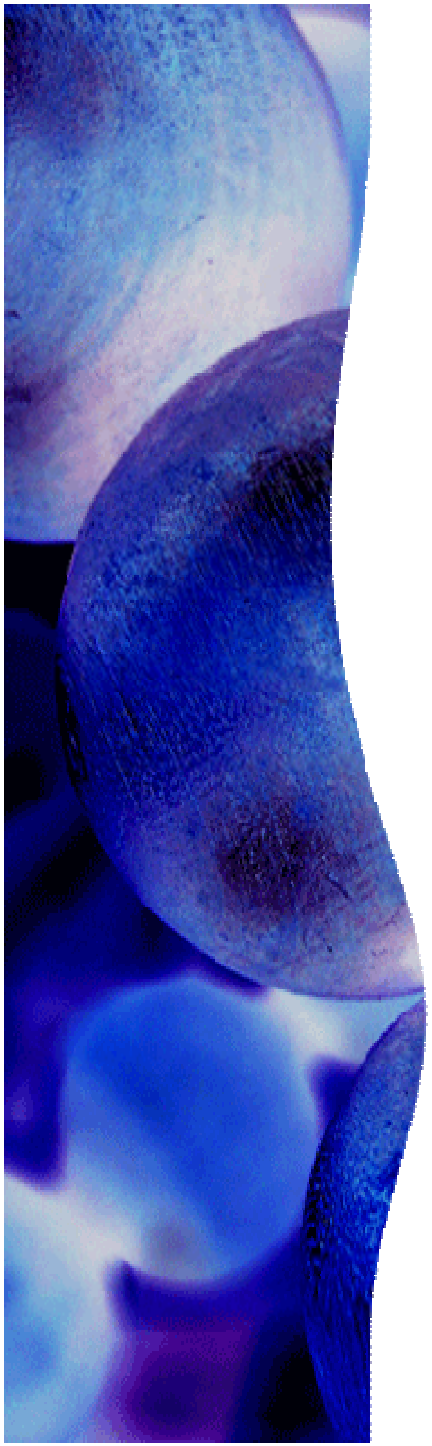

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Arizona Institute for Nanoelectronics: Kick-Off

4 April 2008

David H. Guston, Director

Center for Nanotechnology in Society at ASU

CNS-ASU research, education and outreach activities are supported by the National Science Foundation under cooperative agreement #0531194.

The U.S. 21st Century Nanotechnology R&D Act of 2003 (PL 108-153)

Sec 2(b)(10):

- Establish societal implications research program
- Require NSECs address societal implications
- Integrate societal concerns with nano R&D for benefit of all
- Provide for public input

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Network for Nanotechnology in Society

- **NSEC/Center for Nanotechnology in Society at Arizona State University**

  $6.2 million (Oct 2005 – Sept 2010)

- NCEC/Center for Nanotechnology in Society at UC Santa Barbara

  $5 million

- Projects:
  - Harvard/UCLA

    ($1.7 million)
  - University of South Carolina

    ($1.4 million)

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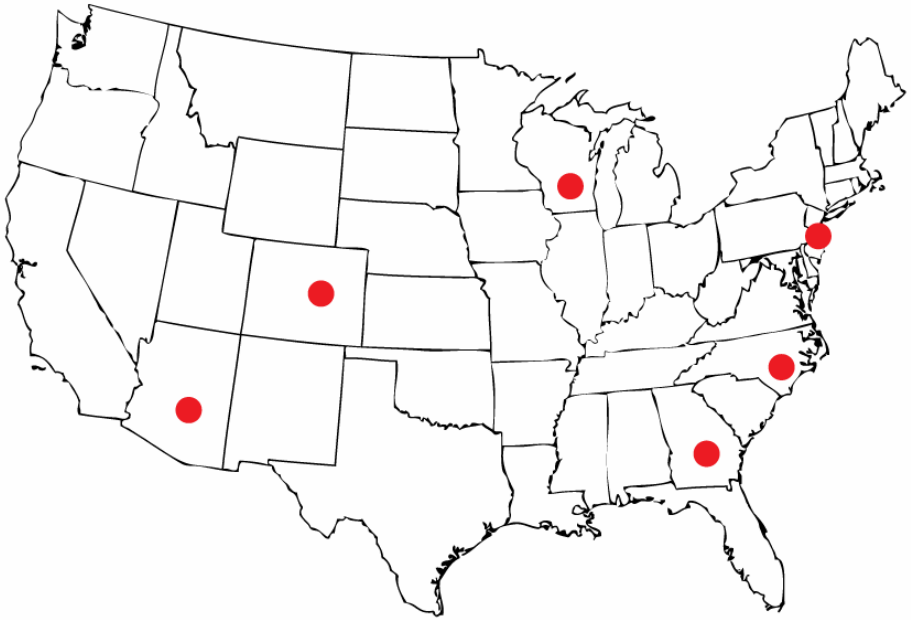
NSEC/CNS-ASU Network

- Arizona State University
- University of Wisconsin-Madison
- Georgia Tech
- North Carolina State University
- Rutgers University
- University of Colorado, Boulder
- University of Georgia

CNS-ASU involves the activities of more than 80 individuals at seven major collaborating institutions, as well as other collaborators, partners, and consultants



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NSEC/CNS-ASU Mission

- **Research** the societal implications of nanotechnologies
- **Train** a community of scholars with new insight into the societal dimensions of nanoscale science & engineering (NSE)
- **Engage** the public, policy makers, business leaders, and NSE researchers in dialogues about the goals and implications of NSE
- ***Partner*** *with NSE laboratories to introduce greater reflexiveness in the R&D process*

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NSEC/CNS-ASU Research Programs

Real-Time Technology Assessment

- Research and Innovation Systems Analysis (RISA)
- Public Opinion and Values (POV)
- Deliberation and Participation (D&P)
- Reflexivity Assessment and Evaluation (RAE)

Thematic Research Clusters

- Equity and Responsibility (E&R)
- Human Identity, Enhancement & Biology (HIEB)

Encouraging reflexivity among NSE research establishment

Building capacity for anticipatory governance

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Clearing Up Some Jargon

Reflexivity

- A capacity for social learning (by individuals, groups, institutions, publics) in the NSE enterprise narrowly, and society broadly, that expands the domain of and informs the available choices in decision making about nano.

Anticipatory Governance

- A broad-based capacity extended through society that can act on a variety of inputs to manage emerging knowledge-based technologies while such management is still possible.

