NSRG
Nanotechnology and Society Research Group

Nanotechnology and Environmental Ethics

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Overview

- Background
  - Nanotechnology
  - Responsible Development
  - Environmental Ethics
- Nanotechnology and Ethics
- Perspectives from Environmental Ethics
  - Discriminatory assessment
  - Environmental justice

NNI Definition of Nanotechnology

1. Research and technology development at the atomic, molecular or macromolecular levels, in the length scale of approximately 1 - 100 nanometer range;
2. Creating and using structures, devices and systems that have novel properties and functions because of their small and/or intermediate size;
3. Ability to control or manipulate on the atomic scale.

Engineering Significance of NT

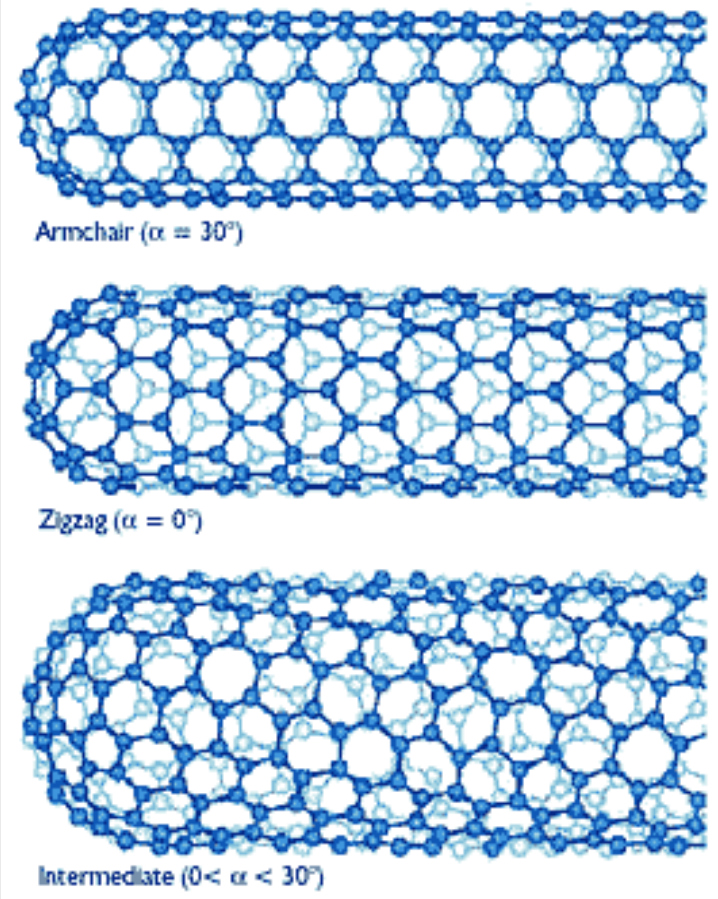
1. Features of the nanoscale

- Intersection of quantum and classical forces
- High surface to volume and mass ratio
- Novel structures or forms of materials
- Variability in physical properties (electrical, optical, tensile, etc.) with changes in size, orientation, bonding patterns, concentration, etc.

<u>Upshot</u>: Materials have diverse and novel properties at the nanoscale, which they do not have in their bulk forms.

Carbon Nanotube Structures

- Graphene sheet rolled into tube
- Three orientations based on direction of rolling
- Properties dependent on orientation of sheets
- Properties dependent also on whether CNT is multi-walled or single-walled, as well as its diameter and its surface chemistry



Engineering Significance of NT

2. What NT enables

- Tight clustering of components/functionalities
- Molecular design (precision and selectivity)
- More detailed/complete data (local imaging and system dynamics)
- Self-assembly and adaptability ("smart" or dynamic technologies)

