

Nanotechnology

Opportunities and Challenges

Andrew D. Maynard

Chief Science Advisor, Project on Emerging Nanotechnologies

Woodrow Wilson International Center for Scholars (in partnership with the Pew Charitable Trusts)

Key Messages:

Nanotechnology has ***great potential***

Some products of nanotechnology have potential to ***cause harm***

Good regulation depends on ***good data*** and a clear perspective

A close-up portrait of Richard Smalley, an older man with white hair and a goatee, looking directly at the camera. The background is dark and out of focus.

Richard Smalley

nano: The

art and *science*

of **building stuff**

that **does stuff**

at the nanometer scale

What sets "nano" apart?

Smallness

Strangeness

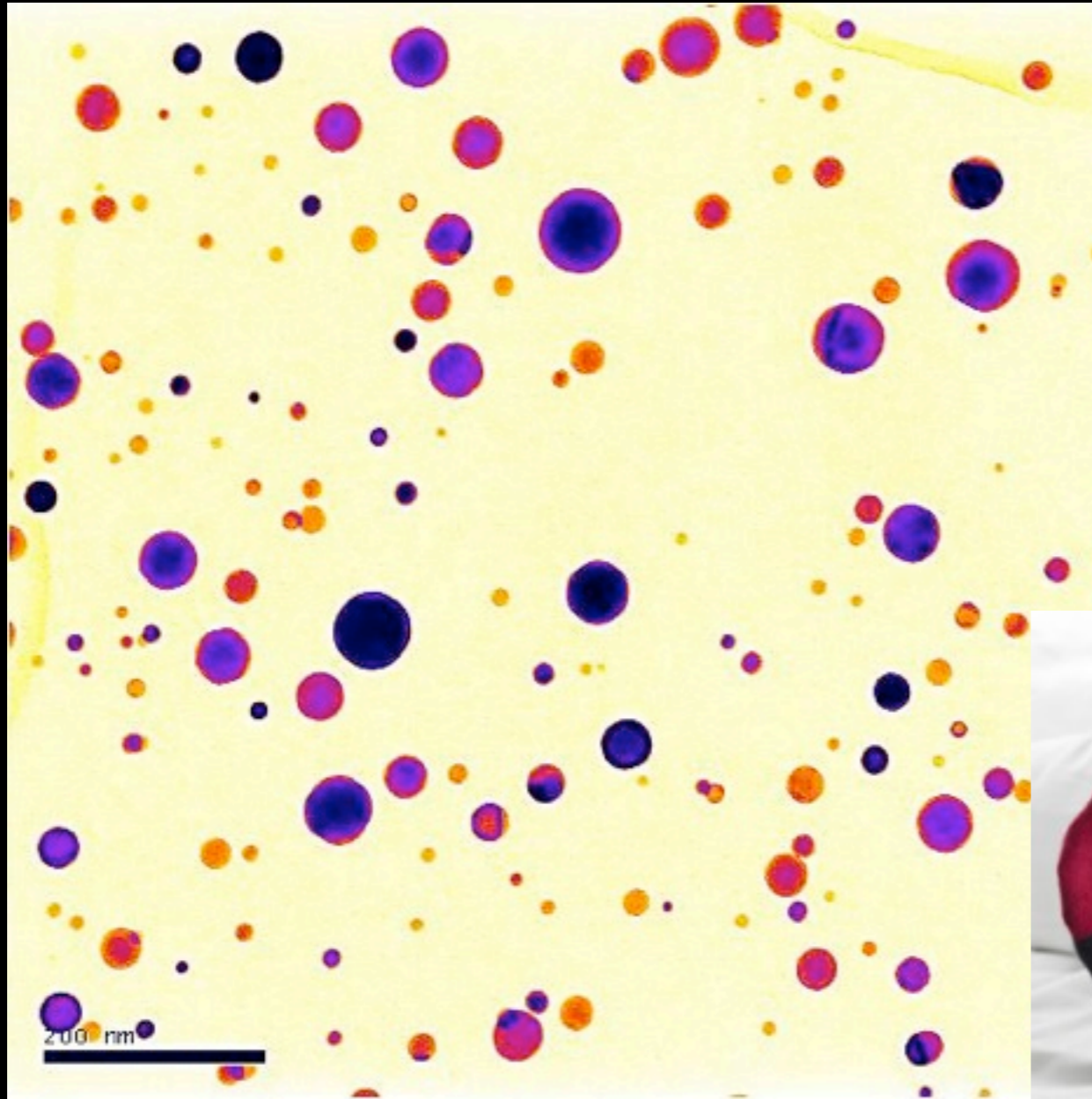
Sophistication

Smallness



Gets you to new places

Smallness



Silver Nanoparticles

Small

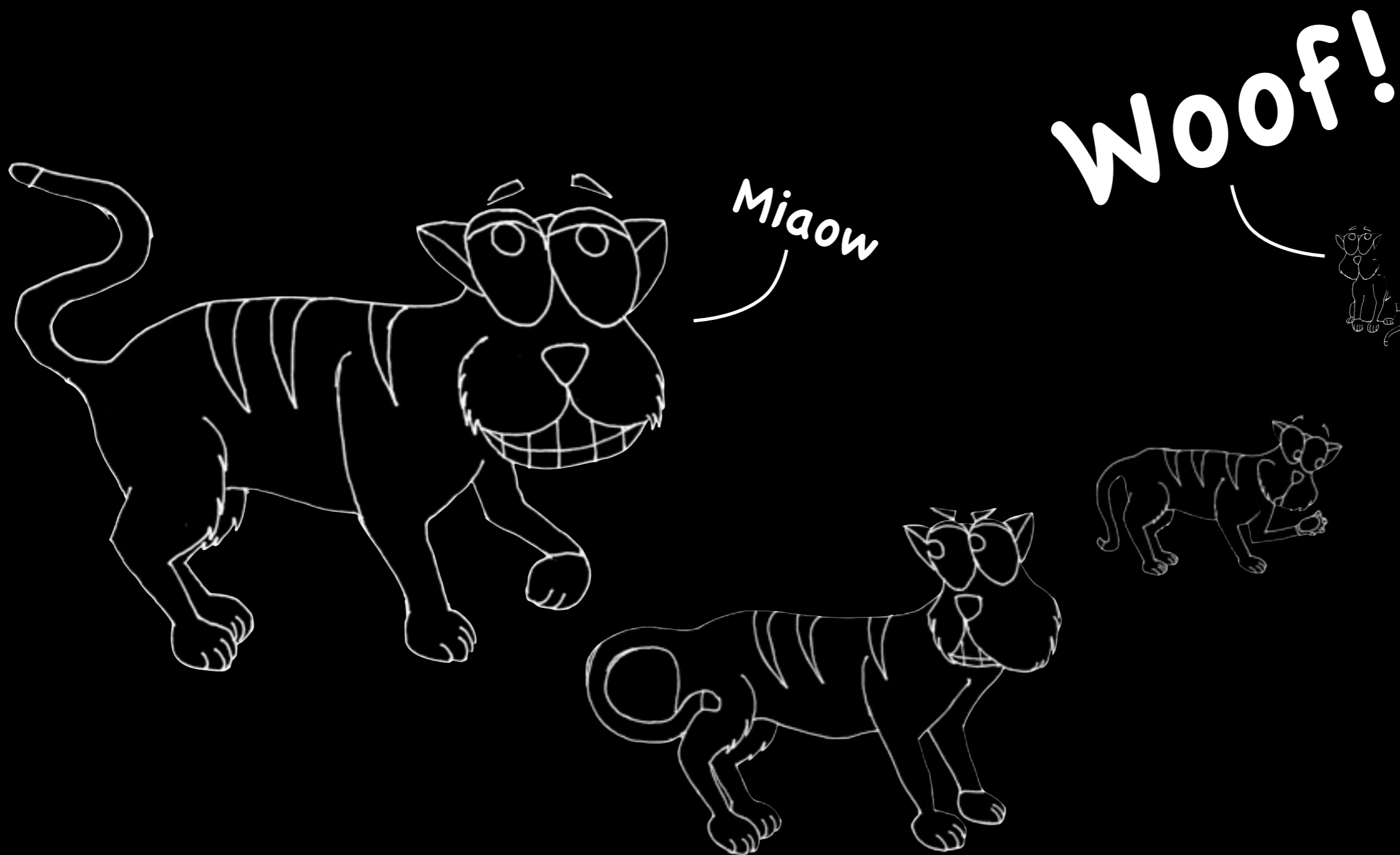
Suffocate bugs

Sweet feet



Gets you to new places

Strangeness



Behaves in unexpected ways

Strangeness

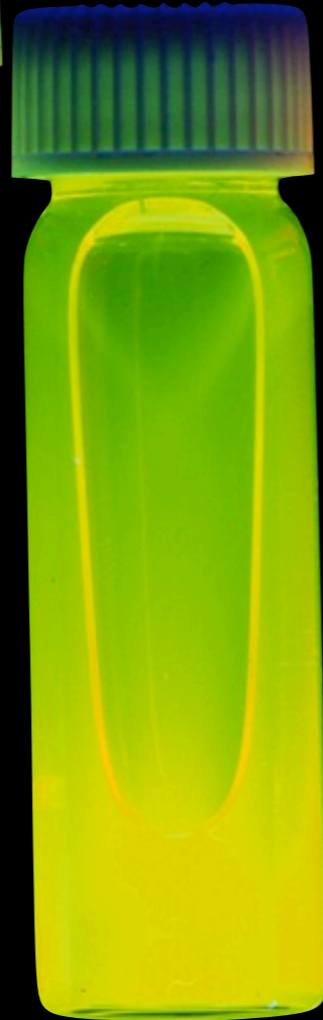
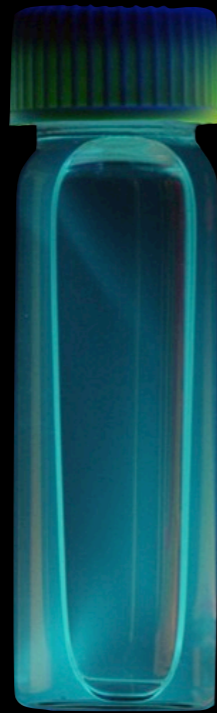


