Nanotechnology in Perspective

Towards science-informed regulatory policies

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Divergence
Relevance
Adaptation

Divergence:

Nanotechnology Oversight

*Deviating from the norm - what makes nanotechnology **different**?*

Richard Smalley

nano: The

art and *science*

of **building stuff**

that **does stuff**

at the nanometer scale

Smallness

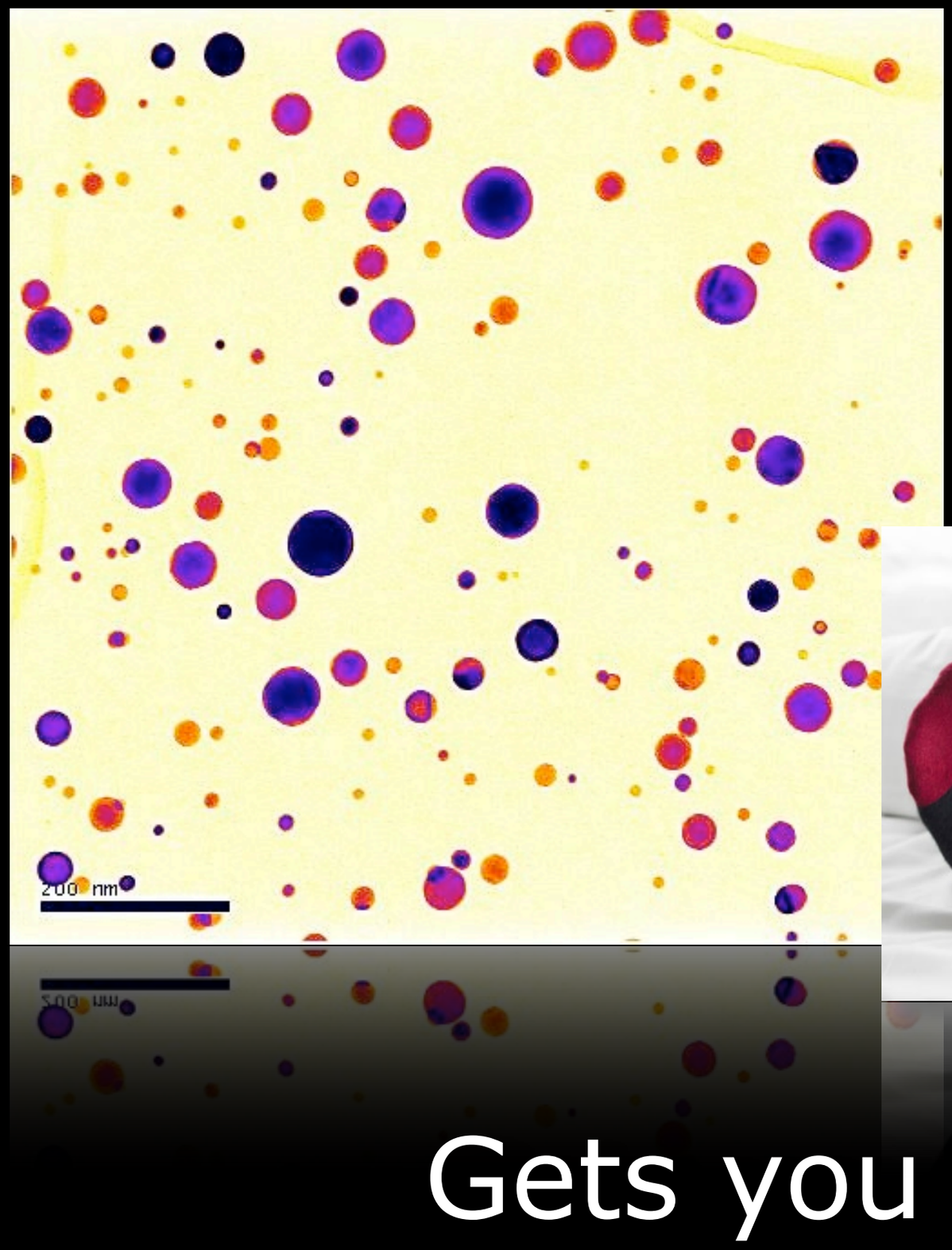
Strangeness

Sophistication

Smallness

Gets you to new places

Smallness



Silver

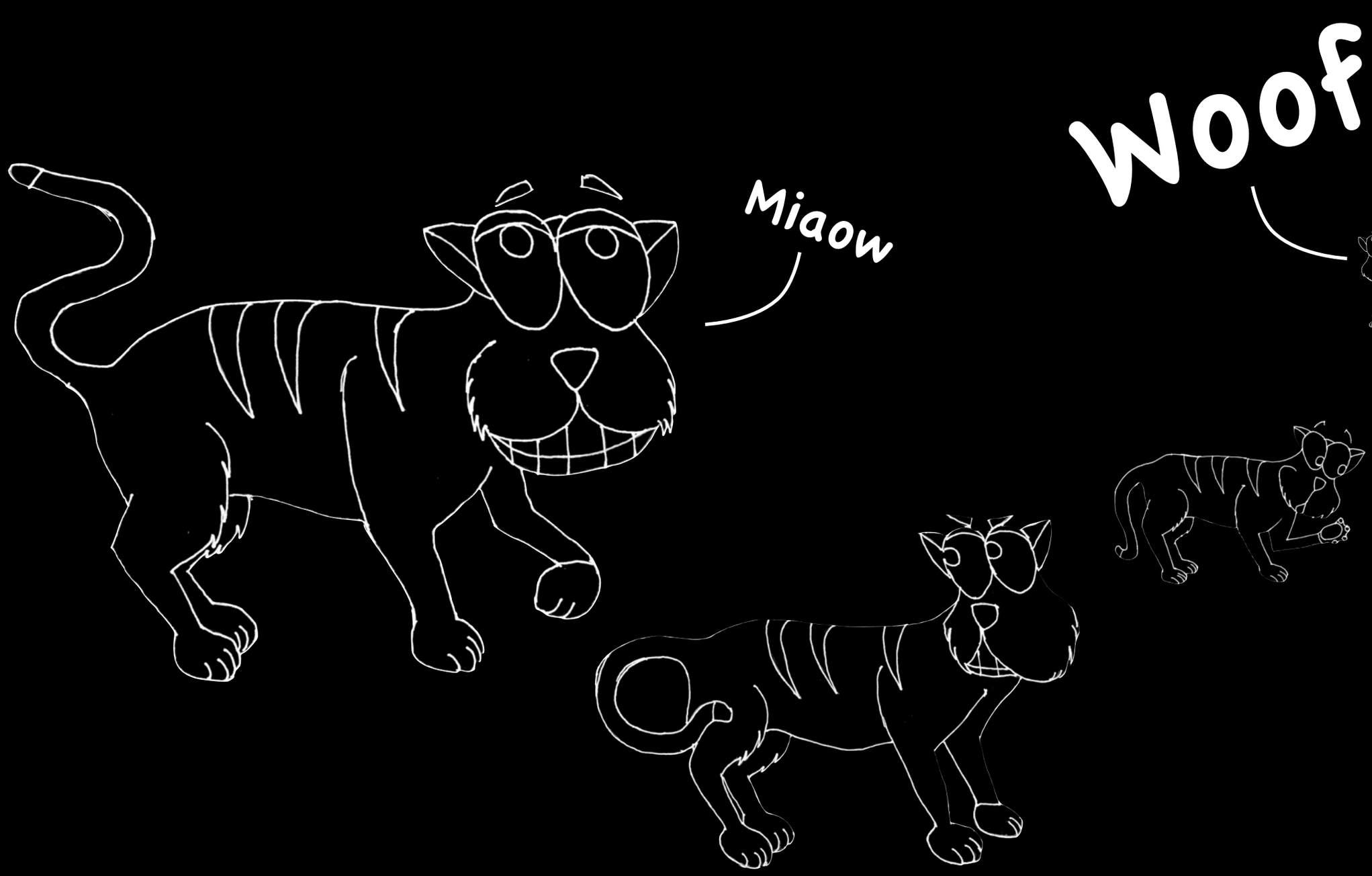
Small

