

# Nanotechnology: How Much EH&S Research is Enough?

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SERDP



THE PEW CHARITABLE TRUSTS

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



# Nanotech in Dollars

- **U.S. government** investment is now over \$1 billion/year through the National Nanotechnology Initiative.
- **U.S. industry** investment now at \$1.6 - 1.7 billion/year
- **States** investing approximately \$400 million per year. Key states are CA, MA, NY, TX, CO, VA.
- **Venture funding:** 2003 - \$301 million, 2004 - \$200 million 2005 - \$400 million (estimated); approximately 1,200 nanotech startups worldwide; about one half in the U.S.; 10% of the startups receive venture funding
- **How much insurance would you like on this investment?**

# How Much is Enough to Protect Workers, Consumers, and the Environment?

3 - 5 percent of total research budget (Genome Project)

\$38 million (National Nanotechnology Initiative estimate)

\$100 million (Environmental Defense recommendation)

\$x, \$2x, \$3x.....for the next 10 years

# Why Do We Need an Inventory?

- Identify gaps in the research portfolio
- Allow more strategic investments or disinvestments to be made at the margins
- Support better collaborative research with industry and with other countries
- Satisfy the public's demand for greater disclosure and transparency

# Nanotech EH&S Database

## Nanotechnology Health and Environmental Implications A database of current research

The emergence and development of sustainable nanotechnologies will depend on strategic, coordinated and integrated research addressing potential health and environmental risks. This database has been developed as a major tool to facilitate such research.

[Browse Records](#)

The database catalogs global government-funded research into the human health, safety and environmental implications of nanotechnology. While not comprehensive, it has been designed to serve as a resource for researchers, policy makers and others engaged in ensuring the success of nanotechnologies through understanding and reducing potential risks.

[Advanced Search](#)

This is a pre-release of the database, and is still undergoing development. Feedback is sought on updates to existing records, information on research not covered, the database interface and the information available. Please email feedback to [nano@wilsoncenter.org](mailto:nano@wilsoncenter.org)

# Search Functions

Principal Investigator name contains:

From the country:

With a funding source including:

With any of these relevance to implications levels:

- High
- Substantial
- Some
- Marginal
- None

Belonging to the following nanomaterial categories:

- Engineered Nanomaterials
- Incidental Nanomaterials
- Natural Nanomaterials
- Generic

With the following impact sectors:

- Human Health
- Environment
- Safety
- Cross-cutting

## Broad Research Categories

- Exposure
- Hazard
- Response
- Generation, Dispersion, Transformation, etc.
- Safety
- Control
- Characterization
- Risk Assessment
- Risk Management

# Search Results

[Home](#) | [Next Page](#)

Displaying records 1 - 10 of 16

16 records found. Total Annual Funding (estimated): \$2,920,708.00

## **Nanoparticles in the Workplace**

**Principle Investigator:** Mark Hoover

**Country:** USA **Funding Source:** NIOSH

## **Health Effects of Inhaled Nanomaterials**

**Principle Investigator:** Kent Pinkerton

**Country:** USA **Funding Source:** EPA

## **Absorption and Release of Contaminants onto Engineered Nanoparticles**

**Principle Investigator:** Mason Tomson

**Country:** USA **Funding Source:** EPA

## **Toxicology of Airborne Environmental and Occupational Particles**

**Principle Investigator:** Gunter Oberdorster

**Country:** USA **Funding Source:** DOD

## **Role of Particle Agglomeration in Nanoparticle Toxicity**

**Principle Investigator:** Terry Gordon

**Country:** USA **Funding Source:** EPA

## **Pulmonary Effects of Exposure to Various Nanoparticles**

**Principle Investigator:** Dale Porter

**Country:** USA **Funding Source:** NIOSH

## **Dermal Effects of Nanoparticles**

**Principle Investigator:** Anna Shvedova

**Country:** USA **Funding Source:** NIOSH

# Project Details

## Health Effects of Inhaled Nanomaterials

### Project Information

**Principle Investigator:** Kent Pinkerton

**PI Institution:**

**Relevance to Implications:** High

**Class of Nanomaterial:** Engineered Nanomaterials

**Impact Sector:** Human Health

### Funding

<b>Country:</b>	USA	<b>Anticipated Total Funding:</b>	\$334,998.00
<b>Funding Source:</b>	EPA	<b>Start Year:</b>	2004
<b>Funding Mechanism:</b>	Extramural	<b>Anticipated End Year:</b>	2007
		<b>Annual Funding (Est.):</b>	\$111,666.00 (Estimated)

### Broad Research Categories

Exposure  
 Hazard  
 Response

Generation, Dispersion, Transformation, etc.  
 Safety  
 Control

Characterization  
 Risk Assessment  
 Risk Management

### Abstract/Summary

**Objective:**

The potential health impact of engineered nanomaterials is unknown. Nanomaterials are particles less than 100 nm in diameter. It is anticipated there will be an exponential increase in the commercial use of these materials in society as carbon nanotubes, nanowires, and silicon/metal alkoxides. This use will lead to a concomitant increase in exposure of the general population to nanomaterials in products and the environment through incidental introduction to the soil, water and air. Little is known what the environmental fate of these particles will be. Epidemiological and toxicological studies on the effects of particulate air pollution support the premise that ultrafine or nanosize particles cause pulmonary inflammation as well as systemic effects. Therefore, we propose to test the hypothesis that inhaled nanomaterials cause respiratory effects in the form of oxidative stress and inflammation. We further propose such events will lead to release of pro-inflammatory cytokines as well as other mediators to induce cell proliferation and alterations in the normal cellular milieu of the airways and alveoli of the lungs. We will test whether these health impacts of nanomaterials on the respiratory system are driven in large measure by (1) particle size, (2) particle composition and/or (3) trace contaminants associated with the manufacturing process of nanomaterials.

**Approach:**

These studies will be done at the Center for Health and the Environment, and the Department of Chemistry, University of California, Davis. Nanomaterials will be obtained from commercial sources as well as generated in our laboratories at the University of California, Davis. To study the health effects of nanomaterials, a novel exposure system will be used to generate aerosols of these materials requiring only small quantities (100 mg) for short-term inhalation in rodents. Exposures will take place for up to 3 consecutive days, with exposures being 6 hours/day. Exposures will use specific types of carbon nanotubes (single-walled, bundled and multiwalled) of known size and composition. Ultrafine titanium dioxide (TiO<sub>2</sub>) and ultrafine carbon black (CB) will also be aerosolized to compare their potential health effects to these various forms of nanotubes in the respiratory tract. Cellular, biochemical and histological assays will be measured in the respiratory tract to determine potential changes due to nanoparticle exposure. These measures include indicators of oxidative stress, inflammation, cell injury and repair and metabolic change. The role of metal contaminants (present in catalysts used in the manufacturing process) will be studied using nanotube preparations with these trace metals/contaminants removed.

