Protecting the health and safety of nanomaterial workers: a progress report

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CDC Workplace Safety and Health

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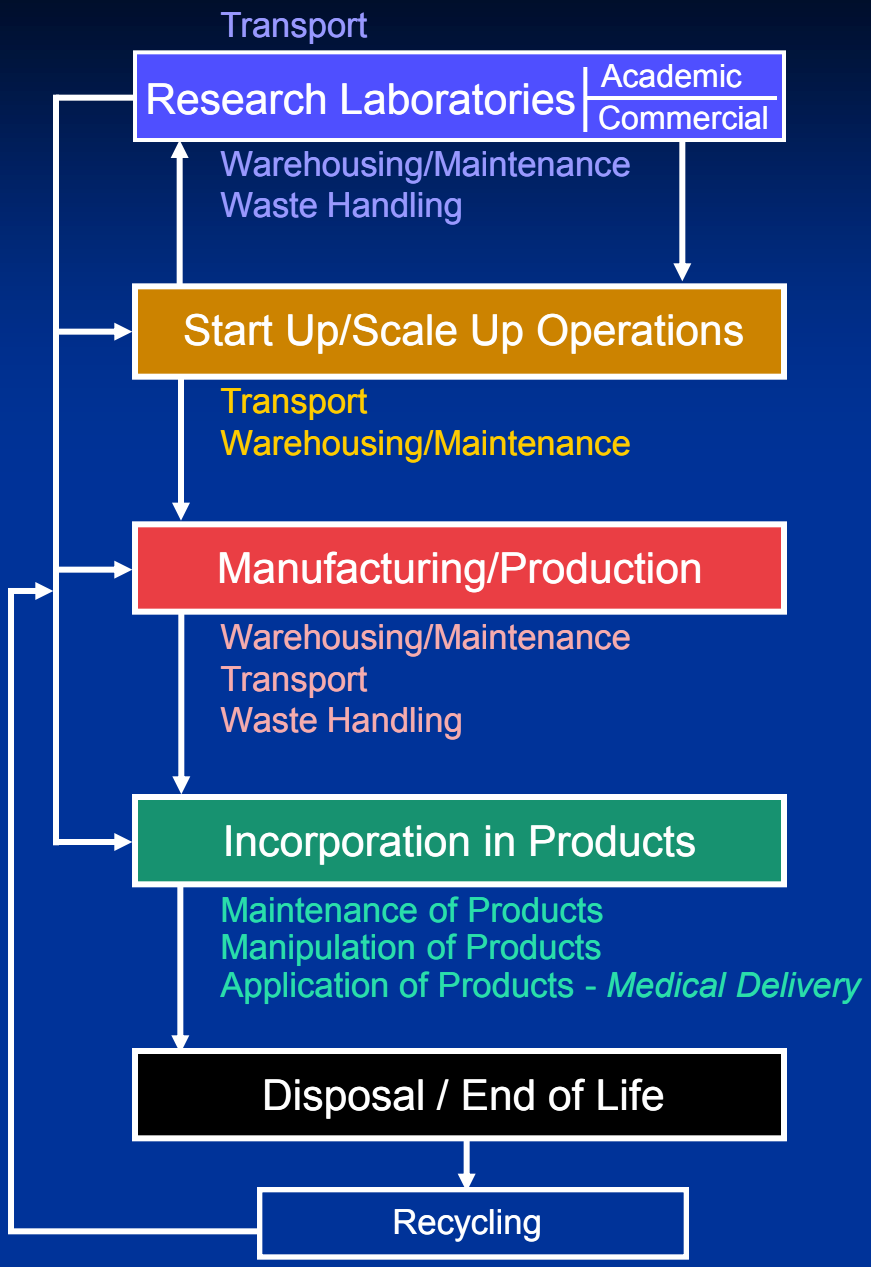
NIOSH

Basis for concern about health and safety effects of nanoparticles

- **Findings from air pollution epidemiology**
  - Particles < 2.5 μm associated with respiratory and cardiovascular effects
- **Studies of industrial fumes (e.g., welding fumes) and combustion (e.g., diesel) products**
  - Wide range of effects: pulmonary and eye irritation, fever, lung cancer
- **Initial animal inhalation studies of engineered nanomaterials**
  - Pulmonary fibrosis, granulomas, and inflammation
  - Lung cancer, mesothelioma-like effects
  - Cardiovascular effects: oxidative stress, plaque

Why the workplace?

- First point of potential exposure
- Exposure concentration greatest
- Early in the history of a material
- “Workplace” = R&D, Scale Up/Pilot, Manufacture, Use, Disposal


Transport
Research Laboratories
Academic
Commercial
Warehousing/Maintenance
Waste Handling
Start Up/Scale Up Operations
Transport
Warehousing/Maintenance
Manufacturing/Production
Warehousing/Maintenance
Transport
Waste Handling
Incorporation in Products
Maintenance of Products
Manipulation of Products
Application of Products - Medical Delivery
Disposal / End of Life
Recycling

etc.

Sector: **Food**

Sector: **Electronics**

Sector: **Medicine**

Sector: **Energy**

Sector: **Materials**

Workplaces	*Nanomaterial Type*			
	Carbon Nanotubes	Metal Oxides	Dendrimers	Fullerenes Metal Nanomaterials Nanowires Nanostructured Metals Nanoporous Materials Nanoscale Encapsulation
Laboratory Research				
Start up/Pilot				
Manufacturing				
Production				
Disposal				

Major knowledge gaps related to nanotechnology health and safety

Hazard Identification
Is there reason to believe this could be harmful?

Exposure Assessment
Will there be exposure in real-world conditions?

Risk Characterization
Is substance hazardous and will there be exposure?

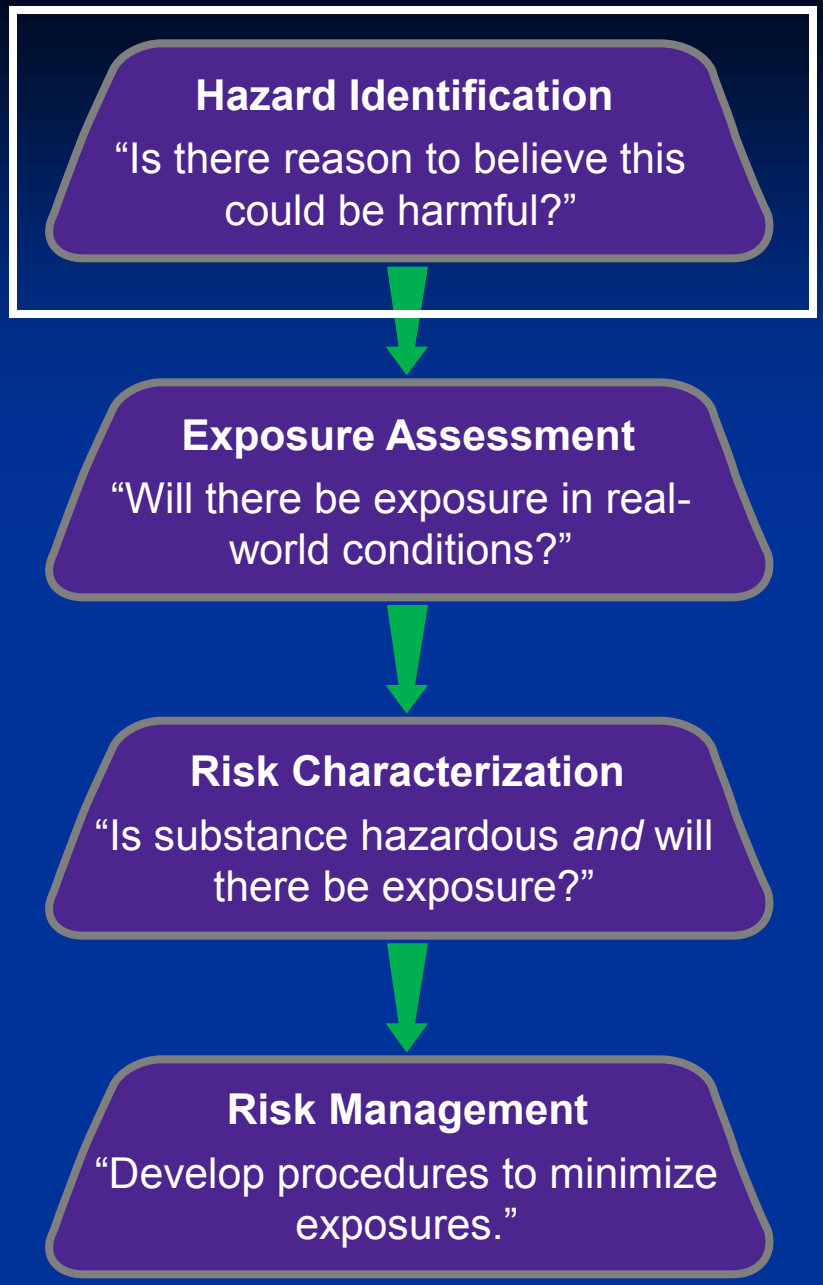
Risk Management
Develop procedures to minimize exposures