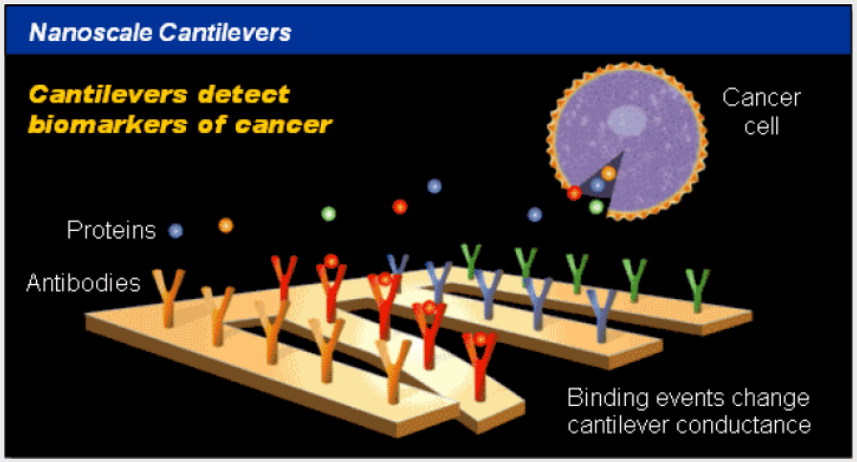
3. Practice of NT

- General use technology
- Enabling technology
- Scientific and engineering convergence

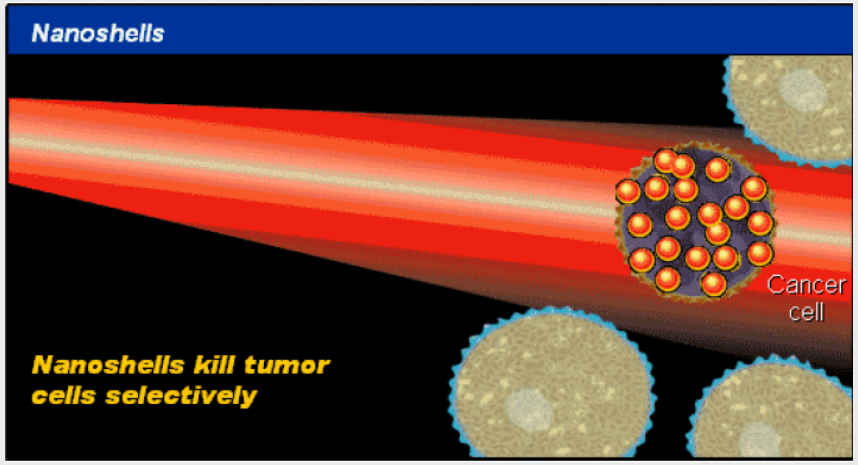
<u>Upshot</u>: Nanoscale science and technology has the potential to enable more and better solutions to a broad range of engineering challenges/problems.

Health Applications

- **Cancer Detection:**
  Nanocantilever conductance changes as antibodies on cantilever receive molecular expressions of cancer
- **Cancer Treatments:**
  Nanoshells attracted to tumors, then using near-infrared light to heat only the nanoshells, tumor cells destroyed, without affecting healthy tissue



Source: Arun Majumdar, UC Berkeley



Source: Jennifer West, Rice University

National Cancer Institute Alliance for Nanotechnology in Cancer
http://nano.cancer.gov/

National Nanotechnology Initiative

- Purpose: To promote NT in a way that, so far as possible, benefits U.S. citizens in particular and humanity in general
- Initiated by the Clinton administration in 2000 in a report titled *National Nanotechnology Initiative: Leading to the Next Industrial Revolution*
- Supported by the Bush administration
- Bolstered by congress in 2003 by the '21st Century Nanotechnology Research and Development Act' (renewal under consideration)

Federal Budget for NNI

Agency	2006 Actual	2007 Estimate*	2008 Proposed
NSF	359.7	373.2	389.9
DOD	423.9	417.2**	374.7
DOE	231.0	235.2	331.5
DHHS (NIH)	191.6	193.8	202.9
DOC(NIST)	77.9	84.2	96.6
NASA	50.0	25.0	24.0
EPA	4.5	8.5	10.2
USDA (CSREES)	3.9	3.4	3.0
DHHS (NIOSH)	3.8	6.6	4.6
USDA/FS	2.3	2.6	4.6
DHS	1.5	2.0	1.0
DOJ	0.3	1.4	0.9
DOT (FHWA)	0.9	0.9	0.9
TOTAL	1351.2	1353.9	1444.8