**Expected Results:**

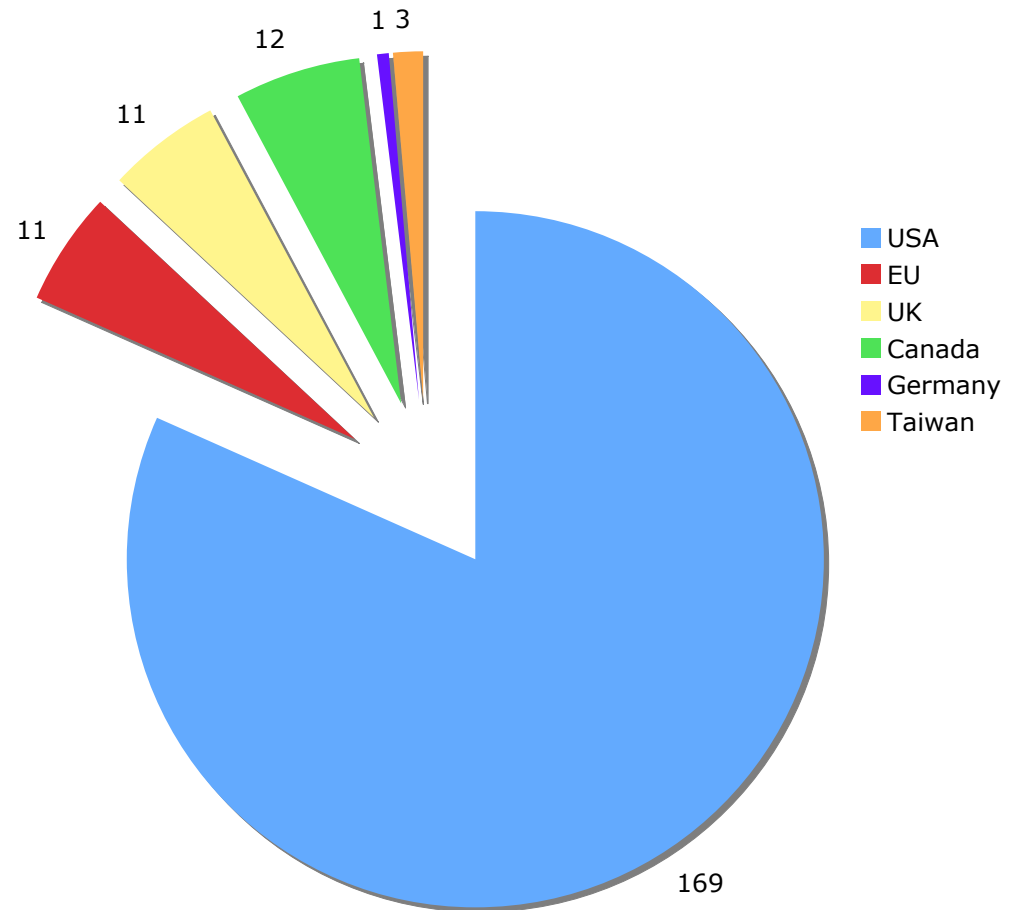
(1) Characterization of aerosolized nanotubes, ultrafine TiO<sub>2</sub>, and CB under environmentally relevant conditions found in the workplace. (2) The influence of uniquely distinct forms of nanotubes to produce health effects in the respiratory system. (3) The impact of trace metals associated with nanotubes to enhance/cause health effects due to inhalation.

