Nanotechnology

Opportunities and Challenges in a Changing World

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Woodrow Wilson International Center for Scholars

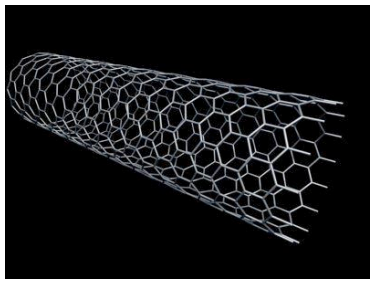
THE PEW CHARITABLE TRUSTS

Project on Emerging Nanotechnologies
at the Woodrow Wilson International Center for Scholars

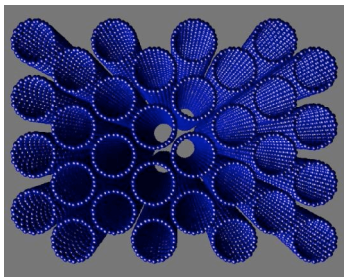
Nanotechnology

Science Fiction or Science Fact?

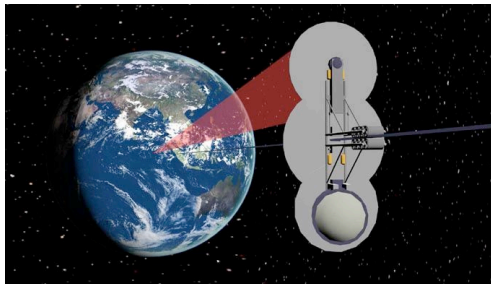
Imagine…



A material where strength is governed by atomic bonds…



… that can be woven into super-strong strands and ropes…



… and used to build an elevator to space!

Nanotechnology is turning fiction to reality…

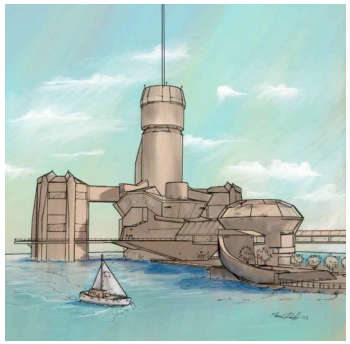
www.liftport.com

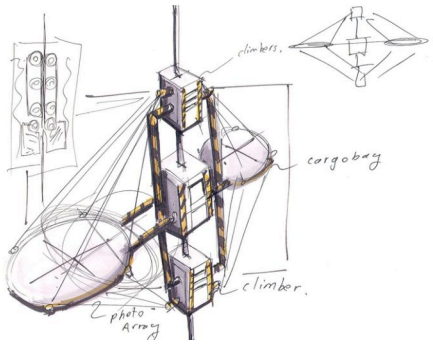
LIFTPORT GROUP

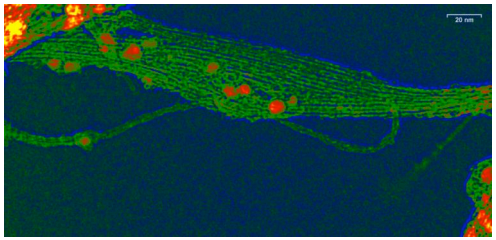
THE SPACE ELEVATOR COMPANIES™

Countdown to Lift: April 12, 2018

4891 days, 10 hours, 33 minutes, 42 seconds







Single Walled Carbon nanotubes

Nanotechnology

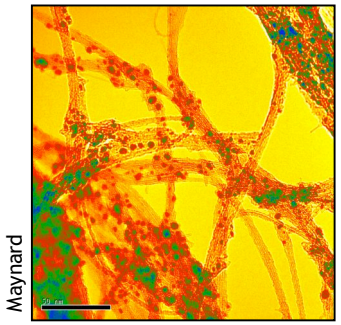
- **Definition**
  - Development/engineering of new devices and materials which demonstrate unique properties asociated with structures on a nanometer length-scale
  - Nanometer scale: less than ~100 nm

- **Includes:**
  - Engineered nano-scale surface layers
  - Engineered nano-scale structures (discrete or heterogeneous)
  - Engineered nano-scale devices

Nanotechnology in context

Nanomaterials

Nanoscale structures in unprocessed form

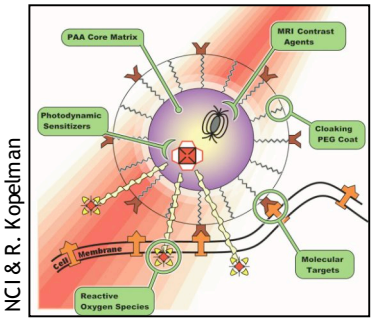


Maynard

Carbon Nanotubes

Nanointermediates

Intermediate products with nanoscale features

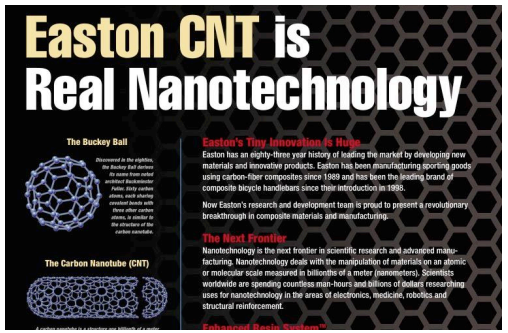


NCI & R. Kopelman

Multifunctional nanoparticles

Nano-enabled products

Finished goods incorporating nanotechnology



Easton

Nanocomposite parts

Nanotools

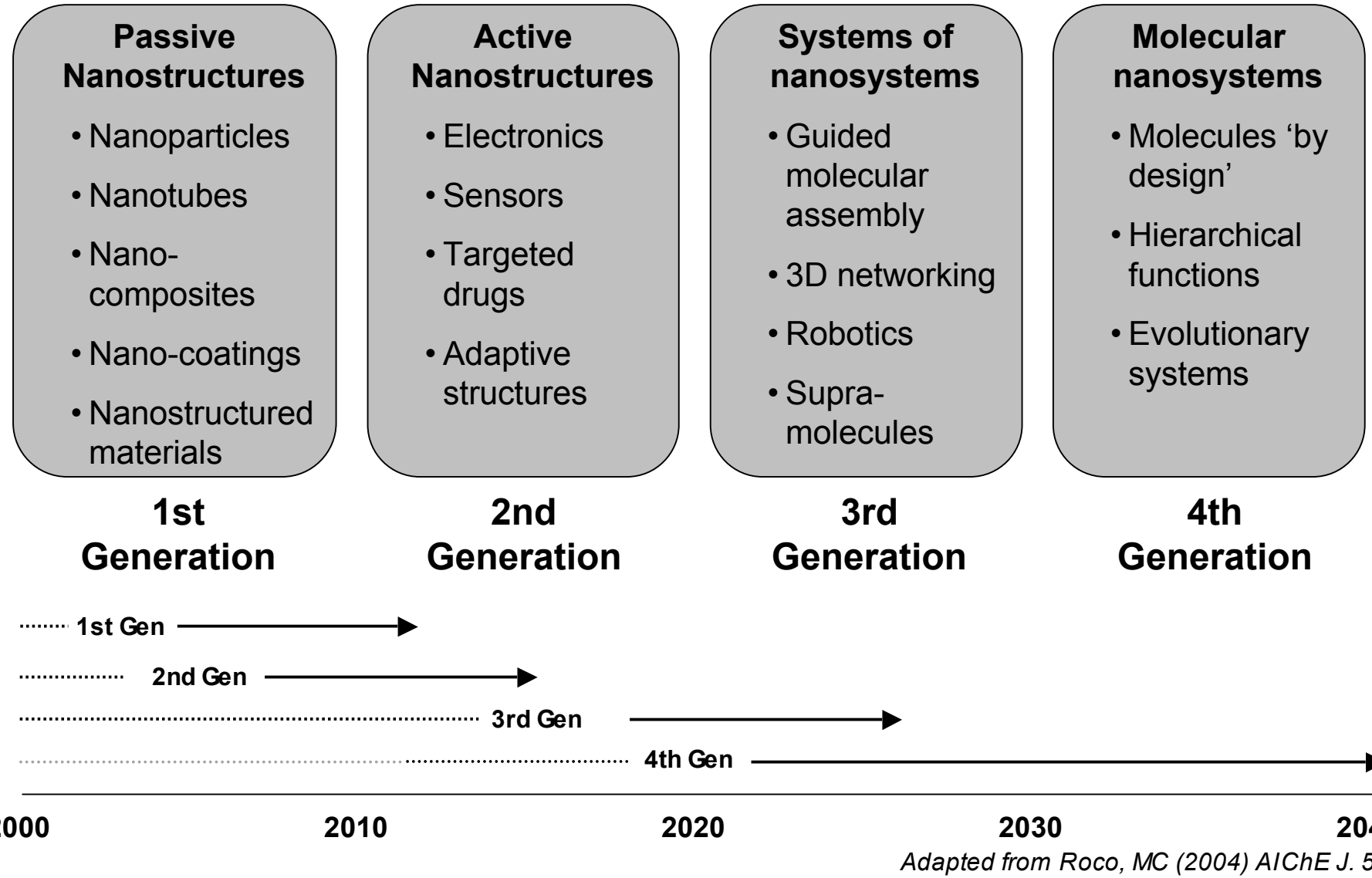
Capital equipment and software used to visualize, manipulate and model matter at the nanoscale