Alphabetized Acronyms:
DHS — Department of Homeland Security
DOC — Department of Commerce
DOD — Department of Defense
DOE — Department of Energy
DOJ — Department of Justice
DOT — Department of Transportation
EPA — Environmental Protection Agency
HHS — Health and Human Services
NASA — Nat'l Aeronautics and Space Admin
NIH — National Institutes of Health
NIST — Nat'l Institute of Stds and Technology
NSF — National Science Foundation
TSA — Transportation Security Admin
USDA — U.S. Department of Agriculture

NNI Strategic Goals

(1) maintain a world-class research and development program aimed at realizing the full potential of nanotechnology;

(2) facilitate transfer of new technologies into products for economic growth, jobs, and other public benefits;

(3) develop educational resources, a skilled workforce, and the supporting infrastructure and tools to advance nanotechnology;

(4) support responsible development of nanotechnology.

NNI Funding by Area

Table 3
Planned 2008 Agency Investments by Program Component Area
(dollars in millions)

	Fundamental Phenomena & Processes	Nanomaterials	Nanoscale Devices & Systems	Instr. Research, Metrology, & Standards	Nano-manufacturing	Major Research Facilities & Instr. Acquisition	Societal Dimensions	NNI Total*
NSF	142.7	60.2	51.1	14.5	26.9	31.6	62.9	389.9
DOD	179.1	91.7	70.6	8.3	1.0	23.0	1.0	374.7
DOE	85.4	99.8	13.5	26.7	2.0	100.6	3.5	331.5
DHHS (NIH)	53.3	16.5	114.9	6.7	1.7	0.1	9.7	202.9
DOC (NIST)	27.1	8.0	13.5	26.4	11.1	4.5	6.0	96.6
NASA	1.0	12.0	10.0	0.0	1.0	0.0	0.0	24.0
EPA	0.2	0.2	0.2	0.0	0.0	0.0	9.6	10.2
USDA (CSREES)	0.4	0.8	1.5	0.0	0.1	0.0	0.2	3.0
DHHS (NIOSH)	0.0	0.0	0.0	0.0	0.0	0.0	4.6	4.6
USDA (FS)	1.7	1.5	1.0	0.2	0.2	0.0	0.0	4.6
DHS	0.0	0.0	1.0	0.0	0.0	0.0	0.0	1.0
DOJ	0.0	0.0	0.1	0.8	0.0	0.0	0.0	0.9
DOT (FHWA)	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.9
TOTAL*	491.8	290.7	277.4	83.6	44.0	159.8	97.5	1,444.8

* Totals may not add due to rounding.

Components of Responsible Development

(1) Promote Beneficial Nanotechnologies

(2) Train Researchers and Workforce

(3) Protect Human Health and the Environment (EHS)

(4) Engage in Public Outreach and Education

(5) **Address Other Ethical, Legal, and Social Issues**

Challenge of Responsible Development

- The Goal
  - Accomplish **proactive** responsible development of NT
- Obstacles
  - Lack of established models (not even ELSI of HGP)
  - Information scarcity (inherent)
  - Relative rate of responsible development research
- Resources
  - Institutions
  - Awareness
  - Commitment
  - Expertise
  - **Experience**

Why Environmental Ethics?

- Subject matter of environmental ethics
- Origins of environmental ethics
- Sources of environmental challenges

Upshot: Contemporary environmental ethics emerged as a critical response to modern technology

Too Soon to Tell

"Currently, ethical considerations specific to nanotechnology have not come into focus…Although near-term and tangible ethical concerns related to use of nanotechnology have yet to be determined, it is not too early now to think about how to inform, communicate with, and engage the public to ensure broad consideration of what responsible development of nanotechnology might entail from a societal perspective."

--National Research Council, *Triennial Review of the National Nanotechnology Initiative* (2006)

Nano-techno-social Optimism

"Given nanotechnology's extraordinary economic and societal potential, it would be unethical, in my view, to attempt to halt scientific and technological progress in nanotechnology. Nanotechnology offers the potential for improving people's standard of living, healthcare, and nutrition; reducing or even eliminating pollution through clean production technologies; repairing existing environmental damage; feeding the world's hungry; enabling the blind to see and the deaf to hear; eradicating diseases and offering protection against harmful bacteria and viruses; and even extending the length and the quality of life through the repair or replacement of failing organs. Given this fantastic potential, how can our attempt to harness nanotechnology's power at the earliest opportunity…be anything other than ethical?"