### Publications/Outcomes

### Notes



# Inventory -- General Information



**208 research projects**

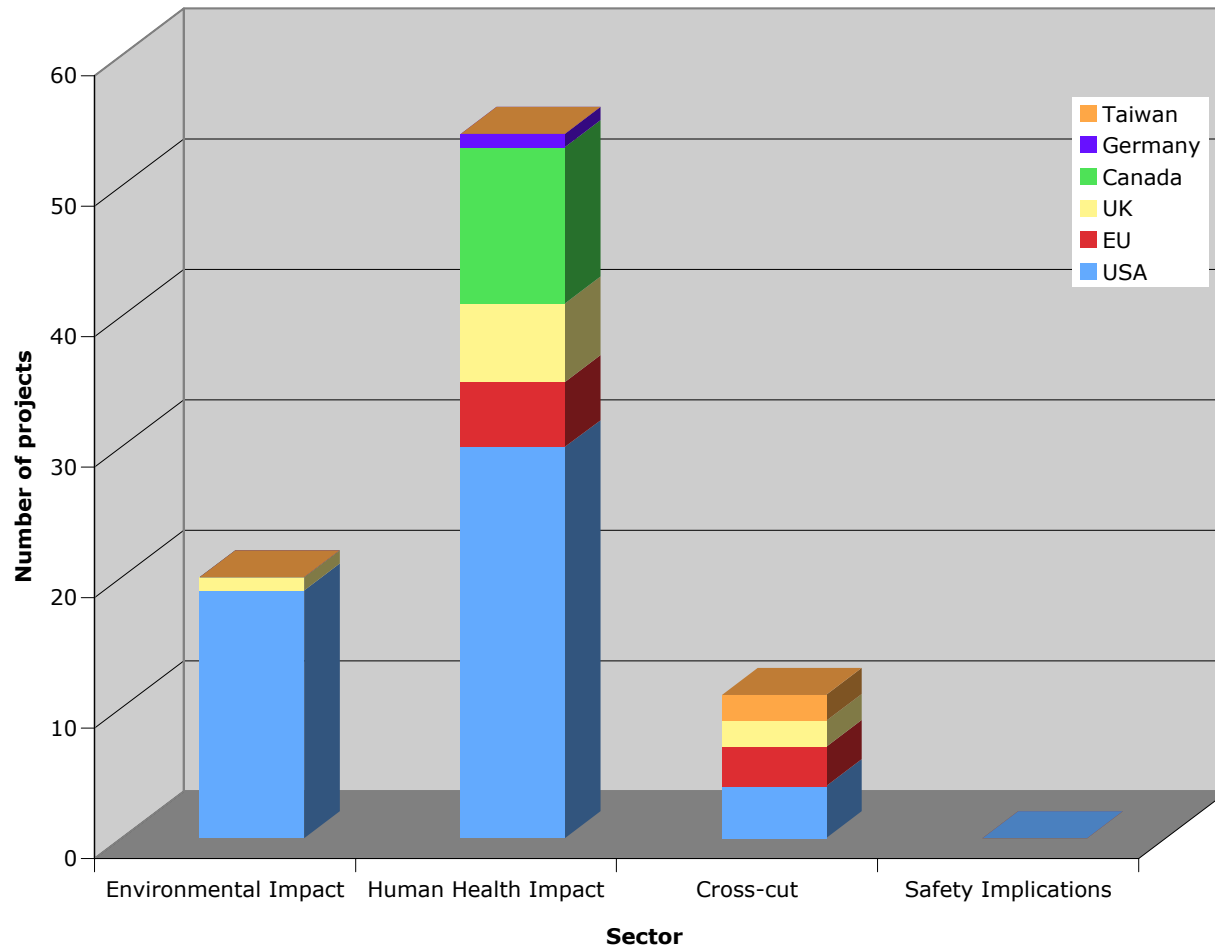
**6 countries and regions**

**\$38 million of research funding annually**

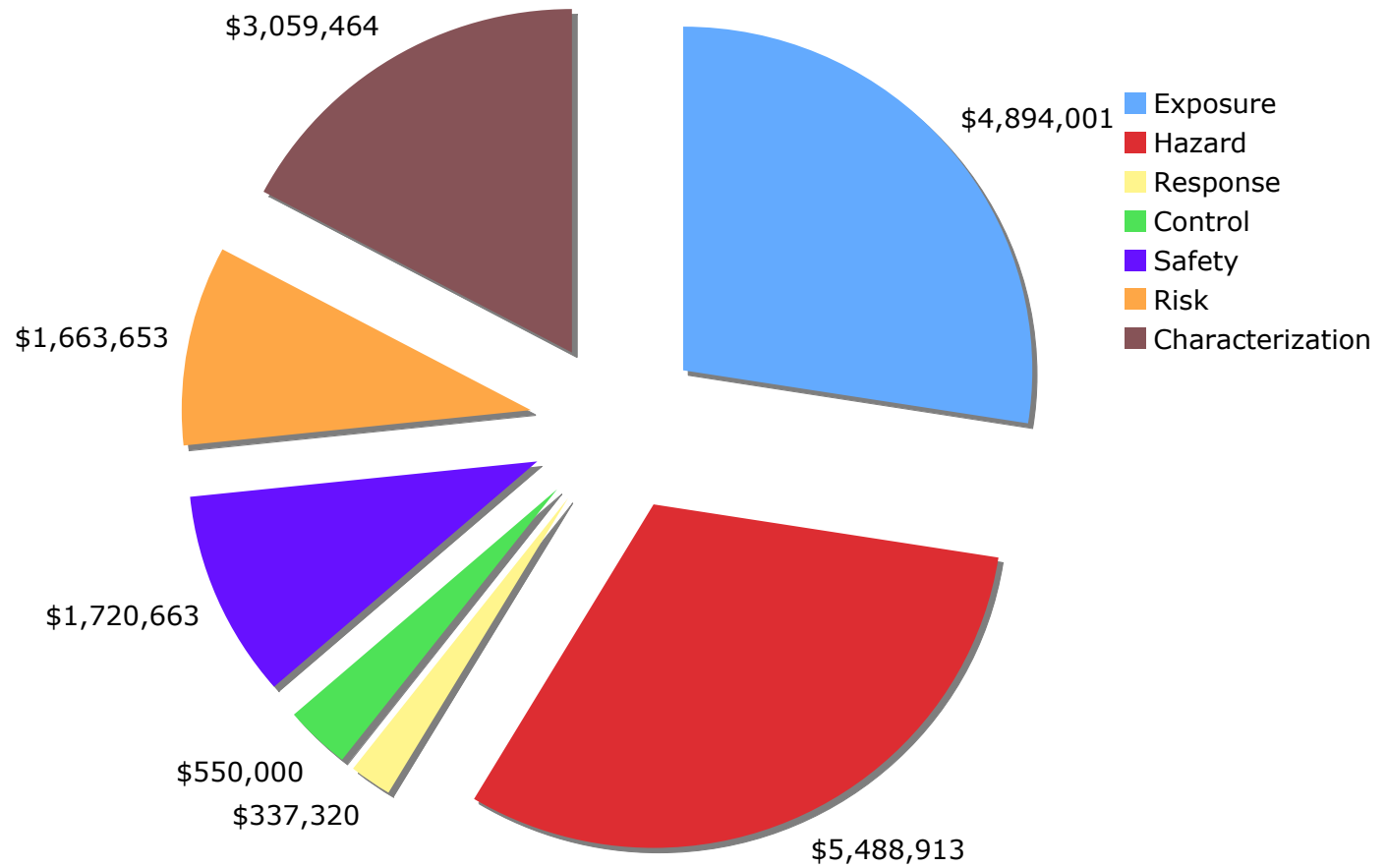
**195 projects are funded by governments (\$31 million)**