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Partnerships: Teaching

- Teaching with:
  - (UG) Learning Community
  - (UG) InnovationSpace
  - NSE Ethics & Responsibility
    - Woodbury lab
    - Eng Ethics course development
- Teaching for:
  - Professionals – NNIN and CINT
  - Grads
    - Summer sessions – DC and IPNS
    - Courses – STSO, NB&F, Nano Law, K-12
  - Undergrads – Perspectives, HE&D, J&F

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Partnerships: ISE & Outreach

- Science Cafés
  - Off-campus events for lay public
  - Matching natural scientists & engineers with social scientists & humanists
- Ten Big Ideas
  - For informal science educators
  - Describing societal perspectives on nano
- National Citizens' Technology Forum
  - 6 panels of lay citizens across country
  - Expert-informed deliberations and recommendations

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Partnerships: Research

- Scenario Development
  - NSE scenes
  - Doc-in-a-box
  - Cancer vaccine
- Tubes in the Desert
  - “embedded” researcher and grad student
- Public Value of Organic Photovoltaics
  - Partial embed
  - Structured workshops
- STIR Proposal
- Training NSE grad students
  - CNS/Biodesign Fellows/PhD+

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Find Out More About CNS-ASU

- Web address:

http://cns.asu.edu

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More on *Anticipatory* Governance

- "Competent social scientists should work hand-in-hand with natural scientists, so that problems may be solved as they arise, and so that many of them may not arise in the first instance."
  - Understand beforehand the political and operational strengths and weaknesses of such activities
  - Imagine sociotechnical futures that might inspire their use

Mike Roco has even started using the language of "anticipatory governance!"

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More on Anticipatory *Governance*

- Not government but governance
- Not "do" or "ban"
  - "Science finds, genius invents, industry applies, man adapts"
  - Moratoriums proposed by ETC Group and Friends of the Earth
- Wide array of mechanisms
  - Licensing, restrictions
  - Liability, indemnification
  - IP
  - Testing
  - Treaties
  - PUS – FSE, ISE
  - Public engagement
  - Public action

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RTTA 1: Research and Innovation Systems Analysis

Who is doing what kind of NSE research?

How can we measure NSE's contribution to broad social goals?

What nano training do we need in regional markets?

Research Program Assessment

- Data-mining, interviews, etc.
- To ID core thrusts and actors

Public Value Mapping

- Conceptual development
- To connect research to promised public values

Workforce Assessment

- Supply and demand analysis
- To assess regional nano workforce

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RTTA 1: Research and Innovation Systems Analysis

Defining *nano*

Search	Terms	2005 SCI Hits
MolEnv-I (inclusive)	(monolayer* or (mono-layer*) or film* or quantum* or multilayer* or (multi-layer*) or array* or molecul* or polymer* or (co-polymer*) or copolymer* or mater* or biolog* or supramolecul*)	>100000
MolEnv-R (more restrictive	(monolayer* or (mono-layer*) or film* or quantum* or multilayer* or (multi-layer*) or array*)	78390
nano*	nano*	39101
Quantum	(quantum dot* OR quantum well* OR quantum wire*) NOT nano*	3633
Self-Assembly	(((SELF ASSEMBL*) or (SELF ORGANIZ*) or (DIRECTED ASSEMBL*)) AND MolEnv-I) NOT nano*	3532
Terms to include as Nano without other delimiters	((molecul* motor*) or (molecul* ruler*) or (molecul* wir*) or (molecul* devic*) or (molecular engineering) or (molecular electronic*) or (single molecul*) or (fullerene*) or (coulomb blockad*) or (bionano*) or (langmuir-blodgett) or (Coulomb-staircase*) or (PDMS stamp*)) NOT nano*	3550
Microscopy - terms to include but limit to the molecular environment	((TEM or STM or EDX or AFM or HRTEM or SEM or EELS) or (atom* force microscop*) or (tunnel* microscop*) or (scanning probe microscop*) or (transmission electron microscop*) or (scanning electron microscop*) or (energy dispersive X-ray) or (X-ray photoelectron*) or (electron energy loss spectroscop*)) AND MolEnv-I) NOT nano*	11665
Nano-pertinent; Limit to the Molecular Environment - More Inclusively	(pebbles OR NEMS OR Quasicrystal* OR (quasi-crystal*)) AND MolEnv-I) NOT nano*	128
Nano-pertinent; limit to the Molecular Environment - More Restrictive	(biosensor* or (sol gel* or solgel*) or dendrimer* or soft lithograph* or molecular simul* or quantum effect* or molecular sieve* or mesoporous material*) AND (MolEnv-R)) NOT nano*	2104
	1 or 2 or 3 or 4 or 5 or 6 or 7	**61173**
Additional Items in Nano Journals	fullerene* or ieee transactions on nano* or journal of nano* or nano* or materials science & engineering C - biomimetic and supramolecular systems (in JOURNAL title field) NOT nano*	506
Total	**1 or 2 or 3 or 4 or 5 or 6 or 7 or 8**	**61479**

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RTTA 1: Research and Innovation Systems Analysis

Nano Data:
Global, 1990-2006

- ISI Web of Science (Science Citation Index – SCI)
  - ~407,000 articles
  - Representing ~2.7% of SCI over the period and 4.1% of SCI for the 2005-06 period
- EI Compendex
  - ~381,000 articles & conference papers
- INSPEC (Engineering Village 2 website)
  - ~334,000 articles & conference papers
- EKMS searched MicroPatent, INPADOC and their proprietary U.S. Patent Citation database
  - ~61,000 patent families (from ~70 patent authorities)