- Philip Bond, US Under-Secretary of Commerce for Technology (2004)

The social and ethical issues are…

- *Determinate*: It is possible to identify clearly many of the social and ethical issues.
- *Immediate*: It is not too soon to begin considering many of the issues.
- *Distinct:* The issues are not reducible to other aspects of responsible development.
- *Significant*: Addressing the issues is crucial to accomplishing responsible development of emerging nanotechnologies.
- *Actionable*: In many cases, there are steps that can be taken to begin addressing the issues.

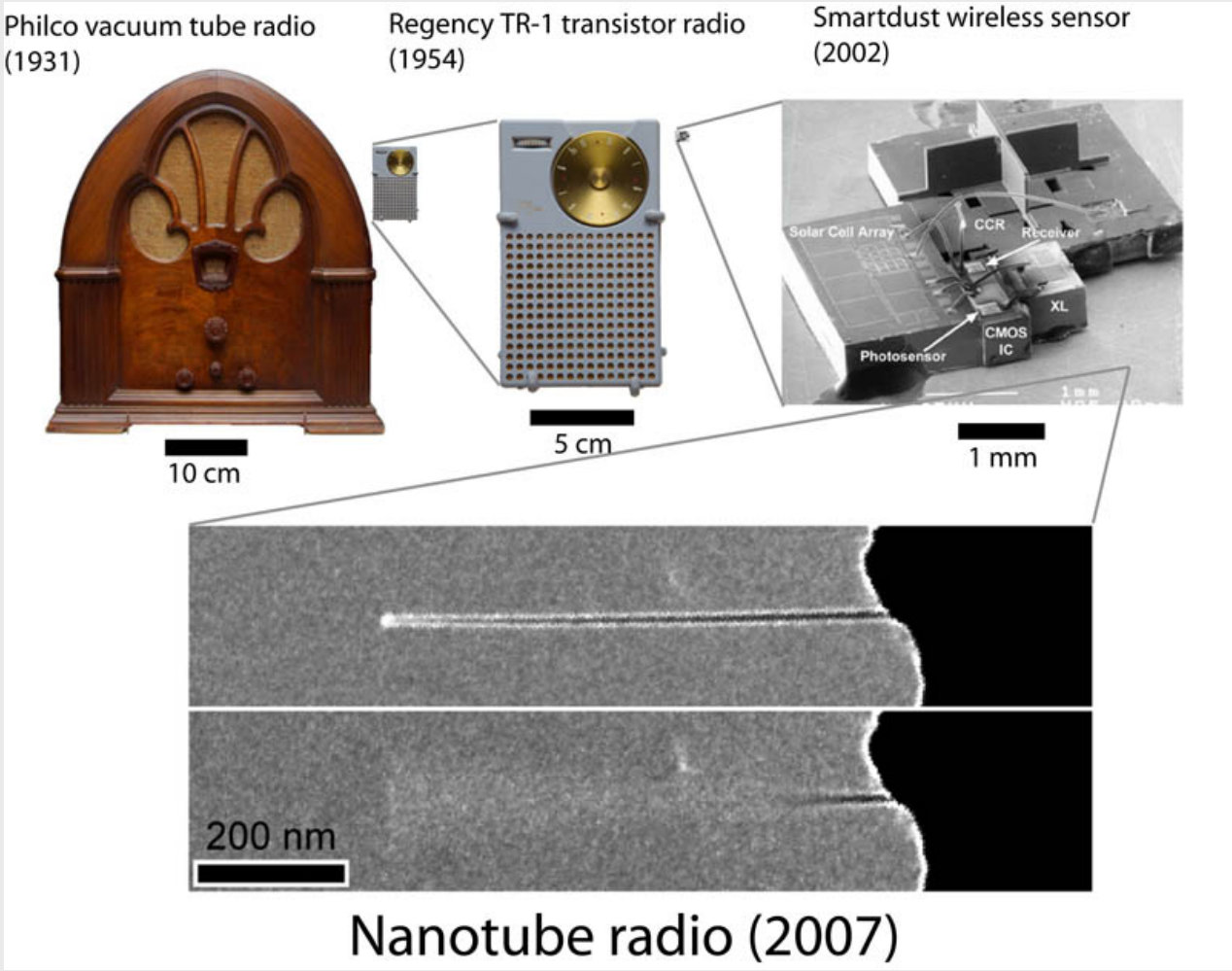
Discriminatory Assessment

- Rejection of nano-techno-social optimism
  - Historical
  - Global
  - Sustainability
- Not anti-technology
- Case by case assessment