Approaches to Safe Nanotechnology (DHHS (NIOSH) Publication 2009-125)

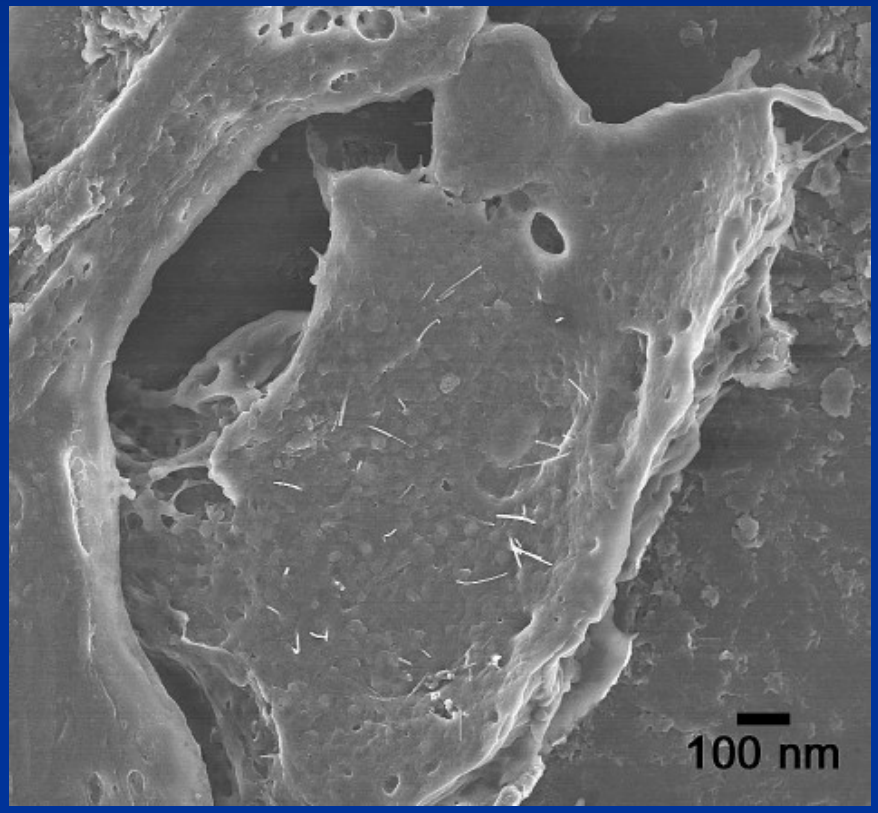
Key elements in worker protection

Hazard

Nanotoxicology
What do we know?
Are there "trends?"



Nanotoxicology: key findings

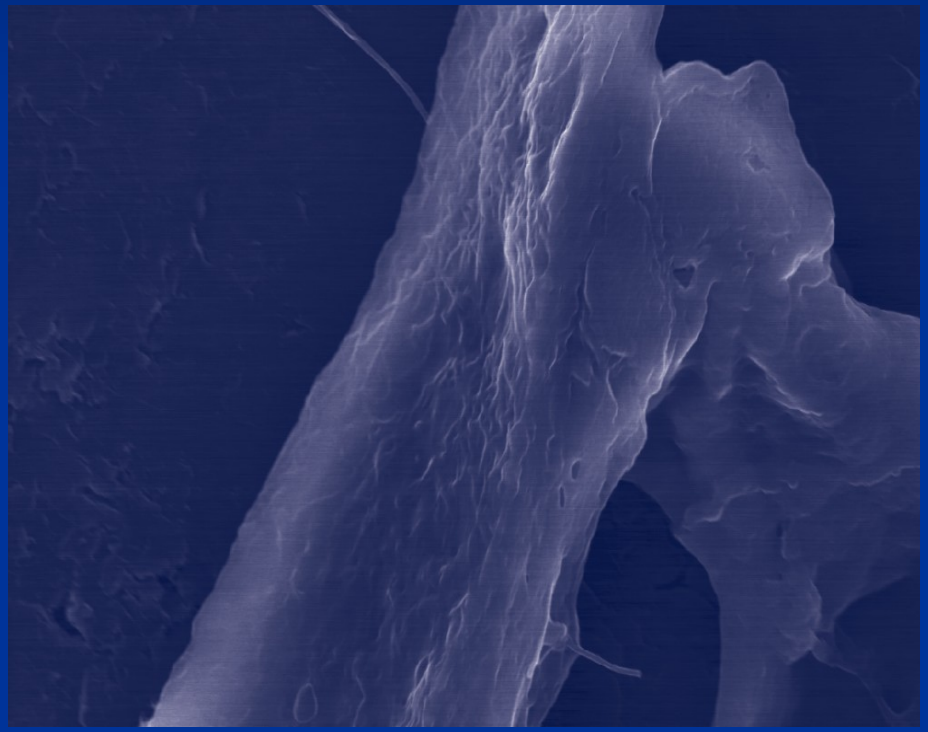


Courtesy of
R. Mercer, NIOSH

Pulmonary exposure to:

- Carbon nanotubes causes rapid and persistent fibrosis in mice
- Certain nanoparticles (SWCNT or TiO_2) can cause cardiovascular dysfunction
- MWCNT or TiO_2 nanowires can induce inflammatory mediators in certain regions of the brain

Nanotoxicology: key findings



Courtesy of
R. Mercer, NIOSH

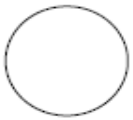
Carbon nanotubes

- Multi-walled nanotubes can reach the intrapleural space (site of mesotheliomia)
- Single-walled nanotubes can interfere with cell division

What could a "nanoparticle" be?

