsalling Sweirstra and others to discuss the emerging concept of nanoethics.

ASU post-doctoral trainee C. Selin traveled to the United Kingdom and Denmark to meet with colleagues who also work on nanotechnologies and the future. In the UK, she consulted with colleagues including Angela Wilkinson at the James Martin Institute at Oxford University and attended a Workshop on The Future of Converging Technologies. In Denmark, she met with Maja Horst, as associate professor at the Copenhagen Business School's Institute for Politics, Philosophy, and Management to discuss a project on "Funding Futures" that culminated in a seed grant application to ASU's Office of Global Engagement to study the effects of international scientific mobility on the prospects of governing emerging technologies. In Denmark, Selin also met with Dr. Mickey Gjerris of the Danish Centre for Bioethics and Risk Assessment to discuss the ethics of nanotechnology and the role of the

future in ethical debate, and with Dr. Christian Vintergaard, Managing Director at Øresund Entrepreneurship Academy, regarding a co-authored paper in progress about using scenarios to evaluate new ventures.

ASU doctoral student W. Valdivia traveled to Turkey and the Netherlands for research and collegial interactions associated with is research on nanotechnologies, equity, and development in the context of TRC 1 Equity and Responsibility. In Istanbul, he met with ResIST, a group of researchers funded by the European Commission and led by Oxford University in studying the relationship between science and technology policies and social inequalities. Valdivia also consulted with a number of senior colleagues who have written on principal-agent theory, a method he intends to use in his dissertation. He further attended a course (for which he had been granted a fee waiver and lodging expenses) organized at Delft University on communication and bio-nanotechnologies. In addition to the ResIST group, Valdivia's trip included meetings with the following colleagues: Steve Rayner (Oxford University), Ruud Smits (Utrecht), Arie Rip and Barend van der Meulen (University of Twente), Lieve Goorden and Marian Deblonde (Universiteit Antwerpen), Martina Merz (Universitat Luzern), Dietmar Braun and Alain Kaufmann (Université de Lausanne), and John Adams (University College London).

During the reporting year, CNS-ASU hosted the following international visitors:

- Daan Schuurbiers (Delft University of Technology, the Netherlands, doctoral student);
- Michiel van Oudheusden (University of Antwerp, Belgium, doctoral student);
- Brice Laurent (Ecole des Mines, France, doctoral student);
- Maja Horst (Copenhagen Business School, Denmark, associate professor);
- Torstein Fleischer (ITAS, Germany, researcher);
- Rene von Schomberg (European Commission RD-G, Brussels, program officer);
- Krsto Pnzda (Leeds University Business School, UK, visiting researcher).

The visits varied in length of stay, ranging from a few days to several months, but in each case, the visitor provided a lecture or seminar on his or her work related to nanotechnology in society and met intensively with CNS-ASU researchers. In many instances, the beginnings of collaborations have been formed.

In Su 08, Shapira, Wang and Tang plan to reprise their trip to China to further refine their approach to the two research themes described above. In particular, Tang will focus on the role of China-US research collaborations and exchanges, and Wang will expand geographic attention to commercialization of NSE from northeastern China (Beijing and Shanghai) to southern China (Guangdong province).
In Su 08, Selin and Valdivia plan to meet with Guillermo Foladori (Zacatecas, Mexico), a member of the International Nanotechnology and Society Network and a founder of a network of nano-in-society researchers in Latin America to prepare to take the NanoFutures project "south" by translating it into Spanish and distributing it through Foladori's network.
In Su 08, Lidberg plans to meet with officials and scholars in India to discuss the role of Indian design policy – instituted in Feb 07 – and its relationship to emerging technologies in India's "design-enabled innovation economy."
In Su 08, Fisher plans to return to Europe to finalize several collaborative manuscripts begun

last summer or with international visitors to CNS-ASU and to pursue additional details of grant proposal, Socio-Technical Integration in Research (STIR), that recently received a strong "revise and resubmit" from NSF.

Connection to Anticipation, Engagement, and/or Integration.

Selin's 07 trip led to a research proposal on *anticipating* future technologies in Second Life; the proposal is progressing with a Martin Institute doctoral student under the guidance of Selin and JIM colleagues. It also led to a manuscript (Mans and Selin in preparation), in collaboration with Risoe National Laboratory, for the *integration* agenda which explores how governmental laboratories become more accountable to social policy and outcomes.

Fisher's 07 trip focused significantly on his previous and ongoing work in integration, and it helped establish connections with researchers who were since recruited as collaborators in his STIR proposal.

Contribution to E2E, "ensemble-ization" or other center-wide activities.

Shapira, Wang and Tang's trip to China under the auspices of RTTA 1 will be also be coordinated in part with a potential proposal or supplement for public opinion and scientists' opinion research from RTTA 2.

Valdivia's 07 trip simultaneously advances the interests of TRC 1 Equity and Responsibility (through thematic focus) and RTTA 1/1 Research Systems Assessment and RTTA 1/2 Public Value Mapping through applied methods.

Connection to Education, Training, and Outreach.

Shapira, Wang and Tang in 07 made contacts in China with key organizations including the Chinese Academy of Sciences and the Beijing Institute of Technology. The research contributed to the post-doctoral research of Wang and the ongoing dissertation of Tang. This work also contributed to Shapira and Wang (in preparation), Tang and Shapira (in preparation), Tang and Shapira (in preparation b) and Youtie, Shapira and Porter (2007), as well as to eight conference presentations including one to the Chinese Academy of Sciences.

Maricle's 07 research trip to the UK contributed to her dissertation (Maricle 2007), to a paper (Maricle under preparation) and to several research presentations.

Selin's 07 trip included a presentation of RTTA and NanoFutures activities at the Martin Institute and at the Risoe National Laboratory.

Fisher's 07 participation in the Norwegian workshops contributed substantially to a paper now published in *NanoEthics* by two junior researchers. His hosts also invited him to contribute a chapter to a book on the same topic. Moreover, Fisher's methodology of midstream modulation (Fisher 2006) was incorporated as a center-piece in a Norwegian research proposal on synthetic biology in which Fisher is a named collaborator; the proposal

has now advanced to the second round of review. Fisher also explicitly trained Schuurbiers and van Oudheusden in midstream modulation both during the trip and in subsequent visits catalyzed by the trip.

Valdivia's 07 trip contributed greatly to his framing of his dissertation, which examines the distributional considerations of innovation policy aimed at economic growth. In particular, he intends to develop theoretical bases and empirical evidence to show that R&D policy designed with distributional considerations results in greater productivity gains than designs lacking these considerations. He deploys this framework to investigate the allocation of research funding in a broad-based program like the NNI.

TABLE 2: NSEC PROGRAM SUPPORT

Projects	**(1)current year 10/01/07-09/30/08 Budget (NSF)**	**(2)current year 10/01/07-09/30/08 Budget (Cost-Share)***	**(3) current year 10/01/07-09/30/08 Budget (Other Support)**	**(4)Sum 1-3 Current year Total Budget**	**(5)Next year 10/01/08-09/30/09 Proposed NSF Budget**
RTTA 1	$302,356	$39,040	$0	$341,396	$302,740
RTTA 2	$317,004	$0	$0	$317,004	$243,000
RTTA 3	$239,823	$35,298	$43,125	$318,246	$255,674
RTTA 4	$19,821	$53,162	$3,000	$75,983	$88,155
TRC 1	$9,185	$20,437	$19,800	$49,422	$37,466
TRC 2	$7,491	$29,744	$3,000	$40,235	$47,500
Seed Projects	$0	$0	$35,000	$35,000	$0
Total Projects	**$895,680**	**$177,681**	**$103,925**	**$1,177,286**	**$974,535**
Education	$7,154	$3,986	$0	$11,140	$21,834
Administration	$89,178	$11,378	$0	$100,556	$107,130
Equipment	$0	$0	$0	$0	$0
Knowledge Transfer	$9,844	$1,797	$123,000	$134,641	$11,421
Indirect Costs	$110,327	$11,153	$0	$121,480	$85,223
Subtotals	**$1,112,183**	**$205,995**	**$226,925**	$1,545,103	**$1,200,143**
Total Budget	**$1,205,000**	**$206,000**	**$0**	$0	**$1,205,000**
Foreign Travel	($65,000)	$0	$0	$0	$0
Uncommitted	**$27,817**	**$5**	**$0**	$27,822	**$4,857**

Please note that Seed Projects have been included in the individual research program to which they are relevant. Seed Projects under Other Support is money that the Rasmussen grant provided for the 2008 All Hands Meeting.

Center Diversity – Progress and Plans

NSEC Diversity Strategic Plan:

CNS-ASU, including its constituent universities, has had a strong record of including women in key research and leadership positions and recruiting members of under-represented groups into graduate and undergraduate research positions. Given that this year is our first with this reporting format, we have not previously created a Diversity Strategic Plan as such. Nevertheless, our diversity activities to date fall into three areas, in accordance with ASU strategic planning:

- People, that is, the composition of the organization;
- Programming, the planning and design of deliverables; and
- Policies, the creation and review of plans to promote equity and success.

People. Across CNS-ASU, we have had strong achievements in including a diverse set of participants in our activities. At the highest levels of leadership, two of our six PIs are female (including the elevating of E. Corley, just promoted to associate professor, to replace original co-PI Schneider). Three of our ten program leaders are female (Corley, Fujimura [in transition from Hogle], and Cozzens), as are several key project leaders (Dunwoody [RTTA 2/2]; and Hejduk [RTTA 3/3] and emerging leaders are female, particularly Youtie, who has taken the lead of many of the RTTA 1/1 activities, and Selin, who has taken the lead of many of the RTTA 3/1 activities. We recognize that we have not progressed well in expanding leadership to a more ethnically diverse set of participants; this fact is recognized in the current strategic plan crafted by CSPO, the parent center of CNS-ASU, and is a high priority in any future faculty searches that CSPO is able to engage in.

At the post-doctoral level (including research faculty as well as post-doctoral trainees), three of seven researchers are female and one is Asian.

At the graduate student level, of 56 supported students across CNS-ASU's participating institutions and throughout its tenure, 27 have been female (48%), 6 have been Hispanic/Latino (11%), 5 have been Asian (9%), 2 have been Native American (4%), 2 has been African-American (4%) and 16 have not provided data.

At the undergraduate level, of 22 supported students across CNS-ASU's participating institutions and throughout its tenure, 7 have been female (32%), 2 have been Asian (9%), 1 has been Hispanic/Latino (5%), 1 has been African-American (5%) and 3 have not provided data.

Programming. A strength of CNS-ASU has been integrating topics related to diversity into its research program. Primarily, we have focused activity – particularly in the current reporting year – on issues related to disability under the TRC 2 Human Identity, Enhancement and Biology theme. Examples include:

- Substantial attention to and research on the needs of persons with a variety of disabilities for student design projects within RTTA 3/2 InnovationSpace. Two of the technologies imagined by ISpace (the variably flexible leg brace and the haptic/Braille

PDA) pertain directly to persons with disabilities, and the teams used methods that engaged potential users in the development of these projects.

- Seminars and more extensive visits and on-going interactions with scholars and writers involved in disability issues, particularly:
  - Gregor Wolbring, a biochemist and bioethicist who is also mobility-disabled, visited ASU to interact directly with ISpace and Learning Community students. Wolbring and CNS-ASU are currently planning distance learning projects around disability studies and emerging technologies, and he will be speaking at the Gordon Research Conference on Science and Technology Policy, "Governing Emerging Technologies," that director Guston is co-chairing; and
  - Michael Chorost, a writer and cochlear implantee, provided a seminar and had extensive interaction with faculty and students through the End-to-End project of TRC 2. Chorost also participated in the Medical Diagnostics scenario workshop and will also be speaking at the GRC on "Governing Emerging Technologies."
- A major portion of RTTA 1/2 Public Value Mapping devoted to the question of whether minority health can expect relative improvements from promised nano-enabled cancer therapies;
- An undergraduate honors thesis by Silverman, who has a vision disability, under the direction of TRC 2 co-leader Robert, on the opinions of persons with visual disabilities toward nano-enabled visual prosthetics and enhancements;
- A focus through the End-to-End project on the histories of some prosthetics and enhancements, particularly cochlear implants, as analogues to potentially emerging nano-neural technologies;
- The development of an undergraduate course on "Human Enhancement and Democracy," in which the subjects of disability and its relationship with human enhancement technology, and the distinction between therapy and enhancement, was debated extensively. Wolbring conducted a guest lecture in which he explained his concept of "ablism" and the shifting perceptions of the disabled related to their therapies and prostheses;
- The second annual symposium for under-represented perspectives on "Whose Nanotechnology," held at ASU on 22 Apr 08 in collaboration with the Hispanic Research Center (HRC; see below for more details).

