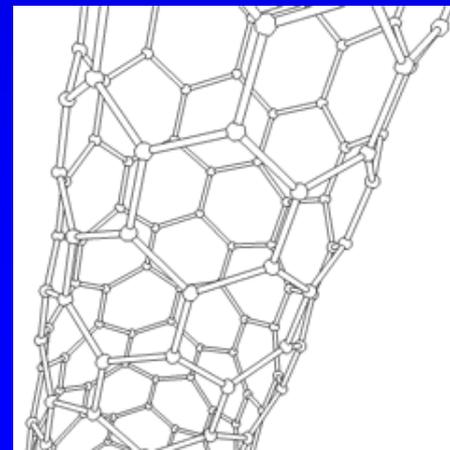


Health and Safety of Nanotechnology

NIEHS Spring Meeting, April 3, 2008

Bruce Lippy, Ph.D., CIH, CSP
The Lippy Group, LLC
410-916-0359



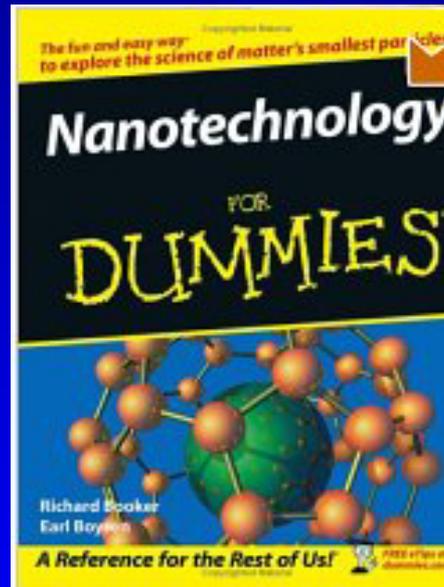
The possibilities are limitless!



SUVs that can
fit in a purse
and get >15
mpg



Wondering about my personal research efforts?



Bought "Nanotechnology for Dummies"

Got 30% off

National Nanotechnology Initiative (NNI) definition

Nanotechnology must have all three:

1. 1-100 nm range in *at least* one dimension
2. Creation and use of structures with novel properties because of size
3. Ability to control or manipulate on the atomic scale.

Thomas and Sayre, Tox. Sciences, July 2005



Getting a handle on size

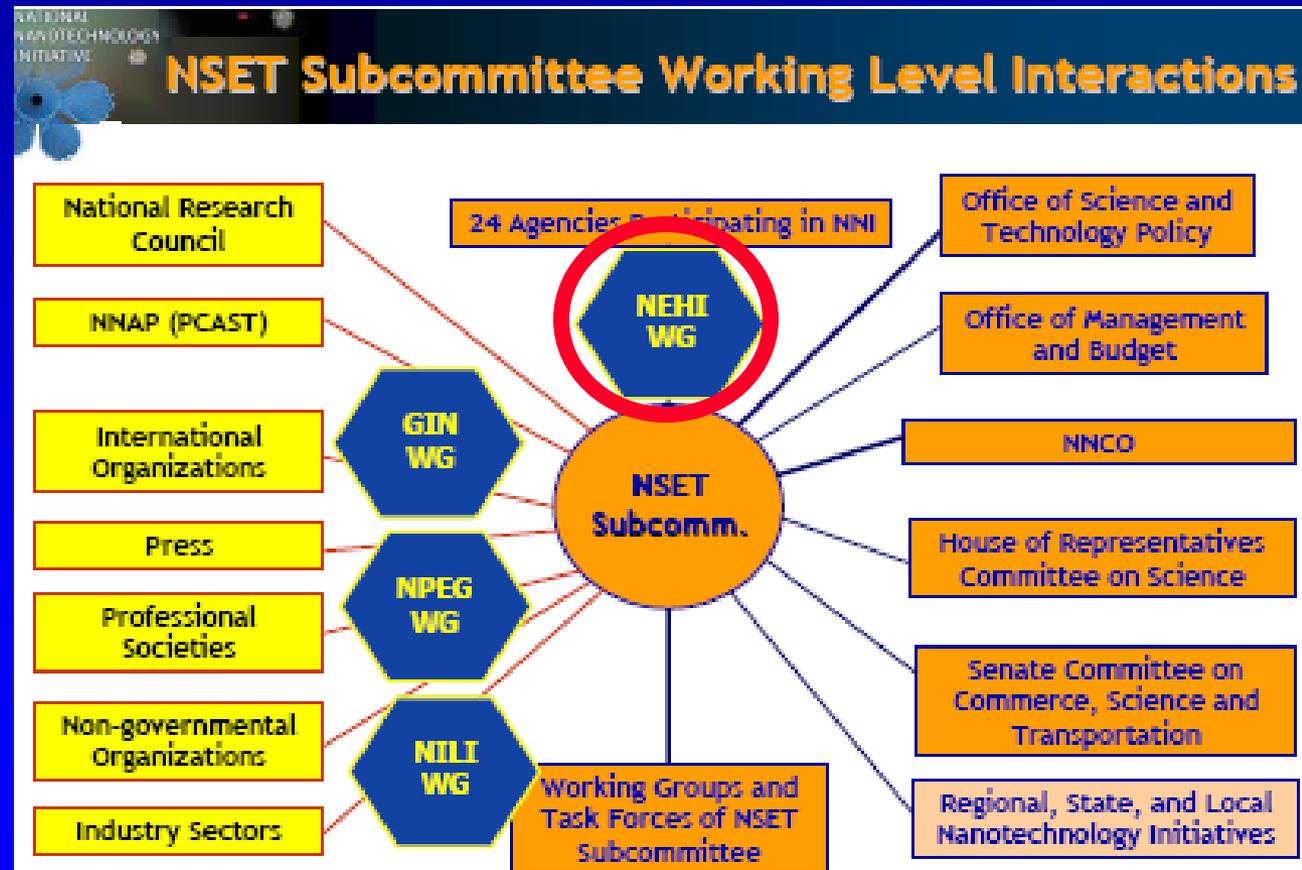


Lux Research projections

- Nanotechnology will affect nearly every type of manufactured good over next 10 years
- Nano will represent 15% of global manufacturing (\$2.6 trillion in 2014).
- 2 million jobs created in nanotech worldwide by 2015 with 5 million more in related areas.