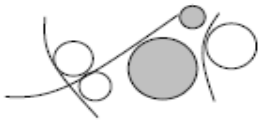
Particle Categories

Classes of engineered nanoparticles



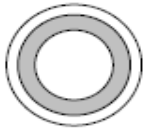
A. Spherical homogeneous

D. Agglomerate homogeneous

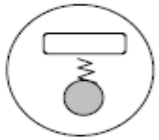


G. Heterogeneous agglomerate

B. Fibrous homogeneous

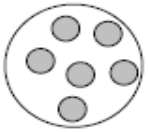


E. Heterogeneous concentric

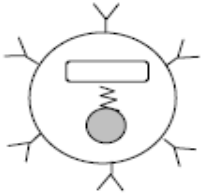


H. Active particle

C. Non-spherical homogeneous



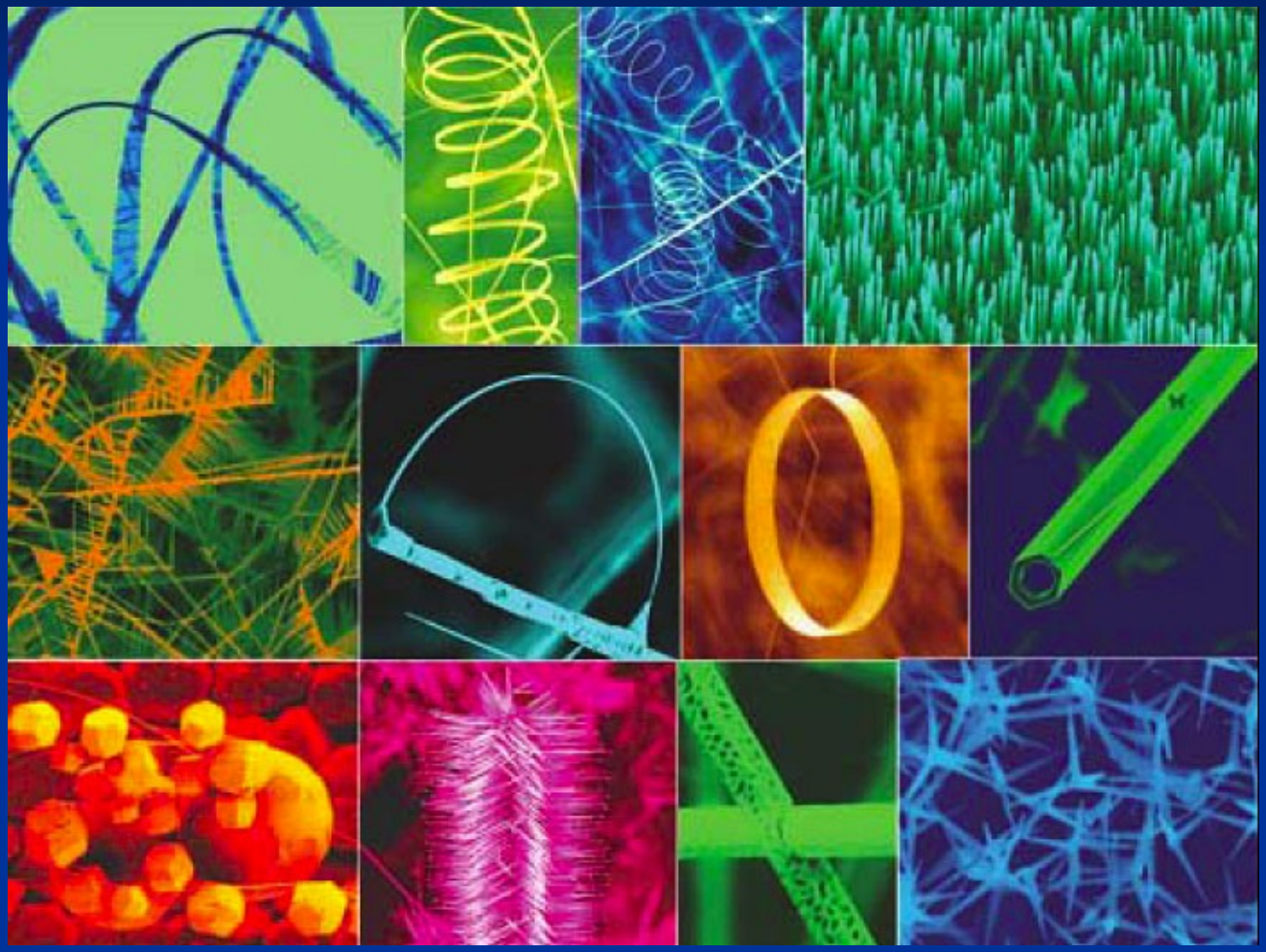
F. Heterogeneous distributed



I. Multifunctional particle

Same composition—different shape

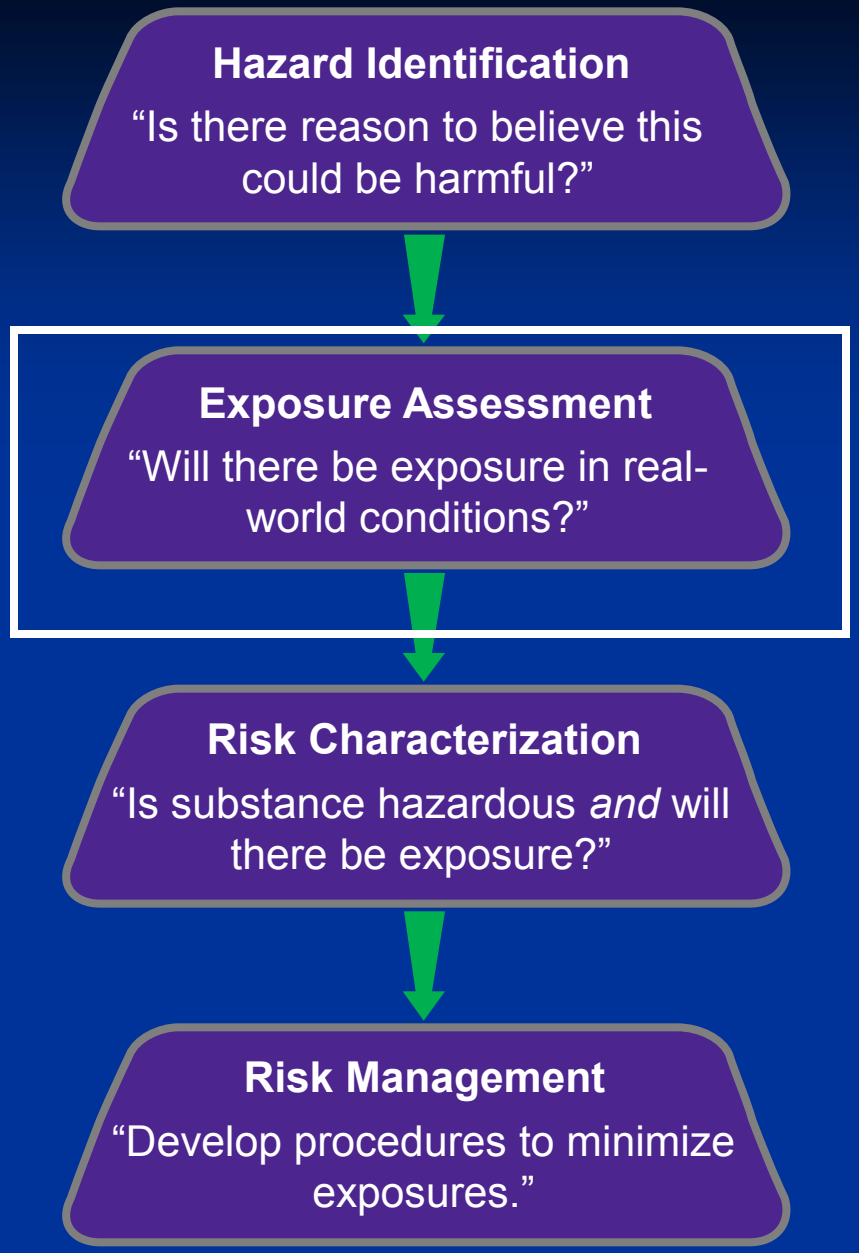
Zinc oxide nanoparticles



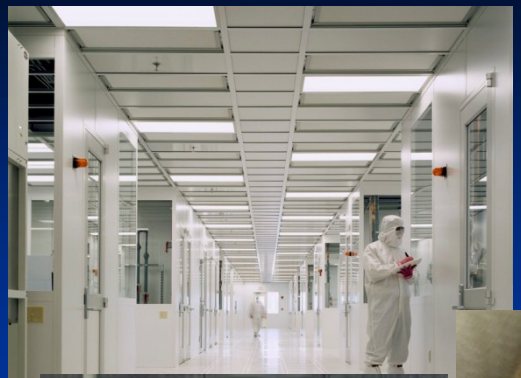
Key elements in worker protection

Exposure →

Can it be measured?
Where is it occurring?
Metric?