Policies. CNS-ASU has had no formal policies as such, although this Diversity Strategic Plan will serve that purpose. See below for more details.

Plans for the next reporting period.

In the coming year, CNS-ASU will take the following steps to increase the diversity of the Center's personnel:

- Improve the quality of the "under-represented perspectives" symposium. In YR 3 (Apr 08) and YR 2 (Apr 07), CNS-ASU has, in collaboration with HRC (which is the LSAMP group at ASU), organized a small conference on nanotechnologies from the

perspective of students from under-represented populations. The YR 2 meeting attracted a large number of applicants and six highly qualified ones, around whom we designed the program. Believing that was a good model from which to proceed, we attempted to broaden the program topic in planning the YR 3 meeting. However, while also attracting a large number of applicants, the YR 3 meeting attracted only one highly qualified one. We have thus decided that our YR 4 activity should be a training activity, akin to the DC Summer Session and other training activities that CNS-ASU has successfully implemented, but targeted for under-represented students. We anticipate holding a winter training session, perhaps adjacent to our YR 4 All-Hands Meeting in January in Tempe, for some one- to two-dozen students from under-represented groups and recruited through HRC's networks as well as our own.

- Reach out to the Ethics and the Nanoscale Nanotechnology Undergraduate Engineering Program at Auburn and Tuskegee Universities. The program, which is a partnership of social and natural scientists at Auburn and the Bioethics Research Center at Tuskegee, provides freshmen and sophomores with an in depth introduction to the social and ethical implications of nanotechnology. CNS-ASU associate director for outreach Miller has already made contact with the leaders of this program (Michelle Sidler [English, Auburn] and Leonard Ortmann [Bioethics, Tuskegee]) in connection with developing other grant proposals, and he will approach them about partnering with CNS-ASU in the coming year and beyond. (The earlier contact led to the application of a student from Tuskegee to the new Human and Social Dimensions of Science and Technology doctoral program at ASU.)
- Submit a proposal to NSF for a REU supplement to run in YR 4 and YR 5 of this collaborative agreement.
- Seek out additional, related groups at ASU (e.g., at Fulton School of Engineering and School of Life Sciences) and its collaborating institutions that have programs for minority students and provide contact, content, and mentoring for students interested in the societal aspects of nanotechnologies and other emerging technologies.
- Engage the CSPO strategic plan and its hiring priority in diversity and encourage our collaborating universities similarly.

Education

CNS-ASU is involved in extensive formal and informal educational activities from post-doctoral training and mentoring to professional development for in-service high school teachers to collaborations with science museums. Many of these activities are tightly integrated with research and outreach activities, and most maintain as their central focus the building of broader societal capacity for anticipatory governance.

Post-doctoral training and junior research scholars. CNS-ASU has put significant effort into building a cohort of junior researchers at ASU. These researchers – Barben (Political Science & Sociology), Bennett (Chemistry), Conz (Sociology), Fisher (Environmental Studies), Selin (Knowledge & Management) and Wetmore (STS) – were all initially hired at the post-doctoral level at ASU. Bennett has remained a post-doc but is slated for promotion to assistant research professor in F 08. Selin and Fisher have already been promoted to assistant research professor. Conz has a joint appointment as assistant research professor and lecturer (in the Bachelor of Interdisciplinary Studies program), and Barben was promoted to associate research professor on the strength of his *Habilitation* in the German system last year. Over the past year, this group has coalesced into a highly interactive cohort, co-authoring a number of important publications and sharing the development of a number of critical research ideas. Publications of this group include an invited chapter in the high-profile *STS Handbook* by Barben, Fisher, Selin & Guston (2008), the first volume of the *Yearbook of Nanotechnology of Society* edited by Fisher, Selin & Wetmore (2008), the white paper on big ideas on nano-in-society for informal science education by Miller, Guston, Barben, Wetmore, Selin, and Fisher (2007), as well as education and training activities designed, delivered and evaluated by Wetmore, Bennett, Fisher & Conz, and integrative activities with NSE researchers designed and executed by Bennett, Wetmore, Fisher, Conz and Selin. The Center is also training post-doctoral trainees at University of Georgia (Slade, under the direction of Bozeman on RTTA 1/2 Public Values Mapping), Georgia Tech (Wang, under the direction of Shapira on RTTA 1/1 Research Systems Assessment), and Wisconsin (Delborne, under the direction of Kleinman on RTTA 3/4 National Citizens' Technology Forum, and Rajagopalan, under the direction of Fujimura, on TRC 2 Human Identity, Enhancement and Biology).

Graduate Education and Training. CNS-ASU organizes a variety graduate education and training activities, aimed at several audiences. The first audience is the graduate students involved in research activities, many of which have led to or are leading to theses. In the reporting year, the Center has been training:

- At ASU, three doctoral students (Garay [Educational Leadership and Policy], Hays [Political Science], and Valdivia [Public Affairs]) and four master's (DiNapoli [Life Sciences], Garcia-Mont [Educational Leadership and Policy], Lidberg [Design], Wheelock [Liberal Studies]). During the year, Garcia-Mont and Lidberg (2008) completed their master's theses, the latter on a CNS-related topic. Panjwani (2007) completed her master's thesis in the Mathematics and Statistics Department in last reporting year.
- At Wisconsin, five doctoral students (Dudo, Ho, Dalrymple, Shih and Hillback, all in Journalism and Mass Communication), each of whom is working with RTTA 2 data, and one master's student, Porter, working with (outgoing) TRC 2 co-leader Hogle.

- At GA Tech, four doctoral students and four master's students work with RTTA 1 and a fifth doctoral student works RTTA 3, all using CNS-ASU data and analyses toward their theses. GA Tech has already graduated one doctoral student (Wang) and one master's student (Mehta).
- Additional graduate students at University of New Hampshire (Barr, Sociology), North Carolina State University (Ndoh, Public Administration), and University of California, Berkeley (Barandiaran, Environmental Sciences), all involved in the organization, conduct and analysis of the National Citizens' Technology Forum.

At ASU, a second graduate student audience has been NSE researchers themselves. For these students, CNS-ASU created the CNS-Biodesign Fellows program, in which CNS pays one-third of the support of three such students (Spadola [Physics; Lindsay lab], Lappe [Chemistry and Biochemistry; Woodbury lab], and Agrawal [School of Materials; Zenhausern lab], and those students, in turn, participate in CNS-related curricular and co-curricular activities and perform what we call the PhD+, adding societal implications material to their doctoral research. This year, CNS graduated its first CNS-Biodesign Fellow, Quinn Spadola, who has recently been admitted to a master of fine arts program at Montana State University to specialize in making documentary science and nature films. Spadola has contributed greatly to CNS through her management of the Science Cafes. Lappe has been active in designing scenes and other futures thinking for his work on lab-on-a-chip, designer enzymes and directed evolution, and Agrawal has been assisting the TRC 2 HIEB/E2E project.

CNS-ASU has also attracted potential PhD+ students not affiliated with the CNS-Biodesign Fellows program, including:

- Troy Benn (environmental engineering, Westerhoff lab), whose work on the fate and transport of nano-silver derived from socks has garnered significant attention and who CNS-ASU is supporting by helping him travel to Washington, DC to consult with EPA officials about how to design his research so that it feeds more productively into the agency's knowledge needs; and
- Ashley Kibel, who initially invited Fisher to interact with her in the summer of 2006, and then attended a course taught by Clark Miller; she is considering two options for the PhD+: a midstream focus on decisions she makes over time as a laboratory research in light of concerns about human and environmental health; or a downstream focus on consumer behavior in relation to envisioned technologies and questions of sustainability.

In Jun 07, CNS-ASU also conducted "Science Outside the Lab: A Policy Dis-Orientation" for NSE doctoral students in the Biodesign Institute and the Fulton School of Engineering at ASU. Developed and taught by Wetmore and Bennett and held in Washington, DC, the course offers graduate NSE students a chance to leave the lab for two weeks to explore the relationships among science, policy and societal outcomes. Students meet the government officials, lobbyists, staffers, regulators, journalists, academics, museum curators, and others who fund, regulate, shape, critique and study science, and they engage in hands-on policy learning through tours and exercises like a mock congressional hearing held in a congressional hearing room and chaired by a former congressional committee staffer with many staff in attendance. (Space for much of the course was generously donated by Jennings,

Strouss, and Salmon PLC.) Graduate student participants in this meeting included: Benn (Civil/Environmental Engineering), Bowen (Chemistry and Biochemistry), Halperin (BioDesign/Molecular and Cellular Biology), Helmy (School of Life Sciences/Biology), Jiang (BioDesign/Chemistry and Biochemistry), Jolley (BioDesign/Physics), Joshi (Electrical Engineering), Larson (Chemistry and Biochemistry), Phoolcharoen (School of Lifes Sciences/Plant Biology), Rinker (Chemistry and Biochemistry) Schloendorn (BioDesign/Molecular and Cellular Biology), Sterns (Chemistry and Biochemistry) and Watkins (Chemistry and Biochemistry).

In the reporting year, CNS-ASU also developed a partnership with a new Professional Master of Science degree program in nano-science, led by the departments of physics and chemistry, to offer a 2-credit graduate course in the societal aspects of nanotechnology required in the program. This course will first be taught in Su 09, but in the meantime CNS-ASU will contribute lectures to the degree program's professional development seminar.

The third graduate student audience at CNS-ASU consists of those students in traditional departments and schools, as well as those in interdisciplinary programs, who are interested in CNS-related coursework. CNS-ASU has established three graduate courses at ASU:

- "Science, Technology & Societal Outcomes," taught in the School of Life Sciences and the School of Human Evolution and Social Change by Wetmore and Bennett and offered in Sp 07 and F 07 but not in the current reporting year;
- "Nanotechnology: Law and Regulation," taught by Sylvester in the O'Connor School of Law. Several other CNS-ASU faculty participated in the course, including Guston, Robert, Marchant, and Selin, and as a major project the students explored potential regulatory and liability issues in the scenes developed by NanoFutures.
- "Nanotechnology, the Brain, and the Future," taught in the School of Life Sciences and the Department of Political Science. This three-credit course offered by Miller and Robert is part of the E2E project and students used it to prepare research projects for E2E and the CNS All-Hands meeting. Miller and Robert will continue the course in the coming academic year.

CNS-ASU is planning a fourth graduate course, "Governing Emerging Technologies," to be offered in F 08 through the Political Science Department by Guston. The course will explore the Center's core concept of anticipatory governance and synthesize many of the Center's findings.

The Center has also been an integral part of the development of a new doctoral program at ASU, the Human and Social Dimensions of Science and Technology, which was approved by the Arizona Board of Regents in December 2007 and has admitted its first class for August 2008. CNS-ASU will be funding one member of the first cohort of students, Lidberg (who will work primarily on RTTA 3/3 CriticalCorps issues and also on the new "Speakeasies" project), and will be housing and working closely with another member, Schwartz (who is interested in RTTA 1 Public Value Mapping).