National Nanotechnology Initiative (NNI)

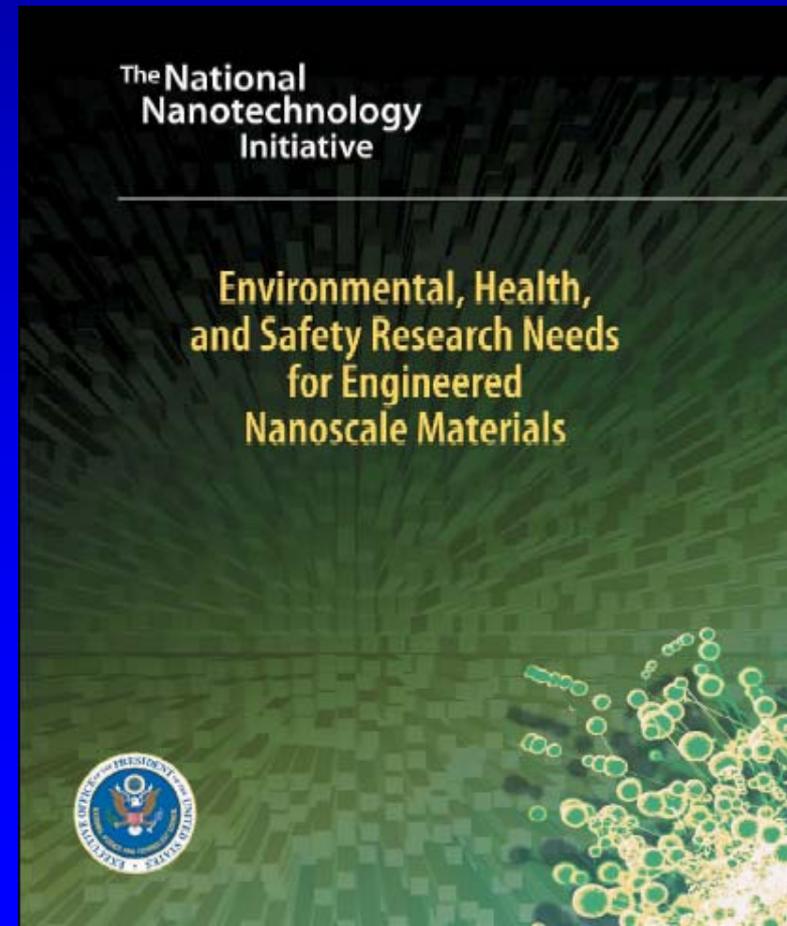
- 2008 budget nearly \$1.5 billion, more than triple the \$464 million spent in 2001
- **\$58.6 M (3%) for ESH (EPA Today, 3/08)**





Nanotechnology Environmental and Health Implications (NEHI) subcommittee of NNI

**Good work! Impressive
example of the federal
government being
proactive and cooperative
on H&S issues**



The promises of nanotechnology

NCI Alliance for Nanotechnology in Cancer

Nano.cancer.gov
Transforming the diagnosis, prevention, treatment and clinical outcomes for cancer patients

 Search

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Nanotech Highlights

[2nd Annual Nanotechnology & the Life Sciences Workshop 2007](#)
March 30-31, 2007

[2007 NIH Director's New Innovator Award Program \(D-2\)](#)
RFA Number: RFA-RM-07-009
Receipt Date: May 22, 2007

[PAR-07-033](#)
Nanoscience and Nanotechnology in Biology and Medicine (R01)



Nanoparticles delivery of "suicide DNA" kills prostate tumors"

Nanotech News

[view all]



[Evaluating Multiple Breakers in Quantum Dots](#) May 22

[Nanoparticles Delivery of "Suicide DNA" Kills Prostate Tumors](#) May 22

[Nanoparticle Self-Assembly Triggered by Tumor-Associated Enzyme](#) May 22

[Analyzing Nanoparticle Levels in Blood](#) May 22

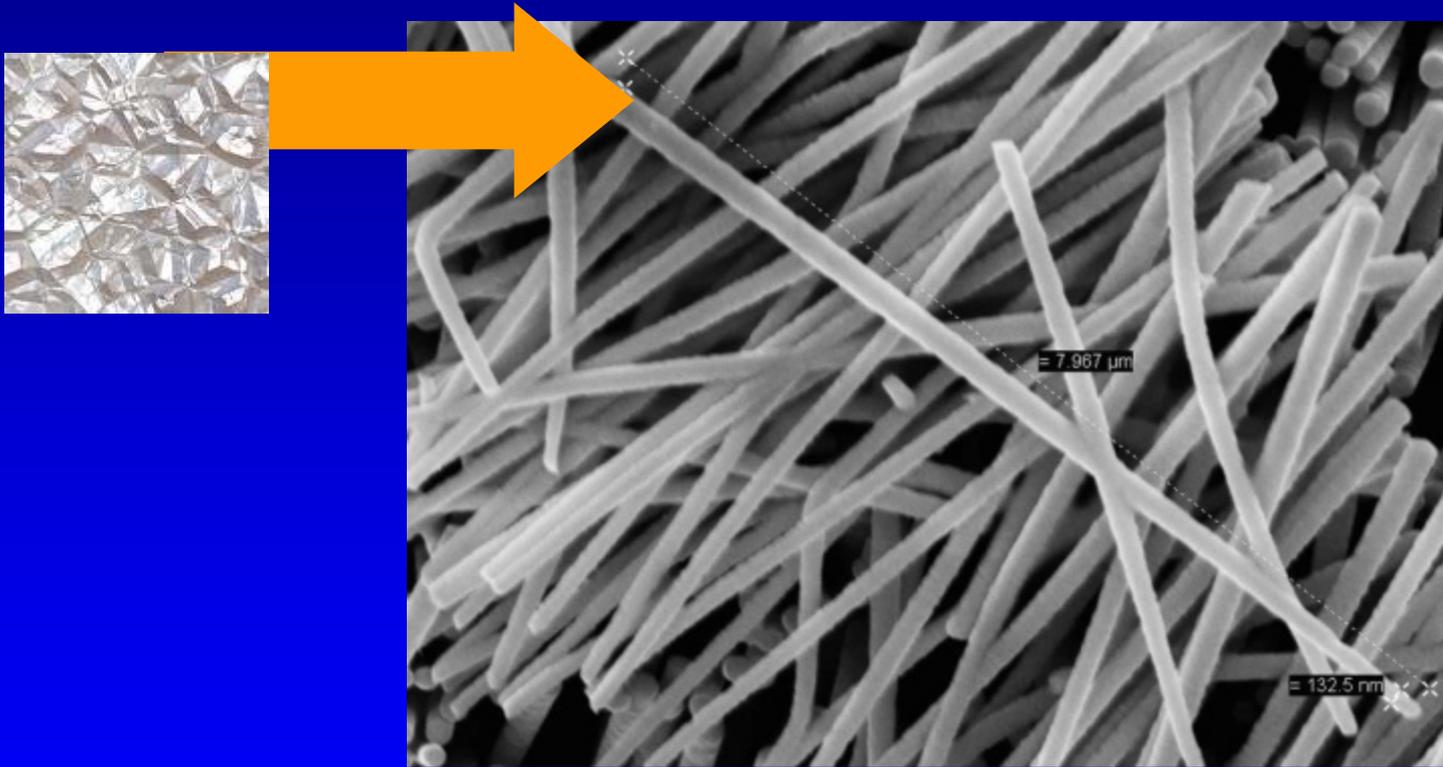
[New Method Weighs Single Living Cells, Nanoparticles, Even Molecules](#) May 22