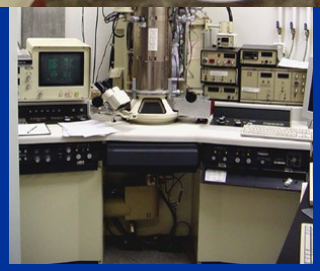


Diverse exposure scenarios evaluated





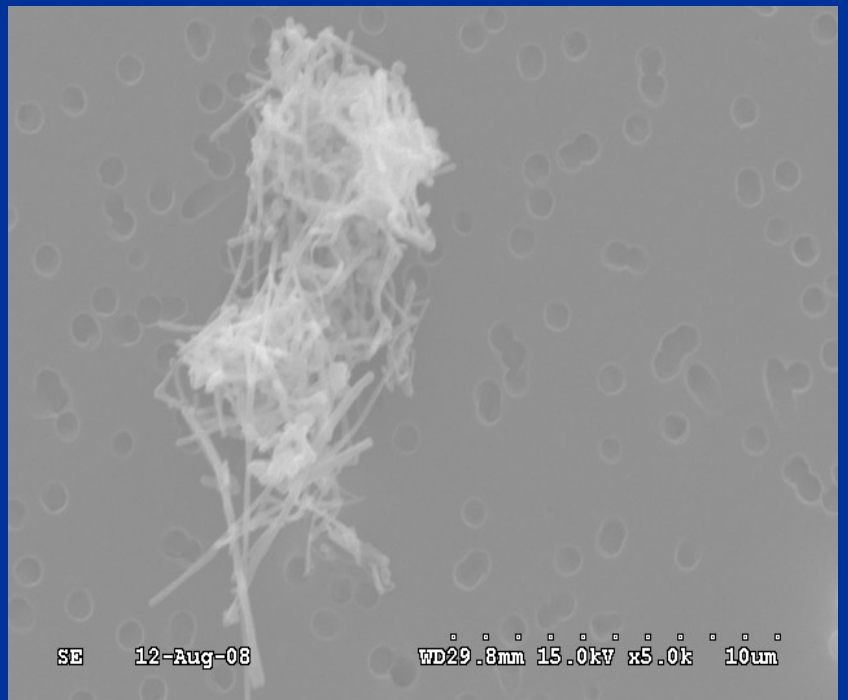



Evidence of exposure

Weighing MWCNT's

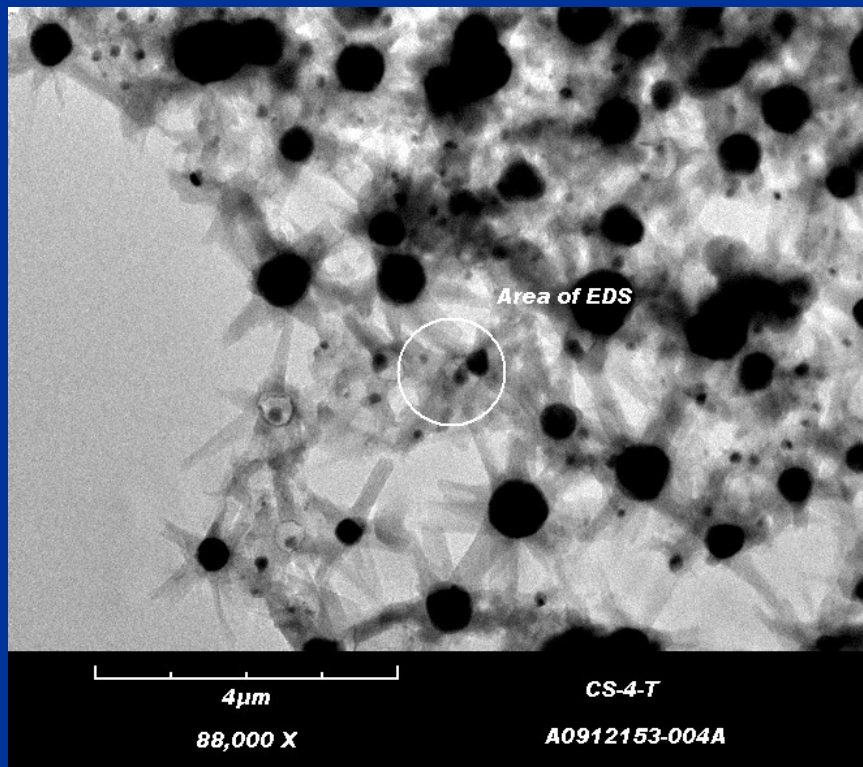
PBZ sample collected on a polycarbonate filter and analyzed by SEM



Evidence of exposure

Harvesting SWCNT's, scraping product from wall of Carbon Arc Reactor

Task-based "At source" air sample



Examples of NIOSH field investigations

Type of Facility	Type of Particle, Morphology	Size of Particle	Range of "Potential" Exposure Concentrations
University Research lab	Carbon Nanofibers	Approx. 100 nm diameter, 1–10 microns long	60-90 µg/m^3 Total Carbon
Metal Oxide Manufacturer	TiO_2, Lithium Titanate, powder	100–200 nm	<100 nm: 1.4 µg/m^3 (TiO_2) Total dust: 4-149 µg/m^3 (TiO_2) <100 nm: ND (Li) Total dust: ND -3 µg/m^3 (Li)
Manufacturer	Carbon Nanofibers	Approx. 100 nm diameter, 1–10 microns long	15 - 1800 µg/m^3 Total carbon
Research and Development lab	Quantum Dots, spheres	2–8 nm	ND
Metal Oxide Manufacturer	Manganese, Silver, Nickel, Cobalt, Iron oxides, spheres	8–50 nm	67 - 3619 µg/m^3 Mg, Ag, Ni, Co, Fe
Research and Development lab (Pilot-Scale)	Aluminum, spheres	50–100 nm	40 - 276 µg/m^3 Al
Research and Development lab	Elemental metals: Silver, copper, TiO_2	15–40 nm	ND
Filter Media Manufacturer	Nylon 6 Nanofiber	70–300 nm diameter, continuous length	ND

Recent published summary of field exposure assessments

Journal of Occupational and Environmental Hygiene March 2010

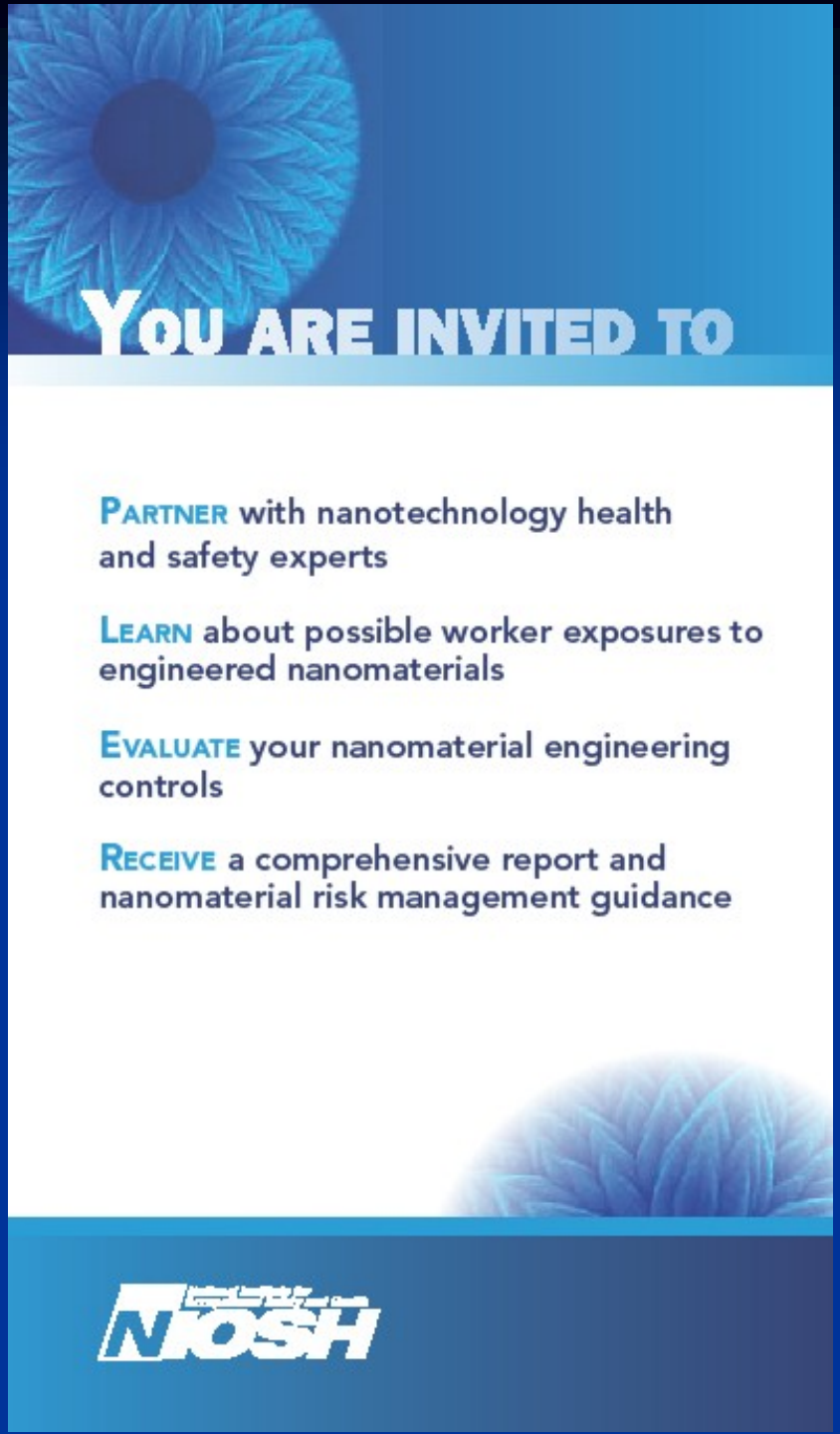
Nanoparticle Emission Assessment Technique (NEAT) for the Identification and Measurement of Potential Inhalation Exposure to Engineered Nanomaterials — Part A