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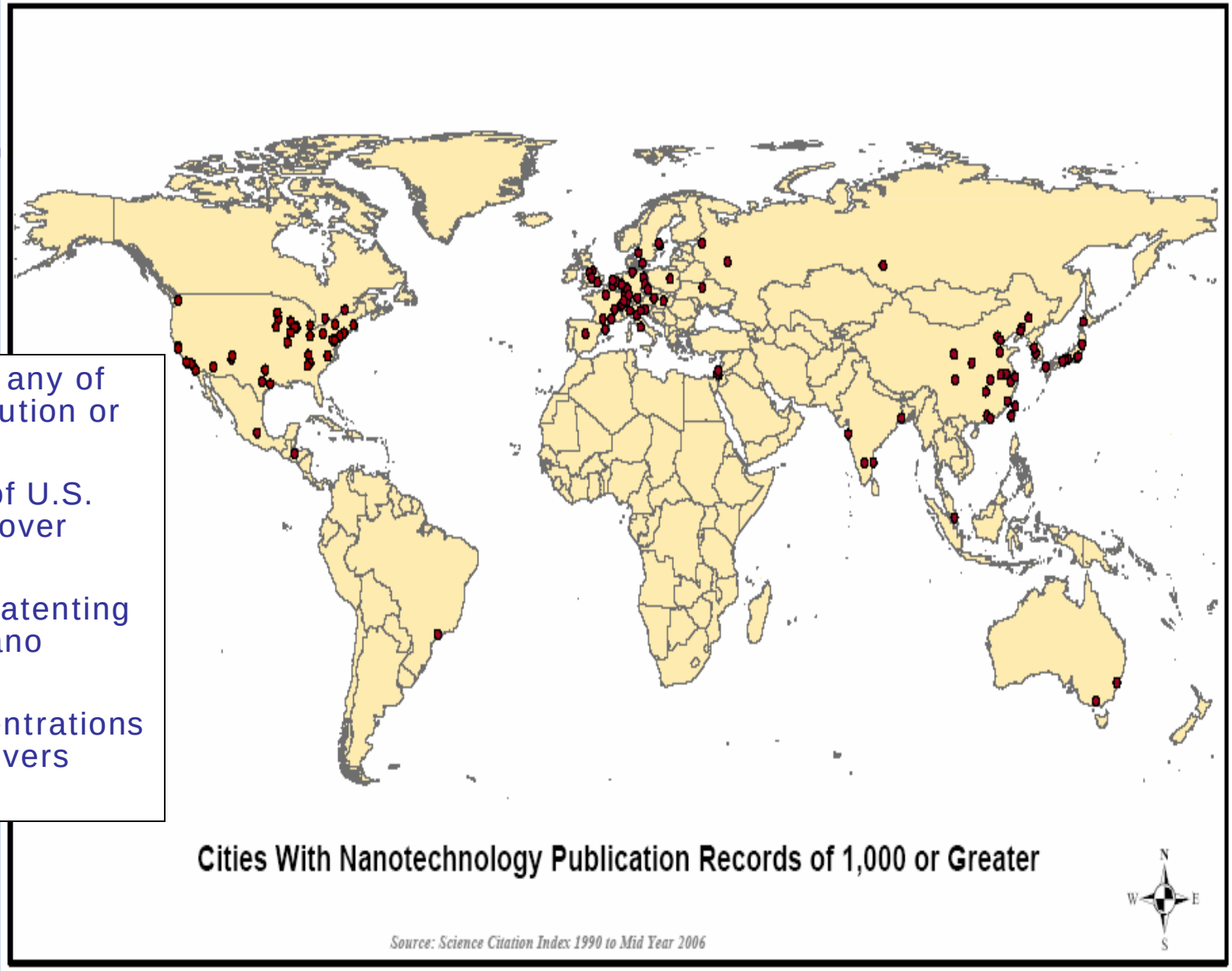
Nano Districts

- Drill down into any of them, by institution or investigator
- Development of U.S. Nano Districts over time
- Publication & Patenting intensity by Nano District
- Regional concentrations and subject drivers



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Comparison of "Generality Index" Scores Across Three Technologies, 1990-1993

	Nanotechnology			Drugs		Computers	
	Variable	**Count**	**Mean**	**Count**	**Mean**	**Count**	**Mean**
1990	Gen US	287	0.620	2188	0.386	1961	0.612
	Gen IC	287	0.642	2187	0.385	1961	0.443
	Gen TC	287	0.540	2187	0.273	1961	0.424
1991	Gen US	293	0.623	2405	0.394	2306	0.610
	Gen IC	293	0.617	2405	0.389	2306	0.445
	Gen TC	293	0.507	2405	0.278	2306	0.431
1992	Gen US	411	0.596	2349	0.387	1956	0.612
	Gen IC	411	0.582	2349	0.388	1956	0.405
	Gen TC	411	0.487	2349	0.268	1956	0.417
1993	Gen US	364	0.608	2499	0.380	2999	0.609
	Gen IC	364	0.605	2498	0.376	2999	0.398
	Gen TC	364	0.511	2498	0.264	2999	0.423

J. Youtie, M. Iacopetta, S. Graham. "Assessing The Nature of Nanotechnology: Can We Uncover an Emerging General Purpose Technology?" *Journal of Technology Transfer* (forthcoming, 2007)

Variable definition:

Gen US = Generality based on USPTO-classes

Gen IC = Generality based on International Patent classes

Gen TC = Generality based upon NBER patent database technology classes (Hall et al., 2001)

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RTTA 2: Public Opinion and Values

What does the public know and feel about nanotechnology?

How does the media influence the public perspective?

What do NSE researchers know and feel about nanotechnology?

Public Opinion

- Longitudinal surveys, linked to themes
- To assess changes in public opinion

Media Influence

- Experimental science news stories
- To assess media influence

Scientists' Opinions

- Surveys of nano researchers
- To assess & compare scientists' values

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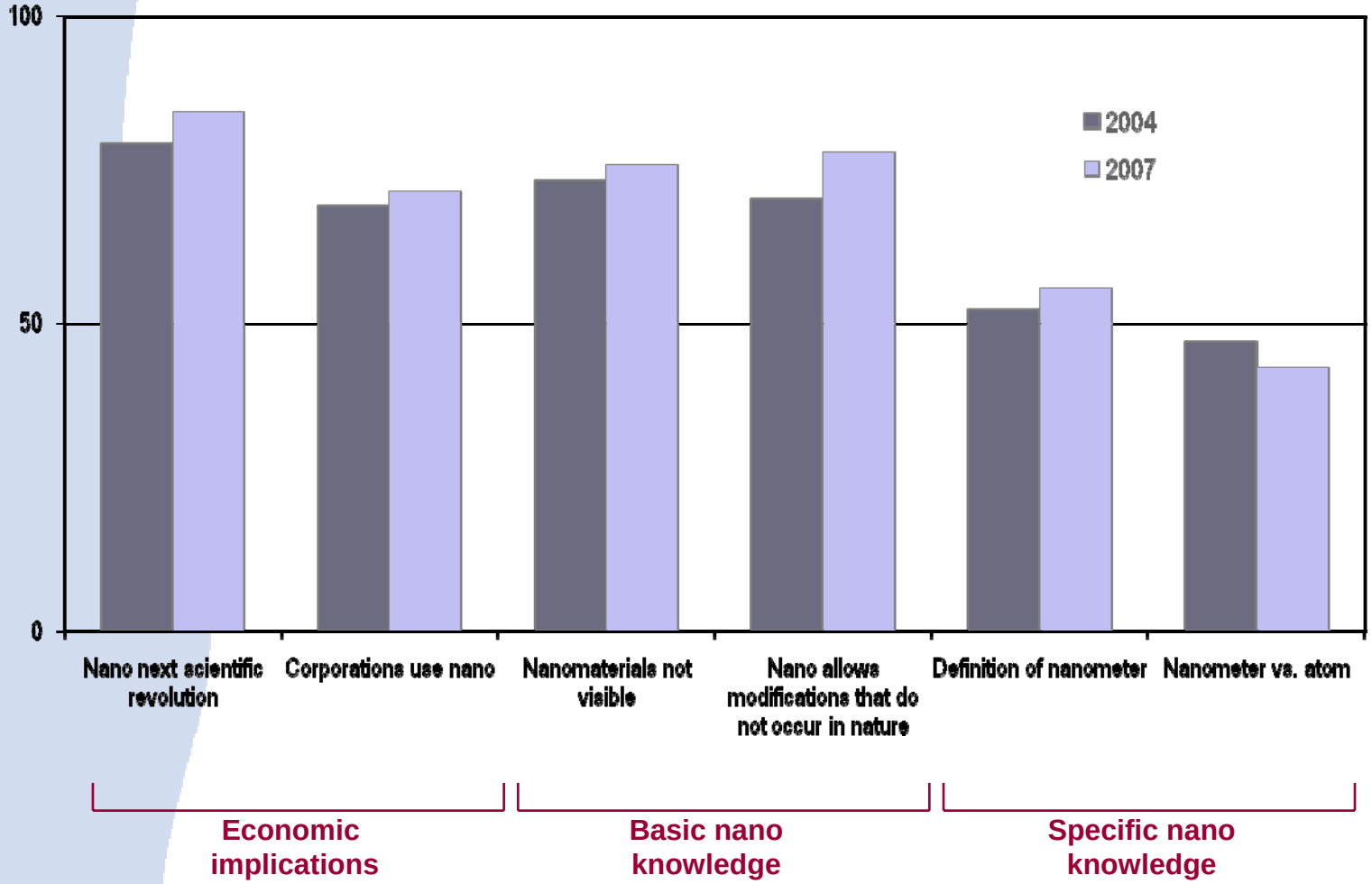
Has Outreach Made a Difference? Nano Knowledge, 2004 vs. 2007