Quick Links

- [Nanotechnology Characterization Laboratory](#)
- [Nanotechnology Teaming Site](#)
- [Funding Opportunities](#)
- [Scientific Bibliography](#)

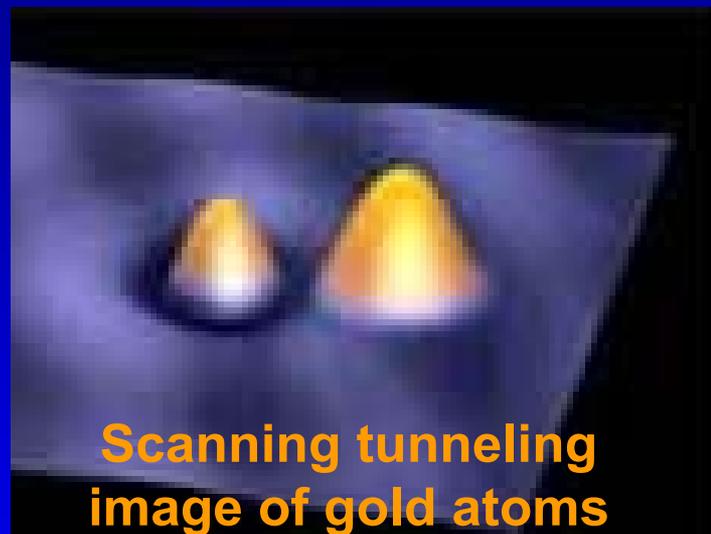
Nano radio from UC Irvine



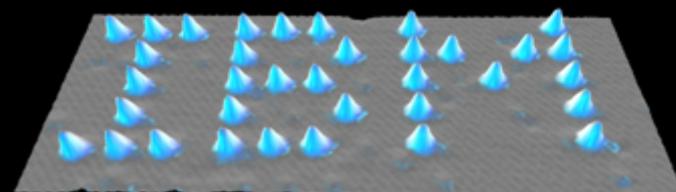
Nano coffee, too?

The promise of chemical variability: amazing (and frightening to an IH)

- OSHA has 40 year-old standards for 600 chemicals
- 4/2/2008 11:00pm
34,540,779 chemicals in CAS
- 112 known elements
- 10^{200} to 10^{900} distinct nanoscale particles



Scanning tunneling image of gold atoms

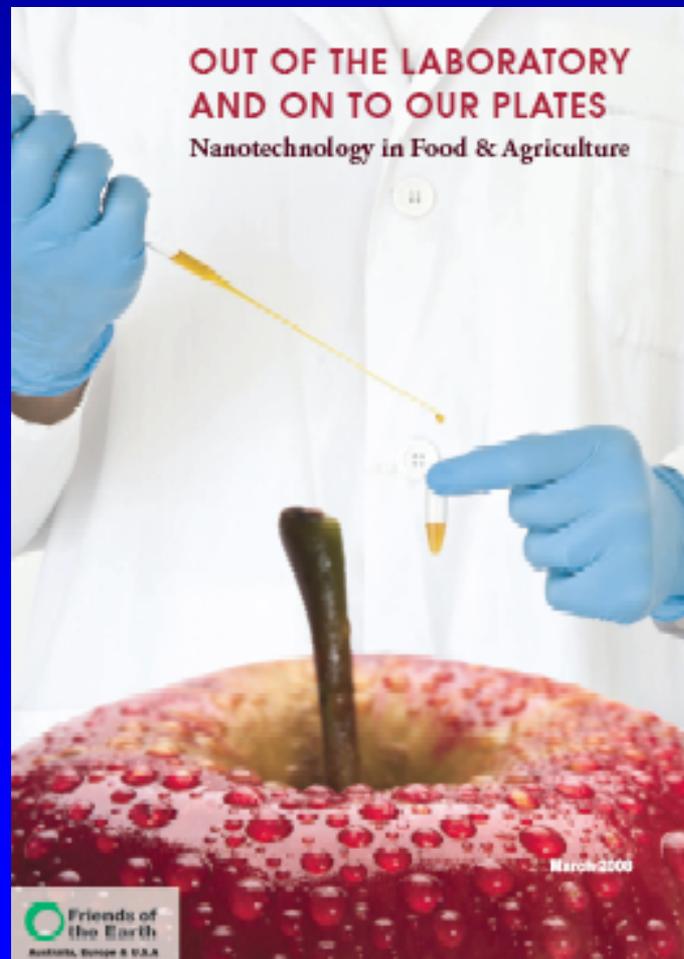


Writing with atoms
(Eigler, 1990)

Criticisms of Nanotechnologies are growing

(With little regulatory relief in
sight)

Very recent Friends of the Earth Report calling for a moratorium on nanofoods



"Nanotechnology requires immediate changes in EPA"

J. Clarence Davies, Woodrow Wilson Center, May 23, 2007

- EPA should revise Toxic Substances Control Act
- Congress should establish committees in both houses to consider nanotechnology oversight
- Congress should remove constraints on EPA to require companies to share data

Precautionary Principle

A moral and political principle which states that if an action or policy might cause severe or irreversible harm to the public, in the absence of a scientific consensus that harm would not ensue, the burden of proof falls on those who would advocate taking the action