JEOL

Electron Microscopy

Concept: Lux Research

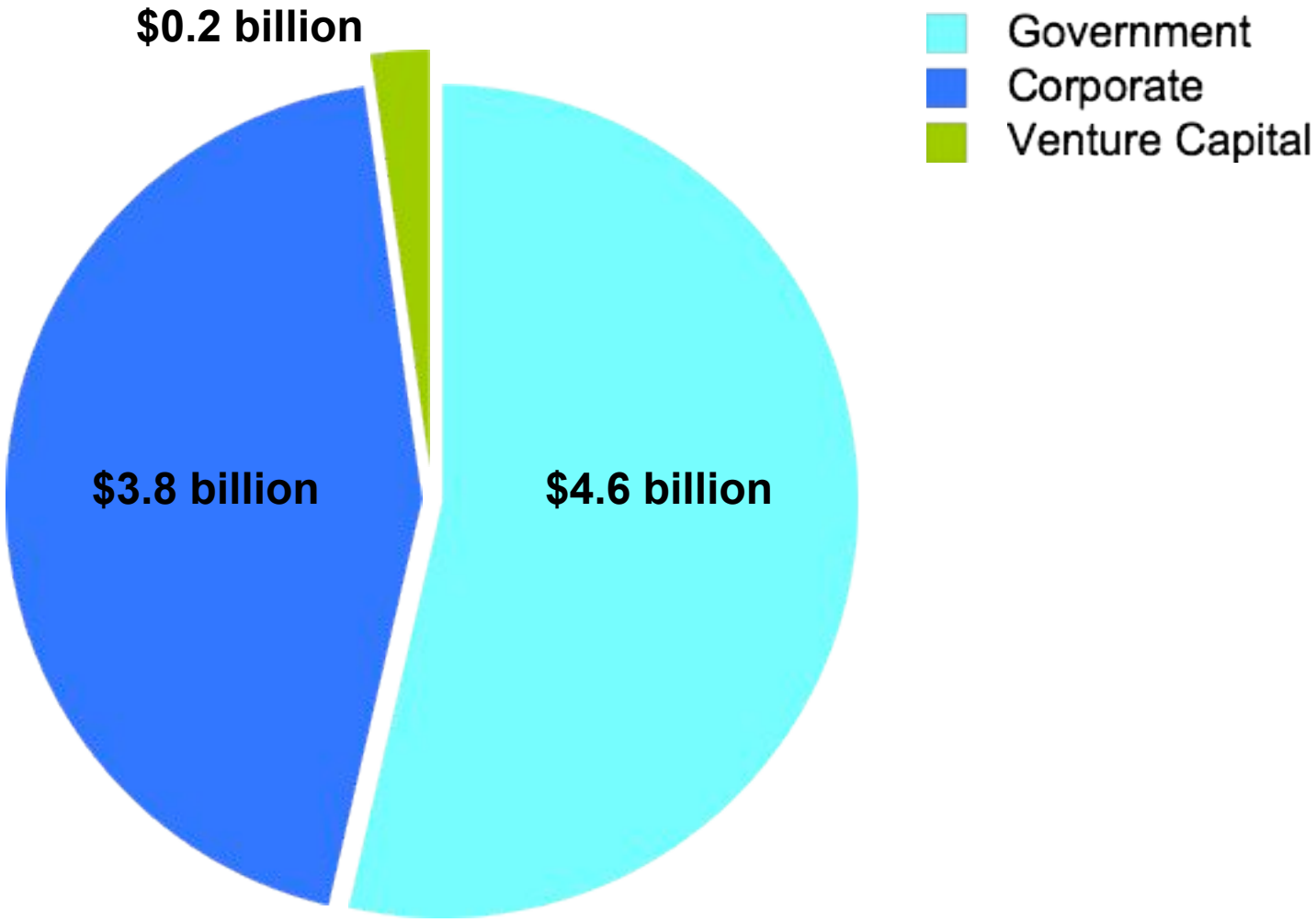
Nanotechnology development and implementation



Adapted from Roco, MC (2004) AIChE J. 50 (5)

Nanotechnology Investment and Impact

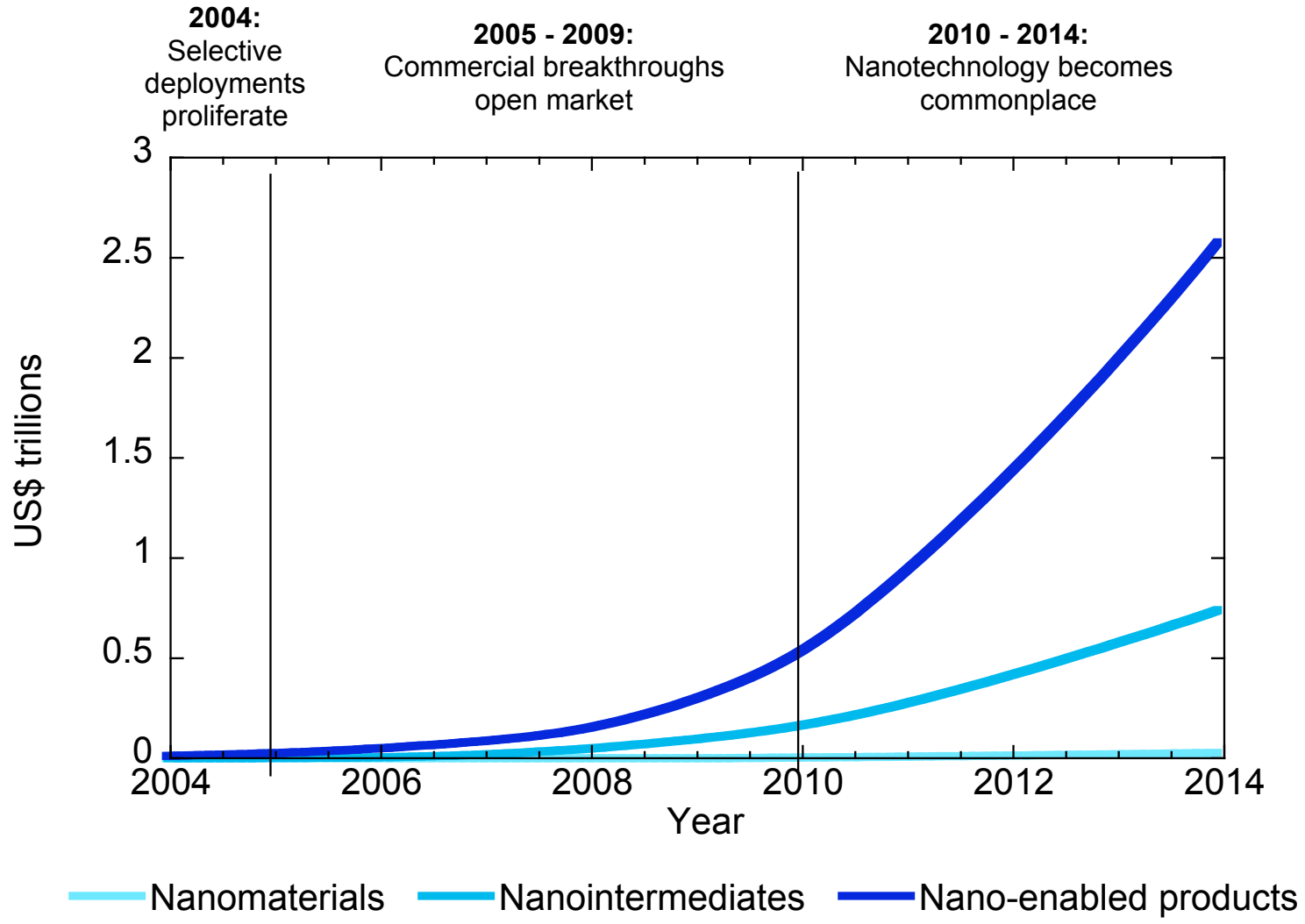
Global R&D Investment in 2004



Source: 2004 Lux Research Reference Study: "The Nanotechnology Report 2004"

Nanotechnology Investment and Impact

Global forecast of products sold incorporating nanotechnology



Source: 2004 Lux Research Report: "Sizing nanotechnology's value chain"

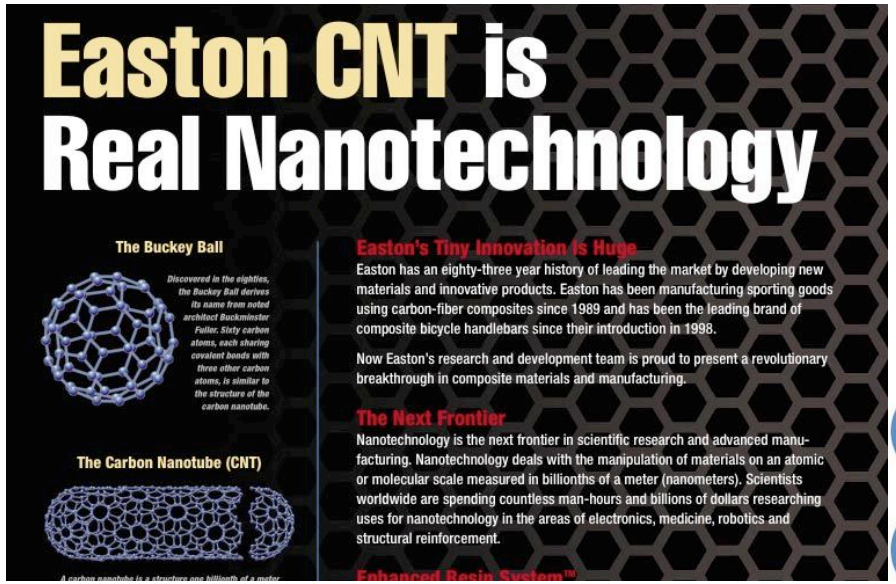
Nanotechnology is 'Now'