Undergraduate Education and Training. CNS organizes a variety of undergraduate education and research training experiences. Undergraduates engaged in research training include:

At ASU, a number of undergraduates have written honors theses with CNS faculty. Honors theses completed in previous years include Davis (2007; Guston, director) and Pirtle (2007; Robert, director). In the current year, Pirtle was awarded a Fulbright Scholarship to study in Mexico with Foladori to work on new versions of NanoFutures scenes that incorporate development issues. In the current year, undergraduates have completed eight honors theses including:

- Arielle Silverman (2007; Robert, director), whose undergraduate thesis in Biology and Society surveyed a population with visual impairments about their attitudes toward nano-enabled therapies and enhancements in conjunction with TRC 2;
- Tobie Milford (2008; Wetmore, director), whose undergraduate thesis in Religious Studies reviewed public participation in science literatures and analyzed TRC 1's Religion and Nanotechnologies workshop; and
- Timothy Shaw (2008; Boradkar director), who undergraduate thesis in Mechanical Engineering examined in greater detail the nano-products derived in RTTA 3/3 InnovationSpace in AY 06-07.

CNS-ASU has established the following undergraduate courses at ASU:

- "Perspectives on Nanotechnology," taught in 06 and 07 by Ramakrishna;
- "Elements of Public Policy: S&T Policy," taught in Sp 06 by Guston and now incorporated into the Learning Community;
- "Justice and the Future," taught in Sp 07 by Selin in the School of Justice and Social Inquiry;
- "Learning Community: Nanotechnology in Society," a nine-credit transdisciplinary course taught in Sp 07 by Conz, Woodbury and Guston and in Sp 08 by Wetmore, Bennett and Guston (see below for details);
- InnovationSpace," a ten-credit transdisciplinary design course for seniors in the schools of design, engineering, and business offered with CNS content in AY 06-07 and AY 07-08 (see below for details); and
- "Human Enhancement and Democracy," taught in the Department of Political Science by Hays (see below for details).

The "Learning Community" (LC) provides three thematically linked courses taught in different departments but taken simultaneously by a cohort of undergraduates. It brings different disciplinary perspectives – in this case, chemistry, political science, and social studies of science – to the exploration of interplay among technology, society and policy, using nanotechnology as its case study. In Sp 07, the LC in Nanotechnology and Society was led by Conz (Sociology) with Woodbury (Chemistry and Biochemistry) and Guston (Political Science) contributing. In Sp 08, Wetmore (Human Evolution and Social Change) led the course, with Bennett (CSPO/CNS but Chemistry PhD) and Guston contributing. The course includes an in-depth introduction to both the technical and socio-political aspects of nanotechnology and emphasizes the interplay between them. It draws on diverse materials for analysis and interpretation of societal dimensions, including government reports, social science research, business materials and websites, film, and novels. The course also hosted a number of guest speakers from CNS-ASU and its scientific collaborators, including Woodbury, Posner, Selin, and Wolbring. The students, this year from chemistry,

biochemistry, physics, and mathematics, also engaged in hands-on and project-based learning, including:

- Glassblowing, to demonstrate that size matters in the color of glass marbles into which nano-particles of gold are infused;
- NanoDays, for which the students staffed a booth at the Tempe Arts Festival and communicated informally with the public there using kits provided through the Nano-scale Informal Science Education Network (NISE Net);
- Science fiction writing and scenario development to explore potential societal implications of nanotechnologies;
- Piloting the NanoFutures site with commentary on the wiki; and
- Touring the AZ Science Center behind-the-scenes to learn about museum-based science communication.

"InnovationSpace" is a two-semester long, transdisciplinary course collaborative among the ASU Schools of Design, Engineering, and Business. It satisfies the design or project requirements for senior majors in each school by creating cross-functional teams who use an Integrated Innovation model to research, develop and refine real-world product concepts for paying sponsors. As last year, CNS-ASU joined Herman Miller and Intel as a sponsor of three, four-person IS teams. CNS-ASU has partnered with InnovationSpace to investigate nano-based technologies that ensure the freedom, privacy and security of citizens (AY 06-07) and to visualize socially beneficial opportunities for nanotechnology in the areas of human health and enhancement (AY 07-08). InnovationSpace is led by Boradkar, and CNS researchers Guston, Selin, Wetmore, Bennett, Robert, and Wolbring each had significant interaction with the students. The three inventions this year were: a hand-held device with a nano-enabled haptic screen that incorporated Braille for use by the visually impaired; a nano-enabled brace for injured limbs that would change rigidity over time to accommodate healing and rehabilitation; and a doc-in-the-box unit that would sample body fluids and display and communicate pre-symptomatic diagnostic information in a patient's own home. Outcomes from InnovationSpace include not only spectacularly detailed documentation of the student-led innovation process (e.g., notebooks, drawings, models, and other ephemera), and seven honors theses in the current year, but also invention disclosures – three from the AY 06-07 class in the last reporting year (although not reported last year) and three from the AY 07-08 class in this reporting year. Boradkar and IS collaborator Fischer, together with Selin and NISE Net collaborator Marks have recently submitted a grant proposal to the National Collegiate Inventors and Innovators Association to document visually the ephemera of the students' work and preserve that documentation through an interactive web site that then might become a learning resource. Boradkar and colleagues were successful last year in obtaining a grant from the same group to support IS activities this year. CNS-ASU is also using InnovationSpace as a way of potentially opening up collaborative opportunities directly with Intel, one of the other sponsors.

"Human Enhancement and Democracy" explores the social and political implications of what some scholars and pundits have referred to as humanity's "directed evolution." The permanent, physical incorporation of technology into the human body, aided by nanotechnologies, is a process that has already begun, and such human technological enhancement will influence our individual identities as well as the way we conceive of

ourselves as a species. It may also create massive changes in governments and other social systems we employ to manage our daily interactions. The course adopts a variety of ways of understanding human enhancement technologies and their impacts that do not utilize the passé moral and economic arguments employed by both sides in this ongoing debate. A set of "open-source" class assignments help students discover information about human enhancement technology and the world it is creating, not from the perspective of some distant and massive event, because such an event will never happen, but from the perspective of the constant and iterative choices we make about technology and its incorporation into our lives every day. Some of the novel assignments in the course – an innovative ways in which students responded to them – include:

- Enrolling students in Second Life as a way of both interacting in the course and of understanding different aspects of human-technology interaction;
- Reading fiction in parallel to academic and polemical writings about human enhancement;
- Constructing a timeline of human enhancement as a group to put current technologies into historical context;
- Engaging in "political action" (e.g., leafleting, speaking, etc.) in Second Life to generate interest around a particular perspective on human enhancement technologies; and
- Fulfilling a final paper or project, for which some students submitted original documentary video, original music score, and other creative pieces.

K-12 Education. In the previous reporting year, CNS-ASU described the development of a graduate course that provides in-service K-12 teachers with research experiences and also helps them develop curricular materials for their own K-12 classrooms on societal aspects of nanotechnologies. CNS offered the course again in the current reporting year, but it was under-subscribed and did not run because our partner in the course development, the Center for Research on Education in Science, Mathematics, Engineering, and Technology (CRESMET) was unable to continue paying for the student credit-hours as they had for the original course. The Center continues to search for ways of paying for such credit-hours and the course is currently on the books to be offered again in Fa 08. The value of the course is demonstrated by continuing follow-ups by the in-service teachers of course co-instructor Bennett, who has consulted with some of those in the course about the development of curricular materials and visited classrooms at Mesa High School and its Biotech Academy. CNS-ASU has also arranged for its Science Cafes, held monthly in conjunction with the Arizona Science Center (see below) to provide in-service teachers with continuing education credit. As reported in the Research Accomplishments and Plans section on RTTA 3/1 Scenario Development, we have new opportunities to use the NanoFutures site and the scenes there to engage with pre-college educators and students that we will pursue.

Informal Science Education. CNS-ASU has engaged in several informal science education activities of varying scale and scope in the last year. The National Citizens' Technology Forum (reported on above in Research Program, Accomplishments, and Plans) is also an exercise in intensive informal science education. CNS also sponsors a Science Café monthly during the academic year at the Arizona Science Center, which typically attracts an audience of 40-50. CNS has created a new format in which two ASU experts – usually one from the natural sciences or engineering and one from the social sciences or humanities – begin the

dialogue. We have found this format more engaging than a single speaker, and it helps break down the implicit barrier of expertise that divides one lecturer from his or her audience. In-service teachers can receive credit for attending the Science Cafes, and in the final café of the current season, we took the opportunity to acknowledge and celebrate the local area participants in the National Citizens' Technology Forum. CNS-ASU has held a total of 18 Science Cafes to date (one in Spanish), and the Center will continue these in coming academic year. We have also succeeded in gaining co-sponsorship of the cafes with Agilent Technologies, which contributes $2500 to cover advertising, printing, etc.

The Center also works with the Nanotechnology Informal Science Education Network (NISENet) to incorporate research on the ethical and societal implications of nanotechnology into museum programs and exhibits around the country. The Center has produced a guide to this topic (Miller et al. 2007) that NISENet distributes as part of its Forums Guide and Nano Days Kit.

Practitioner Training. The Center has developed and piloted training modules in the ethical and societal implications of nanotechnology for scientists and engineers working in user facilities at the DOE Center for Integrated Nanotechnologies and the National Nanotechnology Infrastructure. Much of the DOE/CINT activities occurred in previous reporting years and have not continued intensively in the current year for want of new users at CINT.

At NNIN, CNS director Guston, with Douglas Kysar, the (now former) coordinator for societal and ethical issues of nanotechnology at the National Nanotechnology Infrastructure Network (NNIN) at Cornell (now at Yale) and Ana Viseu, formerly of Cornell and now at the University of Toronto, have begun to create a training module for users of NNIN facilities. Kysar and Guston signed a Memorandum of Understanding in October 2007 outlining the collaboration over the training module. To date, the first version of the PPT presentation of the module has been created, reviewed at CNS-ASU, piloted at Cornell, and distributed to NNIN users. We await feedback from the sites, but we also plan to produce a packet for trainers and a web site with a third layer of depth for further inquiry by interested parties. Individual work by the participants of the group, as well as the Miller et al. (2007) working paper, were influential in framing the training, and other groups – including the Woodrow Wilson International Center – have expressed interest in helping to disseminate it.

Table 3: Education Program Participants														
		Citizenship Status												
		U.S. citizens and permanent residents only												
		Gender		Race					Mixed-incl.	Mixed-				
Student Type	Total	Male	Female	NA	PI	AA	C	A	NA,PI,AA	C,A	Not Provided	Other Non-US	*Ethnicity Hispanic	Disabled
Enrolled in full degree programs														
Undergraduate	21	13	8				13	2			6			
Masters	6		6	1			4	2						
Doctoral	12	8	3				8	3						
Enrolled in NSEC Degree Minors														
Undergraduate														
Masters														
Doctoral														
Enrolled in NSEC Certificate Programs														
Undergraduate														
Masters														
Doctoral														
Practitioners taking courses														
K-12 (Pre-college) Education														
Teachers														
Students														
Total	39	21	17	1			25	7			6			
Please Note: As there were not degree programs directly associated with the NSEC/CNS-ASU, all students have been combined into one group														

Outreach and Knowledge Transfer

State the strategy that guides the Center's outreach program. Describe current and planned collaboration and interaction with industry and other sectors; workshops; web based outreach activities; and others as appropriate. Describe spin-off of companies and other tech transfer activities.

The outreach activities at CNS-ASU are, on one hand, tightly integrated with research and education and, on the other, governed by a strategy that aims at developing broad-based capacities among both NSE researchers and various publics. As described in the strategic research plan, CNS-ASU pursues an agenda of *foresight*, *engagement* and *integration* in order to advance its strategic goal of building capacities for reflexivity and anticipatory governance in the NSE enterprise in particular and in society more broadly. CNS-ASU thus has a dual-tracked outreach strategy that includes, in one track, outreach to various lay-publics (*engagement*) and, in the other track, outreach to scientists and engineers (*integration*).