**13 (\$7 million) funded by industry or other organizations, or receiving joint funding**

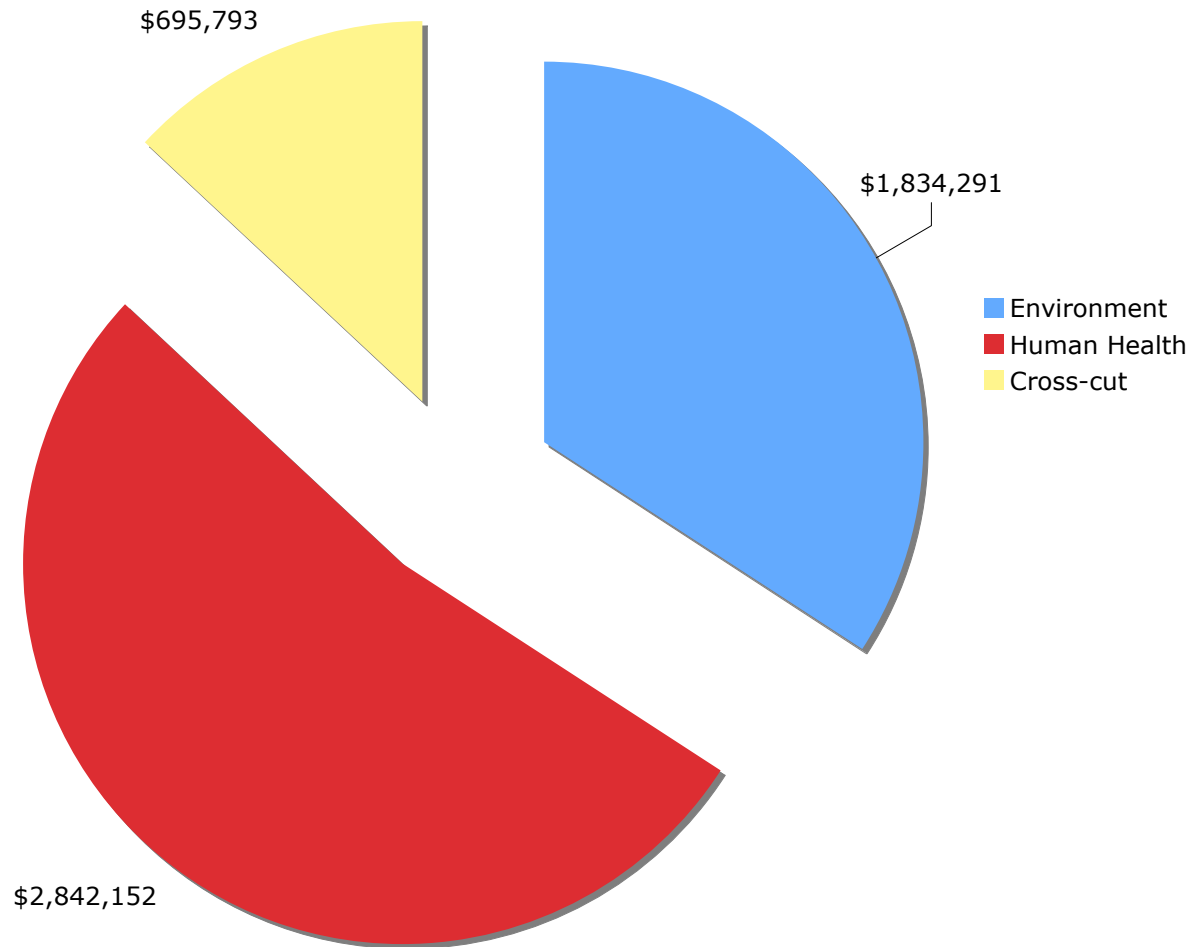
# Highly Relevant Projects on Engineered Nanomaterials — By Impact Sector & Country/Region



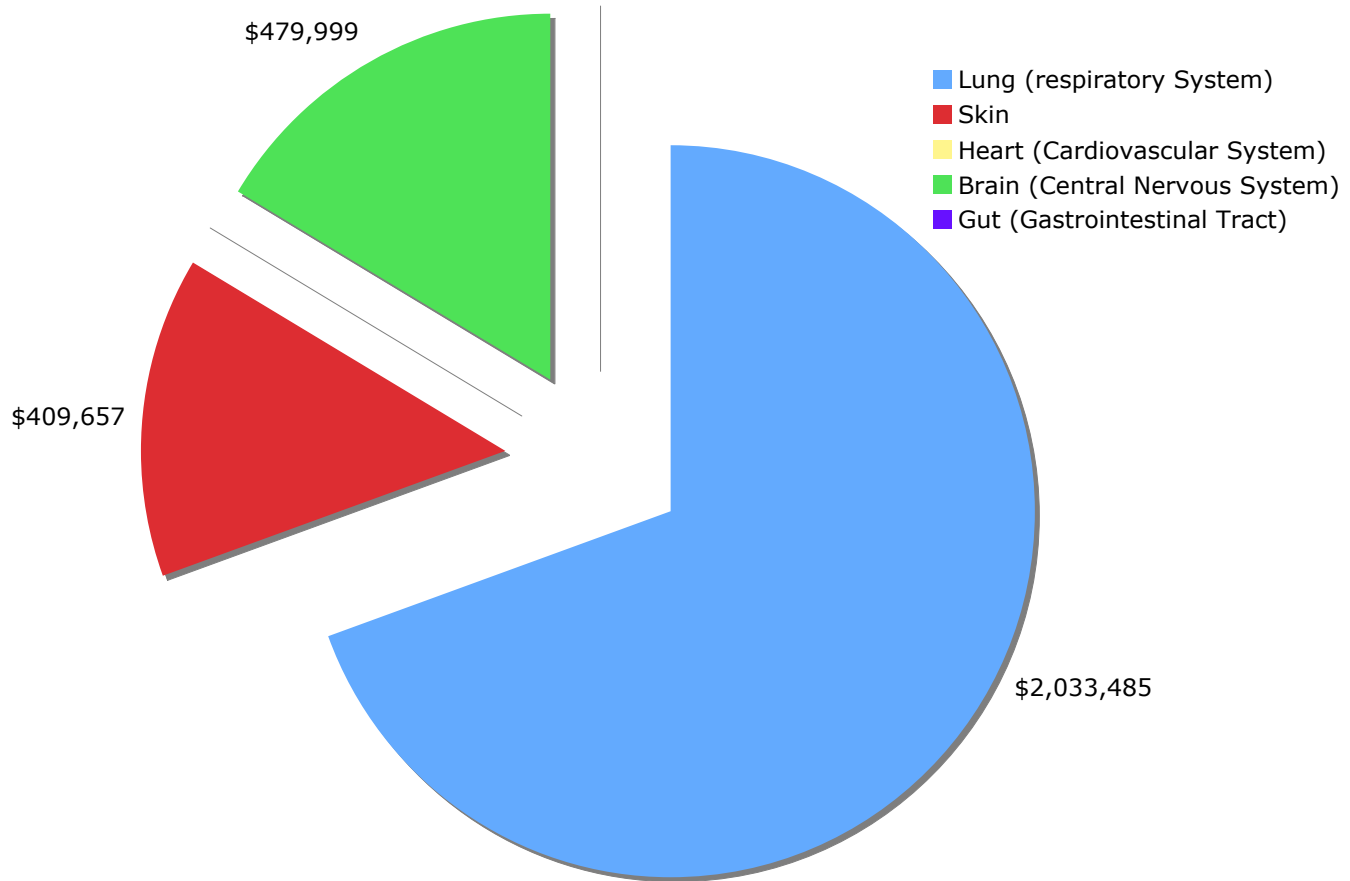
# Highly Relevant Projects on Engineered Nanomaterials in the United States