Lycurgus Cup

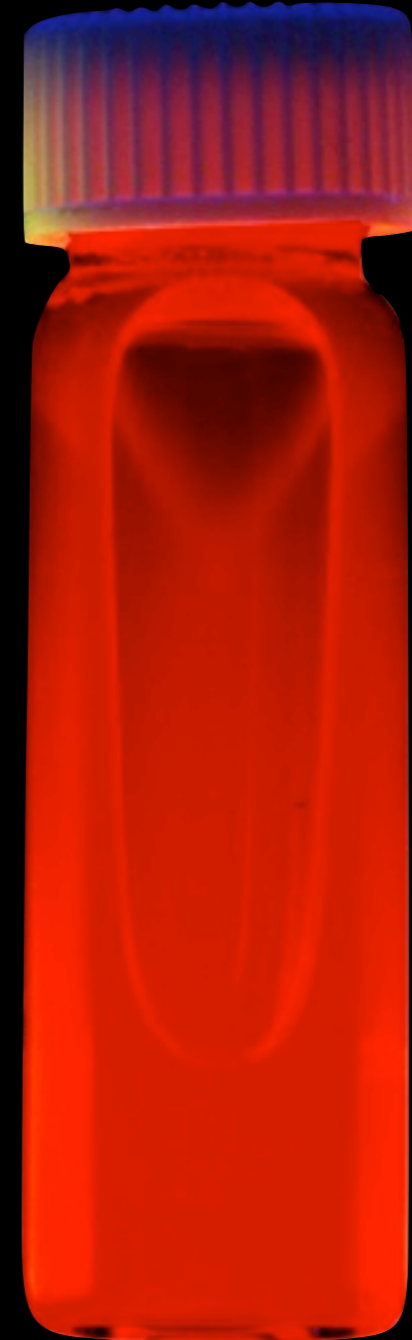


Behaves in unexpected ways

Smallest



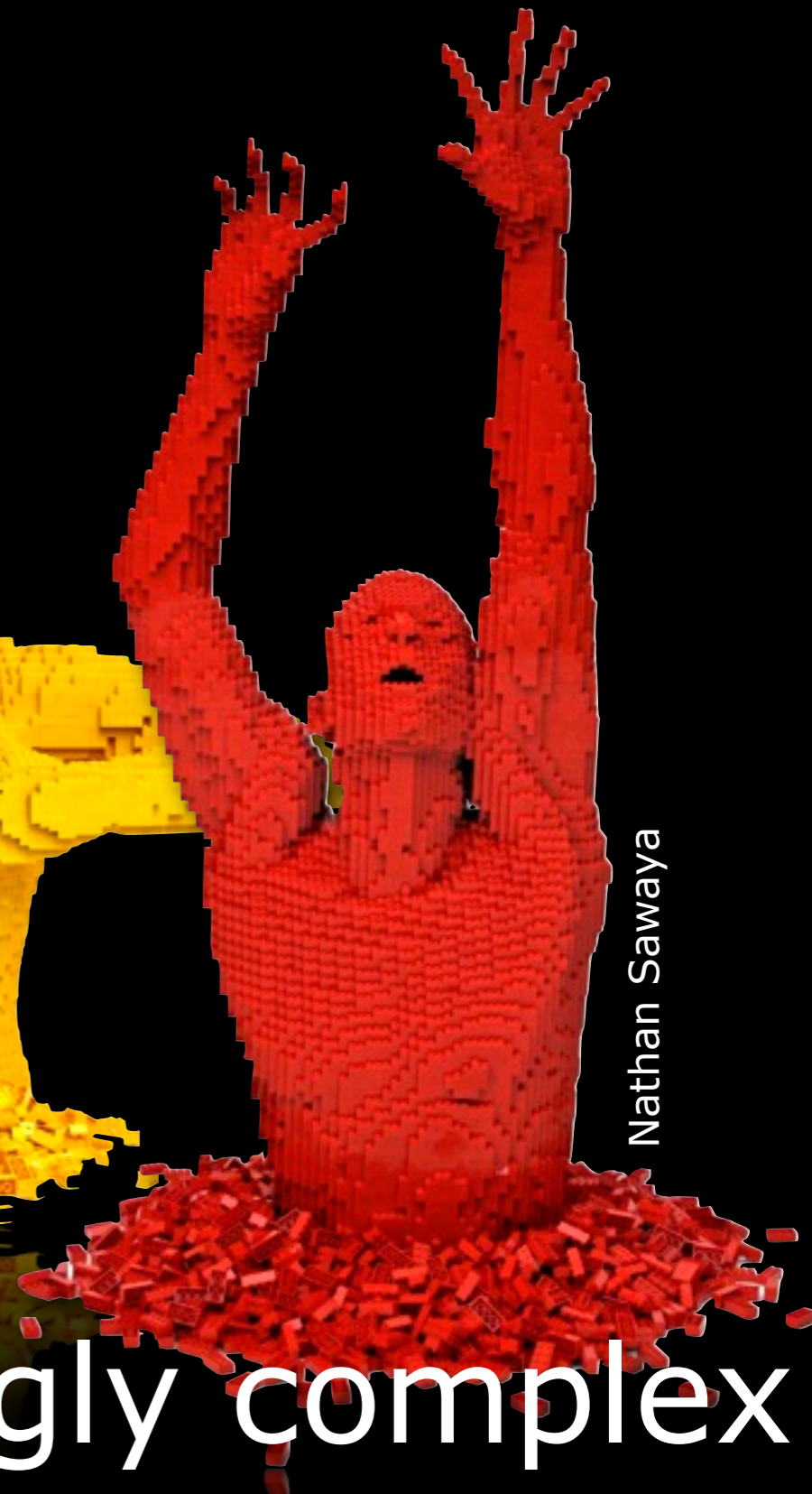
Largest



*Cadmium Selenide
"Quantum Dots"*

©Felice Frankel

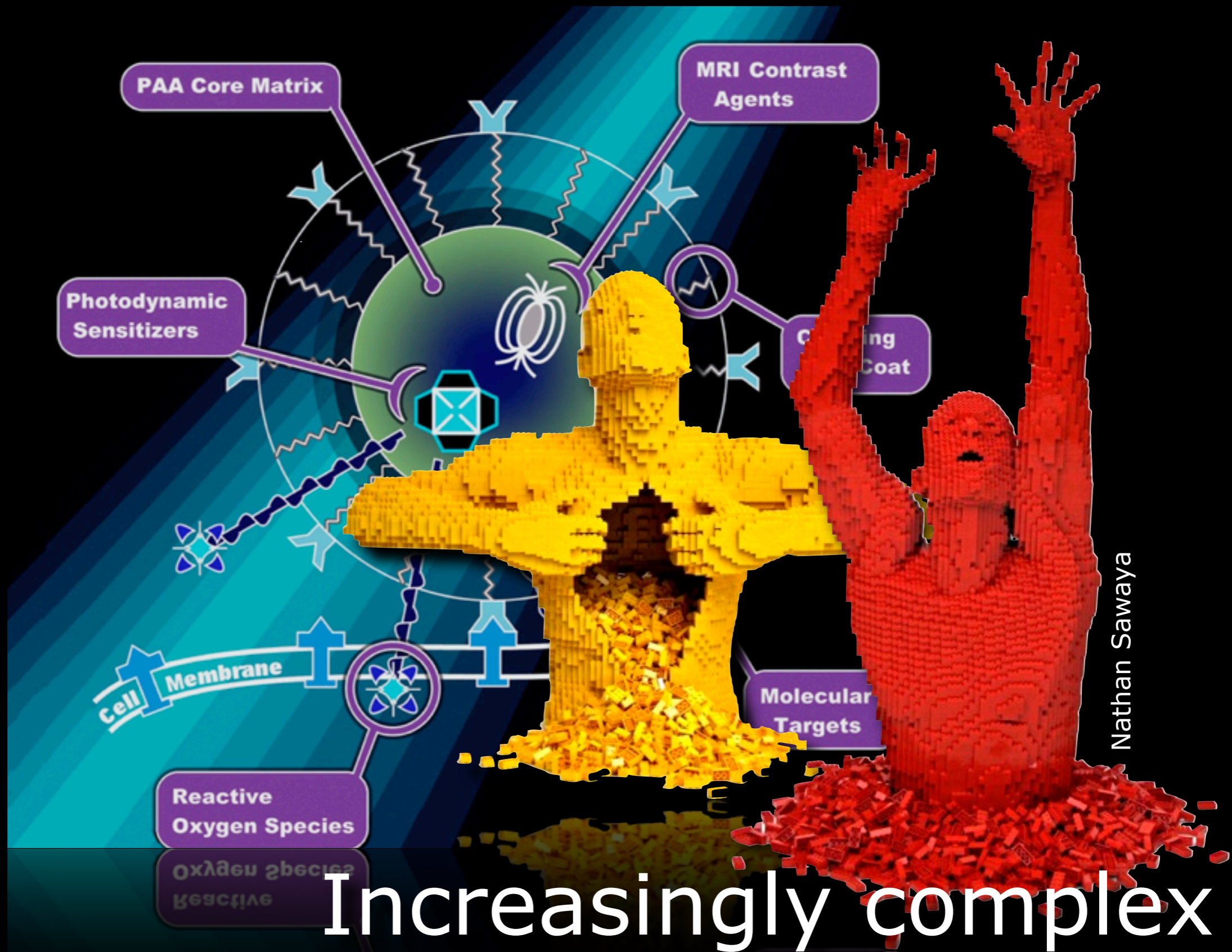
Sophistication



Nathan Sawaya

Increasingly complex

Sophistication



What sets "nano" apart?

It enables materials to
behave differently

It allows us to **do things**
differently

Nanoscale control:

Adding value to products

I wish my sunscreen wasn't so unsightly