Suffocated bugs

Sweet feet

Gets you to new places

Strangeness



Concept: Vicki Colvin

Behaves in unexpected ways

Strangeness

Lycurgus Cup

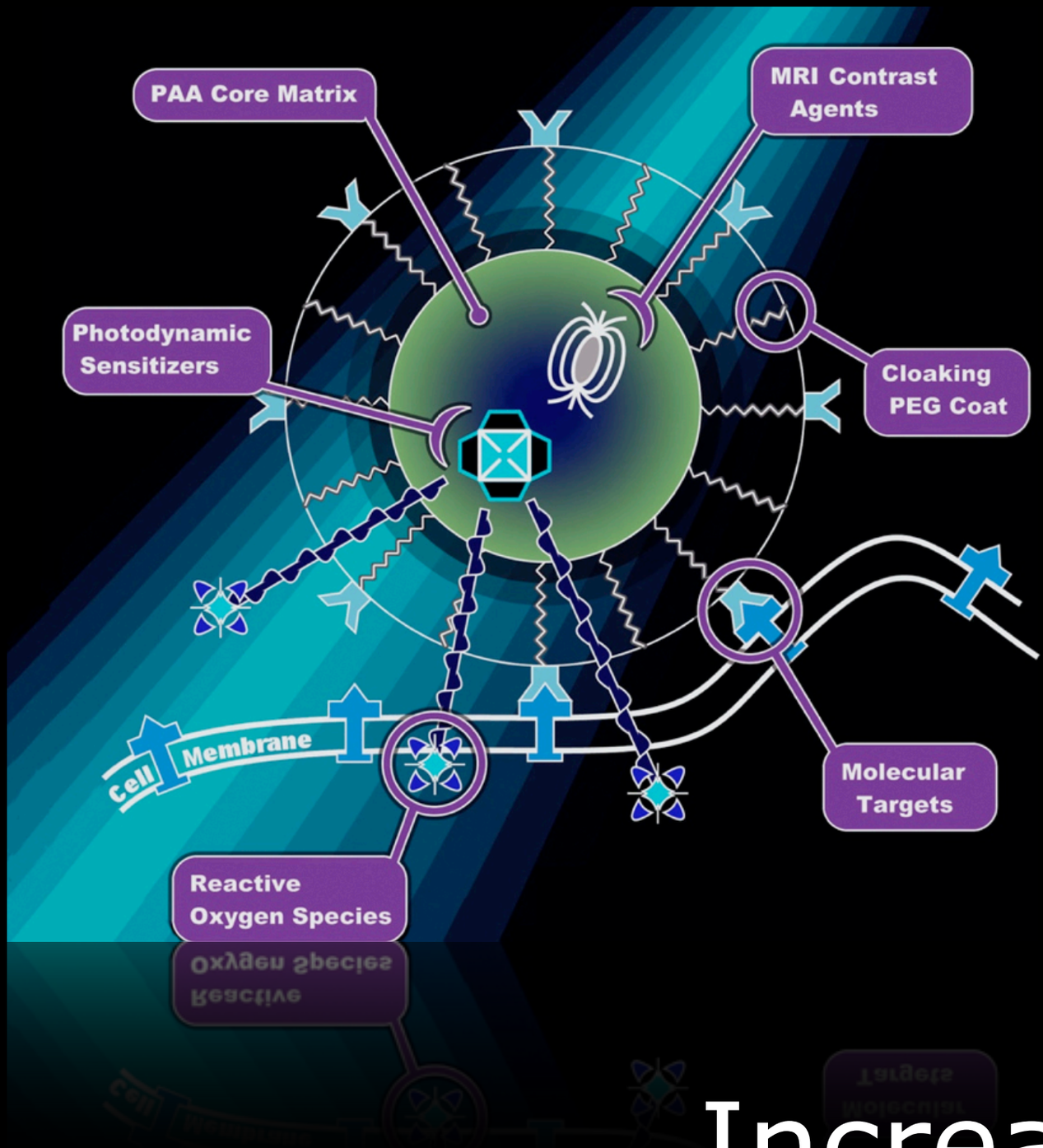
Behaves in unexpected ways


Smallest
Largest
Cadmium Selenide
"Quantum Dots"
©Felice Frankel

Sophistication

Increasingly complex

Sophistication



Smart Drugs

Increasingly complex

Divergence:

Nanotechnology Oversight

Issues:

- ***"Conventional" technologies,*** unconventional behavior
- ***Novel technologies,*** unexpected behavior
- ***New behavior,*** unanticipated risks?