Selected consumer products

Nanoclay Composite

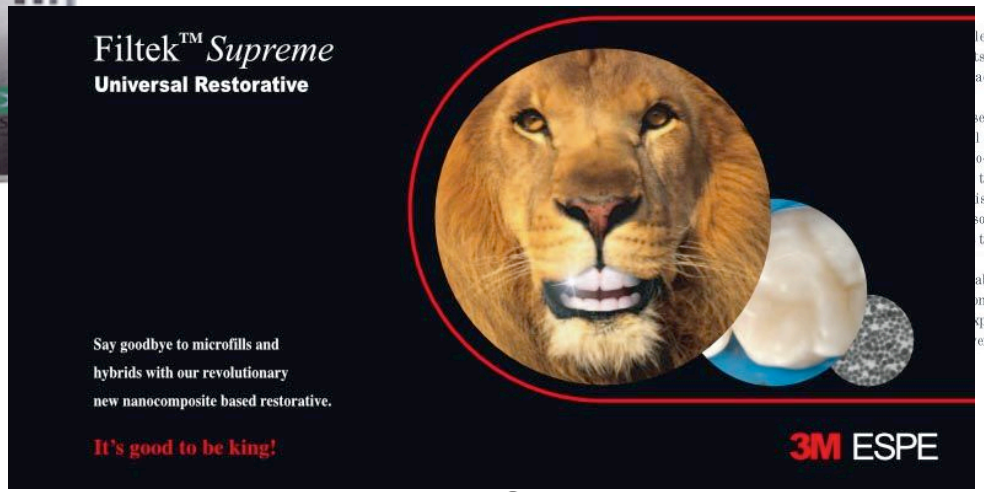
www.wilson.com

Carbon Nanotube Composite



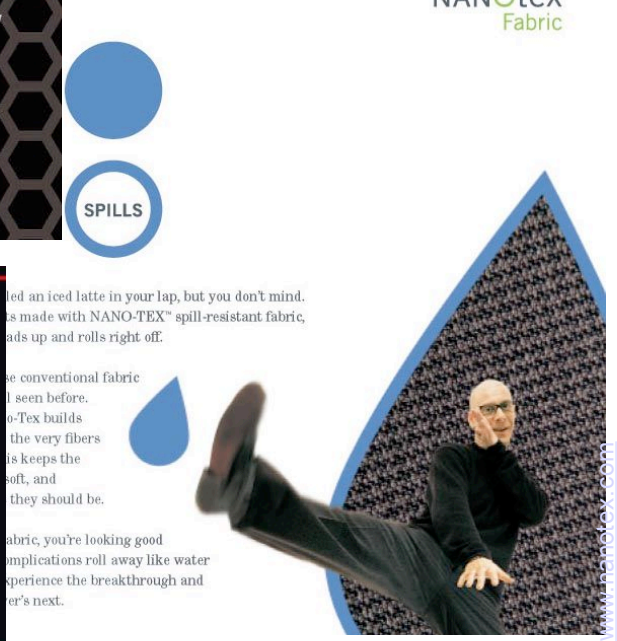
www.eastonbike.com

Nanosilica Composite



www.3M.com

Nano fibers



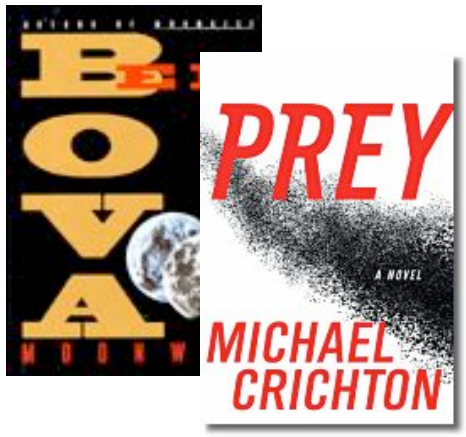
www.nanotex.com

Sustainability

Nanotechnology and risk

- **Nanotechnology - The Motivation**
  - Purposely engineered nanostructured materials and devices demonstrate new, unique and non-scalable properties and behavior
- **Sustainable Nanotechnology - The Challenge**
  - Does the nature of engineered nanostructured materials and devices present new health and environmental risks?
  - How can the benefits of nanotechnology be realized while proactively minimizing the potential risk?
  - How can public trust in the technology be maintained?