# Highly Relevant Projects on Engineered Nanomaterials Hazard in the United States — By Implication Focus



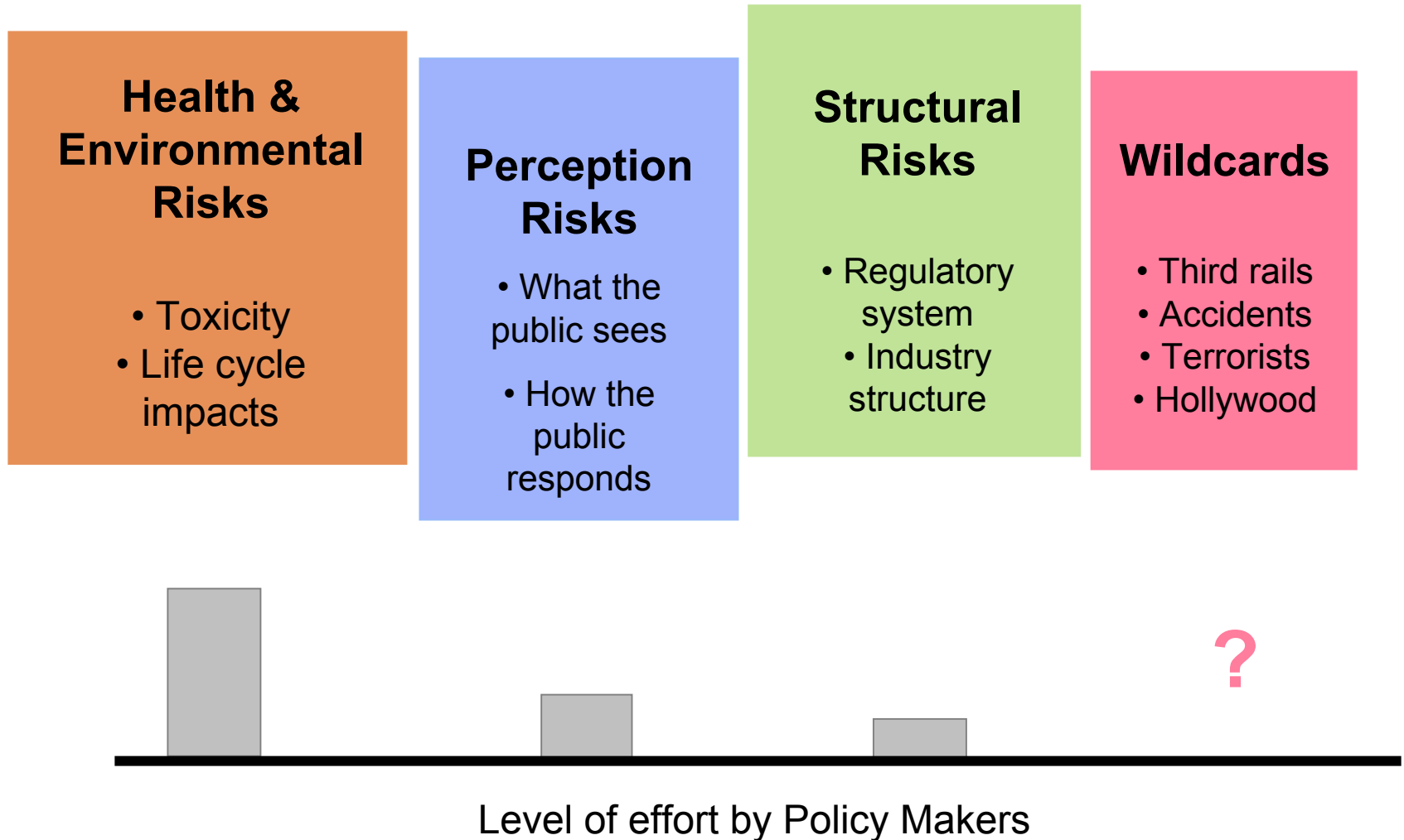
# Funding of Highly Relevant Projects on Engineered Nanomaterials Hazard in the United States — By Specific Organ



# Inventory: Initial Findings

- **Large gaps in research:** no safety research, minimal research on controlling exposure to engineered nanomaterials and the diseases and environmental impacts that may result from exposure, little work on life cycle impacts or emerging nanotechnologies.
- **No obvious overarching research strategy.** Priorities following trends of the past and expertise.
- **Funding levels about \$6 - 10 million** in terms of highly relevant EH&S implications research.
- **Little indication of partnerships** (government-government or government-industry).

# Need a Comprehensive Risk Framework





**Asset or Liability?**





# The Ever Fickle Consumer

- 60 - 70 percent of the public have never heard of nanotechnology (US, UK, and Canadian studies).
- Once informed, public is excited about benefits in areas such as medicine, health, environment, and energy.
- Most frequently mentioned concerns:
  - **Military uses, “evil doers”, weapons of mass destruction**
  - **Long term health effects**
  - **Environmental and ecosystem impacts**
  - **Loss of freedom and privacy**
  - **Regulator loss of control (rush to market)**
  - **Insulation of scientists and regulators from public concerns**
- Trust in both industry or government to manage any risks associated with nanotechnology is low to very low.
- Trust can be enhanced through pre-market testing, more disclosure/transparency, and clear concern for environmental and human health impacts (especially long-term impacts).