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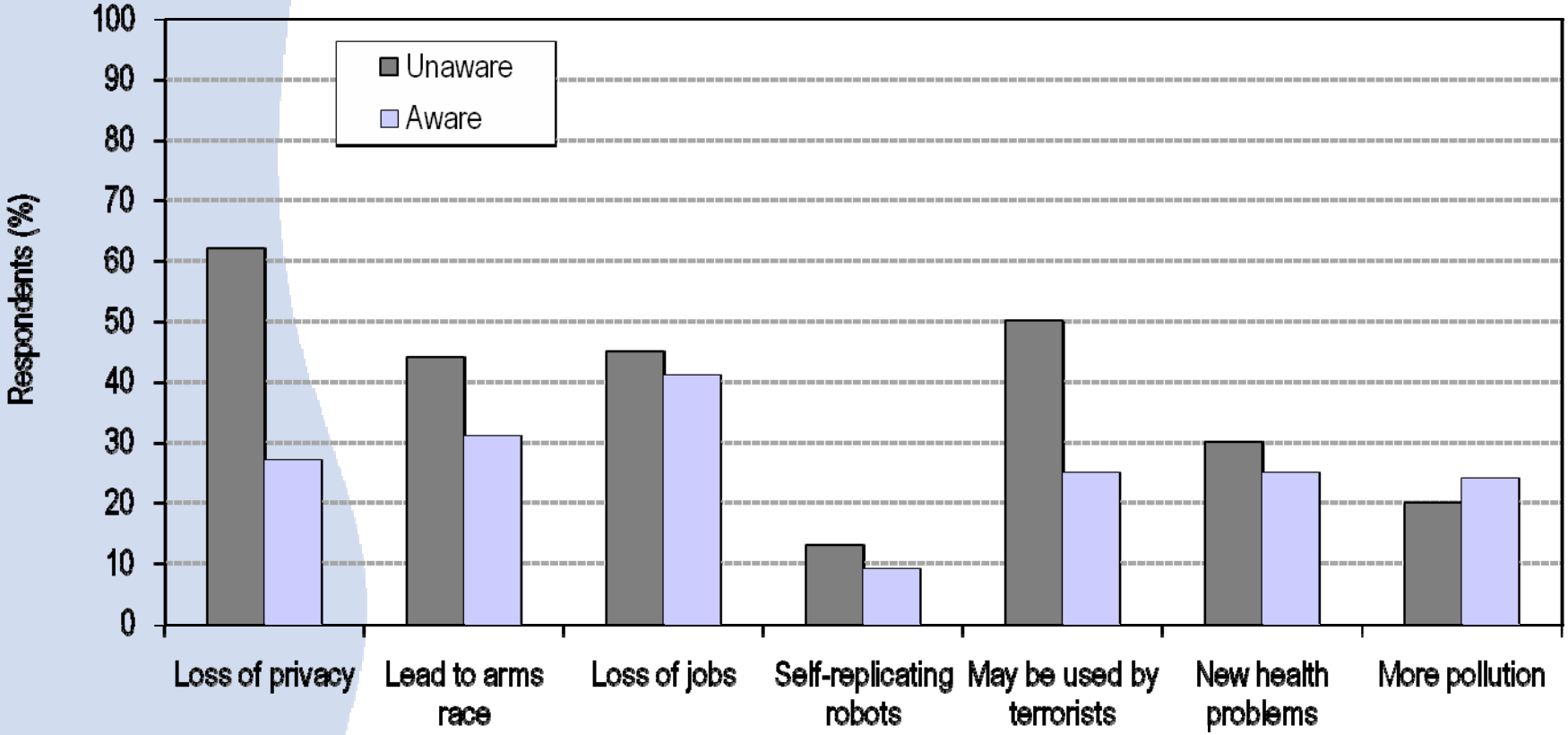
Perceived Risks: Aware vs. Unaware Respondents