Relevance:

Nanotechnology Oversight

*When does "**different**" mean "**dangerous**?"*

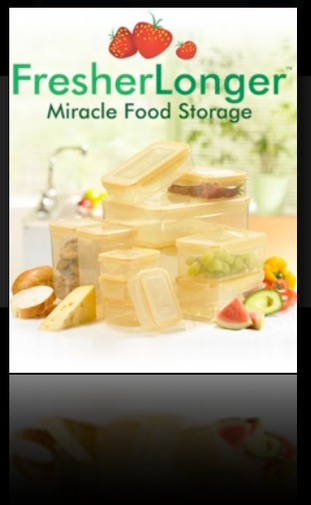
Nanoscale control:
Adding value to products

I wish my sunscreen wasn't so unsightly

I wish my socks didn't smell so much!

I wish my tennis racquet was lighter and stronger

I wish I could keep leftovers for longer, before they go off



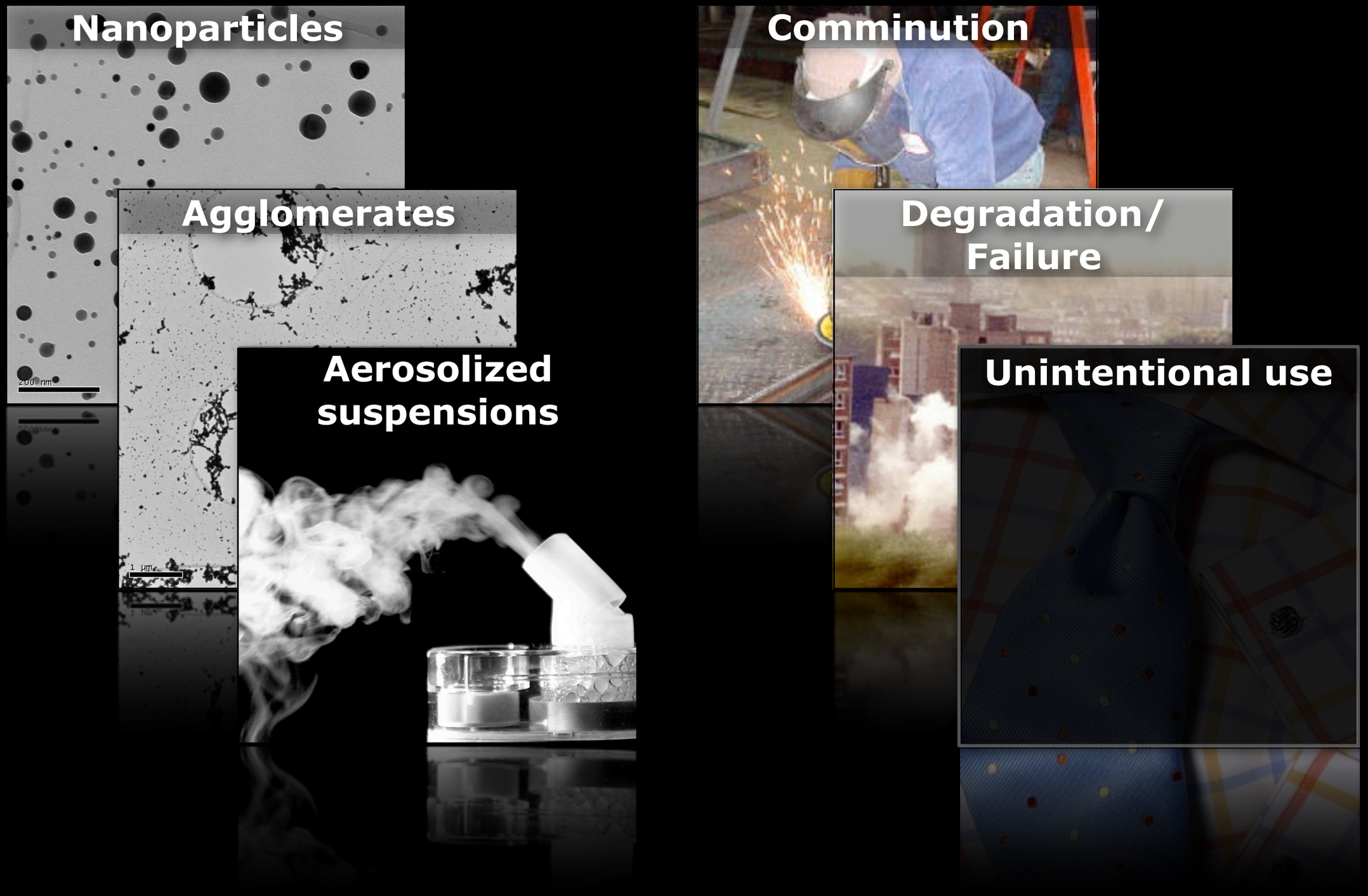
I wish spilt red wine would run off my pants without staining

I wish I could get more songs on my iPod

Over 800 listed manufacturer-identified nanotech consumer products:
www.nanotechproject.org/consumerproducts

Nanoscale materials & products:

Where exposure and hazard matter



Maynard and Kuempel (2005), *J. Nanopart. Res.* 7(6) 587-614

Relevance:
Nanotechnology Oversight

Focus:

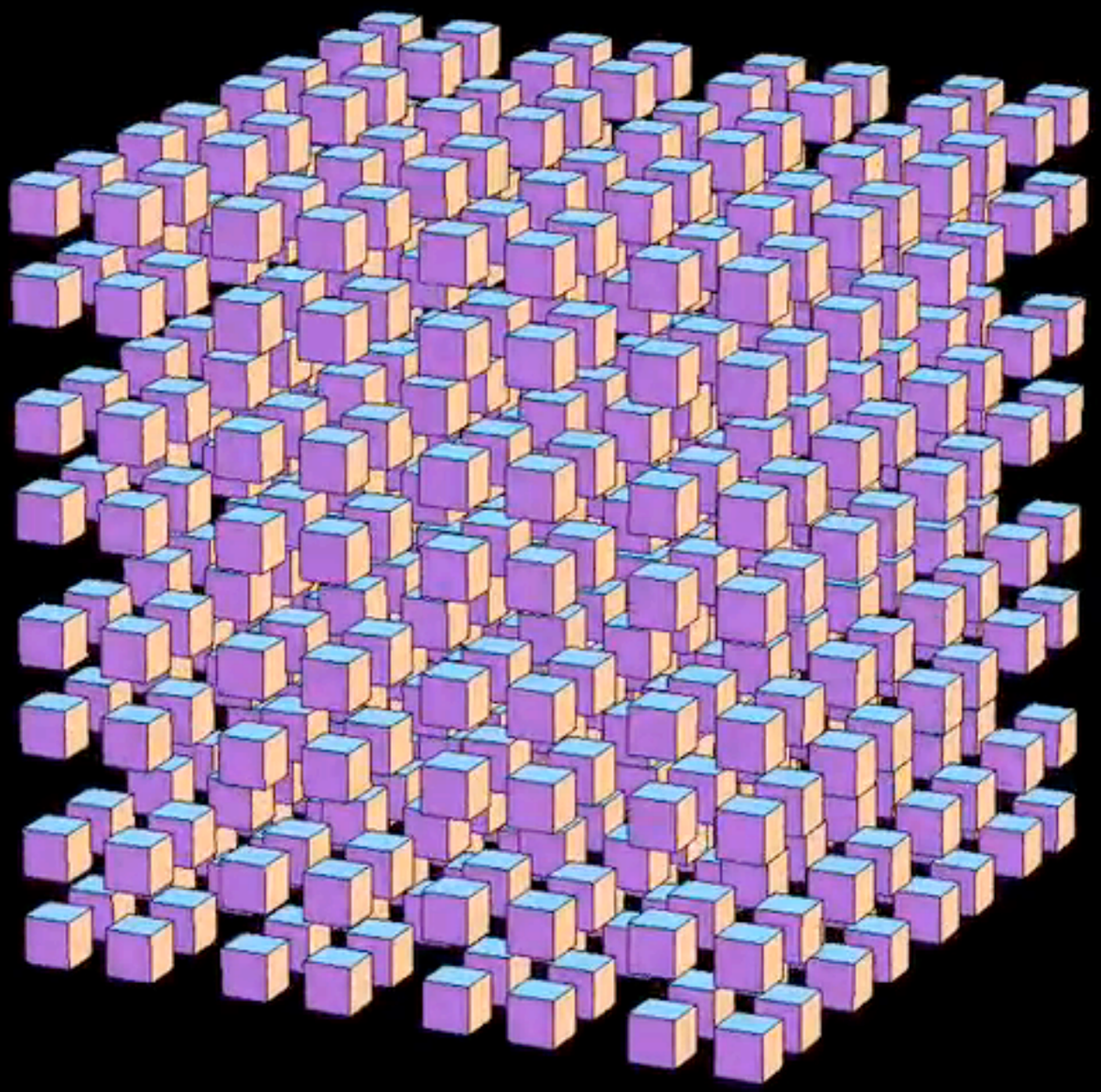
- Where ***exposure*** occurs
- Where ***unanticipated harm*** could occur
- Where existing regulations are ***weak***

Adaptation:

Nanotechnology Oversight

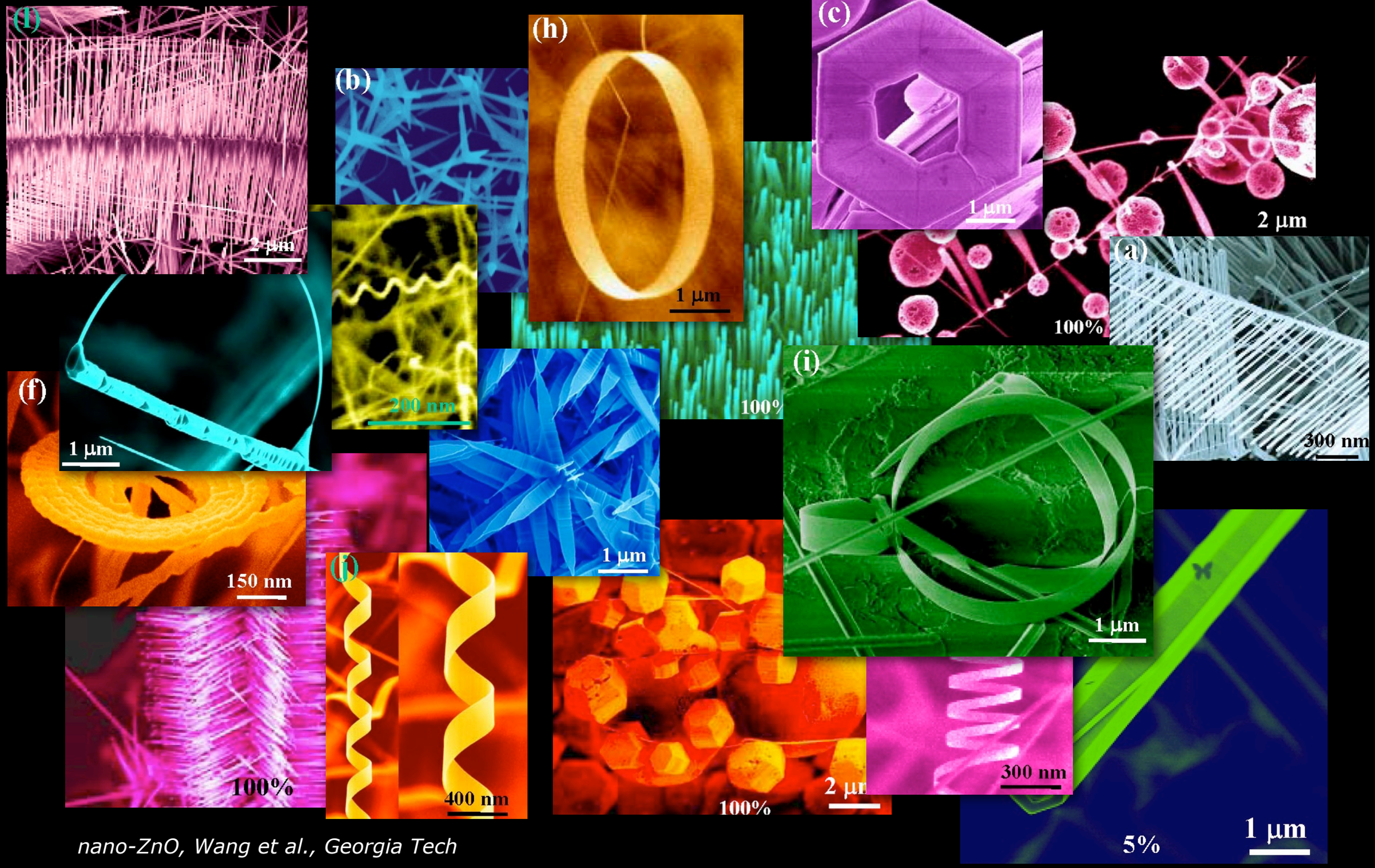
*Bridging the gap between what we **do**, and what we **need to do***