Engagement

The primary public outreach-oriented engagement activities of CNS-ASU have been:

- The National Citizens' Technology Forum (NCTF; described in detail under RTTA 3/4), which conducted six coordinated panels of lay citizens across the country, informing them and allowing them to deliberate both face-to-face and keyboard-to-keyboard on issues in nanotechnologies applied to human therapy and enhancement. NCTF is an intensive form of public engagement that, while reaching only a limited number of people (76), has a profound impact on them directly and a potentially large impact indirectly, depending on follow-on outreach and coverage, which we are currently engaged in. Detailed information, including the citizens' reports from each of the sites, is available at http://www4.ncsu.edu/~pwhmds/.
- The Science Cafés, held in collaboration with the Arizona Science Center and with modest support from Agilent Technologies, which occur roughly once a month during the academic year. In the last year, the cafes have averaged 40-50 attendees, and one had roughly 75. The cafes have attracted speakers from across CNS-ASU's research programs (RTTA 2, RTTA 3, TRC 1 and TRC 2 have all contributed), as have technical collaborators from the Biodesign Institute and the Fulton School of Engineering, among others at ASU. Unlike other Science Cafés, CNS-ASU pairs natural scientists and engineers with social scientists and humanists to break down barriers of expertise and encourage participation. An interesting aspect of the cafes is the questions that arise from the public, which are sampled here:
    - Who should own different kinds of technologies?
    - How do you get this stuff out of your body?
    - Who will control the use of nanotechnology?
    - Is there any system for getting feedback from users to designers?
    - Do you give people in developing countries the technology, the capacity to make the technology, or the education so they can do it themselves?
    - What if, sooner or later, it's going through everyone's blood and there are some people who don't want it?

- The collaboration with NISE Net, which is based in part on a Memorandum of Understanding signed by Guston and NISE Net PI Larry Bell in December 2007. There have been two major aspects of the collaboration to date:
    - Selin has been working with Kate Duckworth of the San Francisco Exploratorium on the wiki scenario project of RTTA 3 as a result of encountering the project at the Apr 07 All Hands meeting. In a follow up meeting in early August, Duckworth and her team at the Exploratorium met with Selin to discuss the contours of the project and how both CNS and NISE Net might develop products effective for their mutual needs. This collaboration continued from the plans outlined at this and additional meetings through Fa 07 and helped lead to the roll-out of the NanoFutures site in Apr 08 (http://cns.asu.edu/nanofutures).
    - At the request of NISE Net, CNS-ASU created compilation of ten important ideas in nanotechnology and society (Miller et al. 2007) to provide a conceptual framework for educators and outreach specialists who wish to include ideas about the societal aspects of nanotechnology in their work. If desired, CNS-ASU will subsequently work closely with educators and outreach specialists to translate these ideas into specific elements to be included in their classes or projects. The document has been sent to:
        - Sherry Hsi at the Exploratorium and Shawn Stevens and Joe Krajcik at the University of Michigan and the National Center for Learning and Teaching in Nanoscale Science and Engineering (NCLT), who were principals in requesting it;
        - Wendy Crone and Greta Zenner at the Materials Research Center (MRSEC) at the University of Wisconsin, who are distributing it to their Interdisciplinary Education Group and Informal Public Science Education group; the MRSEC may also use the white paper in workshops for administrators and journalists in the coming year.
        - Brad Herring of the North Carolina Museum of Life and Science, who included the document in the packet for attendees to its September 2007 Nanotechnology Forum and Workshop.
        - The Science Museum of Minnesota, which is including it as part of up to one hundred kits to be distributed for NISE Net's Nano Days in March and April 2008 in the hopes that the museums using the kits will begin to include societal aspects in their nano exhibits.
    - In collaboration with NISE Net, Boradkar, Fischer and Selin have submitted a grant proposal to the National Collegiate Inventors and Innovators Association to document for the web the innovation process as exemplified by InnovationSpace. Materials would be made available to the public generally and also through NISE Net museums.

Integration

The primary outreach-oriented engagement activities have been:

- CNS-CINT Program on the Societal Dimensions of Nanotechnology, which has resulted, to date, in four sessions for CINT research staff. Each session, the most recent of which was conducted on 27 Jun 07, included background reading materials, briefing packets, lectures, and discussions. Sessions were conducted on:
  - Nanotechnology and Public Policy
  - Nanotechnology and Environment, Health, and Safety
  - Nanotechnology and Ethical and Societal Implications
  - Nanotechnology and Social Science Research

  The program also included two roundtable discussions on Integrating Science and Society in the Laboratory – one on existing methods, the second on emerging methods. CNS and CINT signed a MOU in 2006 to jointly fund the implementation of the project, which has been led by Fisher.
- The Future of Medical Diagnostics workshop, described above in RTTA 4, which involved the following participants:
  - Daniel Barben, PhD, Associate Research Professor, Consortium for Science, Policy and Outcomes, Arizona State University (ASU)
  - Michael Chorost, PhD, author of *Rebuilt: How Becoming Part Computer Made Me More Human*
  - Chris Diehnelt, PhD, Assistant Research Professor, The Biodesign Institute, ASU
  - Scott Endsley, MD, Vice President, System Design for Quality Improvement Organization, ASU adjunct
  - David Guston, PhD, Director, Center for Nanotechnology in Society-ASU; Associate Director, Consortium for Science, Policy, & Outcomes; Professor, ASU Department of Political Science
  - Stephen A. Johnston, PhD, Director, Center for Innovations in Medicine, The Biodesign Institute, ASU
  - Joel Garreau (co-facilitator), Journalist, *Washington Post*; author (*Radical Evolution);* futurist
  - Sean Hays, PhD fellow, Political Science, Center for Nanotechnology in Society researcher, ASU
  - Laurence Miller, MD, Mayo Clinic-Scottsdale
  - Robert J. Milligan, JD, Director, Physician Services Group, Gallagher & Kennedy P.A.
  - Shobita Parthasarathy, PhD, Assistant Professor, Department of Public Policy, University of Michigan; Visiting Scholar, Woodrow Wilson International Center for Scholars
  - Jason Robert, PhD, Assistant Professor, ASU School of Life Sciences; CNS-ASU
  - Cynthia Selin, PhD, Assistant Research Professor ASU Consortium for Science, Policy and Outcomes; CNS-ASU
  - Michael Tracy, PhD, Deputy Director, The Biodesign Institute, ASU
  - Julia Trosman, Director, Center for Business Models in Healthcare

  - Jameson Wetmore, PhD, Assistant Professor, School of Human Evolution & Social Change; CNS-ASU
  - Berea Williams, PhD fellow, Department of Chemistry and Biochemistry, Center for BioOptical Nanotechnology, The Biodesign Institute- ASU
  - Neal Woodbury, PhD, Director, Center for BioOptical Nanotechnology, The Biodesign Institute; Professor, ASU Department of Chemistry and Biochemistry
- The Photon Project Workshop, which involved the following participants:
  - Derrick Anderson, management intern, CNS-ASU
  - Shreya Bhattacharyya, graduate student, Biodesign Institute
  - Bradley Brennan, graduate student, Chemistry & Biochemistry
  - Rahul Chhabra, graduate student, Biodesign Institute
  - Rodolfo Diaz, professor, Electrical Engineering
  - Fanie Duvenhage, MicroChip
  - Erik Fisher, assistant research professor, CNS-ASU
  - Devens Gust, professor, Chemistry and Biochemistry
  - Ashley Kibel, graduate student, Biodesign Institute
  - Frank Laird, associate professor, University of Denver
  - Stuart Lindsay, professor, Biodesign Institute
  - Anastasios Panaretos, post-doctoral trainee, Electrical Engineering
  - Khan Rahi, the Loka Institute
  - David Renolds, undergraduate intern, CNS-ASU
  - Daan Schuurbiers, graduate student, Delft Technical University
  - Jaswinder Sharma, graduate student, Biodesign Institute
  - Qiangbin Wang, research professor, Biodesign Institute
- The Dialogue on Religion and Nanotechnology
  - Barry Ritchie, Professor of Physics, Clergy
  - Steve Helms-Tillery, Neuro-Bioengineering Professor
  - Craig Jolley, Biophysics Postdoc
  - Farzad Mahootian, Philosopher
  - Jim Malone, Cardiovascular surgeon
  - Doe Daughtrey, Religious Studies PhD
  - Chad McAllister, Chemistry and Biochemistry Staff

Collaborations/Interactions with Industry and Other Sectors

The most significant private-sector relations that CNS-ASU has established in the past year are: the completion of the workforce assessment study for the Arizona region, with Feb 08 “Progressive Dialogue” and supplementary interviews with Agilent Technologies; a partnership with Arizona NanoCluster to help plan a portion of their 2009 annual meeting on societal aspects and to encourage a societal aspects component to their student essay contest; the inclusion of a number of private sector participants in the Future of Medical Diagnostics, Photon Project, and Religion and Nanotechnologies workshops; and the recruitment of

Agilent Technologies as a sponsor for CNS-ASU's Science Café series, in collaboration with the Arizona Science Center. The private sector was also represented in Fisher, Selin and Wetmore (2008) by contributions from an architect (Soueid, HDR Architecture, Inc.) and a market analyst/forecaster (Buenger, from Lux Research).

Shared and other Experimental Facilities

CNS-ASU maintains a desk at the Biodesign Institute, which facilitates the collaboration and integration activities of the RTTA 4 projects, particularly the Photon project and Tubes in the Desert.

Personnel

CNS-ASU is managed by a Director (Guston), two Associate Directors (Sarewitz and Miller, who focuses on education and outreach) and an Executive Committee composed of the center's PIs (Guston, Sarewitz, Miller, Poste, Carlson, and Corley) plus senior investigator Allenby. (The replacement of Schneider by Corley as co-PI and member of the Executive Committee has previously been reported to NSF.) The Executive Committee meets twice per semester. Sarewitz has been on sabbatical leave in the current academic year but is in email and telephone contact with Guston on at least a weekly basis, and Miller and Guston work together on a daily basis.

CNS-ASU has two full-time staff: Regina Sanborn, program manager, who reports to the Director, and Michele Iafrat, administrative associate, who reports to the program manager. Graduate research assistant Roxanne Wheelock serves as communication coordinator and – a trained facilitator – facilitated the Tempe site of the National Citizens' Technology Forum. CNS-ASU had funded at one-sixth time Melissa Cornish as a liaison to the Biodesign Institute, but since she left ASU early in 2008, the Center has decided not to replace her. Relations with Biodesign have not suffered given the rapport that we have created at both the faculty and staff levels.

CNS-ASU has a set of team leaders for each of its major RTTA and TRC research programs. These leaders are spread across CNS-ASU participating institutions and in some instances overlap with institutional leaders (see below). The team leaders currently are:

RTTA 1: Philip Shapira, GA Tech
RTTA 2: Elizabeth Corley, ASU; Dietram Scheufele, Wisconsin
RTTA 3: Daniel Sarewitz, ASU; Patrick Hamlett, North Carolina State.
RTTA 4: Erik Fisher, ASU

TRC 1: Susan Cozzens, GA Tech; Jameson Wetmore, ASU
TRC 2: Jason Robert, ASU; Joan Fujimura, Wisconsin

Changes in team leadership from the last annual report include:

- Fisher has replaced Kevin Corley as leader of RTTA 4, at least temporarily. Corley, in a tenure review year, felt under too much additional obligation and requested a hiatus from his leadership position. Fisher had been a supported doctoral student in the first year of the Center at Colorado-Boulder, then a supported post-doctoral trainee, and is now an assistant research professor supported by the Center.
- Joan Fujimura has replaced Linda Hogle as co-leader of TRC 2. Hogle completed a project earlier in the current reporting year with a student and did not feel that her role in the Center would continue to be productive for her or the Center. Fujimura has been a named senior investigator in the Center and has previously supervised the work of a doctoral student supported by CNS-ASU at Wisconsin.

In the current reporting year, CNS-ASU established a monthly telephone conference among center principals, including the leadership of each of the RTTAs and TRCs.