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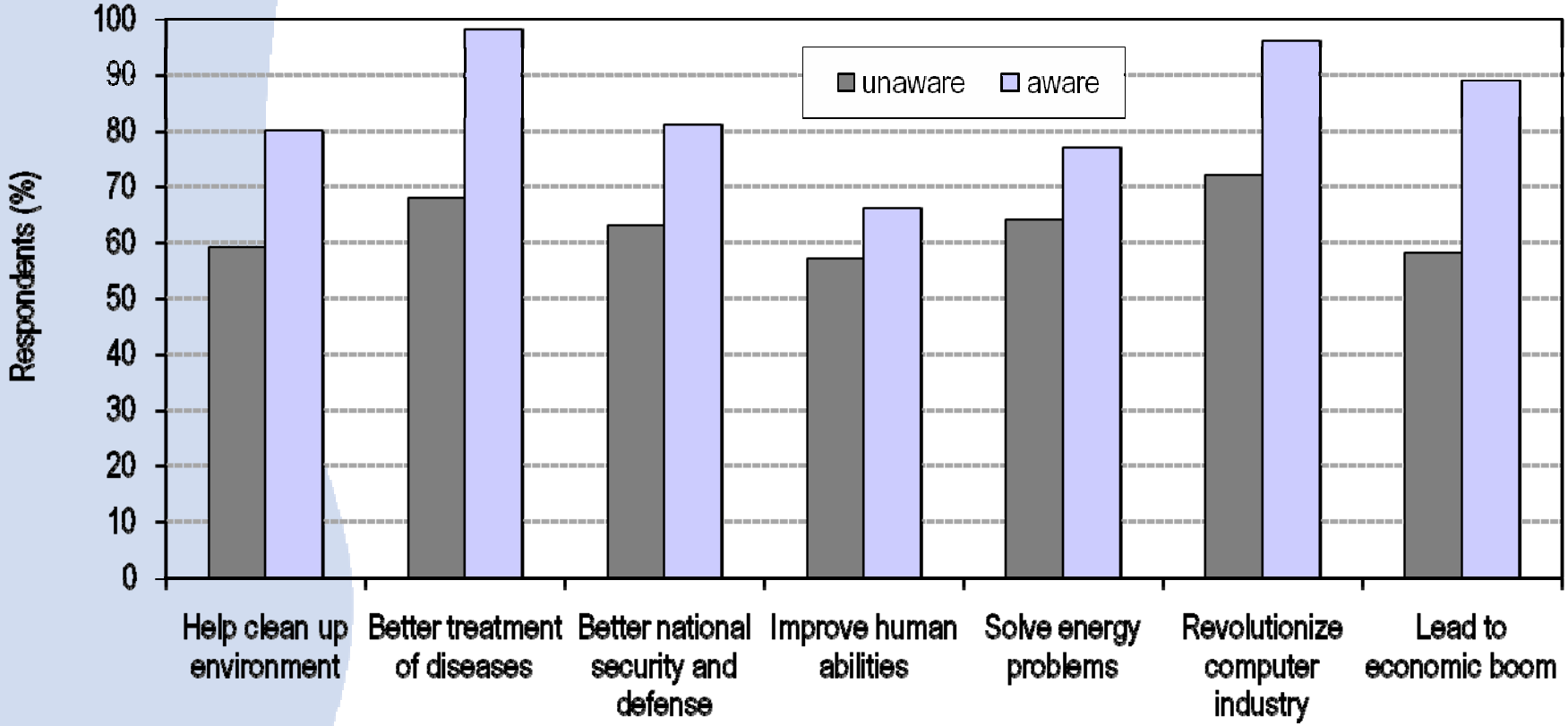
Perceived Benefits: Aware vs. Unaware Respondents



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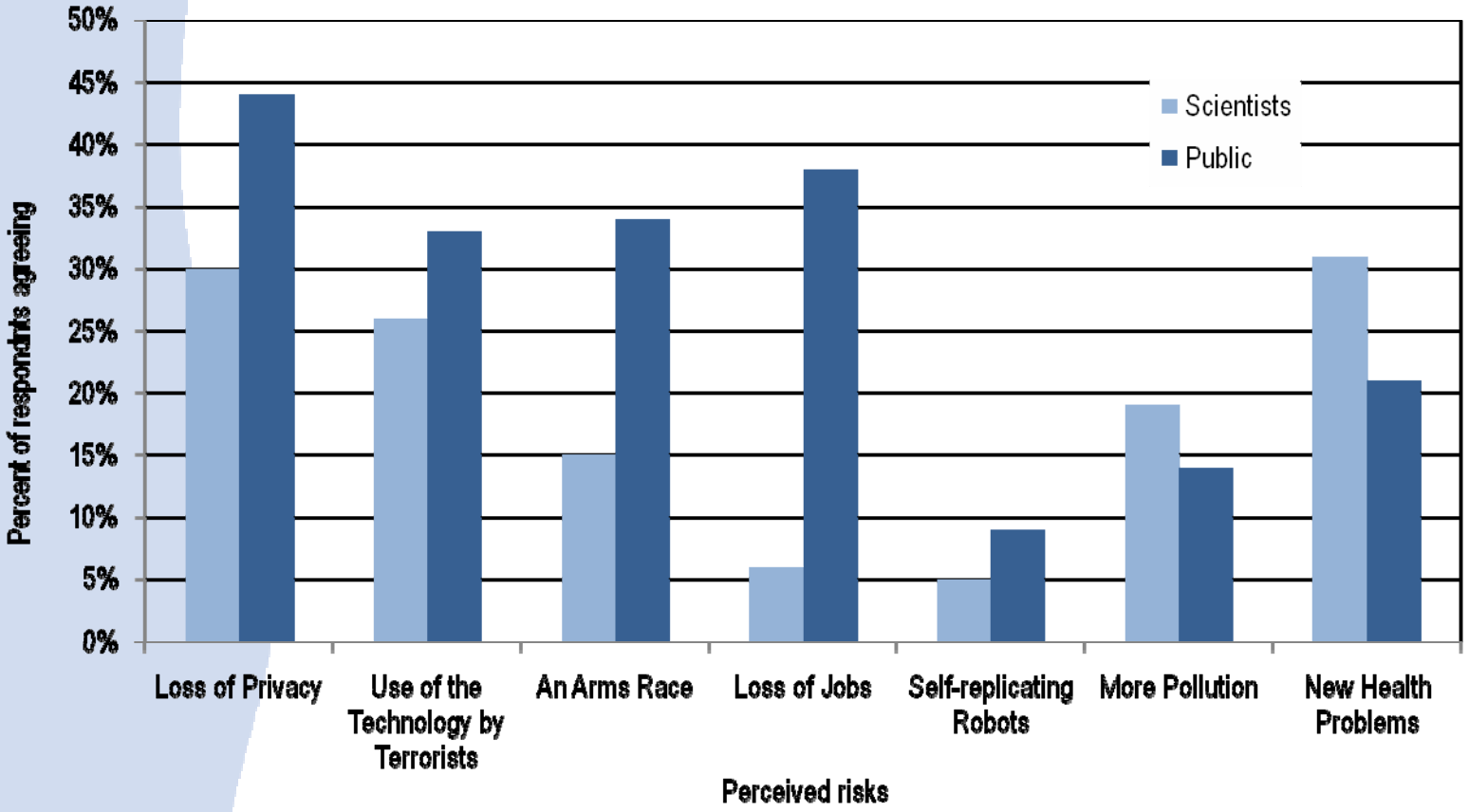
Perceived Risks: 2007
Scientist and Public Opinion Surveys