I wish my socks didn't smell so much!



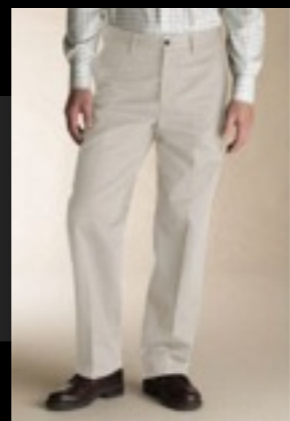
I wish my tennis racquet was lighter and stronger



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



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



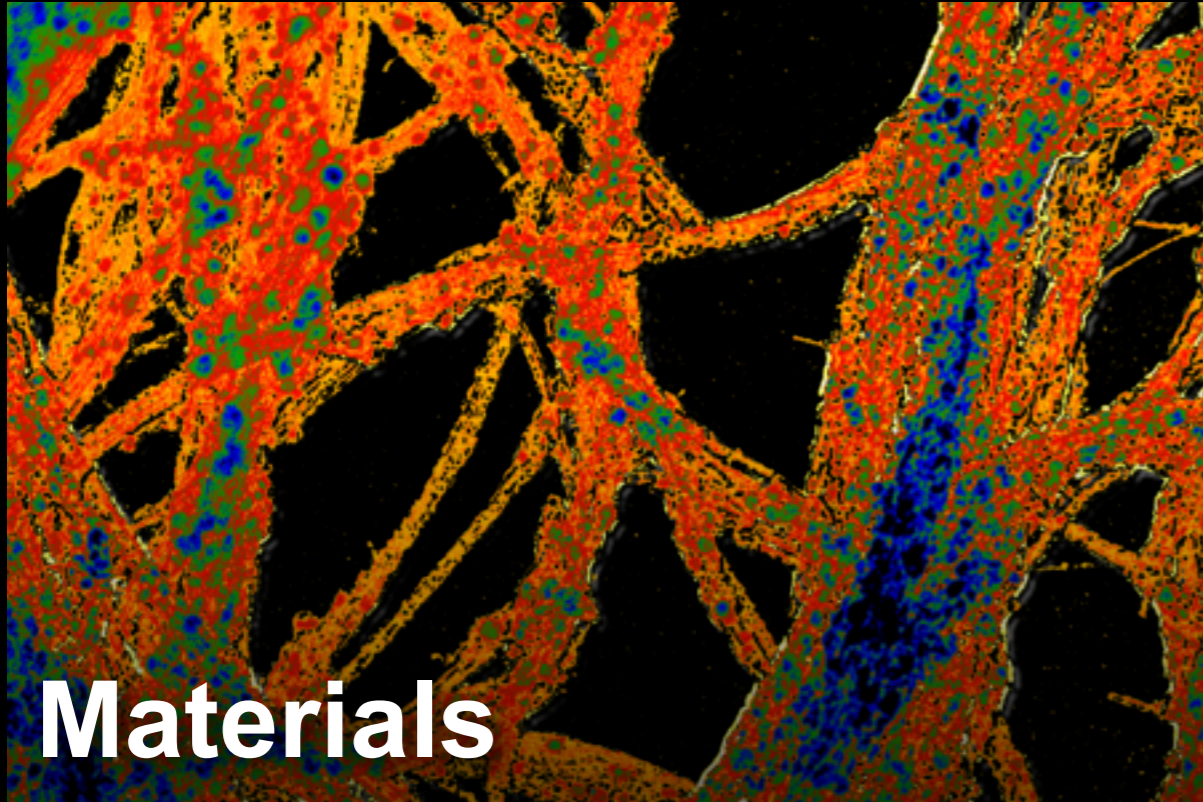
I wish I could get more songs on my iPod



Over 1000 listed manufacturer-identified nanotech consumer products:
www.nanotechproject.org/consumerproducts

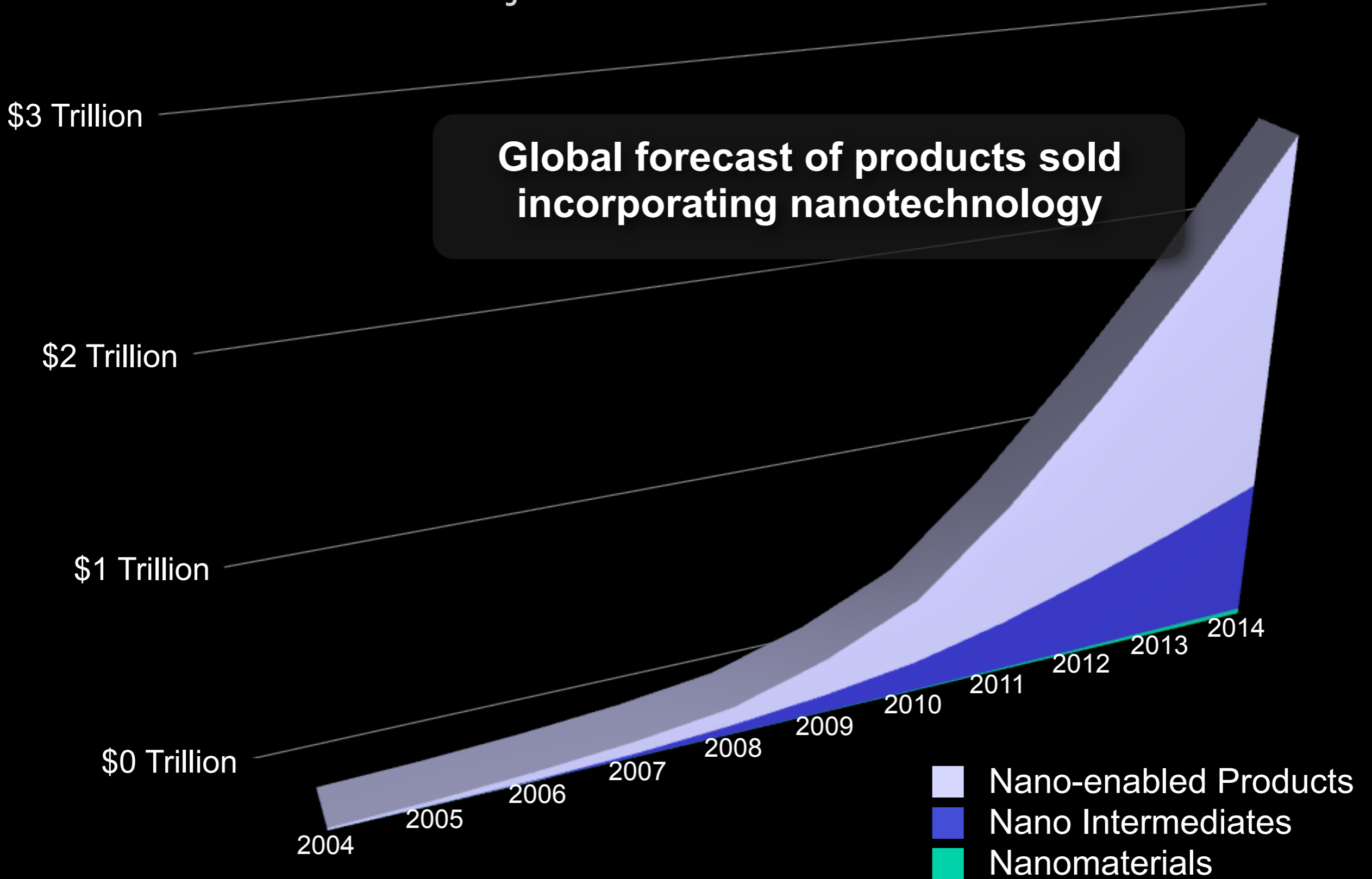
Nanoscale control:

Solutions to problems



Nanoscale control:

Generates wealth and jobs



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

...but is nano
SAFE?

Managing nano risks:

Divergence

Relevance

Adaptation

Divergence:

Nanotechnology Oversight

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

Divergence:

Nanotechnology Oversight

Issues:

“Conventional” technologies, unconventional behavior

Novel technologies, unexpected behavior

New behavior, unanticipated risks?

Relevance:

Nanotechnology Oversight

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

Relevance:

Nanotechnology Oversight

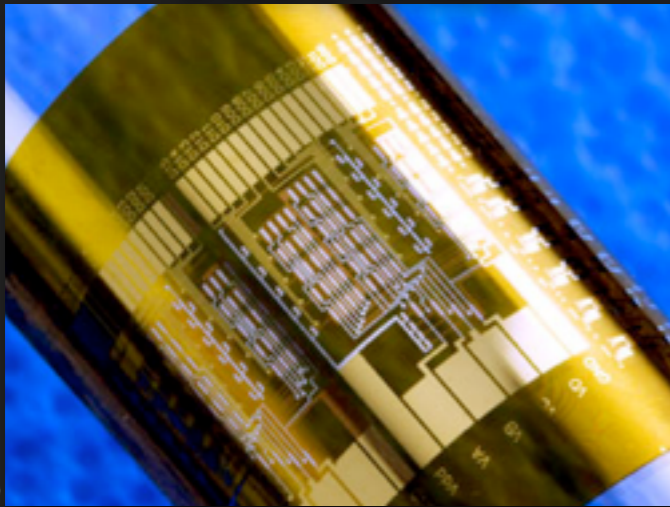
Focus:

Where ***exposure*** occurs

Where ***unanticipated harm*** could occur

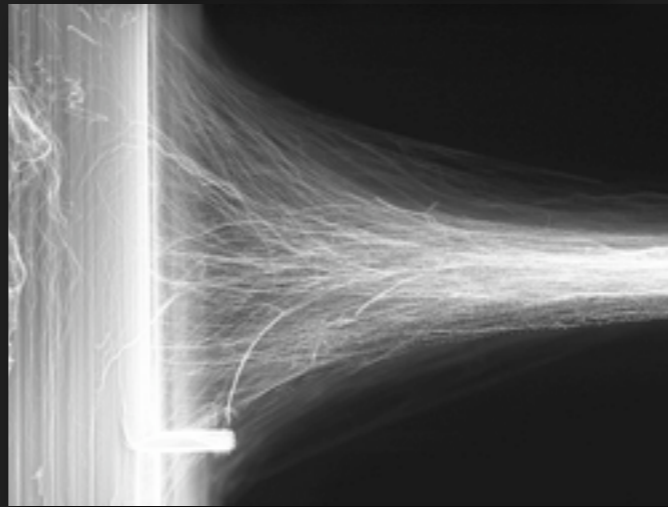
Where existing regulations are ***weak***