Guston is in additional contact with most program and project leaders about specific elements of their work on a frequent but as-needed basis, e.g.,:

- Monthly or more often interactions with RTTA 1 Shapira, generally about the uses to which the nano databases are being put;
- Monthly interactions with RTTA 1/2 leader Bozeman about progress on Public Value Mapping, including meetings at ASU in October and January;
- Weekly interactions with RTTA 1/3 leader Van Horn about the dialogue event around the Phoenix-Tucson nano-workforce assessment held in February;
- Weekly interactions with RTTA 2 leader Scheufele around the analysis of and publications from the first group of surveys and planning for the second group;
- Daily direct contact with Selin, de facto leader (with Sarewitz on sabbatical) of RTTA 3/1 scenario development activities;
- Weekly interaction with RTTA 3/2 InnovationSpace leader Boradkar, including two personal appearances in the fall semester and two in the spring semester in the class;
- Weekly interaction with RTTA 3/4 leader Hamlett over the National Citizens' Technology Forum;
- Daily direct contact with RTTA 4 leader Fisher on plans for annual interviews, etc.;
- Daily direct contact with Wetmore, and monthly interaction with Cozzens, co-leaders of TRC 1; and
- Weekly direct contact with Robert, and weekly email contact with Fujimura, co-leaders of TRC 2.

CNS-ASU also communicates internally through a listserv dedicated to CNS-ASU affiliated personnel at all its institutions, and through an electronic newsletter describing (retrospectively and prospectively) CNS activities on roughly an every-six-week basis. As CNS activities mature and produce more, and more regular, publications and research reports, we are attempting to focus the newsletter on research findings – with abstracts of completed papers highlighted above and beyond the seminars and presentations that have dominated our coverage. In recent months of the current year, newsletter production has slacked off due to the stresses of the All-Hands Meeting and other demands on Center staff. Within the next month or two, CSPO will be hiring a new communication coordinator who may be able to pick up some of the communication tasks at CNS that are getting left behind.

Much of the interaction among CNS personnel is driven by both the preparation for and the consequences of the All-Hands meeting. The first All-Hands meeting, held 19-21 April 2007, involved more than fifty faculty and student researchers from the several universities involved in CNS-ASU, plus about one dozen specially selected nano-in-society scholars from outside of CNS. The formal sessions of this meeting focused on presenting research-in-progress by the various RTTAs and TRCs, and more informal "self-organized activities" scheduled for meals and other breaks in the program allowed for cross-program interaction and planning. The "End-to-End" (E2E) project, for example, was a consequence of the first All-Hands meeting, as were many of the uses of the RTTA 1 data.

CNS-ASU held its second All-Hands meeting 23-25 Apr 08. Approximately seventy-five individuals attended, including CNS-affiliated researchers from each of its participating

universities, local CNS staff, other ASU personnel (e.g., Associate Vice President for Research Steve Goodnick), and a small set of selected invitees from outside CNS and ASU:

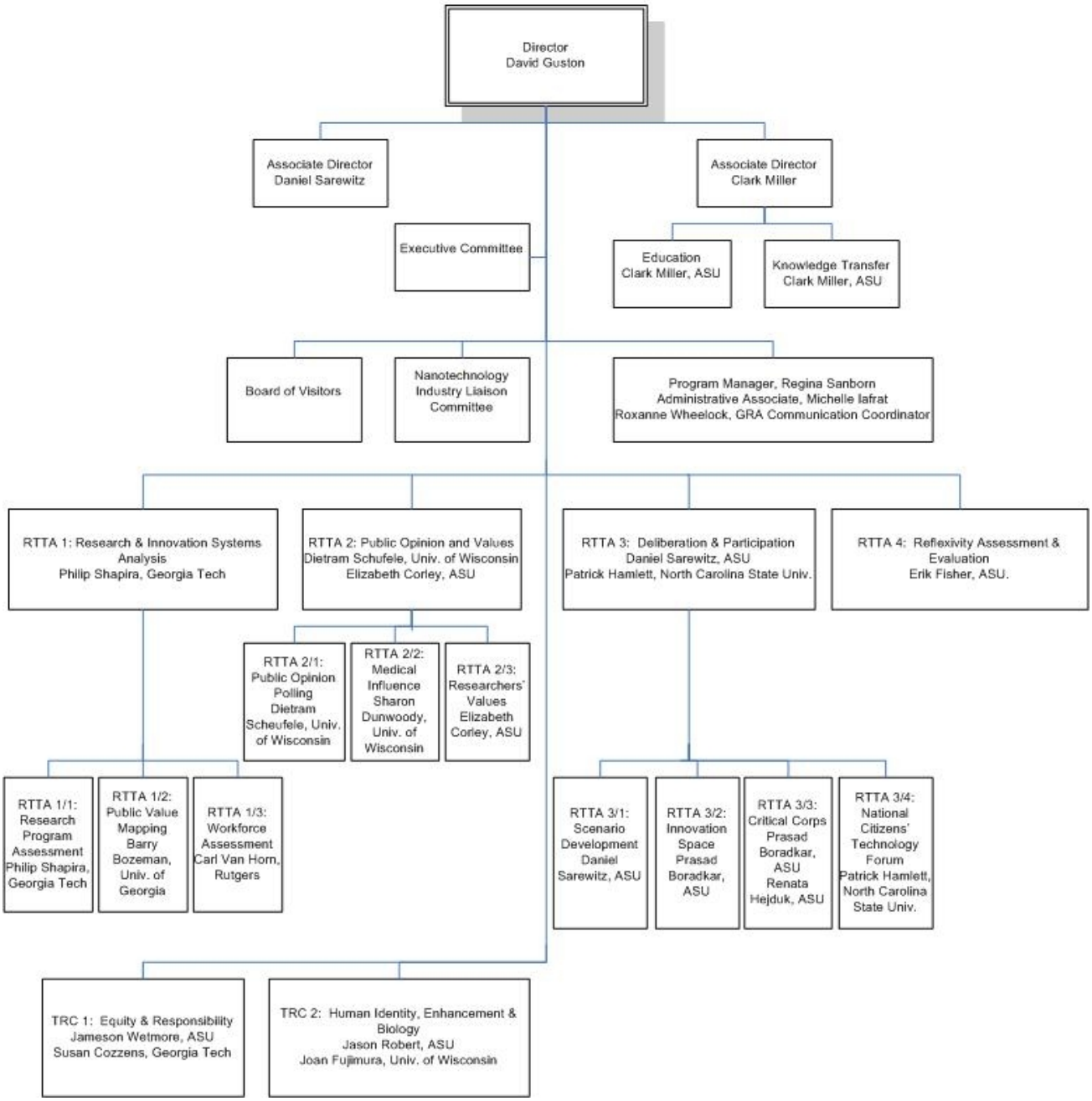
- Larry Bell, NISE Net/Boston Museum of Science;
- L. Cena, University of Iowa;
- W. Cyrs, University of Iowa;
- J.-P. Dupuy, Stanford University;
- A. Farman, City University of New York;
- M. Ingram-Waters, CNS-UCSB;
- R. Marks, NISE Net/Exploratorium;
- D. Morrison, Vanderbilt University;
- D. Schuurbiers, Delft University of Technology, The Netherlands; and
- C. Wobig, University of Illinois, Chicago.

In the coming year, in addition to its All-Hands meeting scheduled 14-16 Jan 09, CNS-ASU will hold a "visioning" workshop in Oct 08 to engage in reflexive scrutiny of our future visions of anticipatory governance and RTTA. We will include CNS-ASU research, education, and outreach leadership, as well as a few select outsiders and several of our NSE research collaborators.

Table 4: NSEC Personnel

							Citizenship Status											
							U.S. Citizen or Permanent Resident											
					Gender		Race					Mixed-indMixed						
Personnel Type				Total	Male	Female	NA	PI	AA	C	A	NA,PI,AA	C,A	Not Provided	Other Non-US	*Ethnicity Hispanic	Disabled	% NSEC Dollars
Director				1	1					1								
Asc. Dir.				2	2					2								
Team Leaders				9	6	3				8	1							
Staff				2		2				2								100%
Collaborators				51	36	15				43	3			4		1		
Research																		
	Post Docs			7	4	3				6						1		
	Doc/Mas. Students			56	30	26	2		2	25	6			16		5		
	Undergraduate Students			22	15	7			1	15	2			3		1		100%
Curriculum Development and Outreach																		
	Senior Faculty																	
	Junior Faculty																	
	Research Staff																	
	Visiting Faculty																	
	Industry Researchers																	
	Post Docs																	
	Doctoral Students																	
	Masters Students																	
	Undergraduate Students																	
REU Student, if applicable																		
	NSF REU Program																	
	NSF/NSEC Program REU																	
	NSEC's Own REU																	
Other Visiting College Students																		
Pre-college (K-12)																		
	Students																	
	Teachers - RET																	
	Teachers - non-RET																	
Total																		
	Totals			**150**	**94**	**56**	**2**		**3**	**102**	**12**			**23**		**8**		

CNS-ASU Organizational Structure – May 2008



Primary NSEC support indicated by (‡) *symbol. Partial NSEC support for all others.*

Books

1. ‡Fisher, E.; C. Selin; and J. Wetmore (eds). 2008. *Yearbook of Nanotechnology in Society, Volume I: Presenting Futures.* Guston, D.H. (series editor). New York: Springer.

2. ‡Guston, D. H. (ed.) under contract. *Encyclopedia of Nano-science and Society* (two volumes). Thousand Oaks, CA: Sage Publications.

3. ‡Miller, C. and D. Barben (eds). in preparation, 2011. *Yearbook of Nanotechnology in Society, Volume IV: Nanotechnology, Equity and Equality.* Guston, D.H. (series editor). New York: Springer.

4. ‡Robert, J.S. (ed). in preparation, 2009. *Yearbook of Nanotechnology in Society, Volume II: Nanotechnology, the Brain and the Future.* Guston, D.H. (series editor). New York: Springer.

5. ‡Wetmore, J. and S. Cozzens (eds). in preparation, 2010. *Yearbook of Nanotechnology in Society, Volume III: Nanotechnology, Equity and Equality.* Guston, D.H. (series editor). New York: Springer.

6. Wetmore, J. and D.G. Johnson. 2008. *Technology and Society: Building our Sociotechnical Future.* Cambridge, MA: MIT Press.

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7. Abbot, K.W.; G.E. Marchant and D.J. Sylvester. 2006. "A Framework Convention for Nanotechnology?" *Environmental Law Reporter*. 36: 10931-10942.

8. Alencar, M.S.M., A.L. Porter, and A.M.S. Antunes. 2007. "Nanopatenting Patterns in Relation to Product Life Cycle." *Technological Forecasting & Social Change*. 74(9):1661-1680.

9. ‡Bennett, I. and D. Sarewitz. 2006. "Too Little, Too Late? Research Policies on the Societal Implications of Nanotechnology in the United States" *Science as Culture*. 15(4): 309-325.

10. ‡Boradkar, P. and C. Selin. in preparation. "Prototyping Nanotechnology: A Pedagogic Approach to Responsible Innovation" *Journal of Nanotechnology Education*.

11. ‡Brossard, D., D.A. Scheufele, E. Kim, and B.V. Lewenstein. Forthcoming. "Religiosity as a Perceptual Filter: Examining Processes of Opinion Formation about Nanotechnology." *Public Understanding of Science*.

12. Brown, M. and D. H. Guston. Forthcoming. "Science, Democracy, and the Right to Research." *Science and Engineering Ethics*.

13. ‡Fernandez-Ribas, A. and P. Shapira. 2008, forthcoming. "Technological Diversity, Scientific Excellence and the Location of Inventive Activities Abroad: The Case of Nanotechnology." *Journal of Technology Transfer*.

14. ‡Fisher, E. 2007. "Ethnographic Invention: Probing the Capacity of Laboratory Decisions" *NanoEthics*. 1(2): 155-165.

15. ‡Fisher, E. & Lightner, M. Under review. "An Overlooked Responsibility: The Informed Consent of Graduate Engineering Researchers." *Science and Engineering Ethics.*

16. ‡Fisher, E. and R.L. Mahajan. 2006. "Nanotechnology Legislation: Contradictory intent? U.S. federal legislation on integrating societal concerns into nanotechnology research and development" *Science and Public Policy*. 33(1): 5-16.

17. ‡Fisher**,** E.; R.L. Mahajan; and C. Mitcham. 2006. "Midstream Modulation of Technology: Governance from Within." *Bulletin of Science, Technology and Society*. 26(6): 486-496.

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65. ‡Davis, R.W. 2007. *Nanotechnology in Society: Stakeholder Analysis and Nanotechnology Stakeholders*. Undergraduate Honors Thesis. The Barrett Honors College, Arizona State University. Tempe, Arizona.