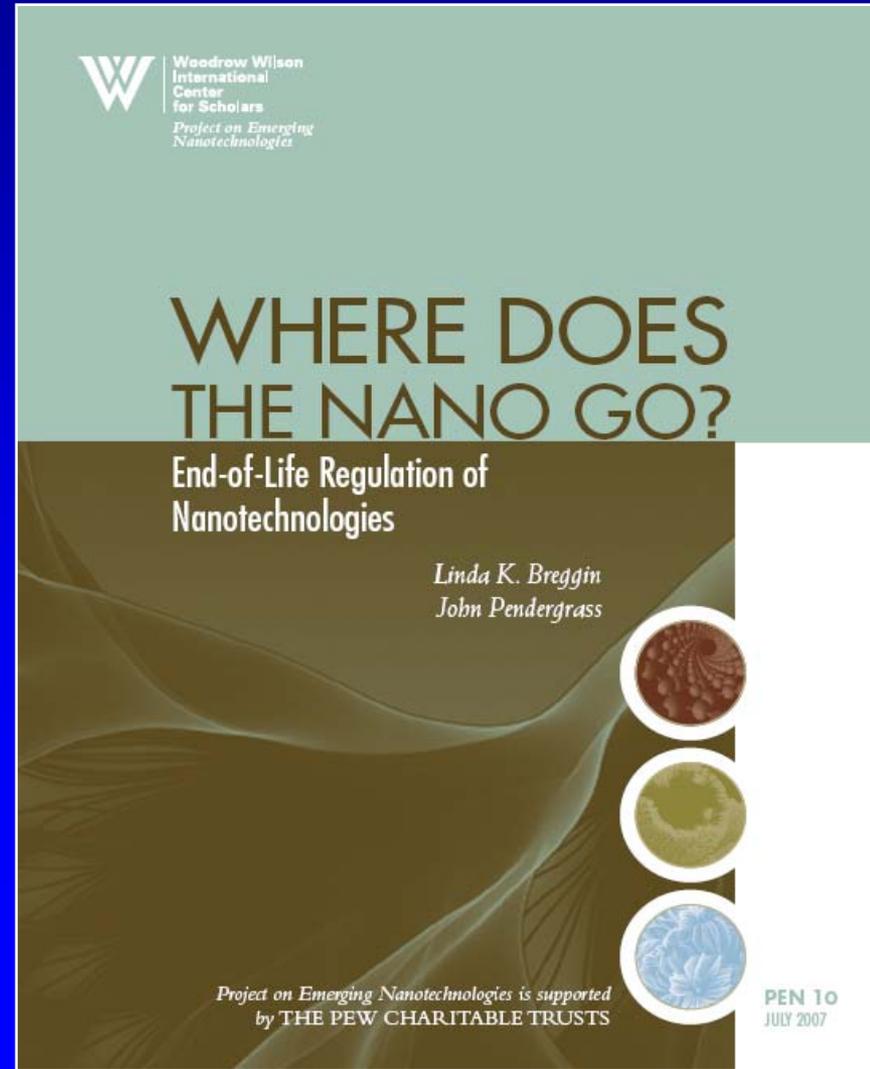
“Observe before you project yourself on a parabolic trajectory.” David Appel, Scientific American 1/2001

End of Life Regulatory Issues "Where Does the Nano Go?"

Wilson Center

Breggin and
Pendergrass, July
2007

Available at:
<http://www.nanotechproject.org/>



Quiz demonstrating federal regulatory conundrum

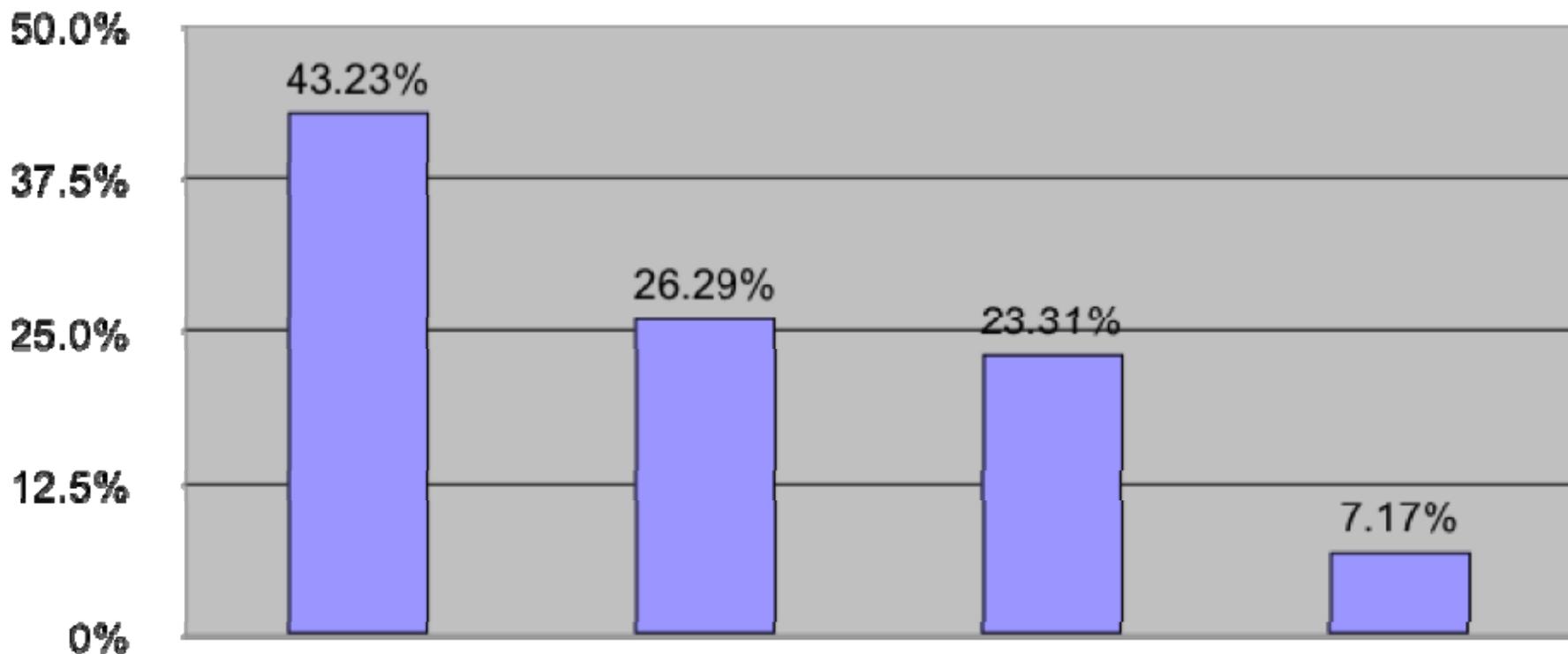
A nano washing machine is a:

device

pesticide under FIFRA



Nano Products in the Waste Stream (courtesy David Rejeski)