Nanotechnology in Poplar Culture



Over 20 science fiction novels since 1982, including Michael Crichton's *Prey*

Variety of films including Spiderman II

Nanobreaker for PSII

Console video games

iPod Nano

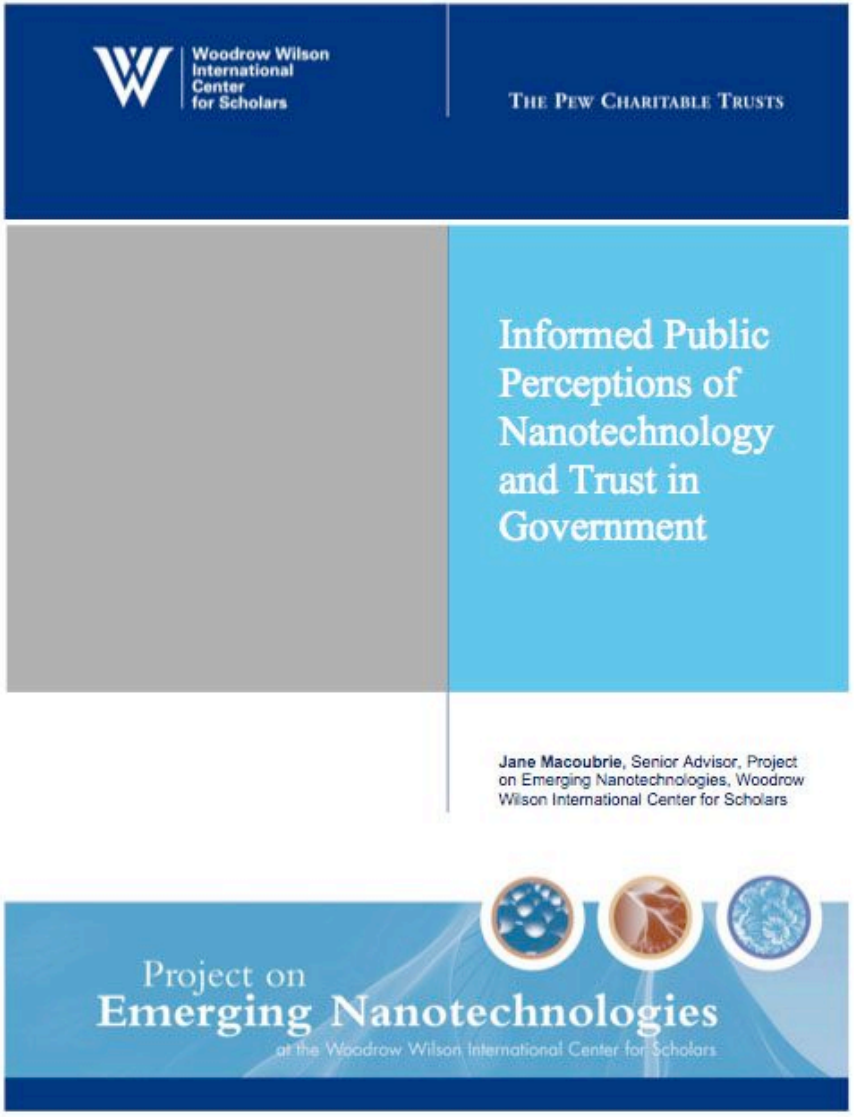
Product branding

THONG

Public protests

Public Perceptions

Macoubrie, September 2005

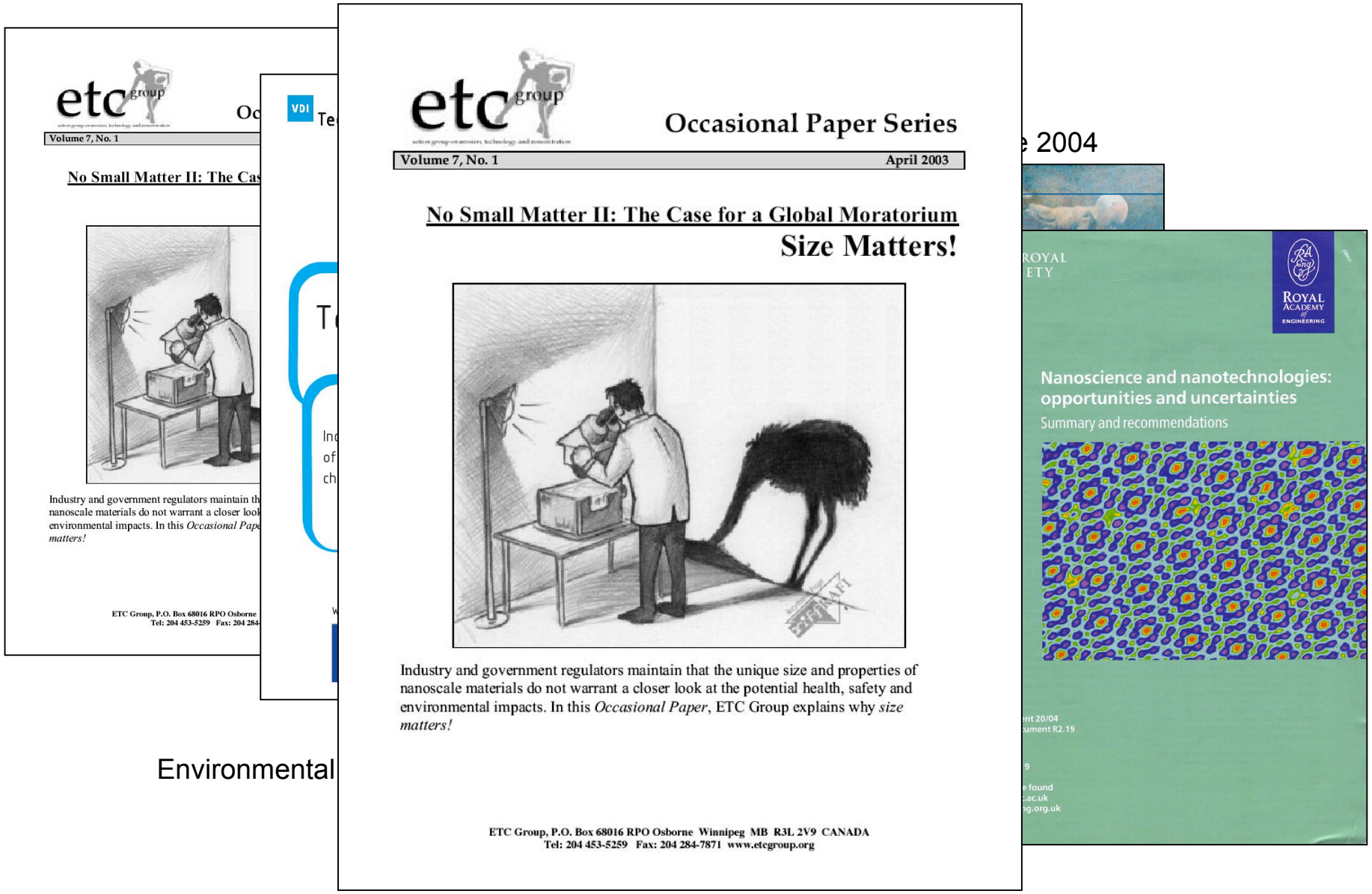


- 80 - 85% of public has heard "little" or "nothing" about nanotechnology
- Perceived benefits outweigh risks
- Top perceived potential benefits include:
  - Disease detection and treatment
  - Environmental remediation
  - National Security
  - Improved human abilities
  - Cheaper, longer lasting consumer products
- Top concerns include:
  - Military uses
  - Long term health effects
  - Environmental impacts
  - Loss of freedom and privacy
- Low trust in both government and industry to manage risk

From: Macoubrie, J. "Nanotechnology: Public Concerns, Reasoning, and Trust in Government"

Potential Impact of Nanotechnology

Concerns



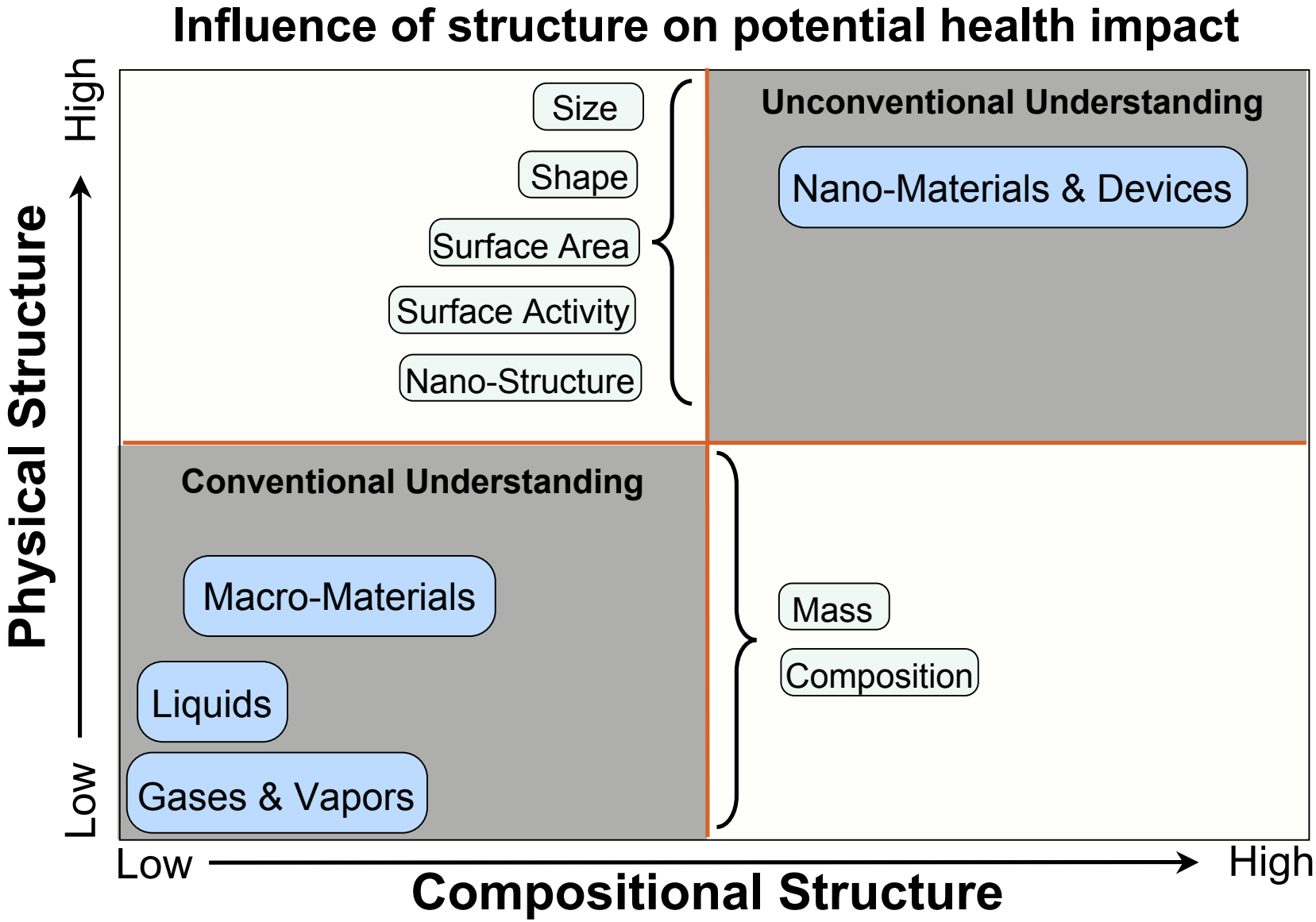
Environmental

Nanomaterial safety - challenging assumptions

Handling unprocessed single walled nanotube material

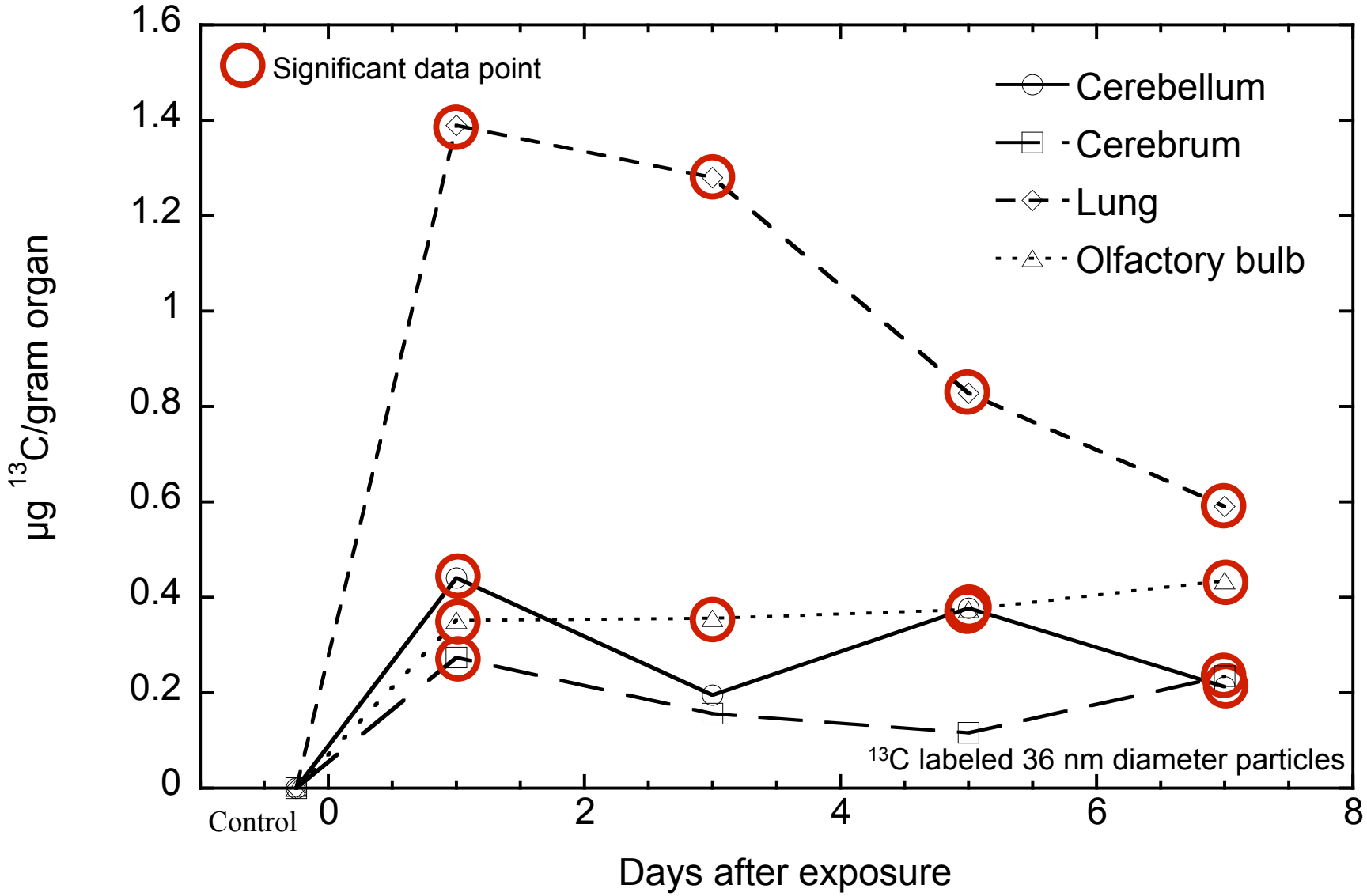
Potential Health Impact

What makes 'nano' different?