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Reports and Working Papers

85. ‡Mans, M. and C. Selin. “Institutionalizing Innovation: Instances of Changes in the Danish System of Innovation.”

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Internet Dissemination

Website: http://cns.asu.edu

Nanofutures: http://cns.asu.edu/nanofutures/
Nano-Governance Wiki (under construction): http://cns.asu.edu/nanogovernance/wiki
NCTF: http://cns.asu.edu/nctf/index.htm
Website, Georgia Institue of Technology: http://www.cherry.gatech.edu/online
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Website: http://studiesinthetranshuman.blogspot.com/
D.H. Guston NLCT podcast: http://www.nanohub.org/resources/3270/
Website, Univesity of Wisconsin, Holtz Center: http://www.sts.wisc.edu/index.html

Presentations

Allenby, B. (2006, August). Chaired and contributed to a session entitled ‘Schumpeter’s Next Wave: Convergence of Nanotechnology, Biotechnology, Information Science, and Cognitive Science.’ Gordon Research Conference on Science and Technology Policy Big Sky, MT.

Barben, D. and F. Laird. (2006, June). “Acceptance Politics of Contested Technologies: A Comparison between Nuclear Power, Biotechnology, and Nanotechnology.” Annual Meeting of the Science and Democracy Network. Kennedy School of Government.

Barben, D. (2006, August). “Visions of Nanotechnology in a Divided World: The Acceptance Politics of a Future Key Technology.” Panel Series on Social Studies of Nanotechnology at the Conference of the European Association for the Study of Science Technology (EASST). University of Lausanne, Switzerland.

Bennett, I. (2007). “What if I don’t want my advisor’s job: Careers outside (gasp) the academic laboratory” Association of Women in Science Central Arizona Chapter. Tempe, AZ.

Bennett, I. (2007). “Frozen in Time: A tour of Alcor Life Extension Foundation” Spirit of the Senses. Scottsdale, AZ.

Bennett, I. (2006). “Emerging Technologies” Spirit of the Senses, Phoenix, AZ.

Brossard, D.; E. Kim; and D.A. Scheufele. (2007, May). *The Politics of nanotech: Communication and opinion formation about scientific issues and policies.* Paper presented to the annual convention of the International Communication Association, San Francisco, CA.

Carlson, M.P. (2006, April). An Overview of a Project to Improve Mathematics and Science Education for a Technical Society: Cognitive Research Informs Curriculum Development and Instructional Support. Presented at the Materials Research Society Symposium on Education in Nanoscience and Engineering, San Francisco.

Carley, S. (2007, October). “Nano Research Profiling On Demand” on nanotechnology datamining techniques and applications. Poster presentation at Atlanta Conference on Science, Technology, and Innovation Policy.

Cobb, M and P. Hamlett. (2008, June). “The first national citizens’ technology forum on converging technologies and human enhancement: Adapting the Danish consensus conference in the USA” Paper prepared for presentation at the Tenth International Conference on Public Communication of Science and Technology (PCST-10). Denmark and Sweden.

Conz, D. (2007) “Reflexivity Assessment of STS Engagement of Nanotechnology” Annual Meeting of the Society for Social Studies of Science. Canada, Montreal.

Corley, E.A. (2008, April). Scientists and the Public: Comparing Views on nanotechnology Risks and Regulations. CSPO Enlightening Lunch, Arizona State University, Tempe, Arizona.

Corley, E.A. and D.A. Scheufele. (2008, February). A Comparative Look at Markets, Media, and Emerging Attitudes about Nanotechnology. American Association for the Advancement of Science (AAAS) Annual Meeting, Boston, Massachusetts.

Corley, E.A.; D.A. Scheufele; S. Dunwoody; E. Hillback; T-J Shih; and D.H. Guston. (2007, October). Nanotechnology Attitudes among Scientists and the Public. Annual Meeting, Society for Social Studies of Science. Montreal, Quebec, Canada.

Corley, E.A. and D.A. Scheufele. (2006, November). 'Factors impacting public support of federal funding for nanotechnology.' To be presented at the 28th Annual Association for Public Policy Analysis and Management Research Conference, Madison, Wisconsin.

Fichtner, A. (2007). “Preliminary Results: The Workforce Needs of Companies Using Nanotechnology in Arizona.” Nanotechnology 2007 Conference. San Jose, California.

Fisher, E. (2008, April). “Embedded humanists.” *Engineering in Context*. Colorado School of Mines, Golden, CO.

Fisher, E. (2008, March). “Midstream Modulation and the Politics of Engagement.” STS in Action. Claremont, California.

Fisher, E. (2007). Integrating Science and Society in the Laboratory. Presentation for the Center of Integrated Nanotechnologies.

Fisher, E. (2007). NNI Meetings & Symposia. Nanotechnology and Society: the Organization and Policy of Innovation.

Fisher, E. (2007). Social and Policy Issues in Nanotechnology. Presentation for the Center of Integrated Nanotechnologies.

Fisher, E. (2007, December). “Inventing the Socially Conscious Laboratory.” Consortium for Science, Policy & Outcomes.

Fisher, E. (2007, August). “’Broader Impacts’ and the Embedded Humanist.” Making Sense of the “Broader Impacts” of Science and Technology.

Fisher, E. (2007, September). “Integrating Social Considerations into Nanotechnology Research.” 1st Rocky Mountain Nanotechnology Showcase. Denver, Colorado.

Fisher, E. (2007, July). “Integrating Societal Considerations and Nanotechnology in the Four Corners Region.” Colorado Nanotechnology Alliance. Denver, Colorado.

Fisher, E. (2007, June). “Drilling Down on US Ethics Policy for Nanotechnology.” Center for Interdisciplinary Research (ZiF), Bielefeld University, Bielefeld, Germany.

Fisher, E. (2007, June). “Integrating Science and Society in the Laboratory.” Center for Integrated Nanotechnologies, Los Alamos National Laboratory. Los Alamos, New Mexico.

Fisher, E. (2007, June). “Socio-technical Integration and the Nanotechnology Laboratory.” Visions about Nanoscience and Technology Workshop. Leuven, Belgium.

Fisher, E. (2007, June). “Investigating the Implementation of US Ethics Policy for Nanotechnology.” Institute for Technology Assessment and Systems Analysis, Forschungszentrum Karlsruhe in der Helmholtz-Gemeinschaft. Karlsruhe, Germany.

Fisher, E. (2007, June). “Engaging the Reflexive Capacity of Nanotechnology Researchers.” Nanotechnology, Ethics & Sustainability; NANOMAT Conference. Bergen, Norway.

Fisher, E. (2007, June). “Socio-technical Integration at Macro and Micro Levels.” Rathenau Institute, Den Haag, The Netherlands.

Fisher, E. (2007, Janurary). “Social and Policy Issues in Nanotechnology.” 5th CINT Users Workshop, Center for Integrated Nanotechnologies. Albuquerque, New Mexico.

Fisher, E. (2006, November). ‘Reflecting on the Shape of Nanotechnology Research from Within.’ 4S Conference (Society for Social Studies of Science). Vancouver.

Fisher, E. (2006, August). Poster presentation: ‘From Upstream Engagement to Midstream Modulation: Shaping Technology from Within.’ 4th Gordon Research Conference on Science and Technology Policy. Big Sky, MT

Fisher. E. (2006, November). “Current Societal Considerations in Nanotechnology.” Center for Integrated Nanotechnologies, Los Alamos National Laboratory. Los Alamos, New Mexico.

Fisher, E. (2006, July). “Midstream Modulation: US Federal Nanotechnology Policy Implementation.” TA NanoNed Day. Utrecht University, Netherlands.

Fisher, E. (2006, May). “Midstream Modulation of Technological Trajectories.” Trading Zones and Interactional Expertise Workshop. Arizona State University, Tempe.

Fisher, E. (2006, September). ‘Socratic Engagement of Nanotechnology: A Case Study in Ethics Policy.’ University of North Texas, Department of Philosophy and Religion Studies.

Fisher, E. and R. Mahajan. (2006 November). 'Midstream Modulation.' International Mechanical Engineering Conference. Chicago.

Gallo, J. (2007, October). “The National Science Foundation and the Creation of a Standing Army for Science” Society for the History of Technology. Washington, DC.

Gallo, J. (2007, April). “The National Science Foundation and the Control of Information.” Department of Life Sciences Communication colloquium series. University of Wisconsin.

Guston, D.H. (2007, November). Towards anticipatory governance of emerging technologies” Special Series on Science and Public Policy. Brown University.

Guston, D.H. (2008, April). “Governing Emerging Technologies”. Arizona Institute of Nano-electronics opening ceremonies.

Guston, D.H. (2007, November). “Governing Emerging Technologies” Spirit of the senses salon. Phoenix.

Guston, D.H. (2006). The Center for Nanotechnology in Society at ASU. AAAS Annual Meeting 2006, Nanotechnology Seminar: Social Science Engages Nanotechnology, St. Louis, MO.

Guston, D.H. (2006). CNS-ASU: Interdisciplinary Programs in a Self-Styled Boundary Organization. Conference of Trading Zones, Interactional Expertise, and Interdisciplinary Collaboration, Arizona State University, Tempe AZ.

Guston, D.H. (2006). Societal Implications of Nanotechnology. Discovery Lecture Series 2006. Transforming Society Through Emerging Technologies: The National Nanotechnology Initiative at Five Years, Purdue University, West Lafayette, IN.

Guston, D.H. (2006, December). “Anticipatory Governance of Emerging Technologies,” monthly meeting of the Arizona Nanotechnology Cluster.

Guston, D.H. **(**2006**,** October). “Anticipatory Governance of Emerging Technologies: The Center for Nanotechnology in Society at ASU” Stanford University Seminar in Science, Technology and Society.

Guston, D.H. (2006, August). “Anticipatory Governance of Emerging Technologies” Gordon Research Conference on Science and Technology Policy. Big Sky, MT.

Hamlett, P. (2008, March). “Public deliberations about science and technology: Should the public have a say on the future of nanotechnology?” NSF Science and Technology Center Program, Center for Environmentally Responsible Solvents and Processes Innovation Seminar Series. NC State University.

Hamlett, P. and M. Cobb. (2008, August). “Reporting the results of the first National Citizens’ Technology Forum” Paper presentation for the Gordon Research Conference: Governing Emerging Technologies. MT: Big Sky.

Hamlett, P. and M. Cobb. (2008, July). “The first National Citizens’ Technology Forum on Human Enhancement : results and prospects”. Paper presentation at VIPSI-2008 (Information Processing Society, International), Conference: “Knowledge Engineering, Tutorials, & Brainstorming”. Italy: Pisa.

Hamlett, P. and M. Cobb. (2008, May). “The first national Citizens’ Technology Forum on Nanotechnology—first results” Univeristy & Industry Consortium, Spring 2008 Meeting. Lansing, MI.

Hogle, L.F. (2007). “Sentinel Beings: the biopolitics of human biosensors” Submitted to BioSocieties (invited paper, theme issue on Biopower, Biotechnology and Globalization; M. Cooper and C. Waldby, guest editors).

Hogle, L.F. (2007, March). ‘Stem cells as a study in transience: a future history.’ Paper presented to the Max Planck Institute for the History of Science, on convergence of nanotechnologies with regenerative medicine and systems biology. Berlin.

Kay, L. (2008, January). “Nanotechnology in Latin America” paper presentation at the conference DRUID-DIME Academy Winter 2008 PhD Conference on Economics and Management of Innovation and Organizational Change, held in Rebild, Denmark.

Libaers, D. (2006, September). 'The Role & Contribution of foreign-born scientists & engineers to the US Nano Science & Technology research enterprise, 2006 Technology Transfer Society Conference, Atlanta.

Laurent, B. & Fisher, E. (2007). “The Integration of Public Input into the American Nanotechnology Federal Program: Meanings and Contradictions.” Third Living Knowledge conference. Ecoles des Mines, Paris, August 30-September 1.

Maricle, G. (2008, January). “Shaping Science: How to Turn Science Studies into Science Action.” Dissertation Defense. Colorado, Boulder.