Electronics



© Beckman Institute

Artificial muscles



blog.wired.com

Spun textiles

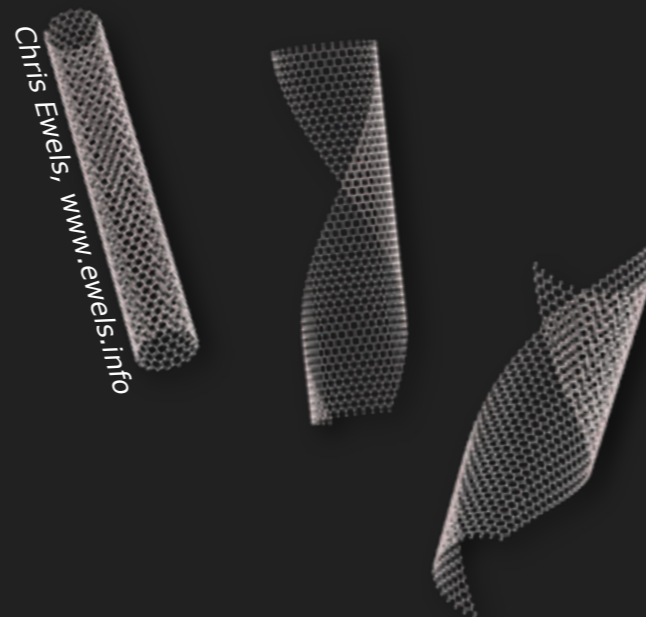


© CSIRO

Medicine

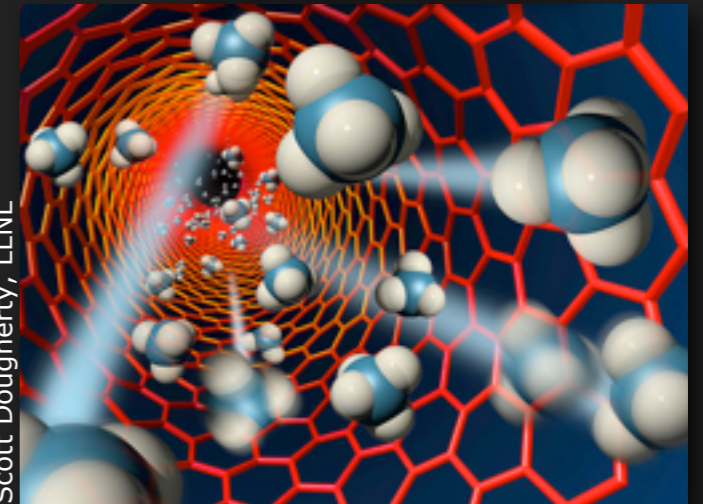


JPL



Chris Ewels, www.ewels.info

Desalination



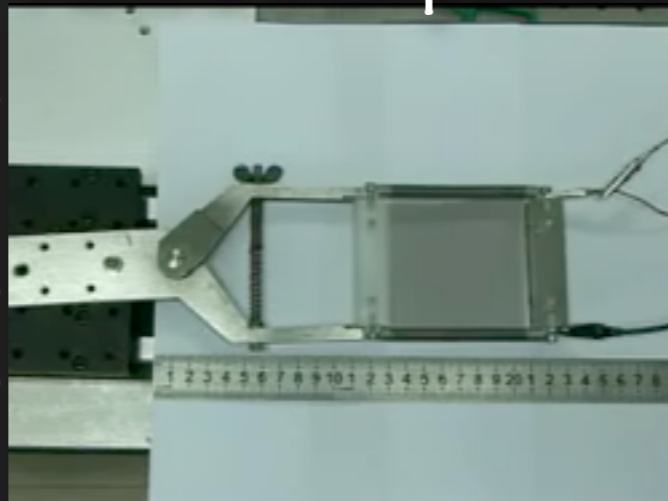
Scott Dougherty, LLNL

Strong materials



Easton

Flexible loudspeakers



Kaili Jiang, Tsinghua University

Space elevator



NASA

REGULATION Challenge
NOVELTY

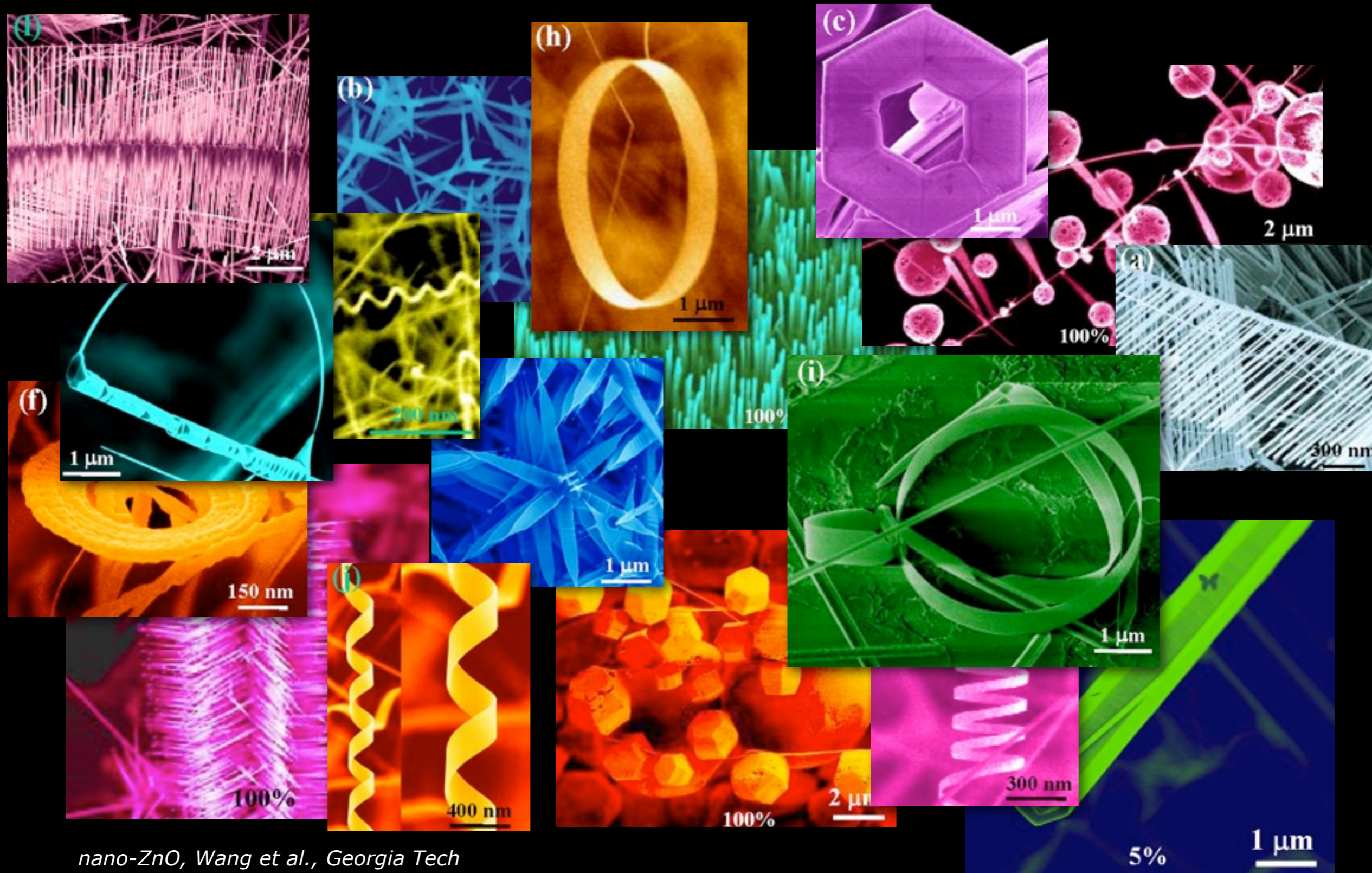
Similar Chemistry