Products Using Nanomaterials

- Cosmetics/Personal Care Products
  - Sunscreens
  - Foundation makeup
  - Moisturizers
- Nano Silver is a powerful antibiotic and preventative against infections
  - Coating surgical tools
  - Bandaging
  - Stink-less socks
- Woodrow Wilson Institute Project on Emerging Nanotechnologies
  - http://www.nanotechproject.org/inventories

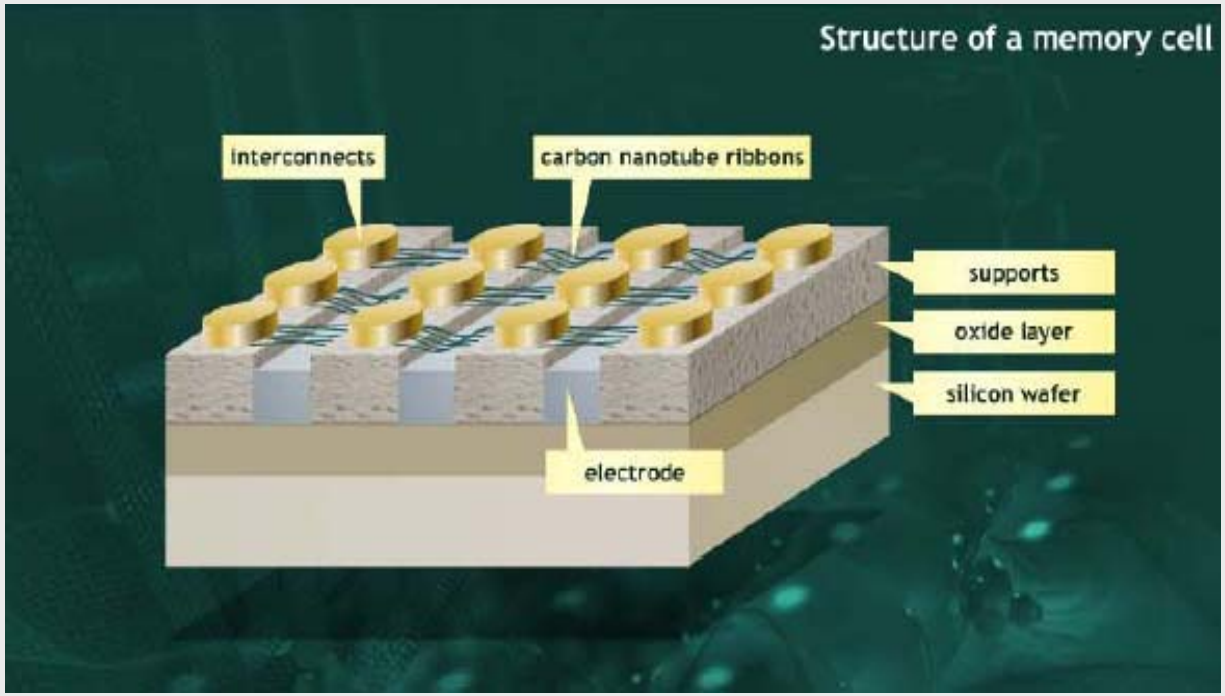
Carbon Nanotube Radio



Zettle, et al., www.physics.berkeley.edu/research/zettl/projects/nanoradio/radio.html

CNTs Used in Memory Chips

- Mobile devices for faster storage of more data
- Cheaper, lighter, energy efficient computers