Measurement...



www.youtube.com/2020science

Same Chemistry

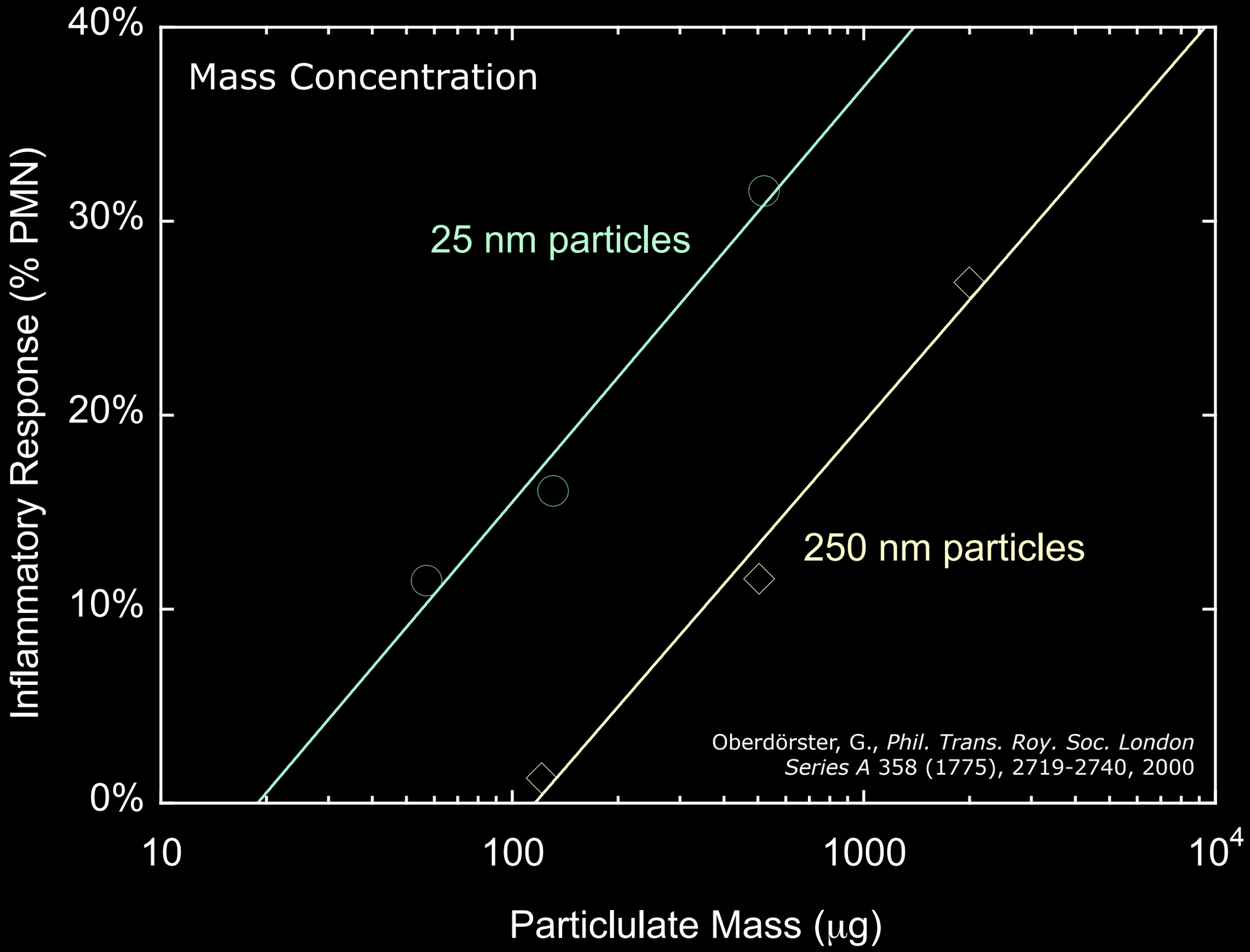


nano-ZnO, Wang et al., Georgia Tech

Potentially Different Risks

Structure-related hazard

TiO_2 Instillation in Rats



Minimum Information for Nanomaterial Characterization Initiative

Supporting Appropriate Material Characterization in Nano-toxicology Studies

MINChar Initiative

The Parameters List

Recommended Minimum Physical and Chemical Parameters for Characterizing Nanomaterials on Toxicology Studies

Note: This is a recommended *minimum* set of parameters, and is not intended to replace more robust guidelines from governments and organizations such as ISO and OECD

What does the material look like?

- Particle size/size distribution
- Agglomeration state/Aggregation
- Shape

What is the material made of?

- Overall composition (including chemical composition and crystal structure)
- Surface Composition
- Purity (including levels of impurities)

What factors affect how a material interacts with its surroundings?

- Surface Area
- Surface Chemistry, including reactivity, hydrophobicity
- Surface Charge

Overarching considerations to take into account when characetrizing engineered nanomaterials in toxicity studies:

- *Stability—how do material properties change with time (dynamic stability), storage, handling, preparation, delivery etc? Include solubility, and the rate of material release through dissolution.*
- *Context/Media—how do material properties change in different media; i.e. from the bulk material to dispersions to material in various biological matrices? ("as administered" characterization is considered to be particularly important)*
- *Where possible, materials should be characterized sufficiently to interpret the response to the amount of material against a range of potentially relevant dose metrics, including mass, surface-area and number concentration.*

Search

WHAT'S NEW?