Different Risks

REGULATION Challenge
NOVELTY

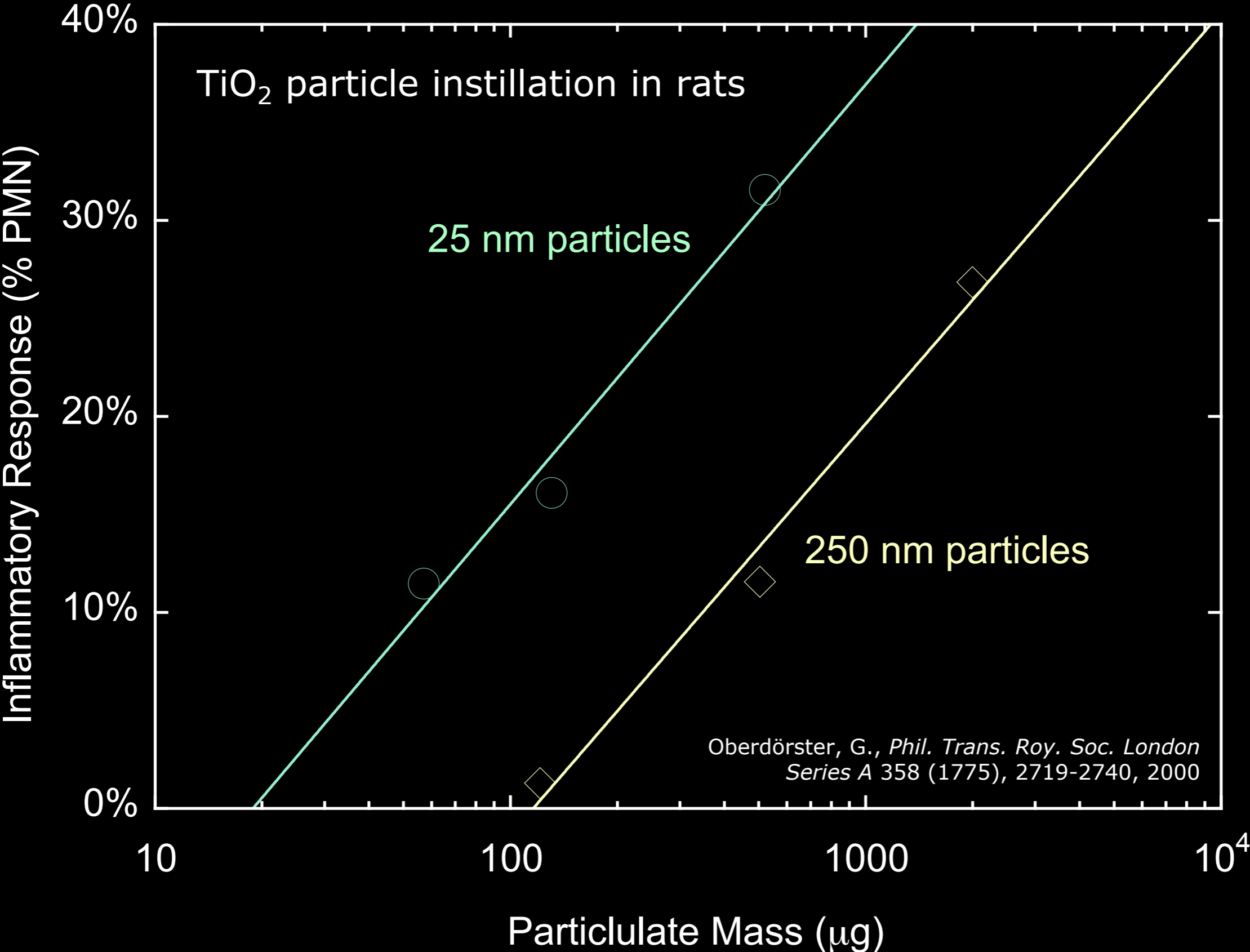
Similar Chemistry



nano-ZnO, Wang et al., Georgia Tech

Potentially Different Risks

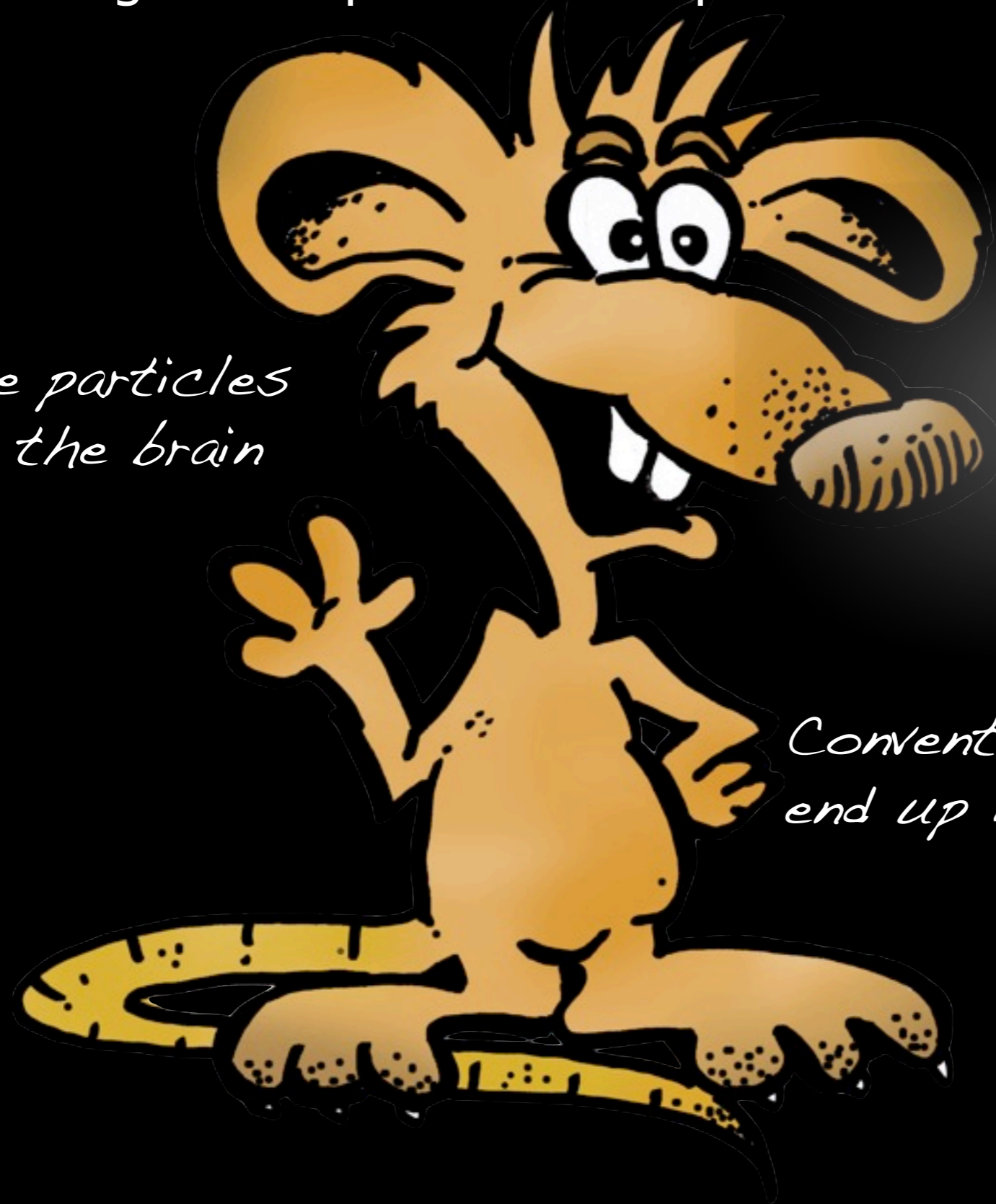
Nanomaterials: Same chemistry - Different response



Nanoparticles:

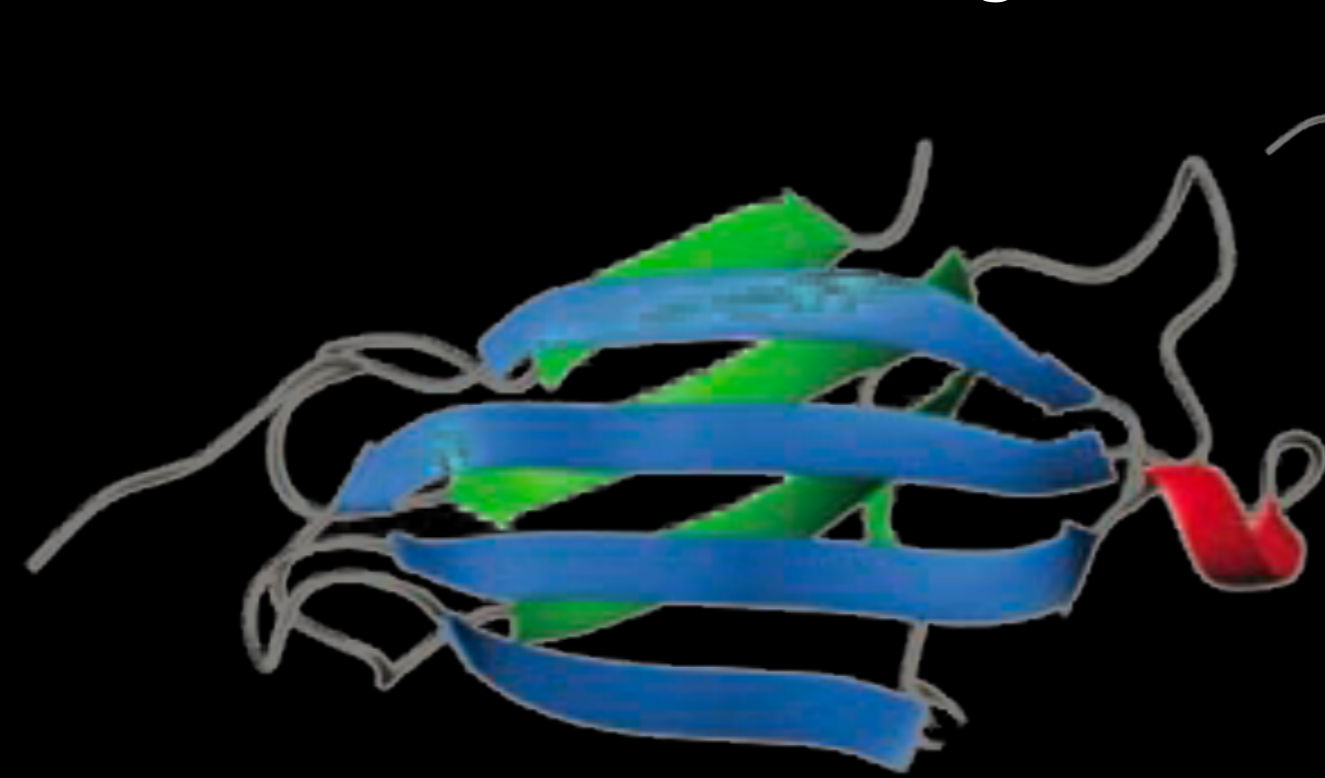
Getting to the places other particles cannot reach

*Nanoscale particles
end up in the brain*

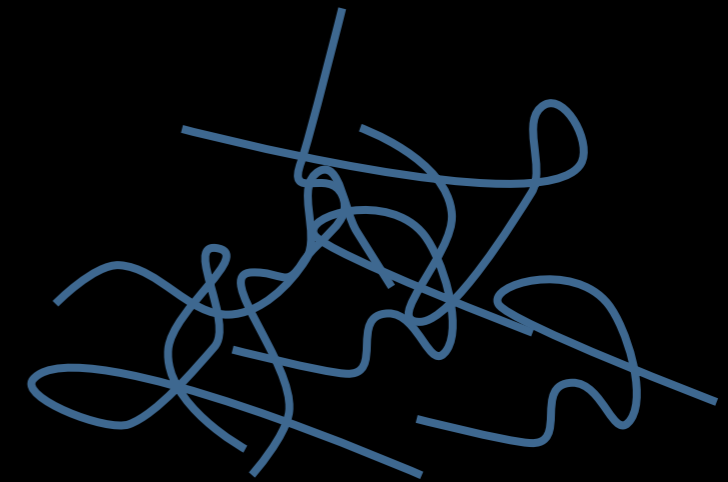
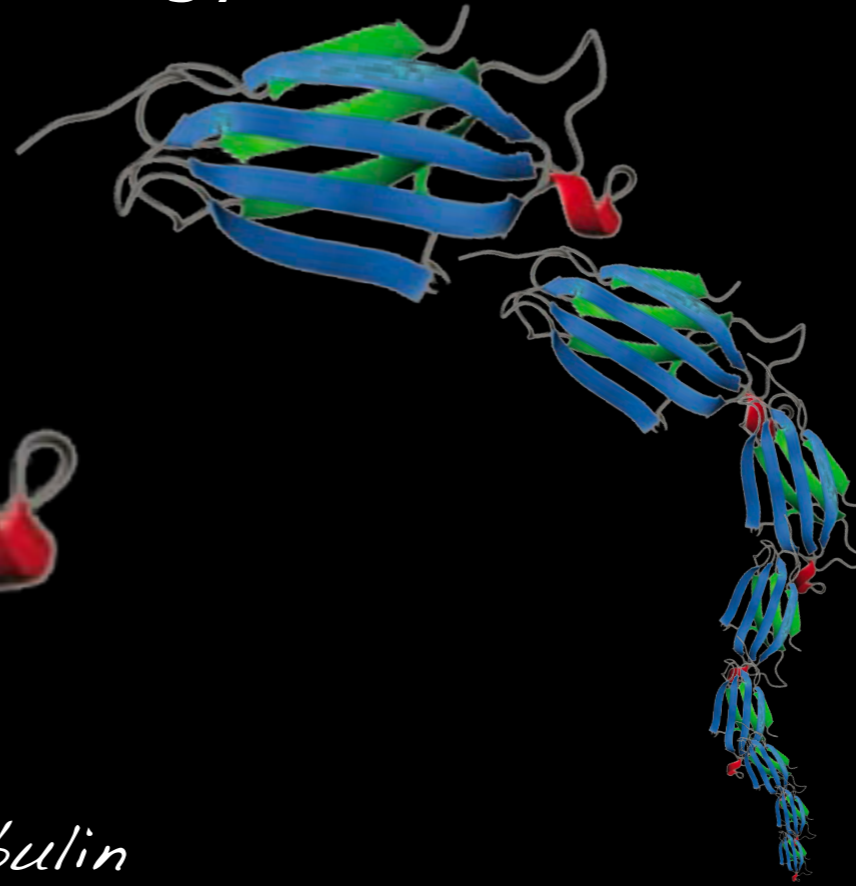