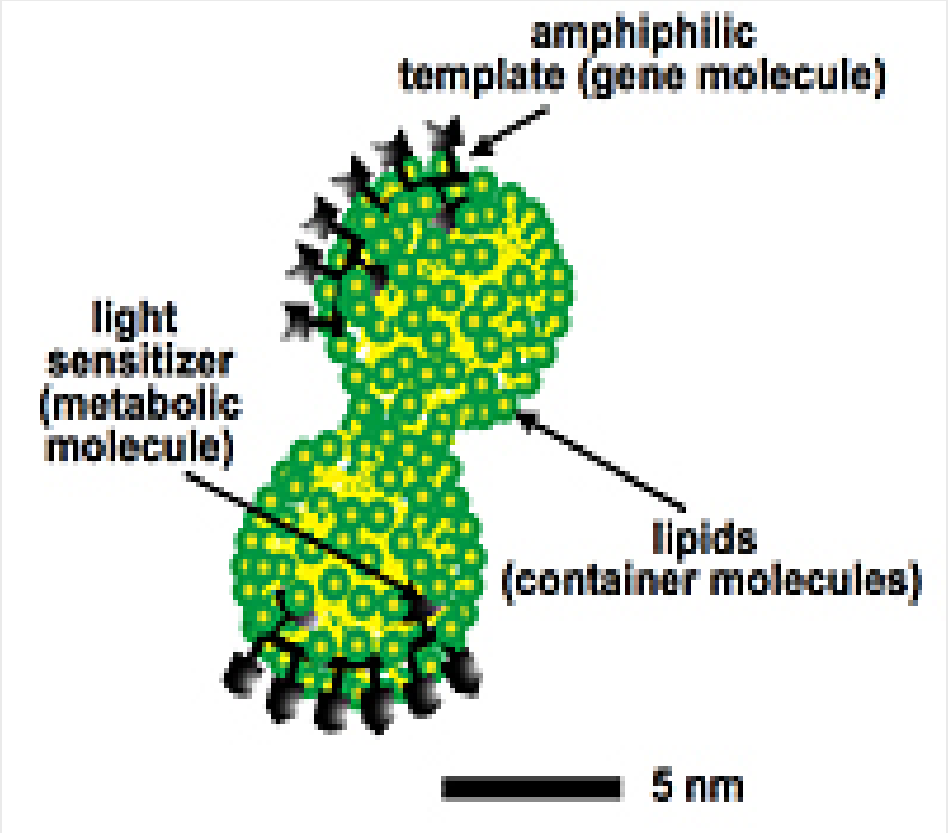
http://nantero.com

NANTERO

Artificial, Non-cellular Life?

The minimal Los Alamos design consists of three different molecules: lipid container molecules (fatty acids) that self-assemble to form a container, genes (modified peptide nucleic acid) that attach to the container surface, and metabolic molecules that are attached to the backbone of the gene. None of these molecules exist in modern cells.

--From AAAS, http://www.aaas.org/news/releases/2005/1208protocell.shtml



Lesson for NT: Case by Case Assessment

- NT includes diverse engineering fields, research programs, and applications
- Different nanotechnologies have different ethical profiles
  - Objectives
  - Intended beneficiaries
  - Risks and who is exposed to them
  - Control/authority/oversight
  - Contested moral issues

Environmental Justice Perspective

Environmental justice concerns the allocation of environmental burdens and benefits.

- Environmental burdens: land uses, facilities, or activities that diminish the quality of a community's environment
- Environmental benefits: commodities, experiences, and wealth, the production of which generates environmental burdens

A Principle of Distributive Justice

"Justice increases when the benefits and burdens of social cooperation are born more equally, except when moral considerations or other values justify greater inequality."

– Peter Wenz, "Does Environmentalism Promote Injustice for the Poor"

Unequal Distribution: Massachusetts

In MA, low income communities (median income less than $39,500) face a cumulative exposure rate to hazardous facilities and sites that is 4 times greater than higher income communities, and communities with high minority populations (greater than 25%) face a cumulative exposure rate that is over 20 times greater than low minority communities (less than 5%).