Unanticipated exposure routes…

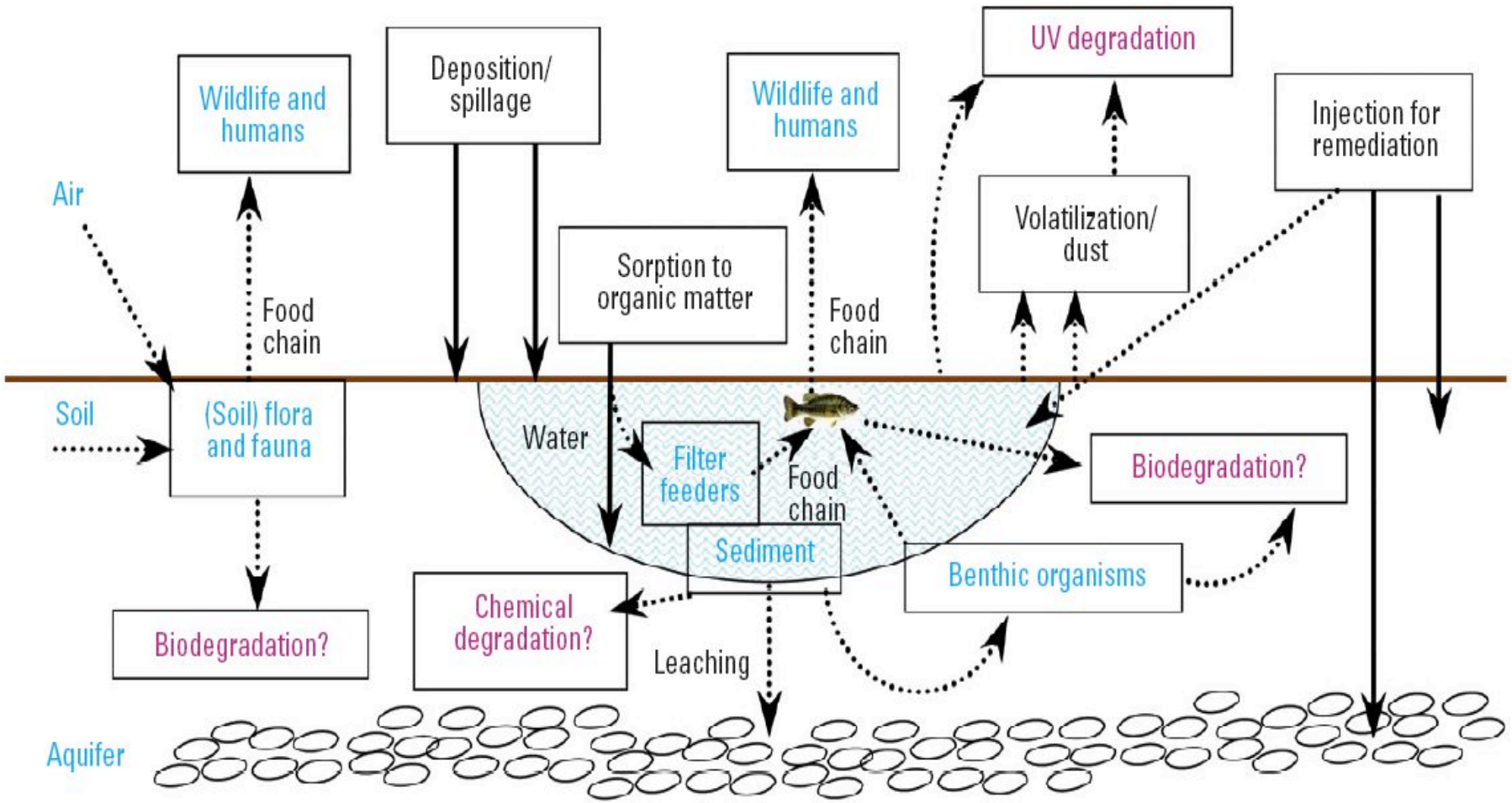
Translocation to the brain following inhalation in rodents



Oberdörster, G., Z. Sharp, V. Atudorei, A. Elder, R. Gelein, W. Kreyling and C. Cox (2004). *Inhal. Toxicol.* **16**(6-7): 437-445.

Nanomaterials in the environment

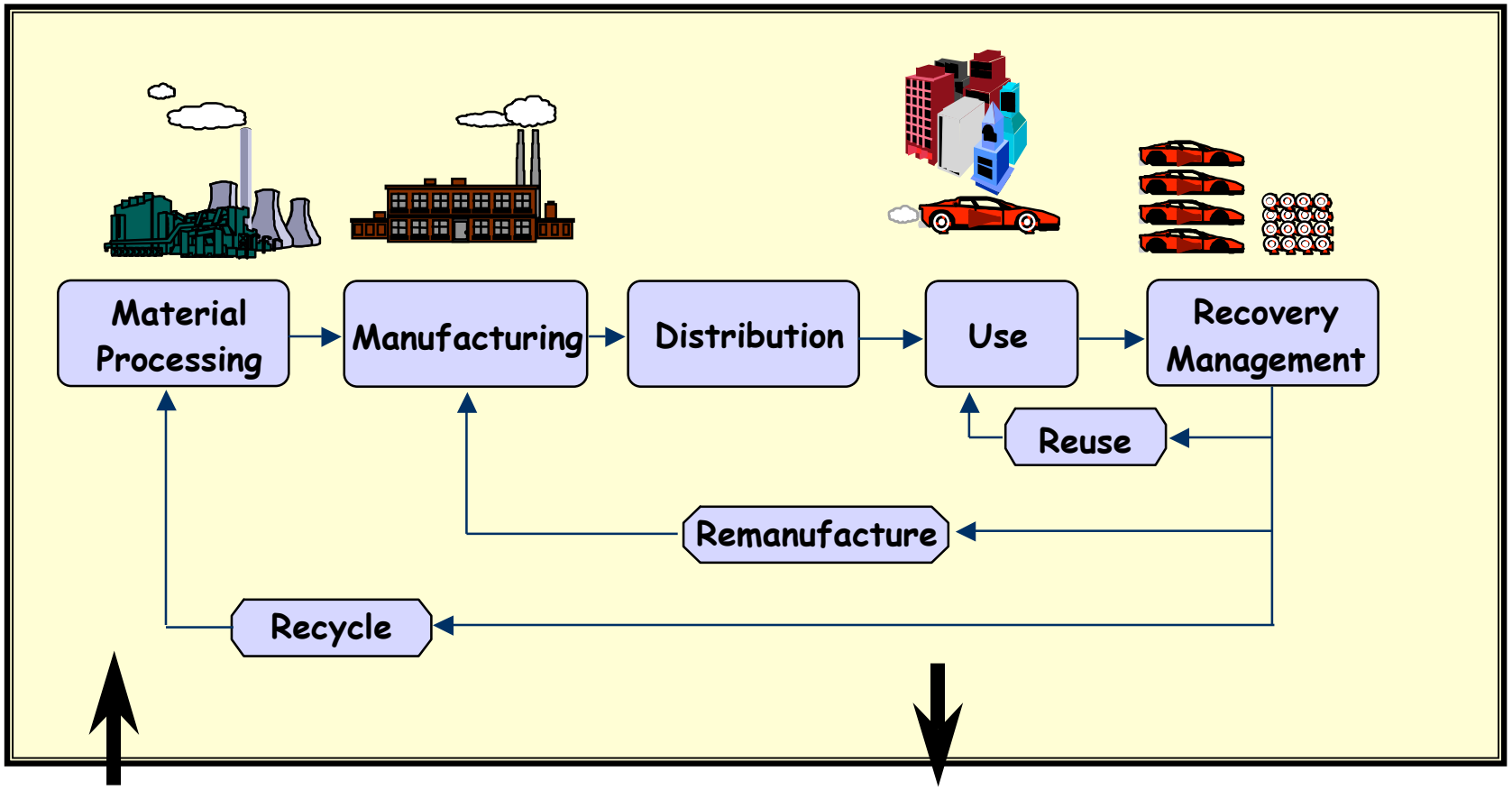
Routes of exposure, uptake, distribution and degradation