Check out and respond to the new comment/question on endotoxin contamination issues from Anil Patri

Pages

- About the Initiative
  - Additional Info
  - Resources
  - Who Are We?
- Join the Community
  - Interest Group
- Join the Conversation
  - General Comments Dec 08
- The Parameters List

Categories

- Information
- Instruments
- News

Archives

- March 2009
- December 2008
- November 2008

Authors

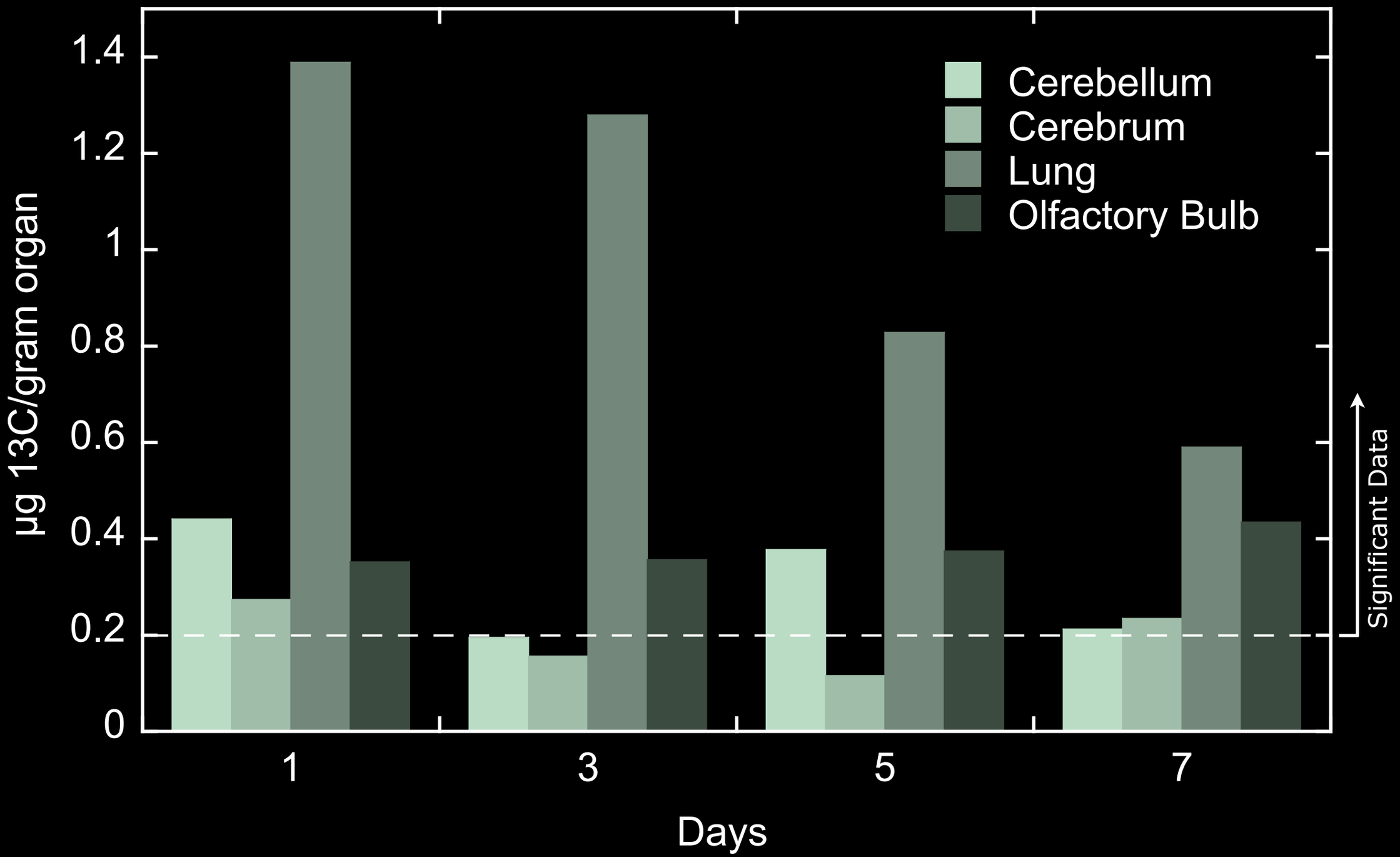
- Andrew Maynard

www.characterizationmatters.org

Novel Behavior…

Structure-related hazard: Translocation

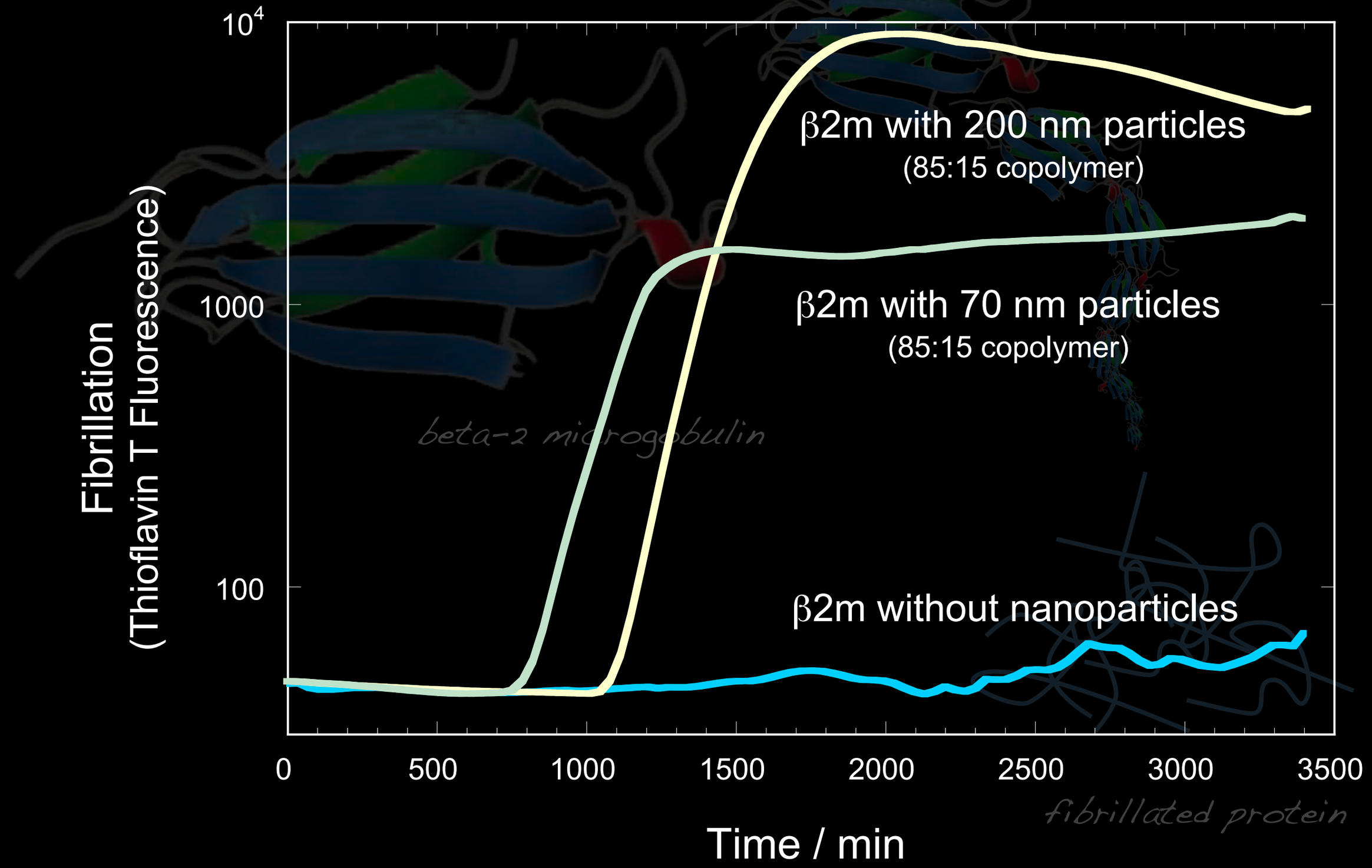
Translocation following inhalation - Nose to Brain