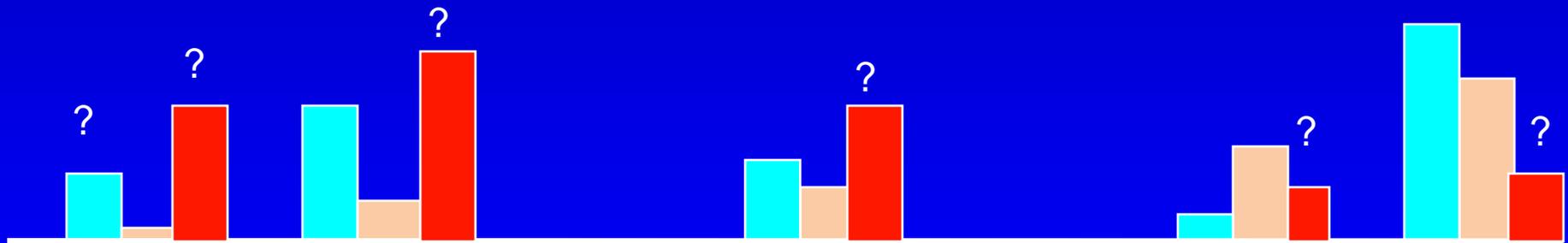
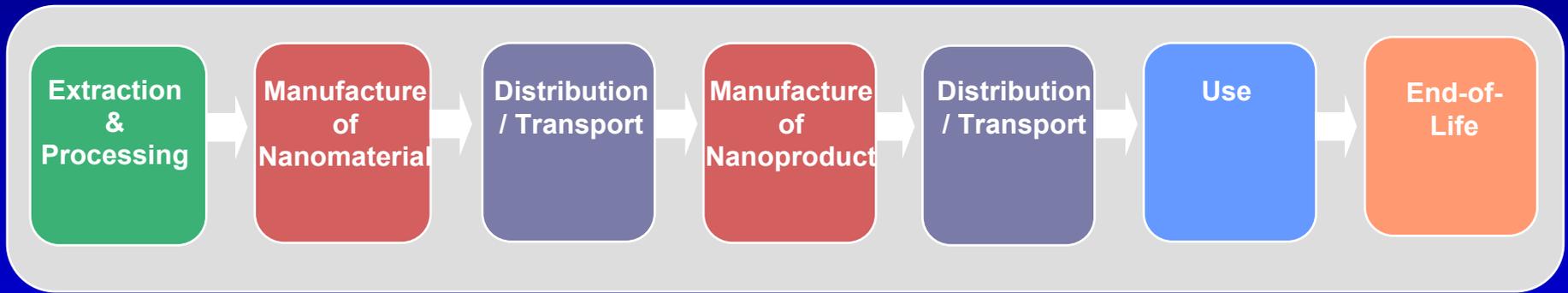
Disposable
(Use for Less
Than 1 Year)

Short-Term
(Use for
1-5 Years)

Long-Term
(Use for
Over 5 Years)

Consumable
(Does Not
Enter Waste
Stream Directly)

Waste and the Nanotech Life Cycle (courtesy David Rejeski, Wilson Center)



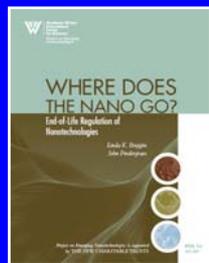
- Amount of nano waste
- Complexity of nano waste
- Risk to workers (Lippy)



"The potential benefits of nanotechnologies should be assessed in terms of life cycle assessment (LCA)." UK Royal Society (2004), *Nanoscience and nanotechnologies: opportunities and uncertainties*.

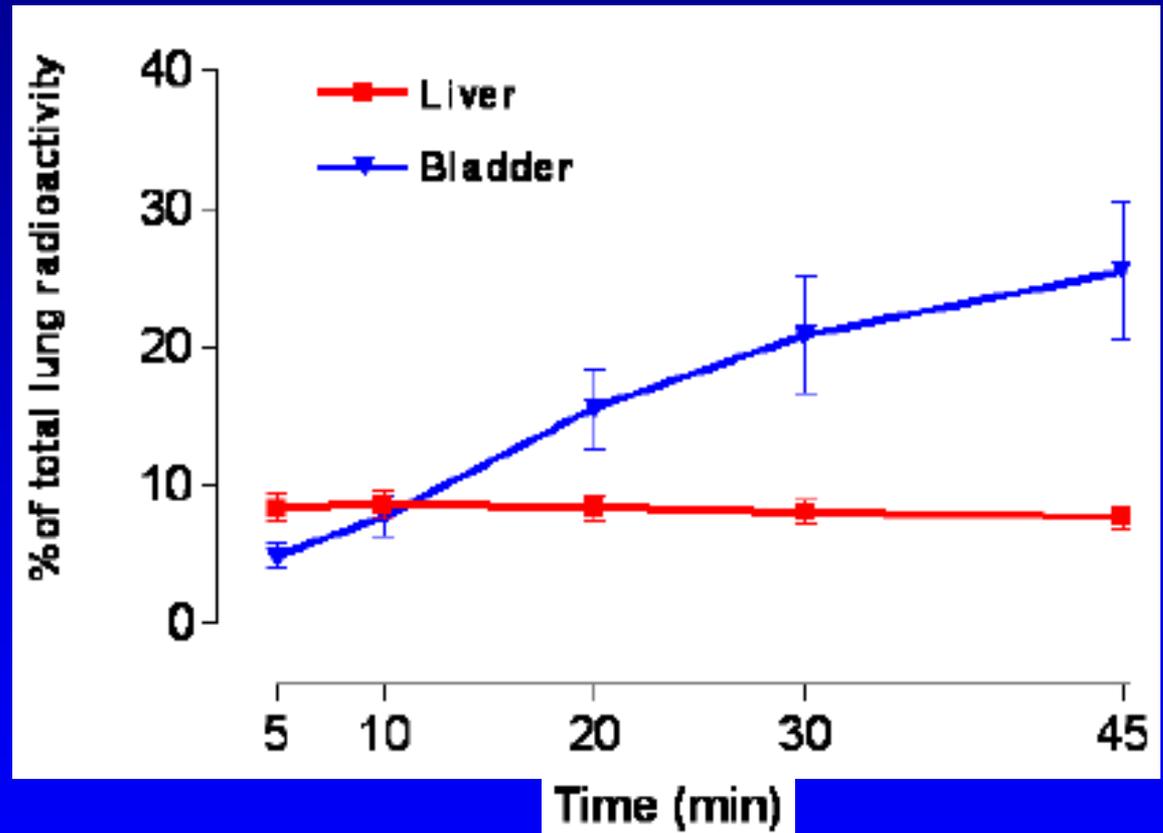
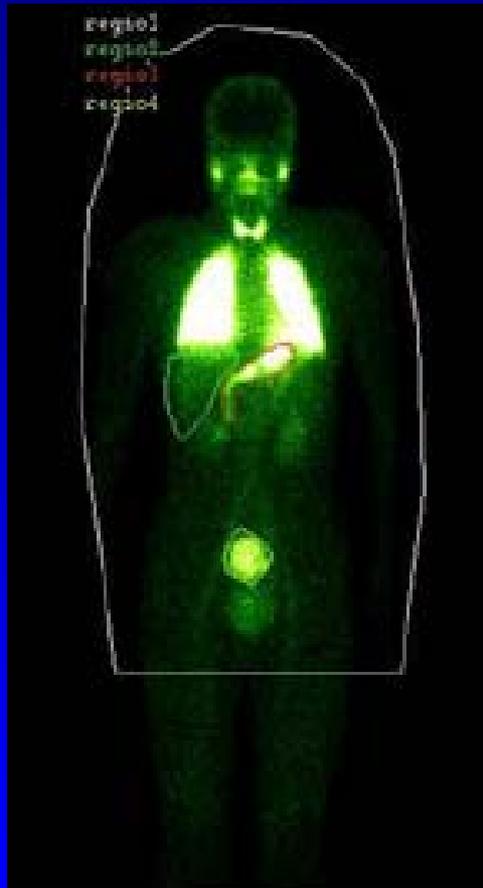
Conclusions from Wilson Center Study (Rejeski)