Oberdörster et al. (2005) EHP. 113(7):823-839

Life Cycle Assessment

Taking a systems approach to environmental protection



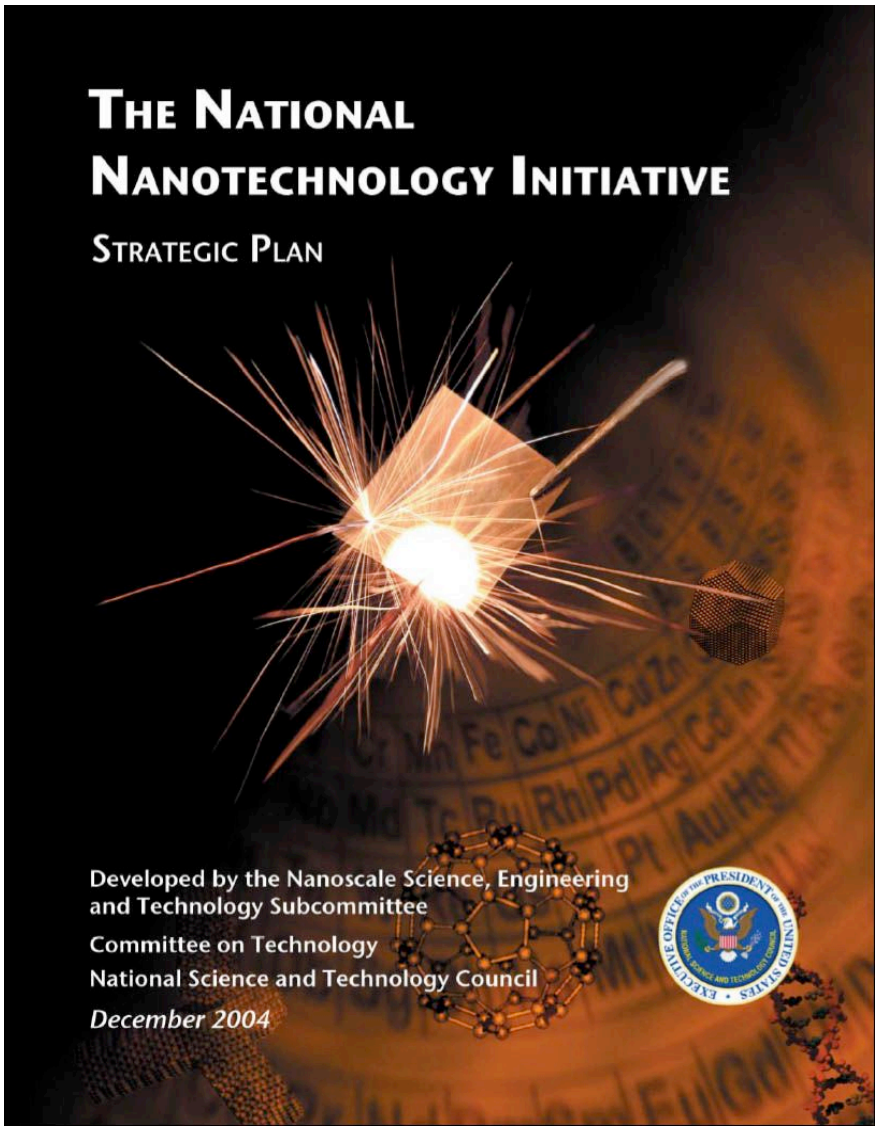
Raw Materials
(Energy, Renewable Resources, Nonrenewable Resources)

Disposal
(Air Emissions, Liquid and Solid Wastes)

J. Golden

National Nanotechnology Initiative

Strategic Plan



- **Goal 4: Support responsible development of nanotechnology**:
  - Environmental, health and safety implications
  - Ethical, legal and all other societal issues
- **Program Component Area 7: Societal Dimensions**
  - Environmental, health and safety research
  - Education
  - Broad societal implications

www.nano.gov

Interagency Coordination of Activities

Nanotechnology, Environment and Health Working Group (NEHI)

- Working group of the Nanoscale Science, Engineering and Technology subcommittee (NSET)
- Membership from all relevant regulatory and research agencies, Office of Science and Technology Policy, and Office of Management and Budget
- Goals of Working Group:
  - Provide for exchange of information among agencies
  - Facilitate the identification/prioritization of research and other activities required for responsible nanotechnology
  - Promote communication of information related to the environmental and health implications of nanotechnology

2006 National Nanotechnology Initiative investment

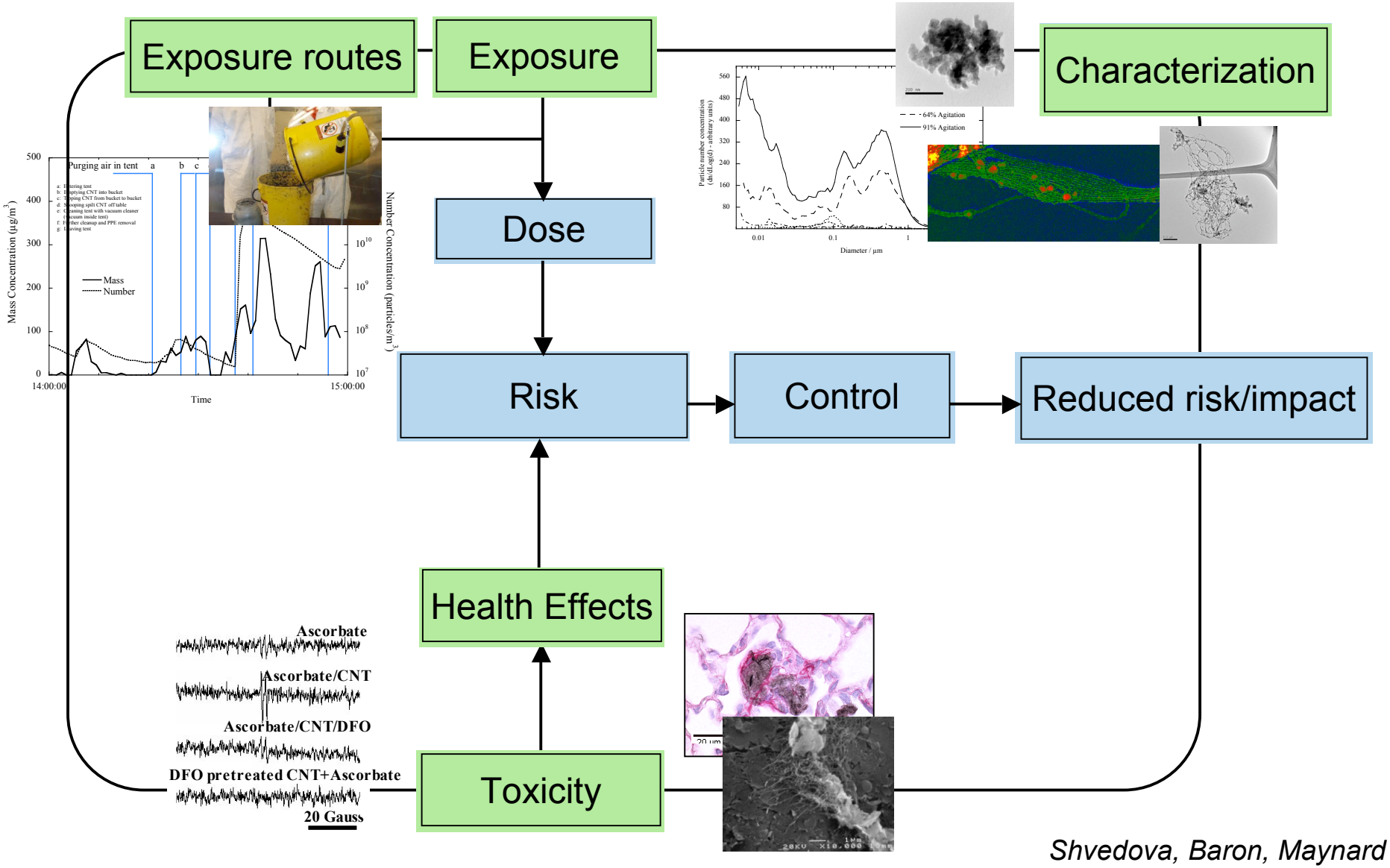
Societal Implications

Estimates of 2006 NNI Investments within Societal Dimensions Program Component Area

	Environmental, Health, and Safety R&D	Education and Ethical, Legal, and other Societal Issues
NSF	$24.0 million	$35.5 million
DOD	$1.0 million	$1.0 million
DOE	$0.5 million	$0.6 million
HHS(NIH)	$3.0 million	$5.0 million
DOC(NIST)	$0.9 million	
NASA		
USDA	$0.5 million	$0.5 million
EPA	$4.0 million	
HHS (NIOSH)	$3.1 million	
DOJ	$1.5 million	
DHS		
TOTAL*	$38.5 million	$42.6 million

National Institute for Occupational Safety and Health

Integrated research into the health impact of carbon nanotubes



Shvedova, Baron, Maynard

Environmental Protection Agency

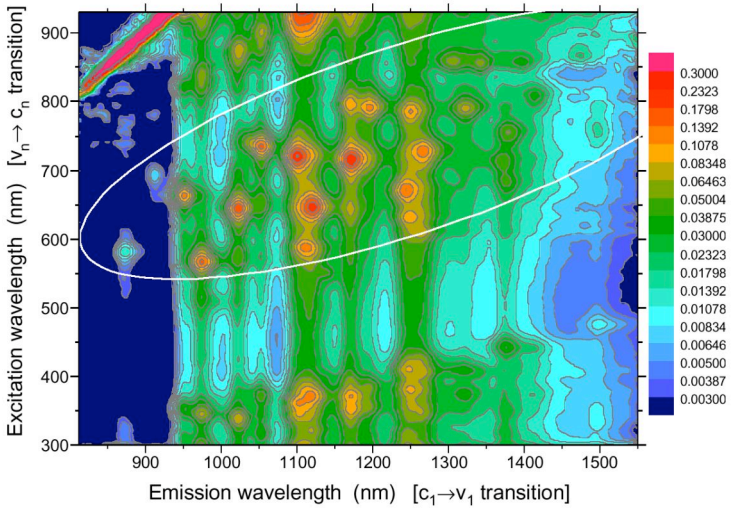
- **Focus on Nanotechnology:**
  - Potential for environmental improvement
  - Possibility for harmful effects on human health/environment
  - EPA's regulatory responsibilities
    - Toxic Substances Control Act, Clean Air Act, Clean Water Act, Comprehensive Environmental Response, Compensation and Liability Act/Superfund