and

Part B: Results from 12 Field Studies

M. Methner, L. Hodson, C. Geraci

National Institute for Occupational Safety and Health (NIOSH), Nanotechnology Research Center, Cincinnati, Ohio



Collaboration

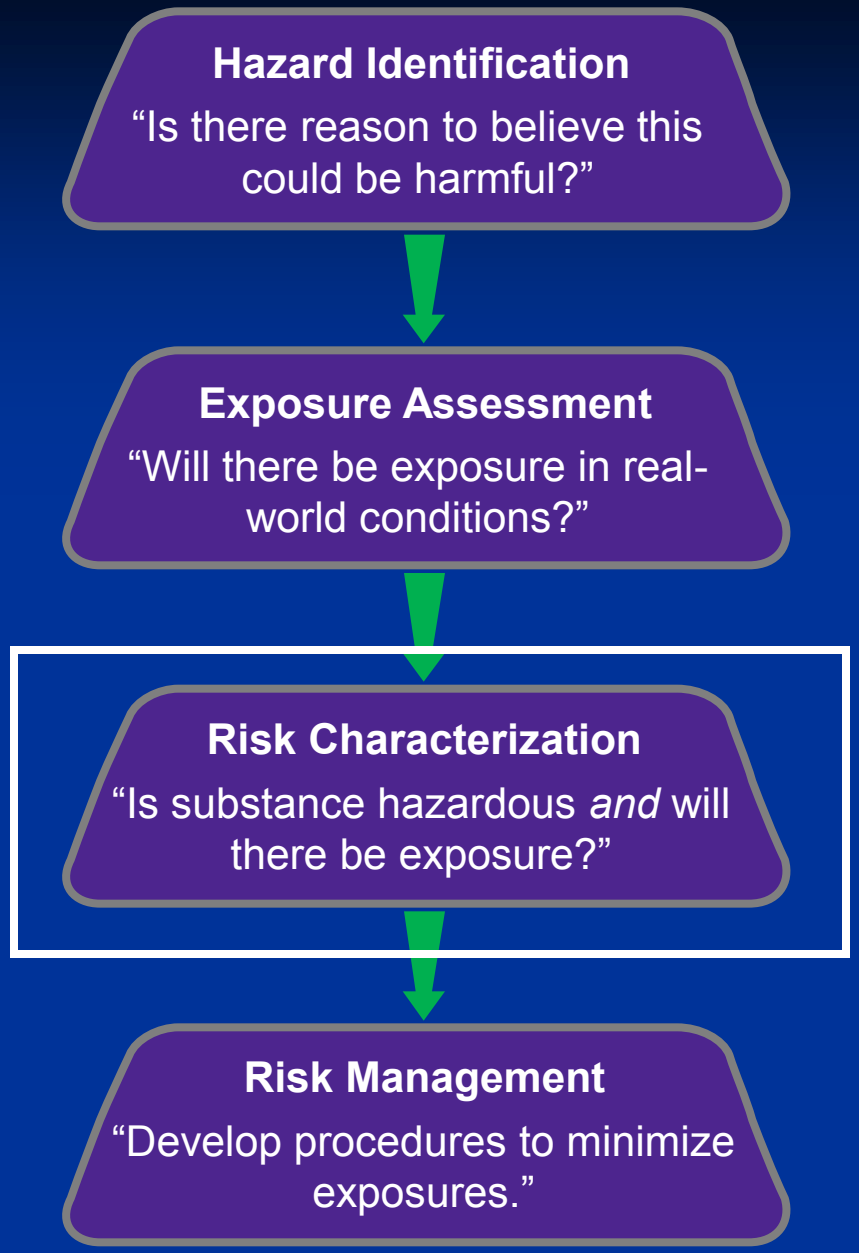
- Share knowledge
- Use expertise
- Build experience
- Partner

The NIOSH Nanotechnology field team is available for field assessments. Contact us.

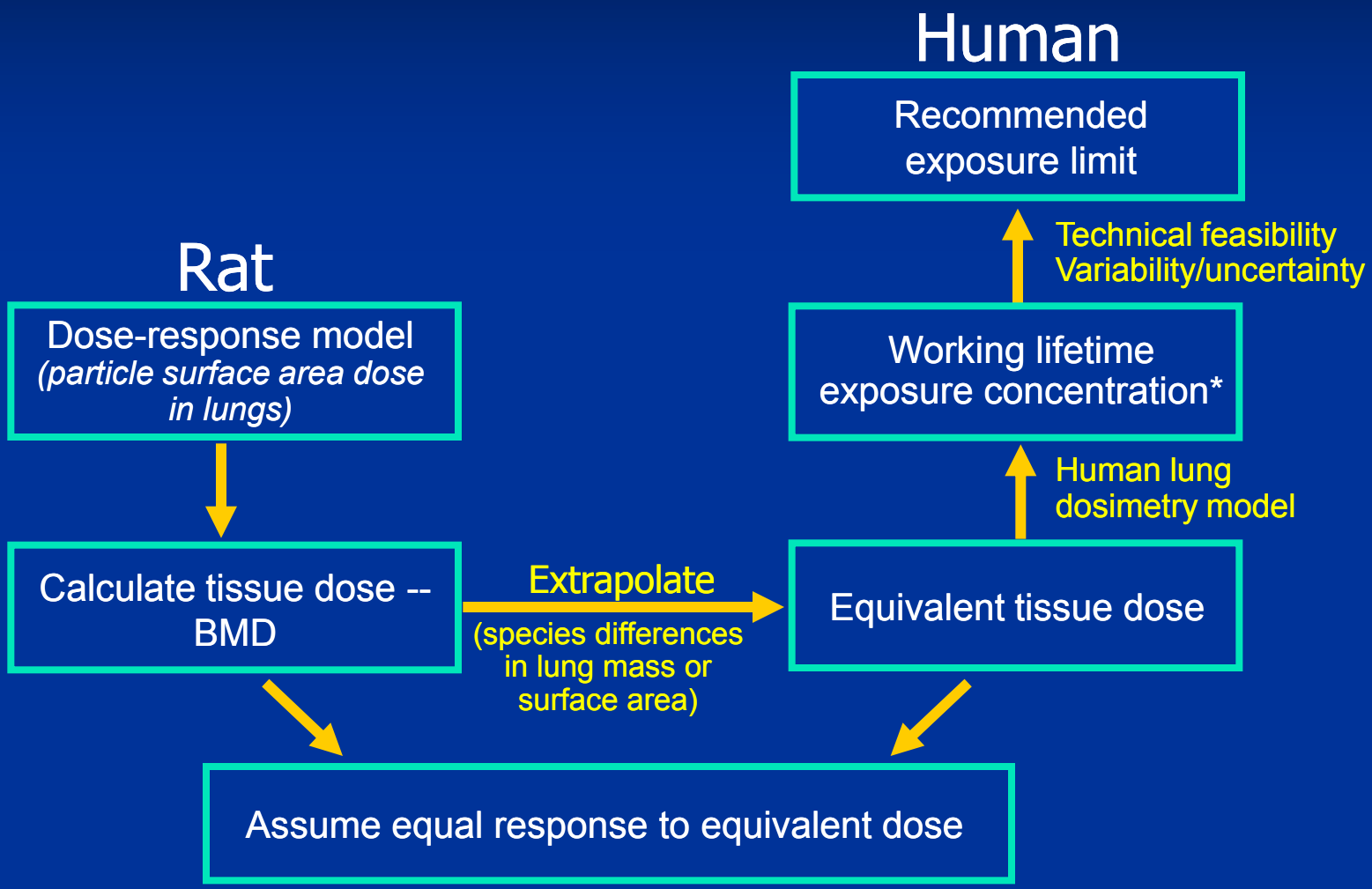
Key elements in worker protection

Risk

Hazard x Exposure



Quantitative Risk Assessment in developing Recommended Exposure Limits for nanoparticles