Maricle, G. (2008, January). “The State of Policy and Socio-Economic Research.” American Meteorological Society Annual Meeting. New Orleans, LA.

Maricle, G. (2007, December). “Shaping Science: Turing Science Studies into Science Action.” Center for Science and Technology Policy Research Noontime Seminar Series. Colorado, Boulder.

Maricle, G. (2007, October). “Wrestling with Engagement: Tools for Iterating Intervention in STS”. Society fo the Social Studies of Science Annual Meeting. Canada, Montreal.

Marchant, G. (2006, July). ‘Nanotechnology Regulation: The United States Approach’ at Monash University’s Conference on New Global Regulatory Frontiers: Evaluating what will work for Nanotechnology in Melbourne, Australia.

Miller, C. and I. Bennett. (2007, April). ‘Science Fiction as Technology Assessment: Some Preliminary Thoughts on Anticipatory Governance for the Rest of Us.’ Cornell University.

Miller, C. (2007, April). ‘Commentary: The Law and the Future Brain.’ US District Court and Sandra Day O’Connor College of Law, Arizona State University.

Miller, C. (2006, November). ‘Informing Anticipatory Governance of New and Emerging Technologies through Nanotechnology in Society Research.’ Nanotechnology Informal Science Education Network.

Miller, C. (2006, October). ‘Reflexive, Anticipatory Governance of Science and Technology.’ National Association of Schools of Public Administration and Affairs.

Miller, C. (2006, June). ‘Think Differently! Strategies for Success in Nano.’ Food Research Institute, University of Wisconsin-Madison.

Miller, C. (2006, April). ‘Nanotechnology in Society Education: Teaching the Mental Habits of Social Engineers and Critical Citizens.’ Materials Research Society.

Miller, C. (2006, March). ‘Nanotechnology in Society.’ Ohio State University.

Miller, C. (2006, December). “Boundary Organizations: Strategies for Linking Knowledge to Action.” Workshop on Boundary Organizations, Tempe, AZ .

Newman, N. (2006, November). “Nanotechnology research mapping and assessment,” STI Indicators Conference, Lueven, Belgium.

Newman, N. (2006, June). “Advancing Measures of Innovation: Knowledge Flows, Business Metrics, and Measurement Strategies.” Workshop on Research and innovation system assessment: a nanotechnology case study. National Science Foundation, Arlington, VA.

Pielke, Jr., R. (2006, August). Discussant: ‘Uncertainty in Science, Uncertainty in Politics.’ Gordon Research Conference on Science and Technology Policy Big Sky, Montana.

Pirtle, Z. (2007). Democratizing Nanotechnology: Intersecting the Philosophy of Science and Science Policy. Barrett Honors College Thesis.

Porter, A.L. (2007, November) Keynote presentation. Conference on Competitive Intelligence, Madrid

Porter, A.L. (2007, October). Public Lecture. Institute for S&T Information in China. Beijing.

Porter, A.L. (2007, March). "Where is Nano Going? R&D Profiling with a Focus on Nanophotonics." Nano Giga Conference. Phoenix, Arizona.

Porter, A.L. (2006, November). "Mining Patents + Research Publications to Improve Technology Management: Nano Illustrations," 2nd PATINEX Conference, Seoul.

Porter, A.L.; P. Shapira; and J. Youtie. (2006, September). "Defining the Nanotechnology Domain in a Real Time Technology Assessment," Technology Transfer Society Annual Conference, Atlanta, Georgia.

Porter, A.L.; D. Schoeneck; N. Newman; P. Shapira; J. Youtie; and R. Kolar. (2006, September). 'Nano R&D Profiles: A Deeper Look.' Presented at 2006 S&T Indicators Conference. Leuven, Belgium.

Porter, A.L.; D. Schoeneck; P. Shapira; J. Youtie; and R. Kolar. (2006, September). 'Defining the Nanotechnology Domain in Realtime Technology Assessment.' Presented at 2006 Technology Transfer Society Conference, Atlanta, Georgia.

Porter, A.L.; J. Youtie; P. Shapira. (2006, August). Refining Search Terms for Nanotechnology. Prepared for Presentation at the National Science Foundation.

Robert, J.S. (2007, April). 'Problematizing "Enhancement"'. Dartmouth College

Robert, J.S. (2007, February). 'Braving the World of Neurotechnology' Health Law Institute Seminar Series, Dalhousie University

Robert, J.S. (2006, November). 'Brain Repair and Neural Enhancement.' 4S Conference (Society for Social Studies of Science). Vancouver. (Session organized by Linda Hogle.)

Robert, J.S. (2006, October). 'Nanotechnology, Neurotechnology, and Society.' *International Institute of Nanotechnology Symposium*, Northwestern University, Evanston, Illinois.

Robert, J.S. (2006, October). "Forbidden Science – Boundaries on New Emerging Science and Technology" Presented at Jewish Women's Symposium, Tempe Arizona.

Robert, J.S. (2006, August). "Controversial Science, Controversial Scientists?" NABIS Conference, Chicago.

Sarewitz. D. (2006, August). Discussant: 'Policy Perspectives' at the panel, 'Meta-Analysis: Emerging Themes in Science Policy.' Gordon Research Conference on Science and Technology Policy Big Sky, Montana.

Scheufele, D. A. (2008, February). 90-minute panel: A comparative look at markets, media, and emerging attitudes about nanotechnology. Organized for the annual convention of the American Association for the Advancement of Science, Boston, Massachusetts. (with E. Corley as speaker)

Scheufele, D. A. (2008, February). Engaging religious audiences on nanotechnology. Presented to the annual convention of the American Association for the Advancement of Science. Boston, Massachusetts.

Scheufele, D.A. (2007, May). 'Public perceptions and understanding of nanotechnology' at the Center for Nanoscale Science and Technology (CNST) Nanotechnology Workshop. University of Illinois at Urbana-Champaign. http://www.cnst.uiuc.edu/NanoWorkshop2007.htm.

Scheufele, D.A.. (2007). Understanding the opinion and communication dynamics surrounding nanotechnology at the Symposium on the "Social Studies of Nanotechnology", University of Pennsylvania, Wharton School of Business & Chemical Heritage Foundation

Scheufele, D.A. (2007). Panelist at symposium on "Risky Business? Risk Perception & Nano Business," Illinois Institute of Technology, Center on Nanotechnology and Society, Chicago, Illinois.

Scheufele, D.A. (2007). 'Public perceptions and understandings of nanotechnology.' Keynote presentation at the "Nano and Giga Challenges in Electronics and Photonics" conference, Tempe, Arizona.

Scheufele, D.A. (2007). 'How media and audiences make sense of scientific issues: The case of nanotechnology.' Talk at the "CMCIS Research Lecture Series, University of South Carolina."

Scheufele, D.A. (2006). 'Public communication and policy making about nanotechnology.' Talk at the "Baldwin Nano Workshop for Policy Makers, Materials Research Science and Engineering Center and Engineering Center on Nanostructured Interfaces, University of Wisconsin. Madison, Wisconsin.

Scheufele, D.A. (2006). 'Influences on public opinion about nanotechnology.' Talk at the "Public Participation in Nanotechnology & Nanoscale Science" workshop, National Nanotechnology Coordination Office, Washington, D.C.

Scheufele, D.A. (2006). 'Successful public communication about nanotechnology.' Talk at the "Integration of Societal Implications into Science" workshop, U.S. Department of Energy, Washington, D.C.

Scheufele, D.A. (2006). 'It's not all about information: Exploring people's attitudes toward new technologies.' Lecture at the Science, Democracy, and Public Policy colloquium, La Follette School of Public Affairs, University of Wisconsin, Madison.

Scheufele, D.A. (2006). 'Successful public communication about nanotechnology.' Talk at the Baldwin Nano Workshop for Journalists, Materials Research Science and Engineering Center and Engineering Center on Nanostructured Interfaces, University of Wisconsin, Madison.

Scheufele, D. A., Brossard, D., & Dalrymple, K. (2007, November). Whose voice matters most? Public opinion about the role of scientists, religious groups, officials, and citizens in public discourse about science. Presented to the annual convention of the Midwest Association for Public Opinion Research, Chicago, IL.

Scheufele, D. A., Corley, E. A., Hillback, E., Shih, T., Dunwoody, S., & Guston, D. (2007, October). Nano attitudes among scientists and the public. Presented to the annual convention of the Society for Social Studies of Science.

Scheufele, D.A. and E. Kim. (2006, May). 'Public opinion, religiosity, and nanotech: Examining processes of opinion formation on emerging technologies.' Paper presented to the annual convention of the World Association for Public Opinion Research, Montréal, Québec.

Selin, C. (2008, May). Chaired panel at the Managing the Uncertainty of Nanotechnologies. Challenges to Law, Ethics, and Policy Making conference at University of Padua.

Selin, C. (2008, February). Evidencing the Future and other Dilemmas Working in the Future Tense. Presented at the Anthropology Department, Rice University, Houston, Texas.

Selin, C. (2007, October). Between Hope and Prudence: Experiments in Scenaric Learning. Society for the Social Studies of Science, Annual Meeting, Montreal, Canada.

Selin, C. (2007, October). 'The Future Tense: The Ways and Means of Anticipation.' CSPO Enlightening Lunch, Tempe.

Selin, C. (2007, September). Chaired panel at CRN conference on Challenges & Opportunities: The Future of Nano & Bio Technologies.

Selin, C. (2007, July). Real Time Technology Assessment: Anticipation, Integration, & Engagement. Presented at The Program on Technology Scenarios, Risoe, National Laboratory, Roskilde, Denmark.

Selin, C. (2006, September). 'The Center for Nanotechnology in Society.' NanoTX Conference, Dallas.

Shanley, L. A. (2006, June). Privacy and Security: Internet Publication of Digital Spatial Data and Land Records in Wisconsin. Presentation at WLIA Regional Meeting on Privacy, Copyright, Data Distribution and GIS Law. Elkhart Lake, Wisconsin.

Shanley, L. A. (2006). Control and Access: GIS Legal Issues for Indian Nations in the United States. In Proceedings from *URISA2006 Annual Conference*. Chicago, IL: URISA.

Shanley, L. A. and S.J. Ventura. (2007). Land Records and Map Services: Internet Privacy Policies in Wisconsin. Accepted for *URISA 2007Annual Conference*. Chicago, IL: URISA.

Shapira, P. (2007, June) "Nanotechnology in Society: Research and Innovation Systems Program Assessment," invited presentation, Beijing Institute of Economic Management, Chinese Academy of Science, Beijing, China, June 19, 2007; and at Institute of Policy and Management, Chinese Academy of Sciences, June 20, 2007.

Shapira, P. (2007, February). "Societal Assessment of Nanotechnology – US Experience" Symposium on Nanotechnology organized by the Ministry of Research, Science and Technology at the Advanced Materials and Nanotechnology (AMN-3) 2007 Conference, Wellington, New Zealand.

Shapira, P. and J. Youtie. (2008, May). "What's new about emerging metropolitan nanodistricts in the United States and Europe? Characteristics of research and commercialization" presentation abstract accepted by the NBER Conference on Emerging Industries: Nanotechnology and NanoIndicators, Cambridge, MA.

Shapira, P. and J. Wang. (2008, April). "From Lab to Market: Strategies and Issues in the Commercialization of Nanotechnology in China." Panel on Cultures Meet Technology: New Approaches to Innovation and Economic Development in Asia and the West, Association for Asian Studies, 2008 Annual Meeting, Atlanta.

Shapira, P.; A. Porter ; and J. Youtie. (2006. August). "Refining Search Terms for Nanotechnology." Presented at the National Science Foundation.

Shapira, P. and D. Guston. (2007, March). "Societal Assessment of Nanotechnology – US Experience," Invited presentation at the Ministry of Research, Science and Technology, Wellington, New Zealand.

Suchman, M.C. (2007). 'The Implications of Nanotechnology for Social Science and Social Policy,' presented to the Cornell CNF Public Interest Talk Series in Ithaca, NY.