- Superfund statutory authorities are broad enough *in theory* to cover nanomaterials
- Key threshold issue is whether any nanomaterials constitute hazardous substances
- How EPA assesses and designates nanomaterials under CERCLA and other statutes is critical
- Critical need for EPA to invest in human health and eco-toxicity data collection

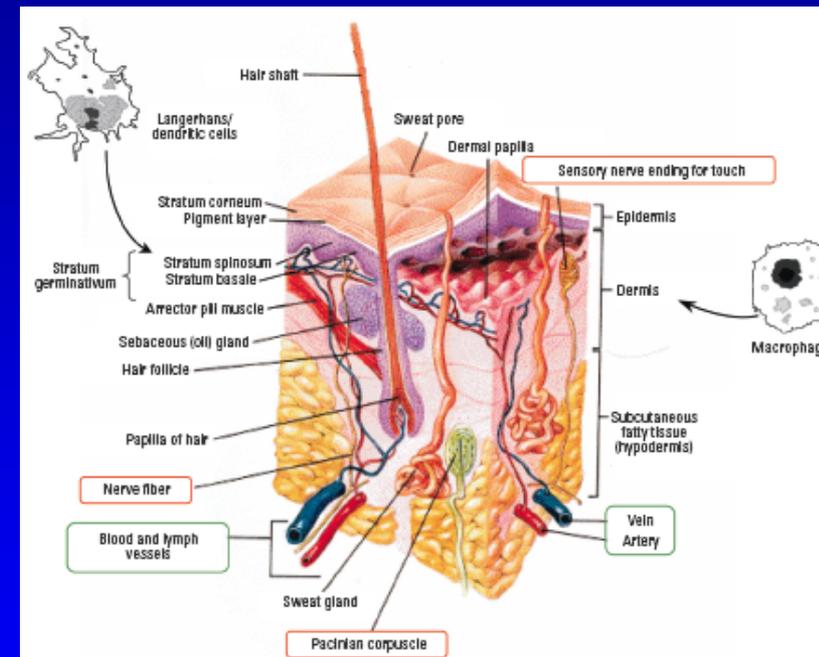
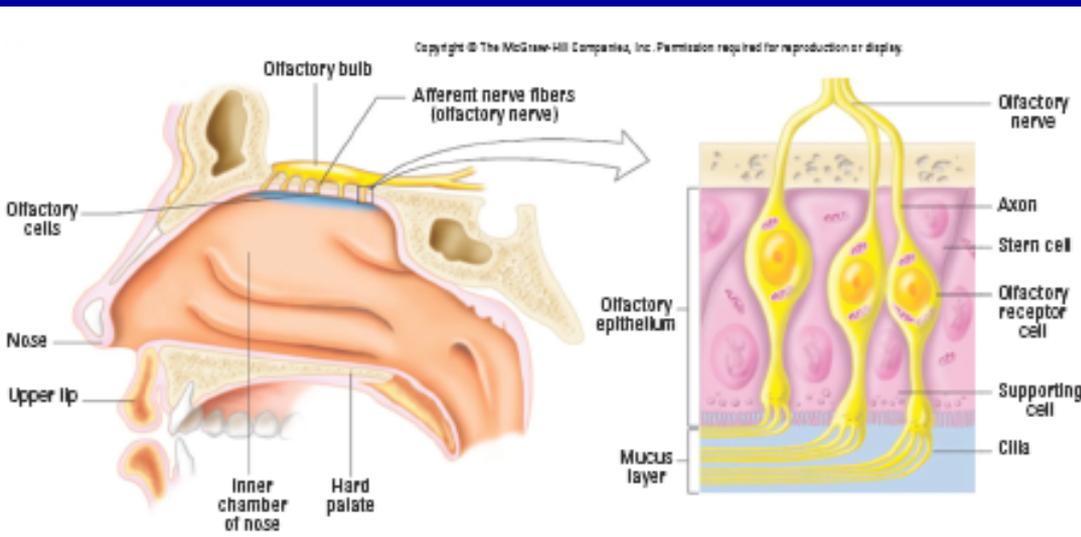


Quick Review of Toxicology and Industrial Hygiene Concerns

Translocation Out of the Exposure Organ



Translocation via olfactory neurons and skin (Oberdorster, EHP, 2005)



Toxicology on Carbon Nanotubes

- **Lam et al. (2004)** *Toxicological Sciences*: “On an equal-weight basis, if carbon nanotubes reach the lungs they can be much more toxic than carbon black and more toxic than quartz.”
- **Oberdörster (2005)** *Environmental Health Perspectives*: “Profound cytotoxicity seen for SWNT...”

Surface area, a major issue

Particle number and particle surface area per constant
10 $\mu\text{g}/\text{m}^3$ concentration