# The Public's Perspective

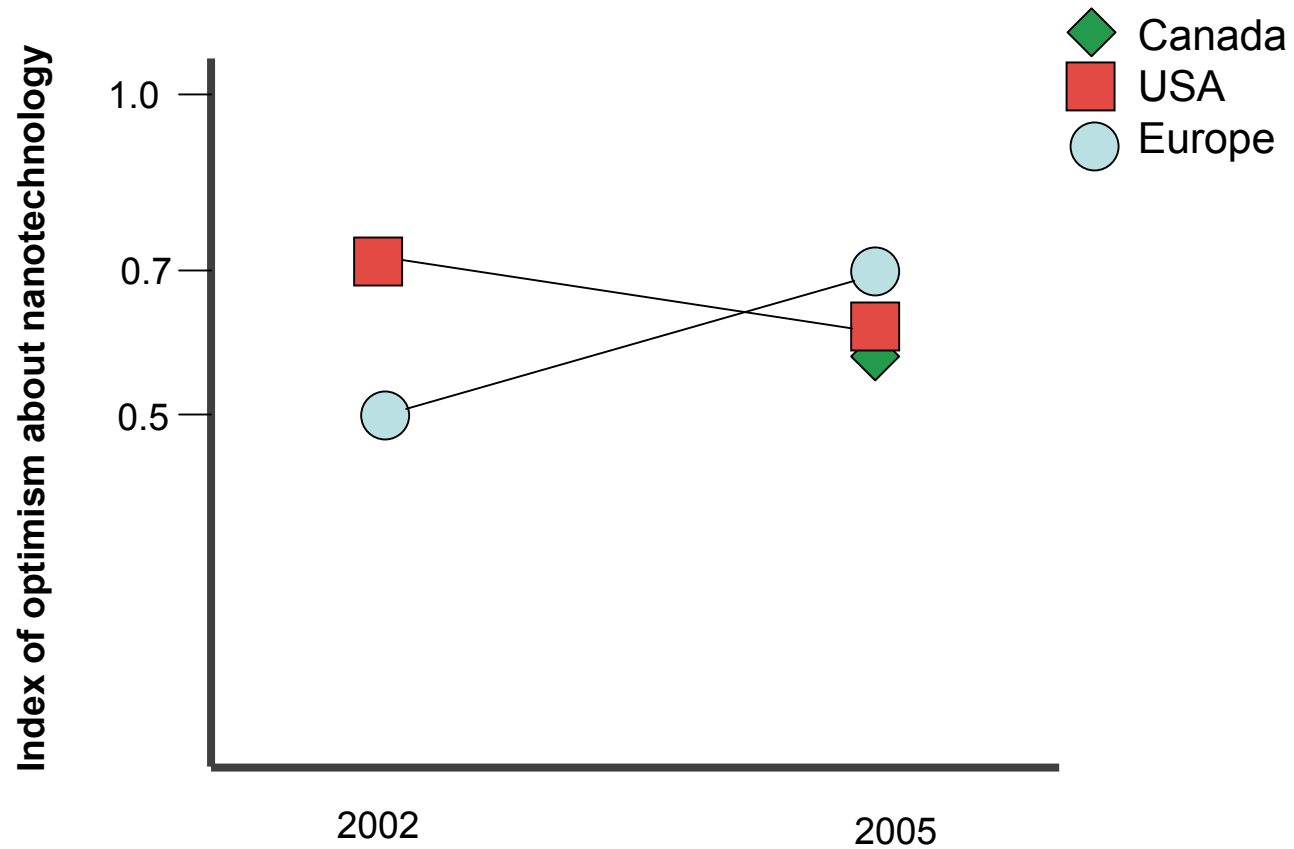
“The genie is out of the bottle and I worry about controlling it and not hurting people. We could feed the world, but with money and power and politics, nanotechnology could be very scary.”

“The problem is if these early release products that appear to be benign are suddenly found to be detrimental to human health, we'll all be hyper-skeptical of the industry.”

“They can't regulate what we're doing now because they can't understand it.” “The regulators don't know. In one small aspect of nanotech, there may only be two people who know.”

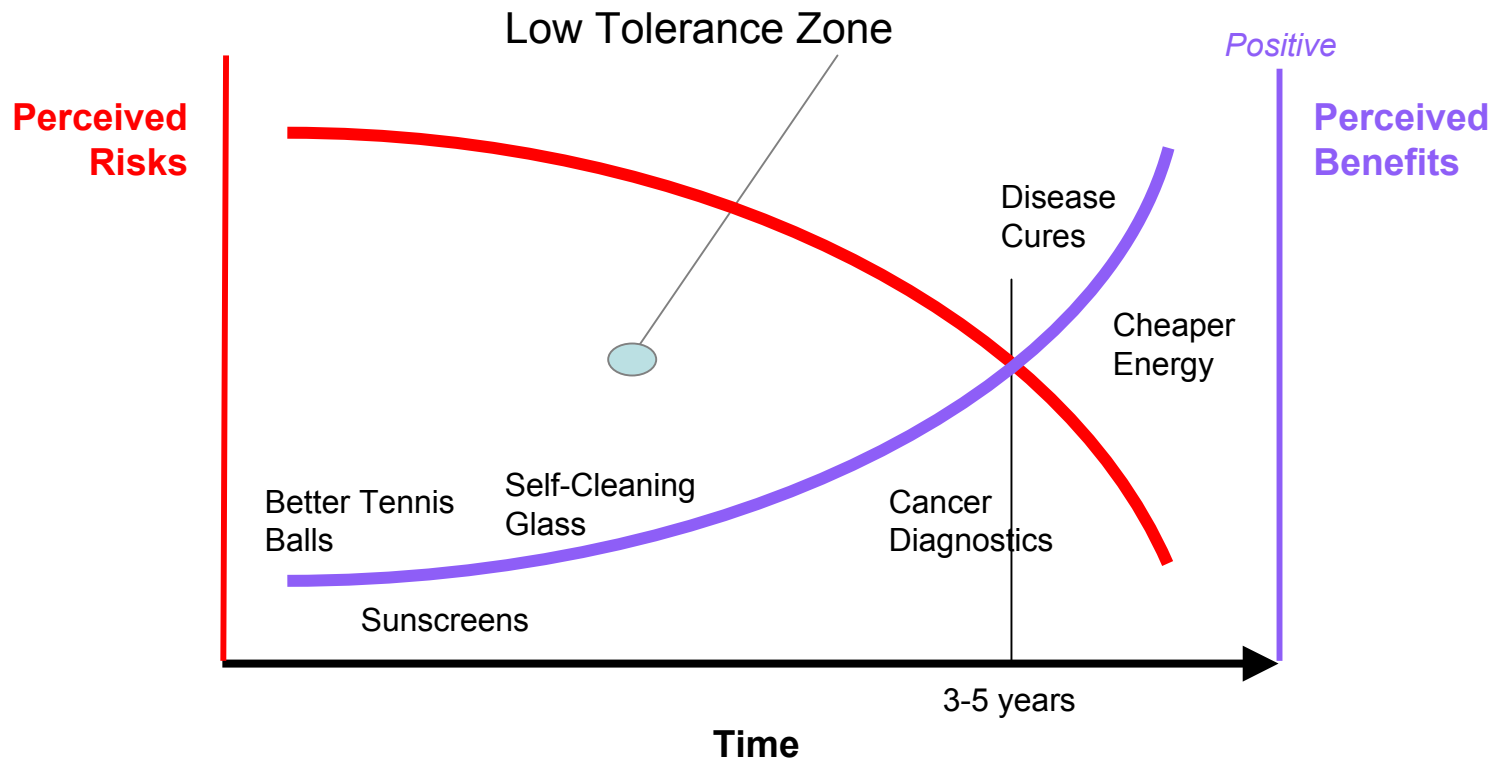
“We need different regulation than we have now. It's a new technology and we need a different set of people to set up a system to see if it's safe. The current system fails at some points. If the new technology is so extensive, we need a new system to regulate it.”