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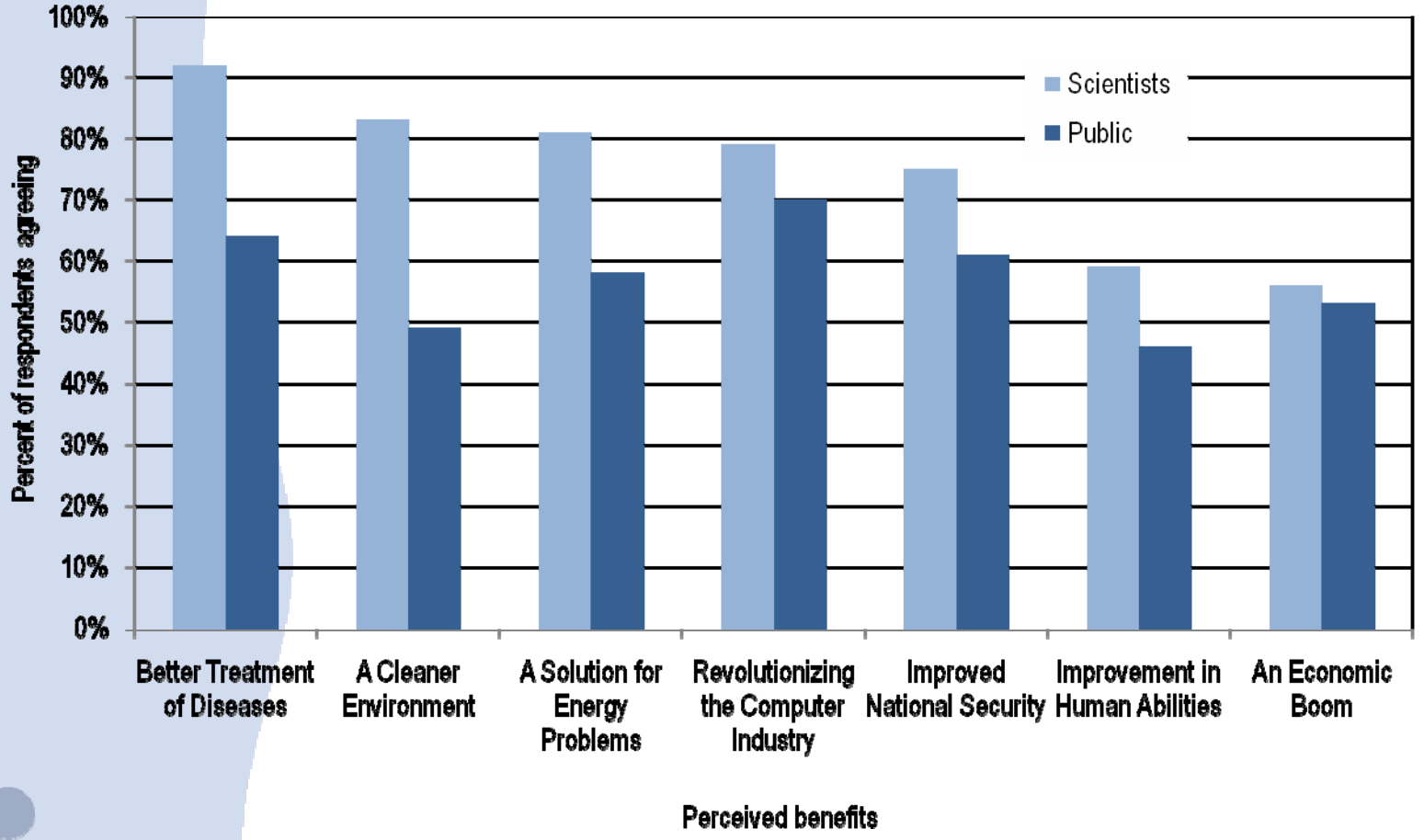
Perceived Benefits: 2007
Scientist and Public Opinion Surveys



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RTTA 3:
Deliberation and Participation

What are plausible nano-enabled futures?

How can we envision responsible NSE products?

What are the cultural resonances of NSE futures?

How can the public be engaged in NSE decision-making?

Scenario Development

- Deliberative exercise among experts
- To provide plausible technological futures

InnovationSpace

- User-centered research and design course
- To create new products/scenarios

CriticalCorps

- Critical Theory
- To engage critically nano products and scenarios

National Citizen's Technology Forum

- Six interlinked citizen's panels
- To deliberate on nano issue of their framing