(Based on Oberdörster, G., *et al. (2004)*, *Inhal. Toxicol.* 16 (6-7), 437-445)

Scale-specific hazard: Form

Interfering with biology at the nanoscale



Linse, S., C. Cabaleiro-Lago, W.-F. Xue, I. Lynch, S. Lindman, E. Thulin, S. E. Radford and K. A. Dawson (2007). "Nucleation of protein fibrillation by nanoparticles." Proc. Natl. Acad. Sci. U. S. A. 104: 8691-8696.

1 - Identification of substance:

Chemical Name: Carbon Nanotubes
Formula: Carbon
Chemical Family: Synthetic Graphite
Synonyms: C
CAS Number

- **Manu**

Cheap
112 M
Brattle
802.25

www.

Revisi

Compo

Synthetic g

Metall

2 - CNT Composition/Data on components:

- **Chemical characterization:**

Description: (CAS#)

3 - CNT Hazards identification

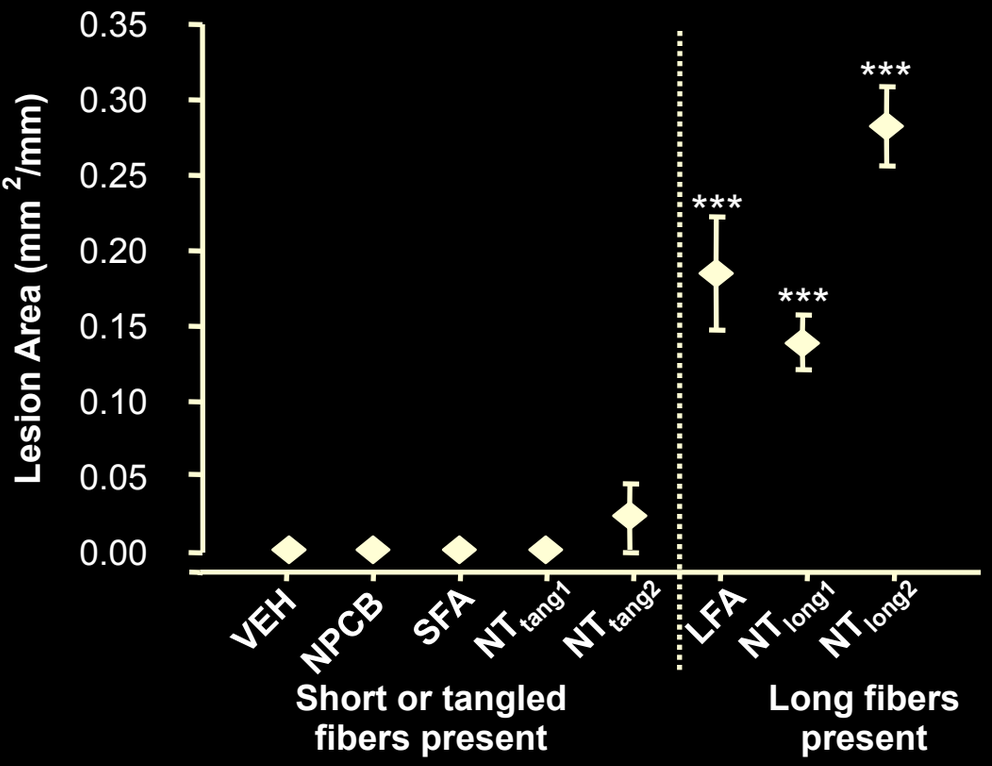
Potential CNT Health Effects

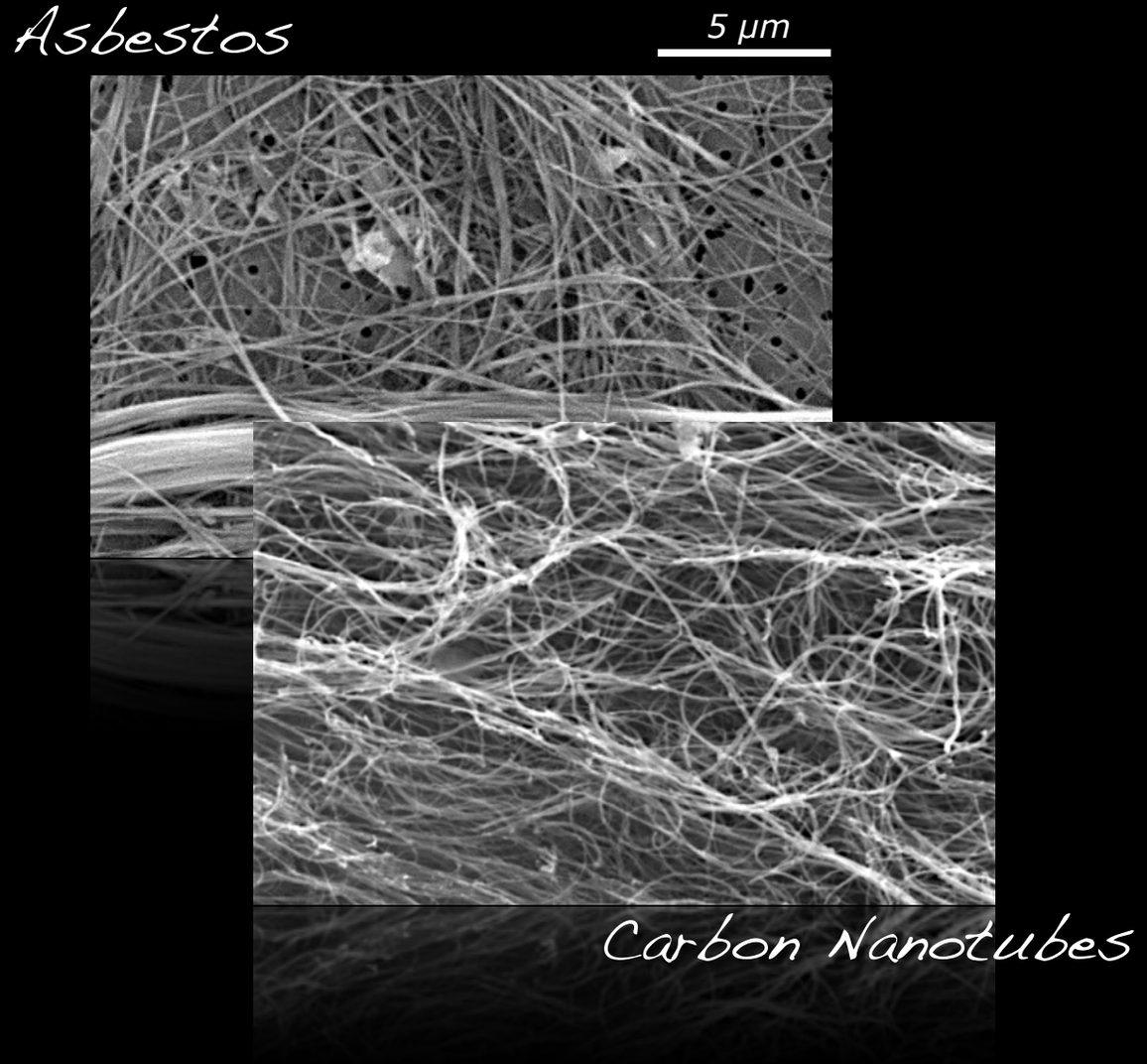
Eye Contact: May cause eye irritation
Skin Contact: No known hazards, but may be mildly irritating
Inhalation: May cause irritation to respiratory tract
Ingestion: No known hazards, but may irritate gastrointestinal tract
Acute and Chronic Health Effects: High concentration of dusts may be irritating to eyes, skin, mucus membranes and respiratory tract.

- **Information pertaining to particular dangers for man and environment**
  R 36/37 Irritating to eyes and respiratory system.

Carbon nanotubes: Possible Risks?

Fiber-like behavior





Carbon nanotubes that look like harmful asbestos fibers, behave like harmful asbestos fibers

Source: Craig Poland