Suchman, M.C. (2007). "Sharing is (S)caring on the Digital Frontier: The Challenges of Information Technology Governance in Health Care Organizations," presented to the Cornell Center for the Study of Economy and Society, 2006-2007 Seminar Series on Institutions, Market Processes, and the Firm, in Ithaca, NY; and to the Brown University Department of Sociology Colloquium in Providence, RI.

Suchman, M.C. (2007). "HIT or Miss? The Governance Challenges of Health Information Technology," presented to the Cornell Law School Faculty Workshop in Ithaca, NY; and to the Duke Law School Faculty Workshop in Durham, NC.

Suchman, M.C. (2006). "Taming the Market for Medical Information: "Sharing is (S)caring' on the Digital Frontier," presented to the University of California-Irvine Critical Legalities Symposium in Irvine, CA.

van Merkerk, R.; D. Guston; and R. Smits. (2006, November). 'An International Comparison of Recent Technology Assessment. Approaches: Bypassing Collingridge.' 4S Conference (Society for Social Studies of Science). Vancouver, British Columbia.

Tang, L. (2008, February). Invited participation and presentation on "Nanotechnology Knowledge Networks in China," at the PRIME Nanotechnology Winter School. Grenoble, France.

Tang, L. (2007, October). *Networks of Research Collaboration in China: Evidence from nanotechnology publication activities, 1990-2006*. presentation at Atlanta Science and Technology Policy Conference.

Tang, L. (2007, October). "New Argonauts & Scientific Networks: Evidence from China's Nanotech Publication," Atlanta Science and Technology Policy Conference. Atlanta, Georgia.

Wang, J. (2008, January). "From Lab to Market: Strategies and Issues in the Commercialization of Nanotechnology in China. Presentation at the National Academy of Sciences, Student Forum on Science and Technology Policy, Washington, DC.

Wang, J. (2007, October). "Nanotechnology in China: Research, Development, and Commercialization, Atlanta Science and Technology Policy Conference. Atlanta, Georgia.

Wang, J. (2007, September). "From lab to market: Strategies and issues in the commercialization of nanotechnology in China." Poster presentation at National Science Foundation, Science and Technology in the New Global Economy: Policy Workshop, Washington, DC.

Wang, J. (2007, September). "From lab to market: Strategies and issues in the commercialization of nanotechnology in China." National Academy of Science, Conference on the Dragon and the Elephant: Understand the Development of Innovation Capacity in China and India, Washington, DC.

Wang, J. (2006, September). "Resource Spillover from Academia to High Tech Industry: Evidence from nanotech start-up enterprises" 2006 Technology Transfer Society Conference, Atlanta.

Wetmore, J. (2006, August). 'Religious Forays into Nanotechnology Policy.' Poster presentation. Gordon Research Conference on Science & Technology Policy in Big Sky, Montana.

Wetmore, J. (2007, February). "Nanotech and Religion: Ambitions, Influence, and Policy" Invited presentation to CNS-UCSB.

Wetmore, J. (2007, March). "STS in the Trenches: Engaging Scientists and Engineers" STS Engaged Workshop, University of Virginia Department of Science, Technology and Society.

Wetmore, J. (2007, June). "Teaching the Ethics and Social Implications of Emerging Technologies to Graduate Level Students" with Joan McGregor, American Society for Engineering Education Annual Conference, Honolulu.

Wetmore, J. (2007, September). "Bureaucrats, Lobbyists, and Regulators, Oh My! Introducing Graduate Students to Science Outside the Lab," with Ira Bennett to CSPO's Enlightening Lunch. Tempe, Arizona.

Wetmore, J. (2008, April). MBB 490: Capstone: Issues in Biotechnology, on Ethics in Biotechnology.

Wetmore, J. (2007, November). ASB 591: Seminar on Professionalism, on the Academic job search.

Wetmore, J. (2008, April). "What do you Think About a Technology You Can't Even See?" CNS-ASU Science Café, Arizona Science Center. Phoenix, Arizona.

Wetmore, J. (2007, December). "Amish Technology" Spirit of the Senses Salon. Phoenix, Arizona.

Wetmore, J. (2007, October). "Less is More' Technology: Is Smaller and Cheaper Always Better?" presentation with Deirdre Meldrum, CNS-ASU Science Café, Arizona Science Center. Phoenix, Arizona.

Wetmore, J. and B. Jacobs. (2007, March). "Transferring Western Technology to Developing Countries: Good Intentions, Unexpected Outcomes" Science Café, Phoenix, Arizona.

Wolbring, G. (2006, August). Presentation on governance of nano-bio-info-cogno-synbio. NABIS Conference. Chicago.

Wolbring, G. (2005, December). The Triangle of Enhancement Medicine, Disabled People, and the Concept of Health: A New Challenge for HTA, Health Research, and Health Policy. Health Technology Assessment (HTA) Initiative #23. Edmonton, Alberta: Alberta Heritage Foundation for Medical Research.

Wetmore, J. (2007, August). "Cat's Cradle, by Kurt Vonnegut" Spirit of the Senses Salon, Scottsdale, AZ.

Youtie, J. (2007, October). "Nanodistricts in the United States: Metropolitan Trajectories and Clustering" presented at the Atlanta Conference on Science, Technology, and Innovation Policy.

Youtie, J. (2007, March). "Nanotechnology Research Program Assessment" Presentation to the National Science Foundation Societal Implications of Nanotechnology: 2007 Principal Investigator's Meeting, Arlington Virginia.

Youtie, J. (2006, October). "Nano research enterprise assessment" Workshop on Next Generation Metrics, SRI, Arlington, Virginia.

Youtie, J.; M. Iacopetta; and S. Graham. (2006, September). "Long Views of Nanotechnology: Is it a General Purpose Technology?" Technology Transfer Society Annual Conference, Atlanta.

BIOGRAPHICAL INFORMATION – NEW SENIOR PERSONNEL

Sheila McNamee, Ph.D., is Professor of Communication at the University of New Hampshire. She is a founder and Board Member of the Taos Institute.

At the University of New Hampshire, she was the 2001 recipient of the Class of 1944 Professorship and the 2007 recipient of the Lindberg Award for Outstanding Scholar/Teacher.

McNamee's work is focused on dialogic transformation within a variety of social and institutional contexts including psychotherapy, organizations, education, healthcare, and local communities. She is author of Relational Responsibility: Resources for Sustainable Dialogue, with Kenneth Gergen (Sage, 1999). Other books include, Therapy as Social Construction, with Kenneth Gergen (Sage, 1992), Philosophy in Therapy: The Social Poetics of Therapeutic Conversation, with Klaus Deissler (Carl Auer Systeme Verlag, 2000), The Appreciative Organization, with her co-founders of the Taos Institute (Taos Institute, 2001) and The Social Construction of Organisation with Dian Marie Hosking (Liber and Copenhagen Business School Press, 2005).

McNamee also has authored numerous articles and chapters on social constructionist theory and practice. She actively engages constructionist practices in a variety of contexts to bring communities of participants with diametrically opposing viewpoints together to create livable futures. McNamee lectures and consults regularly, both nationally and internationally, for universities, private institutes, organizations, and communities.

BIOGRAPHICAL INFORMATION – NEW SENIOR PERSONNEL

Juan D. Rogers, PhD., is Associate Professor of Public Policy and Director of the Research Value Mapping Program at the School of Public Policy, Georgia Institute of Technology. He teaches courses on science and technology policy, information management and policy, knowledge management, logic of policy inquiry, and bureaucracy and policy implementation.

Rogers' current research interests include modeling the R&D process, assessment of R&D impacts, especially in the formation of scientific and technical human capital, technology transfer, R&D policy and evaluation, the interaction of social and technical factors in the development of information technology, and information technology policy.

As a Faculty Research Associate with the Georgia Tech RTT1 CNS-ASU group, Rogers is examining the operation and impacts of U.S. nanotechnology research centers sponsored by the National Nanotechnology Initiative, drawing on a prior large-scale survey of scientists in U.S. research centers. Rogers also is an investigator with an associated project analyzing institutional factors influencing highly creative science in nanotechnology and human genetics.

Rogers received his Ph.D. in science and technology studies from Virginia Polytechnic Institute and State University and an EE from the University of Buenos Aires, Argentina.

Honors and Awards

Prasad Boradkar, an ASU Assistant Professor of Industrial Design was named a finalist for the ASU Parents' Association 2008 Professor of the Year Award, recognizing excellence in contributions to undergraduate education. Boradkar is the team leader for InnovationSpace.

Elizabeth Corley was promoted in 2008 to Associate Professor with tenure in the ASU School of Public Affairs. Corley is CNS-ASU co-PI and co-leader of RTTA 2.

Stuart Lindsay was named a 2008 Arizona State University Regents' Professor, an award that is reserved for faculty members at Arizona's public universities who have demonstrated exceptional scholarship and outstanding achievements. Lindsay's lab is host to numerous CNS interactions, including the Photon project.

Zach Pirtle, a graduate research assistant in Civil and Environmental Engineering, was named a 2008 Fulbright Scholar, and will be conducting research in Mexico this summer. Pirtle was an undergraduate research intern with CNS-ASU and wrote his honors thesis under the direction of Robert and Guston. His Fulbright research is inspired by the CNS NanoFutures project.

Jason Scott Robert was promoted in 2008 to Associate Professor with tenure in the ASU School of Life Sciences. Robert is co-leader of the Thematic Research Cluster on Human Identity, Enhancement, and Biology.

Neal Woodbury, an ASU Professor of Chemistry and Biochemistry was named a finalist for the ASU Parents' Association 2008 Professor of the Year Award, recognizing excellence in contributions to undergraduate education. Woodbury's lab is host to number CNS interactions.

Table 6: Partnering Institutions

Name of Institution	Receives Financial Supports from Center	Contributes financial support to the center	Minority Servicing Institution Partner	Female Serving Institution Partner	National Lab/other govt. Partner	Industry Partner	Museum Partner	International Partner	Other
I.a. Academic Partnering Institutions (ASU)									
Biodesign Institute		x							
CRESMET		x							
CSRC									x
College of Design		x							
CLAS		x							
CSPO									
Decision Theater									x
Global Institute									
Hispanic Res. Ctr.			x						
SOLS									
School of Law		x							
SHESC		x							
SPARC									x
I.b. Academic Partnering Institutions									
Carnegie Mellon									x
CO Schl. of Mines									x
Columbia									x
Copenhagen Bus.									x
Cornell									x
Delft Univ.									x
Ecoles des Mines									x
Georgia Tech	x								
Harvard									x
IL Inst. of Tech									x
Oxford									x
Lancaster									x
Mesa Biotech									x
Mesa High School									x
MI State									x
NCSU	x								
Northeastern									x
Northwestern									x
NSEC/UCSB									x
Rutgers	x								
UCLA/Harvard									x
U of Zacatecas									x
U of Antwerp									x
U of Arizona									x
U of Calgary									x
UC, Berkeley	x								
UC, Irvine									x
U of Co, Boulder	x								
U of Georgia	x								
U of IL, Chicago									x
U of Iowa									x
U of MI									x
UNH	x								
U of SC									x
U of TN, Knoxville									x
U of Twente									x
U of VA									x
U of WI, Madison	x								
Vanderbilt									x
VA Tech									x
Total Number Academic Partners									
54									
II. Non-academic Partnering Institutions									
AAAS									x
AZ Nano Cluster									x
AZ BioIndustry									x
AZ Science Ctr.		x							
Res. & Econ. Affs.		x							
AZ Tech Council									x
BioIndustry of AZ									x
CRN									x
DOE									x
Ecol. Soc. of Amer									x
EPA									x
FDA									x
GRC		x							
INSN									x
Jennings, Strouss		x							
Lawrence Liver. Lab									x
Luxe Ventures									x
MOS									x
NISEnet		x							
Nat. Geo. Soc.									x
Nat. Nano Cor. Off.									x
NRC									x
Nuclear Waste Rev.									x
Sandia Nat. Lab									x
Spirit of the Senses									x
Tgen									x
Tch. America									x
Tempe Festival									x
Televerde									x
The Foresight Inst.									x
US CINT									x
WWC									x
Total Number Non-academic Partners:									
32									