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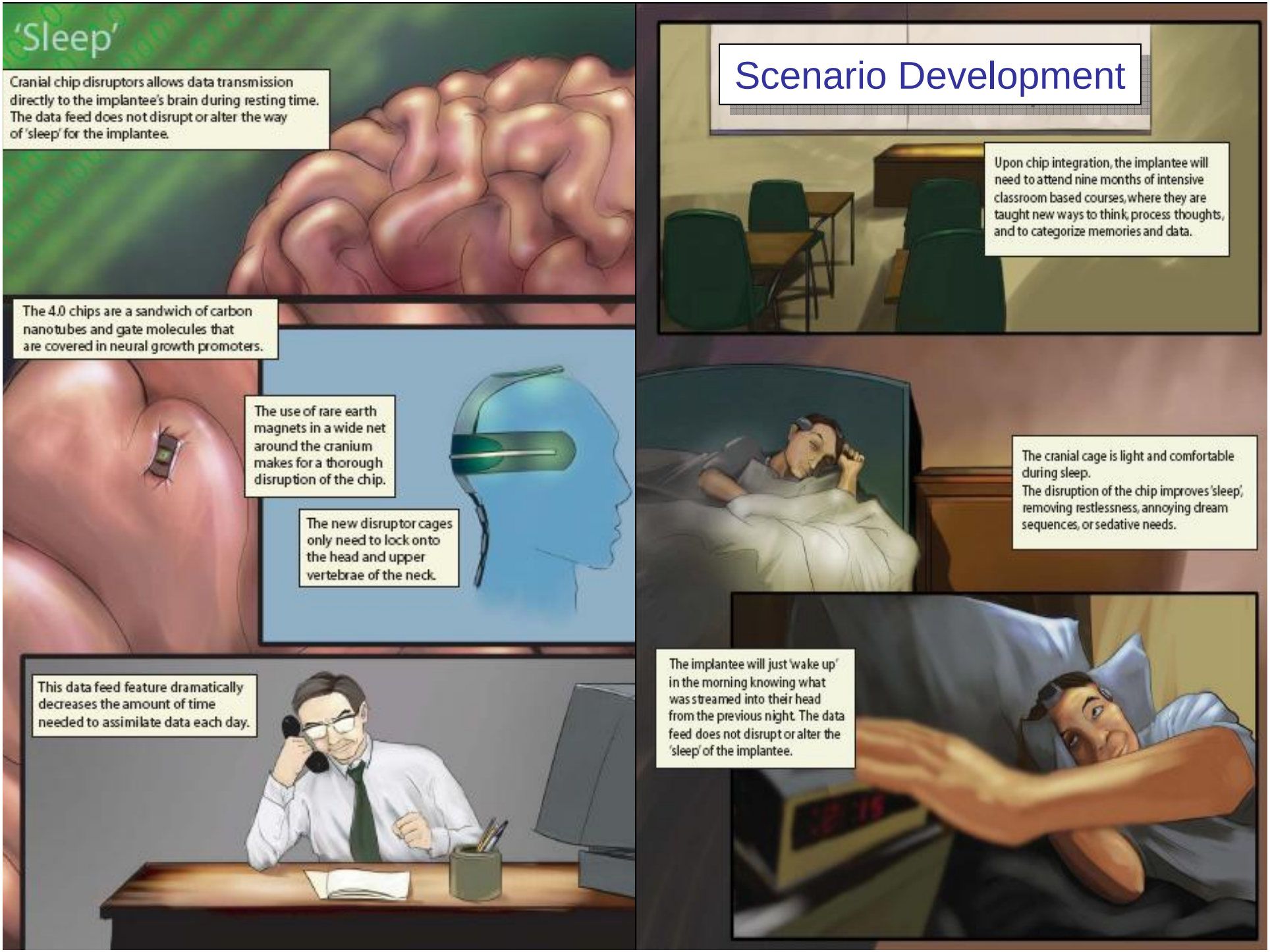
'Sleep'
Cranial chip disruptors allows data transmission directly to the implantee's brain during resting time. The data feed does not disrupt or alter the way of 'sleep' for the implantee.
The 4.0 chips are a sandwich of carbon nanotubes and gate molecules that are covered in neural growth promoters.
The use of rare earth magnets in a wide net around the cranium makes for a thorough disruption of the chip.
The new disruptor cages only need to lock onto the head and upper vertebrae of the neck.
This data feed feature dramatically decreases the amount of time needed to assimilate data each day.
Scenario Development
Upon chip integration, the implantee will need to attend nine months of intensive classroom based courses, where they are taught new ways to think, process thoughts, and to categorize memories and data.
The cranial cage is light and comfortable during sleep.
The disruption of the chip improves 'sleep', removing restlessness, annoying dream sequences, or sedative needs.
The implantee will just 'wake up' in the morning knowing what was streamed into their head from the previous night. The data feed does not disrupt or alter the 'sleep' of the implantee.

RTTA 3: Deliberation and Participation

InnovationSpace

Current

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RTTA 4: Reflexivity, Assessment and Evaluation

How does CNS-ASU know that it is being effective?

How have NSE researchers' views changed over time?

What has CNS-ASU contributed to institutional change?

Reflexivity Assessment

- Intensive interviews with nano researchers
- To understand change in Identity, Knowledge and Practice
  - High familiarity & high involvement associated with significant changes in knowledge & initial changes in practice

Boundary Organizations

- Comparative case studies to assess capacities to bridge "ways of knowing"
- Report of BORGs workshop (9 Nov 06)

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TRC 1: Equity and Responsibility

To explore ways in which NSE research interacts with ideas of social and economic equity and responsible innovation

- Laboratory interactions
- Workshops
- Public Value Mapping
- Broader impacts of NSE

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TRC 1: Equity and Responsibility

- Nanotechnology and Religion
  - Survey of religious statements finds religions more interested in equitable distribution of benefits than "playing God" type issues
  - Workshop on Nano and Religion
- Nanotechnology and "Able-ism"
  - Wolbring – how converging technologies will make us all disabled
- NSE Co-Lab
  - Responsible nanotechnology in the Woodbury lab on BioOptical Nanotechnology
- Public Value Mapping – dissertation in NSE for developing world
- NSE and Broader Impacts
  - NSE applications show minimal attention to equity, societal outcomes

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TRC 2: Human Identity, Enhancement and Biology

To investigate the historical, philosophical, cultural and political dimensions of the interactions between human biology and human values in the context of nano

- Philosophical/Ethical analysis
- Personnel exchange and collaborative deliberation among scientists and ethicists
- Develop and assess case studies and scenarios for participatory analysis

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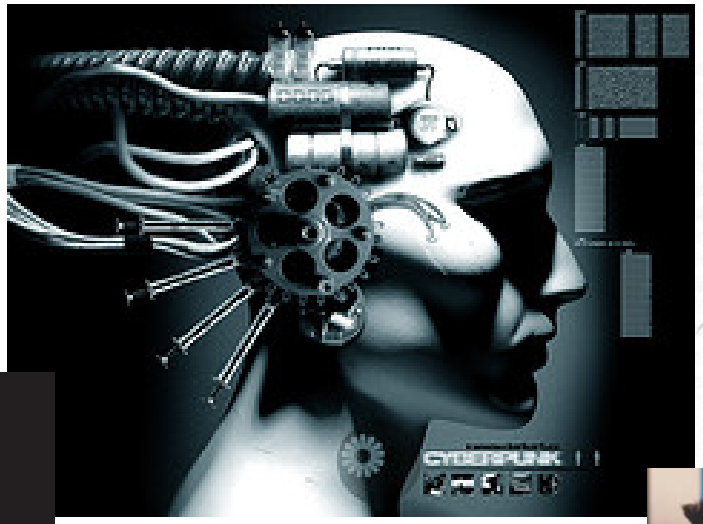
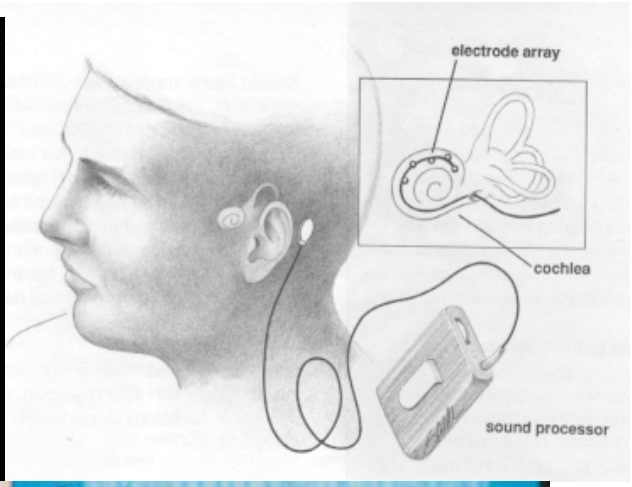
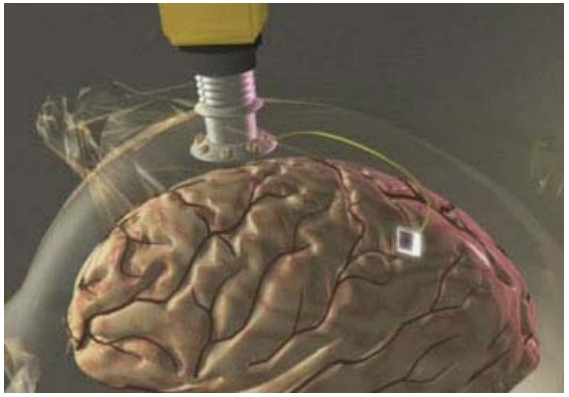
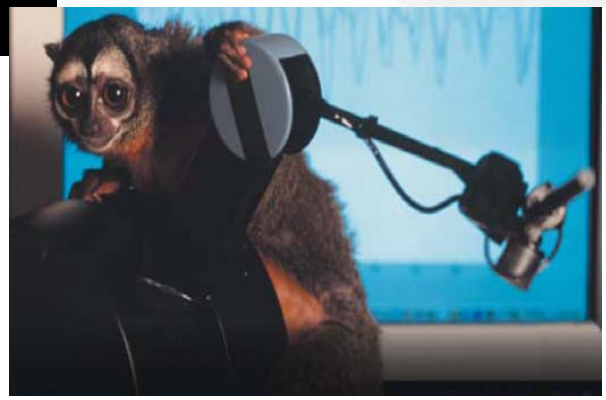
Neural Interface Systems