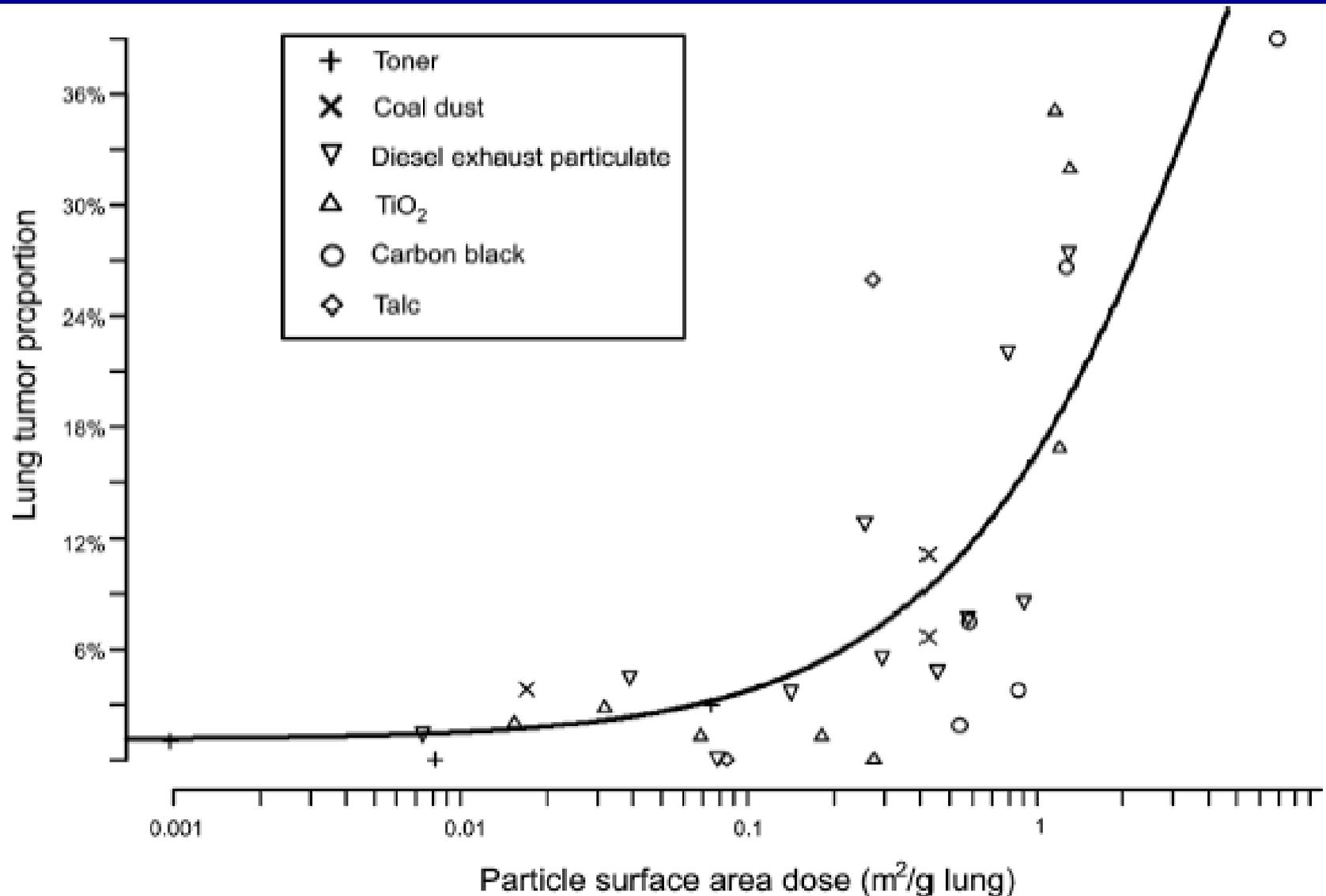
<i>Diameter</i> (nm)	<i>Number</i> <i>density</i> (cm^{-3})	<i>Surface area</i> ($\mu\text{m}^2/\text{cm}^3$)
2500	1.2	24
1000	19	60
500	153	120
100	19,100	600
20	2,400,000	3000

NIOSH researchers just published best summary of health and safety management

Schulte, Geraci, Zumwalde, Hoover & Kuempel
Occupational Risk Management
of Engineered Nanoparticles
JOEH, April 2008



Relationship of surface area to tumor production in rats (Schulte et al. 2008)



Sampling recommendations by Schulte et al. (JOEH, 4/08)

- Adequacy of current, mass-based OEL needs to be evaluated
- Lower limits may need to be established on mass-based or refined using surface area or number.



NIOSH White Paper on Control

- The control of airborne exposures can be accomplished with engineering controls used in reducing exposures to general aerosols
- HEPA filter should remove nanoparticles
- Good work practices can reduce exposures
- No guidelines are available on the selection of clothing for prevention of dermal exposure to nanoparticles

NIOSH is considering control banding (Schulte et al. 2008)

Exposure management control banding concept

	Low Dustiness	Medium Dustiness	High Dustiness
Hazard Group A			
Small	1	1	1
Medium	1	1	2
Large	1	2	2
Hazard Group B			
Small	1	1	1
Medium	1	2	2
Large	1	3	3
Hazard Group C			
Small	1	1	2
Medium	2	3	3
Large	2	4	4
Hazard Group D			
Small	2	2	3
Medium	3	4	4
Large	3	4	4
Hazard Group E			
For all hazard group E substances, choose control approach 4			

Parameters

Amount Used
Dustiness
Hazard Code (R-Phrase)