*Conventional particles
end up in the lungs*

Nanomaterials: Interfering with biology at the nanoscale

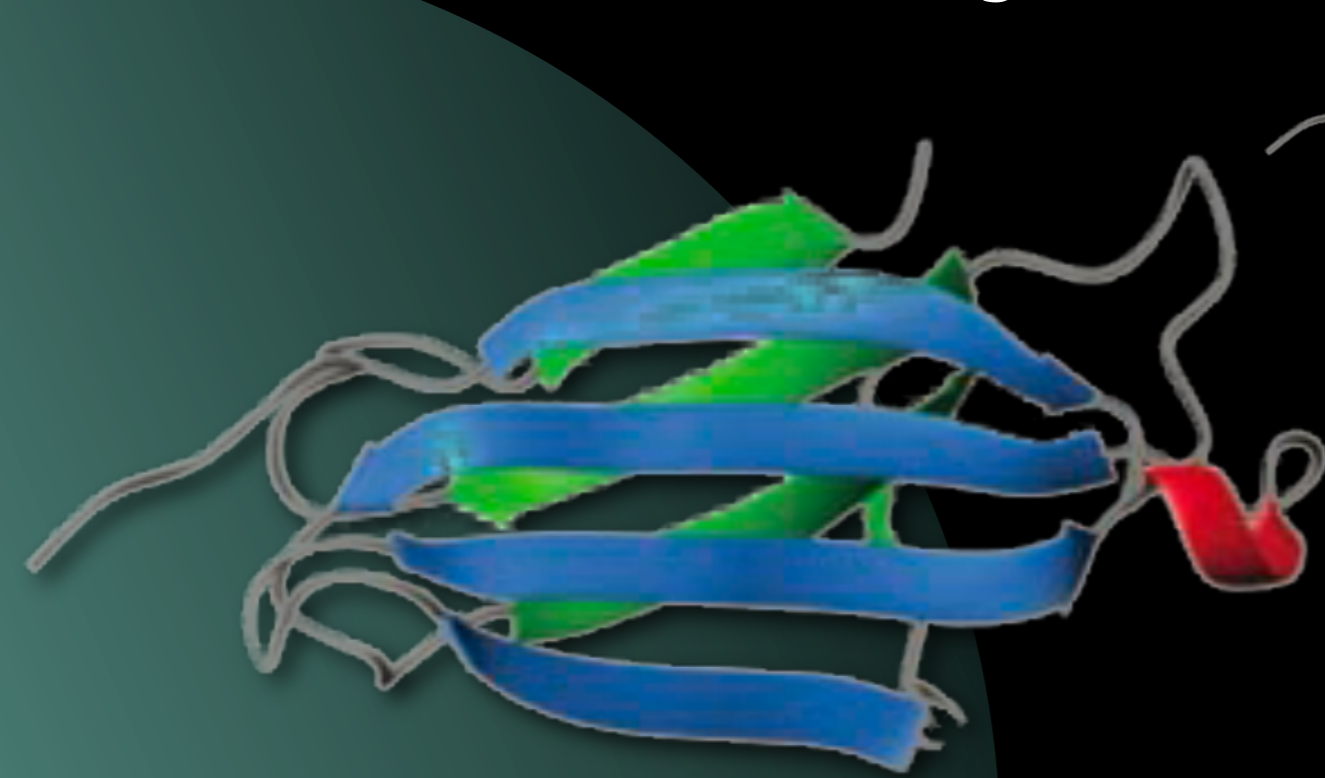


beta-2 microglobulin

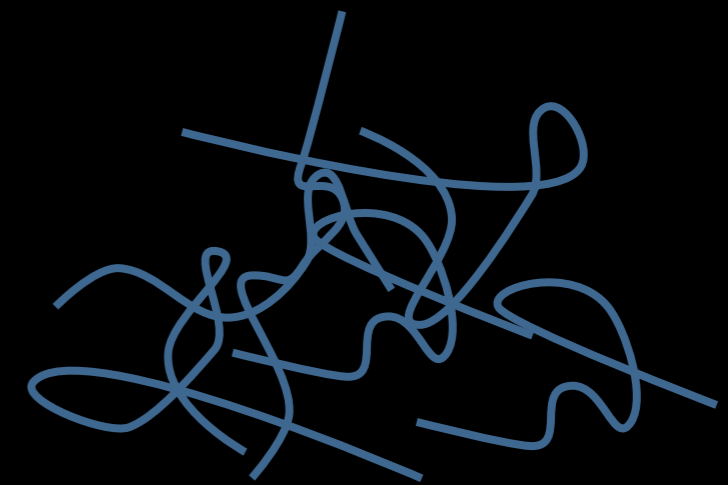
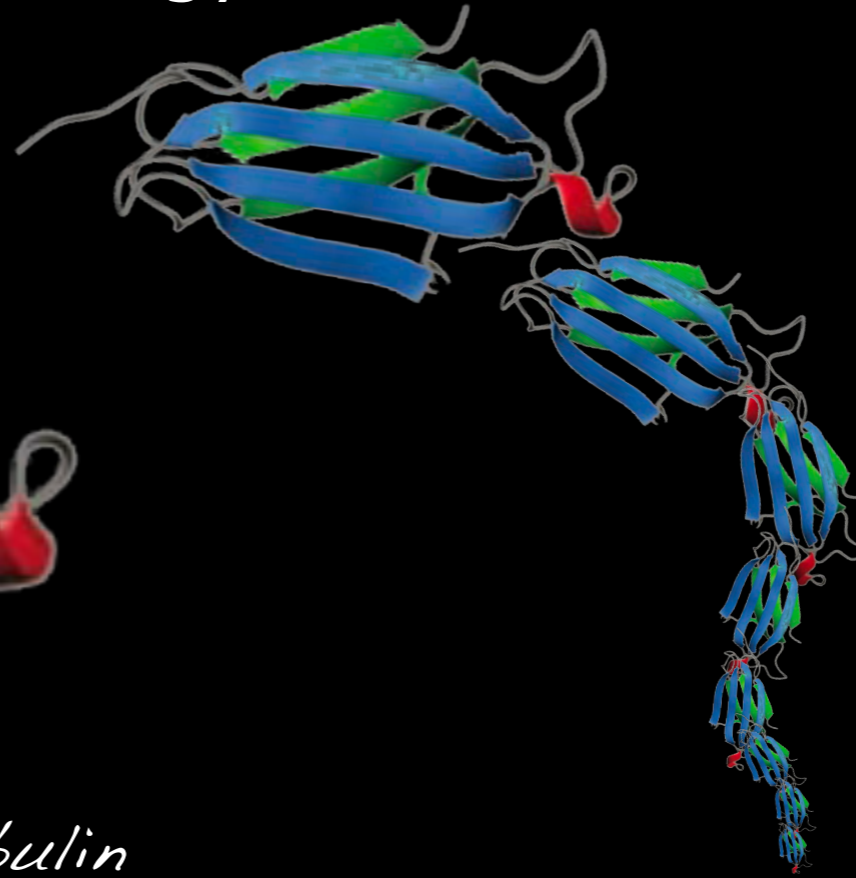