# Optimistic about Nano?



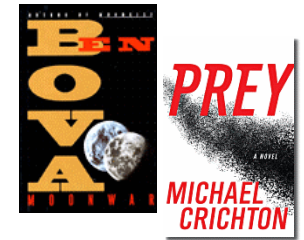
Source: Eurobarometer

# Risks versus Benefits for Nanotechnologies



# Who Controls Message?

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



- Variety of films including Spiderman II



- Console video games (*NanoBreaker* & *James Bond 007: Everything or Nothing*)



Nanobreaker for PS2

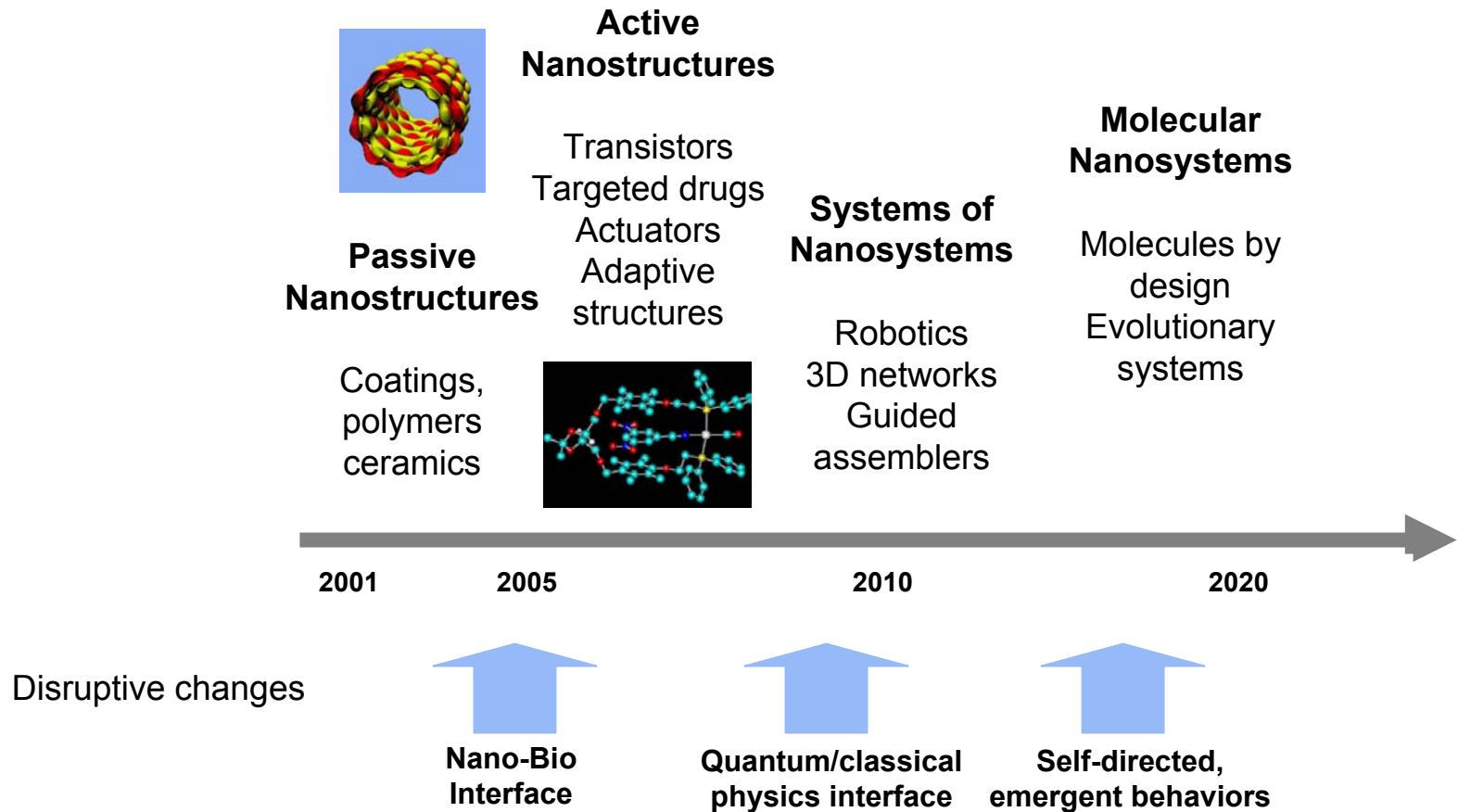
- Massive multiplayer on-line games (*Second Life*)