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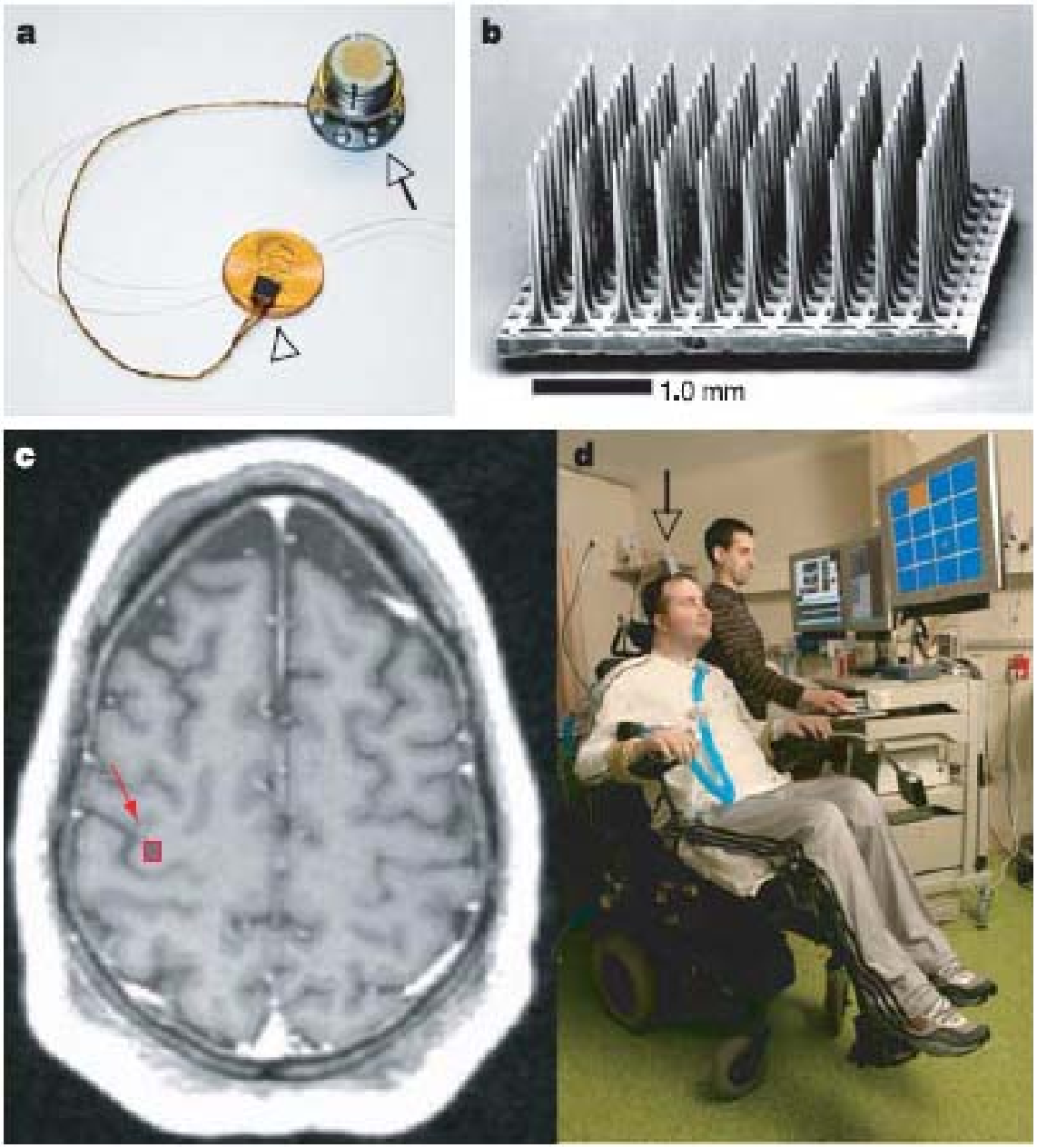
Mind control: Matt Nagle's neuroprosthetic lets him move a cursor using thought alone



Images reproduced from Hochberg et al. (2006)

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Some Exemplary Research Questions

- What is the state of the art of NIS R&D? How do NSE researchers think about this work? Why do they do it?
- Who funds NIS R&D? Why? In what institutional practices and systems is the research embedded?
- What are the relevant values (ethical, religious, scientific, political, economic) at stake in NSE-enabled NIS R&D?
- How should NSE researchers, companies, funders and regulators navigate and negotiate the regulatory terrain?
- What are the specific identity and enhancement concerns, and how should they be addressed?
- How can we, as citizens in a diverse, pluralistic, global society with competing visions of the good, begin to grapple with nano-enabled neural interface systems?

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Neural Implants and Interfaces Raise Ethical, Social, Legal & Policy Questions

- Moral acceptability of research with nonhuman primates
- Determination of appropriate risk/benefit ratio for clinical studies in brain-damaged humans and healthy volunteers
- Clinical decisions to undergo personality-changing procedures
- Threats to the moral and legal identity of humans (and of non-human animals)
- Allocation of scarce research dollars for high-tech treatments
- Social desirability of civilian application of military applications

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