fibrillated protein

Nanomaterials: Interfering with biology at the nanoscale



beta-2 microglobulin

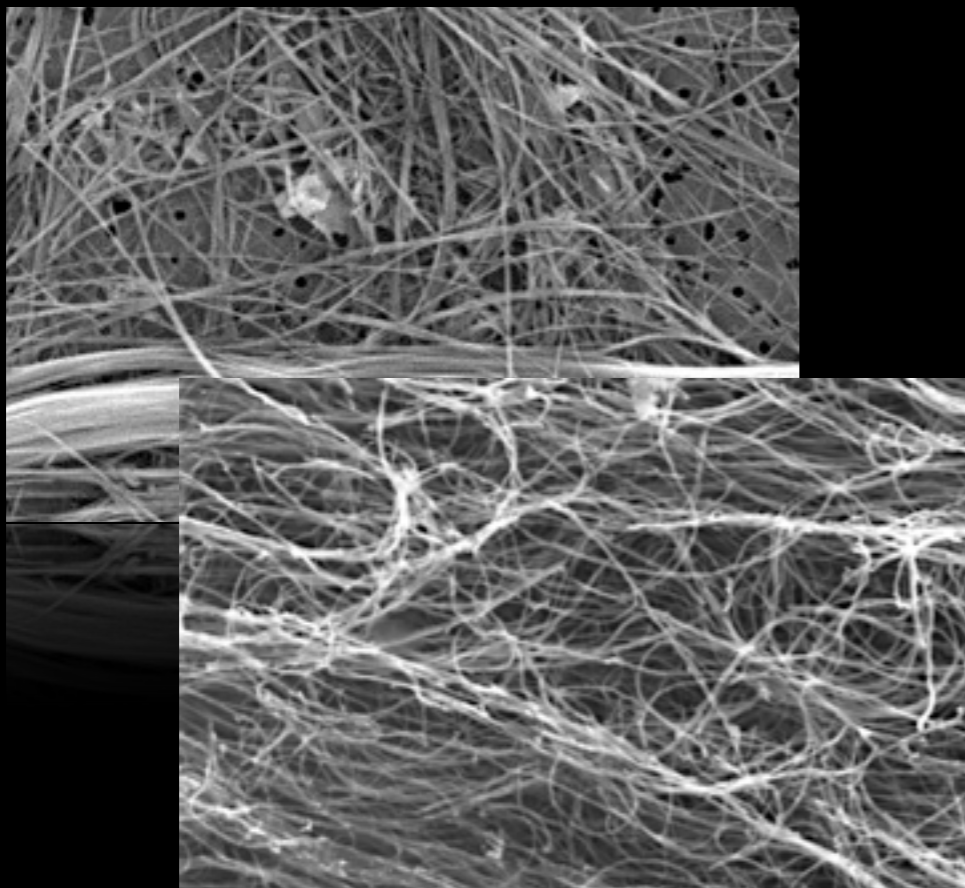


fibrillated protein

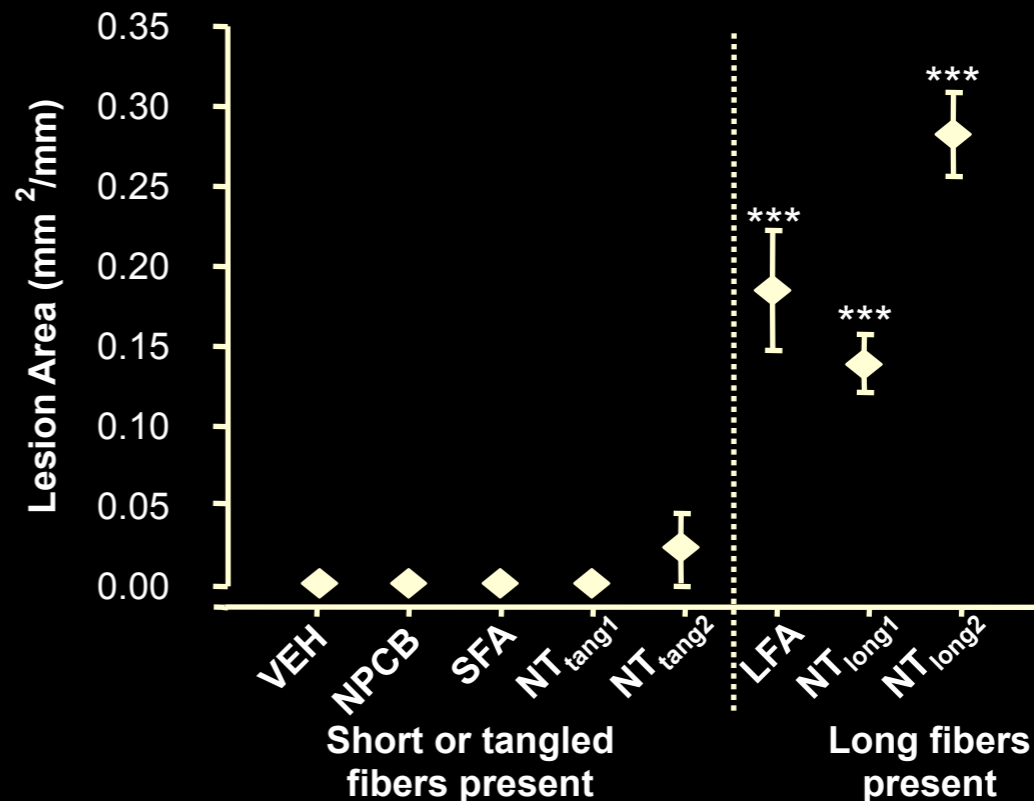
Carbon Nanotubes: Behaving unexpectedly

Asbestos

5 μm



Carbon Nanotubes



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

Adaptation:

Nanotechnology Oversight

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

Adaptation:

Nanotechnology Oversight

Strategic steps:

Know ***what you have***

Know ***what it does***

Know ***how to handle it***

***Across the material
& product life cycle***

Regulation:

A Federal Perspective

In brief:

EPA: *Assessing challenge; data collection; squeezing new challenges into old regs; review.*

FDA: *Assessing challenge; guidance; focus on products, not technology; treating new stuff on case by case basis.*

CPSC: *Assessing challenge.*

OSHA: *Marginal presence.*

Regulation:

A Local Perspective

In brief:

California: *Formal request for information on use, handling, safety and release of carbon nanotubes.*

Berkeley: *Ordinance for nanoparticle disclosure (2007). Information required on use, hazards, safe handling, disposal.*

Cambridge: *Rejected Berkeley-style ordinance in favor of voluntary data collection.*

Regulation:

A European Perspective

In brief:

REACH: *"No data, no market." Responsibility for safety data generation on manufacturers. Potentially covers nanomaterials, but details still to be worked through.*

Cosmetics: *New nano-specific rule covering labeling, definition and safety assessment. Comes into force 2012.*

Novel Foods: *Nano-ingredient definition proposed, that will require nanoscale ingredients in foods to be identified.*

Regulation:

A European Perspective

Nano Definition

COSMETICS

An insoluble or biopersistent and intentionally manufactured material with one or more external dimensions, or an internal structure, on the scale from 1 to 100 nm.

Nano Definition

NOVEL FOODS

Any intentionally produced material that has one or more dimensions of the order of 100 nm or less or is composed of discrete functional parts, either internally or at the surface, many of which have one or more dimensions of the order of 100 nm or less, including structures, agglomerates or aggregates, which may have a size above the order of 100 nm but retain properties that are characteristic to the nanoscale.

OVERSIGHT Challenge IN PERSPECTIVE:

There's no such thing as "**Nanotech risk**"...

...but the **potential dangers** of some nanotech products are very real

It's not so much how **small** something is that is important...

...as how **unusual** its behavior is.

Evidence-based decision-making is **critical** to the development of safe, successful nanotechnologies, but...

...it depends on access to **relevant information**.

REGULATION Challenge IN PERSPECTIVE:

What's Important?

Smallness



Strangeness

Noof!



Sophistication

Additional Resources (Selected)

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Andrew D. Maynard PhD

Chief Science Advisor

Project on Emerging Nanotechnologies

Woodrow Wilson International Center for Scholars

Tel: +1 202 691 4311

Email: andrew.maynard@wilsoncenter.org

Web: www.nanotechproject.org

Writing on emerging technologies at:

<http://2020science.org>