- **Science to Achieve Results program (STAR)**
  - 2004 Program: Environmental and Human Health Effects of nanomaterials
    - $7 million, joint with NSF and NIOSH
    - 18 Grants Awarded – 14 EPA, 2 – NSF, 2 – NIOSH, To be announced
  - 2005 Program: Environmental and Human Health Effects of nanomaterials. Announcement expected Fall 2005

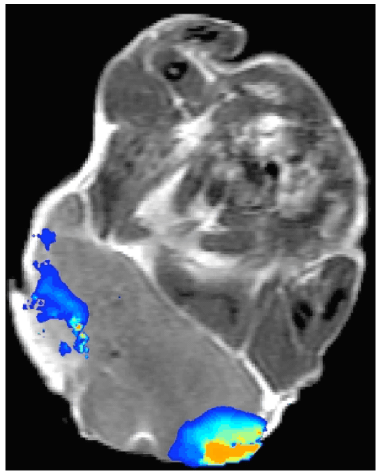
National Science Foundation

Center for Biological and Environmental Nanotechnology - Rice University

- **Highlights:**
  - $12.4 million from NSF, $5.3 million from Rice, over 5 years
  - > 200 invited “center” presentations; > 200 accepted publications
  - Research, education, knowledge transfer, commercialization
  - First observation of carbon nanotube emission and its first application to biological imaging.
  - Near-infrared nanoparticles demonstrated to shrink tumors using photothermal therapy.
  - First publications in the area of nanotechnology and environmental impact.



Nanotube fluorescence

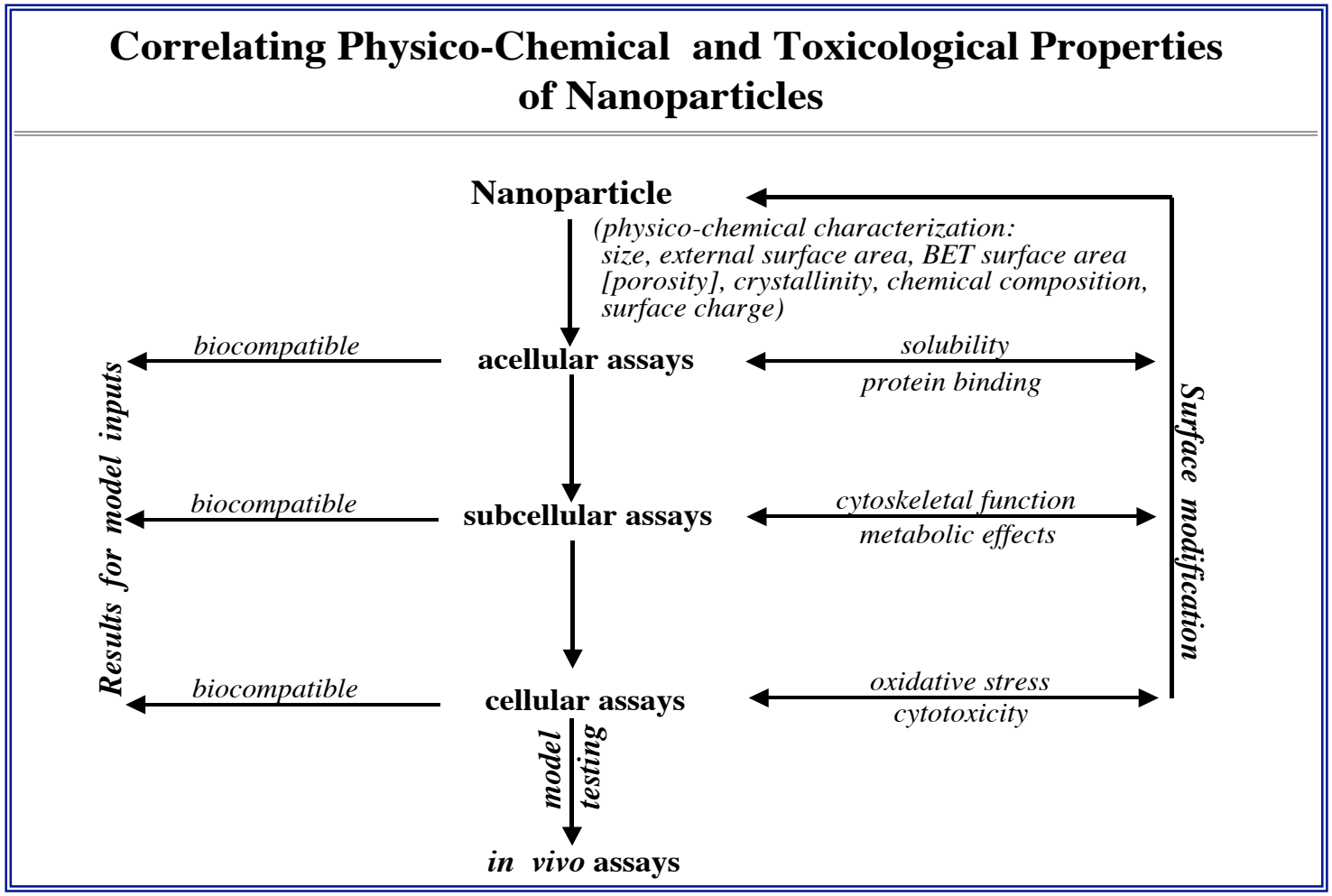


Nanoshell-heated cancer tissue

Ecotoxicology and nanocarbons

Department of Defense (MURI program)

Physicochemical characteristics and toxicological properties of nanoparticles

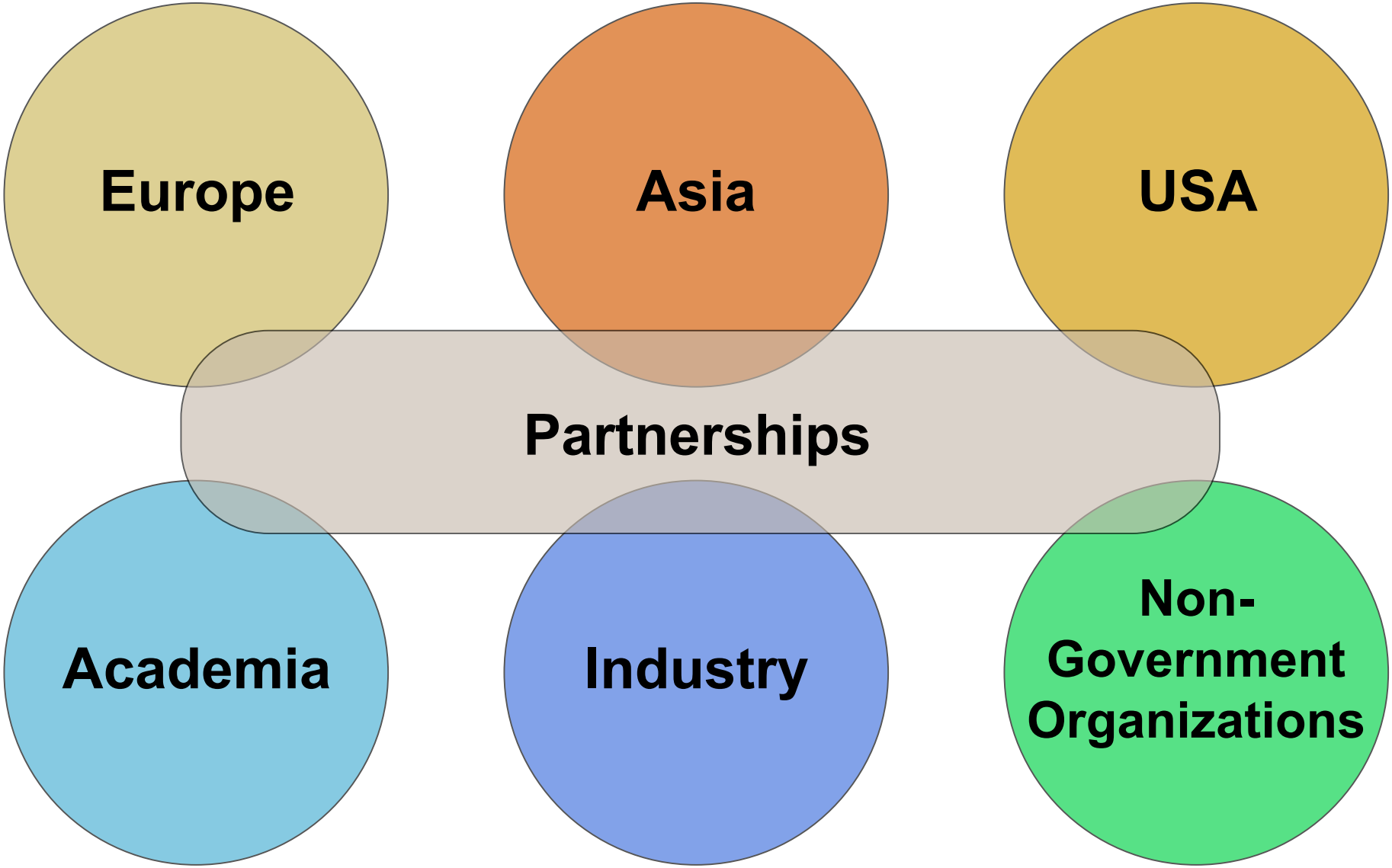


Oberdörster, Pui and Biswas

University of Rochester, University of Minnesota, Washington University St. Louis