Poland, C. A., R. Duffin, I. Kinloch, A. Maynard, W. A. H. Wallace, A. Seaton, V. Stone, S. Brown, W. MacNee and K. Donaldson (2008). "Carbon nanotubes introduced into the abdominal cavity of mice show asbestos-like pathogenicity in a pilot study." Nature Nanotechnology doi:10.1038/nnano.2008.111.

Safe Use...

House Science Subcommittee on Research & Science Education

October 31 2007

Adaptation:
Nanotechnology Oversight

Strategic steps:

- Know ***what you have***
- Know ***what it does***
- Know ***how to handle it***

Across the material & product life cycle

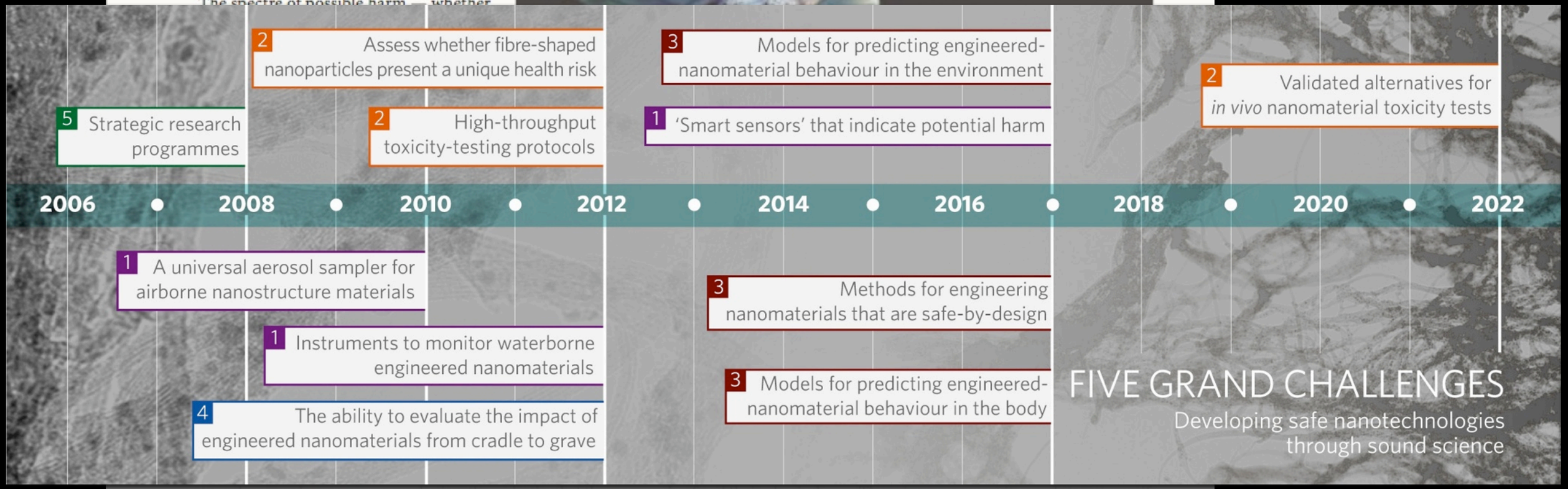
COMMENTARY

Safe handling of nanotechnology

The pursuit of responsible nanotechnologies can be tackled through a series of grand challenges, argue Andrew D. Maynard and his co-authors.

When the physicist and Nobel laureate Richard Feynman challenged the science community to think small in his 1959 lecture 'There's Plenty of Room at the Bottom', he planted the seeds of a new era in science and technology. Nanotechnology, which is about controlling matter at near-atomic scales to produce unique or enhanced materials, products and devices, is now maturing rapidly with more than 300 claimed nanotechnology products already on the market[1]. Yet concerns have been raised that the very properties of nanostructured materials that make them so attractive could potentially lead to unforeseen health or environmental hazards[2].

D. RAMSEY



Nature Vol. 444/16 November 2006

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