*Compare rat-based risk estimates with confidence intervals from human studies

Risk Assessment: ultrafine (nano) TiO_2

- NIOSH draft recommended exposure limits (RELs)
  - 1.5 mg/m3 fine TiO_2
  - 0.1 mg/m3 ultrafine TiO_2
  - Reflects greater inflammation & tumor risk of ultrafine on mass basis
- This recommendation will be released from NIOSH in the Autumn of 2010

- Key message: The OEL for a material in its "large" form may not be appropriate for the nano form.

Hazard and risk picture: carbon nanotubes

- SWCNTs more fibrogenic then an equal mass of ultrafine carbon black or fine quartz
- Doses approximated exposure at the PEL for graphite (5 mg/m^3) for 20 days
- MWCNT can penetrate the pleura
  - More data needed
- Similar message: The OEL for the "large" form of a material may not be a good guide for the nano form.

Key NIOSH project: Current Intelligence Bulletin on Carbon Nanotubes

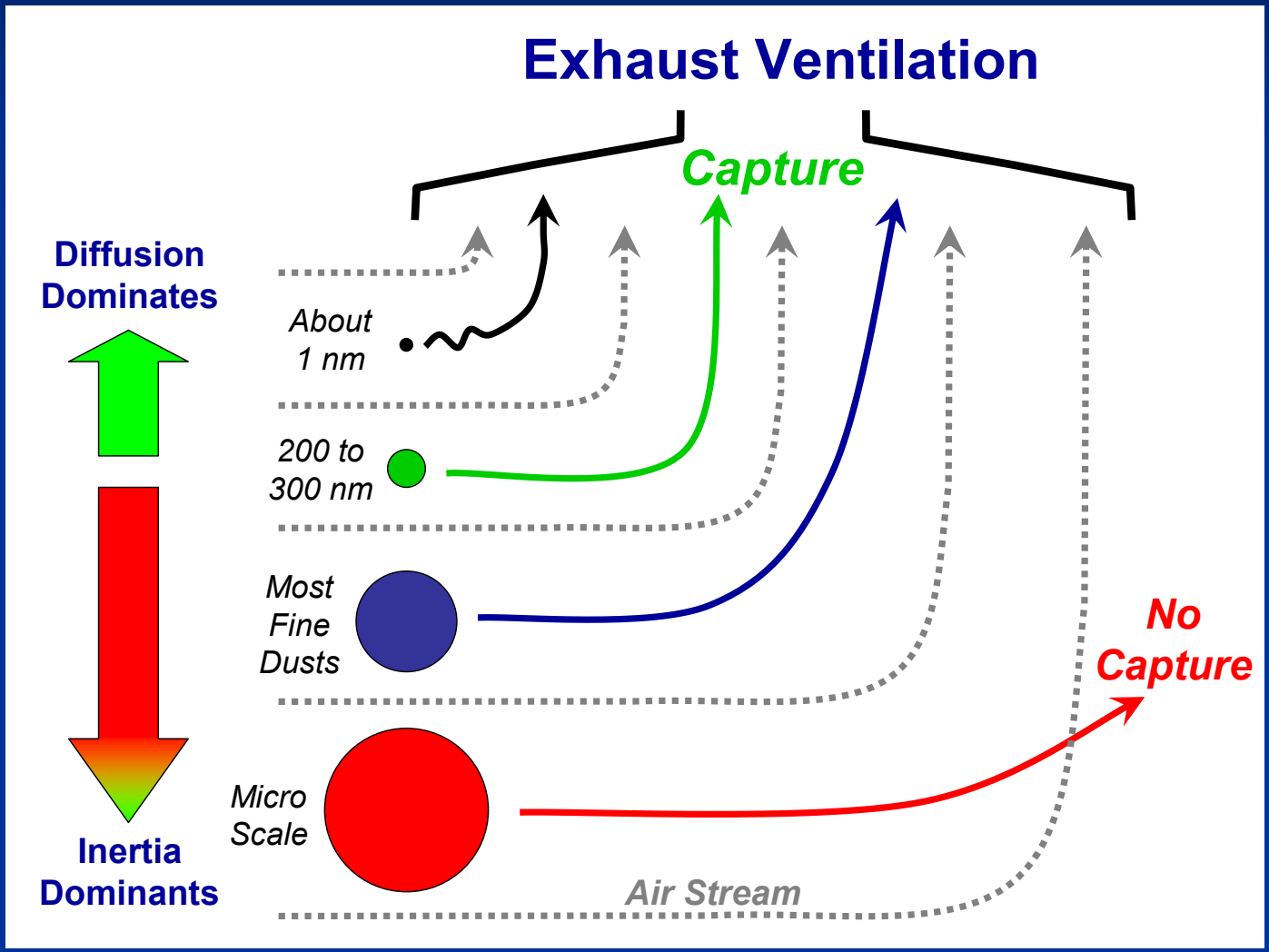
Key responses: Industry OELs

Key elements in worker protection

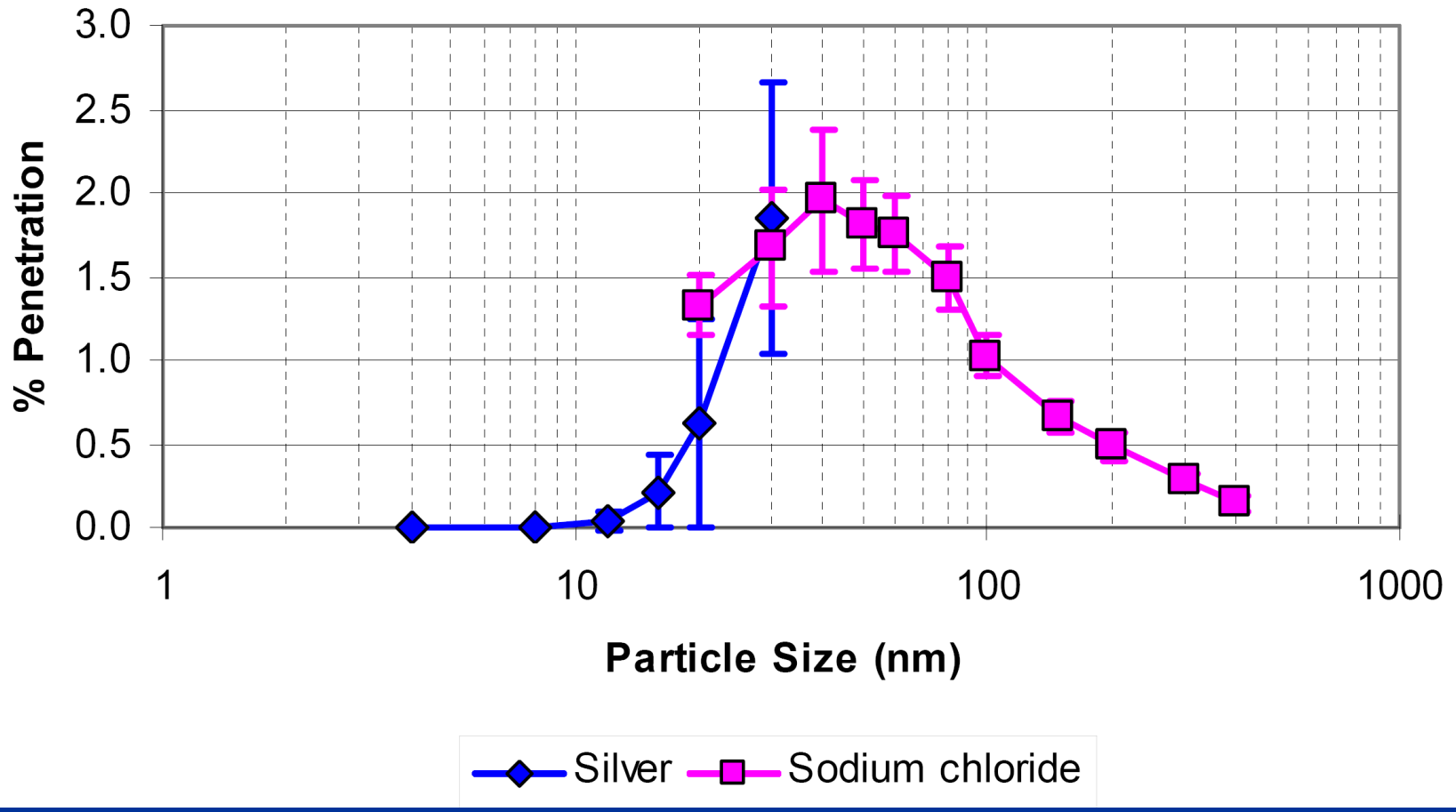
Recognize and Manage Risk

What works?
What has been used?
What can be reapplied?

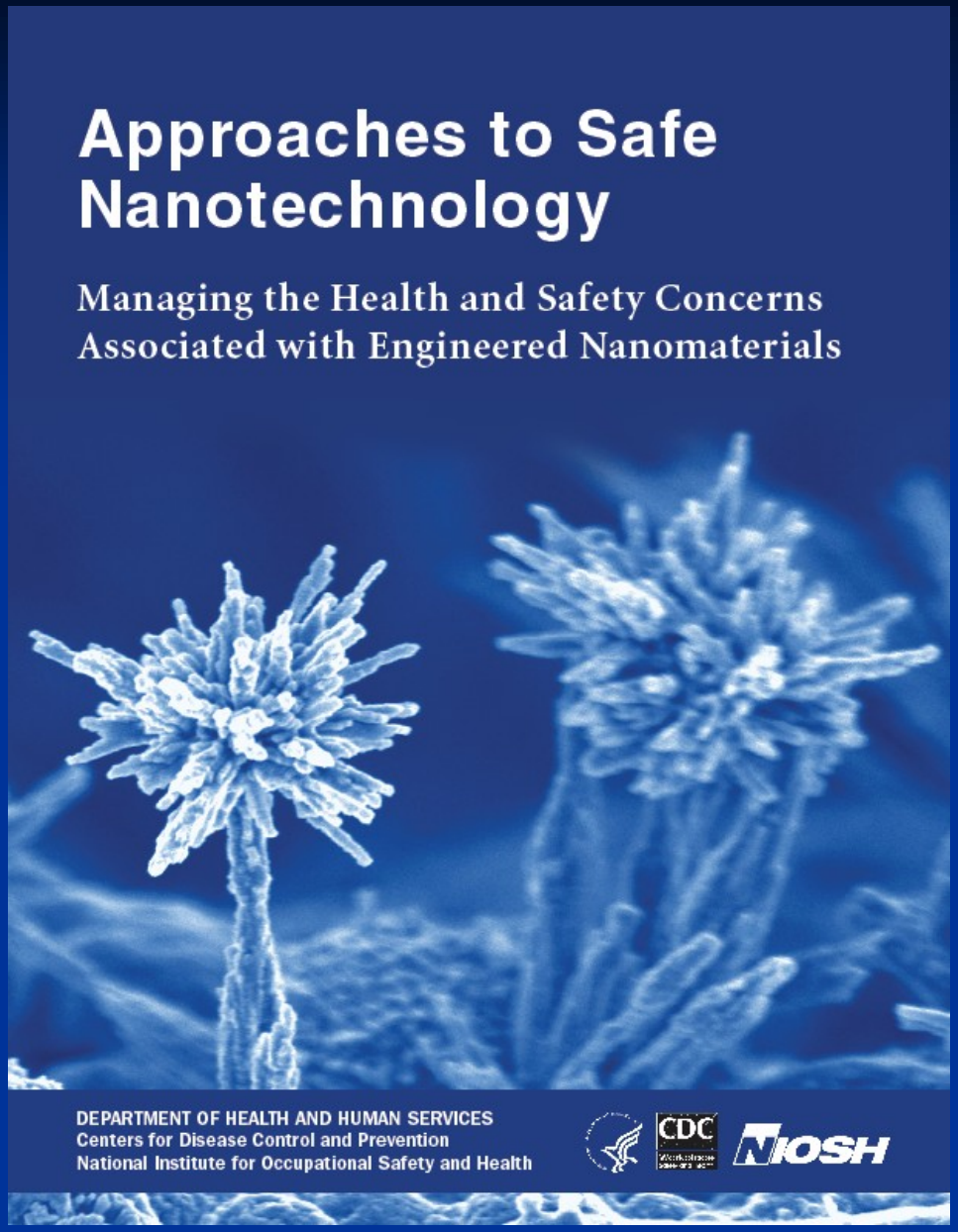
Conventional controls should work



Filtration performance of an example NIOSH approved N95 filtering facepiece respirator



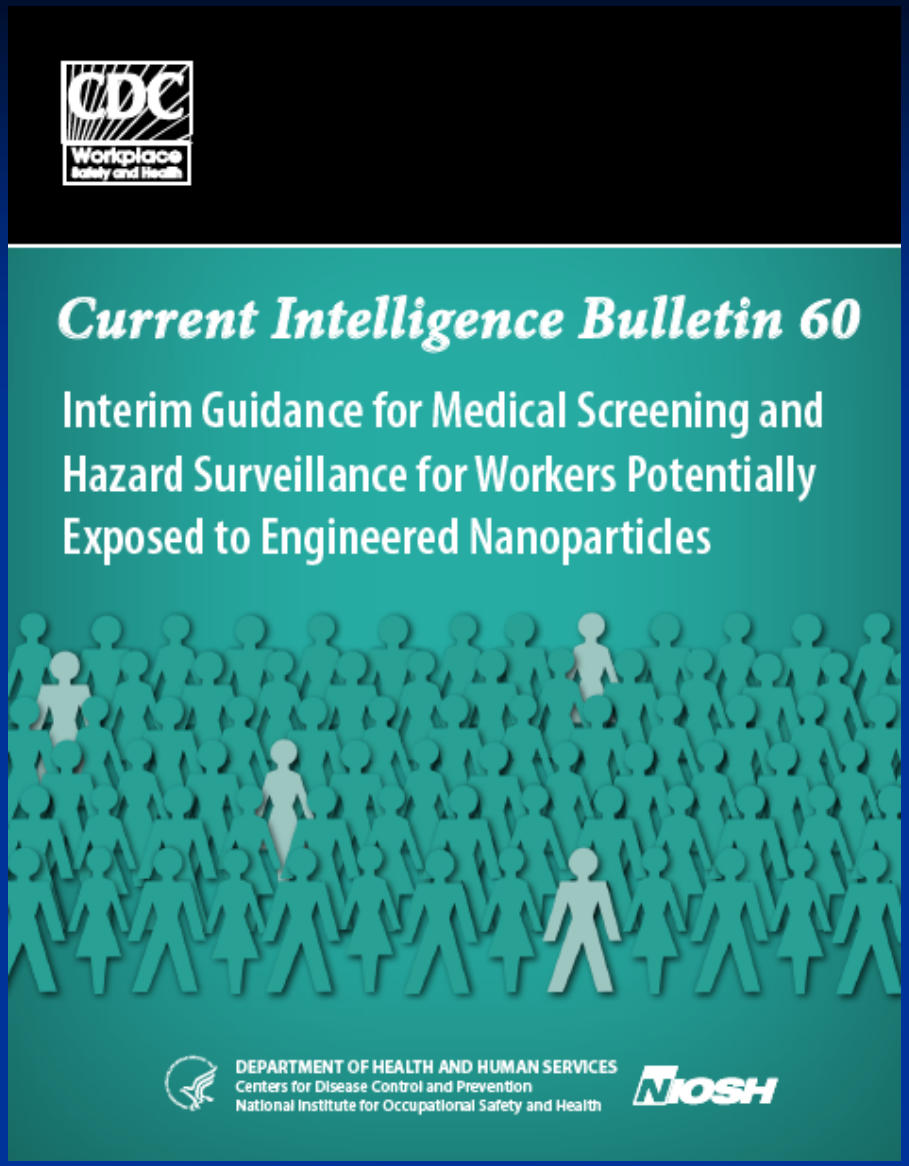
n=5; Error bars represent standard deviations
TSI 3160; Flow rate 85 L/min