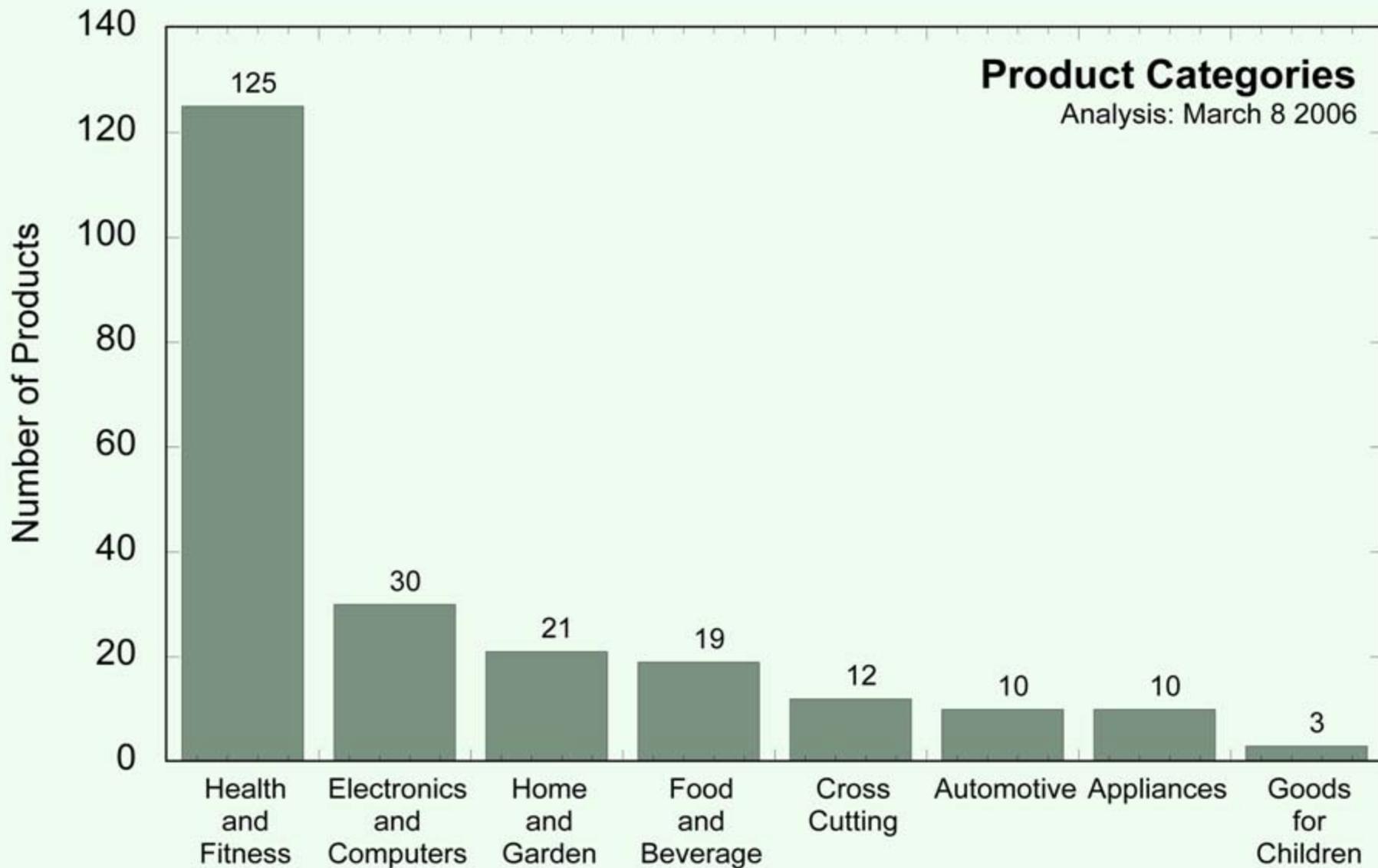
Control Approach

1. General Ventilation
2. Engineering Control
3. Containment
4. Specialist Advice

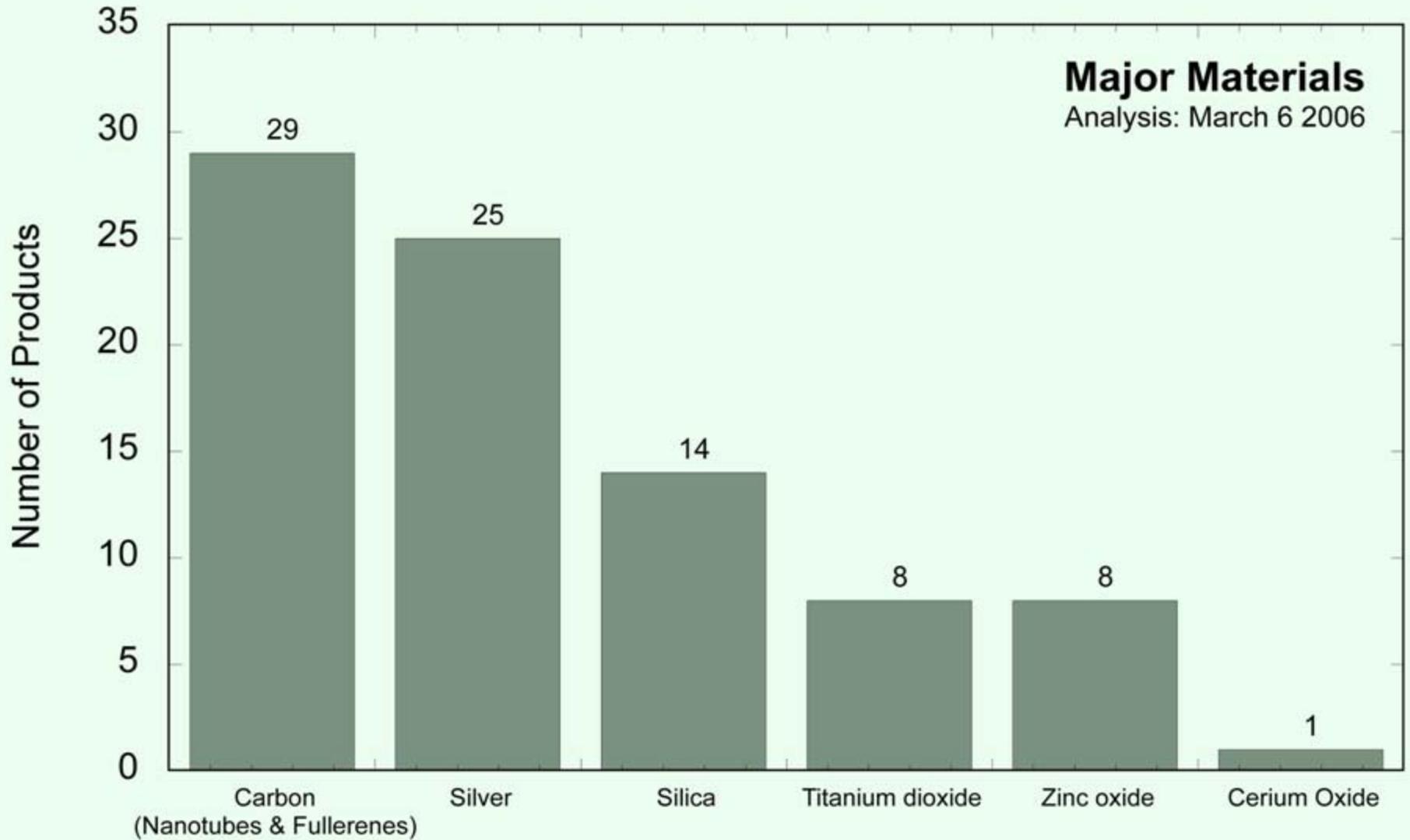
Is it too soon to talk Hazcom?

- **Several at NEHI meetings felt that there was insufficient toxicological data**
- **Over 500 consumer products listed on the Wilson Center for Scholars website**
- **Hazcom expert at OSHA suggested this is an area where they clearly have regulatory authority.**

Product categories (3-06) Courtesy of A. Maynard



Major Materials



Lippy Group Review of NIOSH Nano-MSDS collection

- N = 49 “Improving” MSDSs from NIOSH
- Random review of 25
- 32% did NOT identify the nano component
- 56% did NOT have any cautionary language
- 67% listed a PEL or TLV, but all were tied to *normal* form of the nano (nuisance dust)
- 89% recommended using respiratory protection, but tied it to the normal PEL/TLV

**Those with cautionary language
had the following in nearly half of
cases:**

**“No data exists on the effects of
nanometer sized particles on the
body. Special care should be taken to
avoid inhalation, ingestion, and skin
and eye contact.”**

**Covered zinc oxide, bismuth oxide,
antimony tin oxide, copper, and
magnetic iron oxide**



**Da,
Hell?**

**Language suggested by Dan
Levine, Hazcom Expert
(PSS, 9-15-2006)**

“Established exposure values do not address the small size of particles found in this product and may not provide adequate protection against occupational exposures.”



Concept of Technology Safety Data Sheets

- Conceived in 1994 as a tool for informing users of technologies about hazards
- Patterned on Material Safety Data Sheets
- Developed through 4 DOE and NIEHS National Technical Workshops
- **Cited by Dr. Sally Tinkle of NIEHS as an idea to explore with nanotechnologies**

Questions?



“If it weren’t for the people, the damned people always getting tangled up in the machinery. If it weren’t for them, earth would be an engineer’s paradise.”

Kurt Vonnegut, Player Piano

Bruce@thelippygroup.com