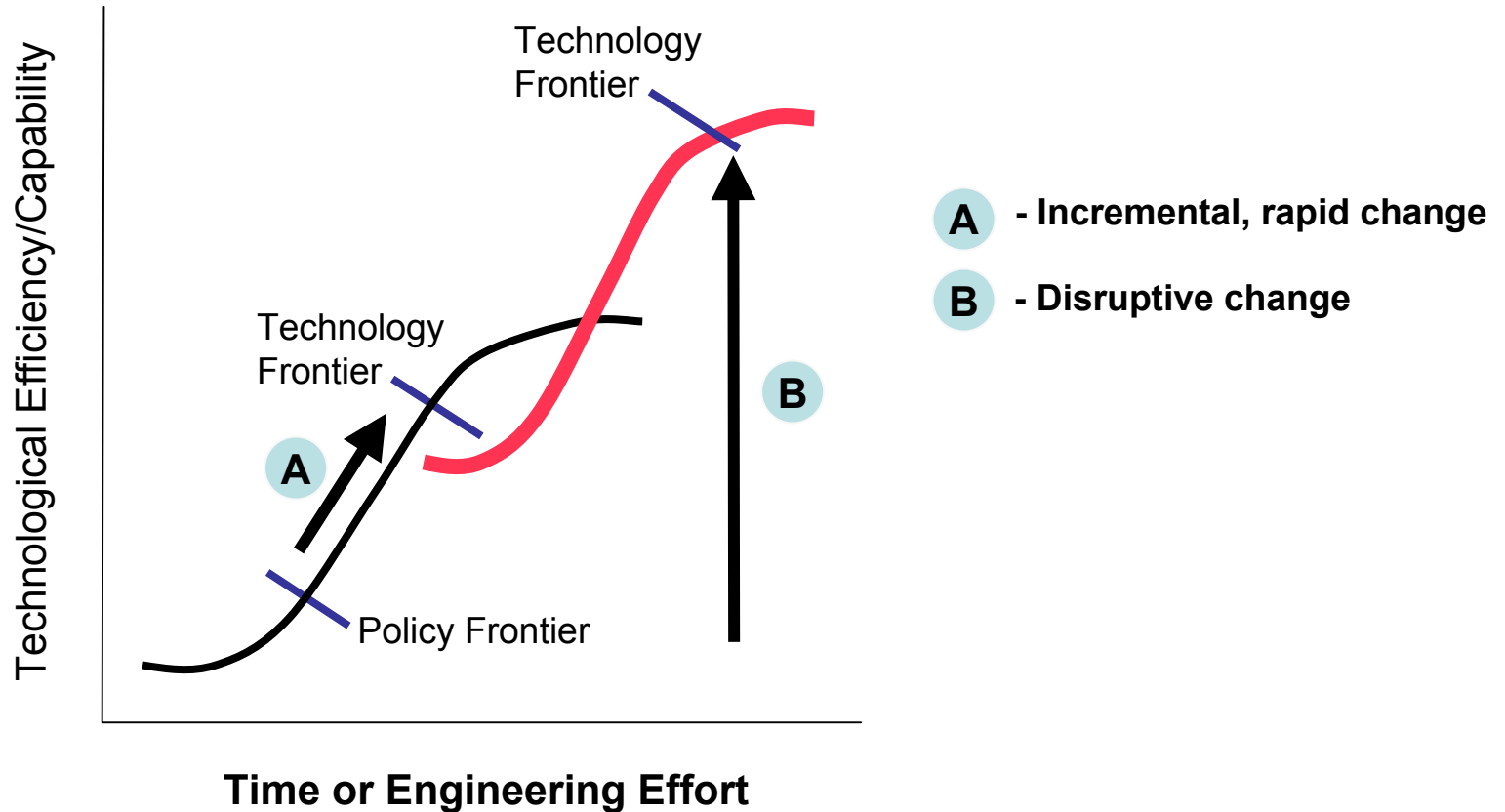
- Embedded messages in advertisements



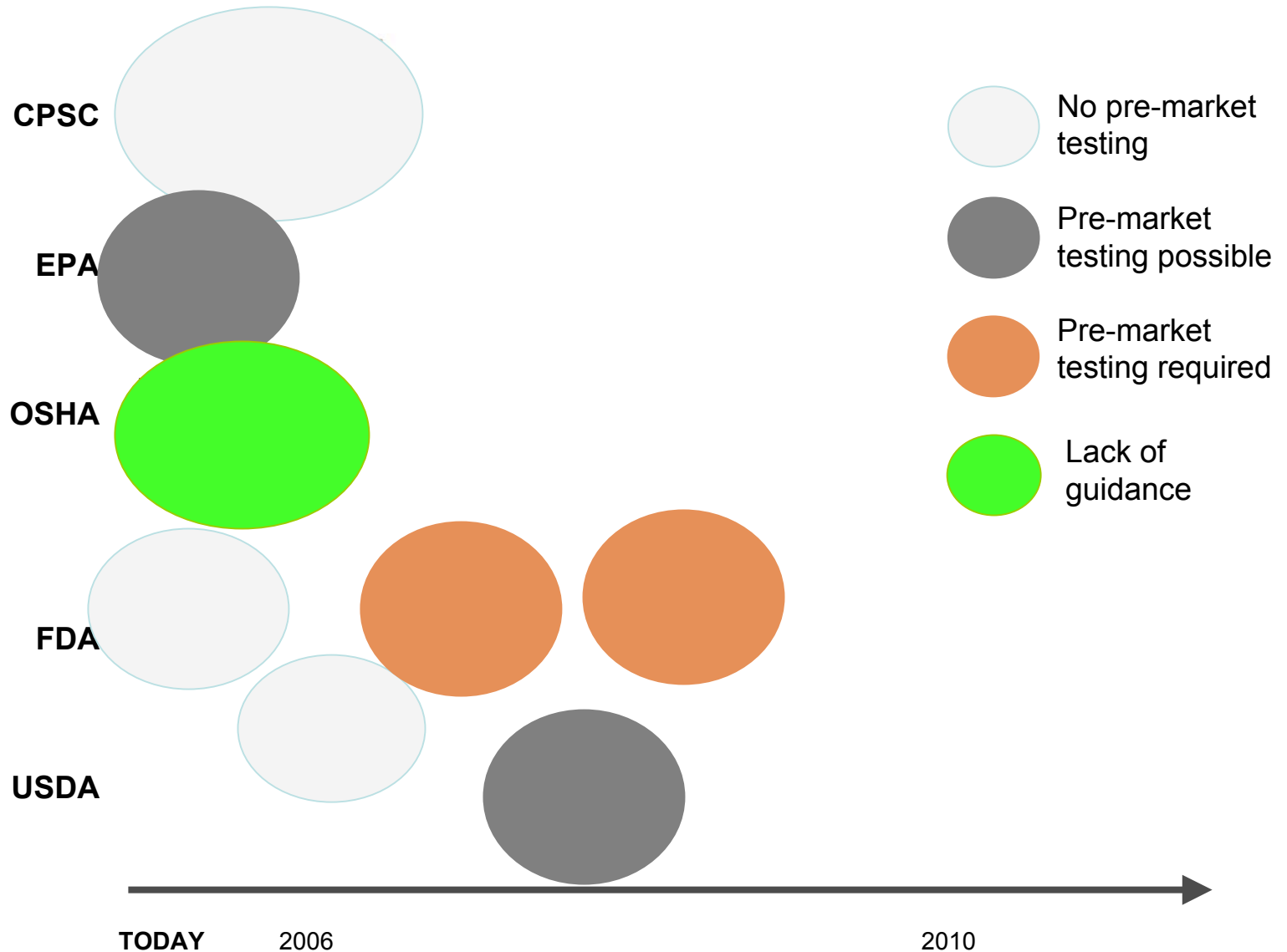
# Just the Beginning



# Incremental or Disruptive Change?



# Structural Risks: Gaps in the Regulatory System





# A Bumpy Road to Market



OSHA Inspector shows up  
Go Directly to Jail

EPA Declares your  
Nanoparticle a New Chemical  
under TSCA  
Pay \$1 million

Product endorsement  
in Sierra Club Magazine

Collect \$500,000

You win IP battle with a  
competitor

Collect 5 patents

# Unanswered Questions

- **Who *does* the public trust to handle the manage the risks posed by nanotechnology?**
- **How is this information communicated and made available to the public?**
- **Are public perceptions being included and used to inform debates about proposed and pending regulation?**
- **What mechanisms work best to regulate nanotechnology-based products?**
- **Have potential long-term risks, issues, and consequences been analyzed? If so, by whom and how?**
- **How have uncertainties and “domains of ignorance” been taken into account during the decision-making, policy-making, and standard-setting process?**
- **Who will be responsible, and who will be held accountable, for any unforeseen harm, ill-use, or dangerous applications of nanotechnology?**

## Contact information:

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