Basic Guidance from NIOSH

- Updated and re-issued in 2009
- Based on direct experience and applied research results
- Updated as new information is developed
- A starting point for building a responsible nanomaterial management program

www.cdc.gov/niosh/topics/nanotech



Interim guidance issued by NIOSH

- Value of medical screening
- Lack of specific health end point
- Hazard Surveillance
- Potential for Exposure Registry

NIOSH Safety and Health Topic:

Nanotechnology

Nanomaterials and Worker Health: Medical Surveillance, Exposure Registries, and Epidemiologic Research

July 21-23, 2010
Keystone Conference Center

Invitation

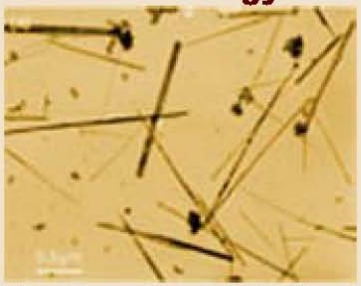
The National Institute for Occupational Safety and Health (NIOSH) and the Mountain and Plains Education and Research Center invite you to attend the conference on "Nanomaterials and Worker Health: Medical Surveillance, Exposure Registries, and Epidemiologic Research." The conference will be held on July 21–23, 2010, at the Keystone Resort and Conference Center in Keystone, Colorado.

The aim of the conference is to identify gaps in information and address questions focusing on occupational health surveillance, exposure registries, and epidemiologic research involving nanotechnology workers. In each of these areas, this conference will:

- Share existing knowledge;
- Identify major issues;
- Examine successful approaches;
- Explore new approaches, techniques, and models.

This conference will enable members of the occupational safety and health community concerned with nanomaterials and the health of workers exposed to these materials to address fundamental questions and seek practical solutions for carrying out occupational health surveillance, developing exposure registries, and conducting epidemiological research. The conference will include invited and submitted papers, breakout sessions to allow for small group discussions, and poster presentation.

Nanotechnology



Conference Details

- Conference invitation

Agenda
- Day 1
- Day 2
- Day 3

Call for abstracts

Registration

Accommodations in Keystone

Travel

Contacts and FAQs

http://www.cdc.gov/niosh/topics/nanotech/keystone2010/default.html

etc.

Sector: **Food**

Sector: **Electronics**

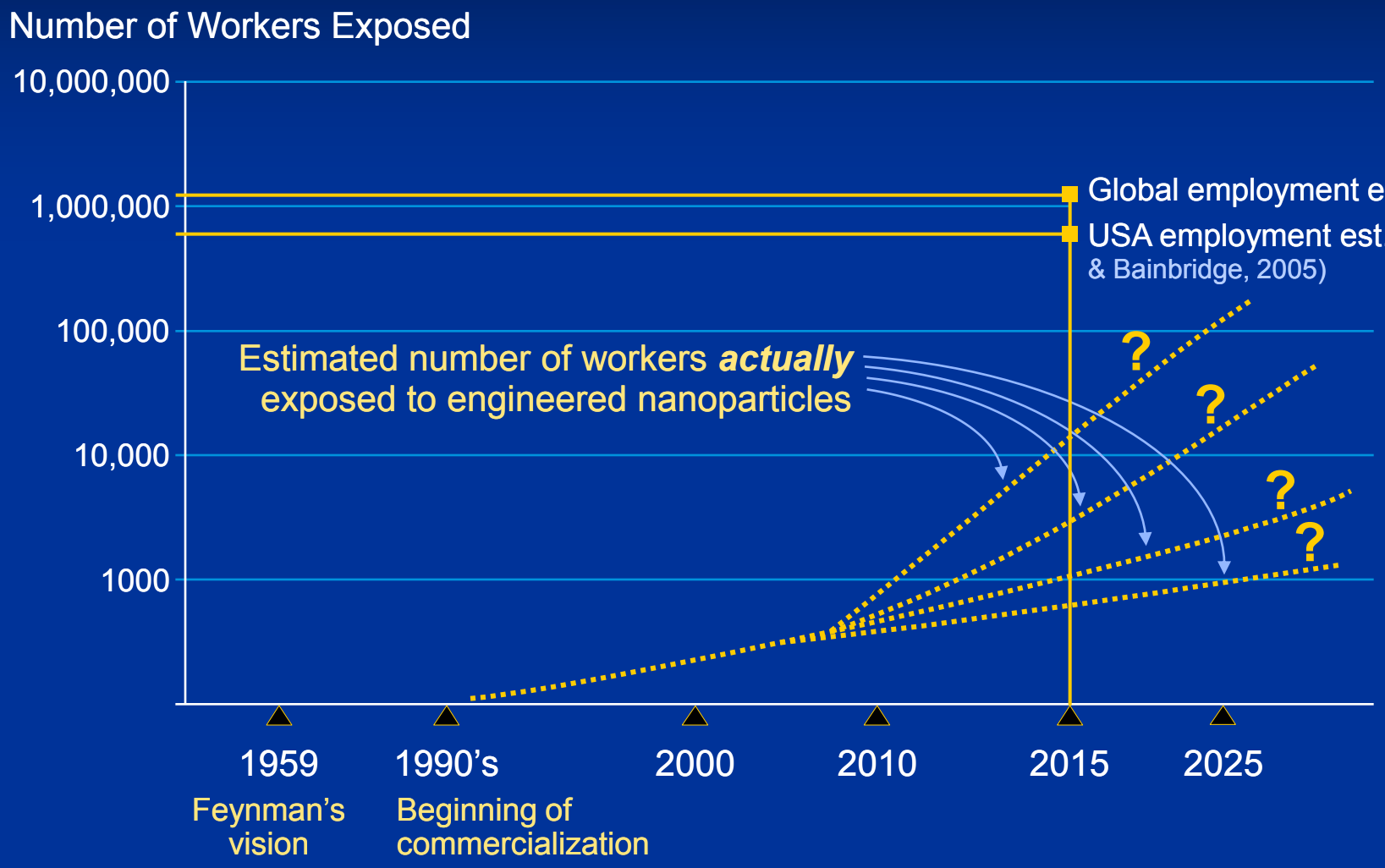
Sector: **Medicine**

Sector: **Energy**

Sector: **Materials**

Workplaces	*Nanomaterial Type*			
	Carbon Nanotubes	Metal Oxides	Dendrimers	Fullerenes Metal Nanomaterials Nanowires Nanostructured Metals Nanoporous Materials Nanoscale Encapsulation
Laboratory Research				
Start up/Pilot				
Manufacturing				
Production				
Disposal				

Dilemmas in identifying workers exposed to engineered nanoparticles



Schulte, 2009

Exposure registries

- Used in public health for over 50 years
- May serve as a societal response to hazardous exposures
- May serve as preparatory step for epidemiological studies

Questions about exposure registries

- Who would manage them?
- What data would be collected?
- Who would have access to the data?
- Could any investigator with a research proposal have access to the registry?
- Are there non-research implications and responsibilities for those who manage registries?
- Are there expectations for those who participate in them?

Thank you!

Pschulte@cdc.hhs.gov