- Daniel Faber and Eric Krieg, *Unequal Exposure in Ecological Hazards, 2005: Environmental Injustice in the Commonwealth of Massachusetts*

Unequal distribution: United States

"For 2000, neighborhoods within 3 kilometers of commercial hazardous waste facilities are 56% people of color whereas non-host areas are 30% people of color. Thus, percentages of people of color as a whole are 1.9 times greater in host neighborhoods than in non-host areas…Poverty rates in the host neighborhoods are 1.5 times greater than non-host areas and mean annual household incomes and mean owner-occupied housing values in host neighborhoods are 15% lower."

– Robert Bullard, Paul Mohai, Robin Saha, and Beverly Wright, *Toxic Wastes and Race at Twenty, 1987-2007*

Environmental Justice and NT?

- Question: What does this have to do with NT?
- Answer One: Nothing. Nanotechnology is not the cause of the obtaining distribution of environmental burdens and benefits. Moreover, there is not anything unjust about the capacity to characterize, design, and construct on the nanoscale.

Environmental Justice and NT?

- Question: What does this have to do with NT?
- Answer Two: The EJ issue is a NT issue, since the social context into which nanotechnology is emerging is one in which this inequality is allowed, and in many ways enabled and encouraged, by obtaining social institutions and practices.
- Implication: Responsible development of NT is incomplete if it does not involve addressing environmental injustice.

Some Causes of Environmental Injustice

- Role of cost benefit analysis in facility siting decisions;
- Zoning and land planning legacies from segregation;
- Racism in job hiring and advancement;
- NIMBY (Not in My Backyard) effects;
- Differential political influence;
- Redlining in insurance and lending practices;
- Discriminatory use of restrictive covenants;
- Marginalization of local communities in land use decisions;
- Corporate personhood status.

Addressing Environmental Injustice

- Effective implementation of executive order “Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations”;
- Stricter Toxics Release Inventory requirements;
- Aggressive toxics reduction mandates;
- Effective enforcement of anti-discrimination laws in employment and lending (and require proving only effect, not intent);
- Emphasize environmentally benign manufacturing, green chemistry, and end of life consideration in engineering curricula;
- Reduce corporate influence in local elections and land use decisions;
- Adopt green procurement policies;
- Adopt no data, no market principle;
- Incentivize community oriented brownfields remediation and redevelopment.

Lesson for NT: Attend to Social Context

- NT, like all technology, is socially embedded
- NT is a general use or enabling technology
- There are all manner of problematic features of obtaining social contexts that are relevant to the implementation, dissemination, control, oversight, responsibility for, access to, protection from, benefits and burdens of, and decision-making regarding nanotechnology.
- “Nanotechnology exacerbates everything”

Some Social Context Issues

- Differential access to medical care and medical technologies
- Educational Inequalities
- Inadequate Information security/privacy protections
- Inefficiencies in intellectual property systems
- Inadequate individual autonomy protections
- Under-representation of women and minority groups in engineering and academia
- Short-sighted/unsustainable agricultural policies and practices
- Unfair tariffs, subsidies, and trade agreements
- Inadequate consumer safety protection
- Conflicts of interests for regulators or researchers
- Externalization of pollution and health costs
- Inadequate biodefense/military research oversight
- Inadequate governmental capacity (resources, expertise, commitment, institutional design, legal authority, public trust, communication, access to information)

Comments on Social Context Issues

- These issues are legion
- They are significant for accomplishing responsible development
- They cannot be fully identified through the features of the technology
- It is not too soon to identify and address them
- They cannot be addressed by technology design and risk management alone
- Must address the problematic aspect of the social context (e.g. access to health care, regulatory capacity, educational inequalities)
- Involve a more expansive conception of responsible development than is found in the NNI

Additional Perspectives from Environmental Ethics

- Natural value
- Biological value
- Holistic
- Commodification of nature
- Mediation of Human-Nature relationship
- Domination of nature
- Precautionary

Summary

- Accomplishing proactive responsible development offers tremendous challenges and opportunities.
- The perspective of environmental ethics demonstrate that..
  - Addressing the “other” ethical issues is crucial to realizing proactive responsible development;
  - The “other” ethical issues are determinate, immediate, distinct, significant, and actionable;
  - Different NT tools, techniques, areas of research and applications have different social and ethical profiles;
  - Attending to social (and environmental) context is crucial to identifying and analyzing the ethical issues.

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