Sustainable Nanotechnology

Global initiatives



Project on
Emerging Nanotechnologies
at the Woodrow Wilson International Center for Scholars

THE PEW CHARITABLE TRUSTS

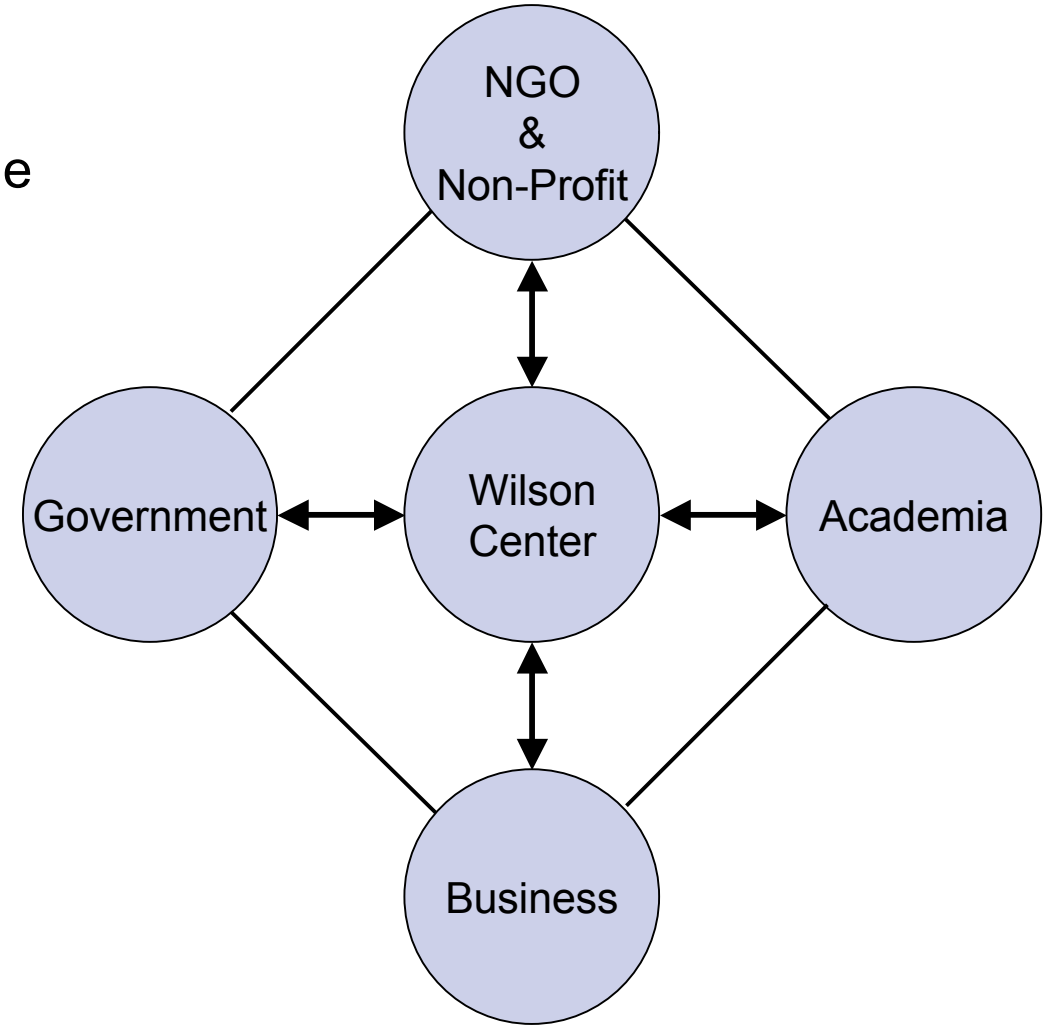
Project on Emerging Nanotechnologies

About the Woodrow Wilson International Center for Scholars

- Living memorial to Former President Wilson established by Congress in 1968
- Non-partisan institution, supported by public and private funds
- A lively, neutral, domestic and international forum for free and informed dialogue
- Integrated into the Smithsonian Institute
- 200 staff, fellows, and scholars
- Annual budget of $30m
- Directed by Former US Congressman Lee Hamilton

Project on Emerging Nanotechnologies

- Goal
  - Ensure government and private sector address the risks as well as the benefits of nanotechnology
- Budget
  - $3 million over 2 years
- Programs
  - Meetings, research, polling, outreach



Created in partnership with the Pew Charitable Trusts

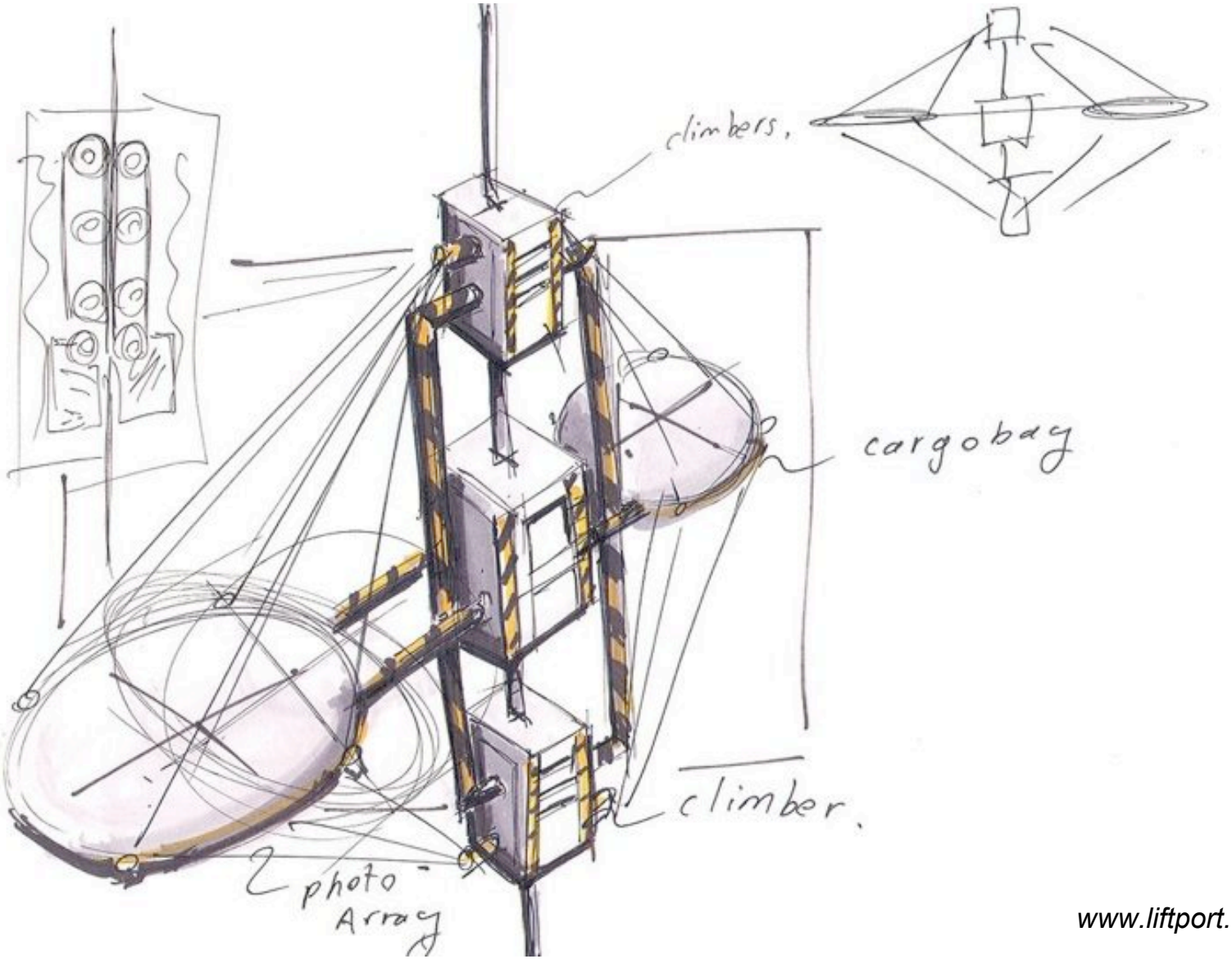
Project on Emerging Nanotechnologies

Current activities include…

- Database of federally funded research on environmental, safety and health implications
  - Providing an overview of research focuses and gaps
- Review of airborne nanomaterial exposure measurement requirements
  - Evaluating current capabilities and research/development needs
- Use of gene arrays in ecotoxicity screening
  - Developing rapid, cost-effective screening assays for early detection of potential issues
- Facilitating domestic and international partnerships

Looking to the Future

Successful implementation of sustainable nanotechnologies



www.liftport.com

Summary

- Nanotechnology is a revolutionary technology
- Significant societal and economic benefits are anticipated
- Conventional risk management models are being challenged
- Successful development and implementation of nanotechnology will require an integrated approach to risk
- Global, interdisciplinary and cross-sector partnerships are essential to developing sustainable nanotechnologies

Contact Information

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